



Involute Simulation Softwares Inc.

HyGEARS® V 4

Updates / Recent changes

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2012-2017

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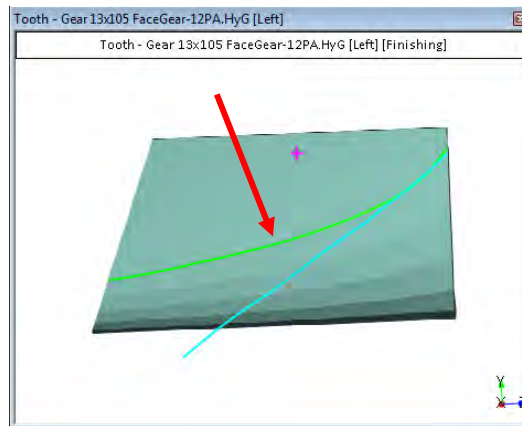
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HyGEARS update -09 April 2017 - Build 405.80 - 461

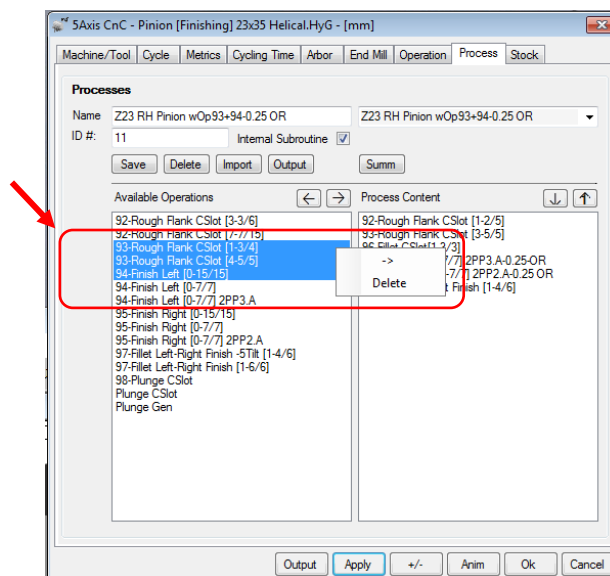
1) For Face Gears, improvement to the digitization of gears with small ID. Face Gears have a Fillet that varies from Toe to Heel; it has a large depth at Toe and is smaller at Heel. The green line, figure below, displays the transition between Flank and Fillet. At Toe, the Fillet covers almost the full tooth depth.



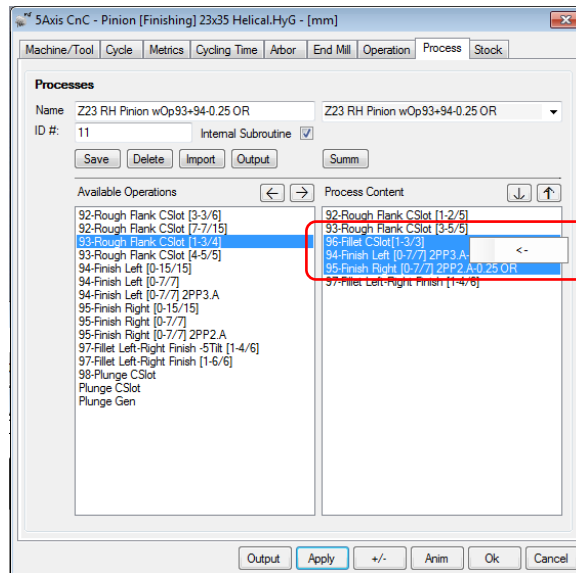
If one attempts to further reduce the ID of the gear, there is no more an active tooth flank, and only the fillet part remains. This is not supported in HyGEARS. However, whereas prior releases of HyGEARS supported ID where the Fillet could reach ~50% of tooth depth, it is now possible to reach full tooth depth, as shown above. Because the fillet varies exponentially near Toe, a small ID change can be significant.

2) In 5Axis, *Process data page*:

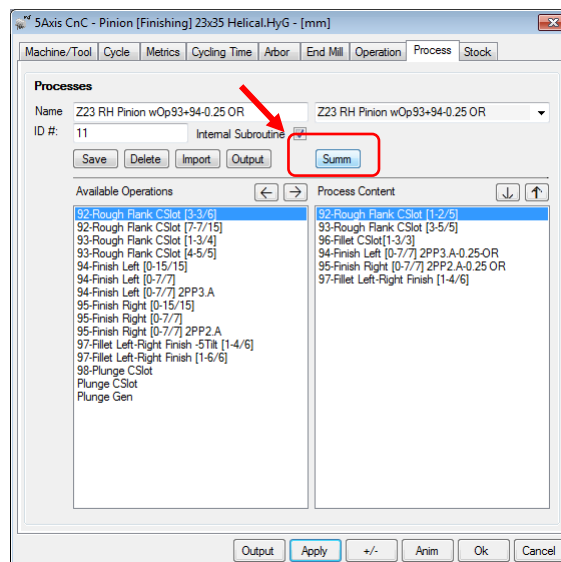
- Several Operations can now be selected from the Available Operations list, and using a Right Mouse click, they can be either Deleted or moved to the Process Content with the “->” selection.



- Likewise, Several Operations can now be selected from the Process Content list, and using a Right Mouse click, they can be moved back to the Available Operations list with the “<-” selection.



- The “Summ” button instructs HyGEARS to scan the selected process and generate a Summary where the Process sequence can be easily consulted to detect potential conflicts.



Summary - CnC Process Z23 RH Pinion wOp93+94-0.25 OR

File Edit

PROCESS: Z23 RH Pinion wOp93+94-0.25 OR - Pinion : 23x35 Helical.HyG [mm]

Seq#	OpID	OpName	Machine	Target	Tool	DLen	ToolName	ToolID	ApexLoc	Start	End	ToeClr	HeelClr	Stock	Time['']
1	92	92-Rough Flank CSlot [1-2/5]	Mori NI4250 / C1 [B+]	Flank	CoSINT	-1.5129	340_220263R7_D1	1030	-25.0000	1	2	28.000	5.000		6.7
2	93	93-Rough Flank CSlot [3-5/5]	Mori NI4250 / C1 [B+]	Flank	CoSINT	-0.7282	001_229263R75_D1	1027	-25.0000	3	5	20.000	5.000		7.5
3	96	96-Fillet CSlot[1-3/3]	Mori NI4250 / C1 [B-]	Fillet	CoSINT	+0.3404	S-327.2PP3.A	1031	-25.0000	1	3	20.000	5.000		7.1
4	94	94-Finish Left [0-7/7] 2PP3.A-0.25-	Mori NI4250 / C1 [B+]	Flank	CoSINT	+0.3404	S-327.2PP3.A	1031	-25.0000	0	7	17.000	17.000	+0.100	15.8
5	95	95-Finish Right [0-7/7] 2PP2.A-0.25	Mori NI4250 / C1 [B+]	Flank	CoSINT	-0.3404	S-327.2PP2.A	1029	-25.0000	0	7	17.000	17.000	+0.100	14.4
6	97	97-Fillet Left-Right Finish [1-4/6]	Mori NI4250 / C1 [B+]	Fillet	EndM		1.5mm Ball Nose	1033	-25.0000	1	4	4.000	4.000	-0.050	81.0

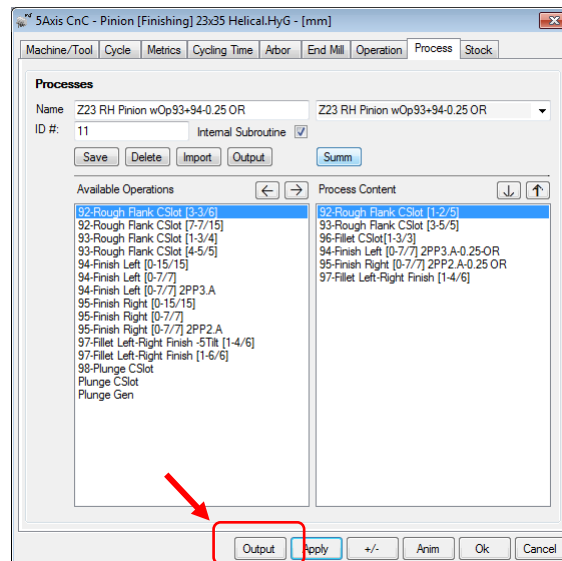
Est.Time : 2.21 H

The information displayed includes:

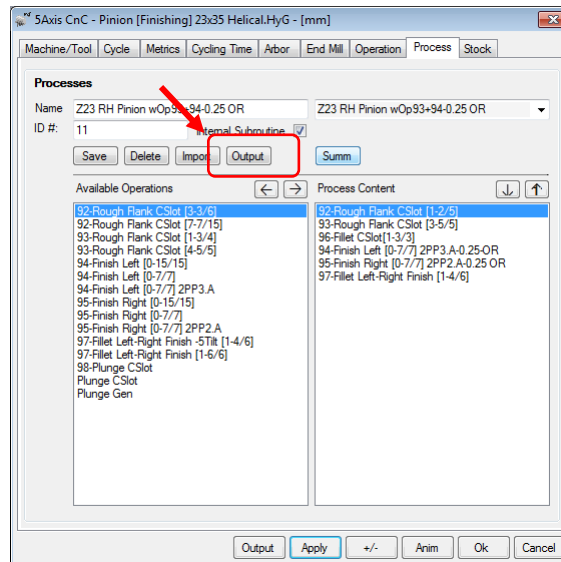
- Seq#: the order in which each Operation is executed;
- OPID: the Operation ID given in the Operation data page;
- OpName: the name given to the Operation;

- Machine: name of the machine used (normally always the same);
 - Target: either Fillet, Flank or Combined;
 - Tool: FMill, CoSIMT, EndM, BallM;
 - DLen: tool length compensation for CoSIMT tools;
 - ToolName: name given to the tool;
 - ToolID: ID given in the Operation data page and used by some controllers;
 - ApexLoc: Apex Location value;
 - Strt: Start step;
 - End: End step;
 - ToeClr: Toe clearance;
 - HeelClr: Heel clearance;
 - Stock: stock, either + or -;
 - Time[']: expected time required for each Operation;
 - Est.Time: estimated total time required for the Process (in Hours).
- The “Output” button, at the bottom of the *Process data page*, now works differently: when clicked, HyGEARS will scan the Process and output each Operation individually, just like if the user had selected each Operation one by one and outputted it.

The idea behind this behavior is to allow re-generating all part programs individually after several changes have been made to the Operations of a given Process.



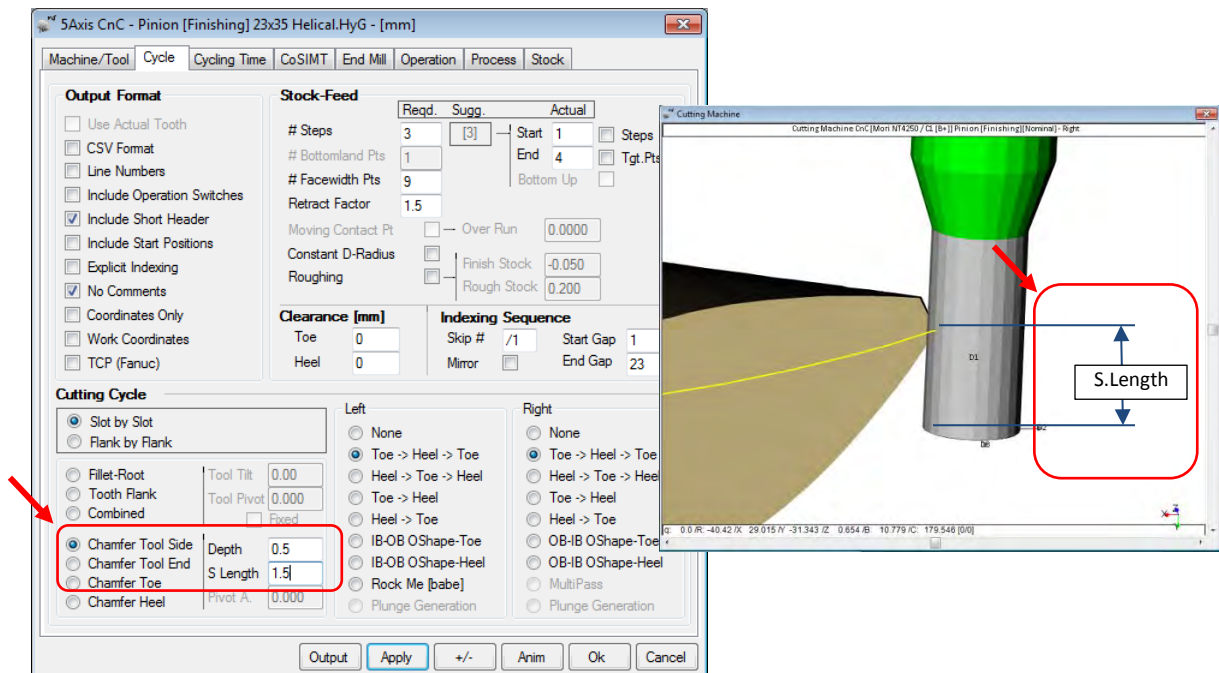
- The “Output” button, at the top of the *Process data page*, still works as before, i.e. it instructs HyGEARS to generate the complete Process, either in 1 file if the Internal Subroutine option has been selected, or else in several separate documents if the Internal Subroutine option is not selected.



3) In 5Axis, Cycle data page:

- when the “Chamfer Tool Side” option is selected, HyGEARS now allows specifying the distance along the cutting edge where chamfering will occur, i.e, the “S.Length”

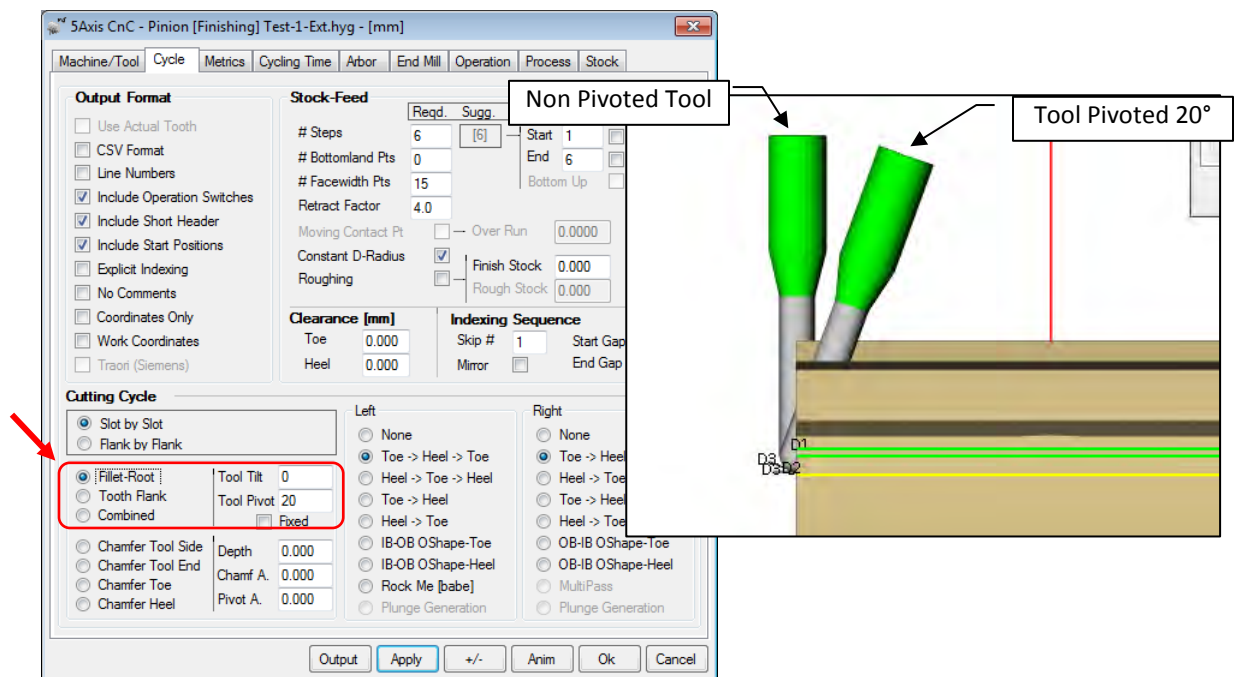
For example, figure below, Chamfer Depth is 0.5 mm and the S.Length is 1.5 mm, which results in the tool working away from its tip.



- when either an End Mill or a Ball Mill tool has been selected, the *Tool Pivot* option is now made available for both Flank and Fillet cutting operations (before, it was available only for Flank cutting).

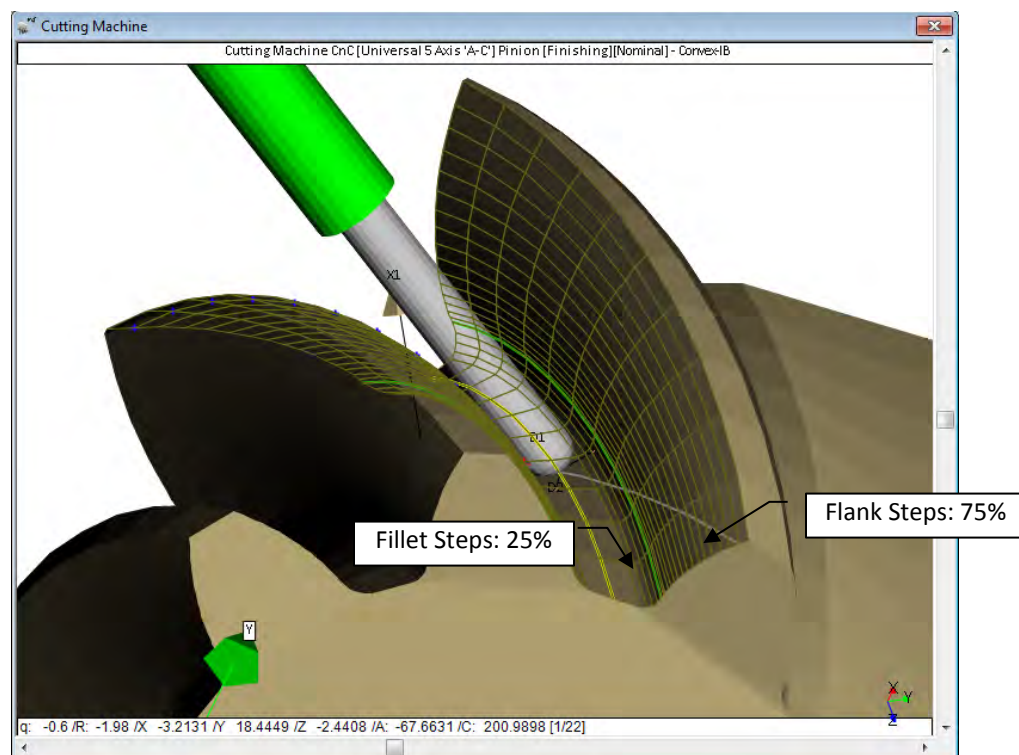
The End Mill and Ball Mill tools used to cut the Fillet part of the tooth normally have a spherical shape, which means that the tip of the tool ends up with a zero circumferential speed with

consequently bad cutting conditions. Pivoting the tool in the direction of the travel path forces the tool to work away from its tip, thereby improving cutting conditions and increasing tool life.



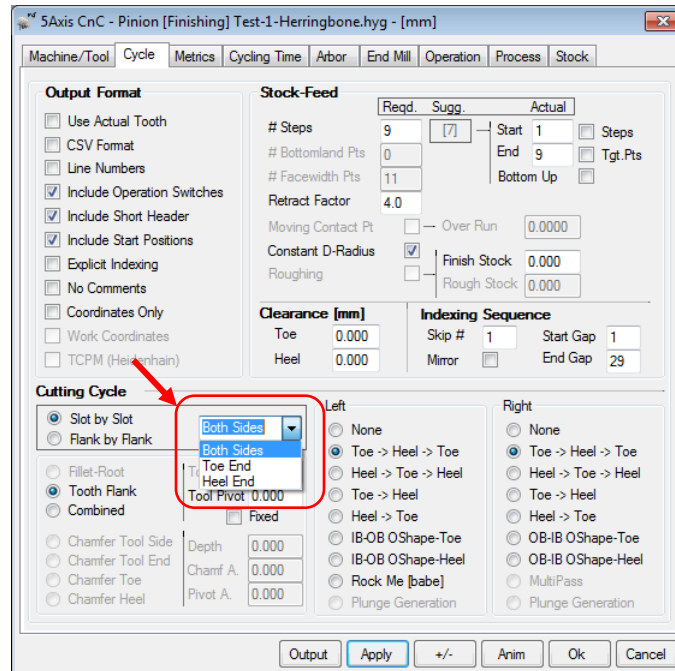
- The Combined cycle has been adjusted to allow cutting Tapered bevel gear teeth. In the case of tapered bevel gear teeth, depth-wise spacing of the target grid is not constant; however, the # Steps on the Flank and in the Fillet will remain constant, such as to ensure that the tool has a predictable motion.

The entered #Steps is divided 25% Fillet / 75% Flank.

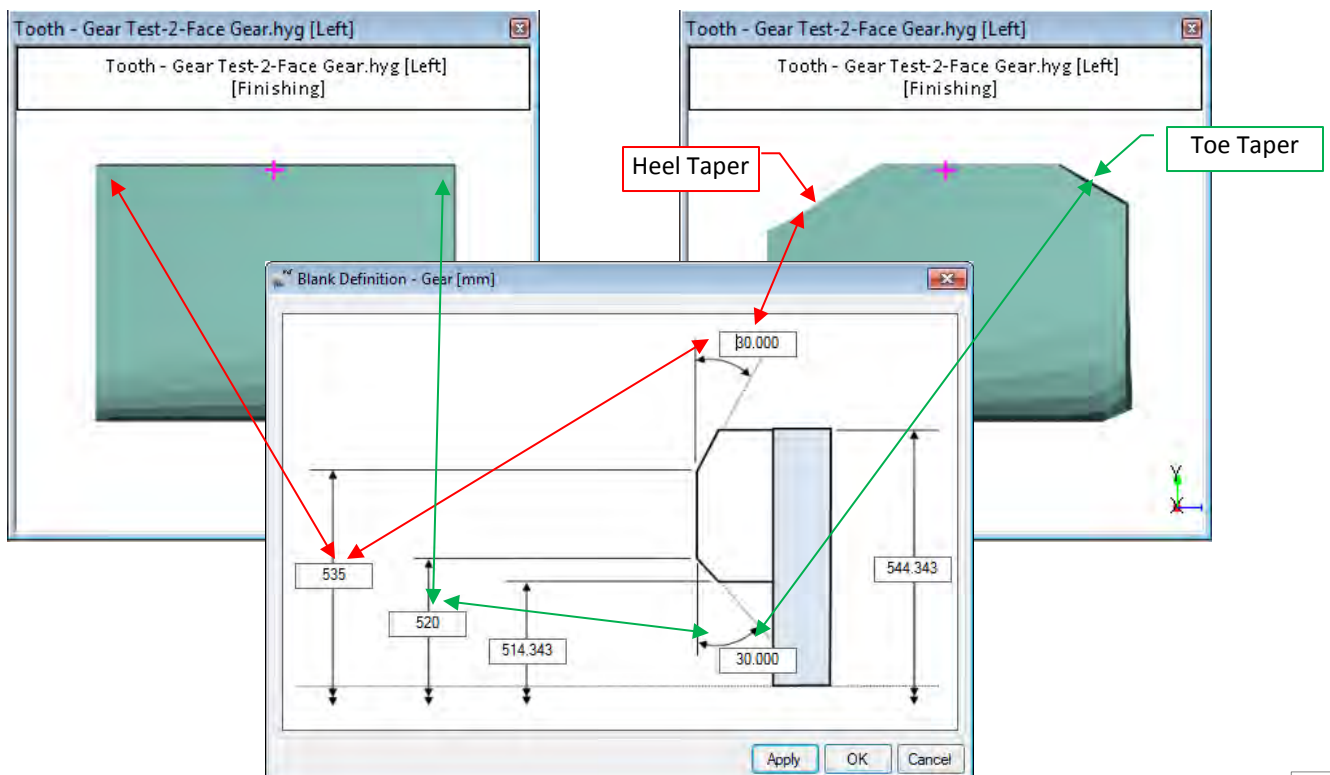


4) In 5Axis, for Herringbone gears (Double Helical cylindrical gears), *Cycle data page*, the user can now decide the sequence used to cut the teeth, i.e.: either:

- Both Sides
- Toe End
- Heel End

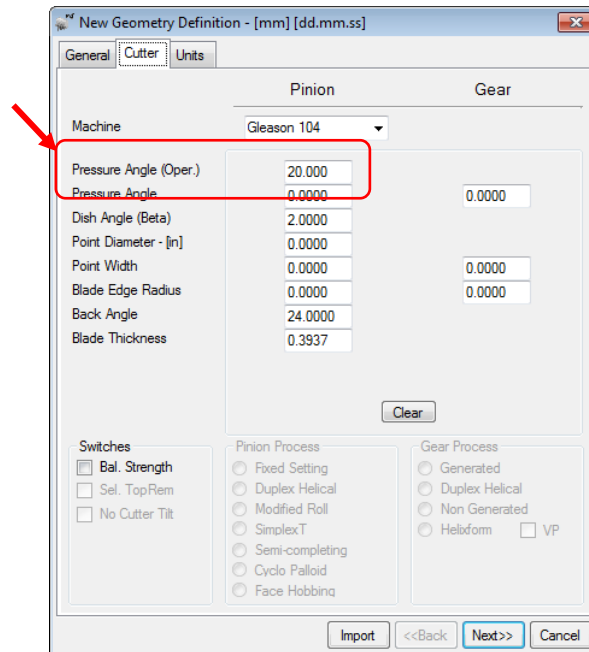


5) Face Gears usually have a tapered Heel in order to avoid pointed teeth; sometimes, the Toe is also tapered. It is now possible to define the Toe and Heel taper. Taper angles are positive values.



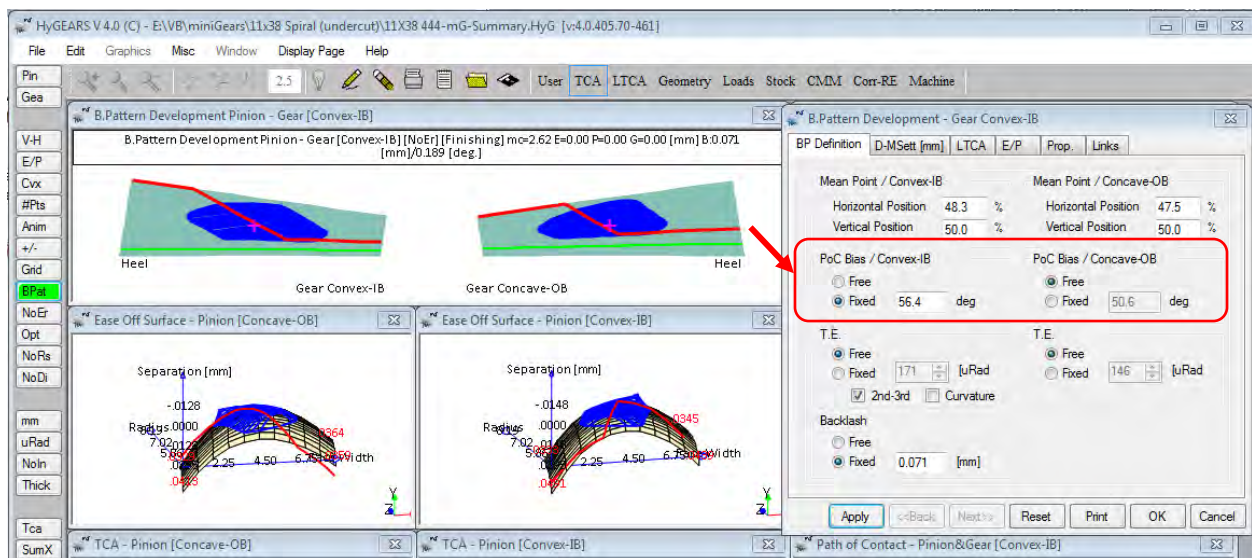
6) For Coniflex gears, it is now possible to impose the *Operating Pressure Angle*. This will result in a gear set where cutter tilt is the default value found on conventional Gleason machines, but with a smaller or larger operating pressure angle to suit the required conditions.

For example, reducing the Operating Pressure angle increases contact ratio, but also increases the likelihood of undercutting; increasing the Operating Pressure angle reduces the contact ratio, but may help avoiding undercutting.

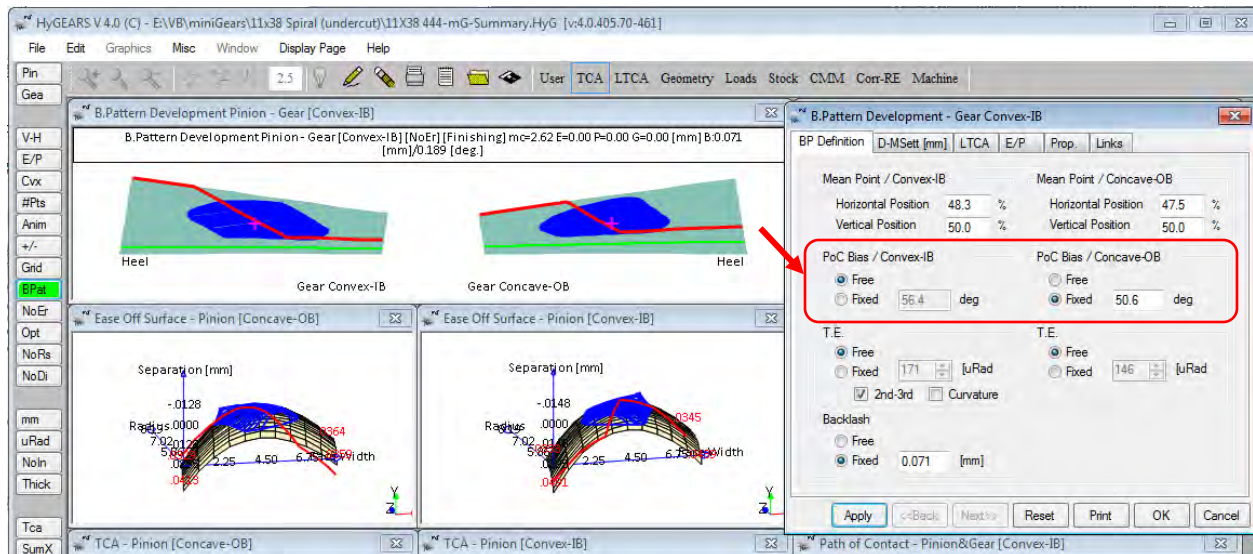


7) When developing the BP of a spiral-bevel gear set with No Cutter Tilt ("BPat" function button), it is now possible to impose the Bias on one tooth flank, the opposite tooth flank being slave to what was required.

For example, figure below, the Pinion cutter Tilt was removed from this generated 11x38 spiral-bevel gear set. Bias on the IB and OB is unequal ("RemT" function button, Geometry mode).



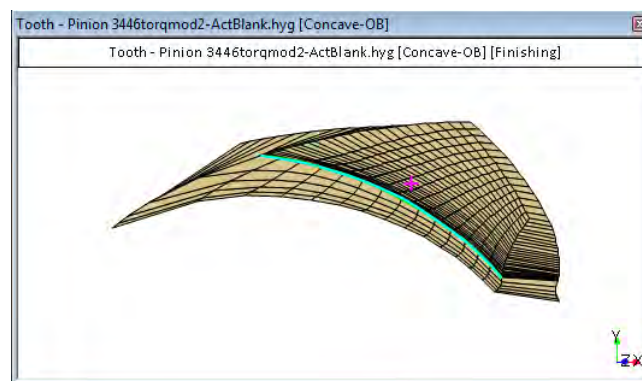
Selecting Fixed on the PoC Bias / Convex-IB side disables the Bias on the Concave-OB side – above figure; selecting Fixed on the PoC Bias / Concave-OB side disables the Bias on the Convex-IB side – figure below.



The user then controls the desired tooth flank for the desired running characteristics, the opposite tooth flank being slave to what was imposed on the desired tooth flank.

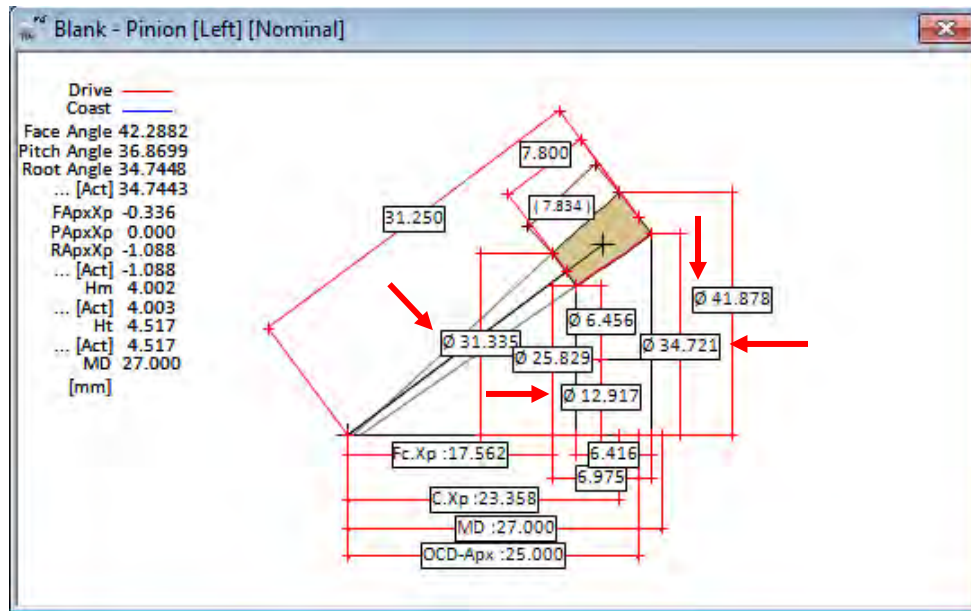
8) For Step output (“STEP” function button, Geometry mode, optional), the Flank and Fillet now are one continuous BSpline surface, as opposed to the previous encoding where the Flank and Fillet were 2 different BSpline surfaces.

HyGEARS also ensures that no gap appears between Fillet and Flank because of undercutting. For example, figure below, this spiral-bevel Pinion sees heavy undercutting all along the Concave flank. The Fillet points are now scanned to ensure no gap appears at the Fillet to Flank junction (cyan-green line).



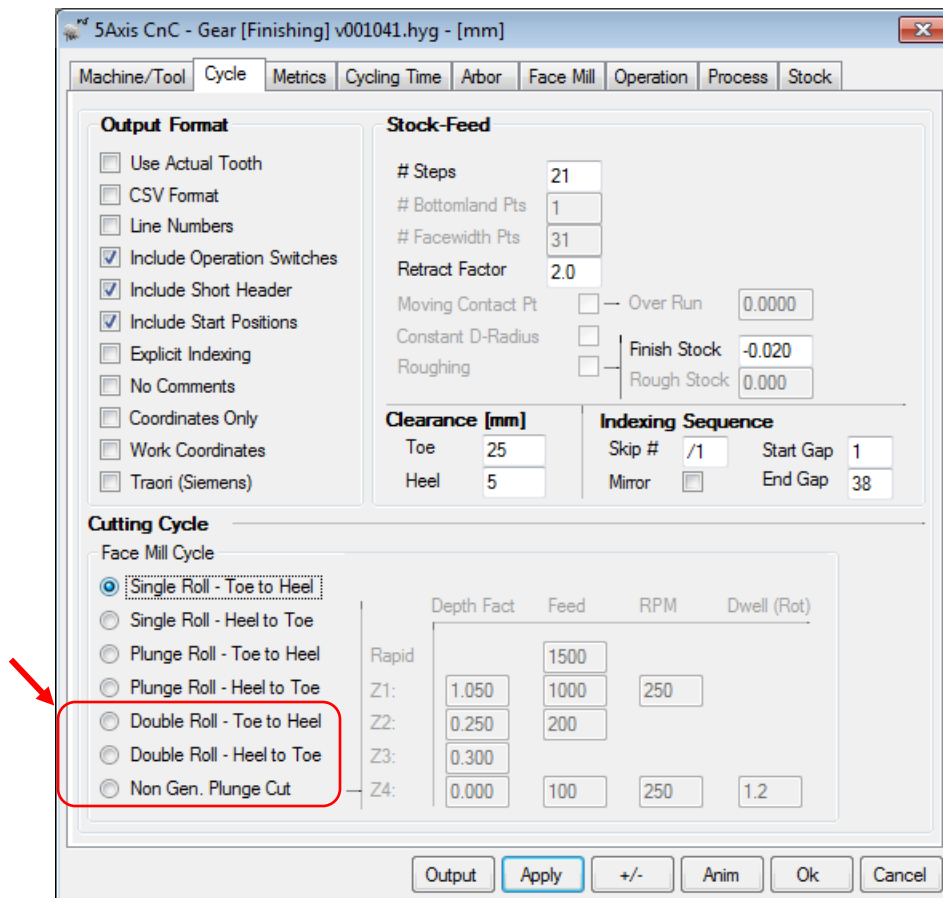
This results in improved import in some CAD systems that can be a bit picky.

9) The Blank display now specifies the diameter dimensions with the \varnothing symbol in order to prevent misinterpretation.



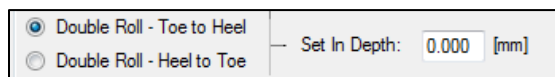
HyGEARS update –15 January 2017 - Build 405.70 - 461

1) In 5Axis, addition of 3 new cutting cycles for *Face Mill cutters*.



Generated spiral-bevel gears: the *Double Roll – Toe to Heel* and *Double Roll –Heel to Toe* cycles do as their names imply, i.e.

- plunge to Set In Depth at Toe or Heel, respecting the imposed Toe and Heel clearances,
- generate at Set In Depth till Heel or Toe, depending on where the cycle started,
- plunge to full depth and return to Toe or Heel full depth, while generating,
- retract, index, and start over again.

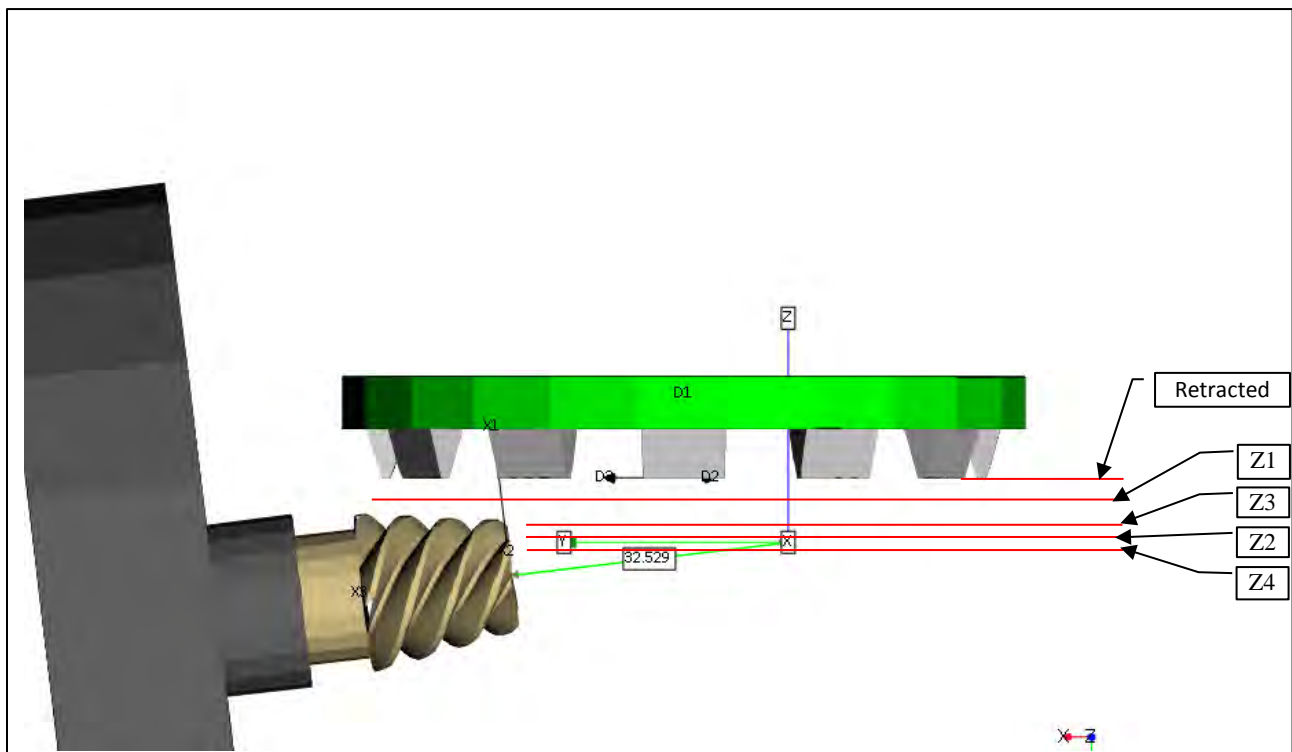


Non Gen. Plunge Cut:

this cycle is intended for either non generated (Formate) gears or to “rough cut” generated gears. It is divided in up to 5 segments as detailed below:

Cutting Cycle				
Face Mill Cycle				
<input type="radio"/> Single Roll - Toe to Heel <input type="radio"/> Single Roll - Heel to Toe <input type="radio"/> Plunge Roll - Toe to Heel <input type="radio"/> Plunge Roll - Heel to Toe <input type="radio"/> Double Roll - Toe to Heel <input type="radio"/> Double Roll - Heel to Toe <input checked="" type="radio"/> Non Gen. Plunge Cut	Depth Fact Rapid Z1: Z2: Z3: Z4:	Feed 1500 1000 200 100	RPM 250 150	Dwell (Rot) 1.2

- In the following, all depths Z1, Z2, etc. are given as *Depth Factors* calculated at **mid-face width**, i.e. tooth depth at mid-face width is multiplied by the *Depth Fact* value to obtain the actual tooth depth;
- The tool is initially in its retracted position; the *Rapid Move* feed is 1500 mm/min; in the current example, the *Retract Factor* is 3.0, and is calculated at *mid-face width*;
- The tool plunges to depth Z1 (i.e. 1.050 times tooth depth at mid-face width) at *Z1 feed* (1000 mm/min above); Z1 **should** be outside the tooth in order to allow a fast plunge, and therefore should always be somewhat larger than 1.0;
- The tool then cuts from depth Z1 (1.050 above) to depth Z2 (0.250 above) at the *Z2 feed* (200 mm/min above) and with the *Z1 RPM* (250 RPM above);
- The tool then retracts from depth Z2 (0.250 above) to depth Z3 (0.300 above) where RPM is changed from 250 to 150 RPM;
- The tool then cuts from depth Z3 (0.300 above) to depth Z4 (0.000 above, i.e. tooth root) at the *Z4 Feed* (100 mm/min above) with the tool rotating at *Z4 RPM* (150 RPM above); when at depth Z4, the tool dwells for *Z4 Dwell (Rot)* (i.e. 1.2 *cutter rotations* above);
- The tool then retracts at *Rapid Feed* (1500 mm/min above) to its retracted position given by the *Retract Factor* (3.0 above), the part is indexed and the cycle starts over again.



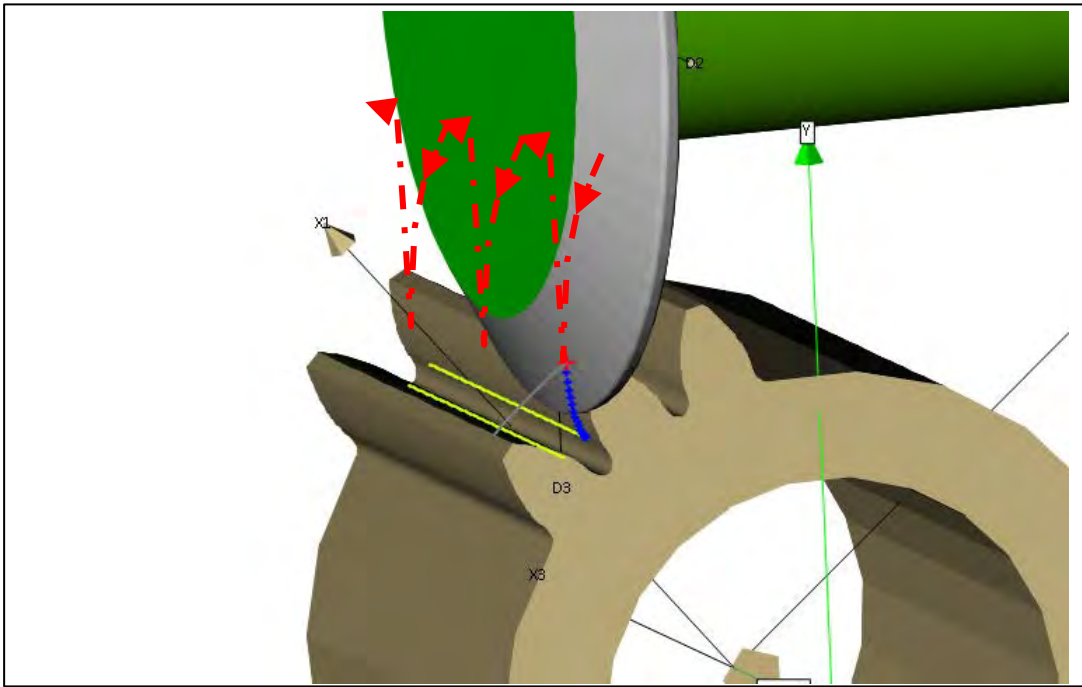
Notes:

- in the above example, Z3 (0.300) is *above* Z2 (0.250) as it is desired to retract the tool in order to change its RPM when it is not contacting the workpiece;
- any of the Z1, Z2 and Z3 *Depth Fact* values can be zero or negative; if so, then the cycle ignores the zero or negative values and aims only for *Depth Fact* Z4, which may be larger, equal, or less than zero;
- if the Z3 *Depth Fact* value is zero or negative, no cutter Z4 RPM change occurs;
- Dwell time is based on the current tool RPM and the number of desired cutter rotations *Dwell (Rot)*.

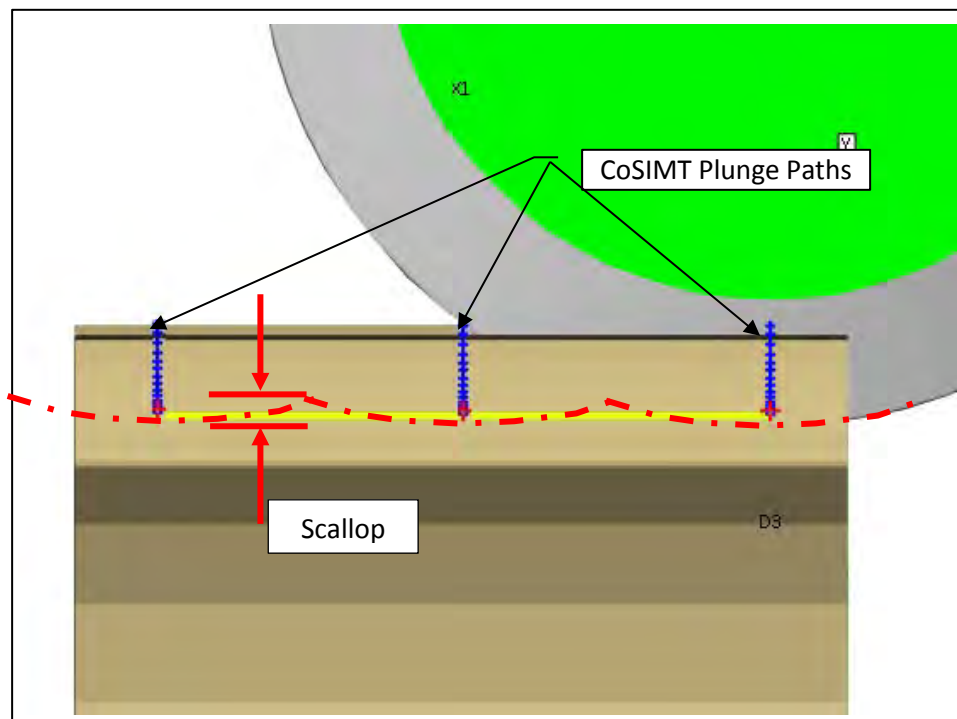
2) In 5Axis, addition of the *Plunge Generation* cutting cycle for CoSIMT tools.

The screenshot shows the '5Axis CnC - Pinion [Finishing] 23x35 Helical.HyG - [mm]' dialog box. The 'Cycle' tab is selected. The 'Output Format' section on the left has several options, with 'Include Short Header' and 'No Comments' checked. The 'Stock-Feed' section on the right has a table with 'Reqd.', 'Sugg.', and 'Actual' columns. The 'Clearance [mm]' section shows 'Toe' at 27.000 and 'Heel' at 30.000. The 'Indexing Sequence' section shows 'Skip #' as /1 and 'End Gap' as 23. The 'Cutting Cycle' section is active, showing 'Slot by Slot' and 'Tooth Flank' selected. The 'Left' and 'Right' sections both have 'Plunge Generation' selected, highlighted by a red box and a red arrow.

Plunge Generation plunges a CoSIMT tool along the profile from the OD to the root of the workpiece (see red dotted line, figure below). When at the bottom of the flank, the CoSIMT is retracted, advanced along the face width, and the *Plunge Generation* movement runs again, until all the targeted face width positions have been cut. It applies only to the tooth flank. The minimum # *Facewidth Pts* is 3.



The *Plunge Generation* cycle can be advantageous to rapidly cut spur and helical gears since the flat face of the CoSIMT can cover a large part of the tooth in one plunge. However, at the bottom of the tooth, a scallop will be left in the overlapping regions (figure below) and the # *Facewidth Pts* may need to be increased, followed by a fillet Operation to ensure an even fillet shape.



For the *Plunge Generation* cycle, the Metrics tab of the 5Axis CnC window displays the expected scallop height based on the Toe and Heel clearances, the #*Facewidth Pts* (which reflect the # of CoSIMT Plunge Paths), and the CoSIMT OD (figure below).

5Axis CnC - Pinion [Finishing] 23x35 Helical.HyG - [mm]

Machine/Tool Cycle Metrics Cycling Time Arbor CoSIMT Operation Process Stock

Stepping Dimensions

Finishing Left Point#	[mm]	Flat Length	Flat-Prof.
[Toe]			
0>1		9.0964	0.0167
1>2		9.0964	0.0167
2>3		9.0964	0.0167
3>4		9.0964	0.0167
4>5		9.0964	0.0167
5>6		9.0964	0.0167
Total :		54.5787	

Finishing Right Point#	[mm]	Flat Length	Flat-Prof.
[Toe]			
0>1		9.1297	0.0199
1>2		9.1297	0.0199
2>3		9.1297	0.0199
3>4		9.1297	0.0199
4>5		9.1297	0.0199
5>6		9.1297	0.0199
Total :		54.7783	

Scallop Height [mm] : 0.266

Output Apply +/- Anim Ok Cancel

3) In 5Axis, addition of the “Use Actual Tooth” option in the Output Format, Cycle tab.

5Axis CnC - Gear [Finishing] 11X38 426-427 mG-Summary Generated OD-56 RE Italy.HyG - [m...]

Machine/Tool Cycle Metrics Cycling Time Arbor End Mill Operation Process Stock

Output Format

☒ Use actual tooth

☐ CSV Format

☐ Line Numbers

☐ Include Operation Switches

☒ Include Short Header

☒ Include Start Positions

☐ Explicit Indexing

☐ No Comments

☐ Coordinates Only

☒ Work Coordinates

☐ TCPM (Heidenhain)

Stock-Feed

	Reqd.	Sugg.	Actual
# Steps	11	[11]	Start 0
# Bottomland Pts	0		End 11
# Facewidth Pts	31		Bottom Up
Retract Factor	4.0		
Moving Contact Pt		Over Run	0.0000
Constant D-Radius		Finish Stock	0.000
Roughing		Rough Stock	0.000

Clearance [mm]

Toe 0

Heel 0

Indexing Sequence

Skip # 1

Mirror ☐

Start Gap 1

End Gap 2

Cutting Cycle

☒ Slot by Slot

☐ Flank by Flank

☐ Fillet-Root

☒ Tooth Flank

☐ Combined

☐ Chamfer Tool Side

☐ Chamfer Tool End

☐ Chamfer Toe

☐ Chamfer Heel

Tool Tilt 10.00

Tool Pivot 0.000

☐ Fixed

Depth 0.000

Chamf A. 0.000

Pivot A. 0.000

Left

☐ None

☒ Toe -> Heel -> Toe

☐ Heel -> Toe -> Heel

☐ Toe -> Heel

☐ Heel -> Toe

☐ IB-OB OShape-Toe

☐ IB-OB OShape-Heel

☐ Rock Me [babe]

☐ Plunge Generation

Right

☐ None

☒ Toe -> Heel -> Toe

☐ Heel -> Toe -> Heel

☐ Toe -> Heel

☐ Heel -> Toe

☐ OB-IB OShape-Toe

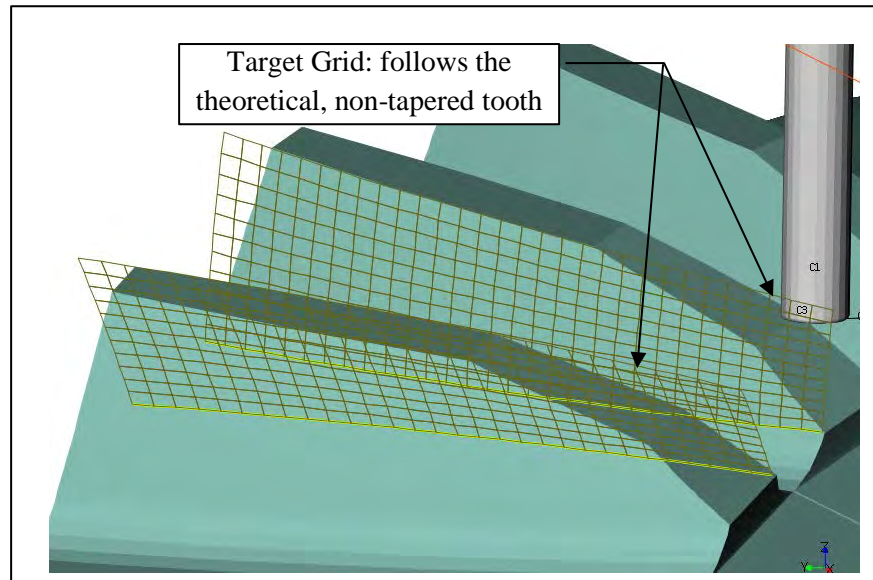
☐ OB-IB OShape-Heel

☐ MultiPass

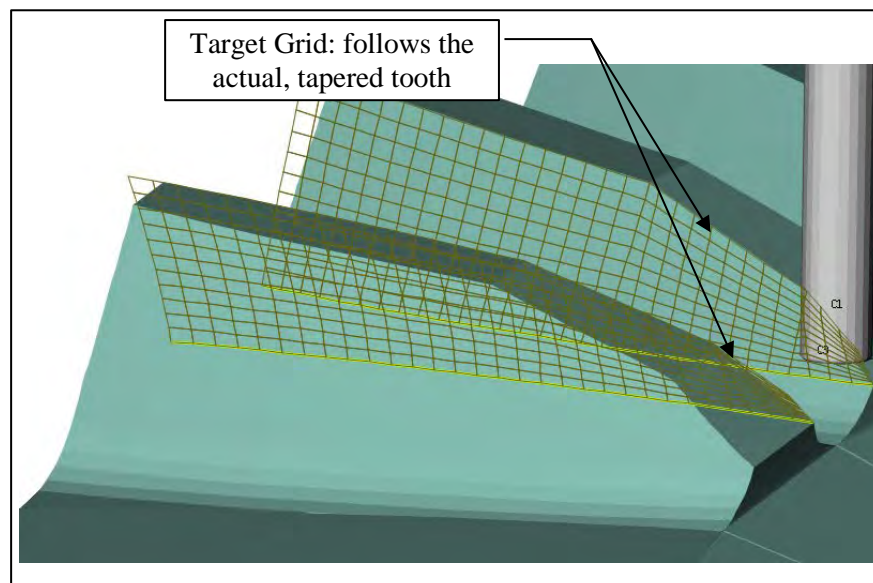
☐ Plunge Generation

Output Apply +/- Anim Ok Cancel

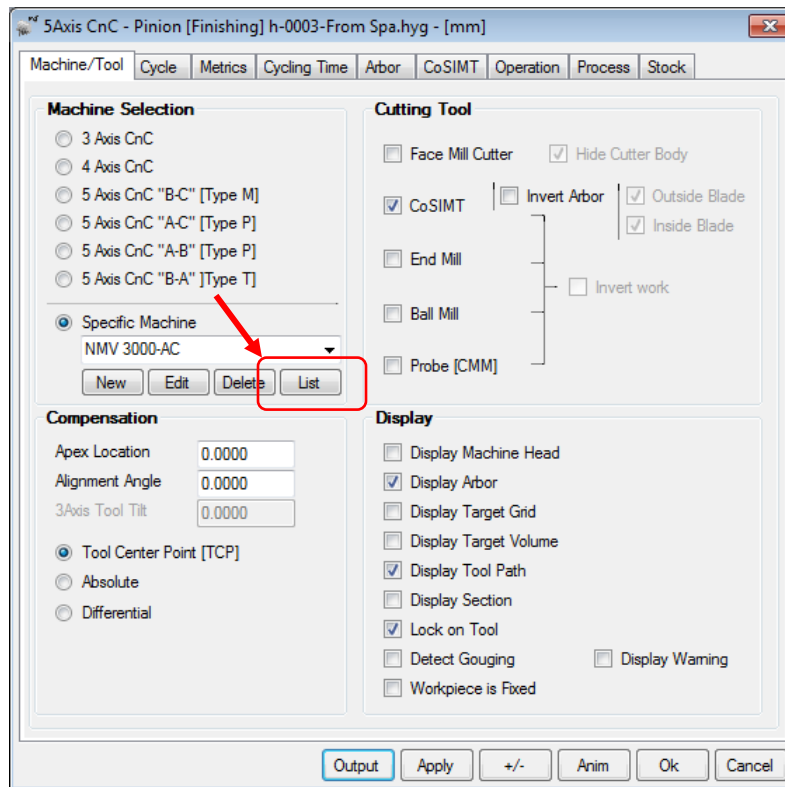
By default, HyGEARS generates the *target grid*, i.e. the grid of points where the tool contacts the work piece, using Front and Back angles equal to the pitch angle, and eliminating any taper on the face cone. Such a *target grid* appears in the figure below, where it is clear that the grid does not follow the actual tooth shape at Toe.



When *Use Actual Tooth* is checked, HyGEARS generates the *target grid* following the actual tooth shape, and the resulting grid appears in the figure below. Clearly, the target grid follows the tooth shape at Toe where the actual tooth shows a double taper along the top land.

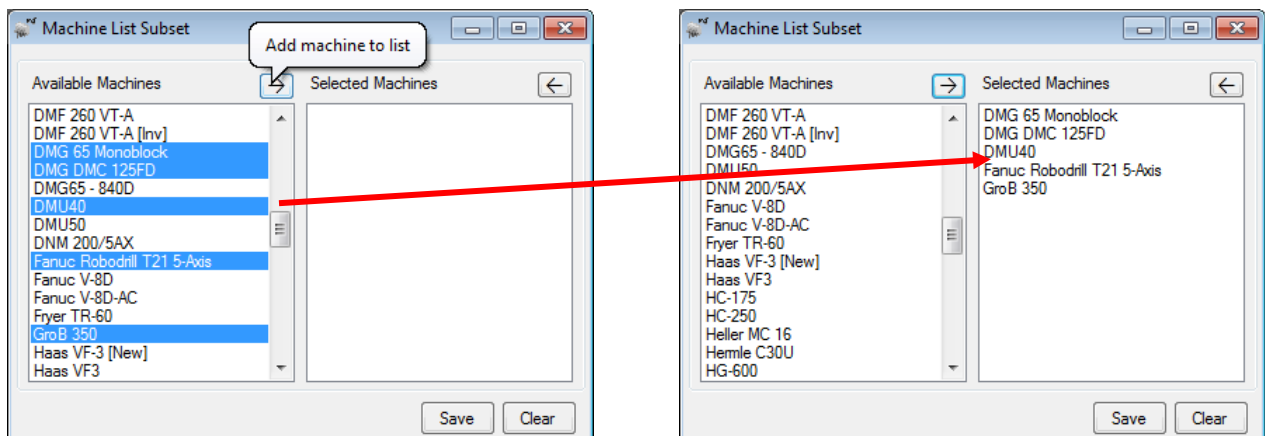


4) In 5Axis, addition of the “List” button to the New, Edit and Delete buttons linked to a *Specific Machine*.

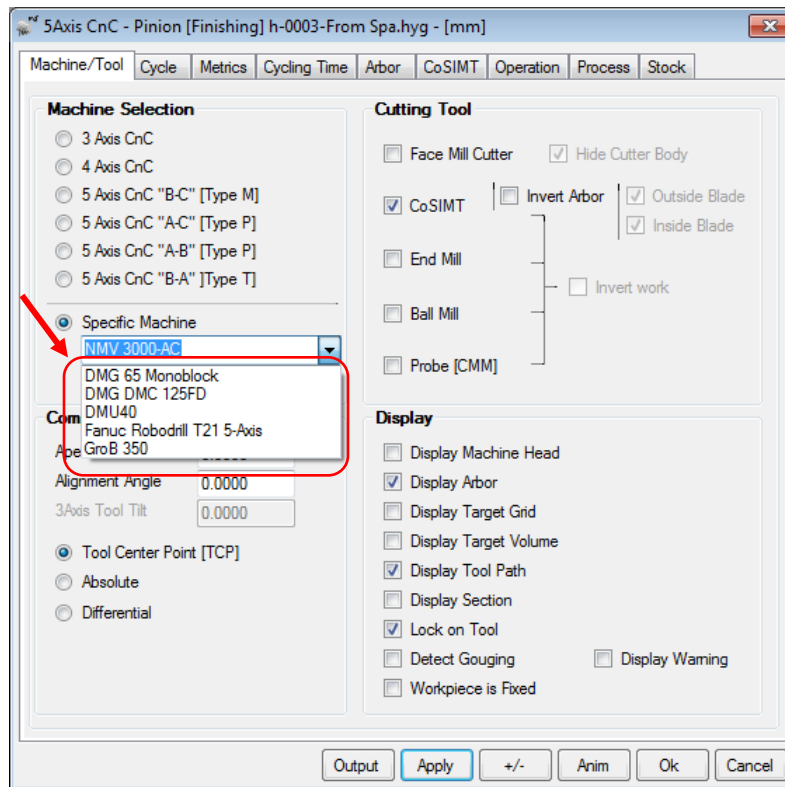


The *List* button allows defining a subset of the machines available in HyGEARS, thereby easing machine selection as the number of HyGEARS machines grows.

The desired machines are selected from the *Available Machines* list and transferred to the *Selected Machines* list using the [->] button. The [-] button is used to remove machines from the *Selected Machines* list. Multi-selection is available. The *Clear* button empties the *Selected Machines* list.

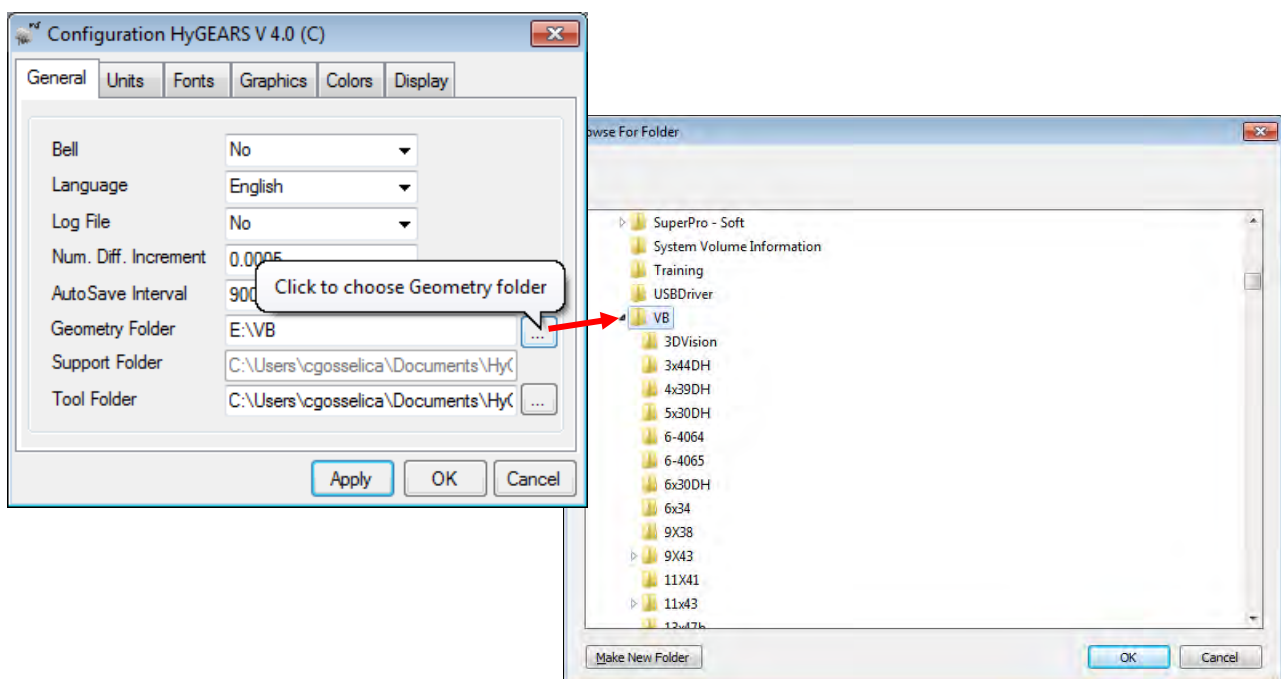


When the *Save* button is clicked, a file called *MachineList.fil* is created that contains only the selected machines. The *Specific Machine* list then shows only the selected machines (figure below). If the *Selected Machines* list is empty, then the full machine list is displayed as usual.

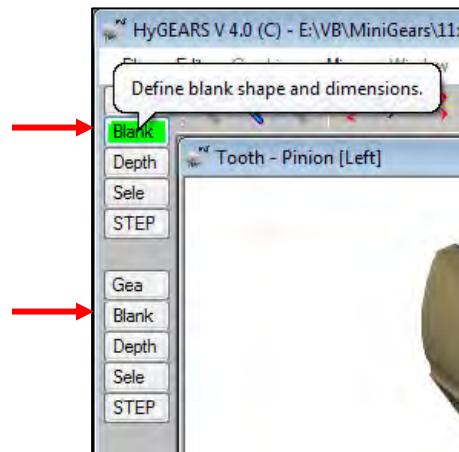


5) In 5Axis, for CoSINT, End Mill and Ball Mill tools, when HyGEARS detects an even number of Toe-Heel and Heel-Toe passes on a tooth flank, the *Return Trip* option of the Operation tab is automatically unchecked, such as to prevent a Return Trip to happen when not needed.

6) In the HyGEARS configuration utility (Edit -> Configuration), General tab, addition of buttons to display a browser to navigate to the desired folders for either the Geometry or Tool folders. This is most useful in a network environment where the folder arborescence can be quite long.

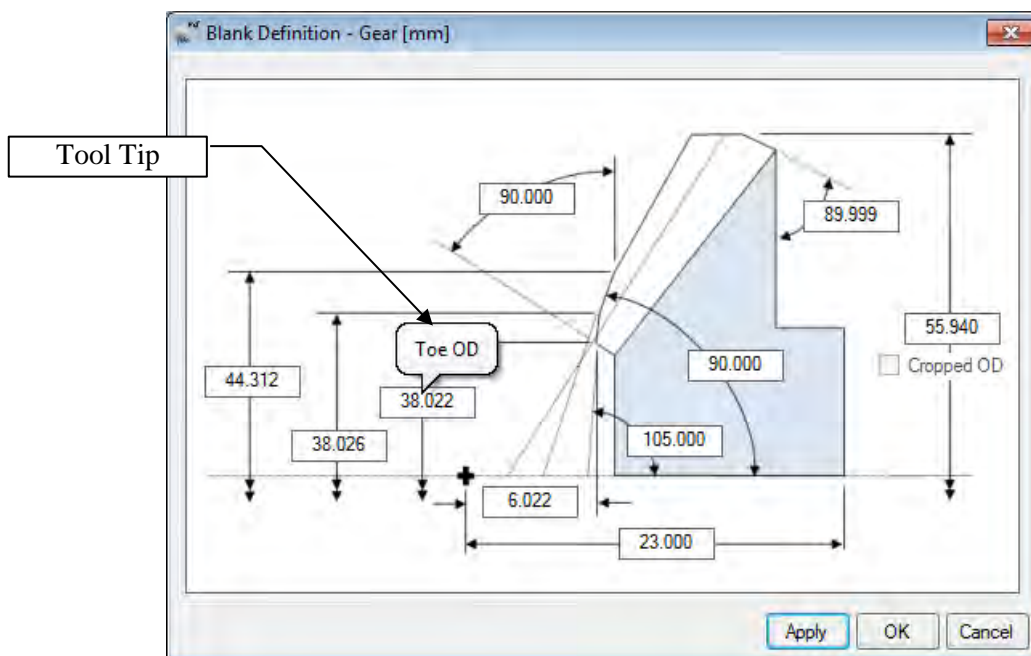


7) In the Geometry pre-defined mode, addition of the *Blank* buttons, one for the Pinion and one for the Gear.



When a *Blank* button is clicked, the *Blank Definition* window is displayed, figure below. The *Blank Definition* window allows entering the values defining the blank without having to follow a defined sequence as was the case when editing the Blank from within the Summary Editor.

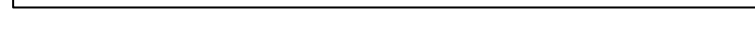
When the mouse is hovering over an entry field, figure below, a “Tool Tip” is displayed to describe the expected entry. Note that a *Cropped OD* is not allowed when the Back angle is larger than 89 deg.

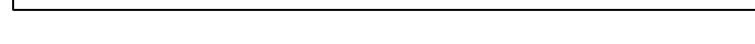


8) Tooth depth for bevel gears: from Build 405.70 and on, tooth depth is maintained at mid-face rather than at heel, whereas before it was rather maintained at heel.

The background reason for this is that for Zerol, spiral-bevel and hypoid gears, the tooth root-line is often curved, either convex or concave, and thus the actual tooth depth is different from the theoretical tooth

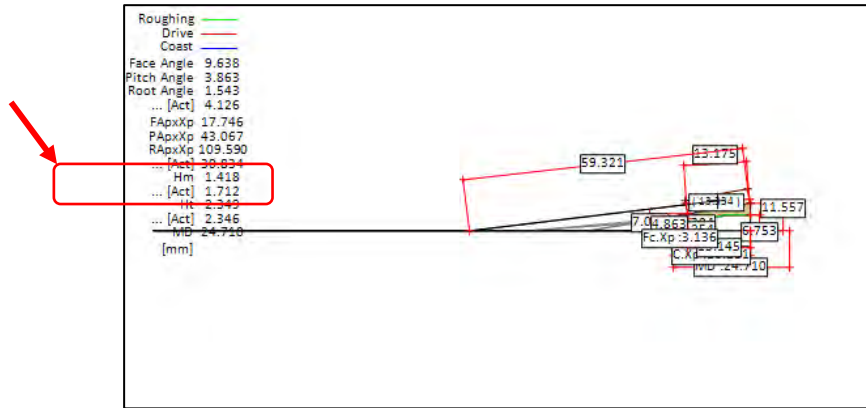






10) Blank: for bevel gears, the Hm value, i.e. tooth depth at mid-face, is now added to the display, as shown below.

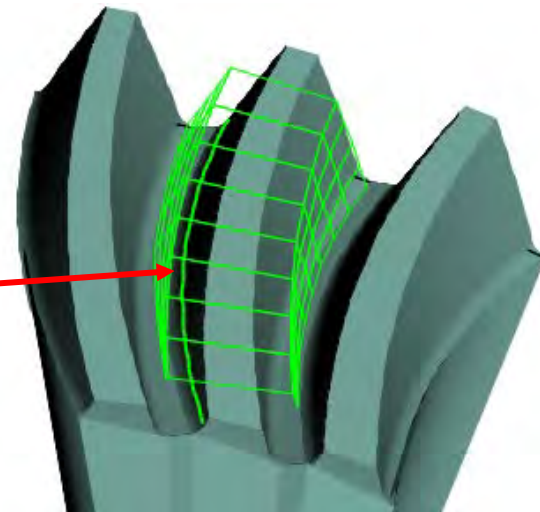
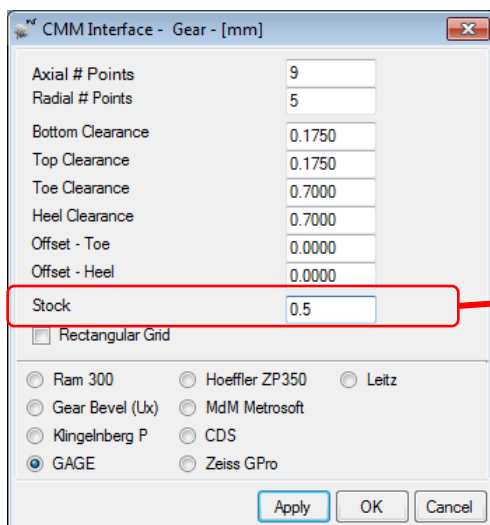
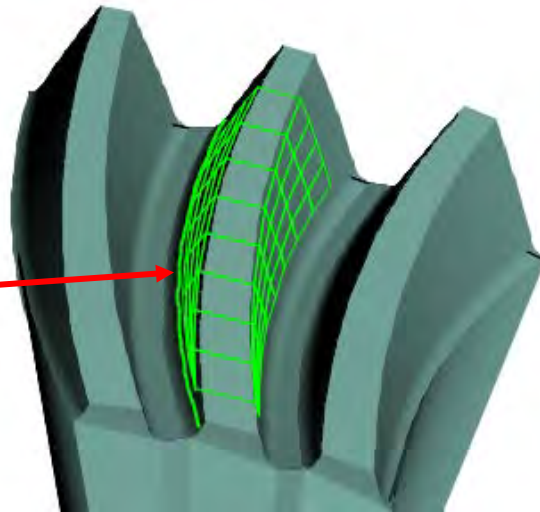
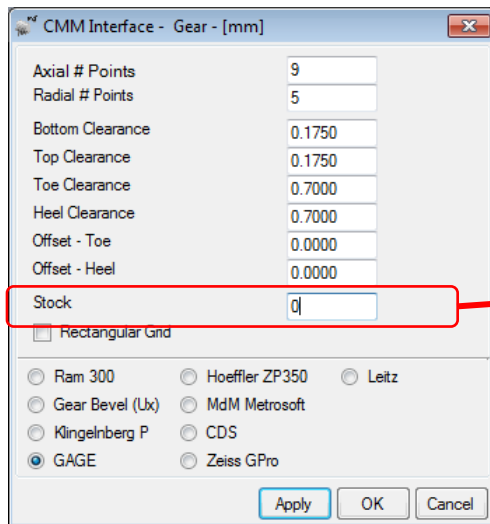
- Hm: theoretical tooth depth based on the currently entered Face angle, Root angle, FApXxp and RApXxp values.
- ... [Act]: actual tooth depth, based on the actual Face angle, Root angle, FApXxp and RApXxp values



11) Summary output: the *Backlash (@Heel)* is added to the output in the Operating Data section of the Summary, as shown below. *Backlash (@Heel)* is obtained by multiplying the calculated *Backlash (@M.Point)* by the ratio of the pitch diameter at Heel and mid-face.

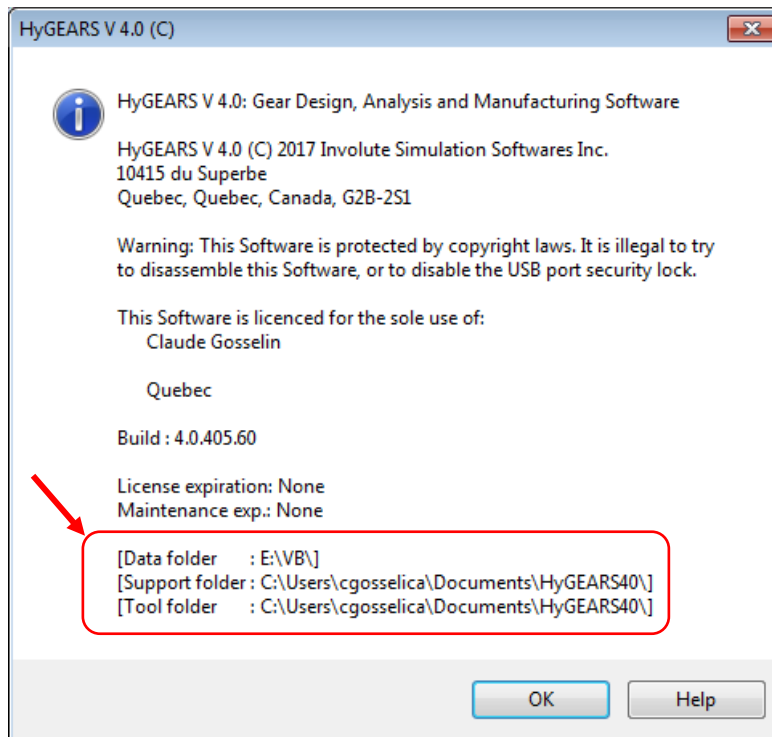
OPERATING DATA	PINION	GEAR
Backlash (Min)	: 0.0210	
Backlash (Max)	: 0.0420	
Backlash (Calc @ M.Point)	: 0.0208	
Backlash (Calc @ M.Poin[deg.]	: 0.0756	
Backlash (@Heel)	: 0.0254	
Backlash (@Heel) [deg.]	: 0.0922	
Bottom Clearance (Toe)	: 9999.0000	9999.0000
Bottom Clearance (Heel)	: 0.1821	-0.1230
(Gear Concave-OB E=0.00 P=0.00 G=0.00 [mm])		
(Gear Convex-IB E=0.00 P=0.00 G=0.00 [mm])		

12) When defining a CMM Target Grid, it is now possible to add *Stock* to the grid, such that the Target Grid follows the expected tooth shape at roughing. Useful when milling with CoSIMT, End Mill or Ball Mill tools.



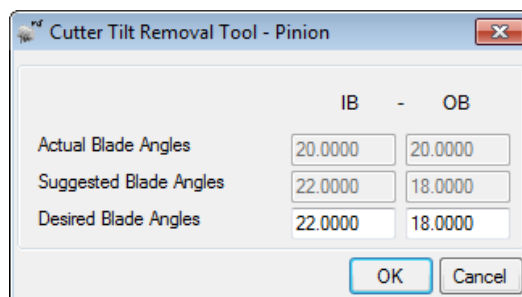
13) When outputting a *Klingelnberg P* CMM Target Grid, the *contur1.dat* and *contur2.dat* files are now generated, respectively for the pinion and gear. The *contur* files provide information to the CMM for Root and Topland measurement.

14) When clicking on the *Help -> About HyGEARS* menu entry, the location of the *Tool* folder is now displayed, in addition to the *Data* and *Support* folders. The *Tool* and *Data* folders are specified in the HyGEARS configuration (*Edit -> Configuration* menu entry).



15) The *RemT* function button, used to remove cutter tilt from either the pinion or gear machine settings, now displays the window shown below, where:

- Actual Blade Angles: current IB and OB cutter blade angles;
- Suggested Blade Angles: recommended blade angles based on the amount of cutter tilt to be removed;
- Desired Blade Angles: desired IB and OB blade angles, based on available cutters.



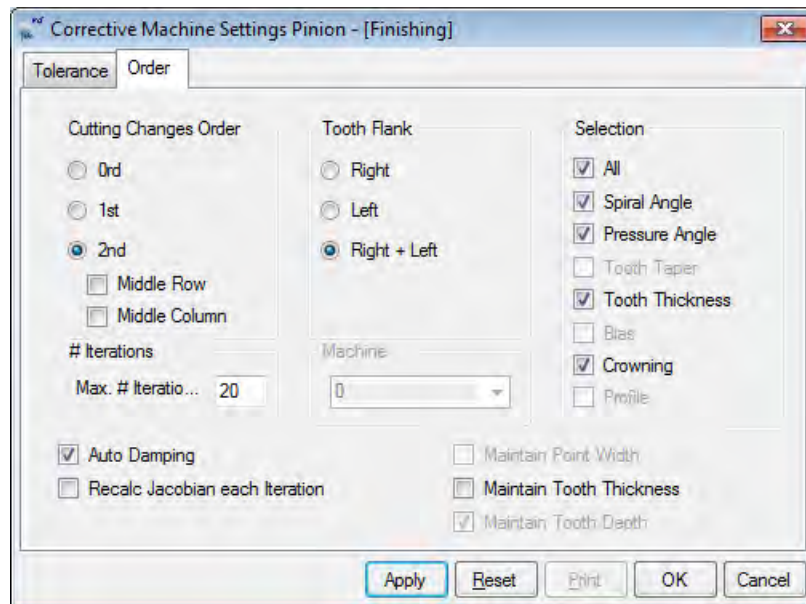
Clicking on Ok initiates the cutter tilt removal algorithm, and the modified teeth are redisplayed.

Note: removing cutter tilt is applicable only if the gear member is generated. Removing cutter tilt usually affects substantially the TE and shape of the Bearing Pattern. The upside is that the part can then be generated on a cheaper machine – not capable of cutter tilt - such as the YH603.

HyGEARS update –17 October2016 - Build 405.60 - 461

1) Corrective Machine Settings (i.e. Closed Loop) and Reverse Engineering (i.e. RE) are now available for Spur, Helical and Beveloid gears. The interface is the same as that used for Straight-bevel and Spiral-bevel gears (figure below).

Correction/RE is available for 1st and 2nd orders (limited to Crowning in 2nd Order). Because Closed Loop is aimed for 5Axis CnC manufacturing, control parameters do affect directly tool dimensions, such as Blade Angle to control Pressure Angle errors, and Blade Thickness to control Tooth Thickness errors. No depth control is applied.



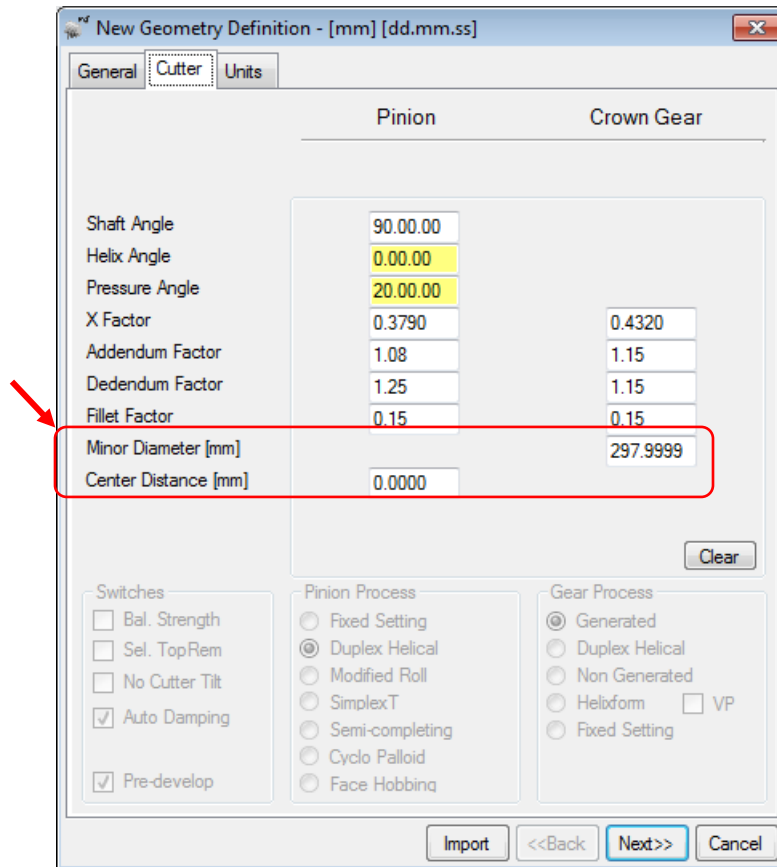
2) In 5Axis, whenever a Process is sent to Output, the list of all tools used for each Operation of the Process is given in the Short Header at the beginning of the Process Output file. This is to help operators install the necessary tools in the machine's tool changer.

```
; *****  
; PROCESS NAME      : 66809735000_Fin_L_neu  
; PROCESS DATE      : 10-07-2016  
; SUMMARY VERSION   : [Nominal]  
; TOOLS IN USE      : #1  
;                   : #2  
;                   : #3  
;                   : #4  
; *****
```

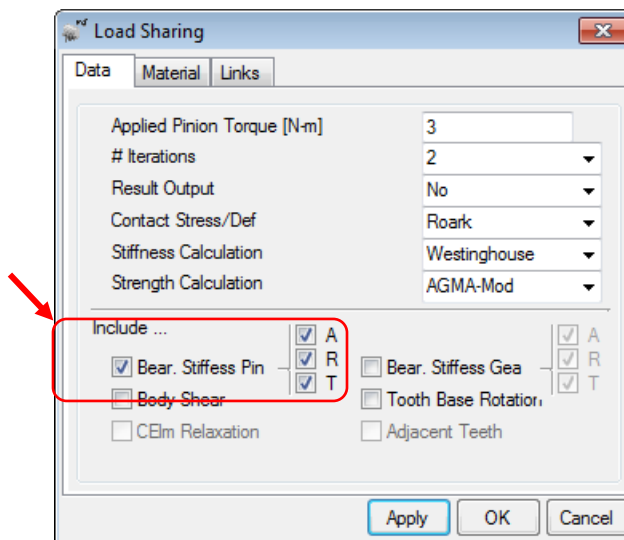
3) When creating a new Face Gear set, HyGEARS now offers 2 new input fields:

- **Minor Diameter:** the ID of the gear member can be imposed; HyGEARS will try to generate the tooth to the requested diameter, but may not succeed if the ID is too small and thus the fillet reaches more than 50% of tooth depth at Toe. If set to 0, HyGEARS will use its calculated default value (recommended as a first approach).

- **Center Distance:** this is the Operating Center Distance; if imposed, HyGEARS will change the machine Tool Center Distance (“Gea” function button, Machine Data Page) until the BP is centered on the gear tooth; if set to 0, HyGEARS will impose the machine Tool Center Distance and modify the Operating Center Distance till the BP is centered on the gear tooth.



4) When calculating the LTCA (“LTCA” Pre-defined mode, “Load” function button), if Bearing Stiffness has been selected, HyGEARS now offers to consider the applied load on the tooth in its different components, i.e.:



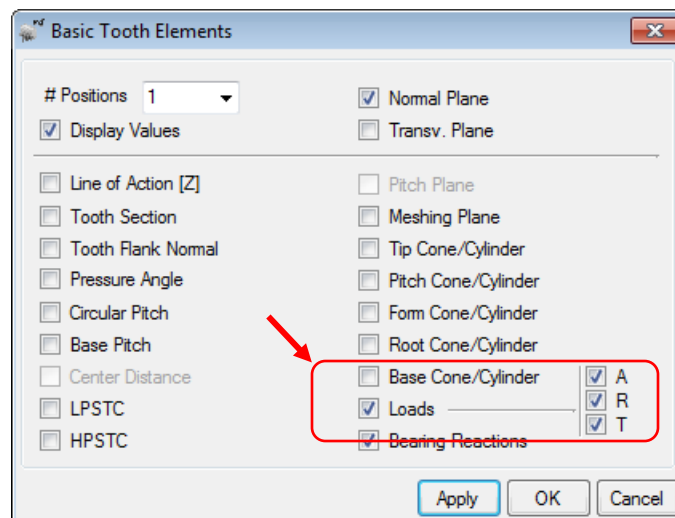
- A: Axial component
- R: Radial component
- T: Tangent component

This allows the user to establish which stiffness and load components are the most significant on BP shift under load. Applies to both the Pinion and Gear.

Note: the LTCA always uses the full load to calculate Bending and Contact stresses; however, bearing displacements under load can be imposed by selecting discrete Load components.

5) When in *User mode*, several Graphics display functions are available, some of which offer the “Prim” function button.

The “Prim” function button allows displaying various gearing “primitives”, including the tooth Loads and associated Bearing Reactions (figure below).



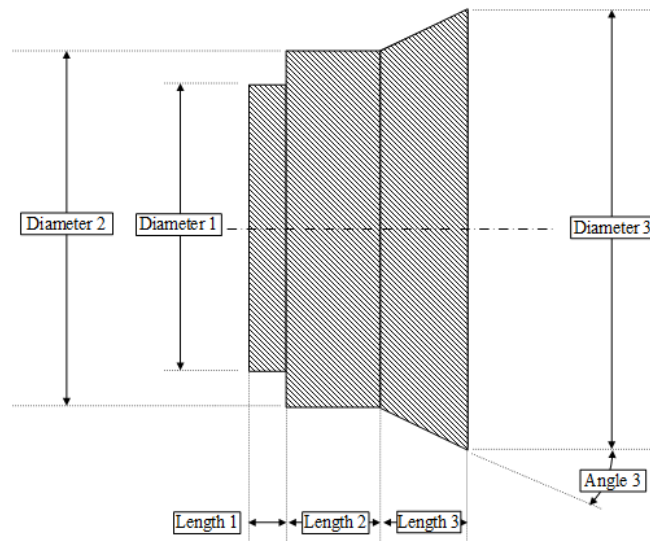
HyGEARS now offers to consider the applied load on the tooth in its different components, i.e.:

- A: Axial component
- R: Radial component
- T: Tangent component

This allows the user to visualize Bearing Reactions caused by selected load components, and thus establish which load component may be most significant. Applies to the displayed member, i.e. Pinion and/or Gear.

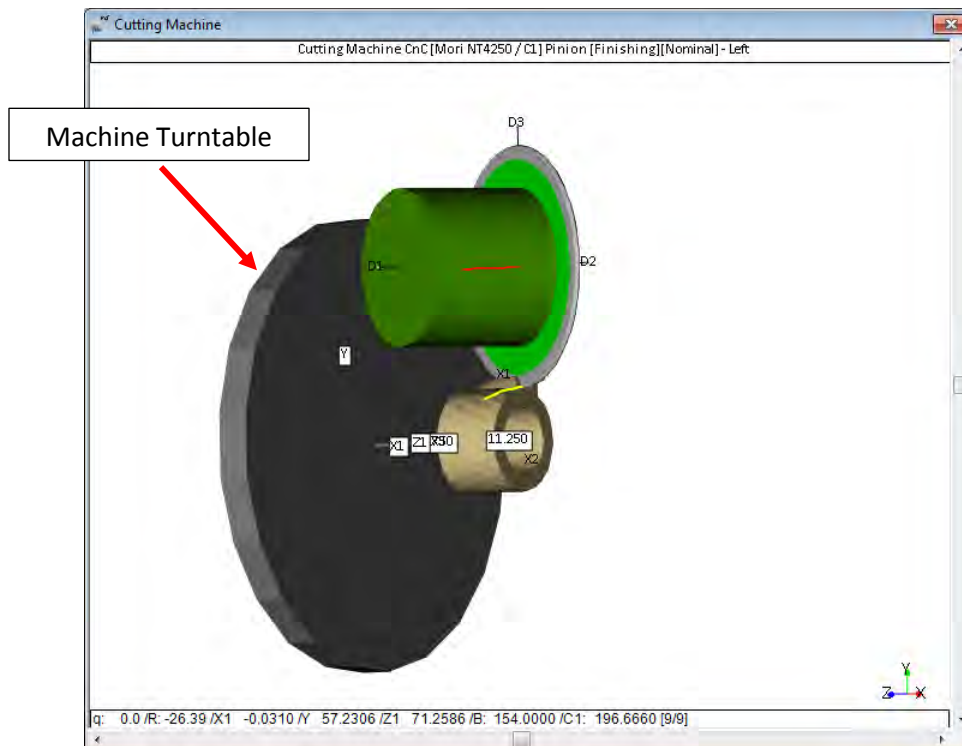
For example, figure below, the Axial load component has been selected for display on the Gear member; when clicking on the “Apply” button, the Bearing Reactions caused by the Axial load component are calculated and displayed.

As shown in the figure above, the Cutter Holder field and [...] button have been added to the Face Mill data page. Clicking on the [...] button displays the Face Mill Holder window, where up to 4 Length-Diameter-Angle combinations can be entered to define the Face Mill holder.



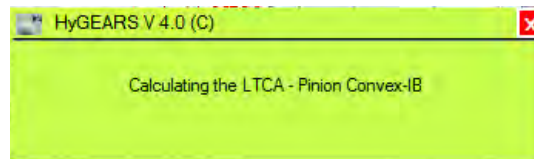
7) In 5Axis, negative Stock is now accepted in Roughing mode.

8) In 5Axis, the Turntable can now be defined in the Machine definition. The turntable gives a much better feel of the Work piece to machine relation, as shown in the figure below. Display is switched On/Off through the “Display Arbor” option, “Machine/Tool” Data Page, Display section.

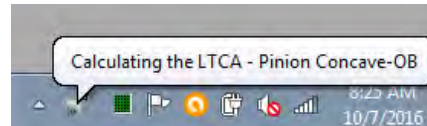


9) Screen notifications have changed. The original Toast Form, i.e. a message displayed in a yellow form at the bottom right corner of the screen, has been replaced by Notification Balloons which are Windows intrinsic components and visually less obtrusive.

- Original Toast Form:

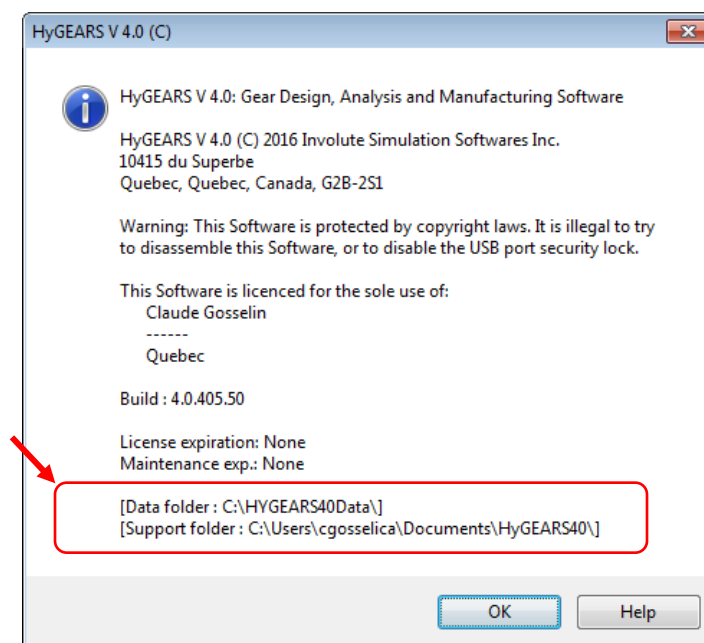


- New Notification Balloon:

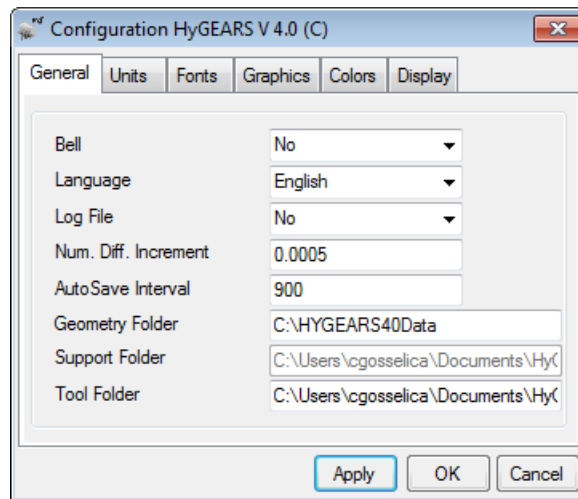


10) In Geometry mode, addition of the “Opp” function button to invert tooth hand. Applies to Helical, Zerol, Spiral-bevel and Hypoid gears.

11) The Help -> About HyGEARS menu function now displays the names of both the Data folder and the Support folder.

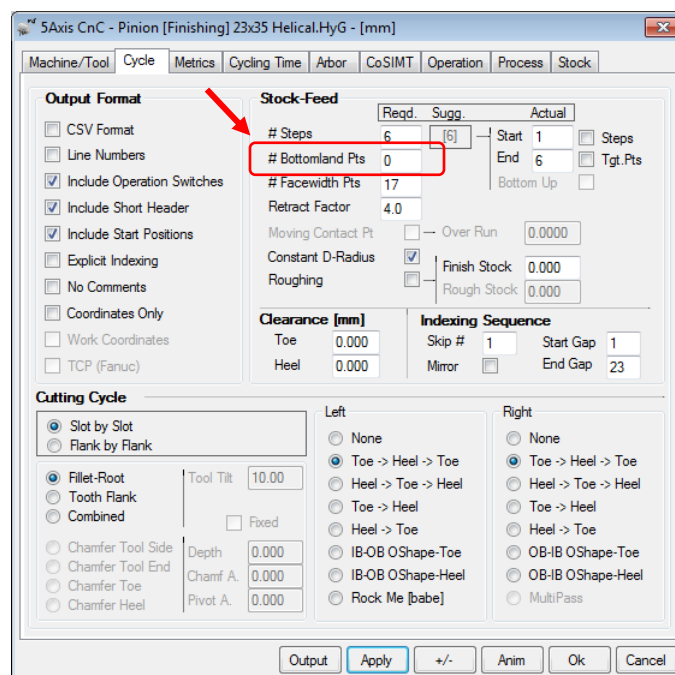


- The [Data folder] is the root folder where the folders for all HyGEARS geometries are expected to be stored; it can be edited in Edit -> Configuration, General Data Page, “Geometry Folder” field:

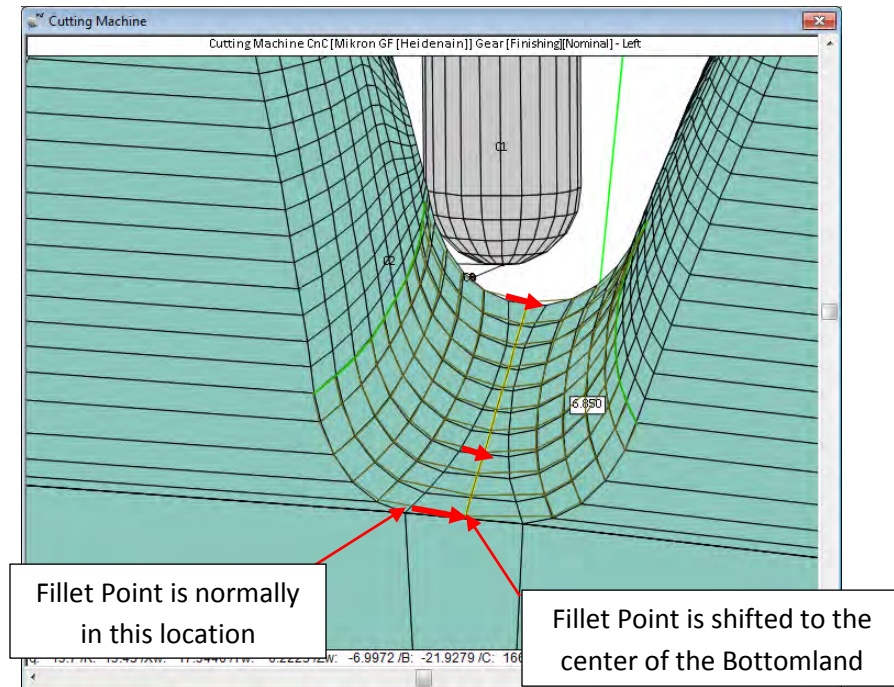


- The *[Support folder]* is where all support files are stored; these include files such as Machine.fil, Oil.fil, Material.fil, etc., which are needed for HyGEARS to run.

12) In 5Axis, addition of the “#Bottomland Pts” field to the Cycle Data page.

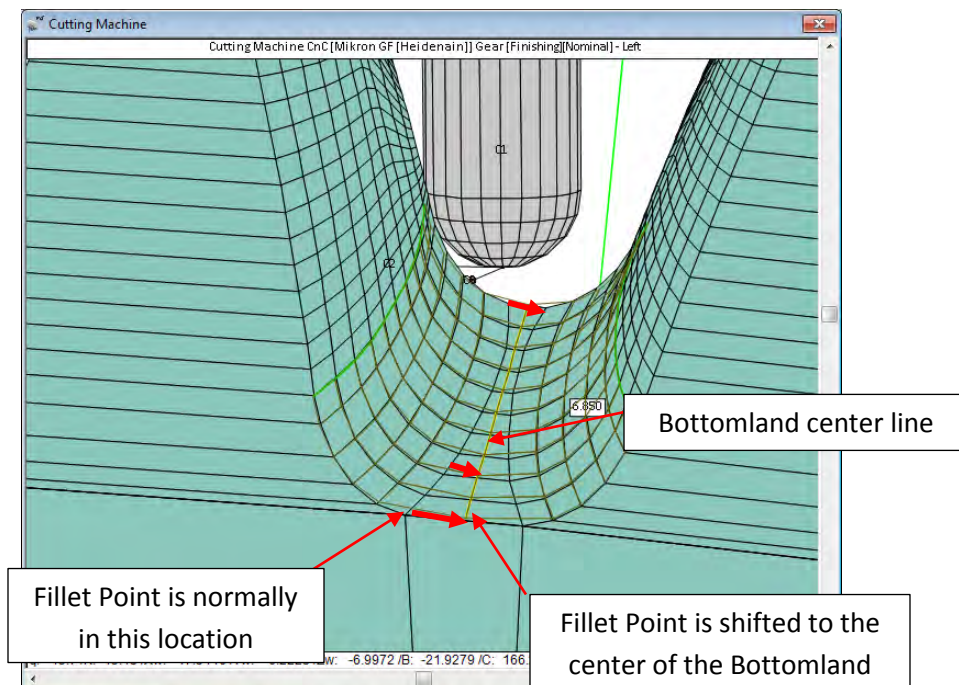


The “#Bottomland Pts” corresponds to the number of passes that the End Mill, Ball Mill or CoSIMT tool will do in the bottom part of the tooth gap, i.e. the Bottomland. Until now, HyGEARS generates the fillet area, and moves the bottom most points – along the facewidth – to the center of the Bottomland such as to ensure a final pass removing leftover material.

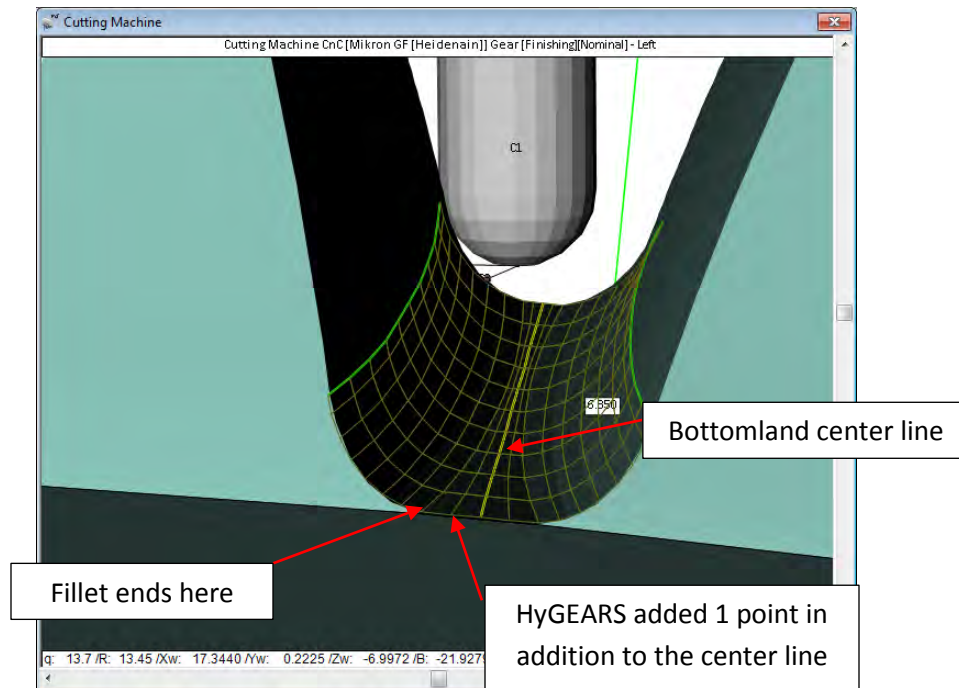


This is fine when the Bottomland is fairly constant in width, such as in Duplex Helical spiral-bevel gears. However, when the Bottomland width is not constant, such as in Straight-bevel gears cut by a 2Tool generator, above figure, one may want to impose how many points will be used across the Bottomland, hence the “#Bottomland Pts” field; valid only when the fillet is considered, and can take several values:

- **0:** as is the case until HyGEARS Build 405.60; the last point in the fillet is moved to the center of the Bottomland flat (figure below);

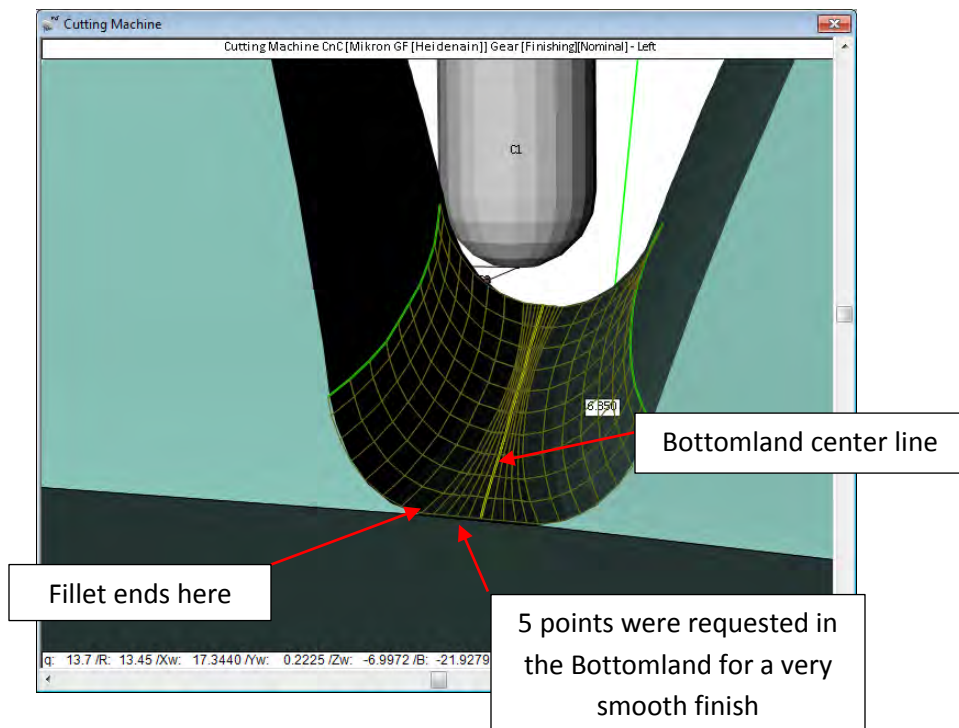


- -1: HyGEARS calculates the "*#Bottomland Pts*" based on point spacing in the fillet:



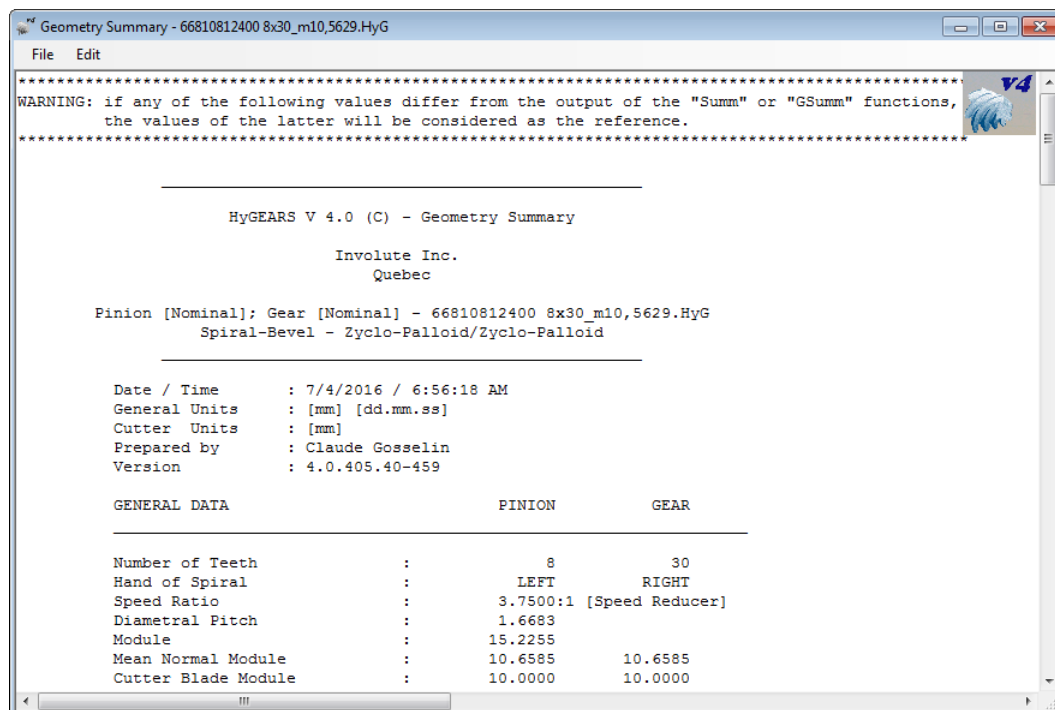
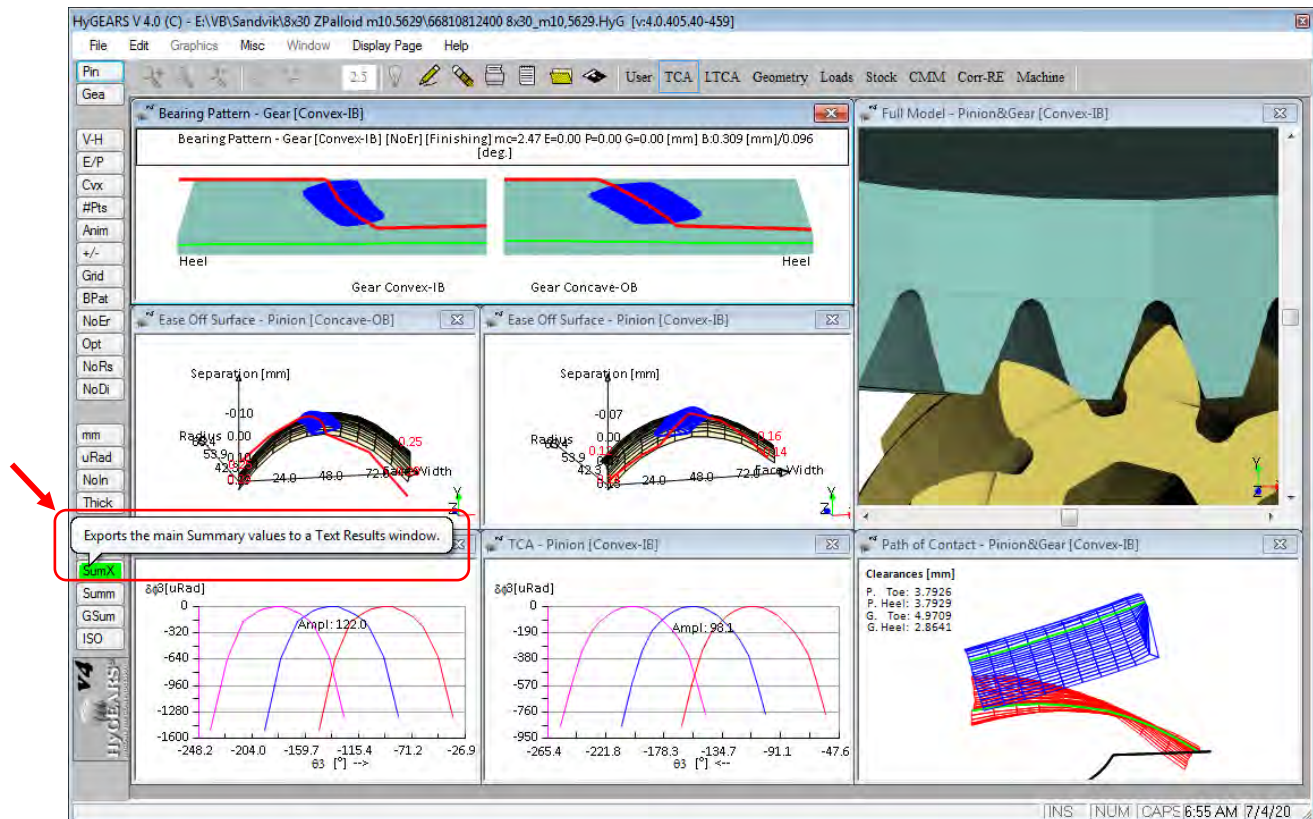
HyGEARS searches for the place where fillet point-to-point spacing is maximum (in the depth-wise direction) and uses this to establish how many points there should be;

- 1, 2, ...: user imposed "*#Bottomland Pts*" - can be anything to user's choice, the maximum being the limit of the storage array; HyGEARS then inserts the requested "*#Bottomland Pts*" between the end of the fillet and the centerline running along the bottomland.



HyGEARS update -20 July2016 - Build 405.50 - 460

1) Addition of the “SumX” function button. *SumX* stands for “Summary Export”, where the Blank, Cutter and Finishing Machine Settings Summary are sent to a Text Results window rather than to a Pdf document. The content of the Text Results window can then be saved as a text file and imported by a 3rd party application.



Whenever a *Summary Export* is produced, the following Warning appears at the beginning of the output:

```
*****
WARNING: if any of the following values differ from the output of the "Summ" or "GSumm" functions,
        the values of the latter will be considered as the reference.
*****
```

This implies that the “Official” Summary data is considered at all times as being that contained in the Graphics Summary (“GSum” function button) or Text Summary (“Summ” function button) since the data contained within those Pdf documents cannot be tampered with.

2) Addition of 2 inputs to the “Operating” data page of the Geometry Summary Editor (“Pin” or “Gea” function buttons), both of which are used in the ISO 10300:2014 calculations (see item 4 below).

Fillet Finish: surface finish (roughness) in the fillet area of the tooth; same units as the *Surf Finish*, surface finish (roughness) of the tooth flank; default value is *Surf. Finish*.

Kpm Mounting: pinion mounting factor; default value is 1.

The screenshot shows the 'Operating' tab of the Geometry Summary Editor. The 'Fillet Finish' field is highlighted with a red box and a red arrow. The 'Kpm: Mounting' field is also highlighted with a red box and a red arrow. The 'Fillet Finish' field is set to 0.81, and the 'Kpm: Mounting' field is set to 1.0000. Other fields include AGMA Class (11), Trans. Quality (Precision), Surf. Finish (0.81), Power (36.000 Kw), RPM (167.25), Torque (2054.509 N-m), Oil Type (ISO 220), Oil T. (82.22 C), Friction Coefficient (0.020), and various stress values.

3) Addition of 2 additional Material input fields to the “Rim-Material” data page of the Geometry Summary Editor (“Pin” or “Gea” function buttons), both of which are used in the ISO 10300:2014 calculations (see item 4 below).

Bending-ISO [MPa]: maximum bending stress of the material, to be used in the ISO-10300 calculations; always in [MPa].

Contact-ISO [MPa]: maximum contact stress of the material, to be used in the ISO-10300 calculations; always in [MPa].

Pinion [Spiral-Bevel] [Finishing][Nominal] 66813095400 9x28_m11,5626_V2.Hy...

Blank Cutter TopRem Machine Hi Order Other Operating Rim-Material Bear

Rim

Rim Thick. 26.0159

Web Thick. 26.0159

Web %Rim [0->100] 50.0

Angle 0.00

Hub OD 0.0000

Hub ID 46.0000

Rim-Web Rad. 0.0000

Web-Hub Rad. 0.0000

Hub (Toe) 0.0000

Hub (Heel) 0.0000

Heel Rib OD 0.0000

Heel Rib Thickness 0.0000

Material

Material 18CrNiMo7-

Young [Mpa] 206000

Poisson 0.3000

Bending [Mpa] 430

Contact [Mpa] 1500

Hardness 61 HRC

R. Density 7.80

Bending-ISO [MPa] 430

Contact-ISO [MPa] 1500

Apply OK Cancel

Accordingly, the “Material.fil” file, in which the materials are defined, has been modified as follows to include the 2 new inputs. Also to be noted: hardness can also be given in Vickers scale (HV).

```

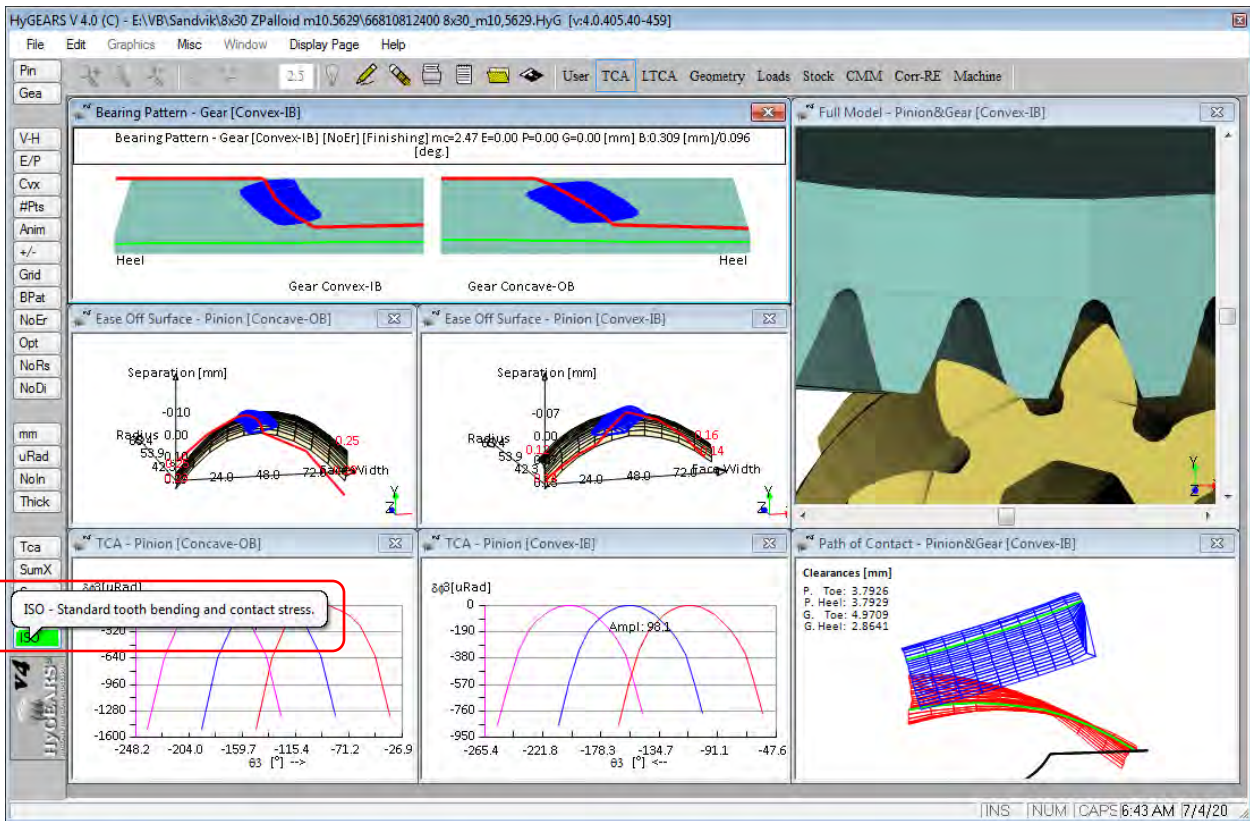
*** HYGears MATERIAL FILE ***
; This is comment line which is ignored
; by HyGEARS. Comment lines should appear at the
; beginning of the file, and start with a ";" semi-colon character.
;
; Material data is given in the following sequence:
;   Material Name
;   Bending Strength
;   Compressive Strength
;   Strength units (PA, KPA, MPA, GPA, PSI, KSI)
;   Young Modulus
;   Poisson ratio
;   Young Modulus units (PA, KPA, MPA, GPA, PSI, KSI)
;   Hardness value
;   Hardness units (BHN, HRC, HRB, HV)
;   Relative density (relative to water)
;   Bending Strength ISO (always MPa)
;   Compressive Strength ISO (always MPa)

```

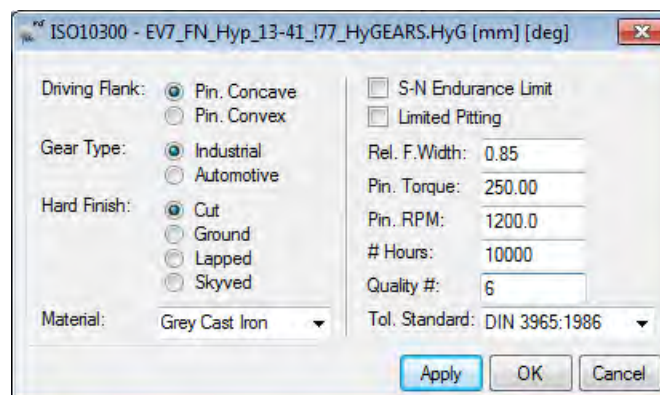
AGMA A-1	, 200, 630, MPA, 206, 0.3, GPA, 180, BHN, 7.8, 380, 620
AGMA A-2	, 250, 750, MPA, 206, 0.3, GPA, 240, BHN, 7.8, 480, 730
AGMA A-3	, 280, 870, MPA, 206, 0.3, GPA, 300, BHN, 7.8, 560, 850
AGMA A-4	, 320, 1050, MPA, 206, 0.3, GPA, 360, BHN, 7.8, 630, 1000
AGMA A-5	, 340, 1150, MPA, 206, 0.3, GPA, 400, BHN, 7.8, 650, 1100
AISI 4140	, 270, 1175, MPA, 206, 0.3, GPA, 48, HRC, 7.8, 550, 1150
AISI 4340	, 290, 1125, MPA, 206, 0.3, GPA, 46, HRC, 7.8, 580, 1080
NITR 135M	, 295, 1250, MPA, 206, 0.3, GPA, 60, HRC, 7.8, 600, 1200
2.5% CHRM	, 415, 1300, MPA, 206, 0.3, GPA, 57, HRC, 7.8, 850, 1250
16 MnCr 5	, 480, 1550, MPA, 206, 0.3, GPA, 59, HRC, 7.8, 960, 1500
18CrNiMo7-6	, 480, 1550, MPA, 206, 0.3, GPA, 61, HRC, 7.8, 1000, 1510
ISO_ME	, 550, 1720, MPA, 206, 0.3, GPA, 61, HRC, 7.8, 1050, 1650
ISO_MQ2	, 480, 1550, MPA, 206, 0.3, GPA, 61, HRC, 7.8, 920, 1500
ISO_MQ3	, 480, 1550, MPA, 206, 0.3, GPA, 61, HRC, 7.8, 1000, 1500
ISO_ML	, 410, 1380, MPA, 206, 0.3, GPA, 61, HRC, 7.8, 624, 1300

4) Addition of the *ISO10300:2014* standard – *Calculation of load capacity of bevel gears* (optional). ISO 10300 can be accessed in 2 ways:

- Through the “GSum” function button; the ISO 10300 output is then part of a HyGEARS *Graphics Summary*;
- Through the “ISO” function button (TCA and LTCA pre-defined modes); the ISO 10300 output is then included in a HyGEARS *ISO Summary*.



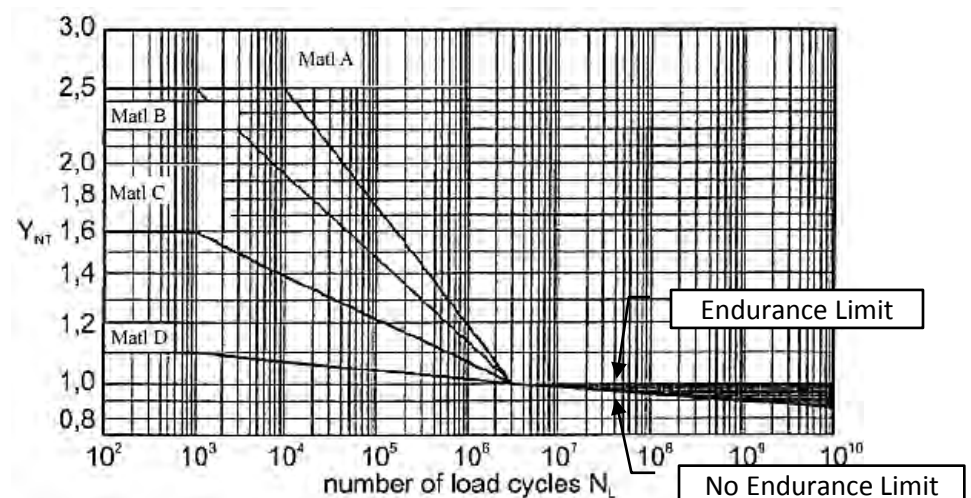
Both accesses use the same interface and input fields, as shown below. The input fields allow the specification of the calculation; selections are conserved when the HyGEARS geometry file is saved:



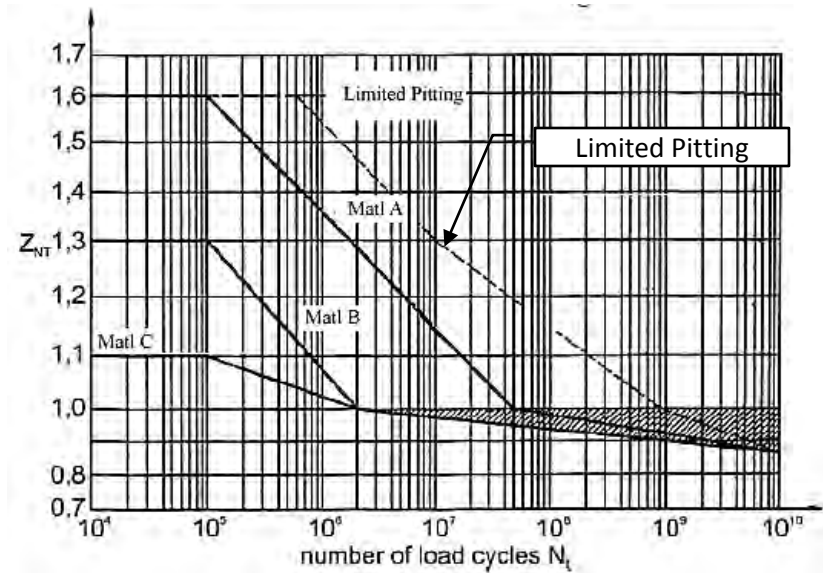
Driving Flank: Pinion Concave
Pinion Convex

<i>Driving Flank:</i>	Industrial (i.e. Low Profile Crowning) Automotive (i.e. High Profile Crowning)
<i>Hard Finish:</i>	Cut Ground Lapped Skyved
<i>Material:</i>	Grey Cast Iron Tempered Steel Induction Hardened, Flame Hardened, Case Hardened Nitrided Steel Nitro-carburized Steel Normalized Cast Steel Tempered Cast Steel Normalized Steel

No S-N Endurance Limit: indicates whether the bending and contact Endurance Limit of the S-N curve for the selected material is considered or not. For example, figure below where S-N curves for bending are displayed for different materials, if the Endurance Limit of the S-N curve is considered, factor Y_{NT} will be obtained from the appropriate curve and above 3×10^6 load cycles, $Y_{NT} = 1$; if the Endurance Limit is not considered, then Y_{NT} is obtained from the lower boundary of the grey area from 3×10^6 load cycles and above.



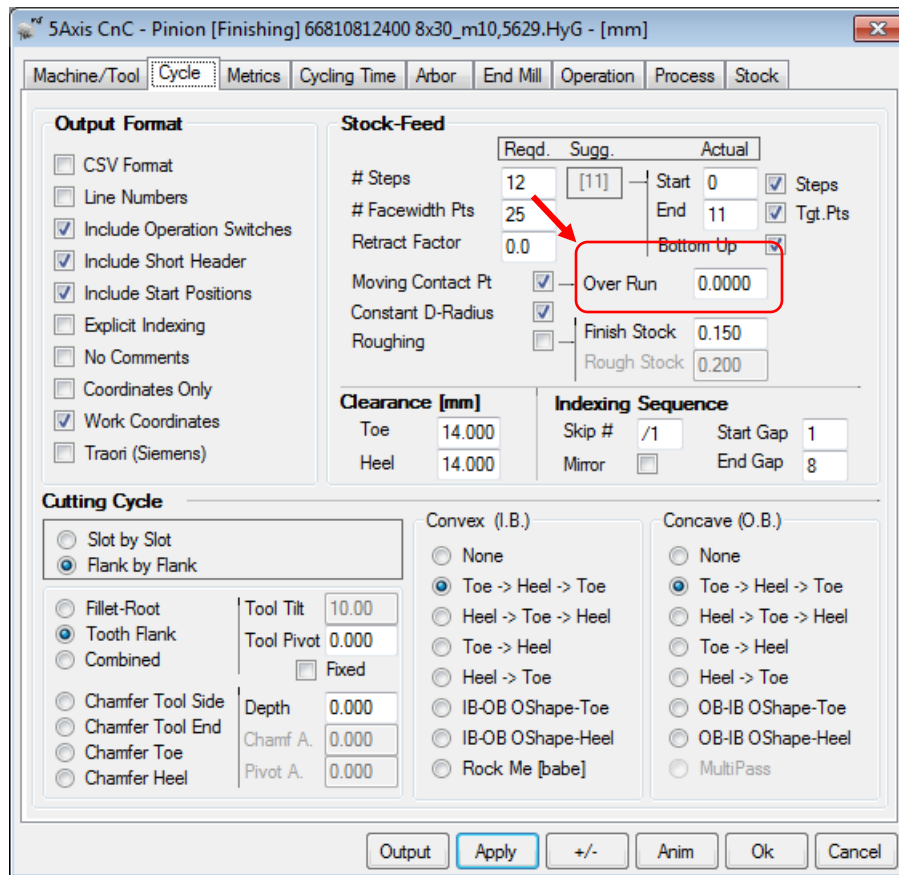
Limited Pitting: indicates that limited pitting is allowed when calculating for limited life (i.e. the S-N curve is shifted to higher load). For example, figure below where S-N curves for contact are displayed for different materials, in the worst case the Endurance Limit is set at 5×10^7 cycles; if limited pitting is allowed, factor Z_{NT} is rather taken from the dotted line to the right, which in practice allows higher contact loading.



<i>Rel. F. Width:</i>	Ratio of face width [covered by the Bearing Pattern] under load to actual face width;
<i>Pin. Torque:</i>	Pinion Torque [Nm];
<i>Pin. RPM:</i>	Pinion rotational speed [min^{-1}];
<i># Hours:</i>	number of hours for requested gear set life. If set to 0, then an infinite life is assumed, the S-N curves are ignored, life factors are set to 1, and no calculation of life limit is performed according to the S-N curves for the selected material;
<i>Quality #:</i>	target quality number of the gear set – related to the selected <i>Tol. Standard</i> below;
<i>Tol. Standard:</i>	tolerance standard targeted for <i>Quality #</i> : <ul style="list-style-type: none"> • DIN 3965:1986 • ISO17485:2006 • AGMA2000-A88 • AGMA2009-B01

The ISO 10300 output is given in 2 different pages:

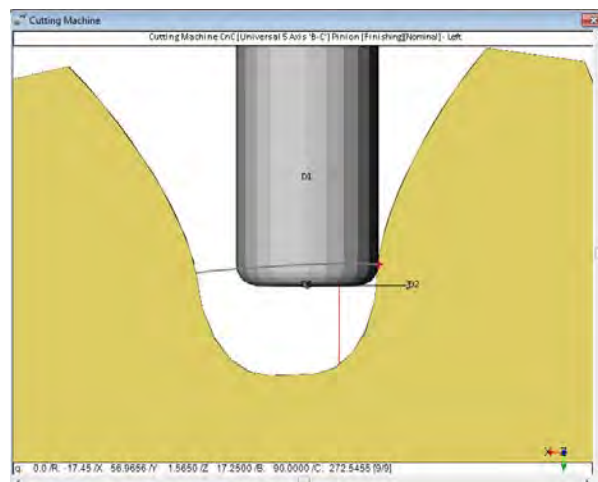
- A) *INPUT DATA* , i.e. data from the above input fields, and extracted from the current gear set, and *OUTPUT – Factors*, i.e. intermediate values used in the calculation of Contact and Bending:



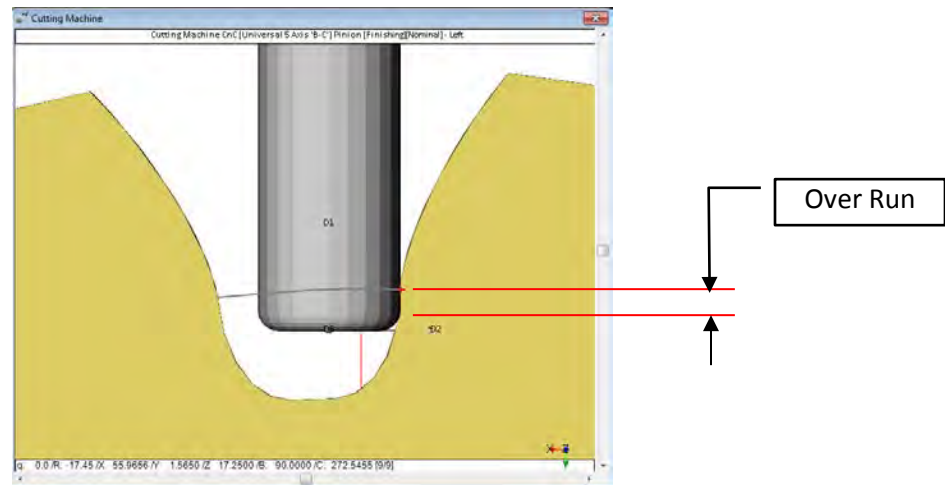
Over Run allows specifying by how much an End Mill or CoSIMT tool may exceed the fillet limit when cutting the tooth flank in Finishing mode (i.e. Roughing unchecked) and Moving Contact Pt, such as to avoid leaving a lip between fillet and flank if the *tooth flank is finished with negative stock*.

This implies that the fillet was cut with *some* negative stock such as to leave a bit of room to allow for negative stock on the tooth flank.

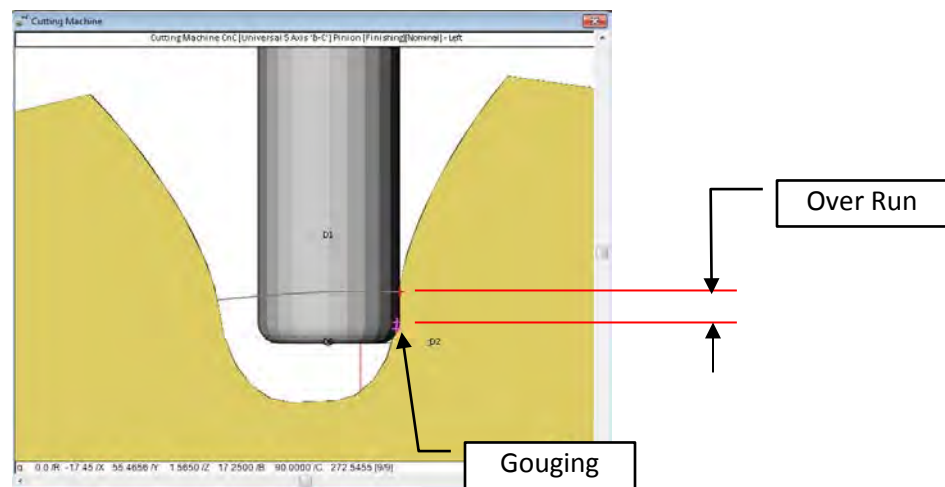
In the figure below, an End Mill is seen finish cutting, with Moving Contact Pt, along the fillet limit of a spur pinion. Normally, as is the case here, the end of the cutting edge of the End Mill coincides with the fillet limit.



If *Over Run* is set to 1 [mm], the End Mill extends *below* the fillet line, and thus allows negative stock on the flank without leaving a lip or step at the fillet to flank limit. It is then possible that the End Mill also re-cuts part of the fillet which is normally finish-cut before the tooth flank.

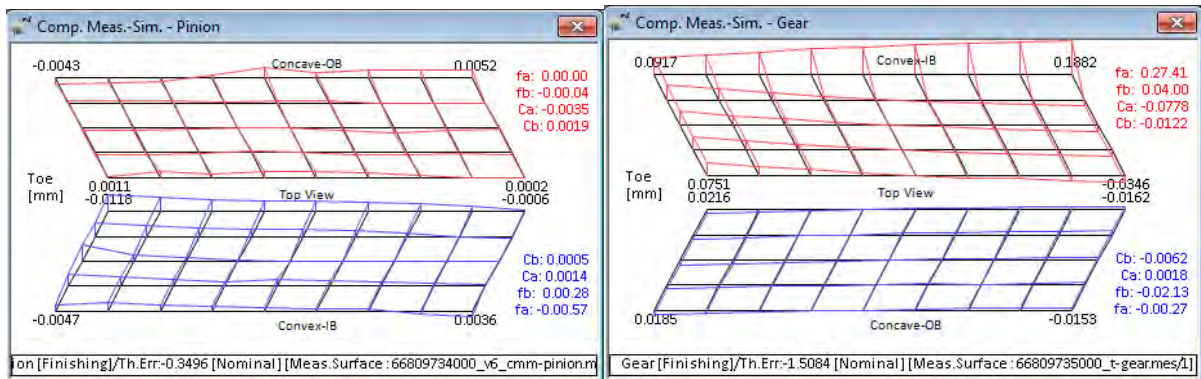


If *Over Run* is set to 1.5 [mm], the End Mill extends *deeper below* the fillet line, and now Gouging (pink crosses) is seen to occur between the bottom of the End Mill and the fillet. Therefore, damage will occur to the already cut fillet if it was cut without negative stock.



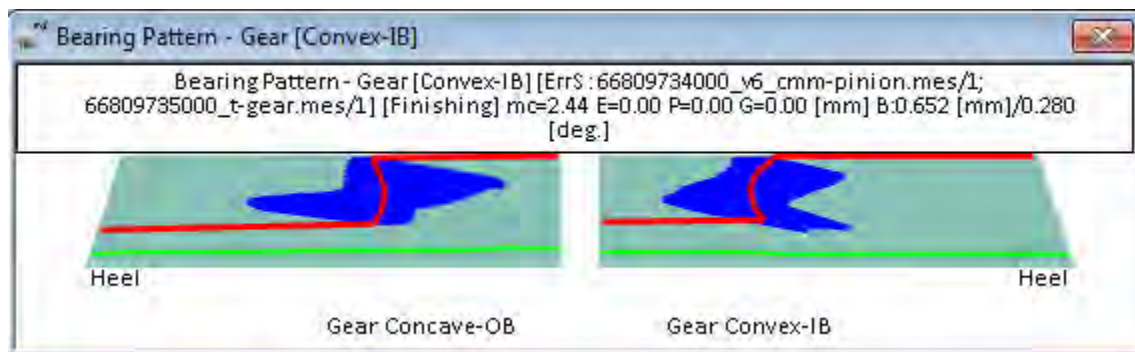
6) Improvement to the algorithm used to calculate the BP in conjunction with CMM data (“ErrS” / “NoEr” function buttons.).

For example, when using the CMM data displayed below, the *original* and *improved* algorithms would produce the shown BPs. It is believed the *improved* algorithm better replicates actual BPs ad TE.

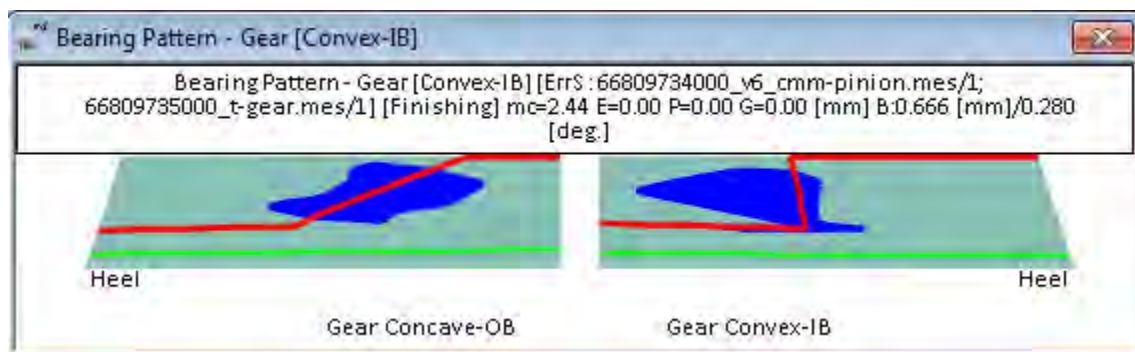


Pinion CMM data

Gear CMM data



Calculated BP using the *original* algorithm



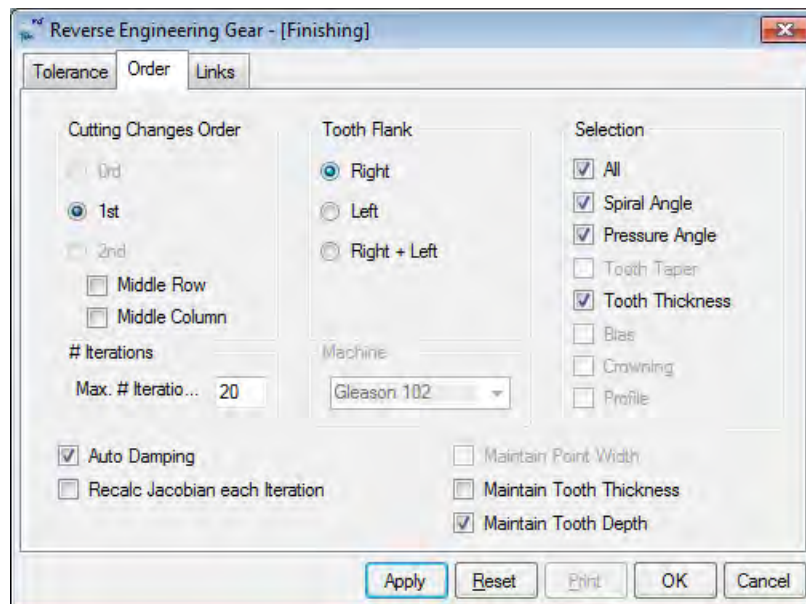
Calculated BP using the *improved* algorithm

7) For Coniflex gears, when applying RE or Corrective Machine Settings (Closed Loop), the tooth flanks are now labeled “Right” and “Left” rather than “Concave” and “Convex”.

The behavior of the RE and Closed Loop algorithm is now as follows when either the Left or Right tooth flank is selected:

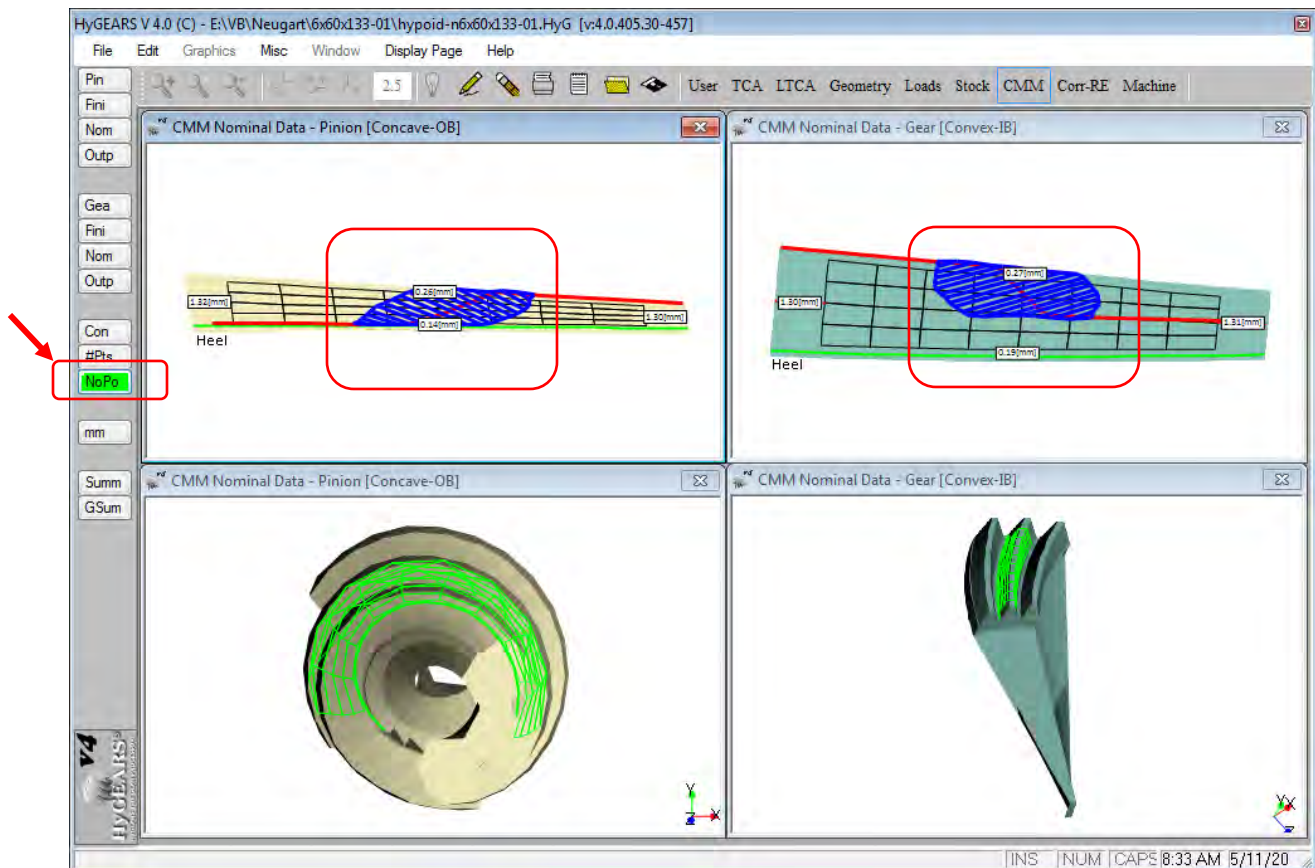
- When the Right flank is selected, the modified machine settings of the Right flank are copied to the Left flank;

- When the Left flank is selected, the modified machine settings of the Left flank are copied to the Right flank;
- When the Right + Left flanks are selected, each flank is treated individually, which usually results in different machine settings for each flank.



HyGEARS update -31 May 2016 - Build 405.40 - 459

1) In CMM pre-defined mode, addition of the “PoC” / “NoPo” function buttons to allow the display of the Path of Contact and Bearing Pattern over the target CMM grid. This allows ensuring that the measured part of the tooth covers correctly the area where the Bearing Pattern is expected to lie.



2) Update of the User Documentation and Context Sensitive Help (F1 key while running HyGEARS). The Context Sensitive Help is installed with HyGEARS, and is always accessible using the F1 key. The User Documentation is a Pdf document which can be downloaded from www.HyGEARS.com, Downloads page, by clicking on the “HyGEARS User Documentation” link.

3) Addition of the “Shift ^C” keyboard shortcut, which copies the screen area occupied by a Child Window, including the Title Bar and borders.

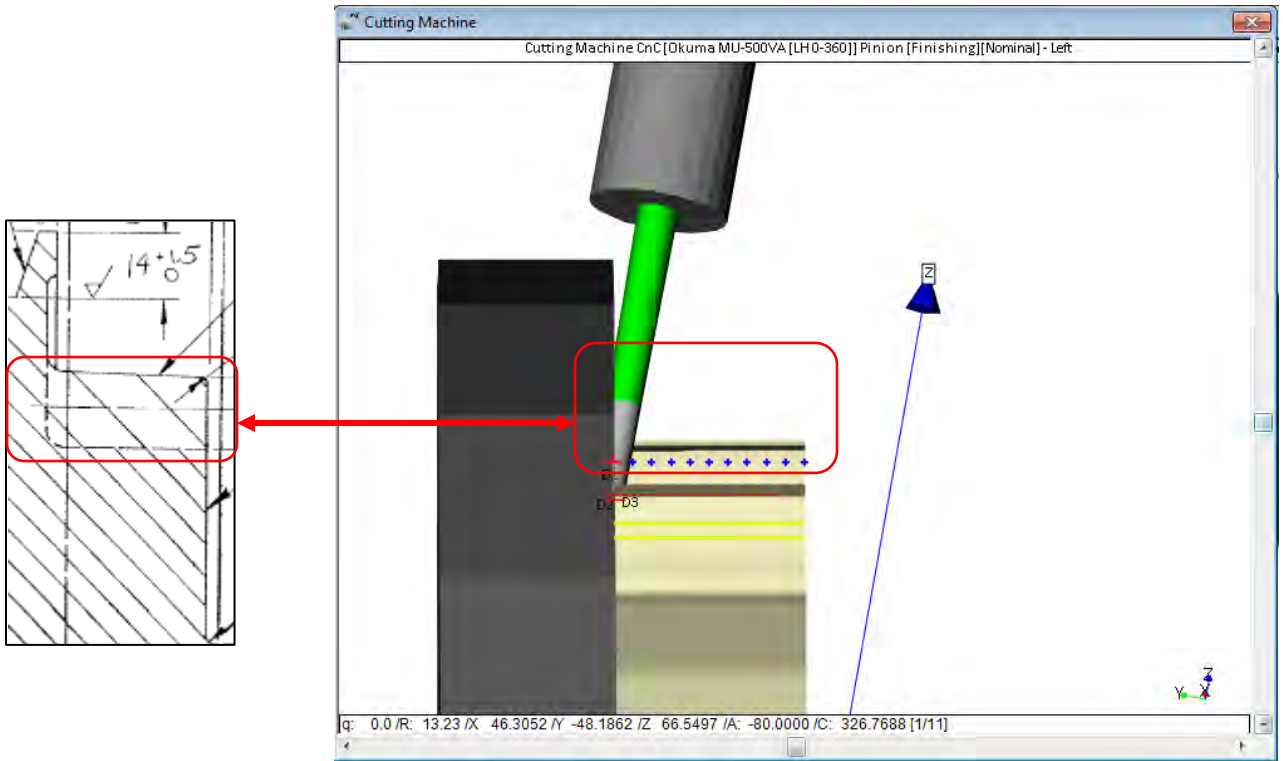
4) In 5Axis:

- Tool Pivot has been extended to the Ball Mill for the tooth flank;
- Tool Pivot can now be Fixed, which means that when tool travel direction reverses, say from Toe->Heel to Heel->Toe, the pivot remains in the same direction.



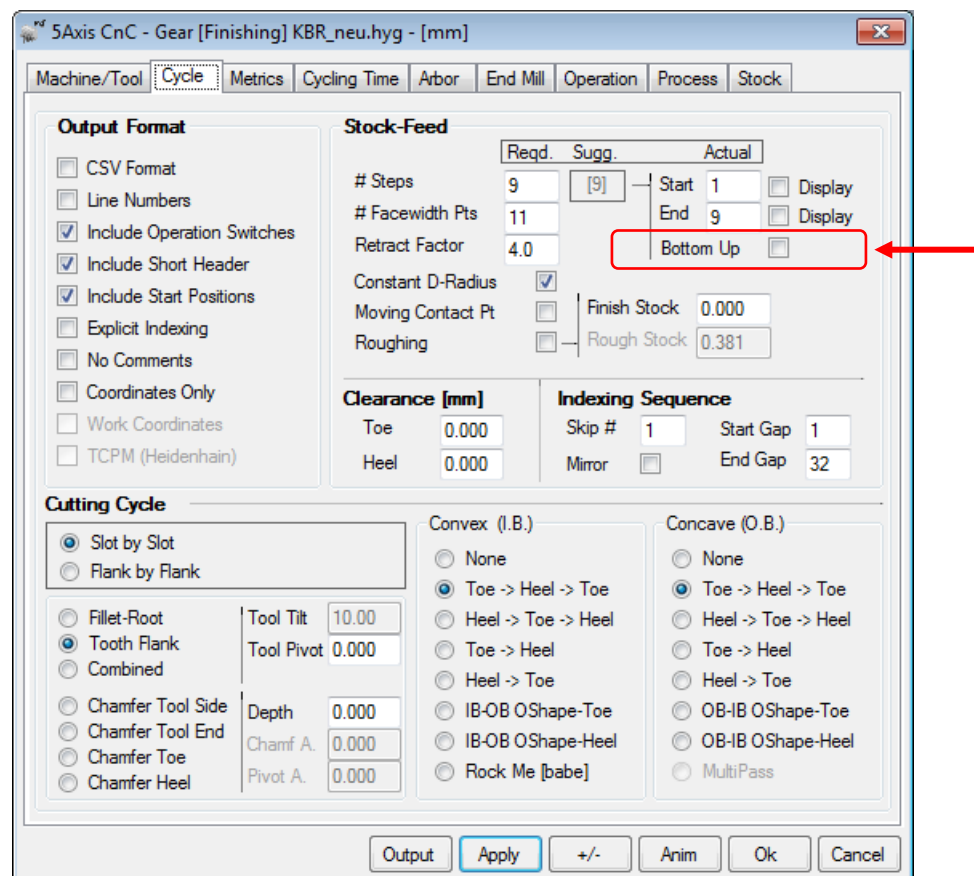
This can become quite handy when it is desired to cut in a “blind” area, such as can be seen in the figures below.

The left figure shows part of the drawing of a spur gear tooth which is abutted to a wall supporting a pulley. The End Mill tool cannot cut at the left end of the spur gear tooth unless it is sufficiently pivoted to prevent the side walls of the End Mill (green part) and the holder (medium grey cylinder) from interfering with the pulley (dark grey cylinder)



HyGEARS update -01 May 2016 - Build 405.30 - 459

1) In 5Axis, Cycle data page, addition of the “Bottom Up” switch to the Stock-Feed options.

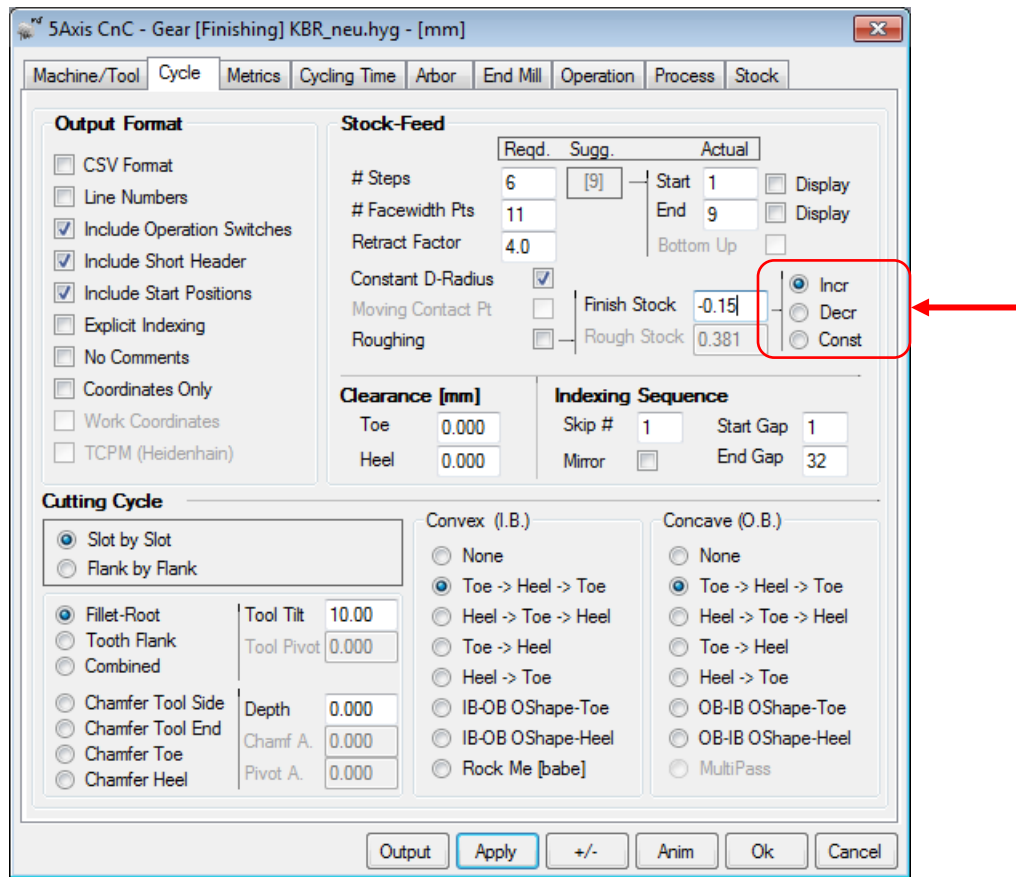


When “Bottom Up” is checked, the cutting sequence will start at the entered End Step and finish at the entered Start Step. Thus, one can impose a sequence starting at the bottom of the tooth gap, using say a large End Mill, to open the gap, and then proceed to cut above.

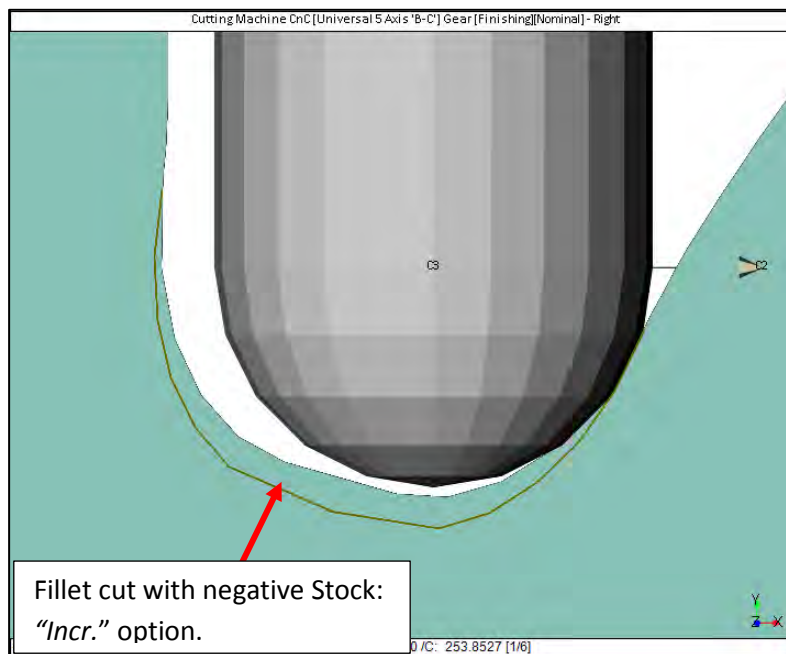
“Bottom Up” applies only to the “Tooth Flank” and “Combined” tooth gap areas, for cycles:

- Toe->Heel->Toe
- Heel->Toe-Heel
- Toe->Heel
- Heel->Toe
- and all O-Shape cycles

2) In 5Axis, Cycle data page, for Fillet finishing, addition of 3 options to control negative Stock.

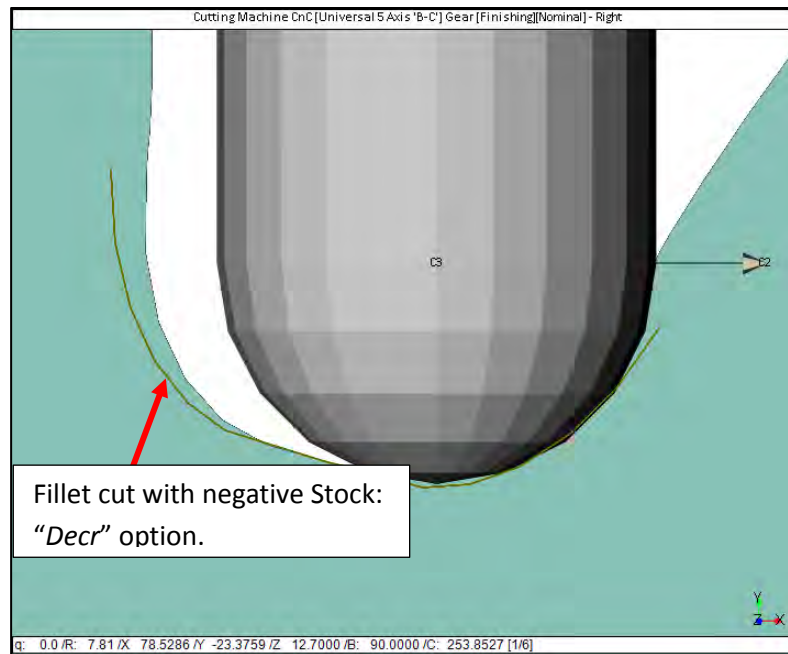


Until now, when negative Stock was entered for Fillet finishing, HyGEARS would create a Fillet as would be cut by a cutter with a protuberance. Stock would be zero at the Fillet line, and maximum in absolute value at the bottom of the gap, as shown in the figure below. This is now called “Incr”, for “Increasing negative Stock”.

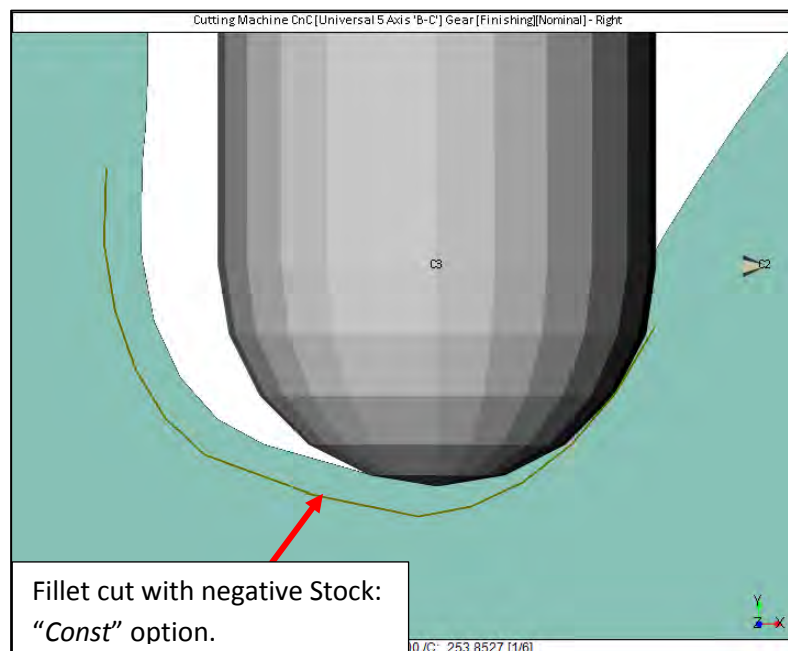


HyGEARS now offers two options on top of the [previously default] “Incr” option:

- “Decr”, or “Decreasing negative Stock”, where negative Stock is maximum in absolute value at the Fillet line, and zero at the bottom of the tooth gap, as shown in the figure below. This can be used when the tooth flank is cut with negative stock, but tooth depth is not to be altered.



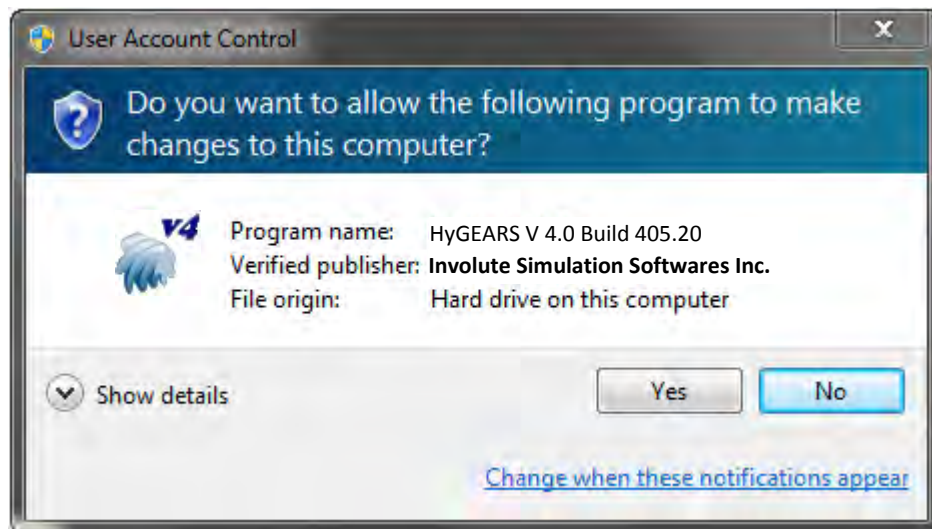
- “Const”, or “Constant negative Stock”, where negative Stock is constant all along the fillet, as shown in the figure below. This can be used, for example, to cut an electrode for EDM manufacturing of a punch for PM gear manufacturing.



HyGEARS update –15 April 2016 - Build 405.20 - 459

1) As you may have noticed at installation time, starting with Build 405.20, HyGEARS has a digital signature which guarantees that the HyGEARS Setup file you downloaded from the www.HyGEARS.com website has not been tampered with by anyone.

When installing or running HyGEARS, the following window will be displayed on screen, where the origin and version of either the HyGEARS Setup program, or HyGEARS Build program, is displayed:



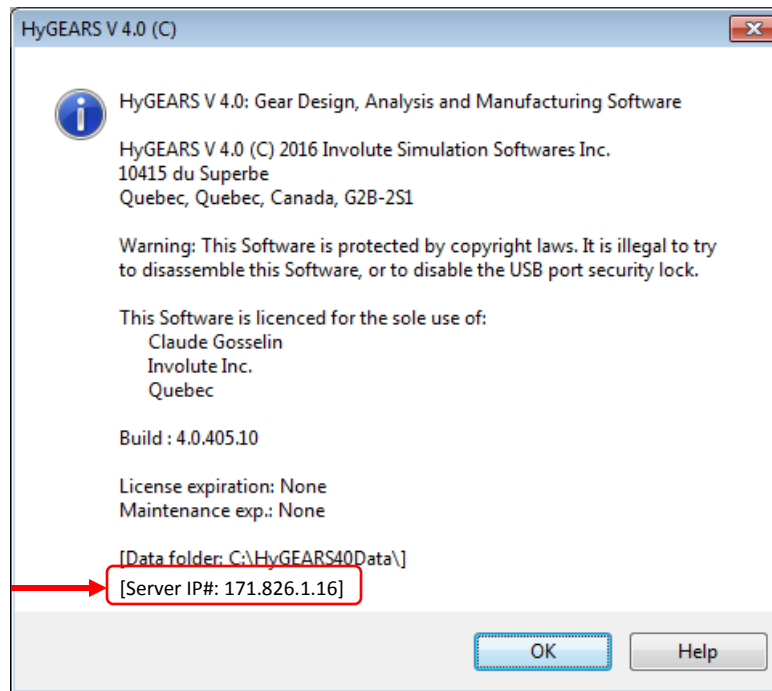
2) Network operation: HyGEARS can now be operated in a network environment, where the HardLock key is located on a server visible throughout the network.

Network operation requires a special Network HardLock key (figure below) which can be obtained from Involute (at a cost). Depending on user options, up to 10 client computers can run HyGEARS concurrently.



Network operation requires a special driver to install on the server; the client computer(s) running HyGEARS continue to use the same driver.

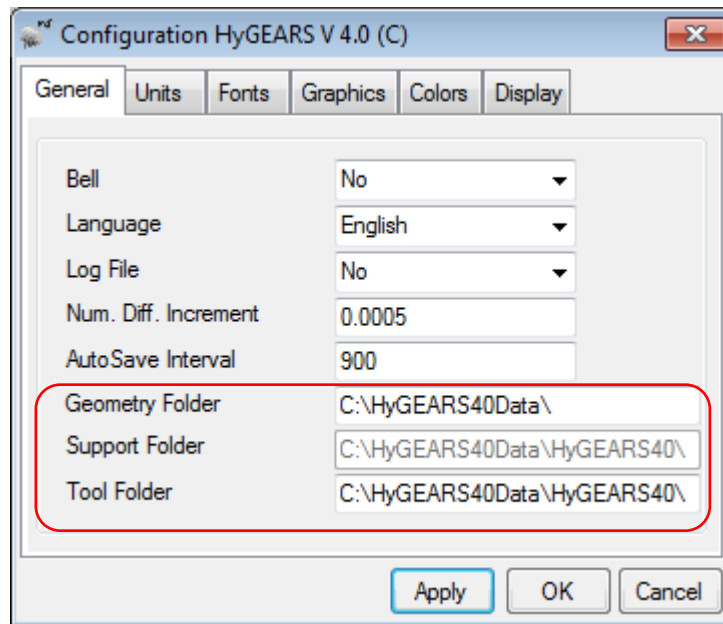
When clicking on the "Help -> About HyGEARS" menu entry, HyGEARS displays the IP address of the network server on which the HardLock key was found, as shown below:



3) HyGEARS configuration:

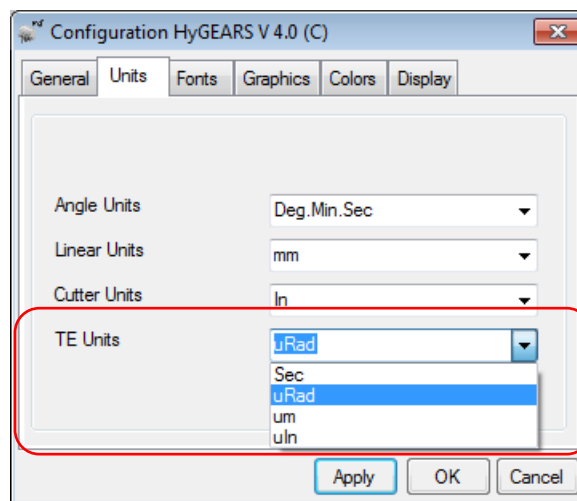
A) To allow using HyGEARS in a network environment, the HyGEARS configuration now includes 3 folders that describe where data is stored, as shown in the figure below, where:

- *Geometry Folder*: this is the root folder where the individual geometry folders are expected. It can be anywhere on the network and HyGEARS will attempt to create the folder if it does not exist; if the folder cannot be created, then the original Geometry Folder name is conserved; no further action occurs after creating the new Geometry Folder, which means that whatever existing geometries must be moved manually to the new Geometry Folder if desired;
- *Support Folder*: this folder holds several support files for HyGEARS, such as the configuration file, the names of the 12 most recently opened geometry files, the input data of the last geometry created, etc. This folder is created when HyGEARS is installed, and cannot be changed afterwards since HyGEARS expects the support files to remain in a defined location;
- *Tool Folder*: this folder is to contain the tool files, such that they are visible to all users in the network; when the Tool Folder name is changed, HyGEARS attempts to create the requested folder; if successful, the existing tool files (CoSIMT.fil, EndMill.fil, BallMill.fil, FaceMill.fil, Probe.Fil) and machine file (Machine.fil) will be moved to the newly created folder, and the original files will be renamed with the string “.old” appended at the end of the file name.



Network support also means that the default configuration file, “Config.inv”, is no longer distributed and copied when installing HyGEARS. Instead, a function detects if the “Config.inv” file is present, and if not present, will create it with default values.

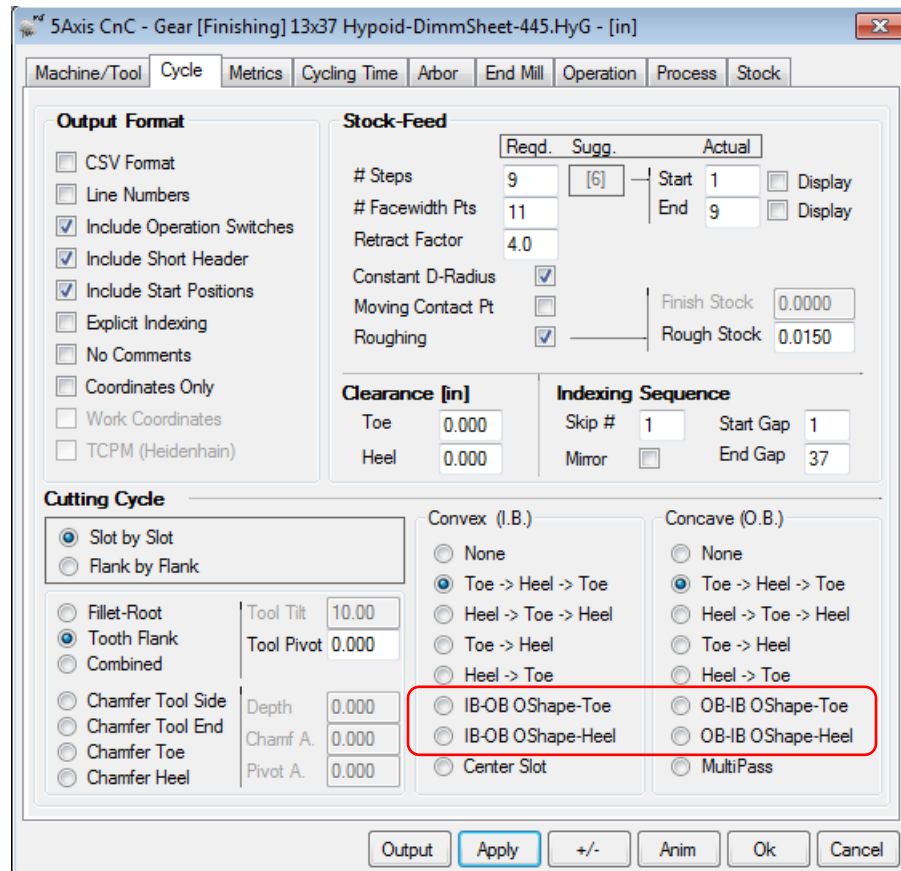
B) TE (Transmission Units) units can now be selected in the Units page of the HyGEARS Configuration, as shown below. Default is uRad.



4) 5Axis function (available in Machine mode for 5Axis CnC manufacturing).

A) Addition of 2 O-Shaped cycles in the Cycle data page, replicating the existing IB-OB and OB-IB OShaped cycles, but starting at Heel rather than starting at Toe. Otherwise, the new OShaped cycles starting at Heel operate like the original OShaped cycles starting at Toe.

- *IB-OB OShape-Toe*: Toe -> Heel on the IB, Heel -> Toe on the OB
- *IB-OB OShape-Heel*: Heel -> Toe on the IB, Toe -> Heel on the OB
- *OB-IB OShape-Toe*: Toe -> Heel on the OB, Heel -> Toe on the IB
- *OB-IB OShape-Heel*: Heel -> Toe on the OB, Toe -> Heel on the IB

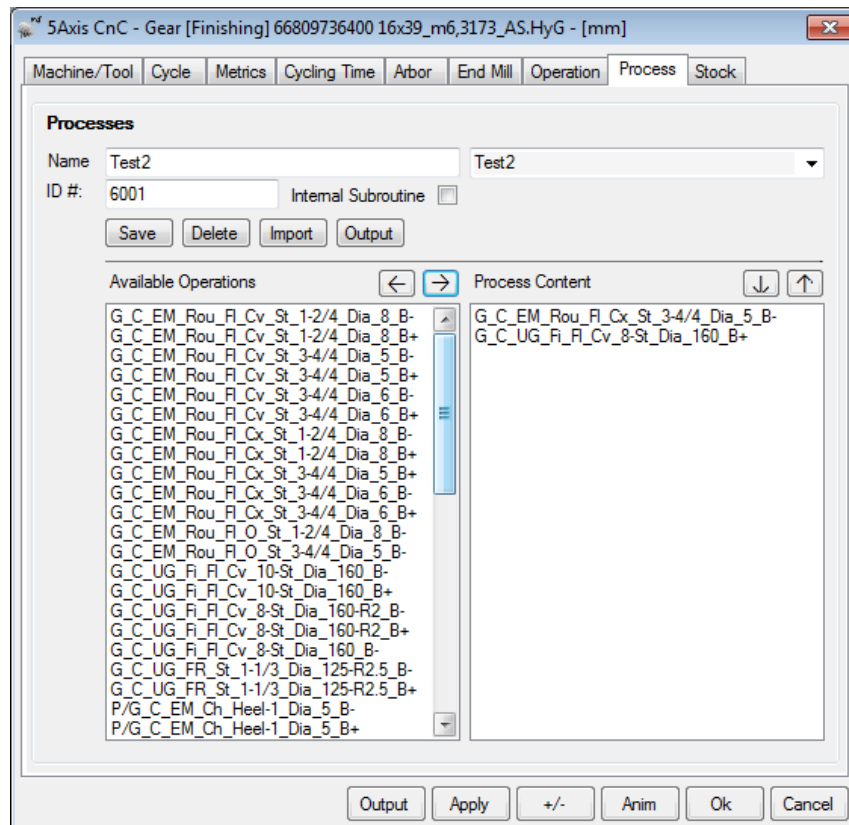


B) End Mill “Tool Pivot” is now supported for Center Slot roughing.

C) In the Process data page, the Available Operations list is now indexed alphabetically, and it shows only those operations NOT already selected and displayed in the Process Content.

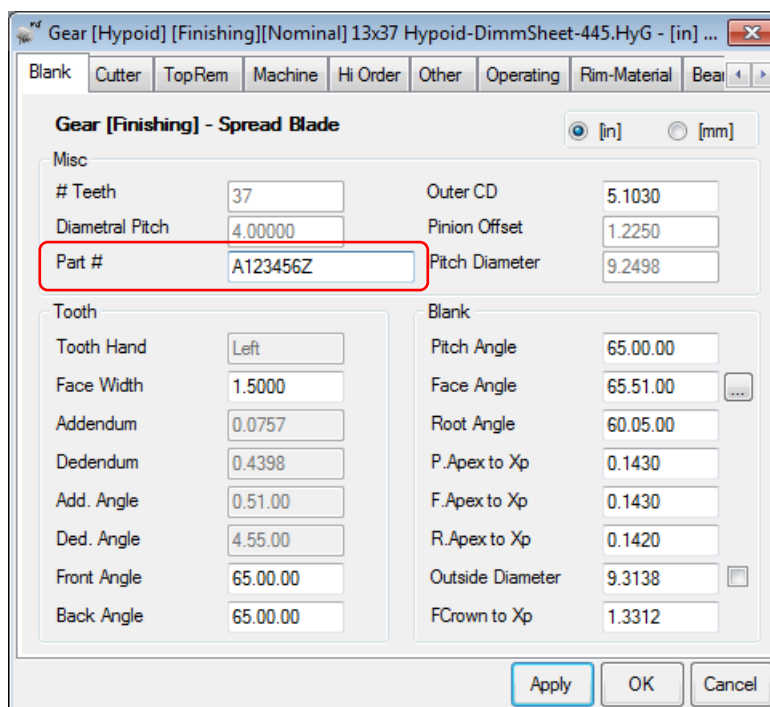
Likewise, when an operation is added to the Process Content, it is removed from the Available Operations list; inversely, whenever an operation is removed from the Process Content, it is returned to the Available Operations list.

This should be of help when a large number of operations is displayed in the Available Operations list.



5) HyGEARS Summary Editor:

A) Addition of the "Part #" field such that the Pinion and Gear can be identified to a specific drawing or part number.



This “Part #” is then outputted in each of the Pdf summaries: “GSum”, “Summ”, and Closed Loop (i.e. Corrective machine settings) summary. The “Part #” is limited to 50 characters.

B) Addition of the “Pinion Offset” and “Pitch Diameter” fields to all bevel gears, hypoid or not (where the Offset is then 0). These values are for consultation only and cannot be edited.

The Pitch Diameter is calculated as: $D = 2 OCD \sin(\gamma)$ where OCD is the Outer Cone Distance (Outer CD below), and γ is the Pitch Angle. Since the calculated Pitch Diameter is based on the OCD and on γ , if any of these have been modified after geometry creation, the displayed Pitch Diameter value may differ from that obtained using either the Module or Diametral Pitch and the # Teeth.

C) It is now easier to define a “Turned OD” when desired:

- enter the Back angle as 90 deg., (HyGEARS will limit to 89.9 deg. to avoid infinite tangent values),
- enter the desired OD,
- click on “Apply”

and HyGEARS will go through a short loop to yield the desired Turned OD (the previous approach required 2 steps, i.e. entering the Back angle and the desired Turned OD, clicking on Apply and re-entering the desired Turned OD a 2nd time to reach the desired OD).

6) In 5Axis, Operations data page, the Cutting Feed is now defined for up to 4 different conditions:

- IB: Toe -> Heel
- IB: Heel -> Toe
- OB: Toe -> Heel
- OB: Heel -> Toe

5Axis CnC - Gear [Finishing] 13x37 Hypoid-DimmSheet-445.HyG - [mm]

Machine/Tool Cycle Metrics Cycling Time Arbor End Mill Operation Process Stock

Operation

Name: Test

ID #: 6001 Internal Subroutine ☐

Save Delete Import Output STEP

Tool Change

Tool ID	1	0	0	0	0	0
Gap #	1	0	0	0	0	0

Switches

☒ Coolant On Coolant On Code: M07 Coolant Off Code: M08

☒ Spindle CW ☐ Spindle CCW Spindle RPM: 1500

☐ Return Trip

Steps: 11

Feeds [mm/min]

Rapid Move	1500								
Plunge	500								
Cutting	<table border="1"> <tr> <th>IB Toe->Heel</th> <th>IB Heel->Toe</th> <th>OB Toe->Heel</th> <th>OB Heel->Toe</th> </tr> <tr> <td>300</td> <td>320</td> <td>300</td> <td>320</td> </tr> </table>	IB Toe->Heel	IB Heel->Toe	OB Toe->Heel	OB Heel->Toe	300	320	300	320
IB Toe->Heel	IB Heel->Toe	OB Toe->Heel	OB Heel->Toe						
300	320	300	320						

Output Apply +/- Anim Ok Cancel

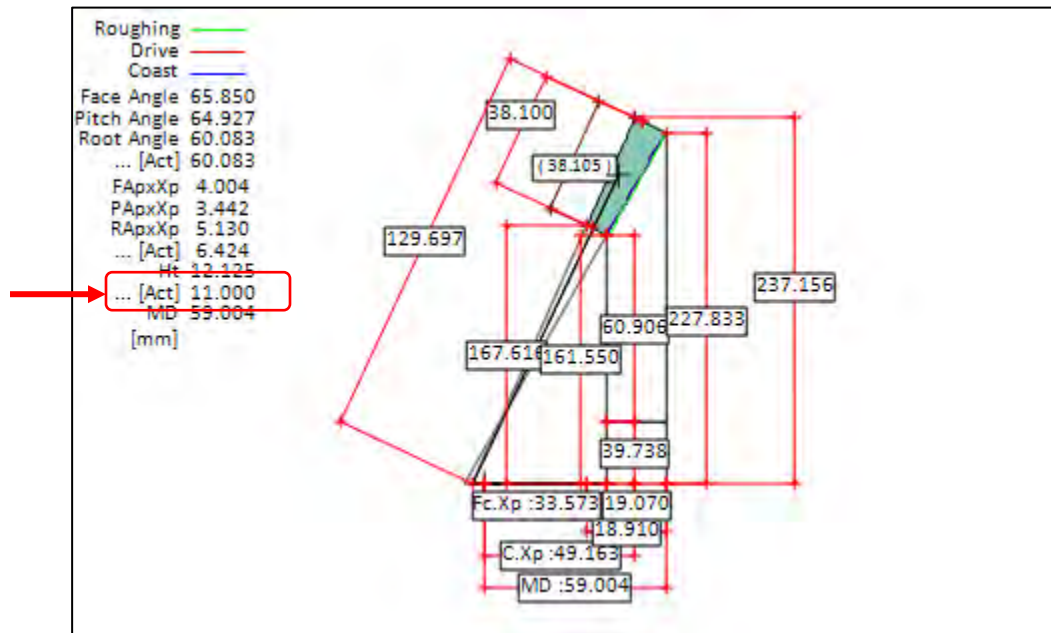
The relevant fields become enabled when the selected cutting cycles warrant it. Initially, the values originate from the Cutting Feed entered for the selected tool; they can then be modified, and become part of an Operation when it is saved.

Such different cutting feeds can be useful for example when opening the tooth gap with a large End Mill; depending if tool rotation is CW or CCW and if movement is Toe->Heel or Heel->Toe, it may be desired to reduce the cutting feed in order to prevent tool vibrations which may arise for example if the tool is plunging into the gap.

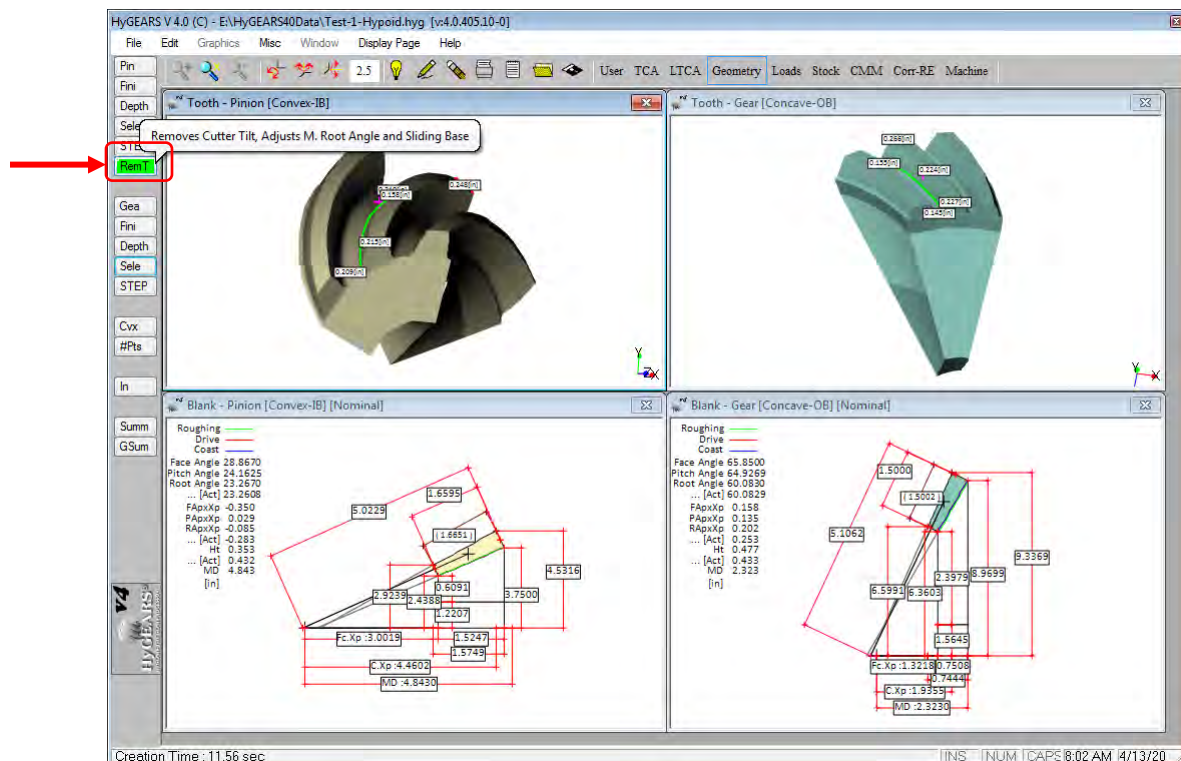
7) In the Blank display, addition of the "... [Act]" output below the "Ht" output. Similarly as for the Root Angle and RApXxp, this "... [Act]" value gives the actual tooth depth at Heel.

Tooth depth "Ht" is calculated perpendicularly to the pitch cone, and is based on the current Summary values of Outer Cone Distance, Pitch angle, Face angle and Root angle, and PApXxp, FApXxp and RApXxp.

Actual tooth depth "... [Act]" - below "Ht" - is also calculated perpendicularly to the pitch cone, and is based on the current Outer Cone Distance, Pitch angle, Face angle, PApxXp, FApxXp and actual Root Angle and RApxXp.



8) Geometry display mode: addition of the "RemT" function button. This function removes cutter tilt on Fixed Setting and Duplex Helical pinions (for generated gear sets only; not for hypoid gears) in order to allow manufacturing on a tilt-less generator such as the YH603.



Note: removing cutter tilt does not always yield acceptable results as cutter tilt is fundamental in controlling lengthwise crowning, and thus Bearing Pattern length and bias of the PoC. However, in some specific cases where cutter tilt is small, good results can be obtained especially for DH spiral-bevel pinions.

9) “GSum” and “Summ” functions: addition of “Ht” and “Ht ...[Act]” to the BLANK DATA section of the Summary output .

Tooth depth “Ht” is calculated perpendicularly to the pitch cone, and is based on the current Summary values of Outer Cone Distance, Pitch angle, Face angle and Root angle, and PApXp, FApXp and RApXp.

Actual tooth depth “Ht ... [Act]” is also calculated perpendicularly to the pitch cone, and is based on the current Outer Cone Distance, Pitch angle, Face angle, PApXp, FApXp and actual values for Root Angle and RApXp.

BLANK DATA	PINION	GEAR
Face Apex Beyond XP	-0.9912	-0.1379
Root Apex Beyond XP (Active)	-0.4439	0.1078
Root Apex Beyond XP (Bottom)	-0.6357	0.1461
Crown to XP	22.0176	5.6891
Front Crown to XP	15.9014	4.3396
Addendum	1.5008	0.4569
Dedendum	0.7042	1.7314
Ht	2.2051	2.1883
Ht ... [Act]	2.2343	2.1868
Addendum Angle	4.31.43	1.27.43
Dedendum Angle	1.27.43	4.31.43
Face Angle of Blank	20.16.47	75.42.39
Pitch Angle	15.45.04	74.14.56
Root Angle	14.17.21	69.43.13
Root Angle (Actual)	14.20.06	69.38.08
Front Angle	15.45.04	90.00.00
Back Angle	15.45.04	89.59.56

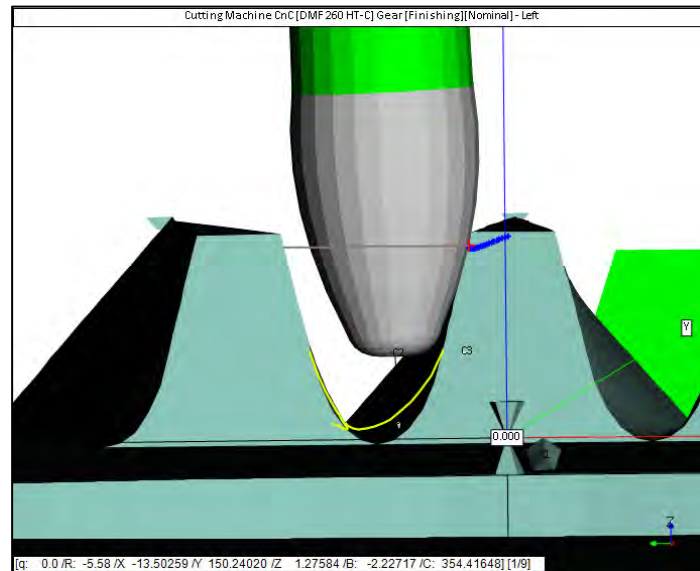
10) “Silent” install / un-install: the HyGEARS Setup program now supports so-called “Silent” install / un-install where a command line can be used to drive the HyGEARS setup. This is intended to ease the task of the IT people who have to install /un-install software updates.

11) Tilt-less Chinese machine YH603 now comes in 2 flavors:

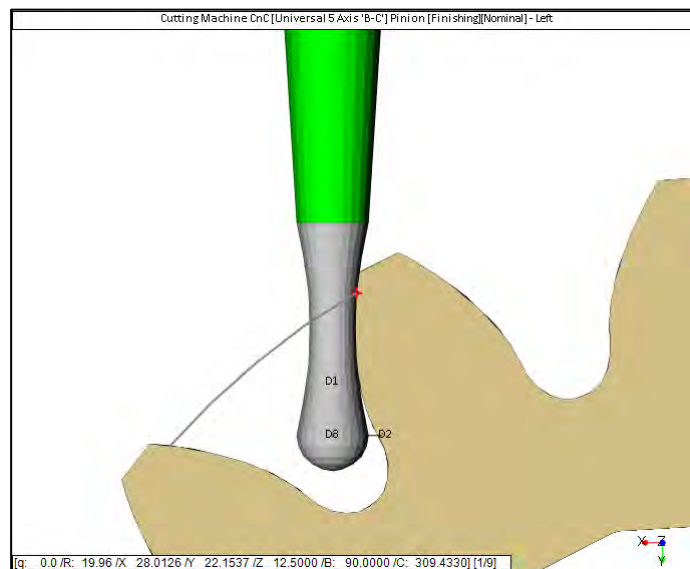
- YH603, where machine settings are given as those of the Gleason Phoenix;
- YH603-Cradle where machine settings are given as those of a cradle + eccentric mechanical generator such as the Gleason #26.

HyGEARS update – 07 March 2016 - Build 405.10 - 458

1) In 5Axis, the End Mill tools are now defined to be curved. This can be advantageous when cutting a Face Gear where the profile curvature is concave, as shown in the figure below:



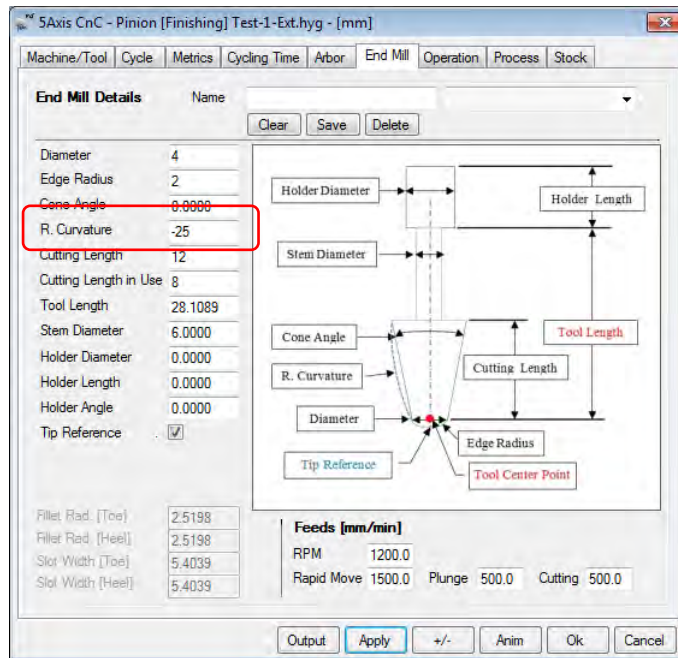
This feature can also be used for Spur and Helical gears, by entering a negative Radius of Curvature, as shown in the following figure:



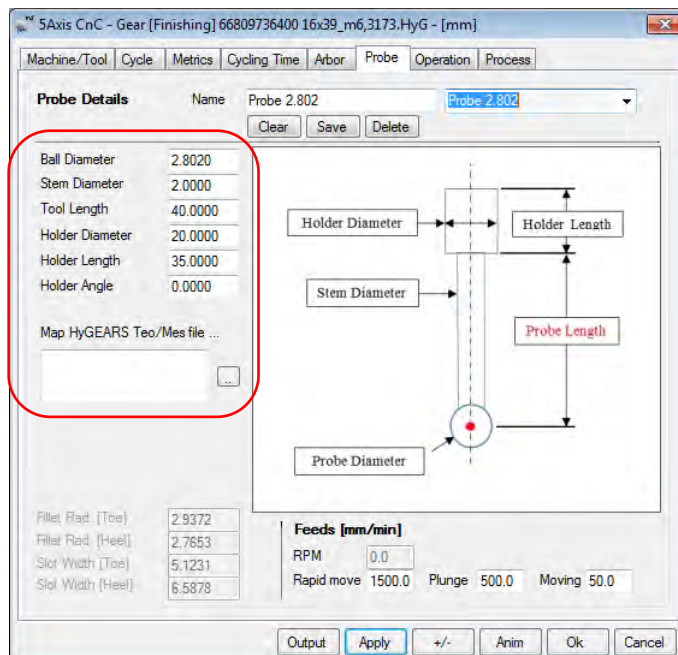
In each case, using a curved End Mill would allow reducing the # Steps needed to attain a given tooth surface quality. In particular, when the profile curvature of the tooth is concave, not using a curved tool will lead to the mutilation of the upper portion of the tooth when the tool is cutting the lower part of the tooth.

The main limitation in using these tools may be the quality that the tool manufacturer can attain and guarantee.

The curved End Mill is defined by entering the Radius of Curvature. A positive value denotes a Convex tool, a negative value denotes a Concave tool, and a Zero value denotes a standard, straight, End Mill.



2) In 5Axis, the “Probe [CMM]” tool now has a specific tab where different probes can be defined and associated with a specific Operation. By default, the coordinates are always given at the center of the probe sphere. The figure below shows the different values used to define a Probe tool.

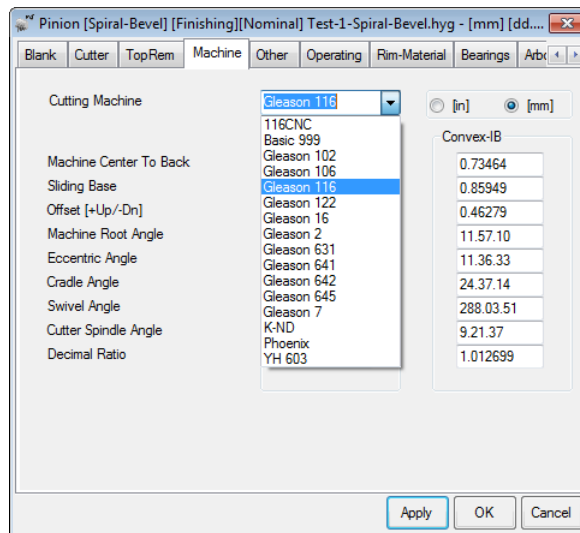


The “Map HyGEARS Teo/Mes file ...” entry is used to identify either a CMM target or actual CMM output file (Zeiss, CAGE, KIMoS, MdM, etc.) that has been converted to the HyGEARS format. The selected file will be mapped to the tooth surface such that measurement occurs at the same place on the tooth as if measuring on the target CMM. Measurements using a CnC machine or a CMM can thus be compared to assess accuracy and repeatability.

When the [...] button to the right of the “Map HyGEARS Teo/Mes file ...” entry is clicked, a navigation window is displayed to select the desired file. An error message is displayed if the selected file is not of the correct type, or if it does not identify to the current member, i.e. pinion or gear.

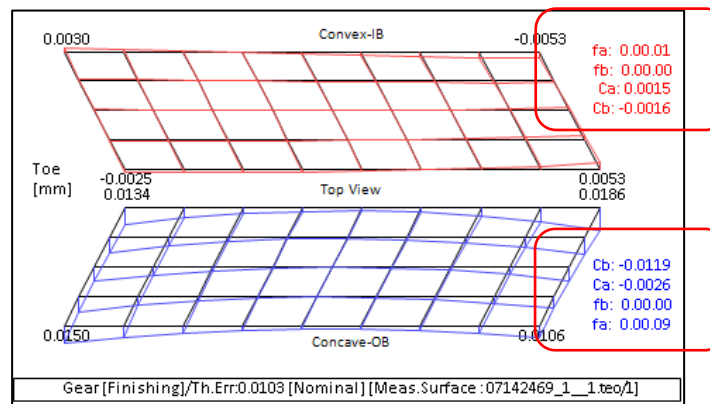
3) For spiral-bevel, hypoid or Zerol gear sets, when creating a New Geometry, when editing the Pinion or Gear Summaries, or when outputting a Text / Graphics Summary, the machine is now identified by its manufacturer name and model, rather than by the older combination of machine number and cutting process letter.

Thus, when a machine is selected for the Fixed Setting cutting process, the following list would be available, depending on user options:

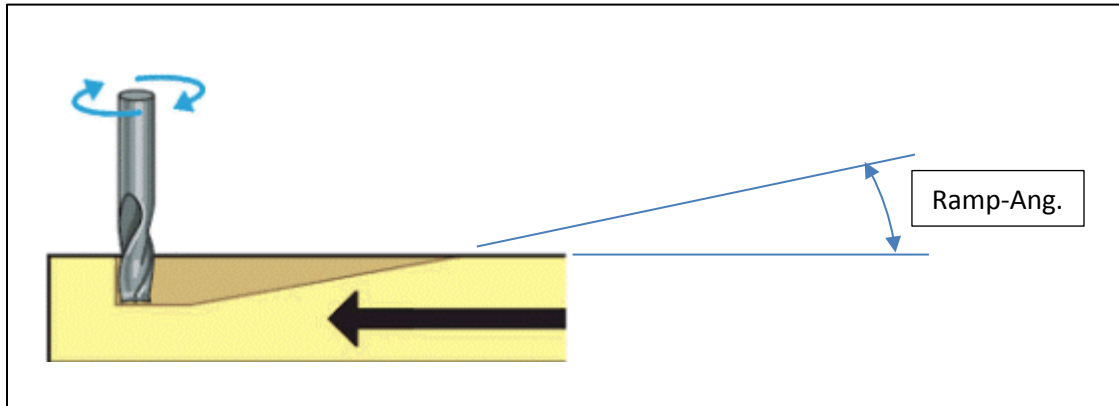


4) In Corr-RE, i.e. Corrective Machine Settings (Closed Loop) – or Reverse Engineering, the “fa” and “fb” values given to the right of the display now include “Ca” and “Cb”, where:

- “fa” is the average pressure angle error, in DD.MM.SS format;
- “fb” is the average spiral angle error, in DD.MM.SS format;
- “Ca” is the average profile curvature error, in the current linear units;
- “Cb” is the average lengthwise crowning error, in the current linear units.



5) In 5Axis, Metrics tab, addition of the “Ramp-Ang.” output. The “Ramp-Ang.” is the angle caused by the difference in step depth at Toe and Heel in tapered teeth. It is usual in tool makers’ data to quote the cutting feed rate as a function of the Ramp Angle. The “Ramp-Ang.” is given in the Heel table below.



Profile-Wise Steps

Finishing Concave-OB [Toe] [mm]

Step# Slot-Width Step-Depth Tot.Depth Flat-Width Flat-Prof. Ramp-Ang.

[Tooth Tip Diameter]

Starting Depth:	0.1553					
1>2	1.6427	0.1481	0.3034	0.1602	0.0002	-
2>3	1.5359	0.1411	0.4445	0.1521	0.0002	-
3>4	1.4342	0.1345	0.5790	0.1445	0.0001	-
4>5	1.3369	0.1277	0.7067	0.1367	0.0001	-
...						
8>9	0.9907	0.1035	1.1559	0.1090	0.0001	-
Total :		1.0006				
Ending Depth :		1.1559				

Finishing Concave-OB [Heel] [mm]

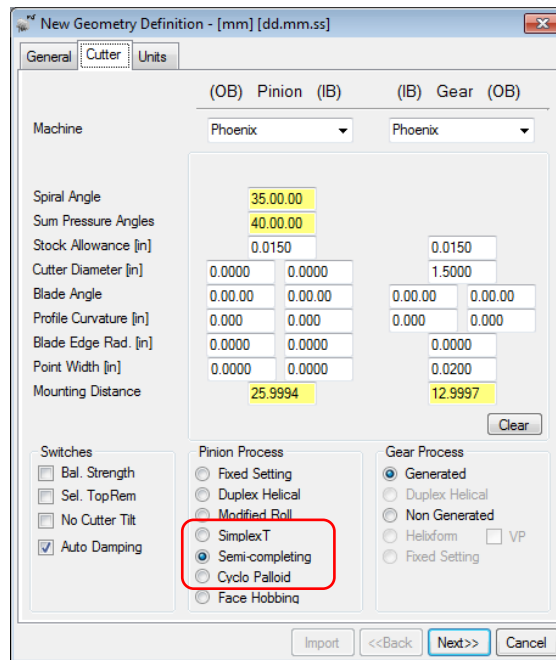
Step# Slot-Width Step-Depth Tot.Depth Flat-Width Flat-Prof. Ramp-Ang.

[Tooth Tip Diameter]

Starting Depth:	0.3287					
1>2	2.5109	0.3143	0.6430	0.3616	0.0003	0.6162
2>3	2.2982	0.3004	0.9434	0.3446	0.0003	0.5904
3>4	2.0915	0.2869	1.2303	0.3282	0.0003	0.5648
4>5	1.8902	0.2738	1.5041	0.3121	0.0003	0.5414
...						
8>9	1.1294	0.2252	2.4759	0.2519	0.0002	0.4510
Total :		2.1473				
Ending Depth :		2.4759				

6) When creating a New Geometry, the (optional) Semi Completing process is now offered for Zerol, spiral-bevel and hypoid gears.

The Semi Completing process uses a completing Face Mill cutter head, like those used for the Duplex Helical process, but the machine settings on the Convex and Concave tooth flanks are different, thereby allowing greater flexibility in designing the kinematic characteristics.



The Semi Completing process behaves differently, depending on the selected tooth taper:

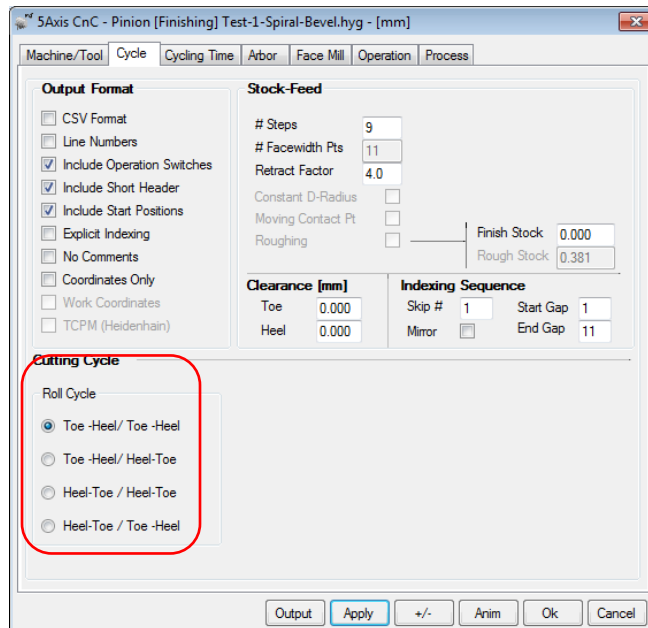
- for Standard and Uniform tooth tapers, the Semi Completing process works pretty much like the Spread Blade cycle, to the difference that the machine settings are different on each tooth flank;
- for Duplex tooth taper, Helical Motion is also used, just like for the Duplex Helical process; again, the machine settings are different on each tooth flank.

In each case, whenever possible, the pinion cutter is identical to the gear cutter, thus allowing for smaller cutter inventory.

7) In 5Axis, addition of specific cutting cycles for the Fixed Setting, Modified Roll and Semi-Completing processes when using a Face Mill cutter.

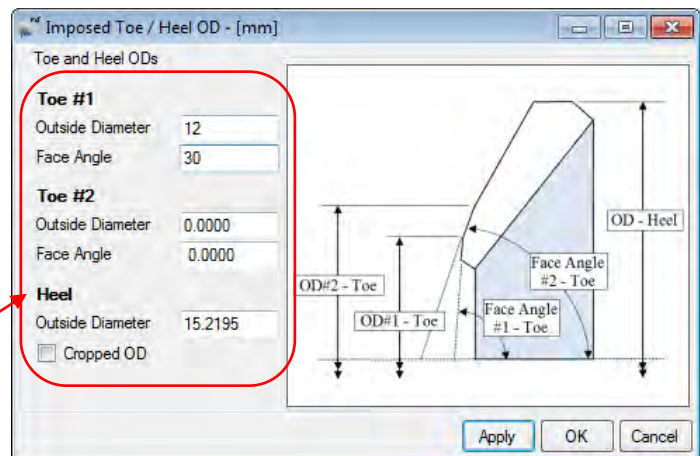
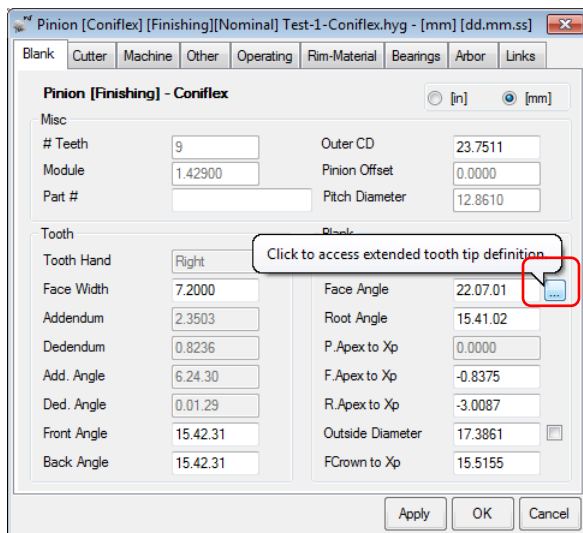
In each case, the 1st part of the cycle name is on the Convex flank, and the 2nd part on the Concave flank.

- Toe- Heel / Toe- Heel: the cutter moves from Toe to Heel on both the Convex and Concave flanks;
- Toe-Heel / Heel-Toe: the cutter moves from Toe to Heel on the Convex flank, and from Heel to Toe on the Concave flank; thus, there is a time saving as the cutter does not have to return twice to the Toe; on the other hand, the cutter will be cutting up-roll on one flank, and down-roll on the other flank;
- Heel – Toe / Heel- Toe: the cutter moves from Heel to Toe on both the Convex and Concave flanks;
- Heel- Toe / Toe- Heel: the cutter moves from Heel to Toe on the Convex flank, and from Toe to Heel on the Concave flank; thus, there is a time saving as the cutter does not have to return twice to the Heel; again, the cutter will be cutting up-roll on one flank, and down-roll on the other flank.



Of course, depending if the cutter is LH or RH, and depending on the expected surface roughness and tool life, cutting in the same direction for both tooth flanks may be preferred, or not.

8) In the Summary Editor ("Pin" or "Gea" function buttons), addition of a link to define a Tapered Toe Tip and a Cropped OD.

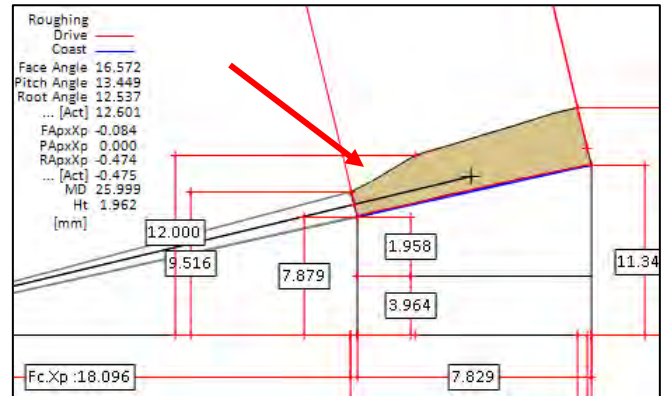
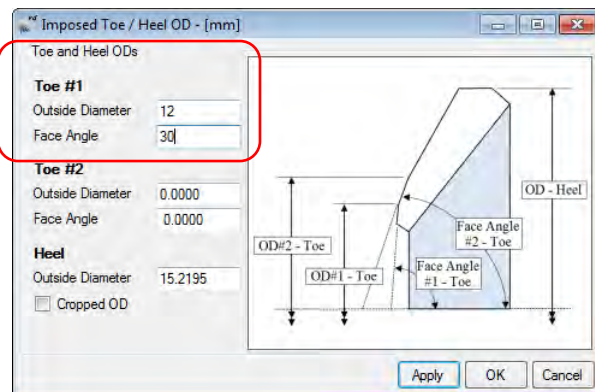


The Tapered Toe Tip can be done in 2 steps; if only 1 step, either the Toe #1 or Toe #2 can be used; in 2 steps are needed, then Toe #1 is closest to Toe, while Toe #2 is between Heel and Toe #1.

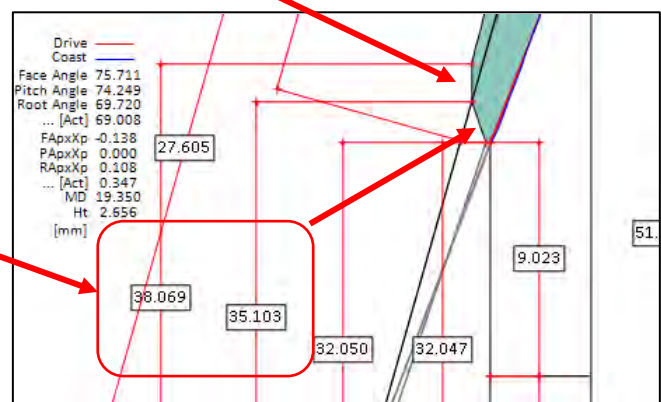
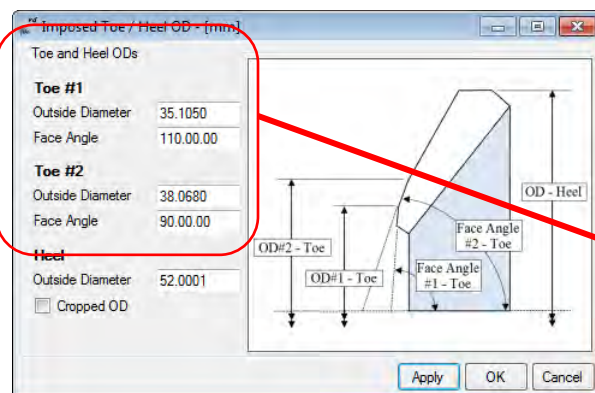
The following rules apply:

- The Face Angle of each step must be larger than the design Face Angle of the part;
- The OD of each step must be larger than the tip OD at Toe, but smaller than the tip OD at Heel.

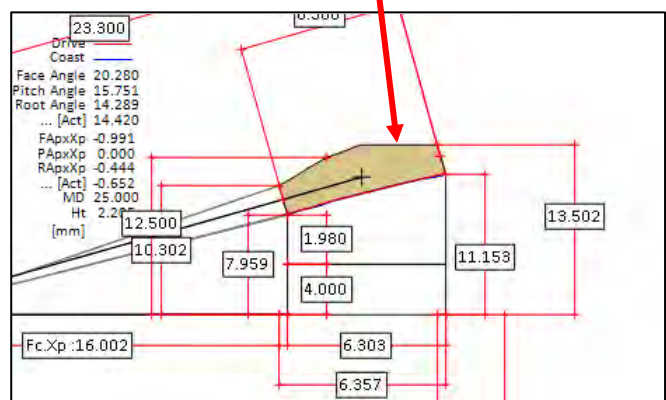
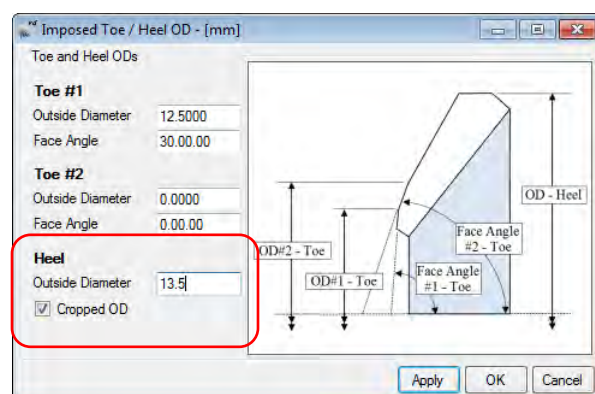
The two figures below show a 1 Step Tapered Toe Tip, with its definition.



By contrast, the two figures below show a 2 Step Tapered Toe Tip, with its definition. It is clear that Toe #2 lies between Toe #1 and Heel.



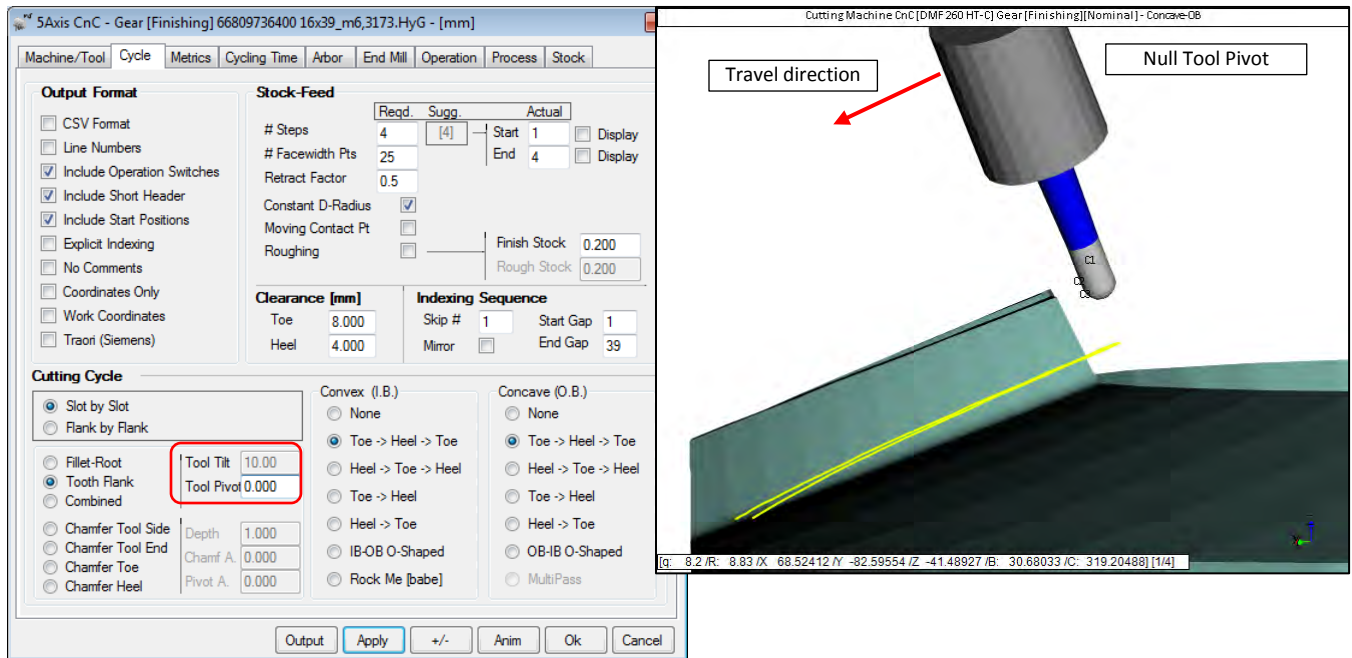
A cropped OD is defined by clicking on the “Cropped OD” check box, left figure below, entering the desired OD and clicking on the “Apply” button.



9) In 5Axis, addition of the “Tool Pivot” for End Mill cutters. This is used when cutting the Tooth Flank only.

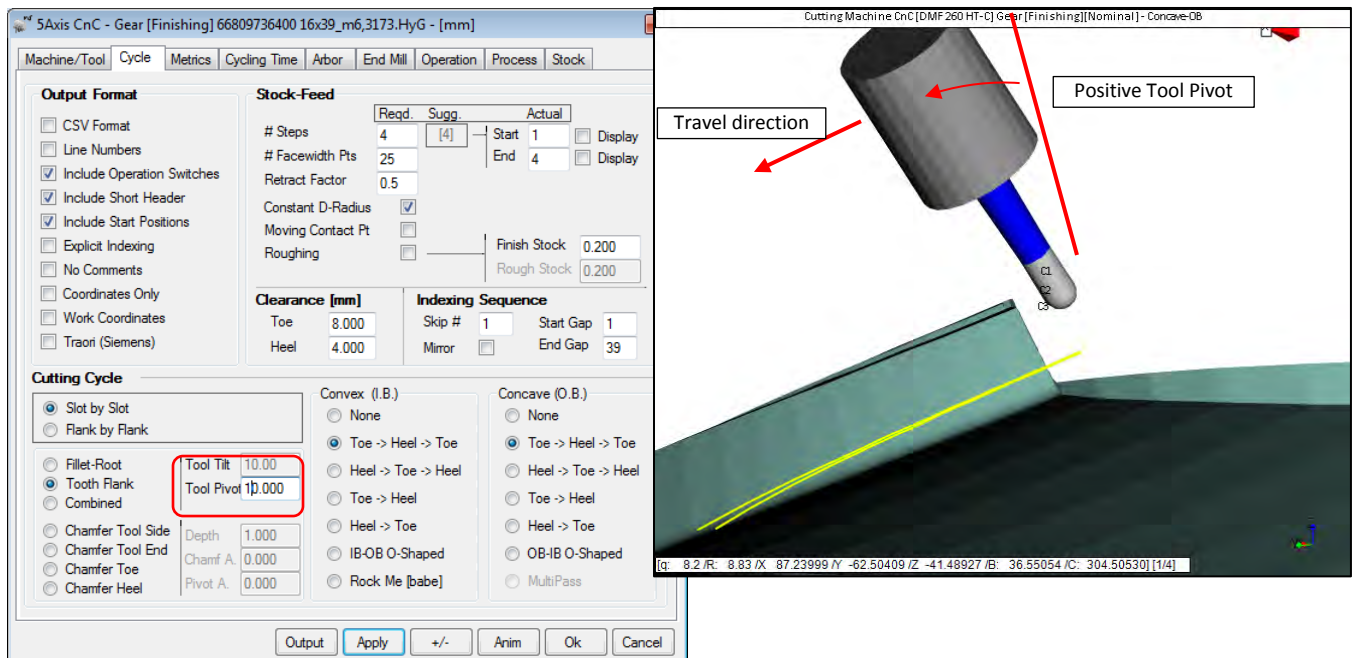
The “Tool Pivot” is an angle that pivots the End Mill in the tangent plane at the current cutting point. Thus, one can ensure that the End Mill will always present a cutting edge to the material rather than the tip of the tool. This is especially important when slotting the raw blank at the roughing stage.

For example, left figure below, the Tool Pivot angle is zero; thus, the tool is in its default orientation as can be seen in the right figure below.



If the above case, the tool will travel from Right to Left.

Imposing a +10 deg. Tool Pivot angle pivots the End Mill in the direction of travel, as shown in the right figure below. When travel direction reverses, so does the Pivot direction such as to always present the desired End Mill part to raw material.



Imposing a -10 deg. Tool Pivot angle pivots the End Mill in the direction opposite to travel, as shown in the right figure below. Again, when travel direction reverses, so does the Pivot direction.

5Axis CnC - Gear [Finishing] 66809736400 16x39_m6,3173.HyG - [mm]

Machine/Tool Cycle Metrics Cycling Time Arbor End Mill Operation Process Stock

Output Format

☐ CSV Format
☐ Line Numbers
☒ Include Operation Switches
☒ Include Short Header
☒ Include Start Positions
☐ Explicit Indexing
☐ No Comments
☐ Coordinates Only
☐ Work Coordinates
☐ Traori (Siemens)

Stock-Feed

	Reqd.	Sugg.	Actual
# Steps	4	[4]	Start 1
# Facewidth Pts	25		End 4
Retract Factor	0.5		
Constant D-Radius	<input checked="" type="checkbox"/>		
Moving Contact Pt	<input type="checkbox"/>		
Roughing	<input type="checkbox"/>		
Finish Stock	0.200		
Rough Stock	0.200		

Clearance [mm]

Toe	8.000
Heel	4.000

Indexing Sequence

Skip #	1	Start Gap	1
Mirror	<input type="checkbox"/>	End Gap	39

Cutting Cycle

☒ Slot by Slot
☐ Flank by Flank

☐ Fillet-Root
☒ Tooth Flank
☐ Combined

☐ Chamfer Tool Side
☐ Chamfer Tool End
☐ Chamfer Toe
☐ Chamfer Heel

Depth 1.000
Chamf A. 0.000
Pivot A. 0.000

Convex (I.B.)

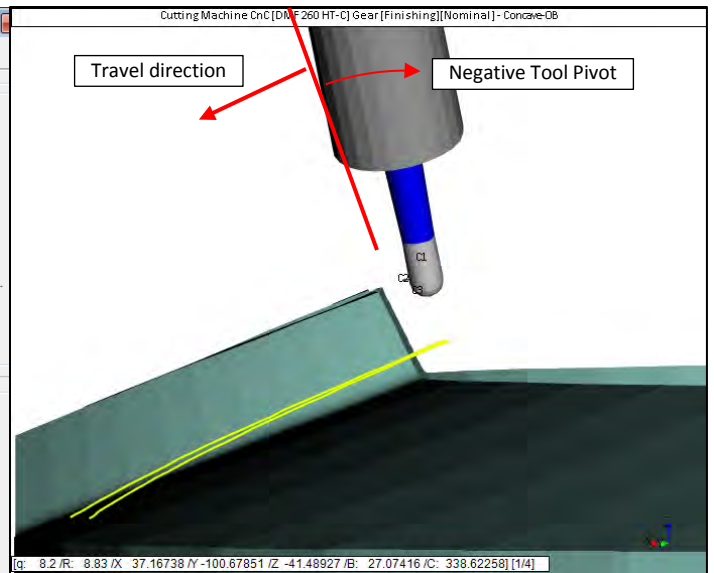
☐ None
☒ Toe -> Heel -> Toe
☐ Heel -> Toe -> Heel
☐ Toe -> Heel
☐ Heel -> Toe
☐ IB-OB O-Shaped
☐ Rock Me [babe]

Concave (O.B.)

☐ None
☒ Toe -> Heel -> Toe
☐ Heel -> Toe -> Heel
☐ Toe -> Heel
☐ Heel -> Toe
☐ OB-IB O-Shaped
☐ MultiPass

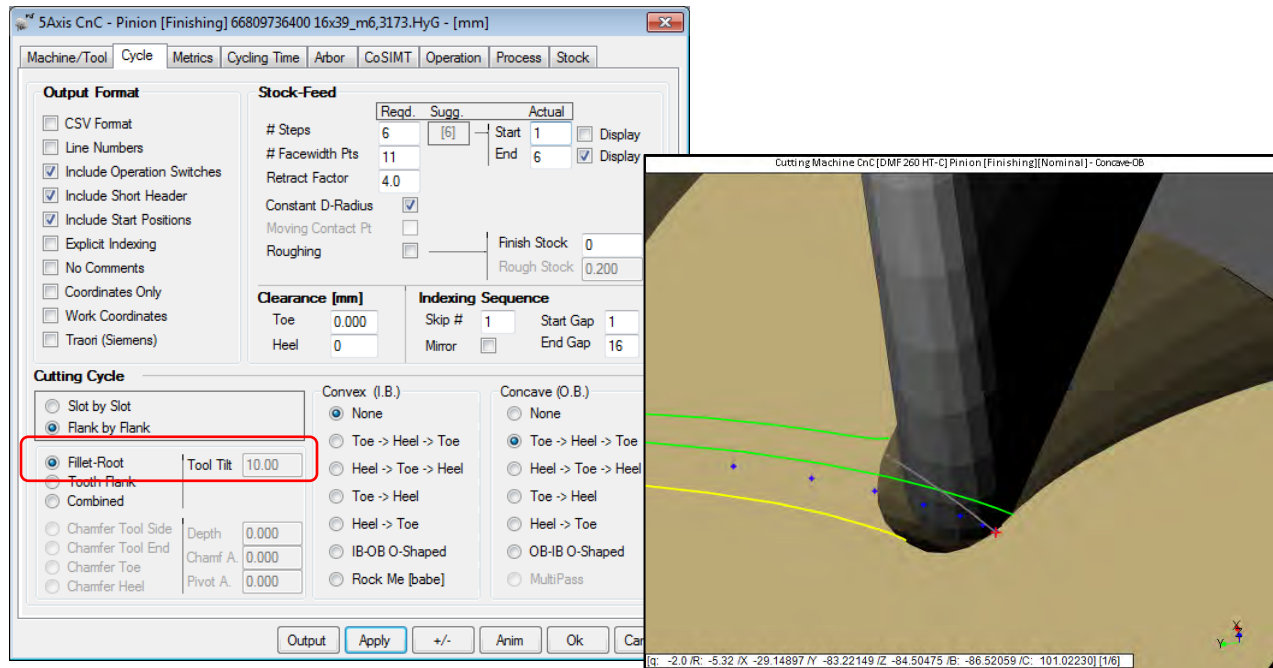
Tool Tilt 10.00
Tool Pivot -10.000

Output Apply +/- Anim Ok Cancel



HyGEARS update – 05 January 2016 - Build 405.00 - 457

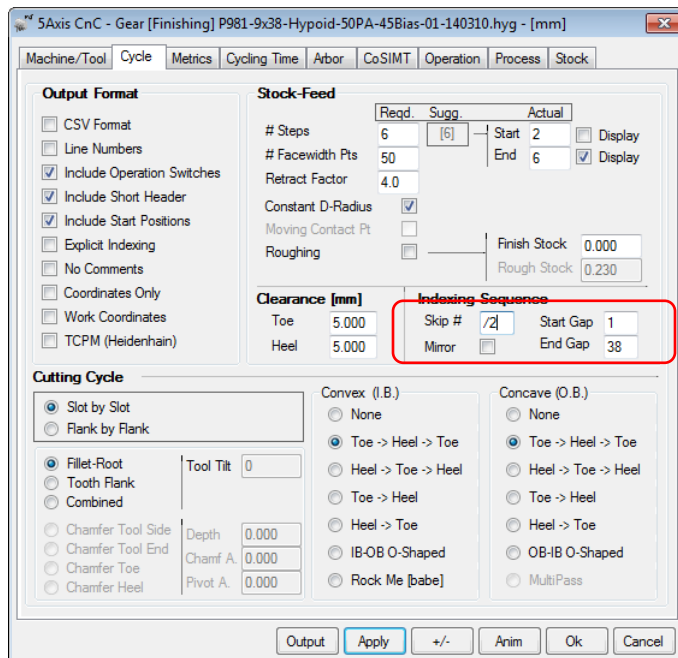
1) In 5Axis, the CoSIMT tool is now defined to cut the Fillet, just like the End Mill and Ball Mill tools. However, Tool Tilt is not used by the CoSIMT when cutting the Fillet.



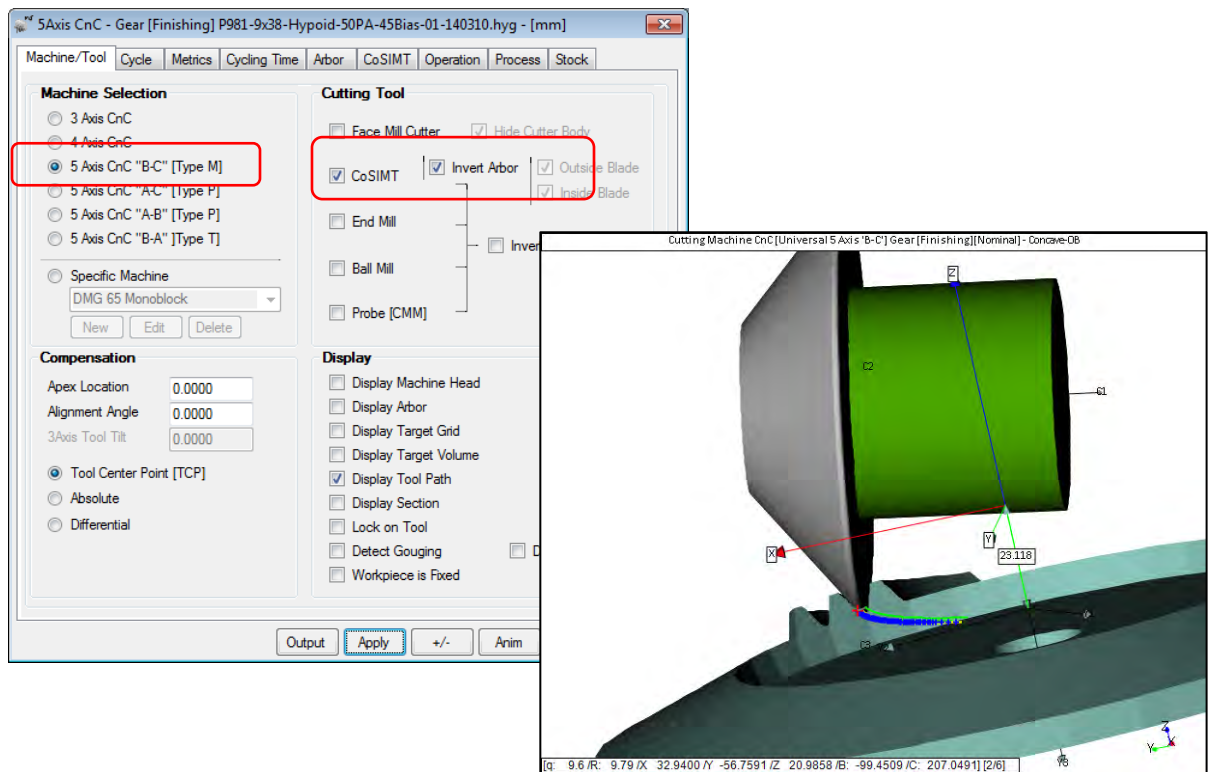
2) In 5Axis, Cycle tab, in the **Indexing Sequence**, the "Skip #" field can now be entered as $/x$ where "x" is any integer larger than 0 and smaller than, or equal to, the tooth number Z .

This tells HyGEARS that the tooth number Z of the current workpiece is to be divided by the entered "x" value to establish how many teeth are to be skipped when indexing from one tooth gap to the next. The interest of this is the ability to define a generic Operation using, say, $/2$, $/3$ or $/4$ as Skip # and have HyGEARS calculate how many teeth are to be skipped in order to spread tool wear. The Operation can thus be applied to parts with different tooth numbers.

When clicking on the "Apply" button, whenever $/$ is detected in the Skip # input field, HyGEARS reads the number to the right of the $/$ character to establish the dividing factor, and the Start Gap and End Gap automatically default to 1 and Z where Z is the tooth number for the current part.

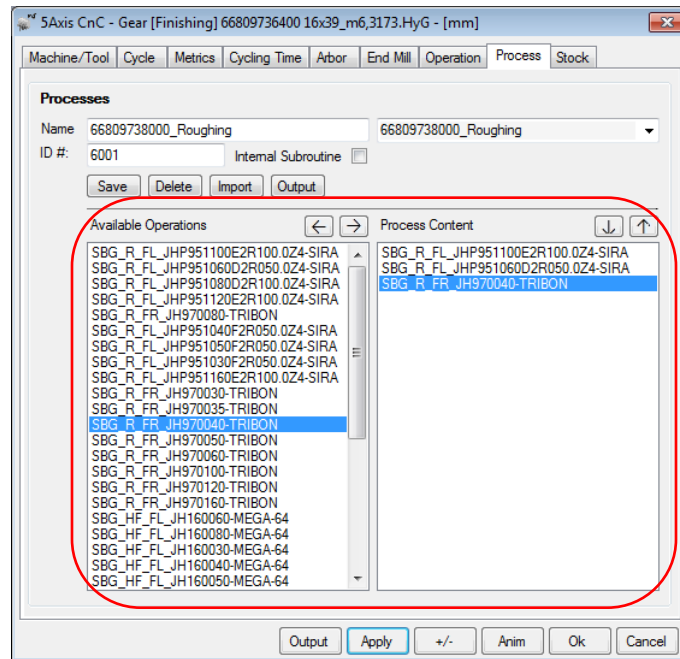


3) In 5Axis, for BC type machines, the arbor of the CoSIMT tool can now be inverted. In some situations, this allows using a CoSIMT where, with the arbor on the standard inside blade side, tool tilt would be beyond the normal capabilities of a BC machine.



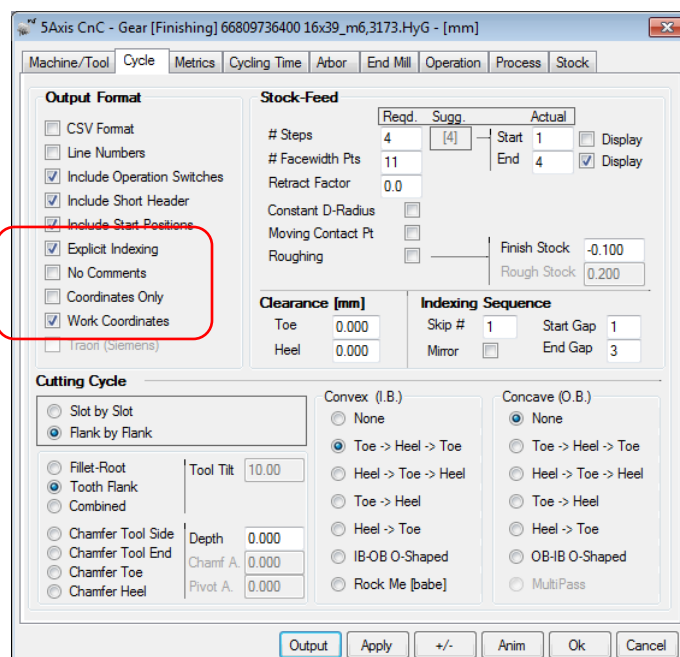
4) In 5Axis, Process tab, the "Available Operations" and "Process Content" lists have been widened to allow reading the complete names of the Operations they contain. Consequently, the arrows allowing the

addition/removal of Available Operations to Process content, and sequencing order of the Process Content, have been moved above the respective lists.



5) In 5Axis, the Part Program output can now be done with Explicit Indexing both in Machine and Work Coordinates (not applicable – yet – to Traori, TCPM, TCP or TCPC).

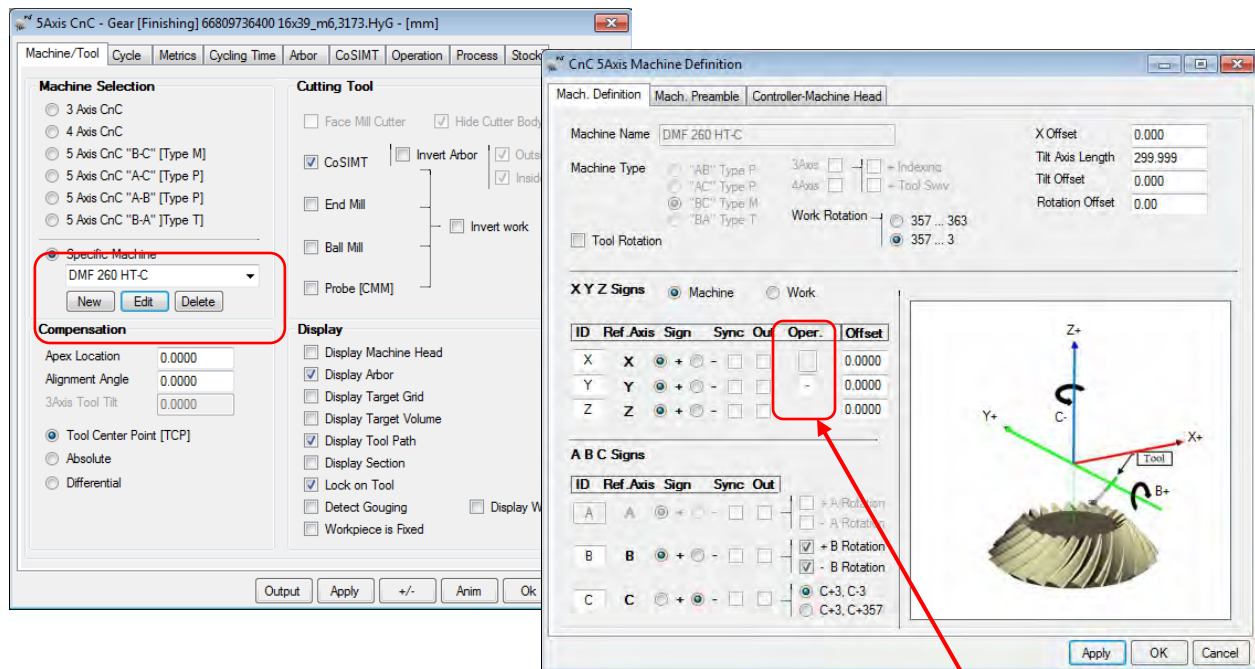
When either in Machine or Work Coordinates, if Explicit Indexing is selected, the Part Program lists a specific code sequence for each tooth gap in which the rotation angle of the work piece is indexed by the angular pitch while the X Y Z coordinates and A or B angle remain the same, depending if an AB, AC or BC type machine is selected.



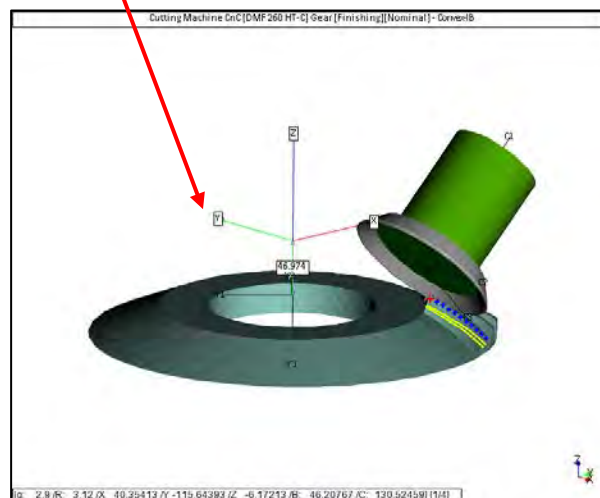
6) In 5Axis, for BC type machines, it is now possible to define where the Operator stands in reference to the Y direction of the machine, such that the cutting tool is always visible to the Operator. This applies only to CoSIMT and Coniflex Dish Type tools at this time. By default, the Operator's position is ignored.

The Operator's position along the Y axis is defined by clicking on the "Edit" button in the "Machine/Tool" tab to edit the current machine. The sign of the Y axis where the Operator is standing can then be given in the "Oper." field as:

- " ", i.e. ignore Operator's position
- "+", i.e. Operator on the Y+ side
- "-", i.e. Operator on the Y- side



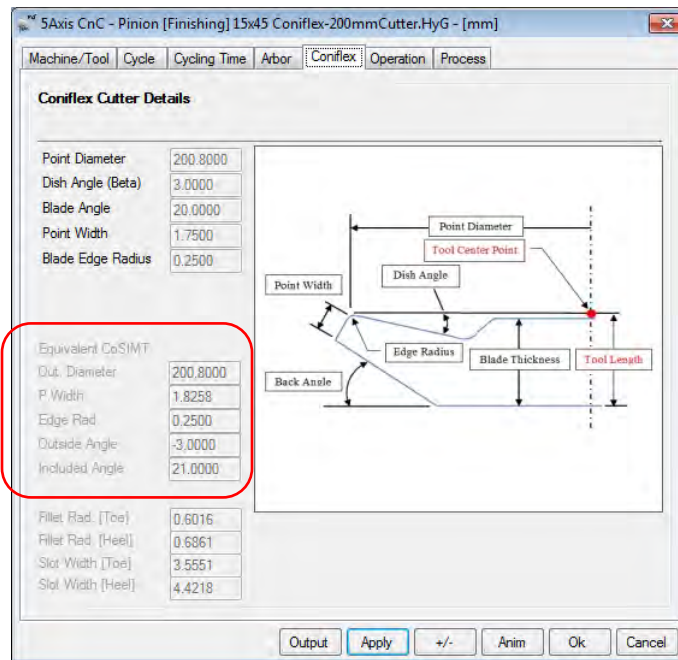
For example, with ref. to the above right figure where the Operator is defined as being on the Y- side, the CoSIMT tool is set on the machine side opposite Y+ such that it is always visible to the Operator.



7) In 5Axis, when a Dish Type cutter is selected for a Coniflex work piece, given that a Dish Type cutter is essentially a specialized CoSIMT tool, HyGEARS now calculates and displays the main dimensions of the equivalent CoSIMT tool.

For example, figure below, the equivalent main CoSIMT values are displayed; all the other values defining a CoSIMT are derived from these main values.

The key in using a CoSIMT instead of a Dish Type cutter is that the blades cutting the tooth profile, i.e. those on the Outside Angle of the CoSIMT, must be exactly aligned. A CoSIMT can then be used with all the inherent advantages linked to using replaceable inserts rather than having to grind a solid cutter as is usually the case for Dish Type cutters.



8) In 5Axis, in order to ease the determination of where the tool is between one Operation and the following, the Metrics tab now includes:

- The Step change: 1>2, 2>3, etc.
- The gap depth at which cutting starts: Starting Depth
- The gap depth at which cutting ends: Ending Depth
- The gap depth as cutting proceeds: Tot. Depth

Profile-Wise Steps					
Finishing Convex-IB	[Toe]	[mm]			
Step#	Slot Width	Step Depth	Tot. Depth	Flat Width	Flat-Prof.
[Tooth Tip Diameter]					
Starting Depth:		0.7174			
1>2	16.4593	0.7173	1.4348	0.8876	0.0030
2>3	15.3393	0.7173	2.1520	0.8755	0.0030
3>4	14.2616	0.7173	2.8693	0.8635	0.0030
4>5	13.2276	0.7173	3.5866	0.8514	0.0031
5>6	12.2385	0.7177	4.3043	0.8396	0.0031
6>7	11.2956	0.7179	5.0222	0.8276	0.0032

7>8	10.4009	0.7183	5.7406	0.8157	0.0033
8>9	9.5559	0.7190	6.4595	0.8039	0.0034
9>10	8.7629	0.7197	7.1792	0.7921	0.0035
10>11	8.0244	0.7207	7.8999	0.7805	0.0037
11>12	7.3436	0.7220	8.6218	0.7689	0.0040
12>13	6.7243	0.7236	9.3455	0.7574	0.0043
13>14	6.1721	0.7259	10.0713	0.7462	0.0048
14>15	5.6949	0.7290	10.8003	0.7352	0.0057
15>16	5.3063	0.7342	11.5345	0.7245	0.0074
Total :	10.8171				
Ending Depth :	11.5345				

9) In 5Axis, when cutting a Coniflex gear using a Dish Type cutter, HyGEARS now plunges the tool at the given Plunge rate until the tool is 1.5 times the Heel tooth depth away from the target starting point, and then changes the feed rate to Cutting. This way, Plunge rate can be increased to decrease cycle time without risk for the tool.

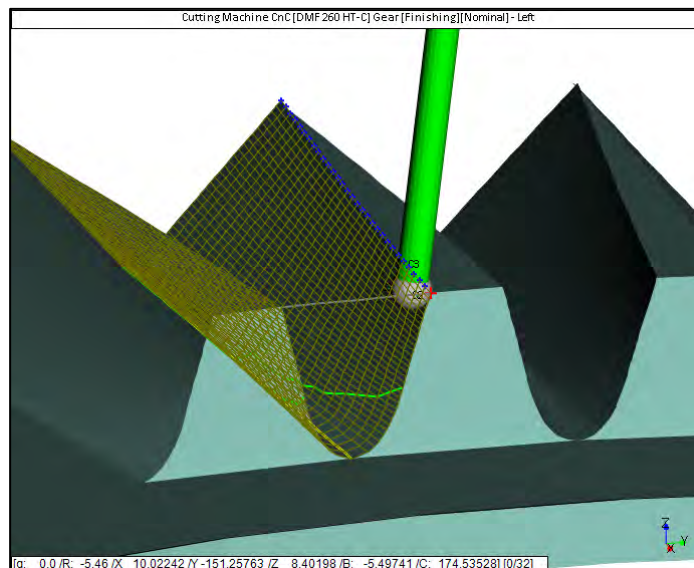
For example, figure below, the tool is retracted at the beginning of the cutting cycle; the Plunge Feed rate is imposed; the tool is plunged toward the target cutting point until it reaches a position 1.5 times the Heel tooth depth away from the target point, and then the Cutting Feed is imposed before plunging completes

```

( ----- Cutting Cycle ----- )
( ----- Left ----- )
O99901 ( Sub program to cut tooth space )
      ( Section 1 )
G01 X71.4449 Y-143.8731 Z16.4316 A-82.1074 C80.2727 (Retracted Tool - Roll: -16.28 Cradle: 0.00)
G04 X#565 (Dwell)
F#567 (Plunge Feed)
G01 X68.8955 Y-141.0761 Z16.2995 A-82.1074 C80.2727 (Plunging Tool - Roll: -16.28)
F#568 (Cutting Feed)
G01 X65.0713 Y-136.8804 Z16.1012 A-82.1074 C80.2727 (Roll: -16.28 Cradle: -11.72)
F#568 (Cutting Feed)
G01 X65.2690 Y-135.9055 Z18.4244 A-80.9591 C78.9604 (Roll: -13.90 Cradle: -10.01)

```

10) In 5Axis, when choosing the “Combined” cycle, the tooth is now separated in equal increments over the whole depth rather than aiming to have a coordinate at the point of transition between Flank and Fillet, which could result in unequal Step depths between Flank and Fillet. A much more constant tooth is thus obtained, with predictable Step depths over the whole depth. This is especially convenient for Face Gears.



11) When creating a New Geometry of any bevel gear type, HyGEARS now offers to define the tooth proportion factors in 2 modes, AGMA and ISO, as per the following relations:

ISO	AGMA
$x_{hm1} = k_d \left(\frac{1}{2} - c_{ham} \right)$	$c_{ham} = \frac{1}{2} \left(1 - \frac{x_{hm1}}{k_{hap}} \right)$
$k_{hap} = \frac{k_d}{2}$	$k_d = 2k_{hap}$
$k_{hfp} = k_d \left(k_c + \frac{1}{2} \right)$	$k_c = \frac{1}{2} \left(\frac{k_{hfp}}{k_{hap}} - 1 \right)$

where:

ISO	AGMA
x_{hm1} Gear profile shift coefficient	c_{ham} Gear mean addendum factor
k_{hap} Gear mean addendum factor	k_d Gear mean depth factor
k_{hfp} Gear mean dedendum factor	k_c Gear clearance factor

For spiral-bevel, Zerol and hypoid gears, k_d , the Gear mean depth factor, is normally around 4 and is divided by 2 in order to convert from AGMA to ISO; conversely, when converting from ISO to AGMA, for the same gears, the resulting k_d is multiplied by 2 to obtain the AGMA value. For straight, skewed and Coniflex bevel gears the k_d value is normally around 2, and is used as is.

In AGMA mode, which is the default when the New Geometry input window is displayed, the usual Depth and Addendum Factors for the gear are now complemented by the Clearance Factor, as shown in the above figure.

When clicking on the “ISO” mode option, the currently entered Depth, Addendum and Clearance factors are converted to their ISO equivalents, i.e. Addendum, Dedendum and Profile Shift factors. If any of the AGMA Depth, Addendum or Clearance factor is set to zero, HyGEARS will provide default values and then convert to ISO equivalents.

New Geometry Definition - [mm] [dd.mm.ss]

General Cutter Units

Names ...
 Geometry Name: Test-1-Spiral-Bevel
 Directory: C:\HYGEARS40Data\
 Geometry Source File: SpirBevl.lst

Types ...
 Geometry Type: Spiral-Bevel
 Material: AISI 4140
 Pinion Tooth Hand: Left
 Tooth Taper: Duplex

Misc ...
 Power [Kw] / Torque [N-m]: 5.40 / 85.90
 Pinion Speed (RPM): 600.00
 Number of Teeth [Pinion - Gear]: 9 / 31
 Module/Pitch Diameter: 10.718729 / 332.2810
 Gear Tooth Face Width: 0.000
 Shaft Angle: 90.00.00
 Addendum Factor: 0.970
 Dedendum Factor: 1.090
 Profile Shift Factor: 0.650

AGMA / ISO
☐ AGMA
☒ ISO

Import <<Back Next>> Cancel

When geometry creation proceeds, if the “ISO” mode option is selected, the entered Addendum, Dedendum and Profile Shift factors are converted to their AGMA equivalents and geometry creation proceeds as usual.

12) When creating a new Straight Bevel gear (New Geometry menu entry), HyGEARS now offers only the “Straight Bevel (Generated)” variant since the Blank Data on the Units tab offers all the necessary options to define a differential type gear such as the Front Crown to Crossing Point value (FC.Xp) and Zero Front Angle.

New Geometry Definition - [mm] [dd.mm.ss]

General Cutter Units

Names ...
 Geometry Name: Test-1-Straight Bevel (Generated)
 Directory: C:\HYGEARS40Data\
 Geometry Source File: StraBevlGen.lst

Types ...
 Geometry Type: Straight Bevel (Generated)
 Material: Straight Bevel (Generated)
 Pinion Tooth Hand: Zero
 Tooth Taper: Face Gear

Misc ...
 Power [Kw] / Torque [N-m]: 1000.00 / 1.455
 Pinion Speed (RPM): 16
 Number of Teeth [Pinion - Gear]: 11 / 16
 Module/Pitch Diameter: 5.080000 / 81.280
 Gear Tooth Face Width: 16.002
 Shaft Angle: 90.00.00
 Depth Factor (Gear): 2.0000
 Addendum Factor (Gear): 0.2100
 Clearance Factor: 0.1250

AGMA / ISO
☒ AGMA
☐ ISO

Import <<Back Next>> Cancel

New Geometry Definition - [mm] [dd.mm.ss]

General Cutter Units

Blank Data

	Pinion	Gear
Backlash		0.127
FC.Xp	0.000	0.000
Zero Front Angle		
Outside Diameter(Heel)	64.230	0.000
Face Angle	41.450	60.167
Root Angle	29.833	48.550
Dedendum Angle	0.000	0.000
Whole Depth	@Mid-F: 9.744	@Heel: 9.744
Bore Diameter	0.000	0.000
Min Bore to Root @ Toe	0.000	0.000

Clear

Units
 Linear Units: mm
 Angular Units: Deg.Min.Sec
 Cutter Units: In

Import <<Back Next>> Cancel

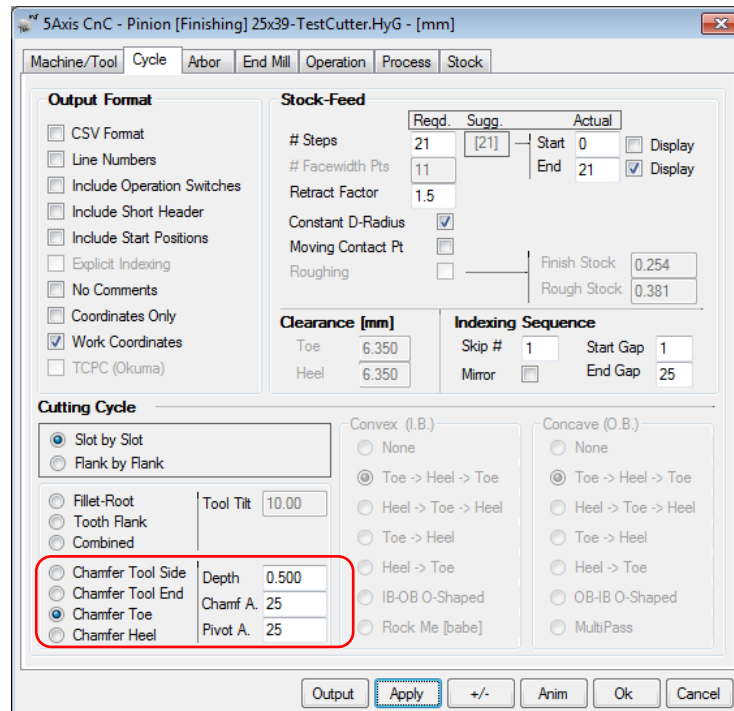
13) In the Graphic and Text Geometry Summary Pdf documents (“GSum” and “Summ” function buttons), both the AGMA and ISO tooth proportion factors are now listed in the General section, as shown in the following figure.

GENERAL DATA		PINION	GEAR
Number of Teeth	:	11	43
Hand of Spiral	:	LEFT	RIGHT
Speed Ratio	:	3.9091:1 [Speed Reducer]	
Diametral Pitch	:	5.0800	
Module	:	5.0000	
Mean Normal Module	:	3.7057	3.7057
Face Width	:	32.0000	32.0000
Angular Face	:		29.10.39
Outer Cone Distance	:	110.9617	110.9617
Mean Cone Distance	:	94.9617	94.9617
Ratio Involute/Cone Dist	:	1.05	
Shaft Angle	:	90.00.00	
Pitch Diameter	:	55.0004	214.9999
Outside Diameter	:	68.2179	216.0549
Tooth Taper	:	Standard	
AGMA Depth Factor	:	3.9900	3.9900
Addendum Factor	:	0.2283	0.2283
Clearance Factor	:	0.2500	0.2500
ISO Addendum Factor	:	0.9975	0.9975
Dedendum Factor	:	1.4963	1.4963
Profile Shift Factor	:	0.5420	-0.5420
Face Width * Cone Distance	:	28.8388	28.8388
Mounting Distance	:	112.0000	32.0000
Profile C.Ratio [Drive/Coast]	:	1.3637	1.2316
Actual C.Ratio	:	1.5334	1.5429
Face C.Ratio	:	2.1467	2.2245
Total C.Ratio	:	2.5432	2.5427

14) When creating a New non generated Hypoid gear set (i.e. Formate gear member), the Front and Back angles of the pinion now default to the pitch angle rather than 0 as was the case before.

HyGEARS update -22 November 2015 - Build 404.90 - 457

1) In 5Axis, addition of the Chamfer Toe and Chamfer Heel cycles. These cycles are available with both End Mill and Ball Mill tools. They are designed to remove material at the Toe and Heel ends of the teeth.



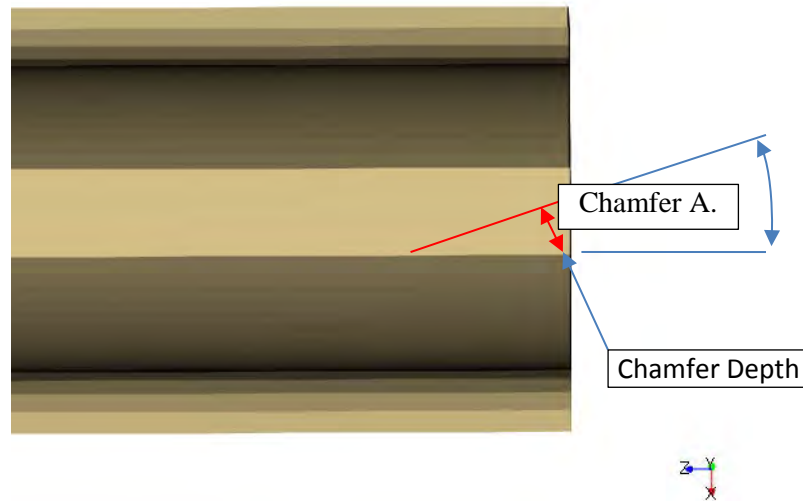
When either Chamfer Toe or Chamfer Heel is selected, switches and inputs such as Detect Gouging, Moving Contact Pt, Roughing, Finish Stock, Rough Stock, Toe and Heel Clearances, and any Toe->Heel->Toe cycle or else are ignored while the Indexing Sequence is honored.

The following selections are significant:

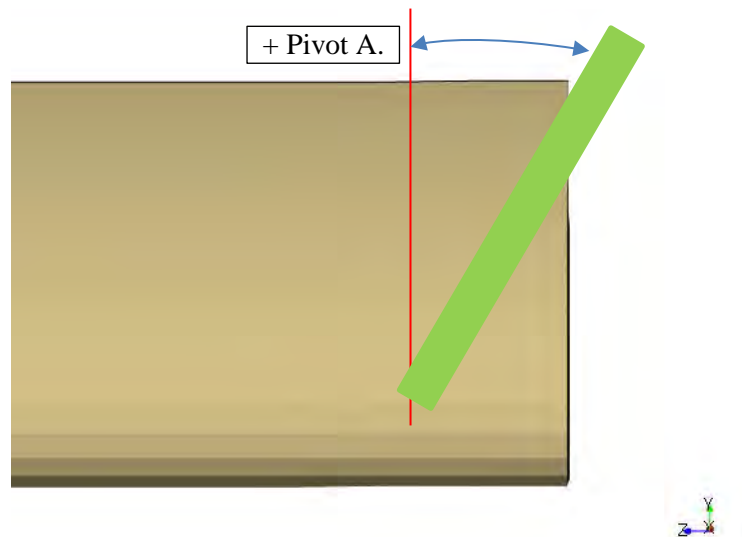
- **# Steps:** determines the number of depth-wise points along the tooth edge; the points are distributed 67% on the tooth Flank and 33% in the Fillet in order to provide a smooth motion;
- **Start:** should always be 0 (zero) such that chamfering begins at tip. Note: when the tool is plunged to start chamfering from tip, the tool moves at Plunge Feed from its retracted position until 1.5 times the End Mill radius or Ball Mill radius outside the 1st target point, i.e. tip; from then on, the tool starts moving at Cutting Feed; thus, if Start is different from zero, a collision between tool and tooth edge may occur;
- **End:** if equal to the # Steps, chamfering will move from tip to fillet of one flank, continue across the bottom on to the fillet on the opposite tooth flank and up to tip in one continuous motion; if "End" is different from the # Steps, chamfering will be piecewise, i.e. from Start to End on one flank, the tool will retract and then do the opposite tooth flank in the same way.
- **Clearance:** becomes inactive, and any value is ignored;
- **Retract Factor:** can be a small value of 1.25 to 1.5 to minimize time spent when switching from one tooth gap to the next.
- **Depth:** determines how deep the tool will cut into the tooth edge;
- **Chamf. A.:** chamfer angle, i.e. the angular deviation between the lengthwise direction of the tooth flank and the chamfer;

- **Pivot A.:** Pivot Angle, used to move the tool holder and machine head out of or into the tooth gap to provide a flat chamfer when using an End Mill. A positive Pivot Angle pivots the tool out of the tooth gap; a negative value pivots the tool into the tooth gap.

Top View



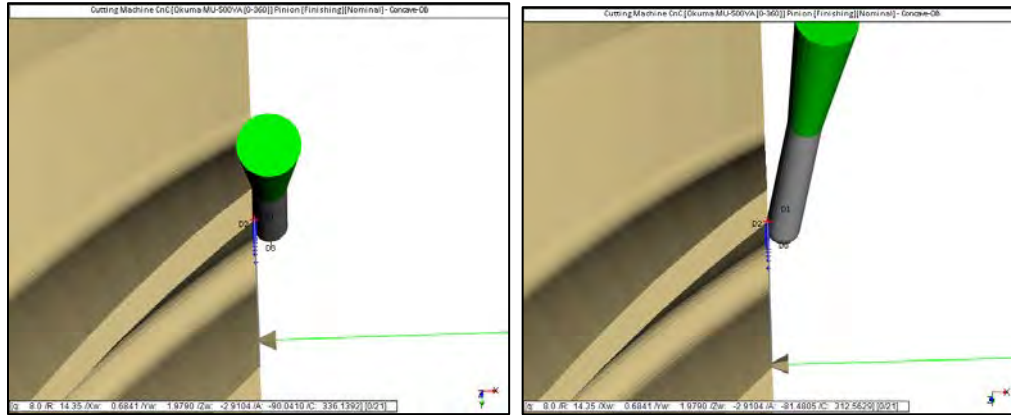
Side View



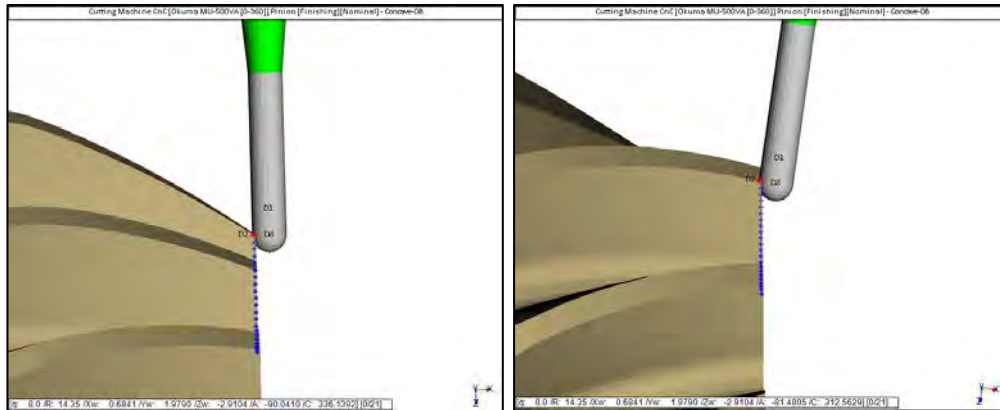
Different rules apply depending whether an End Mill or a Ball Mill tool is used.

End Mill: When an End Mill is selected for Toe or Heel Chamfering, the cylindrical part of the End Mill is used to chamfer the tooth flank section of the gap, and the spherical end is used to chamfer the fillet section. Thus, a discontinuity in the movement may occur when the tool moves from flank to fillet and vice-versa (this does not happen with the Ball Mill). "Pivot A." is an angular value that instructs HyGEARS to pivot the tool out of the gap (with a positive value), thereby cutting a flat chamfer; if the Pivot angle is zero, then the End Mill axis moves parallel to the tooth end and thus cuts a circular chamfer.

Top View



Side View

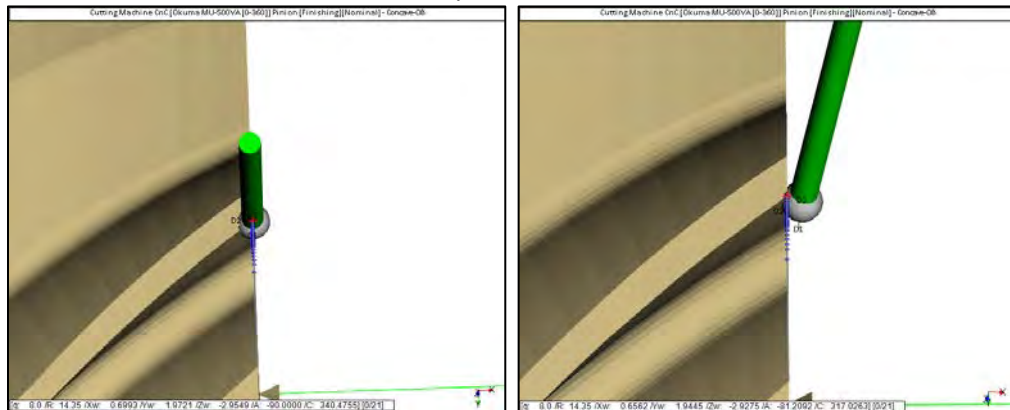


Pivot A.: 0.00

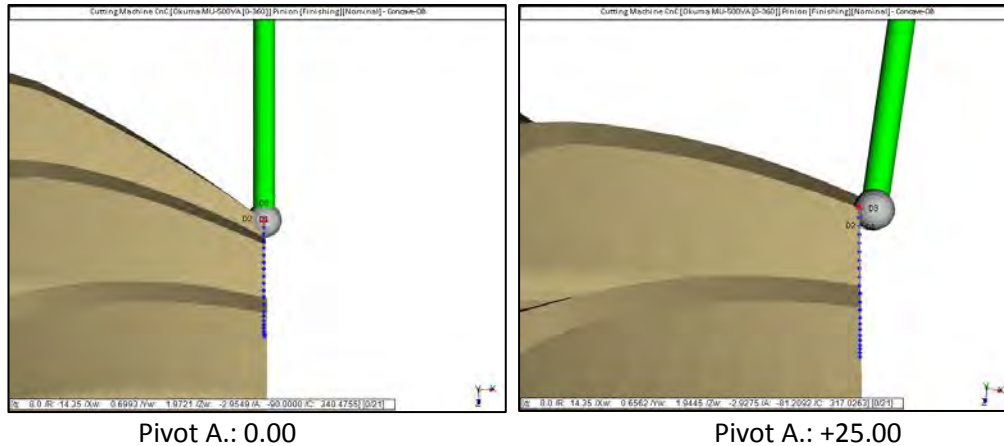
Pivot A.: +25.00

Ball Mill: When a Ball Mill is selected for Toe or Heel Chamfering, cutting always occurs in the lower part of the Ball Mill sphere. Thus, a continuous movement is obtained all along the tooth flank and fillet edge. The “Pivot A.” angle can be used, but is not necessary and will not change the shape of the chamfer.

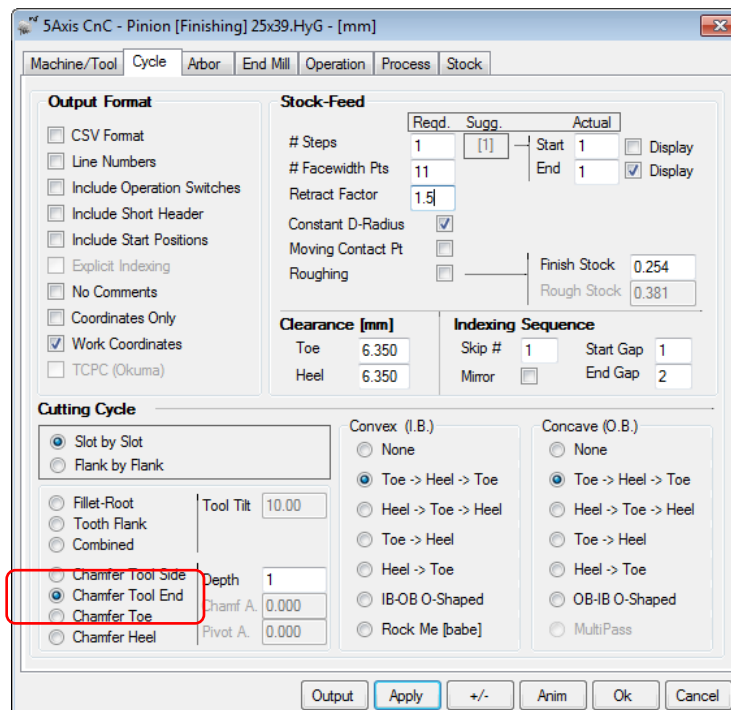
Top View



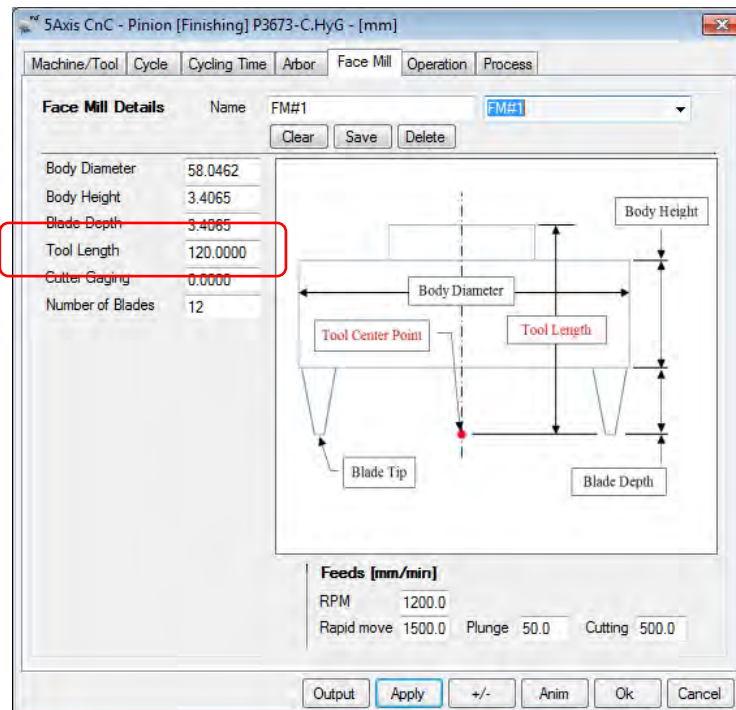
Side View



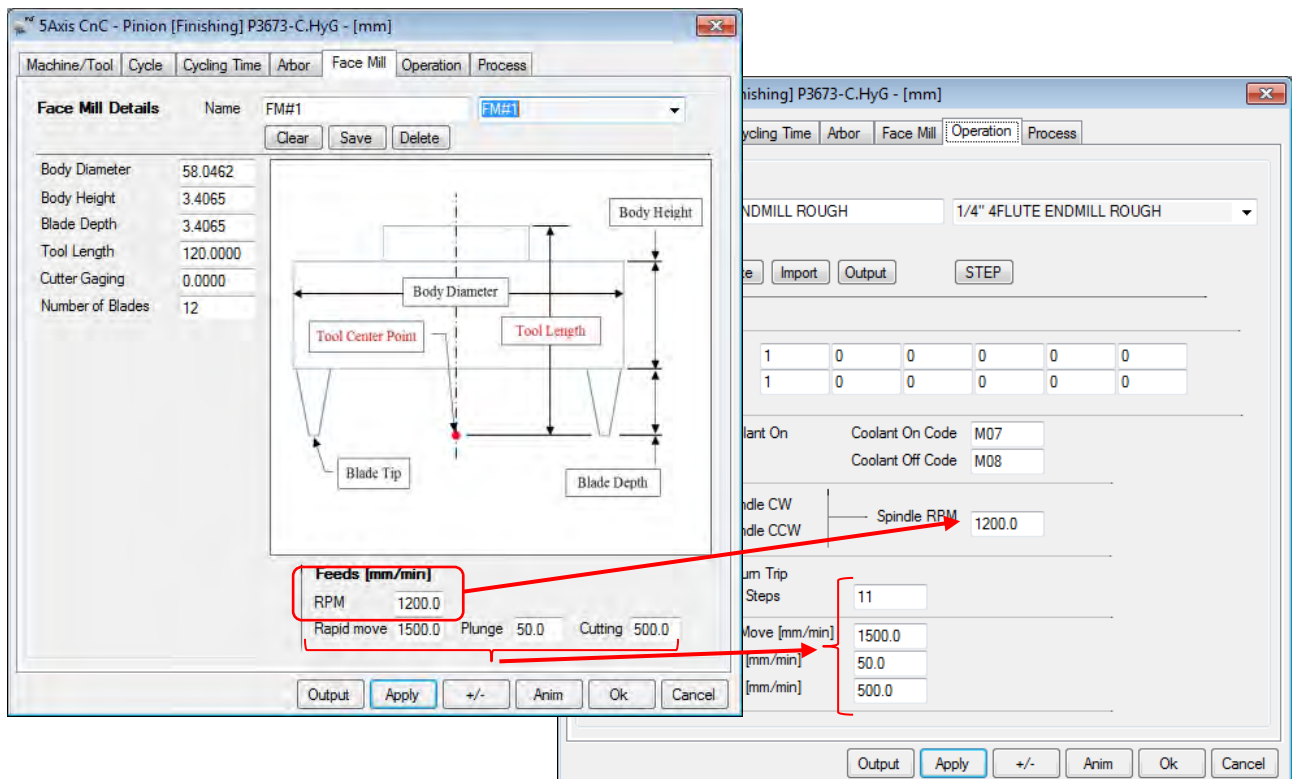
2) In 5Axis, addition of the “Chamfer Tool End” cycle for the Ball Mill tool which allows chamfering the tooth tip edges with a Ball Mill. The cycle works the same way as for the End Mill.



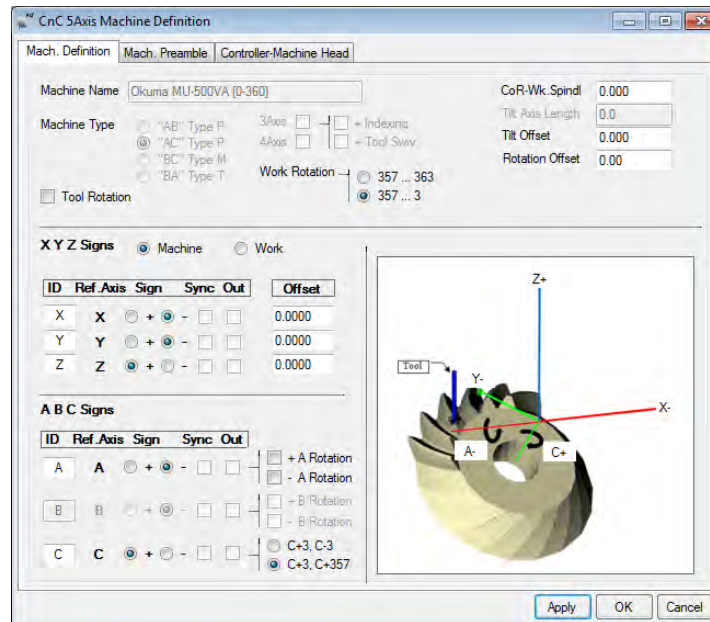
3) In 5Axis, the Face Mill tool now has a “Tool Length” entry to describe the tool more completely. This value may also be used by adding, in the Preamble, machine specific commands that use the Tool Length, for example to compensate for tool wear.



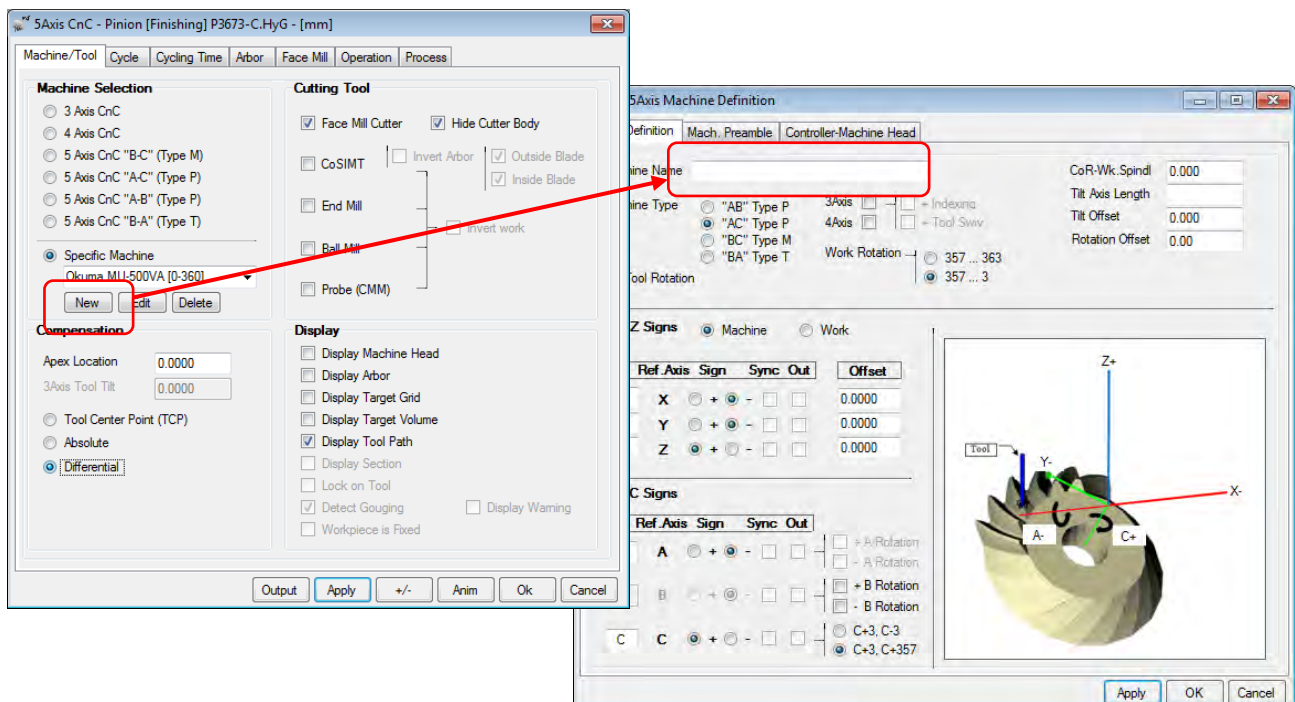
4) In 5Axis, for the CoSIMT, End Mill, Ball Mill and Face Mill tools, addition of the RPM value to the list of Feeds given at the bottom of the data page. The RPM entry allows users to enter and retain the RPM value recommended by the tool manufacturer. Whenever a tool is selected from the list of defined tools, its RPM, Rapid Move, Plunge and Cutting values are copied to the relevant fields in the Operation data page.



5) In 5Axis, HyGEARS now recognizes those CnC machines created by Involute Inc. and those created by the user. The machine “behavior values” of machines created by Involute Inc., i.e. those values in the “Mach. Definition” data page, figure below, can no longer be modified by users; for example, all the data related to axis names and signs is no longer user-modifiable in order to maintain machine consistency.



However, the user can select a specific machine, click on the “Apply”, and then click on the “New” button to clone the currently selected machine. Upon clicking on the “New” function button, the machine definition window is displayed along with the data relevant to the current machine; the machine must be named, and is then fully user-modifiable. **Note:** Users should notify Involute of the user-created machines in order to add these to the standard machine definitions distributed and installed with HyGEARS as the Machine.fil file is overwritten each time a new HyGEARS release is installed.



6) In 5Axis, controller-specific data is now moved to the “Controller-Machine Head” data page, as shown below. When the mouse is left hovering above one of the blue “?” symbols, a “tip” is displayed giving hints as how to use the entries.

CnC 5Axis Machine Definition

Mach. Definition | Mach. Preamble | **Controller-Machine Head**

Controller

Controller: Okuma | Linear Decimals: 4 | Angle Decimals: 4

External Subs: ☐ | Use CYCL 19: ☐

Pgm Start #: 1000 | Main Program Prefix: O | Sub Program Prefix: O | Main Pgm File Ext.: MIN | Sub Pgm File Ext.: SUB

Spindle CW: M3 | Spindle CCW: M4 | Coolant On Code: M08 | Coolant Off Code: M09 | Subroutine End: RTS | Program End: M2

Machine Head

Length	Diameter	Square
13.2080	32.5120	<input type="checkbox"/>
25.7175	62.8650	<input type="checkbox"/>
50.8000	220.2180	<input type="checkbox"/>
0.0000	0.0000	<input type="checkbox"/>
0.0000	0.0000	<input type="checkbox"/>

Clear

Apply | OK | Cancel

Controller-specific data is user-modifiable, and includes the following fields:

- **Controller:** GCodes, Heidenhain, Okuma, Siemens and Fanuc; selected from the list;
- **External Subs:** determines whether code to cut the tooth gap is in a separate subroutine file or in the main program; external files are not desirable as they increase the risk of losing or overwriting a file, but may be required for memory reasons;
- **Use CYCL 19:** specific to Heidenhain controllers; when used, excludes the use of CYCL 7.x;
- **Decimals:** determines the number of decimal places for the linear and angular values;
- **Pgm Start #:** program names are made of a Prefix and a number; for example “O600”; the “Pgm Start #” determines the number appearing in the program name after the Prefix, i.e. “1000” in the above figure;
- **Pgm Start/End Char:** some controllers such as Heidenhain require delimiters to enclose the Program name such as “<” and “>”; the program name thus becomes “<O1000>” rather than “O1000” for other controllers; empty by default;
- **Main/Sub Pgm Prefix:** character chain at the beginning of the main or sub program name; for example “O”; can be more than one character, for example “MAIN” or “SUB”;
- **Main/Sub Pgm F. Ext.:** default extension of the main or sub program file; for Siemens, “MPF” and “SPF” are defaults; for Okuma, “MIN” and “SUB” are defaults; for other controllers, CNC is the current default;
- **Spindle CW/CCW:** character chain used to control the direction of spindle rotation; M3 and M4 are the defaults;
- **Subroutine End:** character chain used to signify the end of a subroutine and return to the calling program; M99 is the default;
- **Coolant On/Off Code:** code to be used to switch coolant On/Off; default are M07 and M08;
- **Program End:** character chain used to signify the end of a program; M30 is the default.

7) In 5Axis, addition of the “ID #” and “Internal Subroutine” fields to the Operation data page.

The “ID #” field determines the number identifying the program name associated to an Operation; for example, “OA1000” would be the name of the program created by the Operation shown in the figure below. The default value for the “ID #” is that of the “Pgm Start #” defined in the controller section of the machine (see 6) above).

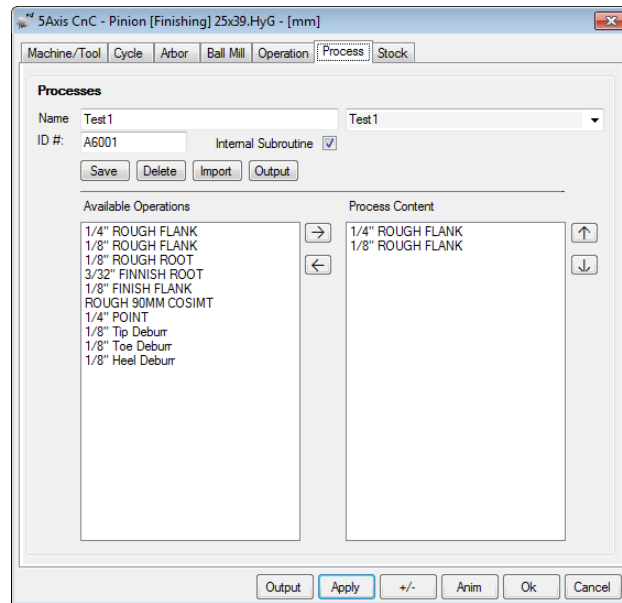
The “ID #” field is alphanumeric, which means that letters and numbers can be used.

When saved, the part program file name will default to the “ID #”, plus the file extension specified in the Controller section of the machine definition (for example, “A1000.CNC “if the file extension is CNC);.

The “Internal Subroutine” field, when checked, instructs HyGEARS to include all code in one single file, which is a lot easier to handle than separate files.

When the “Internal Subroutine” is unchecked, the header and logic will be in one file, and the cutting cycle specific code will be in a separate file. This can be necessary when controllers have limited memory. The default file name for the header and logic is the “ID #” plus the file extension specified in the Controller section of the machine definition (for example, “A1000.CNC “if the file extension is CNC); for the cutting cycle specific code, the default file name will be the “ID #” field, plus “1” for the 1st cutting cycle code section, “2” for the 2nd cutting cycle code section, etc., plus the file extension specified in the Controller section of the machine definition (for example, “A10001.CNC” if the file extension is CNC).

8) In 5Axis, addition of the Process data page. A Process is an ordered sequence of Operations in which a Main, or Calling, program is generated which calls the selected Operations in the requested order. For example, right column in the figure below, the Main program would call Operation “1/4” ROUGH FLANK” first, and then Operation “1/8” ROUGH FLANK”.



Processes are geometry specific, i.e. they are saved in the “Processes.fil” file which is stored in the folder where the HyG geometry file is saved.

A Process includes the following fields and buttons:

- **Name:** the name given to a Process; max. is 50 characters;
- **ID #:** determines the alphanumeric character string from which the Process will be numbered, and how the Operations called from the Main program are numbered; the default value for the “ID #” is that of the “Pgm Start #” defined in the controller section of the machine (see 5) above).

The Process name is based on the ID #; all Operations in the sequence increase by 3; since there can be up to 2 sections in each Operation, Section #1 = Operation + 1; Section #2 = Operation + 2. Sections in an Operation can be internal or external files as well.

Thus, for a Process “ID #” = A6001, as in the above figure, assuming the Main and Sub program Prefix is “O”, we would have the following names for each program in the Process:









Main:	“OA6001”	
Operation 1:	“OA60011”	(i.e. Main + “1”)
Section 1:	“OA60012”	(i.e. Main + “2”)
Section 2:	“OA60013”	(i.e. Main + “3”)
Operation 2:	“OA60014”	(i.e. Main + “4”)
Section 1:	“OA60015”	(i.e. Main + “5”)
Section 2:	“OA60016”	(i.e. Main + “6”)
...		

- **Internal Subroutine:** instructs HyGEARS to include all code in one single file, which is a lot easier to handle than separate files.

When the “Internal Subroutine” is unchecked, the main header will be in the Main or calling file, from which individual Operations are called; Operations

are stored in separate file, contain the logic and call the cutting cycle specific code, also in separate files, as is shown above.

Again this can be necessary when controllers have limited memory. The default name for the Main or calling program is the "ID #" plus the file extension specified in the Controller section of the machine definition (for example, "A6001.CNC" if the file extension is CNC); for the Operations, the file names would be "A60011.CNC" for the 1st Operation, "A60014.CNC" for the 2nd Operation, etc.; for the cutting cycle specific code, the file names would be the Operation file name plus "1" for the 1st cutting cycle code section, "2" for the 2nd cutting cycle code section, etc., plus the file extension specified in the Controller section of the machine definition (for example, "A60012.CNC", "A60013.CNC", etc. if the file extension is CNC).

-  saves the currently defined Process under the name given; if the Process already exists, a warning is given to confirm replacing the existing Process;
-  deletes the currently selected Process; a warning is given to confirm deleting the selected Process;
-  to import Processes from another HyG geometry folder; when Import is clicked, a Windows Explorer window is displayed to navigate to the folder of the "Processes.fil" file from which processes are to be imported. No verification is made whether the operations contained in the imported processes exist or not in the current geometry folder;
-  outputs the selected Process; see below for details;
- Available Operations: lists the currently defined Operations for the current geometry;
- Process Content: lists the currently selected Operations for the current Process; the Operations are listed in the order they will be executed;
-  adds the currently selected "Available Operation" at the end of the "Process Content"; an Operation cannot appear more than once;
-  removes the currently selected Operation from the "Process Content";
-  moves Up one step the currently selected Operation in the "Process Content";
-  moves Down one step the currently selected Operation in the "Process Content"

Output behavior:

- when the Output button is clicked, the selected Operations are posted in the given order into the 5Axis window, their specifics are read and a sub-program for each of the selected Operation is created and displayed on screen for review;
- if the "Internal Subroutine" is unchecked, each Operation in the sequence is given a file name based on the name of the Operation and the sub-program file extension defined in the controller section of the machine; for example "OA60011.SUB", or "OA60011.CNC"; thus when saving the Operation, a default name is proposed;
- the Operations of a Process are identical to stand alone Operations, except for the following points:
 - the End Program command, normally "M30", is replaced by the End Subroutine command, normally "M99", which returns control to the Main program;

- the Program Trailer is given at the end of the Main program rather than in the sub-program;
- the Main or calling program is then displayed on screen for review, and the Process sequence ends; if the Main program is acceptable to the user, it can be saved to disk; a default name is proposed, for example "OA6001.MIN";
- The Main or calling program contains:
 - the Short Header, if selected;
 - the geometry definition: units, cutter and machine settings, if Comments are not Off;
 - work piece dimensions if Comments are not Off;
 - the calling sequence of Operations;
 - the Trailer;
 - the End Program command, as illustrated in *italics* below:

```

OA6001                                     ( Start Process OA6001 )

( Date / Time       : 11/17/2015 / 1:43:59 PM )
( General Units     : [mm] [D.dec] )
( Cutter Units      : [in] )
( Prepared by       : Claude Gosselin )
( Version           : 4.0.404.80-457 )

( PINION [FINISHING] )
( CUTTER SPECIFICATIONS [O.B.] [I.B.] )
( _____ )

( Point Diameter      : 9.0600 8.9400 )
( Blade Angle         : 17.5000 22.5000 )
( Blade Edge Radius   : 0.0470 0.0470 )
( Point Width         : 0.0000 0.0000 )
...

( PINION [FINISHING] :Fixed Setting )
( MACHINE SETTINGS - #175-F [O.B.] [I.B.] )
( _____ )

( Radial Distance      : 100.8863 101.1377 )
( Cutter Tilt          : 1.8797 2.4201 )
( Swivel Angle         : 214.5055 213.8803 )
( Blank Offset         : 1.1110 -2.0257 )
...

( WORKPIECE DIMENSIONS )
( _____ )
( # Teeth              : 25 )
( Module               : 5.080 )
( Face Angle           : 35.799 )
...

CALL OA60011                               ( Calling Operation "1/4" ROUGH FLANK" )

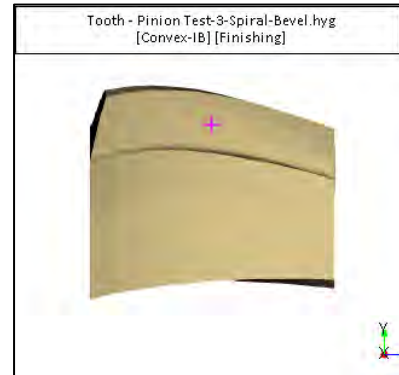
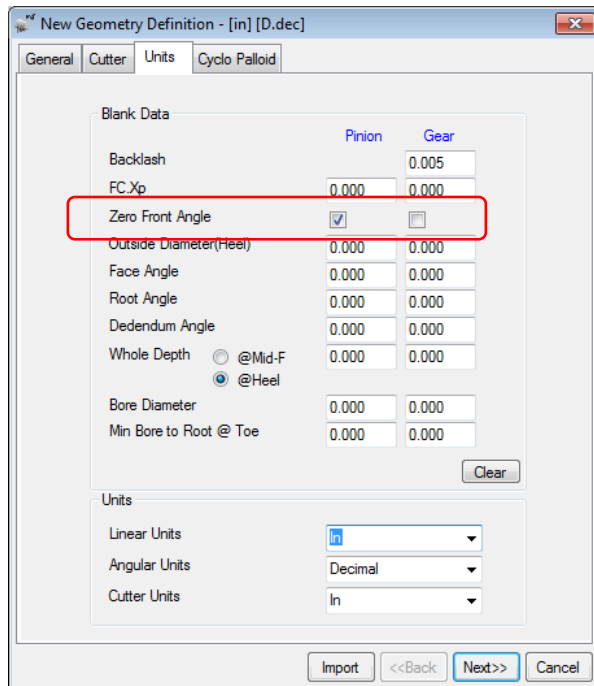
CALL OA60014                               ( Calling Operation "1/8" ROUGH FLANK" )

( ----- Start Trailer ----- )
G30P11                                     ( ----- End Trailer ----- )

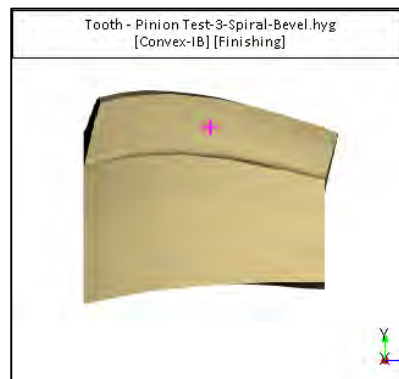
( ----- End of Program ----- )
M2                                         ( End Process OA6001 )
END                                         ( End Program )

```

9) When creating a New Geometry (Zero, Spiral-Bevel, Hypoid, Coniflex, Straight-Bevel), it is now possible to instruct HyGEARS that the Front Face of the blank is flat, i.e. the Front Angle = 0, by checking the corresponding option, as shown below for the Pinion.



Zero Front Angle



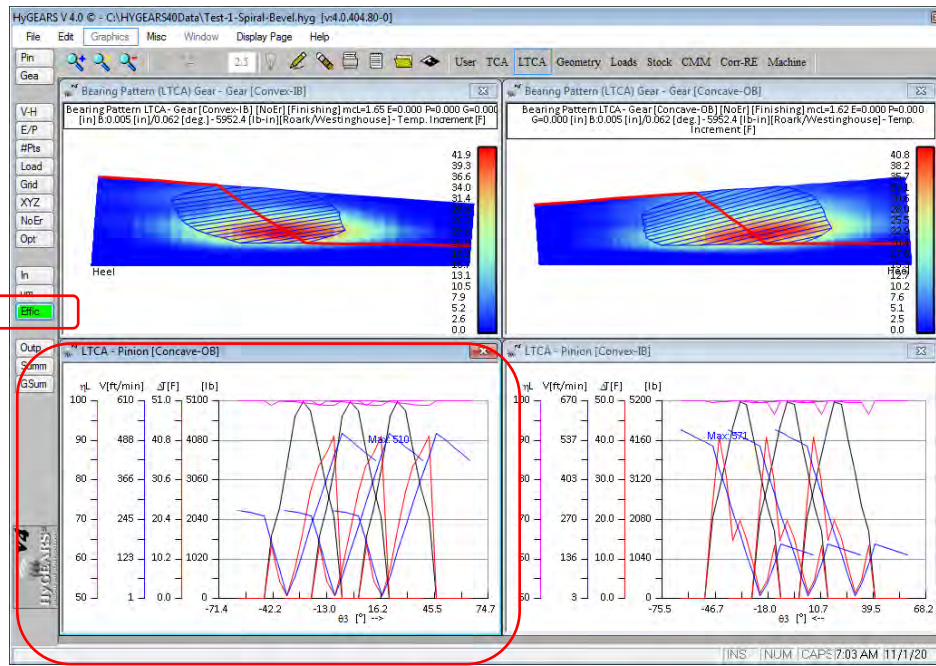
Normal Front Angle

10) In 5Axis, whenever the Stock is changed and the “Apply” button is clicked, the Slot Width [Toe] and Slot Width [Heel] are recalculated and redisplayed for all tools (Coniflex dish type, CoSIMT, End Mill, Ball Mill, Probe).

11) HyGEARS now retains where the Parent window was located, and its size, when HyGEARS is exited such that at the next use, it will be located where it was left.

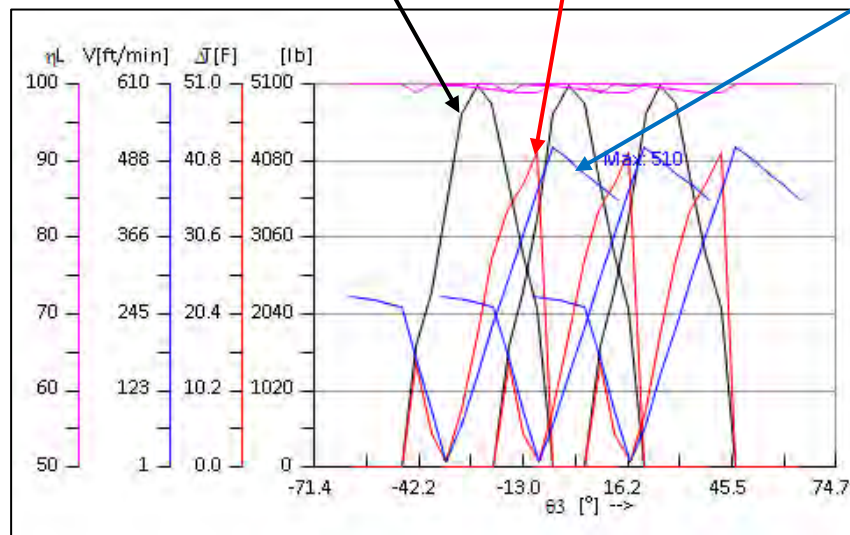
12) In Corr-RE, the correction # identifier is now changed from “[2/2]”, where “[2” means 2nd machine settings Summary and “/2]” means out of 2 (1 being Nominal), to [Nominal], [Corr #1], [Corr #2], etc. Yeah – this certainly is a lot easier to understand !

13) In the LTCA Mode display, 2D Graphs at the bottom of the Parent window, when the “Str-C” button is clicked twice until it becomes “Effic”, the display now adds the curve for the Temperature Rise, or ΔT [°F, °C], caused by sliding across the contact area.

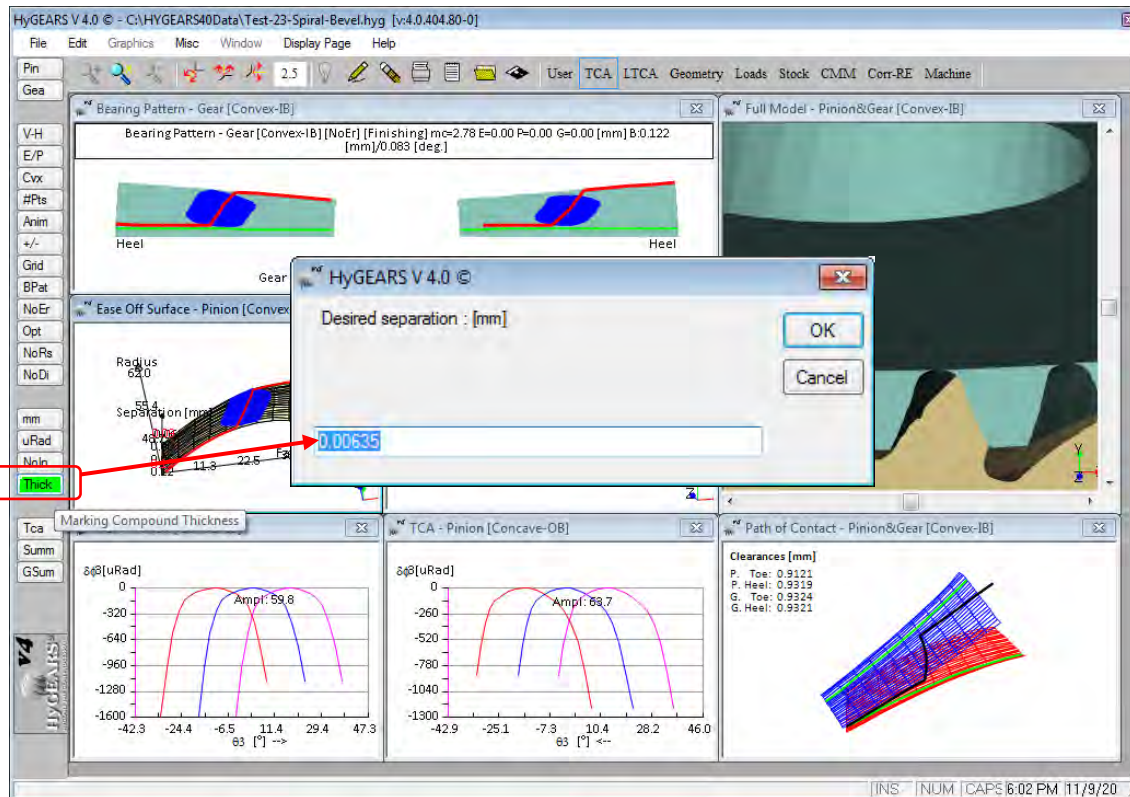


The ΔT curve appears in red, figure below, and gives a relative indication as to how hot a gear mesh is likely to run. ΔT is influenced by the applied load, coefficient of friction, and pinion RPM which dictate sliding and the speed at which contact moves across the tooth.

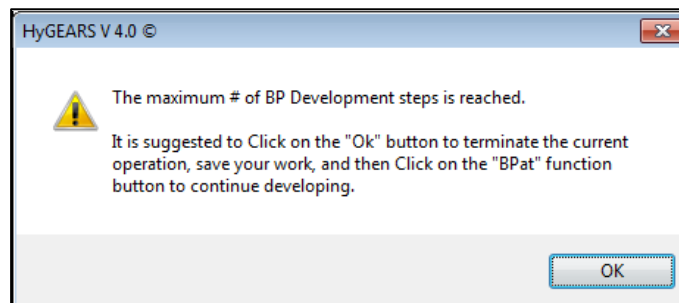
For example, figure below, a spiral-bevel gear set is considered; ΔT [°F] peaks near pinion tip where sliding V [ft/min] is at a maximum, even though the applied load ([lb] is no longer at its maximum value.



14) In the TCA Mode display, addition of the “Thick” function button. This function button is used to modify the default tooth separation value (0.00025”, 0.00635 mm) used to calculate the extent of the Bearing Pattern.

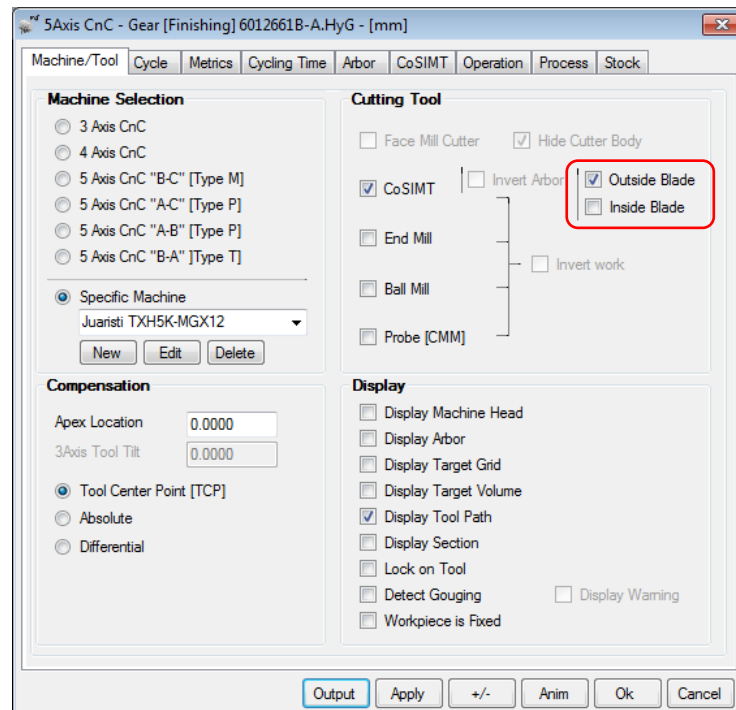


15) In the TCA Mode display, when developing a gear set through the “BPat” function button, the number of allowed steps (accessed through the “Next>>” and “<<Back” buttons) is extended from 10 to 20. When the maximum number of steps is reached, a warning message is displayed to inform the user that there is no more memory available to continue BP development.



The user should then exit the current “BPat” session by clicking on the “Ok” button, save the geometry and, if desired, continue BP development with the “BPat” function.

16) In 5Axis, when a CoSIMT is defined to work on only one of its faces (available only for cylindrical and straight bevel gears), as shown below where the Outside Blade is selected, but not the Inside Blade, HyGEARS now supports separate cutting cycles for the “Rock me (babe)” cycle; thus, all flanks on one side will be cut, the tool will be withdrawn to clear the work piece, the tool will shift to the opposite side of the work piece, and will then proceed to cut all the tooth flanks.

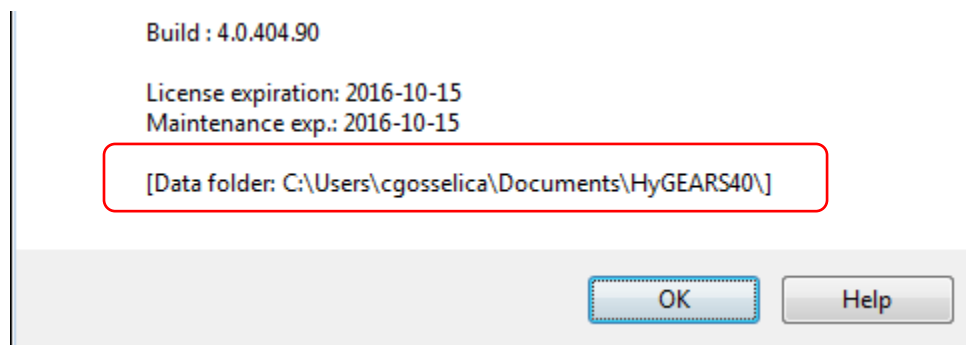


17) In the CnC part programs generated by HyGEARS, addition of 1 variable which tracks the current tooth gap being cut, such that the operator can monitor this variable on the controller screen and thus know how much work is left to do in the current Operation.

The name of the variable changes with the controller, as follows:

- Siemens: RESTART_TEETH
- Okuma: NUMT
- Heindehain: Q1607
- Fanuc: #563

18) When clicking on the “Help -> About HyGEARS” entry in the menu bar of the Parent window, the “Data folder” is now displayed to inform the user where the HyGEARS support files such as configuration file, tool boxes and machine definition, are stored.



19) When creating a New Cyclo-Palloid Geometry, HyGEARS now disables all the input fields which are not considered for the design of Cyclo-Palloid gears, in order to alert the user that some input values are not needed.

For example, figures below, when creating a New Cyclo-Palloid gear set, the following values are disabled since they are not needed:

General Tab:

- Module or Diametral Pitch
- Depth Factor
- Addendum Factor

Cutter Tab:

- Pinion Cutter Diameter
- Blade Angles
- Profile Curvature (of the cutter blade)
- Blade Edge Rad.
- Point Width

20) When developing a Cyclo-Palloid gear set (“BPAT” function button), the “Crowning” fields have been replaced by the “Diff. in Radius / Convex” and “Diff. in Radius / Concave” fields, traditional values in Klingelnberg designs which are easier to relate to changes occurring in the Contact Pattern.

The “Diff. in Radius” value is the difference in pinion and gear cutter radius, in the pitch plane, for the given flank, i.e. Pinion Convex + Gear Concave, Pinion Concave + Gear Convex. A larger “Diff. in Radius” value results in smaller bias of the PoC but larger TE; conversely, a smaller “Diff. in Radius” value results in more bias in the PoC, but less TE.

B.Pattern Development - Gear Convex-IB

BP Definition: D-MSett [mm] LTCA E/P Prop. Links

Mean Point / Convex-IB: Horizontal Position 50.4 % Vertical Position 50.0 %

Mean Point / Concave-OB: Horizontal Position 49.8 % Vertical Position 50.0 %

Diff. in Radius / Convex-IB: ☐ Free ☒ Fixed 1 [mm]

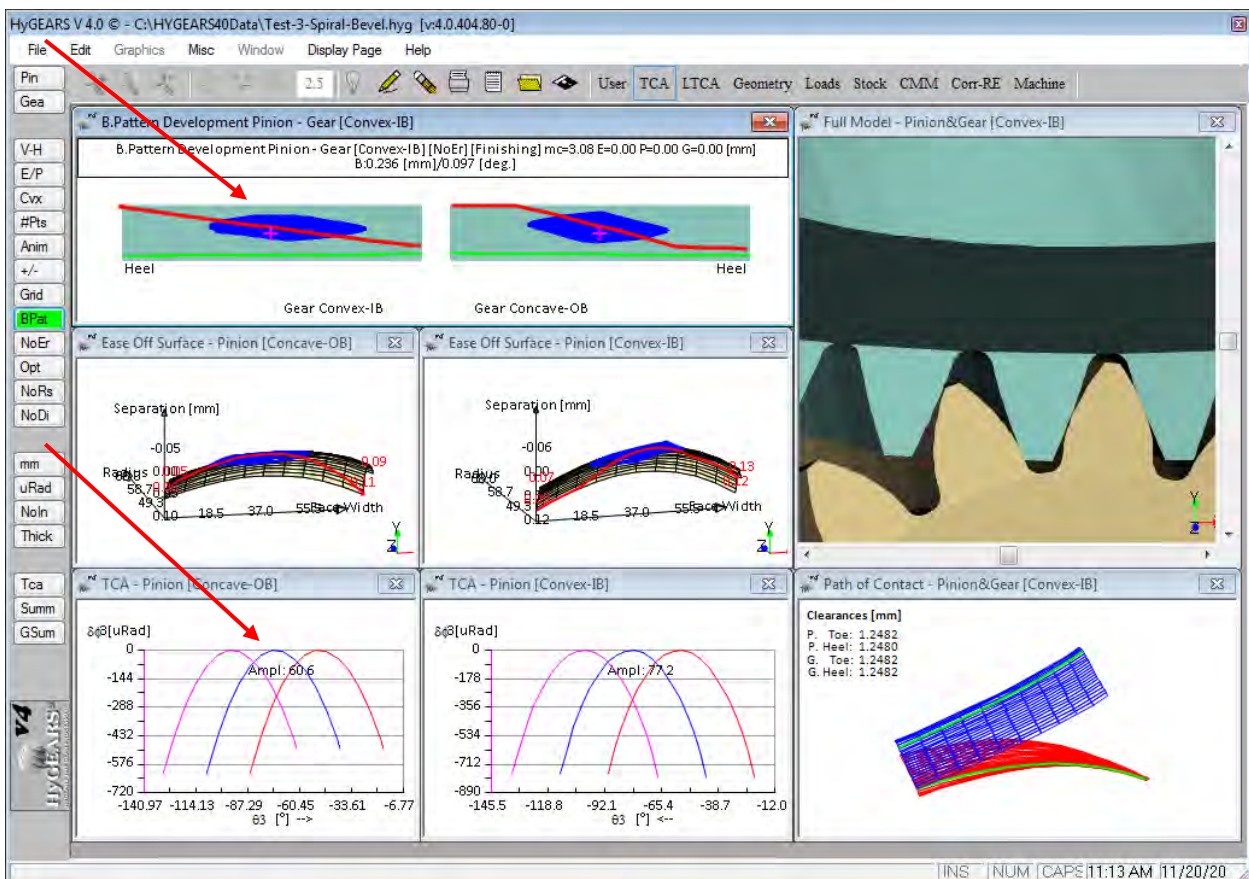
Diff. in Radius / Concave-OB: ☐ Free ☒ Fixed 1.5015 [mm]

Profile Crowning / Pinion: ☒ Free ☐ Fixed 0.0215 [mm]

Profile Crowning / Gear: ☒ Free ☐ Fixed 0.0215 [mm]

Backlash: ☐ Free ☒ Fixed 0.244 [mm]

Apply <<Back Next>> Reset Print OK Cancel

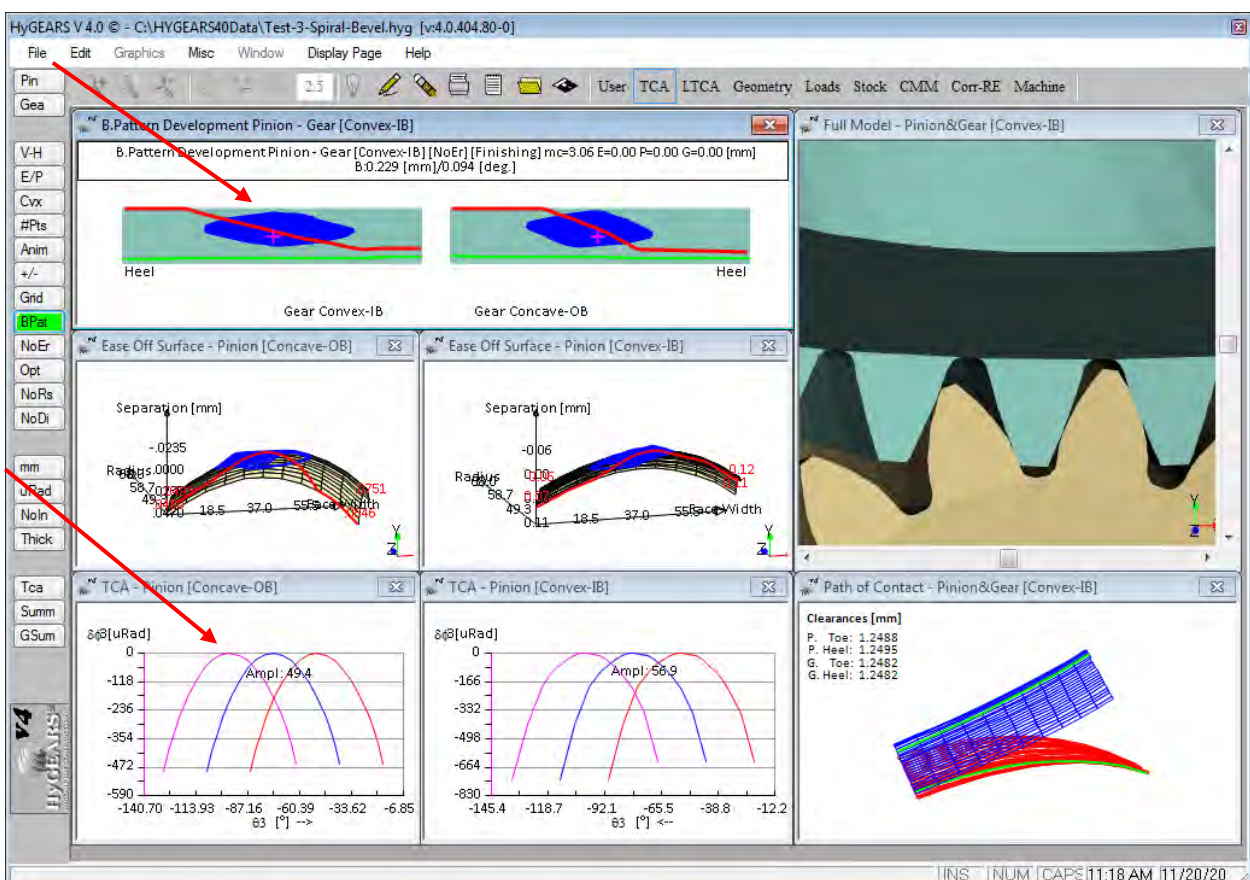
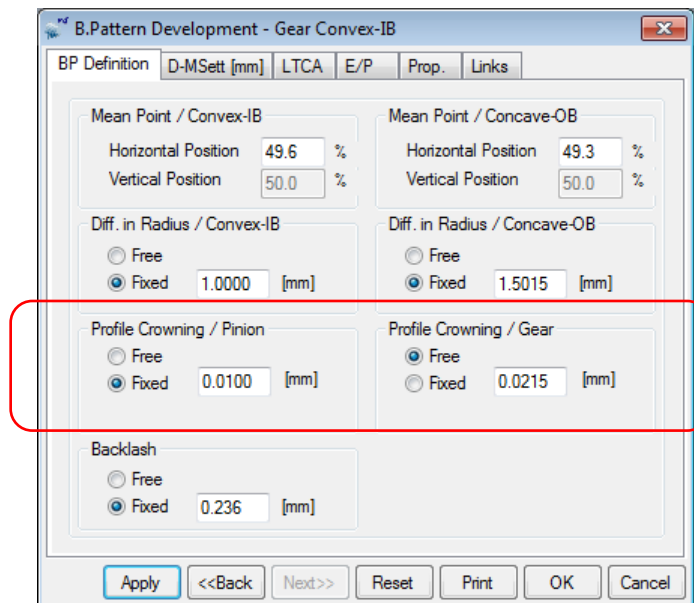


For example, figures above, on the gear Concave flank “Diff. in Radius” = 1.50 [mm], and “Diff. in Radius” = 1.0 [mm] on the gear Convex flank. TE is ~ 77 uRad on the gear Concave flank and ~ 60 uRad on the gear Convex flank; the PoC is seen to be much more biased on the Convex flank when compared to the Concave flank.

The “Profile Crowning” entry is used to modify the radius of the circular edge on the cutter blade. Decreasing the “Profile Crowning” decreases the curvature, which increases the size of the bearing pattern depthwise, meaning less TE.

For example, figures below, Pinion "Profile Crowning" is changed from 0.0215 [mm] to 0.0100 [mm] in reference to the results displayed above.


The contact pattern is seen to shorten along the facewidth, bias of the PoC decreases, and the contact pattern becomes much fatter depthwise because of the decreased TE; TE changes from ~ 60 uRad to ~ 49 uRad on the Pinion Concave flank, and from ~ 77 uRad to ~ 58 uRad on the Pinion Convex flank.

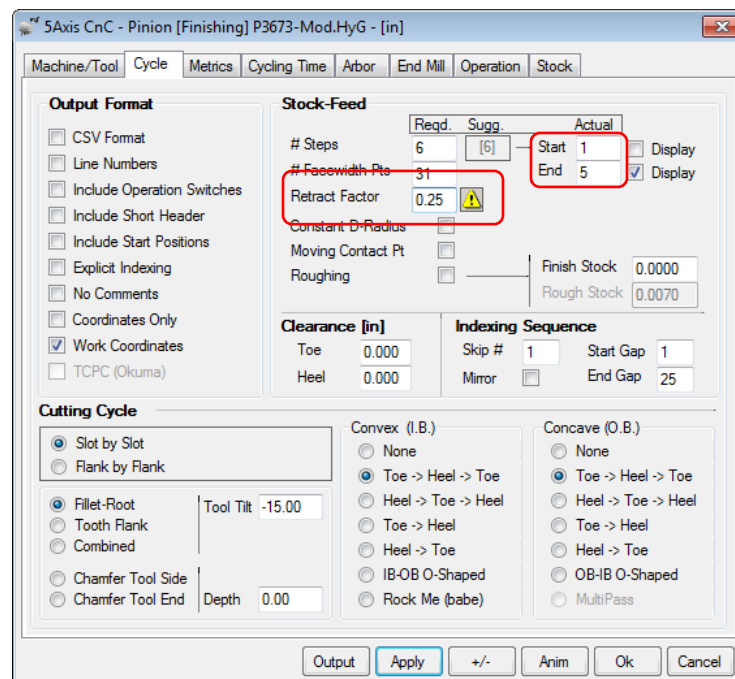



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1) In 5Axis, the criterion to determine whether Gouging is occurring in the Fillet area has been expanded to better follow the fillet geometry as in some spiral bevel geometry cases, Gouging would be detected that was not present in practice.

2) In 5Axis, the minimum Retract Factor is now set to 0.01 rather than 1. Entering a Retract Factor value of, say 0.01, effectively transforms *Radial* tool retract into *Axial* tool retract as long as the Toe and Heel clearances are sufficient. Since the workpiece rotates when inverting motion from Toe->Heel or vice versa, the tool must be *completely outside the workpiece* to avoid collision when the workpiece rotates.

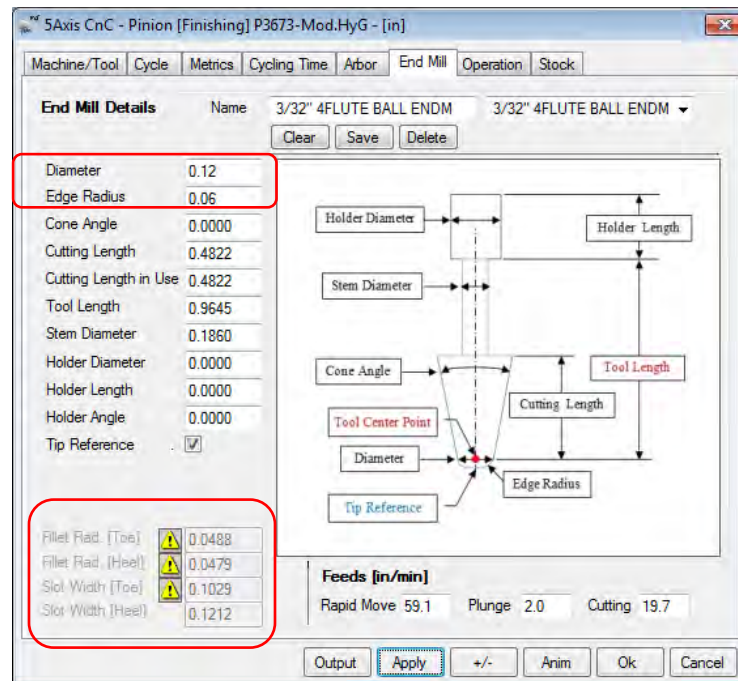
Warning: Using a nearly zero Retract factor, say 0.01, implies that the tool entry and exit into the gap are at the same end of the tooth in order to avoid the Return trip across the facewidth. If the tool enters at Toe and exits at Heel, while using a Retract factor less than 2, tool to work collision is likely to happen. A  is then displayed besides the Retract Factor input field to alert the user.




3) In 5Axis, when using a CoSIMT, End Mill, Ball Mill or Dish type (Coniflex) cutter, if the Slot Width at Toe or Heel is less than the End Mill or Ball Mill diameter, or less than the CoSIMT or Dish type cutter Point Width, HyGEARS displays the considered tool data page with  Exclamation marks identifying the offending value(s) such as to draw user attention that one or more values may cause mutilation on the opposite tooth flank.

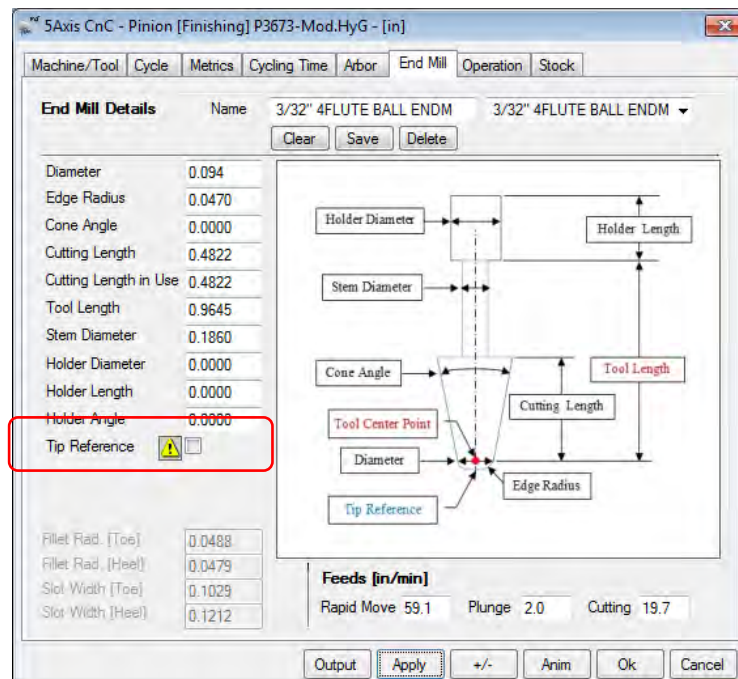
For example, figure below, the End Mill diameter is larger than the Slot Width [Toe]; likewise, the Edge Radius is larger than Fillet Rad. [Toe] and [Heel]; hence, the  is displayed to alert the user.

This is done only once per session. A session begins from the moment the “5Axis” function button is clicked. Thus, each time the 5Axis window is opened, if any cutting tool value is offending, the tool data page is displayed.

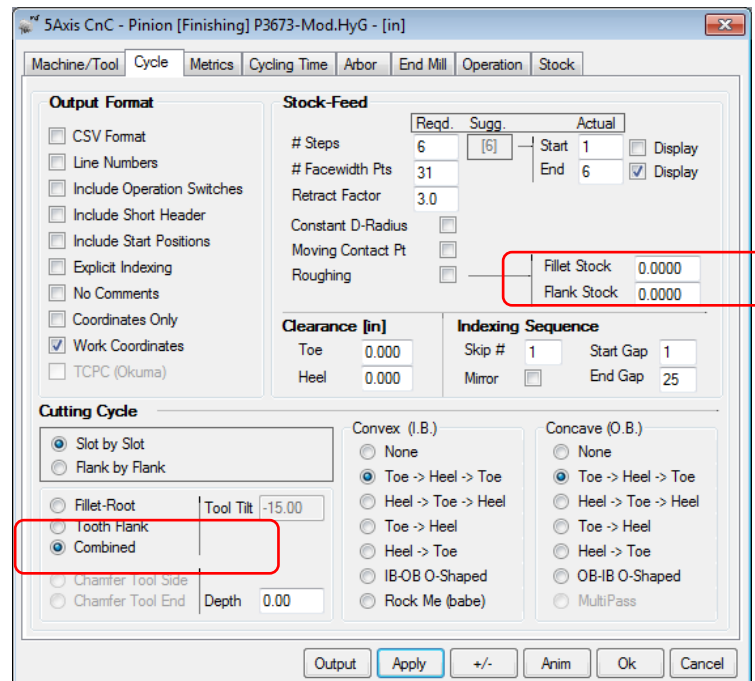


4) In 5Axis, when using an End Mill or Ball Mill tool, if the “Tip Reference” option is not checked, HyGEARS displays the considered tool data page with a  mark besides the “Tip Reference” option such as to alert the user that the tool length must be given at TCP, or Tool Center Point, on the machine, unless “Tip Reference” is selected.

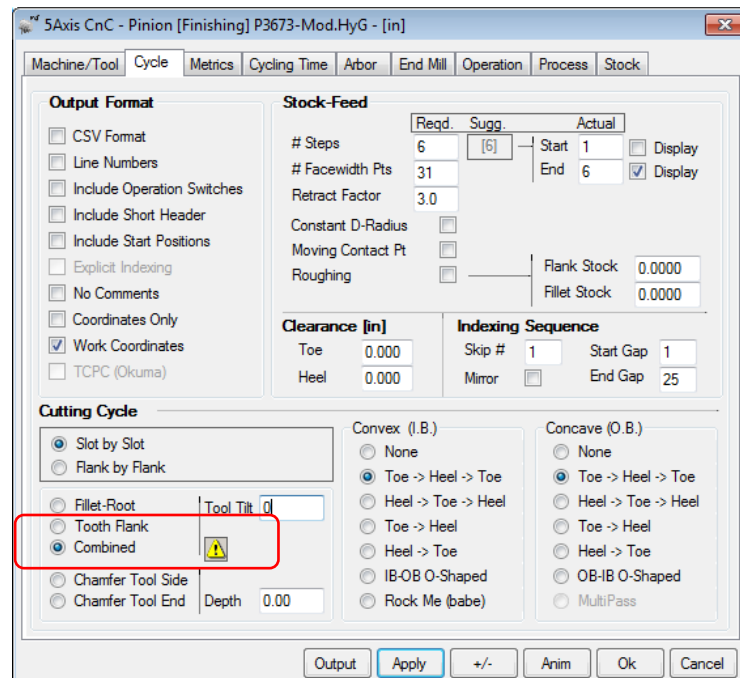
This is done only once per session. A session begins from the moment the “5Axis” function button is clicked.



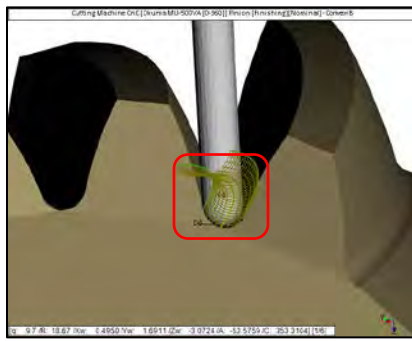
5) In 5Axis, the Combined cycle has been added. The Combined cycle creates a continuous part program for the Flank and Fillet based on the required # Steps. Thus, equally spaced steps depthwise can be obtained in one cycle.



Warning: the Combined cycle is very well adapted to constant depth teeth. For variable depth teeth, the #Steps in the Fillet changes along the tooth flank, and therefore variations in tool and work relative positions will occur. In such a situation, an ⚠ exclamation mark is displayed besides the “Combined” option in order to alert the user.



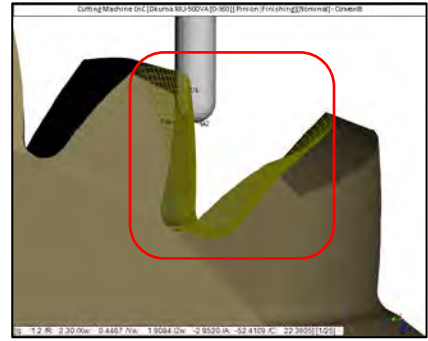
The 3 figures below display the Target Grid to illustrate the differences between the Fillet, Flank and Combined cycles.



Fillet Cycle



Flank Cycle

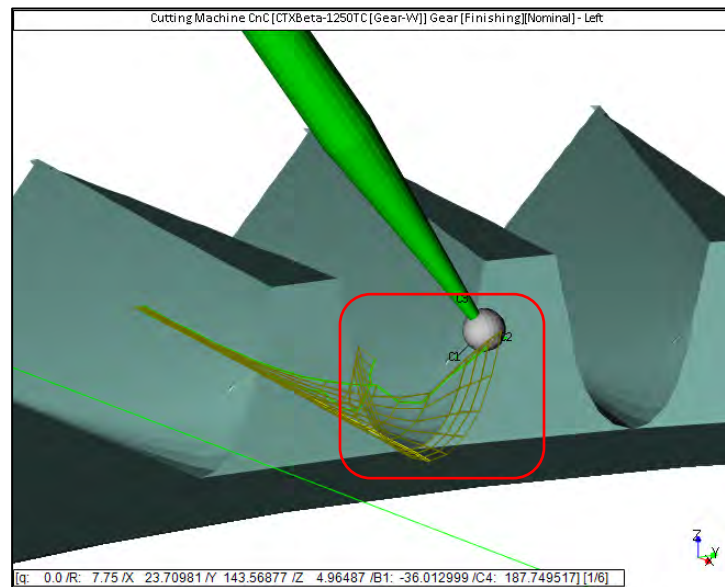


Combined Cycle

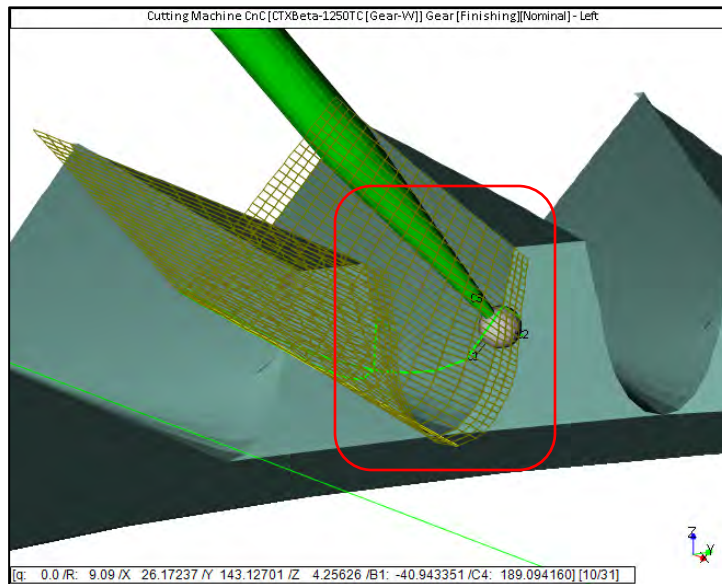
The Combined cycle is available only in Finishing mode, i.e. the “Roughing” checkbox is not checked, and precludes tool change.

Stock for the Fillet and Flank is entered separately; Fillet Stock can be negative and if so, then the full negative value is applied at the bottom of the root, and is zero at the Fillet line. Positive Stock is constant over the complete Fillet. For the Flank, either Positive or Negative Stock can be entered, which is constant over the complete flank.

The Combined cycle can be especially advantageous to cut Face Gears where the depth of the Fillet varies along the facewidth. For example, figure below, the # Steps in the Fillet is 6; it is obvious that at Toe, spacing between cutting passes will be quite large, and close to zero at Heel.



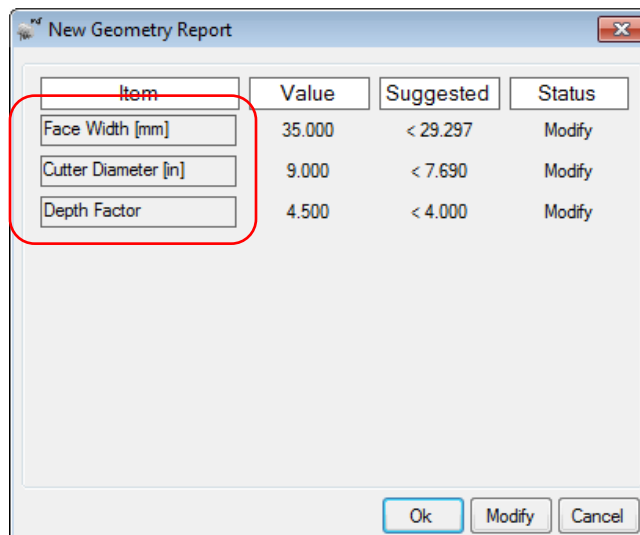
Specifying the Combined cycle with 31 depthwise Steps, we obtain the following where it is clear that cutting steps are equally spaced depthwise.



Since the Ball Mill is defined to cut in its lower hemisphere, movement will appear continuous when moving from Flank to Fillet. For an End Mill, the flutes of the End Mill will cut the tooth Flank, and the Edge Radius will cut the Fillet; therefore, a significant re-orientation of the tool and work piece will be apparent when the tool moves from Flank to Fillet and it is important to allow sufficient Toe and Heel clearances to allow such movement.

6) In 5Axis, corrected an animation error, on the Convex flank, when using a Toe->Heel cycle in the Fillet area, where the tool would retract when reaching the bottom of the slot, but would then plunge to tooth tip rather than at its starting point, and would remain on the same tooth flank.

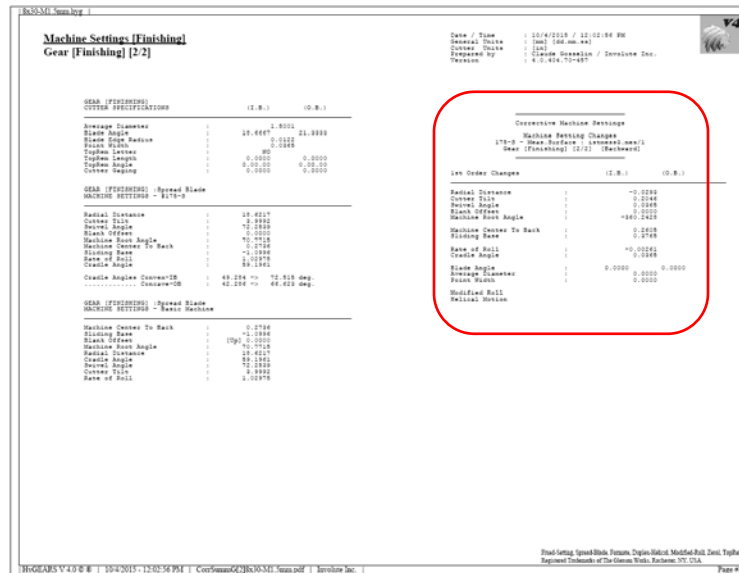
7) When creating a New Geometry, rather than asking several questions one after the other, HyGEARS now displays a "New Geometry Report" where all the user input values out of the normally recommended range are displayed, along with the recommended range within which they should reside.



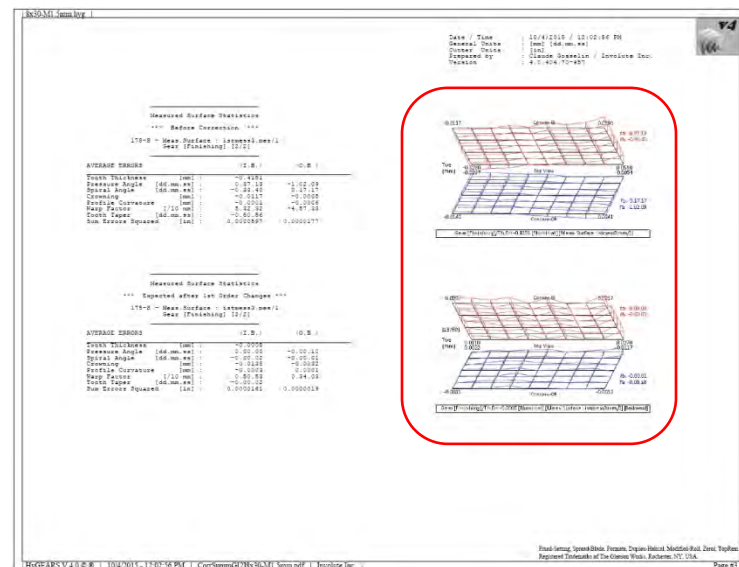
For example, above figure, some of the user entered values are out of the recommended range; HyGEARS displays a Report, recommends to modify these values by clicking on the "Modify" button, but still allows to override the recommendations by clicking "Ok". If "Cancel" is pressed, then the New Geometry creation is dropped altogether.

8) In Corrective Machine Settings, the Pdf Summary that is displayed after accepting the proposed corrections has been reorganized as follows:

- the 1st page is unchanged;
- the 2nd page now contains both the corrected Machine Settings, and the calculated changes in Machine Settings, as shown below:

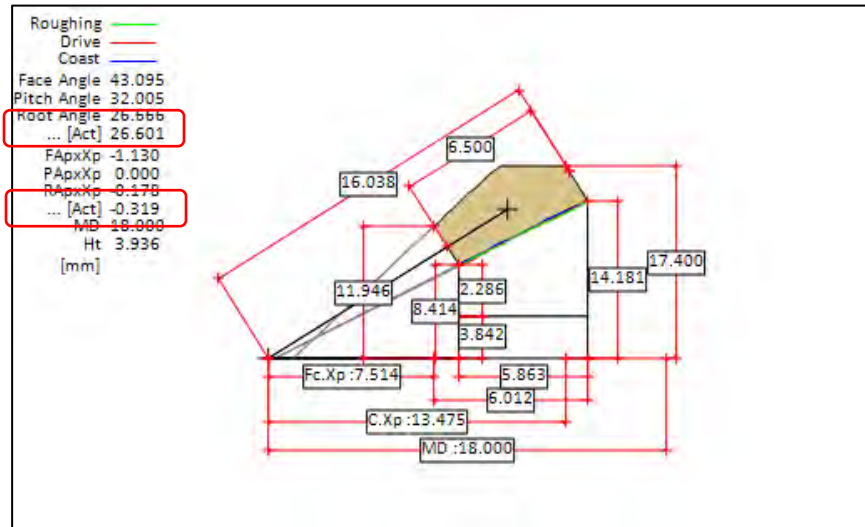


- the 3rd page now contains both the current surface statistics and expected surface statistics after correction, plus their graphic representation, as shown below:



9) In the Blank display, the output has been re-arranged somewhat. Two values, the Root Angle and the RApXxp, are each followed by the line "...[Act]", where the actual value, as calculated using the root line of the tooth.

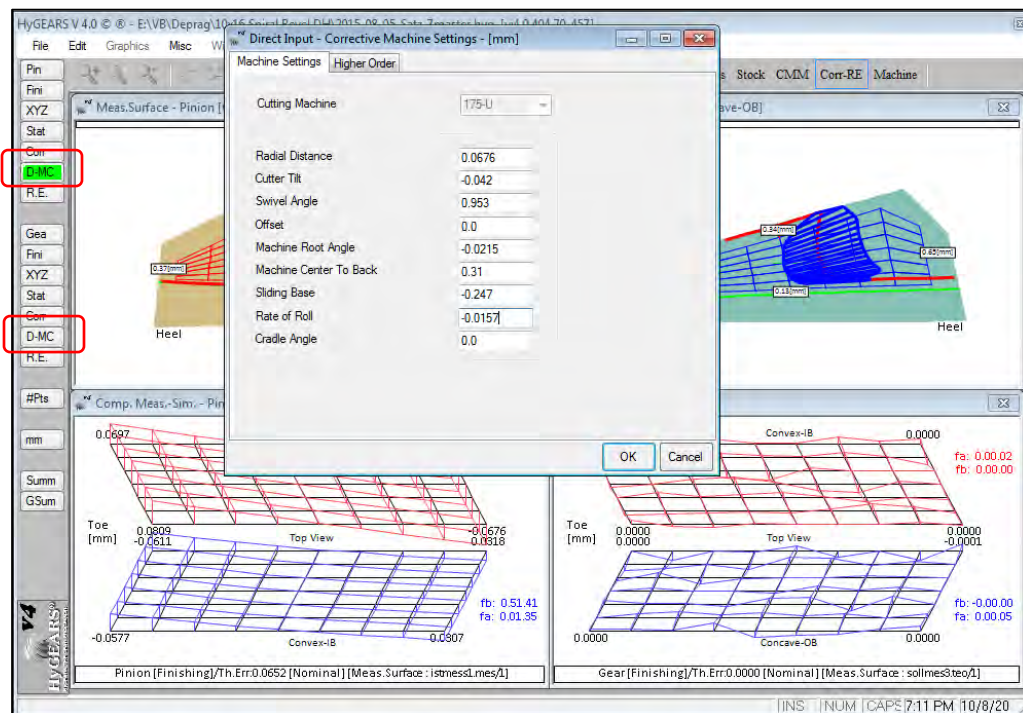
The "...[Act]" value can show some difference with the theoretical value which precedes it when the cutter diameter is small and the tooth number is small, such that the tooth root line shows some curvature, either convex or concave.



10) When in the 5Axis window, the Pinion and Gear Summary editors can be accessed. Since some values are initialized when first opening the 5Axis window, editing the Pinion or Gear summaries can lead to some values not being updated which could lead to wrong CnC coordinates.

Therefore, the Summary Editor now checks to see if the 5Axis window is open and, if so, recalculates the distance from the Apex to the origin of the reference frame linked to the work piece, in order to ensure consistency in coordinate output.

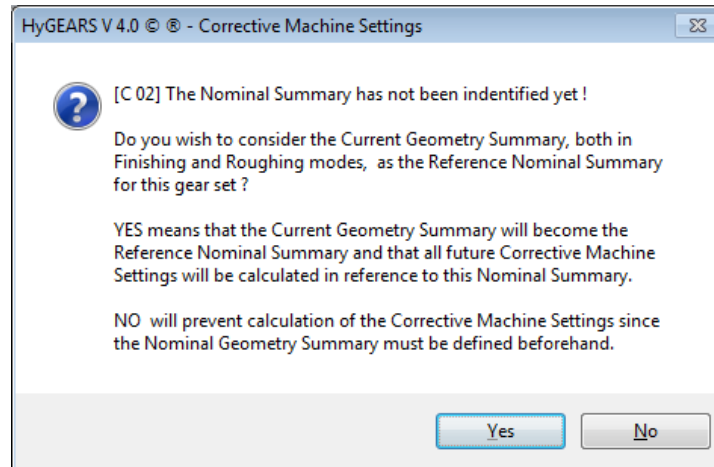
11) In Corr-RE mode, addition of the "D-MC" function button, for each of the Pinion and Gear, where it is possible to enter machine setting corrections obtained from Gleason's GAGE or Klingelnberg's KOMET.



The current linear units are given in the title bar itself and the currently selected machine is displayed below the title bar of the input window.

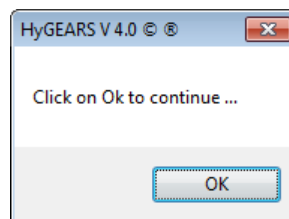
This is available for all the currently machines supported in HyGEARS. The desired machine is selected in the Pinion or Gear Summary Editor, Machine data page. Higher order changes are given in the “Higher Order” data page.

When the “Ok” button is clicked, if the Nominal has not already been defined, the user is requested to confirm that the current set of machine settings are to be considered as the reference Nominal to which the entered values are to be added.



Once confirmation has been given by clicking on the “Yes” button, HyGEARS proceeds as for usual Corrective Machine settings, i.e.:

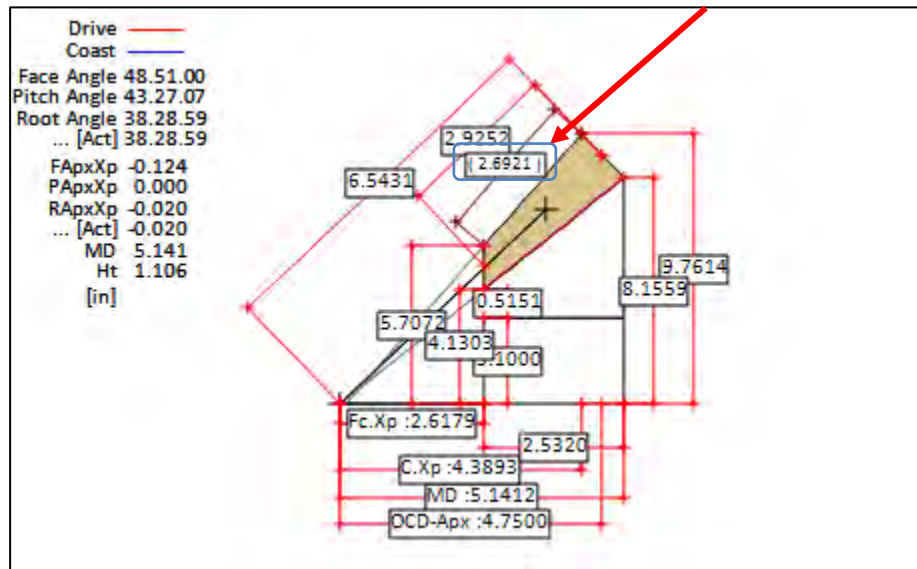
- the entered changes in machine settings are added to the Nominal to create a modified set of machine settings describing the 1st correction iteration;
- the display is updated to show the expected error surface after correction; a prompt is then shown to give the user the time needed to view the expected error surface after correction, such as follows:



- a correction Summary is generated and displayed with Blank data, corrected machine settings, machine setting changes, and error surfaces before and expected after correction;
- once this is completed, the geometry should be saved in order to conserve the entered data; it is good practice to add “-CorrP” or “-CorrG” at the end of the filename (but before the “.HyG” extension) in order to identify that the geometry file contains correction data.

Note: For Phoenix machines, it appears that KOMET correction for Helical Motion is given in “mm/20 cradle angle” rather than in the usual units of “mm/Radian”; it is therefore necessary to multiply the KOMET Helical Motion correction data by $180/\pi/20$, i.e. 2.8648, to obtain the correct Phoenix value.

12) For bevel gears, addition of the Face Width along the tooth topline in the Blank Child Window. In order to distinguish this value from the usual Face Width along the Pitch cone, the value is displayed within parenthesis, i.e., “(” and “)”, 1 point smaller font size, and in a slightly different color, as shown below



This addition is to help users trying to replicate existing gear sets for which the actual Face width along the Pitch cone may be difficult to measure, for example on differential type gears, or simply may not be given on old drawings as is often the case.

13) When creating a New Geometry, the Blank Data section for Bevel gears now includes the “FC.Xp” entry where the user can impose the “Front Crown to Xp” distance which is often given on old bevel gear drawings. This eases somewhat the description of the actual gear blank in HyGEARS.

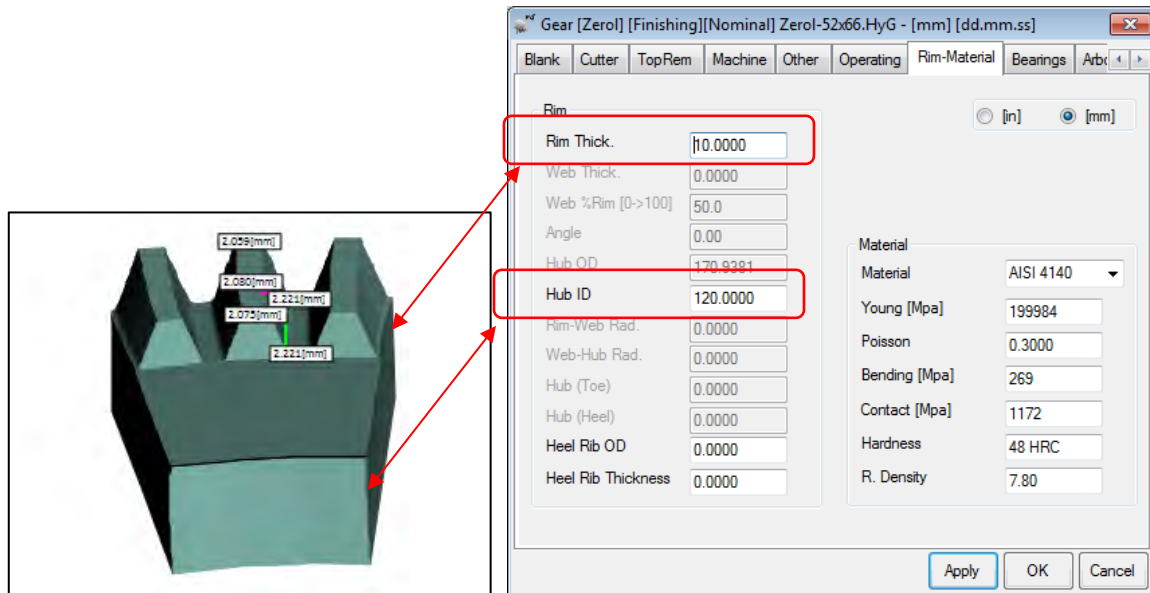
The screenshot shows the 'New Geometry Definition' dialog box in HyGEARS software. The 'Blank Data' section is active, and the 'FC.Xp' entry is highlighted with a red box. The 'Pinion' and 'Gear' columns are visible, with values for 'FC.Xp' of 0.000 and 63.424 respectively. The 'Units' section at the bottom shows 'Linear Units' set to 'mm', 'Angular Units' set to 'Deg.Min.Sec', and 'Cutter Units' set to 'In'.

Blank Data	Pinion	Gear
Backlash		0.076
FC.Xp	0.000	63.424
Outside Diameter (Heel)	247.955	257.810
Face Angle	48.850	51.517
Root Angle	38.483	41.150
Dedendum Angle	0.000	0.000
Whole Depth	@Mid-F 27.788	@Heel 27.788
Bore Diameter	0.000	0.000
Min Bore to Root @ Toe	0.000	0.000

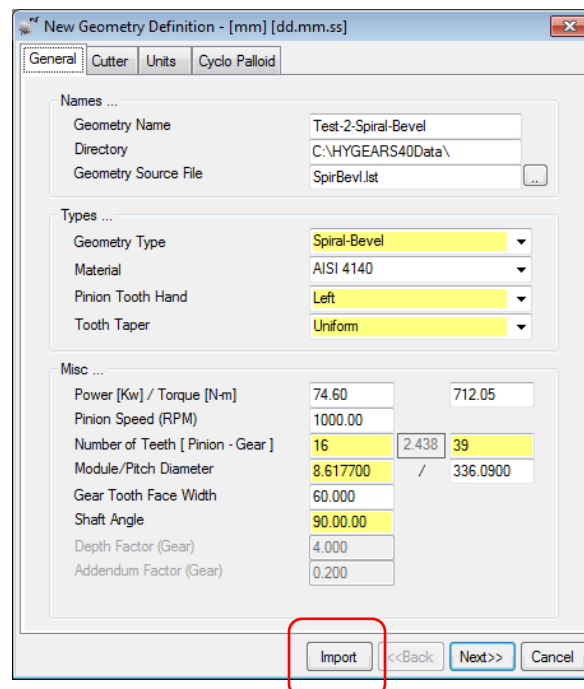
Units:
 Linear Units: mm
 Angular Units: Deg.Min.Sec
 Cutter Units: In

When the “FC.Xp” value is imposed, the Front angle is set to zero, such as in differential gears.

14) For crown spiral bevel gears, the display of the hub has been corrected such as to reflect correctly the Hub ID (inside diameter) and Rim Thickness. At the same time, the Rim Thickness can now be edited in the Gear Summary, “Rim-Material” data page.

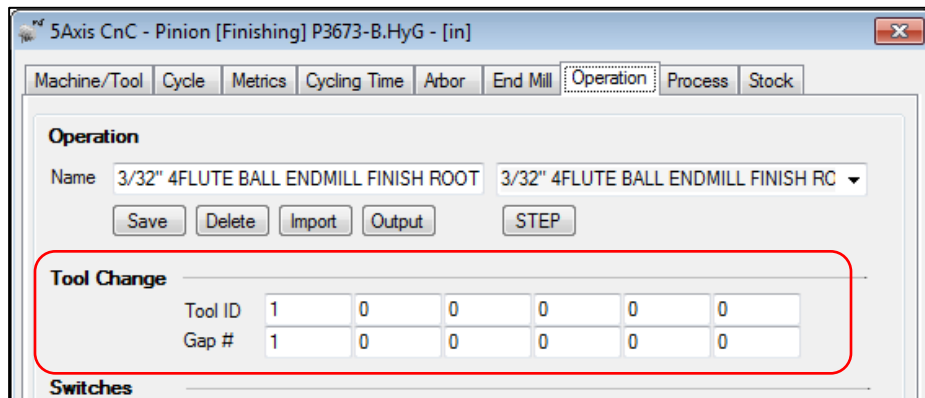
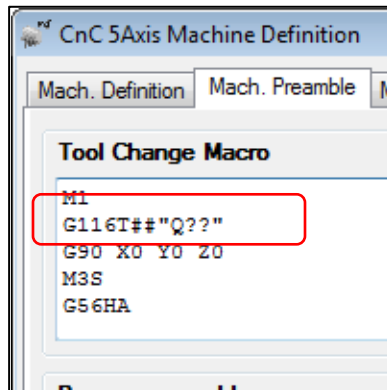


15) When creating a new geometry, it is now possible to populate the New Geometry input window by clicking on the “Import” button, as long as a geometry is already present in memory.



When the Import button is clicked, the defining parameters of the current geometry are extracted and inserted in New Geometry definition window. This simplifies the creation of a new geometry which would be based on an existing one, but with some variations in the input values.

16) In 5Axis, the “Tool Change Macro” is now multiline, which means that several lines can be used to program tool change during the cutting cycle. The “Tool Change Macro” is linked to a specific machine and is defined in the “Tool Change Macro” section of the “Mach. Preamble” tab of the CnC 5Axis Machine Definition window for the given machine.



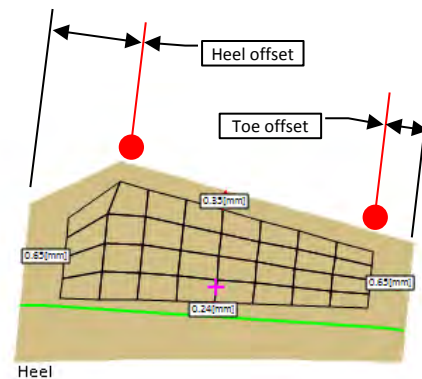
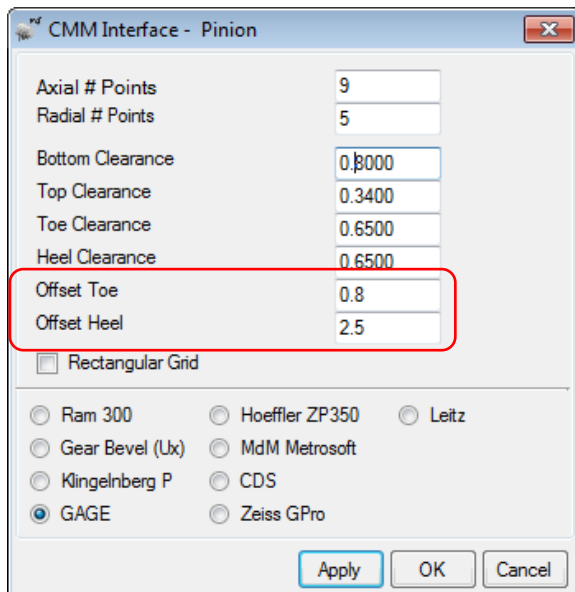
The following rules are applied:

- The tool number given in the Operation tab of the 5Axis window replaces the ## sequence in the Tool Change Macro; for example, first figure above, the sequence is T##;
- The following tool number given in the Operation tab replaces the ?? sequence in the Tool Change Macro – this is the “Prepare Next Tool” command, which may, or may not, be given; the “Prepare Next Tool” command must be enclosed within double quotes such that HyGEARS can identify the correct character sequence; for example, first figure above, the “Prepare Next Tool” command is “Q??”; when this sequence is not needed, for example at the very end of the cutting cycle as there is no need to prepare another tool, this sequence is removed from the tool macro.

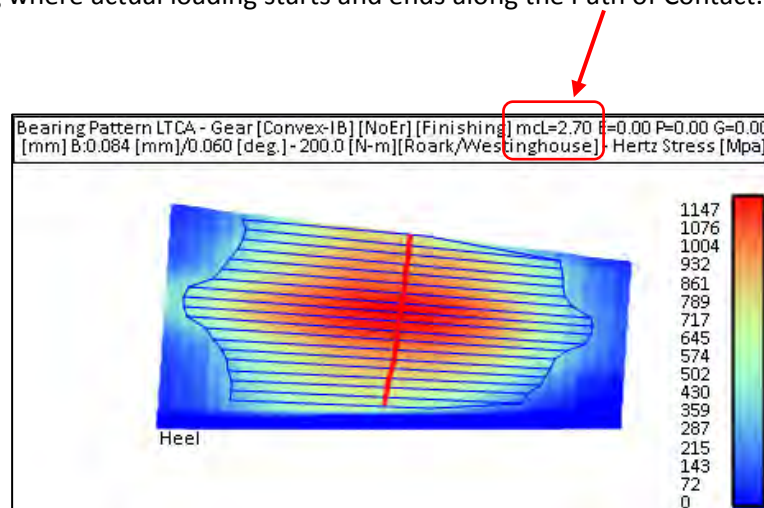
Note: the “Prepare Next Tool” command allows telling the controller to go fetch and prepare the required tool that will be needed after the current tool is done cutting. This would allow for time savings.

17) When creating a CMM Target file for Gleason CMMs, it is now possible to specify Toe and Heel offsets which are used to locate axially where the Root and Face cones will be measured. The offsets are understood as being along the pitch cone of the measured member. A positive offset value moves the measurement point inside the tooth boundaries.

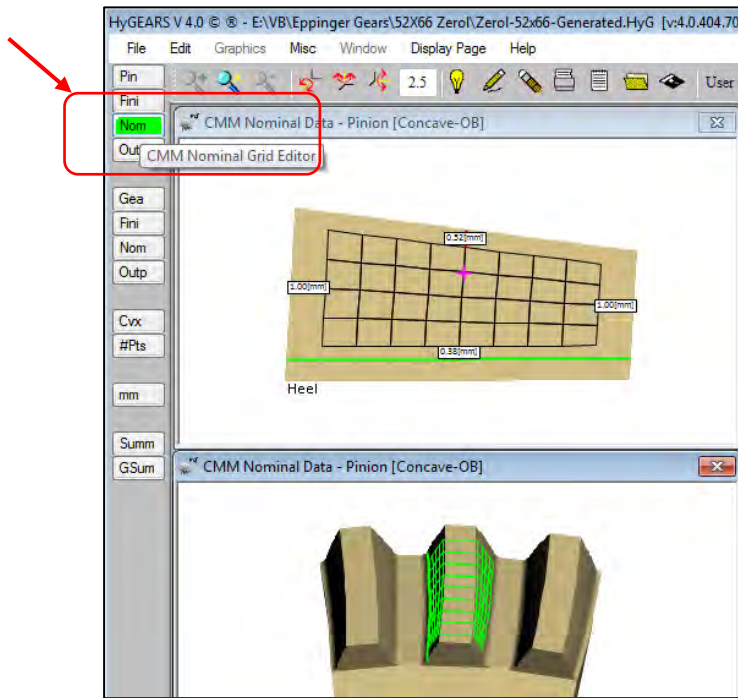
The Toe and Heel offsets can be useful when the Face cone has a chamfer at Toe or Heel, or a turned diameter at Heel, and thus the CMM may give an error in the value of the Face Angle. It may also happen that the blank is a bit short at Toe or Heel, and then the CMM probe could fall outside of the blank.



17) In the LTCA display, the contact ratio under load, i.e. the extent of contact duration under load, is now displayed as “mcl=x.xx”, as shown below. The “mcl” value is established by scanning the TCA curve under load and establishing where actual loading starts and ends along the Path of Contact.



18) In the CMM pre-defined mode, the CMM Nominal definition window is now accessed through the “Nom” function button (as opposed to “Ram” before).



19) In 5Axis, modification to the “Return Trip” which, previously, was based on the starting and ending positions of the tool, and a linear interpolation was made between these 2 points.

Since in some cases, especially when using work piece coordinates, some coordinates could start and end with positive values but could have negative values in between, the Return Trip is now based on several coordinates along the tool path such as to reflect any dip that could occur in the coordinates between the start and end points.

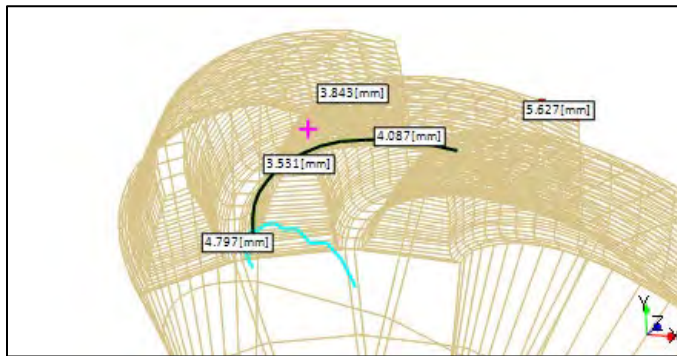
20) In 5Axis, corrected a condition where when the Rapid Move, Plunge and Cutting feeds were specified for a given tool, these feeds would not be redisplayed when the tool was selected at a later stage.

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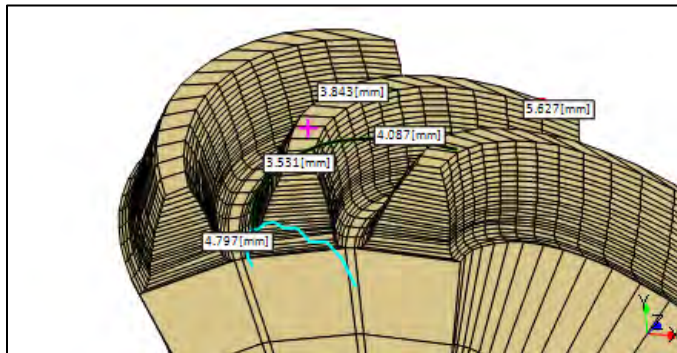
1) The graphics subsystem is reviewed and updated to improve the ease of use of HyGEARS. The following behavior now prevails:

- When rotating the display of a zoomed 3D Child Window, the display now remains centered in the Child Window; this in stark contrast with the previous behavior where the zoomed area, usually the teeth, would go out of the visible area because the rotation was done in reference to the pitch apex.
- The display modes, accessed using the ^H keyboard combination, can now all be seen in Auto and Manual zoom modes whereas, before, only the Total and Rendering modes could be seen in Auto zoom;
- The ^H keyboard combination now cycles through only 3 possibilities: Wireframe – or no hidden line removal, Total hidden line removal – where the individual facets making up the volume can be seen, and Rendering, - where color changes continuously with the direction of the facet, as shown below:

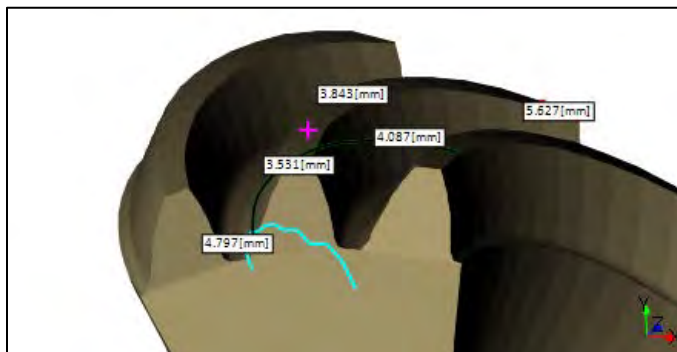
○ Wireframe:



○ Total:



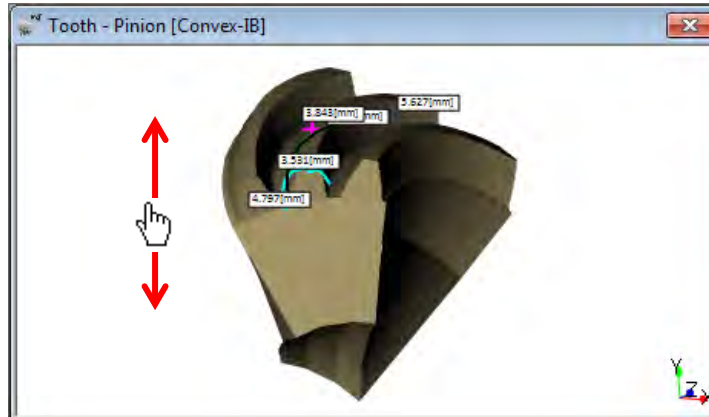
○ Rendering:



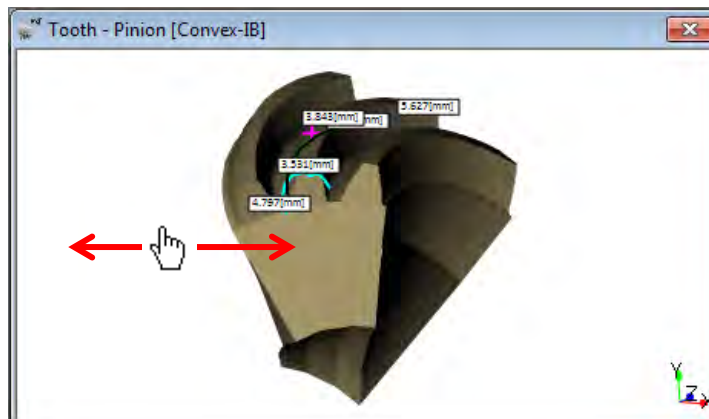
- In Wireframe display mode, the displayed object is now in color rather than in black lines;

- When the left mouse button is pressed with the cursor over a 3D Child Window, the display can be rotated by keeping the left mouse button depressed; the cursor is then shown as a small hand and behaves as follow:

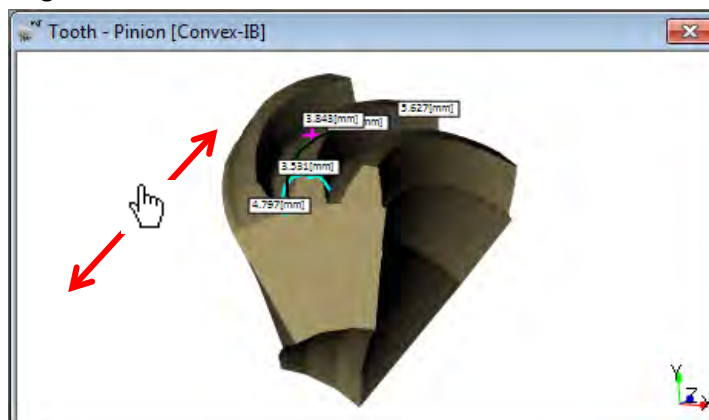
- Vertical motion: same as Rotate about X



- Horizontal motion: same as Rotate about Y



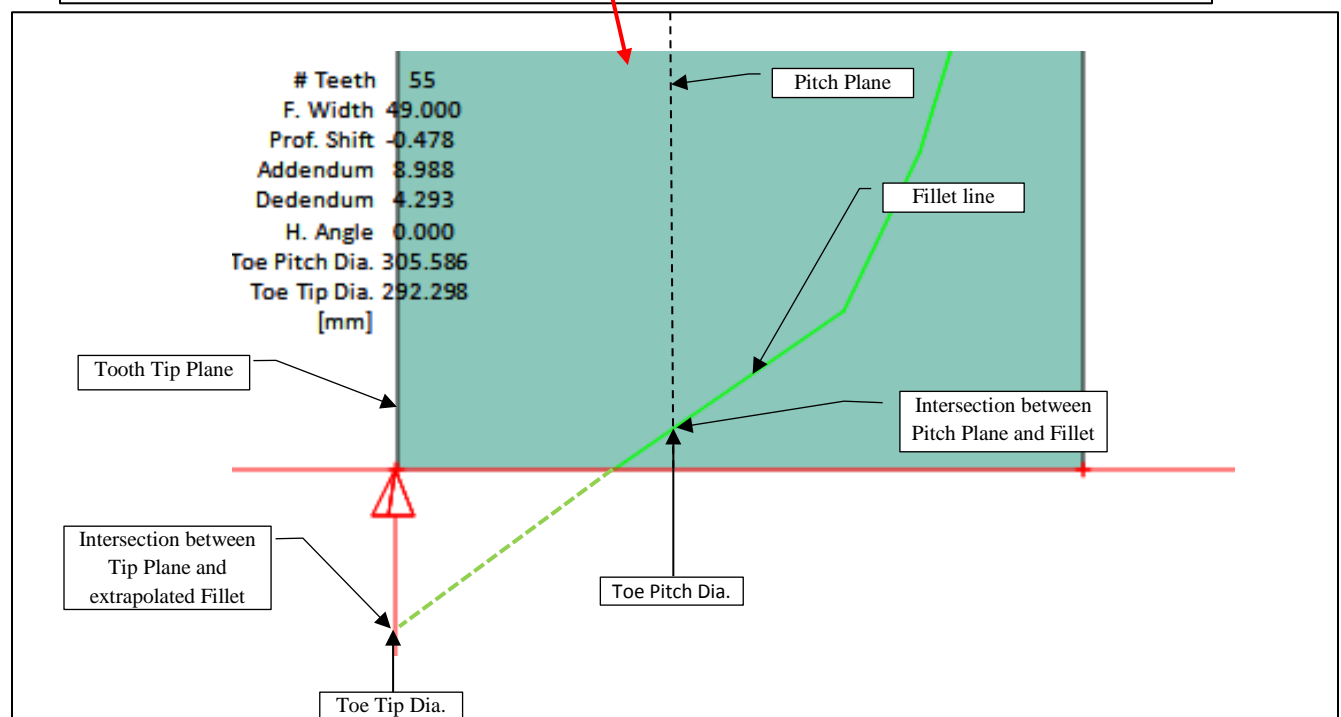
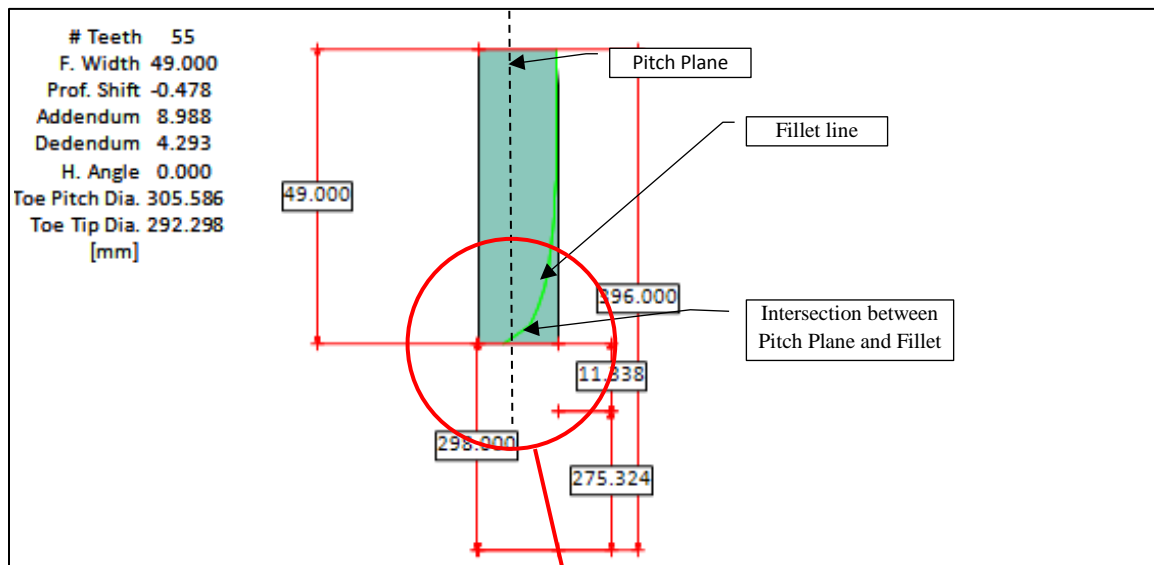
- Angle motion: same as Rotate about Z



- In 5Axis mode, the “Lock on Tool” option better centers the display and maintains the contact point between the tool and work piece as zoomed in the Child Window.

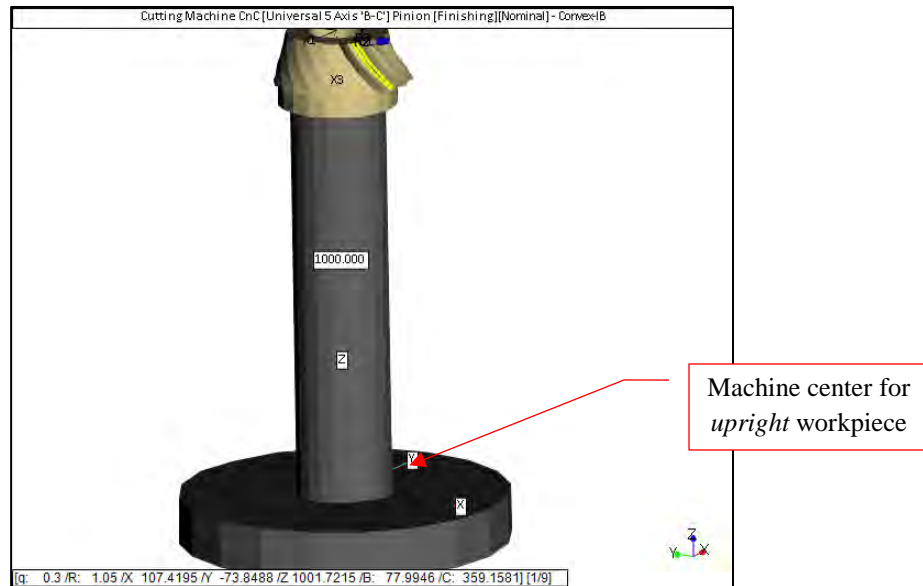
2) For Face Gears, the Blank display is expanded to include the following elements:

- The details given to the left of the display add the :
 - # Teeth: the number of gear teeth,
 - F. Width: the tooth Face Width,
 - Prof. Shift: the Profile Shift factor,
 - H. Angle: the Helix Angle,
 - Toe Pitch Dia.: the diameter at which the Fillet line, in green, crosses the Pitch plane;
 - Toe Tip Dia.: the diameter at which the Fillet line, in green, crosses the Tip plane; this value is an extrapolation of the Fillet line.
- The Fillet line (green line) is added to the display, to ease the interpretation of the “Toe Tip Dia.;
- The Inside Diameter (“298.000” below) is shrunk in order to have a better size factor to display the tooth and Fillet line.

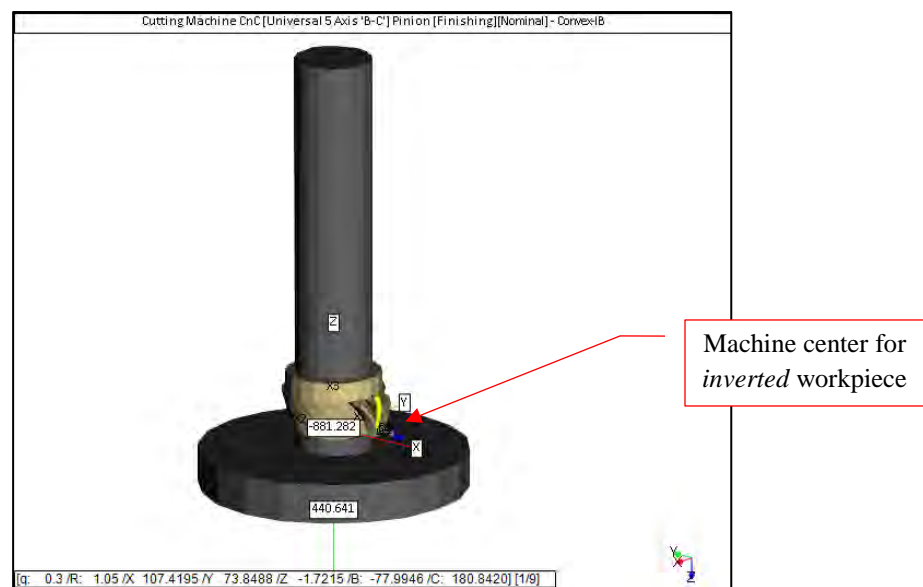


3) In 5Axis, when using CoSIMT, End Mill, Ball Mill or Probe tools on BC type 5Axis machines, the workpiece can now be inverted, i.e. tilted upside down, such as to allow manufacturing pinions with long integral shafts, or bypassing the tool tilt limit of certain machines such as the DMU40 where tool tilt cannot exceed 95°.

For example, figure below, the shaft of the pinion workpiece is 840 mm long; if the part is installed in a conventional manner, the bottom of the shaft would be resting on the machine cradle and the workpiece would be in an unstable position, or else, would require a significant support system.

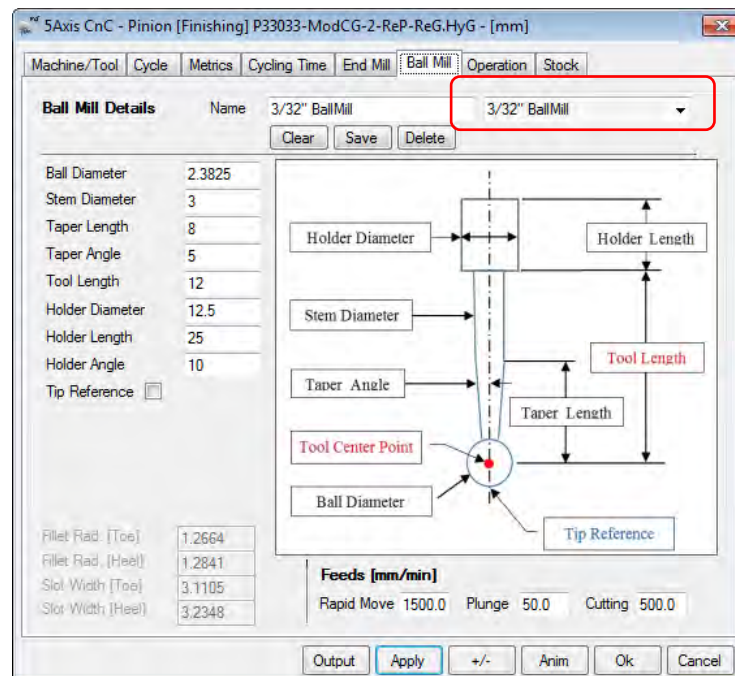


Inverting the workpiece, figure below, allows holding the workpiece on a short leash, close to the machine center, for greater stiffness.

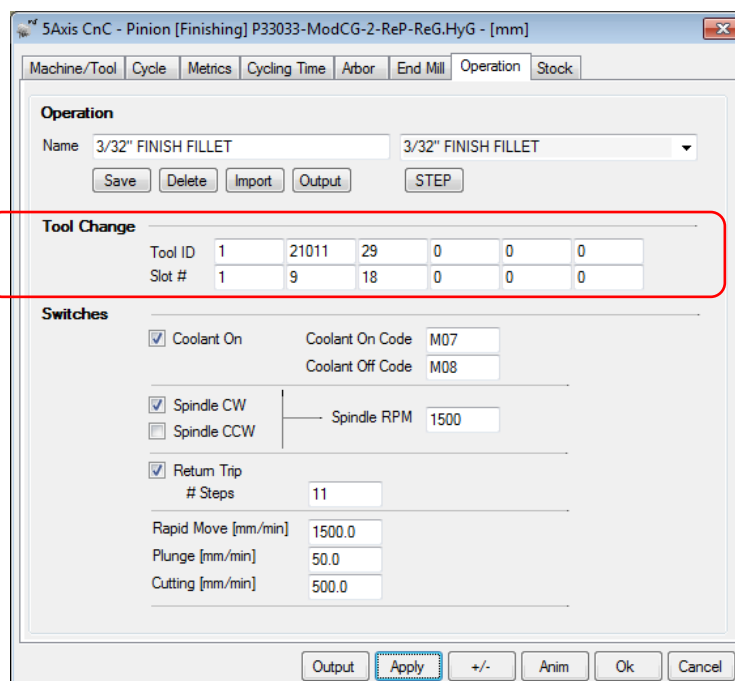


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1) In 5Axis, the Tool List for End Mill, Ball Mill, CoSIMT and Face Mill tools, is now lightly greyed to distinguish it from the Tool Name which is white and where text can be entered.



2) In 5Axis, addition of the programmed "Tool Change" to the Operation tab, in replacement of the "Tool ID". "Tool Change" uses a macro to specify, at set tooth gap intervals, what tool should be used. This allows bypassing the controller command which may be used to impose regular tool change.



For example, above figure, a 25 tooth part is cut, with tool #1 for tooth gap 1 to 8, tool #21011 for tooth gap 9 to 17, and tool #29 for tooth gap 18 to 25. At the end of the cycle, the tool is returned to that of tooth gap 1, i.e. tool #1, but without loading it (thus M6 is not shown).

The control sequence of the part program then takes on the following shape:

```
( ----- Start of Program ----- )
( ----- Start of Cycle ----- )
(           Section 1           )
```

T1 M6 (Tool Change Macro)

```
( ----- Tooth Space # 1 ----- )
G52 C-14.400          ( Increment gap space angle )
M98 P6002             ( GoTo Subroutine 6002 )
```

...

```
( ----- Tooth Space # 8 ----- )
G52 C-115.200         ( Increment gap space angle )
M98 P6002             ( GoTo Subroutine 6002 )
```

T21011 M6 (Tool Change Macro)

```
( ----- Tooth Space # 9 ----- )
G52 C-129.600         ( Increment gap space angle )
M98 P6002             ( GoTo Subroutine 6002 )
```

...

```
( ----- Tooth Space # 17 ----- )
G52 C-244.800         ( Increment gap space angle )
M98 P6002             ( GoTo Subroutine 6002 )
```

T29 M6 (Tool Change Macro)

```
( ----- Tooth Space # 18 ----- )
G52 C-259.200         ( Increment gap space angle )
M98 P6002             ( GoTo Subroutine 6002 )
```

...

```
( ----- Tooth Space # 25 ----- )
G52 C-0.000           ( Increment gap space angle )
M98 P6002             ( GoTo Subroutine 6002 )
( ----- End of Cycle ----- )
```

T1 (Tool Change Macro)

Notes:

- The Tool Change option calls a Tool Change macro specifically defined for a given machine; by default, the Tool Change macro is "T## M6" where "##" indicates the tool ID; it is also possible to

tell the controller to prepare the next tool to be called by using the appropriate command followed by “??”; for example, on the Okuma controller, using the “G116 T## Q??” macro tells the controller to load tool “##” and prepare tool “??” which will be used next after “##”; the “load next tool” command (“Q??” above) must follow the “select tool command” (“T##” above);

- the Tool Change macro can be given on one line only;
- in the sample code given above, the default Tool Change macro “T## M6” is used;
- if no Tool Change macro is given, then nothing is displayed;
- Tool #1 is always given in the Operation switches, even if no Tool Changes are requested;
- If no tool ID is given, then no Tool Change occurs;
- If only 1 tool is given, then the Tool Change macro is called at the very beginning of the Cycle sequence;
- If more than 1 tool is given, the 1st tool is recalled at the end of the Cycle sequence;
- when more than 1 tool is used for Siemens controllers, instead of using the usual internal control loop and subroutine, an EXTCALL is programmed, and the main program and subprogram(s) are given in separate Text Results windows; they are assigned the default names of MAIN.MPF, PROC1.SPF (and PROC2.MPF if the operation is Flank by Flank);
- The Short Header now lists all the tools used, i.e., for the above example:

```
( ***** )
(PROGRAM NAME      : 3/32" FINISH FILLET)
(PROGRAM DATE      : 07-18-2015)
(SUMMARY VERSION   : [Nominal])
(TOOL ID           : 1 21011 29)
(TOOL DIAMETER     : 2.39[mm])
(TOOL LENGTH       : 12.00 [mm])
( ***** )
```

3) In 5Axis, addition of the “Start Gap” and “End Gap” to the Indexing Sequence. The Start and End Gap define where on the work the operation is to start and end; this allows, for example, to restart an operation, which may have been stopped because of a broken tool, where it was when interrupted.

For example, figure below, the operation was stopped at tooth Gap #9 because of a broken tool; the operator changes the tool, modifies the Indexing Sequence to force a re-start where the interruption occurred, which is Gap #9, regenerates the part program and uploads it to the machine controller. Before, this had to be done directly on the machine and at times, some controllers would simply not accept to do what was requested, i.e. start from a specific tooth gap.

5Axis CnC - Pinion [Finishing] P33033-ModCG-2-ReP-ReG.HyG - [mm]

Machine/Tool Cycle Metrics Cycling Time Arbor End Mill Operation Stock

Output Format

☐ CSV Format
☐ Line Numbers
☒ Include Operation Switches
☒ Include Short Header
☒ Include Start Positions
☐ Explicit Indexing
☐ No Comments
☐ Coordinates Only
☐ Work Coordinates
☐ TCP (Fanuc)

Stock-Feed

	Reqd.	Sugg.	Actual	
# Steps	3	[3]	Start 1	<input type="checkbox"/> Display
# Facewidth Pts	51		End 3	<input type="checkbox"/> Display
Retract Factor	10.0			
Constant D-Radius	<input type="checkbox"/>			
Moving Contact Pt	<input type="checkbox"/>			
Roughing	<input type="checkbox"/>			
			Finish Stock 0.000	
			Rough Stock 0.381	

Clearance [mm]

Toe	5.1
Heel	5.1

Indexing Sequence

Skip #	1	Start Gap 9
Mirror	<input type="checkbox"/>	End Gap 25

Cutting Cycle

☒ Slot by Slot
☐ Flank by Flank

☒ Fillet-Root
☐ Tooth Flank
☐ Chamfer Tool Side
☐ Chamfer Tool End

Tool Tilt 10.00
Depth 0.00

Convex (I.B.)

☐ None
☒ Toe -> Heel -> Toe
☐ Heel -> Toe -> Heel
☐ Toe -> Heel
☐ Heel -> Toe
☐ IB-OB O-Shaped
☐ Rock Me (babe)

Concave (O.B.)

☐ None
☒ Toe -> Heel -> Toe
☐ Heel -> Toe -> Heel
☐ Toe -> Heel
☐ Heel -> Toe
☐ OB-IB O-Shaped
☐ MultiPass

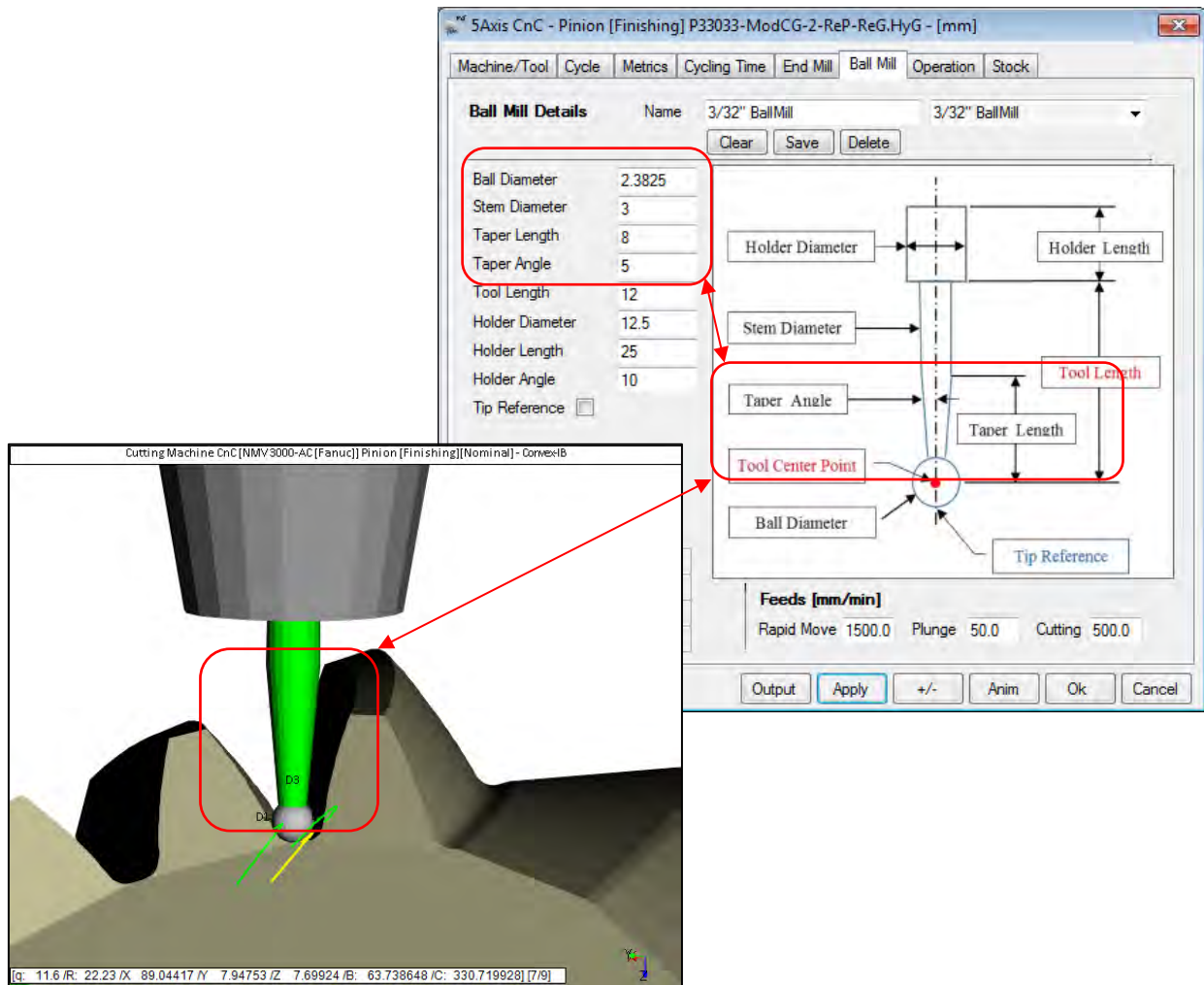
Output Apply +/- Anim Ok Cancel

4) In 5Axis, extension to the definition of the Ball Mill tool, to include a closer shape to what is found in practice. For example, figure below, Ball Mill tools usually have a spherical cutting end followed by a tapered shaft up to a stem of constant diameter; this gives stiffness to the tool while offering a clean cutting spherical end.



The modified HyGEARS definition is displayed below, where the Taper Length and Taper Angle have been added; note that

- the Taper Angle is half that of the total cone angle, as displayed below.
- the order of the Ball Diameter and Stem Diameter has been inverted.



This extended definition allows better visual assessment of possible tool to flank interference when cutting the tooth fillet for example. In the figure above, it is clear that even if the tool is tapered and the Stem Diameter is larger than the Ball Diameter, there is no risk of tool to flank interference.

5) When creating a New Geometry, the requested Pressure and Spiral Angles are conserved in the Pinion and Gear data structures, and in the geometry file when the geometry is saved; thus, when requesting either a Text Summary ("Summ" function button) or a Graphic Summary ("GSum" function button), these angles are given as reference values in the Blank Data section of the 1st Summary page, as shown below:

BLANK DATA		PINION	GEAR
Face Apex Beyond XP	:	8.1341	6.7784
Root Apex Beyond XP (Active)	:	-10.1640	-8.4704
Root Apex Beyond XP (Bottom)	:	-10.1640	-8.4703
Crown to XP	:	156.6654	129.3322
Front Crown to XP	:	103.6581	85.1594
Addendum	:	5.2073	5.2073
Dedendum	:	6.5068	6.5071
Addendum Angle	:	0.00.00	0.00.00
Dedendum Angle	:	0.00.00	0.00.00
Face Angle of Blank	:	39.48.20	50.11.40
Pitch Angle	:	39.48.20	50.11.40
Root Angle	:	39.48.20	50.11.40
Root Angle (Actual)	:	39.48.20	50.11.40
Front Angle	:	39.48.20	50.11.40
Back Angle	:	39.48.20	50.11.40
Spiral Pressure Angles - Pitch Cone			
Ref. Spiral Angle	:	35.00.00	35.00.00
" Press Angle (IB)	:	20.00.00	20.00.00
" Press Angle (OB)	:	20.00.00	20.00.00
Mean Spiral Angle	:		
... Toe	:	24.04.13	24.04.34
... Center	:	34.58.12	34.58.08
... Heel	:	45.40.16	45.40.12
Mean Press Angle (IB)	:	20.04.07	20.01.29
Mean Press Angle (OB)	:	20.03.22	20.00.55
Spiral Pressure Angles - Root Cone			
Mean Spiral Angle	:	34.58.12	34.58.08
Mean Press Angle (IB)	:	20.04.07	20.01.29
Mean Press Angle (OB)	:	20.03.22	20.00.55

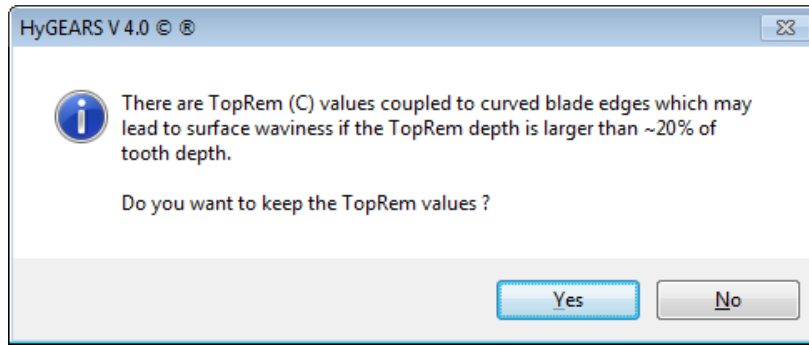
Ref. Spiral Angle:

1. For straight, spiral and Zerol bevel gears, the pinion and gear ref. spiral angles are the same, and equal to that requested.
2. For hypoid gears, the requested pinion spiral angle is given when creating a New Geometry; the consequent gear spiral angle is calculated as a function of the requested pinion offset and spiral angle, and these become the reference values.

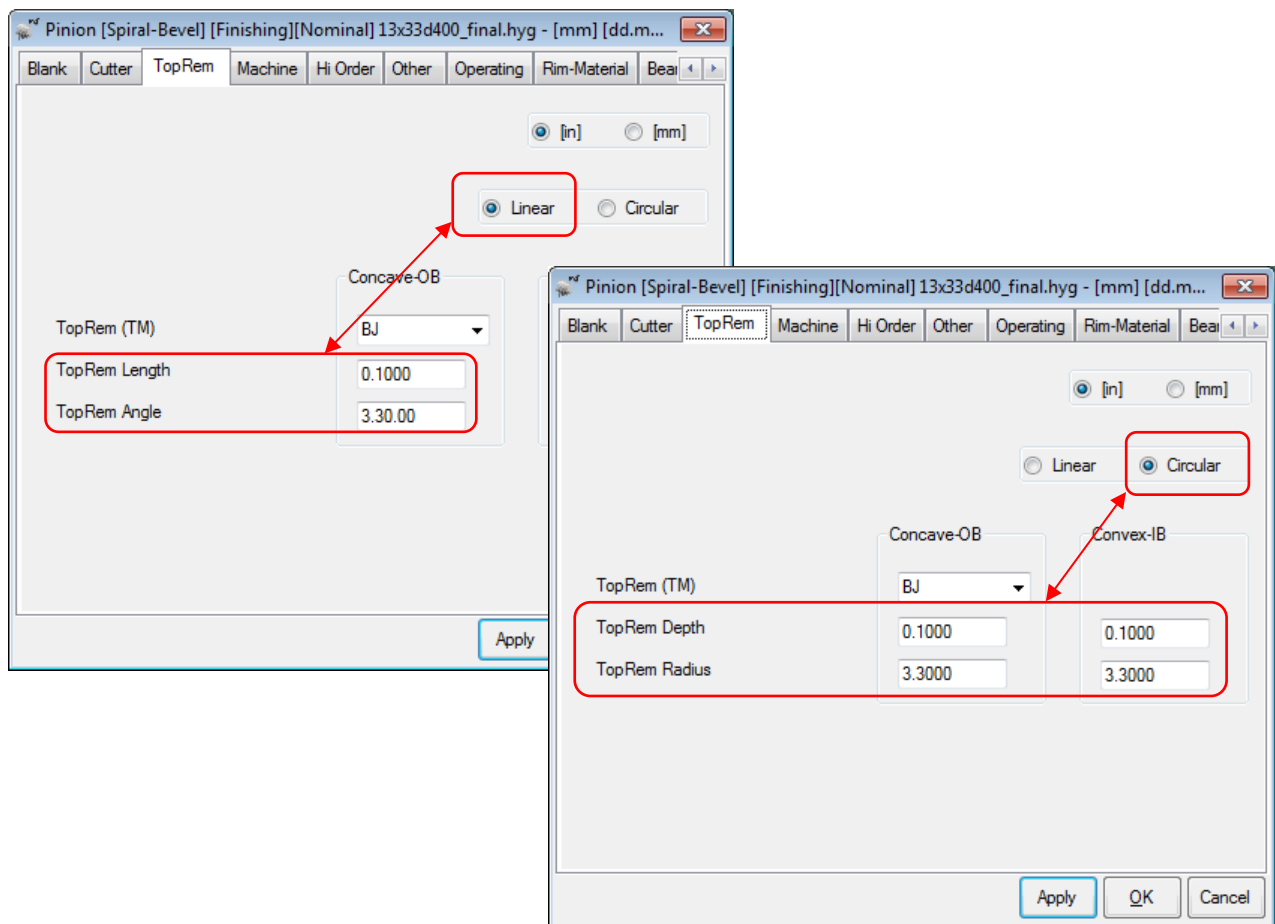
Ref. Press Angle:

1. For straight, spiral and Zerol bevel gears, the pinion and gear pressure angles are assumed the same, and equal to half the requested Sum Pressure Angles.
2. For hypoid gears, the pinion and gear pressure angles are equal to half the Sum Pressure angles +/- the limit pressure angle, transformed in the pitch cone.

6) When importing a Gleason Spa file, if the combination of circular blade edges and circular TopRem is detected, a message is displayed to warn the user that if the TopRem value is more than about 20% of tooth depth, waviness may show near the fillet of the digitized tooth. The user then has the option to import, or not, the TopRem values.



7) For all spiral bevel gears, it is now possible to combine Straight and Circular TopRem with straight or circular edge cutter blades. For example, figures below, circular edge blades are used. TopRem can be either Linear or Circular.

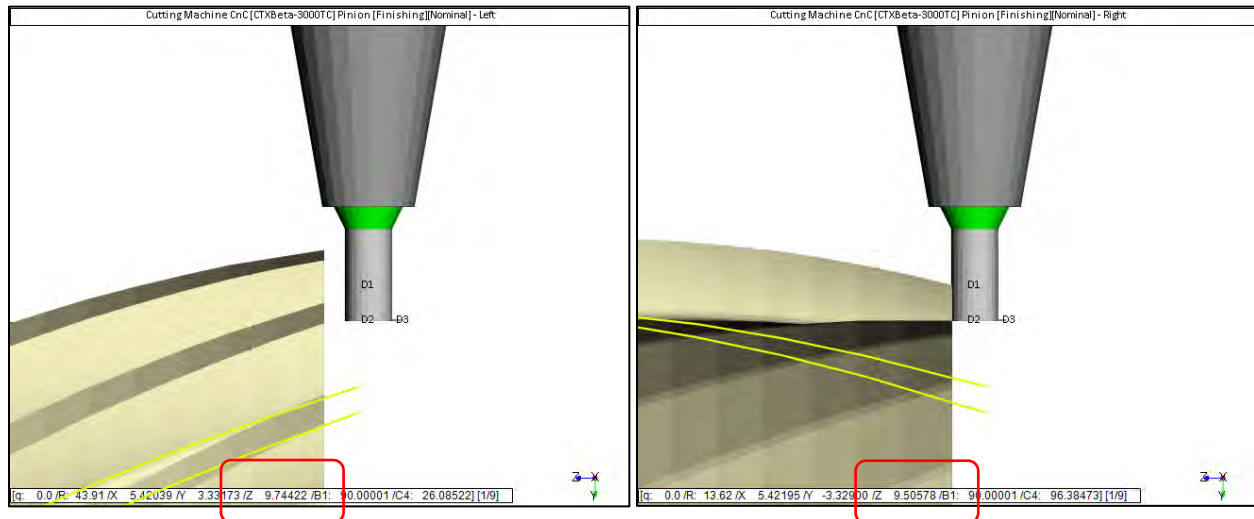


8) In 5Axis, for cylindrical gears, the Toe and Heel clearances now locate the center of the tool at the required distance, for both the Left and Right tooth flanks, whose extension becomes uneven, rather than applying an even extension to both tooth flanks.

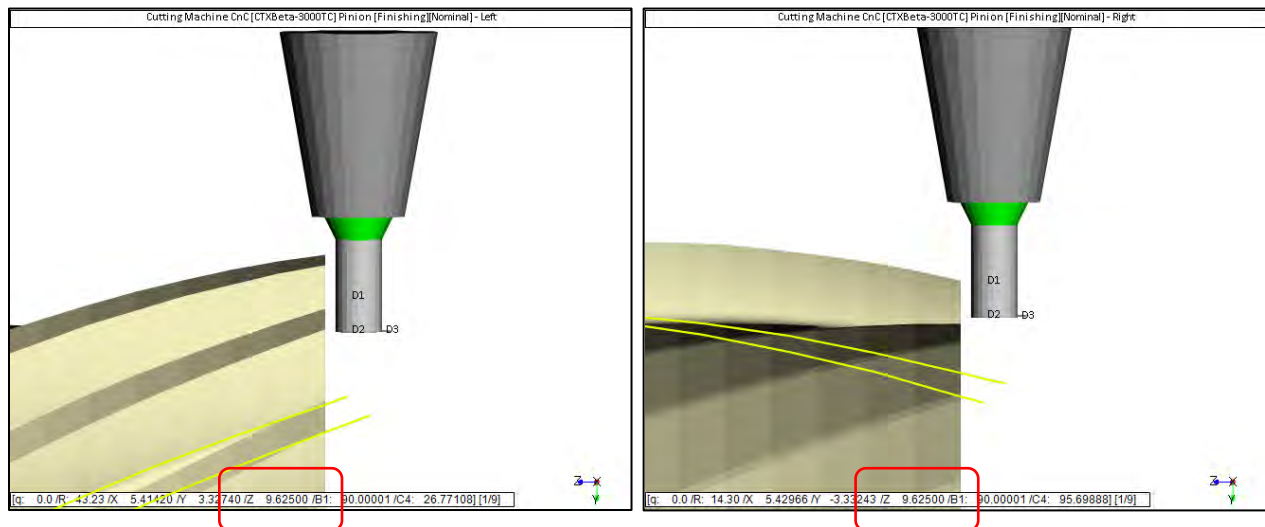
This is required because, for example, if a helical gear is used to cut one side of a Herringbone gear, the clearance at the center gap must be controlled precisely. However, because of the helix angle, if the tooth extension is the same on both tooth flanks, the tool, for example an End Mill, will not be at the same axial position on both tooth flanks and interference could occur.

With the modified definition, the tool center will be at the same axial position when a positive clearance is given, whatever tooth flank is considered. If the clearance is null, nothing is done; if the clearance is negative, the tooth is shortened by an equal amount on each flank.

Original definition: the End Mill Z coordinate is different for the Left and Right tooth flanks.



New definition: the End Mill Z coordinate is identical for the Left and Right tooth flanks.

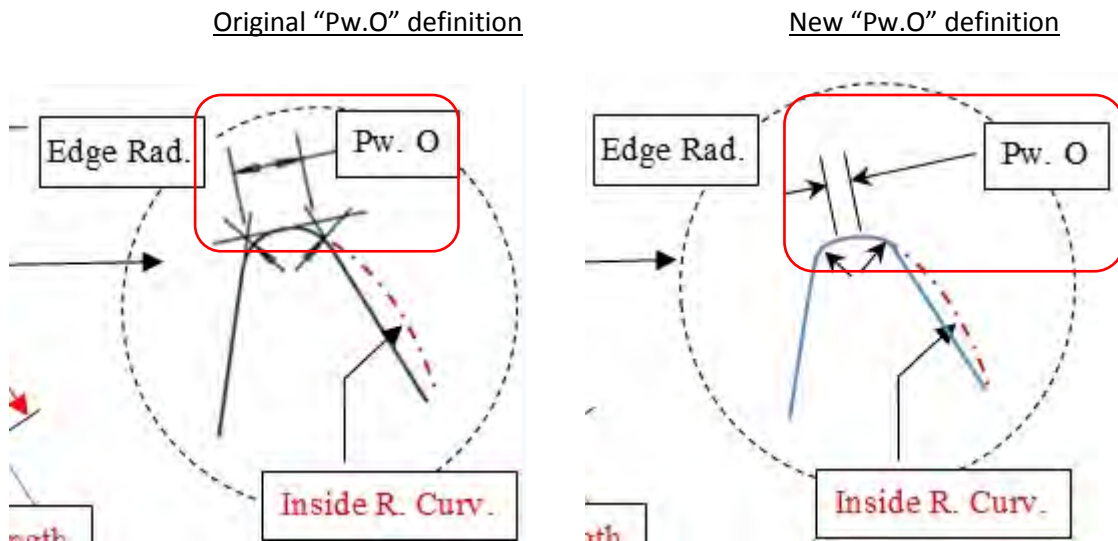


9) In 5Axis, for CoSIMT tools, the definition of the “Pw.O” dimension has changed. While it was originally considered as a “Point Width” similar to that on a Face Mill cutter, it is now considered as the length of the flat between the Edge Radii on the outside rim – see right figure below.

The new definition is more useful since it tells the user when the Edge Radii start overlapping since “Pw.O” will then become negative.

The “Pw.O” value is not updated automatically because it does not have any influence per se. To update the “Pw.O” value to the new definition, simply add a “0” (zero) at the end of the “P.Width” entry in the

CoSIMT tab; “Pw.O” is recalculated as “Point Width” changes, and the modified CoSIMT only need be saved.



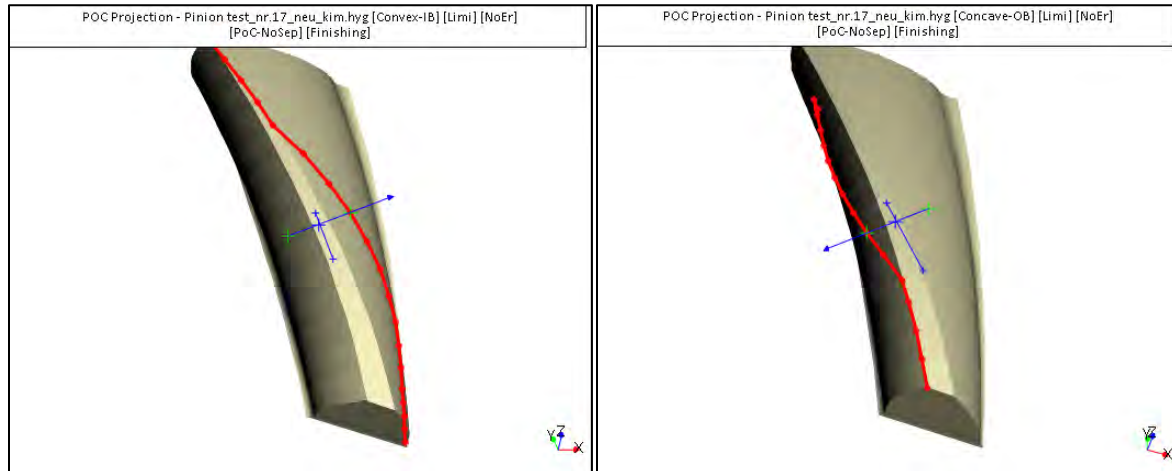
10) Correction of the Transverse Tooth Thickness “@ Mean Point” and “(Mid-Height)” In the Summary output (“Summ”, “GSum” function buttons), which would give an error originating in the calculation of the transverse direction vector at the desired coordinate on the tooth flank. This had no influence on the actual tooth thickness nor on the calculated backlash.

11) In the Summary output (“Summ”, “GSum” function buttons), the Chordal Normal Thickness “@ Mean Point” and “(Mid-Height)” is now calculated as the Transverse Thickness * Cos(PsiMoy) where PsiMoy is the mean spiral angle at mid-face. This modified calculation is desired such that the output is conform to the AGMA and ISO definitions.

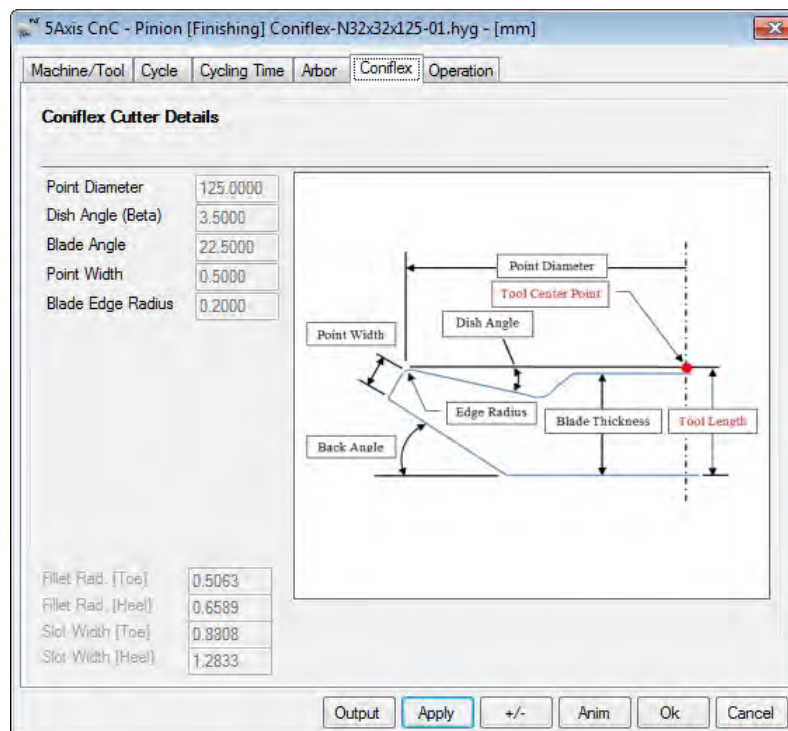
Previously, the Normal Chordal Thickness was calculated by starting at the requested point on the tooth flank – left figure below, on the PoC (in red); the desired starting point is a green cross on the convex flank – where the normal vector is displayed as an arrow; then the exit point is found on the opposite flank along the normal vector - another green cross, this time on the concave flank. This procedure is repeated for the concave flank, right figure below, i.e. find the exit point on the convex flank. Then, the values for the convex and concave flanks are averaged for the actual Normal Tooth Thickness.

Exit Point – Convex Flank

Exit Point – Concave Flank



12) In 5Axis, for Coniflex gears when using a Dish type cutter, addition of a Tab giving the main dimensions of the actual cutter and, especially, the fillet radii and slot widths at Toe and Heel, such that the user can assess if the tool Edge Radius or Point Width exceeds the dimension prior to actual cutting. None of the displayed values can be edited.



HyGEARS update -28 June 2015 - Build 404.50 - 457

1) In 5Axis, addition of the Summary ID to the Short Header. The Summary ID gives whether the Nominal or some iteration over Closed Loop is being used. This allows a quick confirmation that the correct machine settings Summary has been used.

- When the initial machine settings Summary is used to create a part program, the [Nominal] ID is given, as shown below:

```
( ***** )
(PROGRAM NAME      : FM-51steps ExtSub_P)
(PROGRAM DATE      : 06-14-2015)
(SUMMARY VERSION   : [Nominal])
(TOOL ID           : 6666)
(TOOL DIAMETER     : 2.78[in])
(TOOL LENGTH       : 14.34[mm])
( ***** )
```

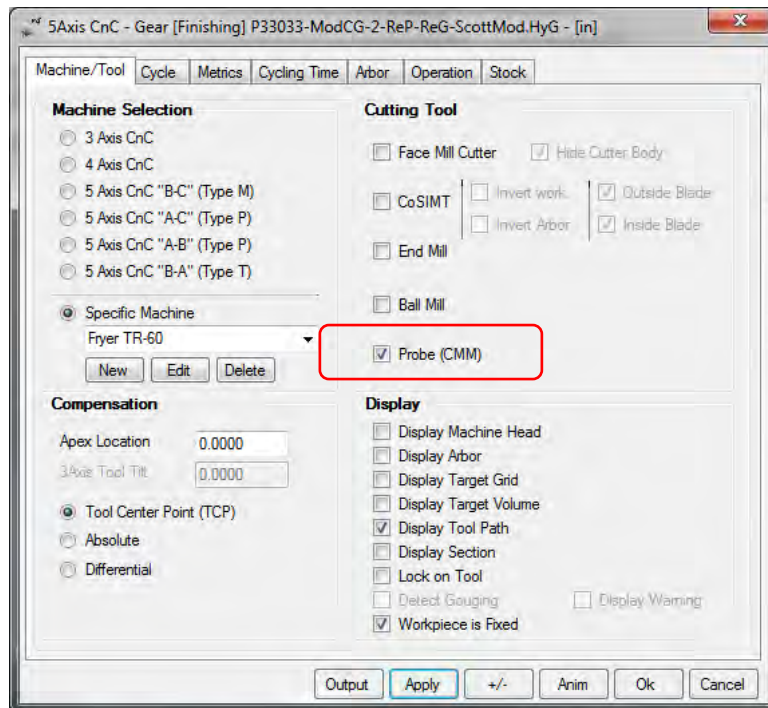
- When an iteration in Corrective Machine Settings (i.e. Closed Loop) is selected through the “Sele” function to create a part program, the selected correction ID is given such as shown below, where [2/2] means the 2nd machine settings Summary, i.e. the 1st correction (the 1st machine settings Summary is always the Nominal)

```
( ***** )
(PROGRAM NAME      : FM-51steps ExtSub_P)
(PROGRAM DATE      : 06-14-2015)
(SUMMARY VERSION   : [2/2])
(TOOL ID           : 6666)
(TOOL DIAMETER     : 2.78[in])
(TOOL LENGTH       : 14.34[mm])
( ***** )
```

2) In 5Axis, addition of the “Probe (CMM)” tool to the the available tools list. The “Probe” tool is used in conjunction with a Renishaw type probe to measure gear teeth on site, i.e. directly in the 5Axis CnC machine.

While nobody expects such a Probe to offer the precision reached with CMMs in temperature controlled rooms, the on-site Probe can give a good estimate of 1st order deviations without having to remove the work piece.

The “Probe (CMM)” uses a HyGEARS function which calls the necessary measuring function on the 5Axis machine. This implies a measuring function specific to the 5Axis CnC machine.

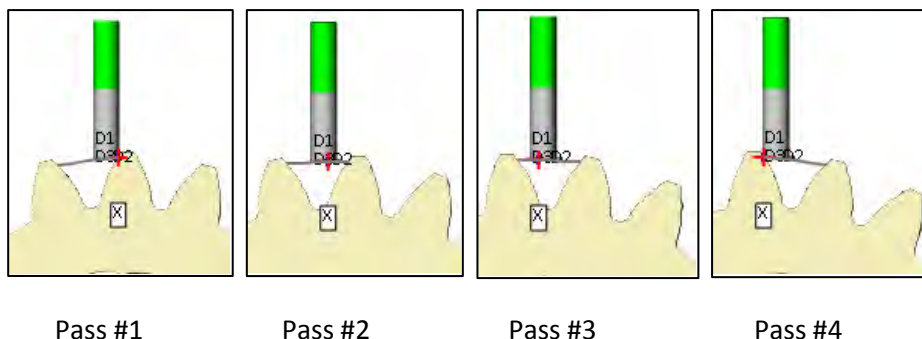


3) When creating a New Geometry, HyGEARS does not attempt anymore to control and prevent undercutting as this would interfere with the user's wish to given Addendum and Dedendum factors.

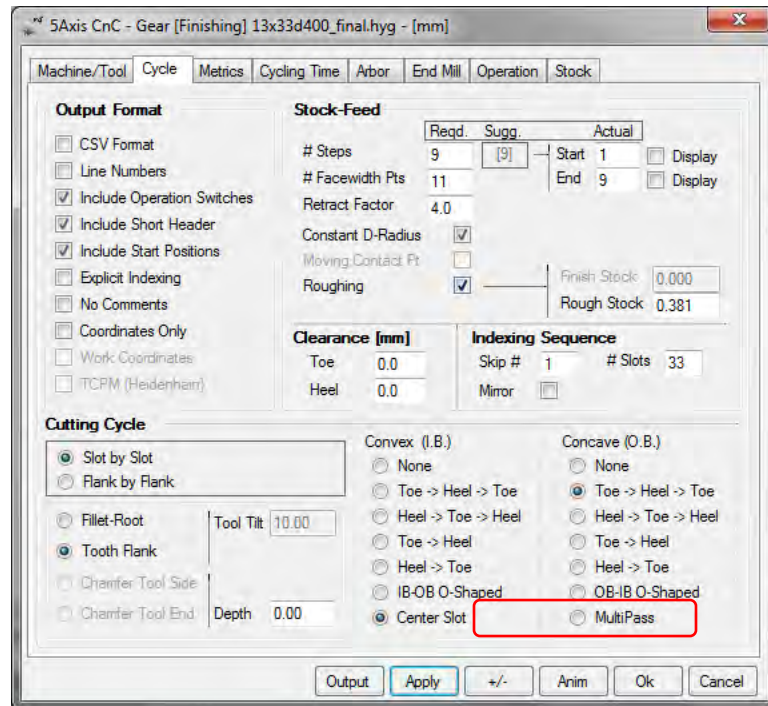
4) In 5Axis, addition of the "MultiPass" cycle in Roughing mode, for CoSIMT, End Mill and Ball Mill tools.

MultiPass will 1st move the tool from Toe to Heel along the Convex flank at a given depth-wise step; then based on the slot width at the current depth-wise step, a return pass at the same depth-wise step will be done; HyGEARS will make an even number of passes to entirely cover the slot width at the current depth-wise step, based on the slot width and the tool size (Point Width for CoSIMT, End Mill diameter, or Ball Mill diameter). Then, the next depth-wise step will be targeted. The tool will maintain perpendicularity to the blank at all times.

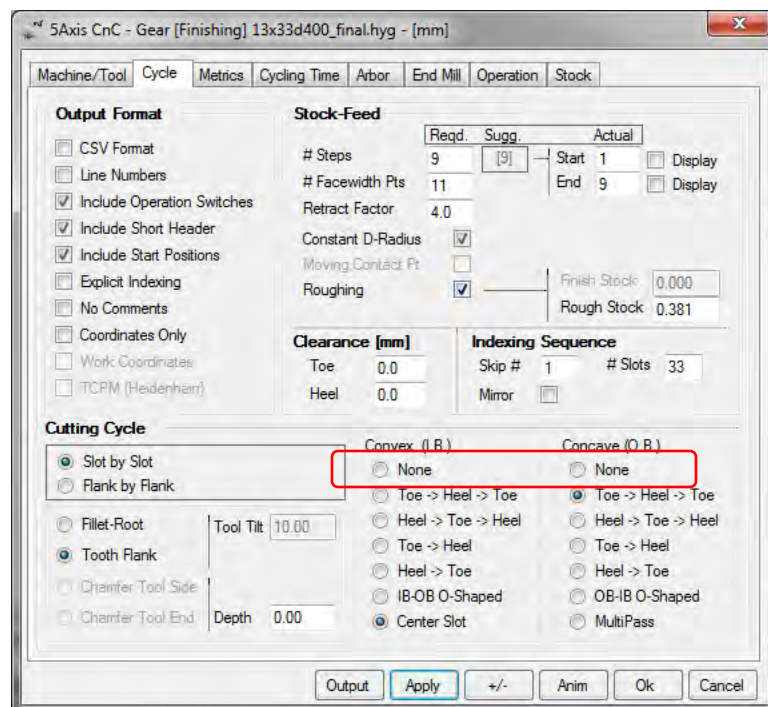
For example, the 4 images below show the End Mill tool at the same depth-wise step; each image shows the tool in a different pass. Once the 4th pass is completed, the tool will move to the next depth-wise step, and do as many passes as required to cover the local slot width.



One major advantage of MultiPass in Roughing is that a smaller tool could be used, which could cover the full tooth slot, rather than having to make different operations with different tools. Also, given the tool is not in a slot as would be the case with “Center Slot”, it can easily eject the chips and higher feeds can be used.



5) In 5Axis, addition of the “None” cycle, for CoSIMT, End Mill and Ball Mill tools. “None” is a “Flank by Flank” cycle which allows selecting only one tooth flank to be targeted for a given operation, such that a specific tool can be used for the selected tooth flank, or else, a different “# Steps”, “# Facewidth Pts”, or any other cycle combination can be chosen for each tooth flank.



6) In 5Axis, addition of the “Work Back” to the Arbor tab; the Work Back defines the volume comprised between the end of the teeth on the blank, where normally HyGEARS will stop showing the blank, and the beginning of the Heel Arbor.

5Axis CnC - Gear [Finishing] P33033-ModCG-2-ReP-ReG-ScottMod.HyG - [in]

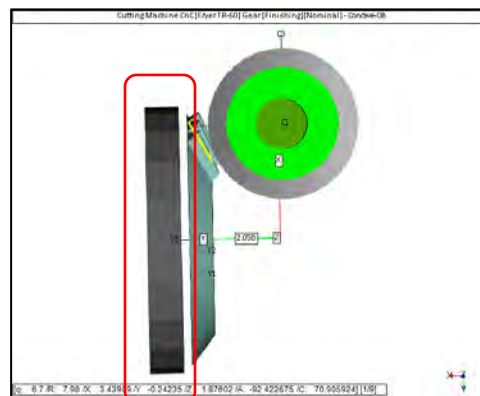
Machine/Tool Cycle Metrics Cycling Time **Arbor** CoSIMT Operation Stock

Arbor Details

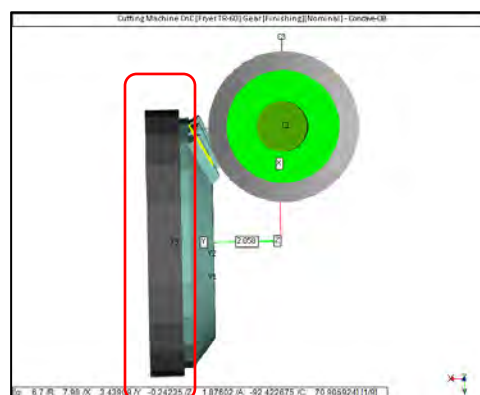
	Length	Diameter	Angle
Work Back			
	0.75	7.5	0.00
	0.00	0.00	0.00
	0.00	0.00	0.00
			Clear
Heel			
	1	8	0.00
	0.00	0.00	0.00
	0.00	0.00	0.00
	0.00	0.00	0.00
	0.00	0.00	0.00
			Clear
Toe			
	0.00	0.00	0.00
	0.00	0.00	0.00
	0.00	0.00	0.00
			Clear

Output **Apply** +/- Anim Ok Cancel

For example, in the figure below, a gap is seen where the “Work Back” could take place.

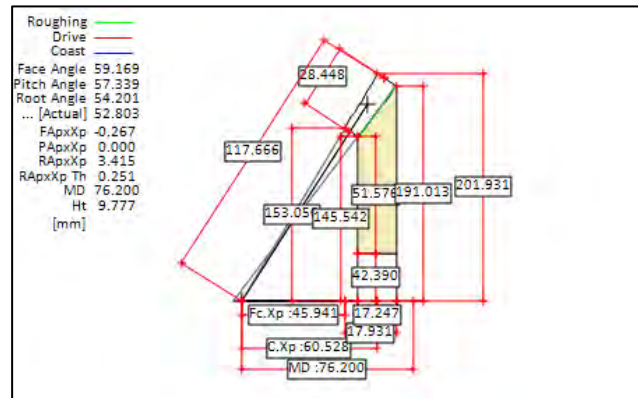


Defining the “Work Back” allows filling this space, as is shown below:

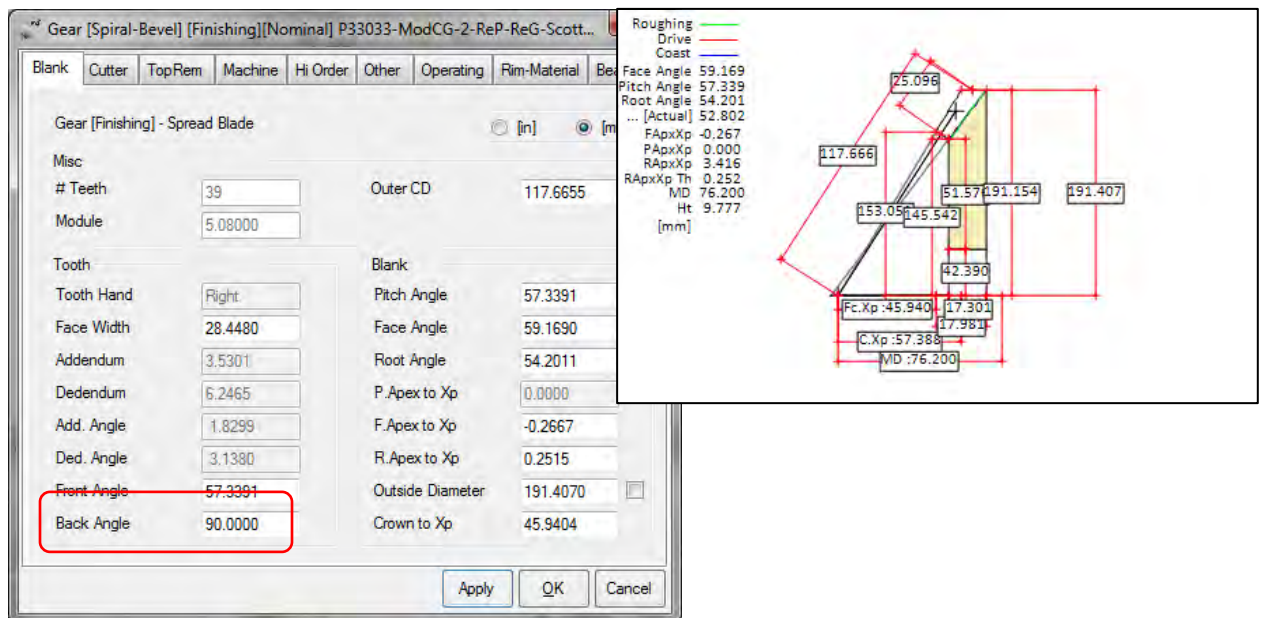


7) HyGEARS now allows defining “Turned OD” easily. Defining a “Turned OD” is done in 3 steps:

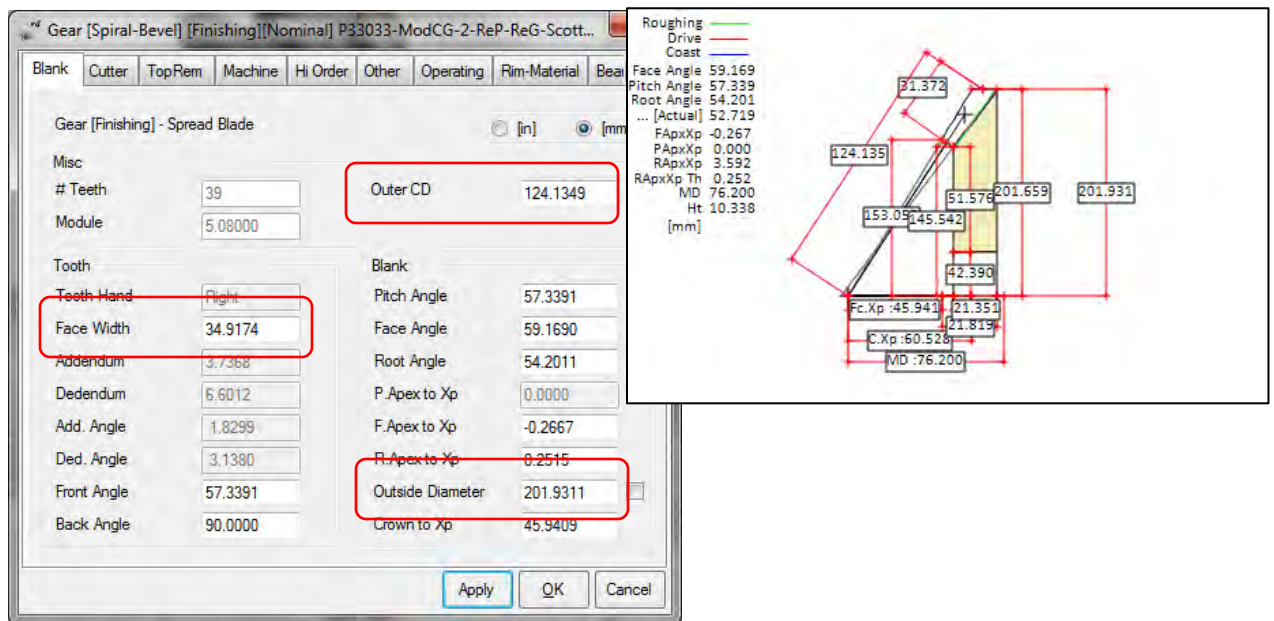
A. Select the Geometry mode to display the blanks; the gear blank is used below for this example;



B. Open the gear Summary editor (“Gea” function button). On the Blank page, enter the “Back Angle” as 90° and click on Apply; the OD is now shown as much smaller because the Outer Cone Distance (OCD) has not been adjusted;



C. Now, still on the Blank page, enter the desired Turned OD and click on “Apply”; HyGEARS will extend the OCD and Face Width to match the desired Turned OD while maintaining the Front Crown OD.

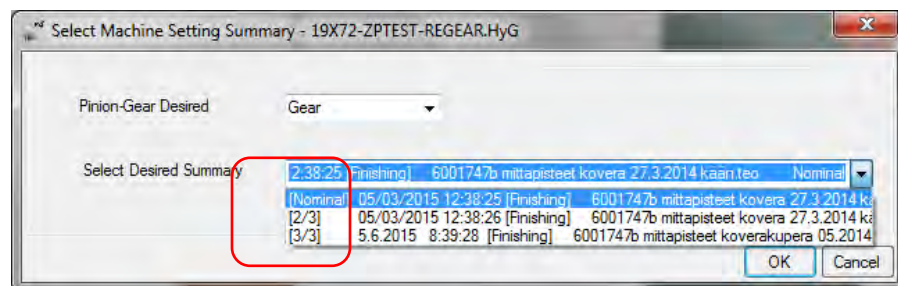


8) In “Machine” mode, using the “Sele” function (to determine which machine settings Summary is to be used in 5Axis) is now easier as HyGEARS displays at the beginning of each line which Correction iteration is considered.

For example, in the figure below, there are 3 machine settings Summaries:

- [Nominal] contains the original machine settings, i.e. those used to cut the original part;
- [2/3] contains the machine settings after the 1st correction;
- [3/3] contains the machine settings after the 2nd correction.

There are thus 1 Nominal and 2 corrections, hence 3 machine settings Summaries for this gear.

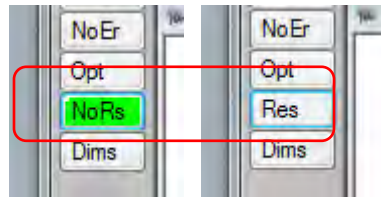


9) In 5Axis, the subroutine containing the specific codes to cut the tooth flank can now be given in a separate results window, implying that one results window is the “main program” - or calling program, and the other results window(s) is(are) the called “subprogram(s)”.

This stems from the fact that some controllers do not accept internal subroutines (for example some newer Fanuc controllers) while other controllers seem to “forget” what the calling address to an internal subroutine was when reaching the end of the internal subroutine, and thus generate an error when they cannot return to the calling line (Siemens SL on DMG CTXB 3000, HMCgears).

Internal subroutines, as was the HyGEARS default before, are more convenient to maintain since only 1 file is needed. The use of internal/external subroutines is defined when defining the machine and is machine specific, so users are recommended not to tamper with this.

10) In the TCA mode, addition of the “NoRs” / “Res” function button, used to toggle the BP display from the traditional view, where the contours of the BP are solid blue lines, to a view using a diffusion technique which shows the BP much like it will be when doing an actual VH test with marking compound.



Clicking on “NoRs” toggles the display to the diffused view and changes the name of the function button to “Res”; clicking on “Res” brings the display back to the default view and the function button becomes “NoRs” again.

Traditional view

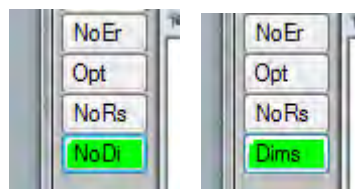


Diffused view

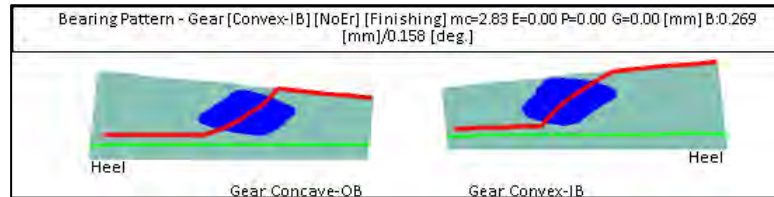


Using the “diffusion” technique can be quite useful in assessing what area of the tooth flank the BP will actually cover.

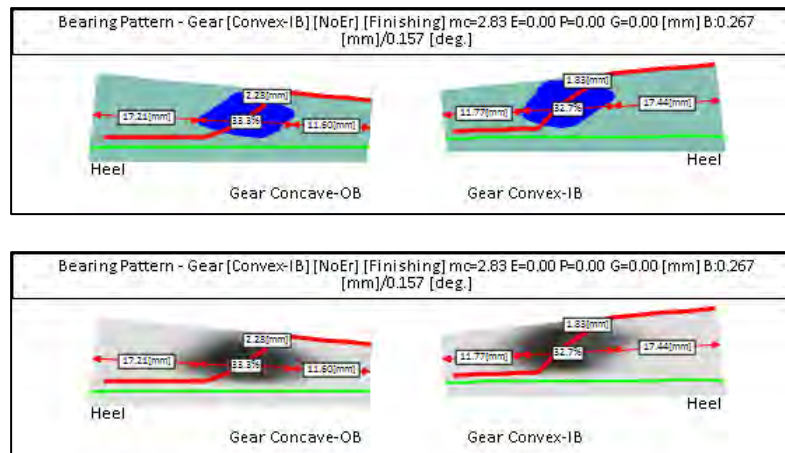
11) In the TCA mode, addition of the “NoDi” / “Dims” function button, used to toggle on and off the dimensions of the BP.



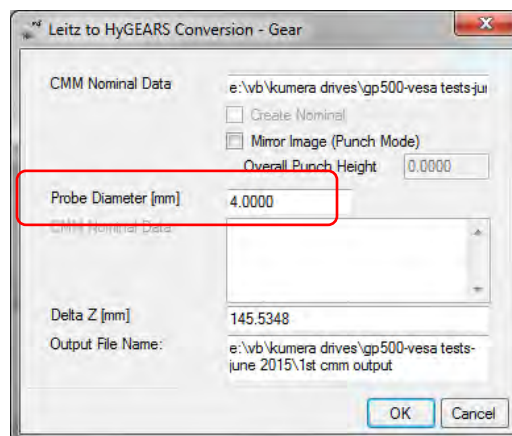
NoDi



Dims



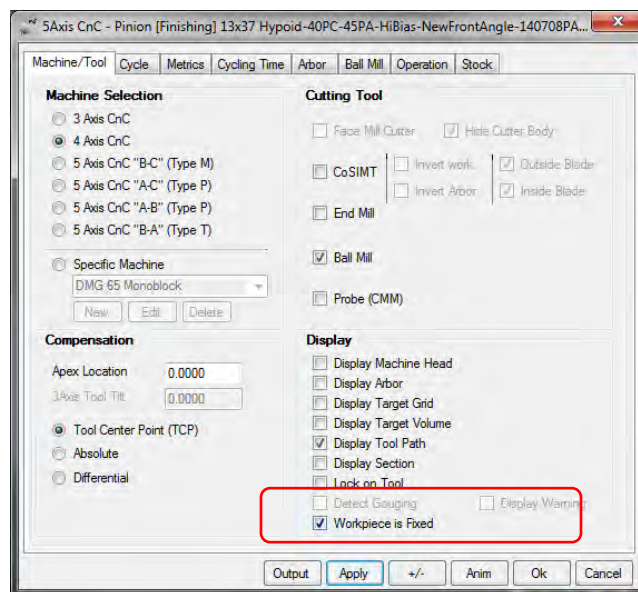
12) When converting CMM output data from a Leitz CMM, HyGEARS now offers to input the diameter of the Probe used for measurement. This is required because some CMM output comes out at the center of the probe, and then the probe diameter is needed for compensation.



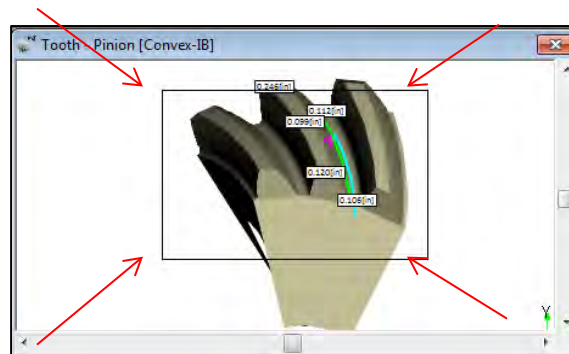
13) In “Corr-RE” mode, addition of the “Stat” function buttons to both the Pinion and Gear groups. The “Stat” button calculates and displays the surface statistics for the chosen member based on the current measurement data file.

Measured Surface Statistics			
175-F - Meas.Surface : Test-1.mes/1 Pinion [Finishing] [Nominal]			
Date	:	17/06/2015	
Time	:	5:22:58 PM	
Units	:	[mm] [dd.mm.ss]	
Prepared by	:	Claude	
AVERAGE ERRORS		(O.B.)	(I.B.)
Tooth Thickness	[mm] :	0.4991	
Pressure Angle	[dd.mm.ss] :	0.05.54	-0.03.02
Spiral Angle	[dd.mm.ss] :	0.03.07	-0.04.16
Crowning	[mm] :	-0.0023	-0.0020
Profile Curvature	[mm] :	0.0289	0.0352
Warp Factor	[/10 mm] :	0.06.16	-0.02.37
Sum Errors Squared	[in] :	0.0000349	0.0000521

14) In “5Axis”, when animating with the “Workpiece is Fixed” display option, the tool would be seen jumping all over the place during the retract segment of the animation because of an unset variable related to the work rotation angle.. This is now corrected.

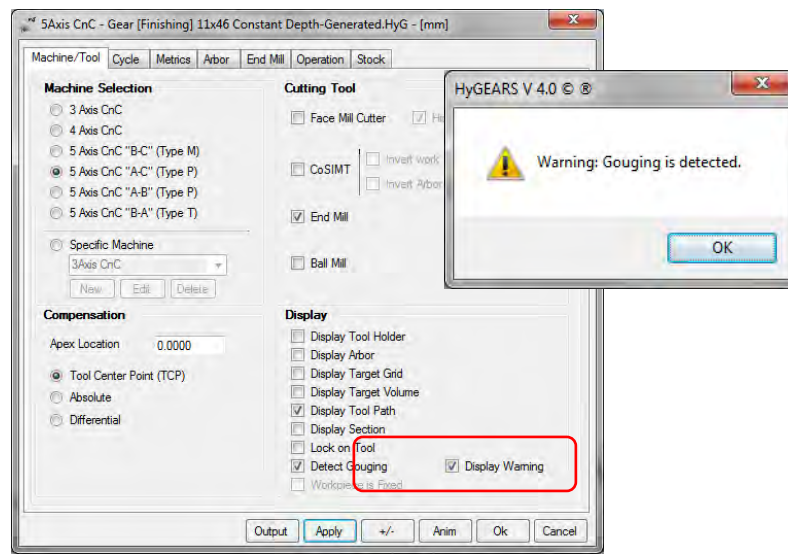


15) When Zooming in a Childwindow using the “Ctrl” key and Right Mouse button click, the bounding rectangle delimiting the Zoom area can now be initiated from anywhere and be incremented in any direction, whereas before, it had to be started in the Upper Left corner and ended in the Lower Right corner.

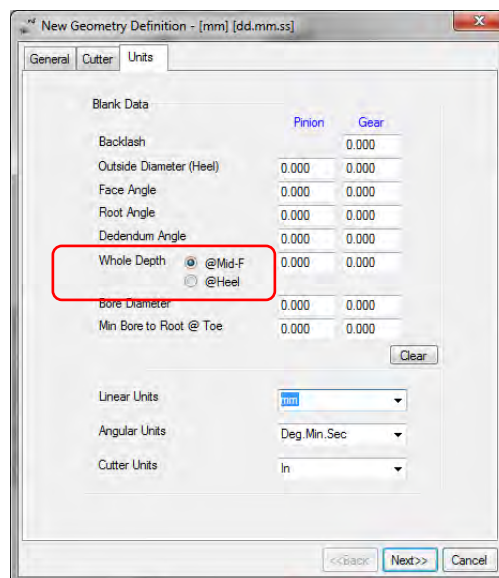


HyGEARS update – 05 May 2015 - Build 404.40 - 457

- 1) In 5Axis, extension of the Metrics output such that it covers both straight edged tools (CoSIMT, End Mill) and curved edge tools (Ball Mills) on the tooth flank profile when calculating the “Flat-Prof” (for straight edged tools) of the “Peak-Prof” (for curved edged tools) deviations that are used to decide on the number of depth wise steps needed for a given surface finish.
- 2) In 5Axis, it is now possible to ask HyGEARS to display a Warning message whenever Gouging is detected.

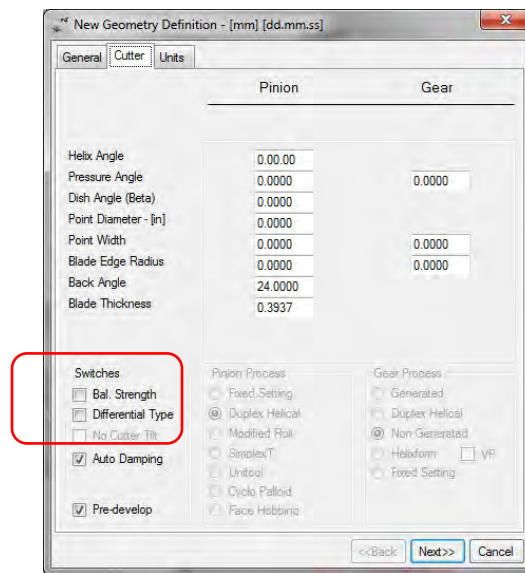


- 3) When creating a New Geometry of the spiral bevel, hypoid, Zerol or Coniflex type, the Whole Tooth Depth can now be specified at either Mid-Face or Heel, thereby offering more flexibility in reproducing existing gear blanks.

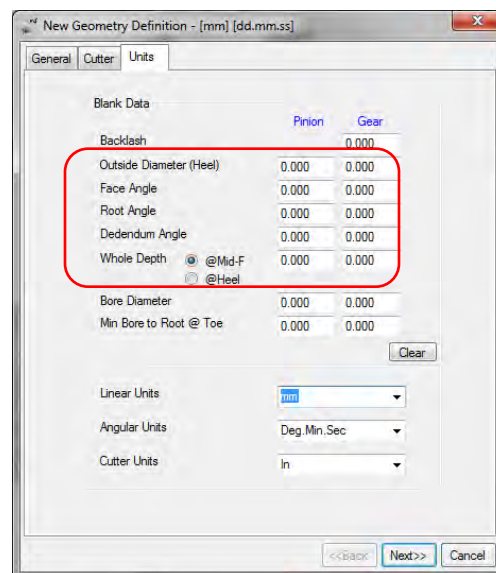


- 4) When creating a New Coniflex gear set, blank shape can now be imposed as “Differential Type” and the “Bal. Strength” switch can be selected to ensure the static bending capacity of the Pinion and Gear teeth

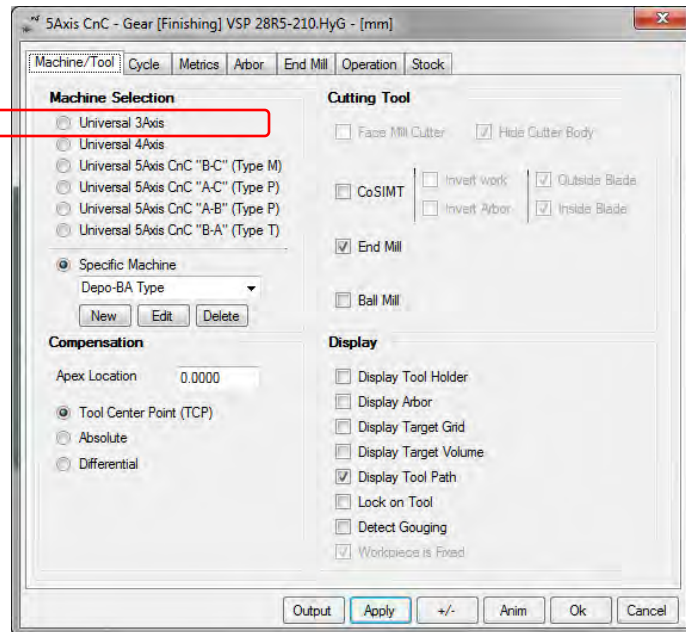
are comparable. This is especially important when imposing Whole Tooth Depths (above) which are significantly different from the default values calculated by HyGEARS.



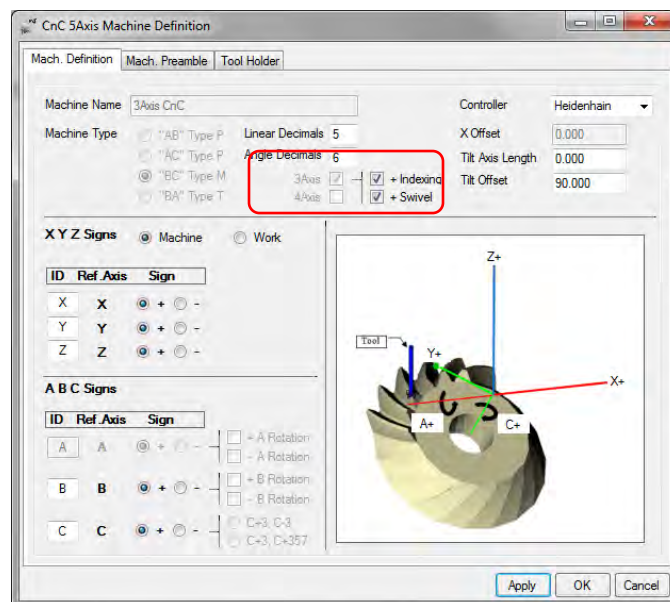
5) When creating a New Coniflex gear set, blank dimensions can now be specified in the same way as those of a spiral bevel gear.



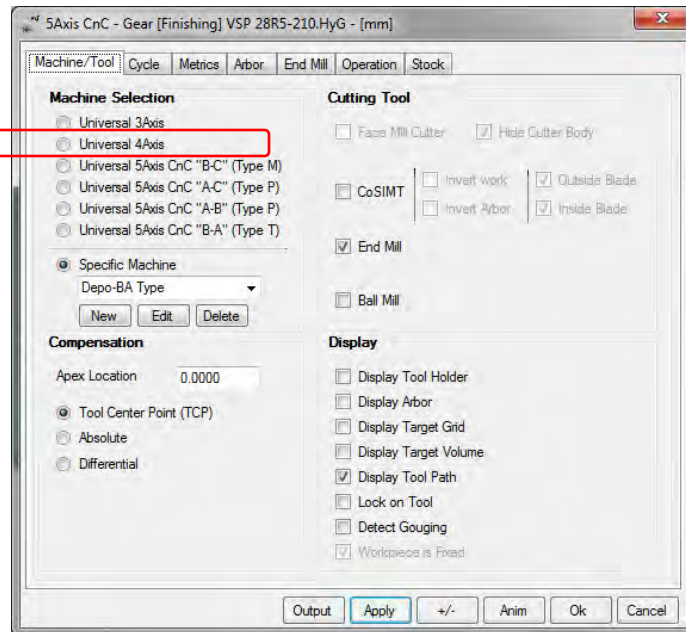
6) CnC manufacturing ("5Axis" function button) now offers 3Axis machines (sold as options). The 3Axis machines can only use End Mill and Ball Mill tools.



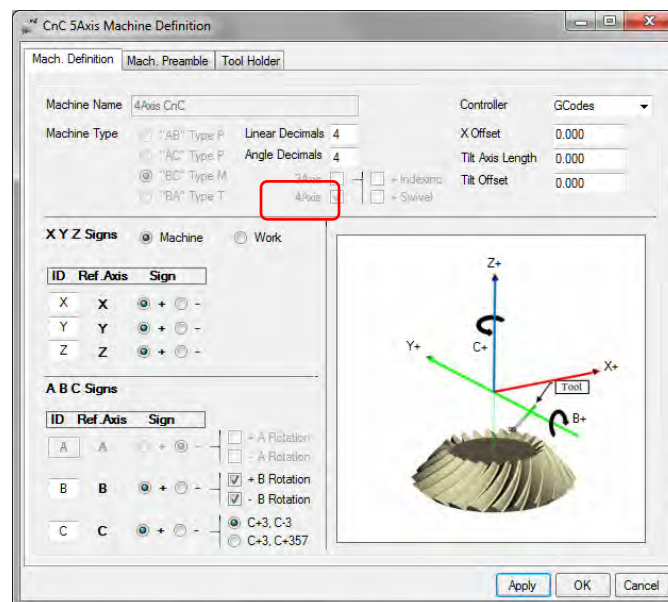
3Axis machines can be used on bevel gears with straight teeth and a large enough pitch cone angle. They can be defined as XYZ only; tool tilt and work indexing can also be defined, such as would happen in 3+1 and 3+2 machines where the B (tool tilt) and C (work indexing) axes are not controlled simultaneously. Thus, in the part program, B and C would be given on separate lines at the beginning of each program section.



7) CnC manufacturing ("5Axis" function button) also offers 4Axis CnC machines (sold as options). The 4Axis machines can use End Mill, Ball Mill and CoSIMT tools for all gear types; Face Mill cutters can be used when there is no cutter tilt. Like their 5Axis counterparts, specific machines can also be defined.

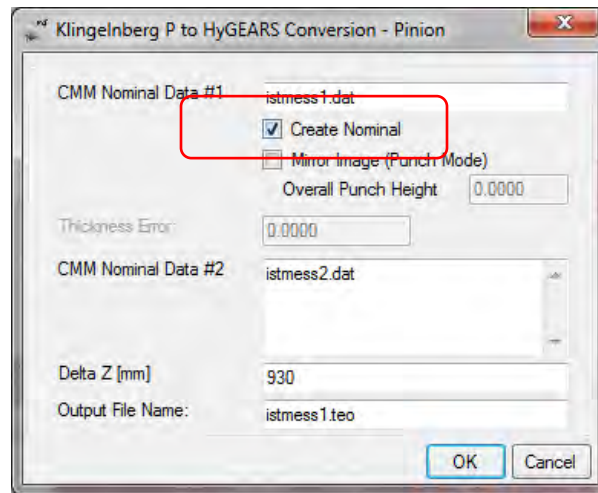


4Axis machines can be used on spur and helical gears, with and without lengthwise crowning, using End Mill, Ball Mill and CoSIMT tools; they can also be used to cut generated and non-generated (Formate) spiral-bevel gears, using a Face Mill cutter, when cutter tilt is zero since the B angle does not change.

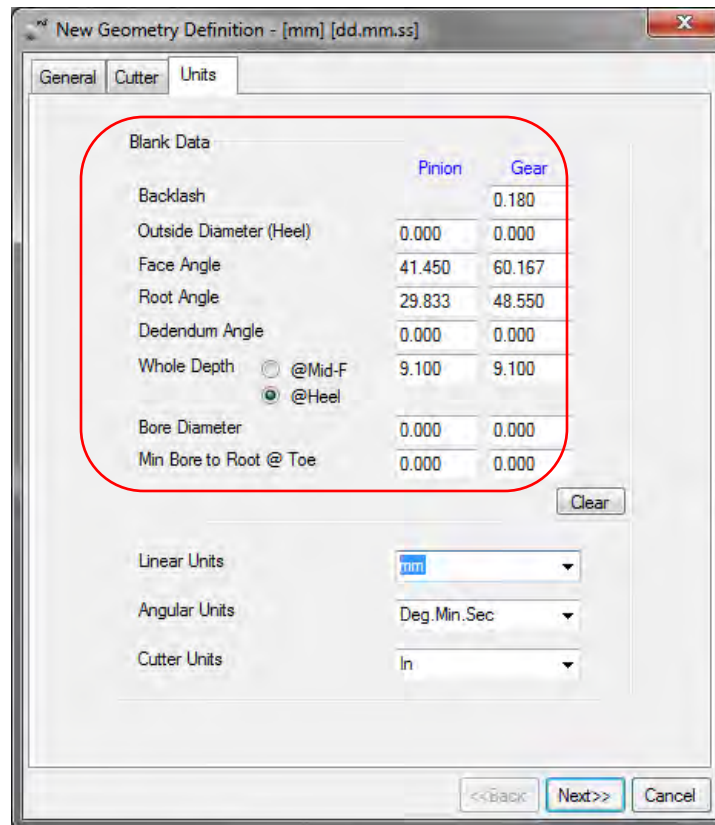


8) Modification in the way the Klingelnberg-P CMM output is converted to HyGEARS: whenever a CMM output file is detected as being passed to the conversion function, HyGEARS will display the conversion window where selections can be made, such as extracting the “Nominal”, i.e. without the errors, thereby allowing the verification of the CMM target file that was employed for measurement.

Such a verification may be desired when measured deviations are large and one wants to confirm how the CMM Target file complies with the theoretical topography.



9) When creating a New Straight Bevel gear set (either Generated or Net Shape), the Blank Data is now changed to the common bevel gear interface as shown below:



10) In 5Axis, the End Mill and Ball Mill tools now have 3 additional features describing them: Holder Diameter, Length and Angle. These describe the tool holder which normally sits between the Machine Head and the tool. Whenever Diameter and Length values are given, the holder will be displayed with the tool. Leaving any of these values blank results in no holder display.

Cutting Machine CnC [Universal 5 Axis 'A-C'] Pinion [Finishing][Nominal] - Left

5Axis CnC - Pinion [Finishing] Test-1-Ext.hyg - [mm]

Machine/Tool Cycle Metrics Cycling Time Arbor End Mill Operation Stock

End Mill Details Name

Clear Save Delete

Diameter	12
Edge Radius	3
Cone Angle	0.0000
Cutting Length	20
Cutting Length in Use	15
Tool Length	30
Stem Diameter	12
Holder Diameter	25
Holder Length	35
Holder Angle	10

Tip Reference ☒

Fillet Rad. [Toe] 5.5442
Fillet Rad. [Heel] 5.5442
Slot Width [Toe] 14.9364
Slot Width [Heel] 14.9364

Feeds [mm/min]
Rapid Move 1500.0 Plunge 50.0 Cutting 500.0

Output Apply +/- Anim Ok Cancel

12) In 5Axis, introduction of the Cycling Time, i.e. the estimated duration of the cutting cycle based on the tool feeds and cycle selection. Cycling time includes values for each tooth flank:

- Line: time needed to do one Toe to Heel or Heel to Toe pass;
- Face: time needed to complete one tooth flank;
- Plunge/Retract: time needed to either plunge or retract the tool;
- Return: time needed for the Return Trip, i.e. after retracting to the next plunge.

Then, the times needed per slot, indexing and operation are given, along with the Feeds used in the calculations.

Cycling Time	
Left	
Line:	38.10 [sec]
Face:	190.50 [sec]
Plunge/Retract:	136.36 [sec]
Return:	12.70 [sec]
Flank:	475.91 [sec]
Right	
Line:	38.10 [sec]
Face:	190.50 [sec]
Plunge/Retract:	136.36 [sec]
Return:	12.70 [sec]
Flank:	475.91 [sec]

```

Total/Slot:    951.82 [sec]
Indexing:      1.59 [sec]
# Slots:       21
Operation:     333.69 [min]

Cutting Feed:  500.00 [mm/min]
Plunge Feed:   50.00 [mm/min]
Rapid Move Feed: 1500.00 [mm/min]

```

13) In 5Axis, addition of 2 switches to the Cycle / Output selection, where the “Short Header” and the “Start Positions” can be explicitly included or excluded from the part program.

- The “Short Header” is the very 1st section of the part program, which gives a brief review of what is at stake:

```

;*****
;PROGRAM NAME      :
;PROGRAM DATE      : 05-05-2015
;TOOL ID           : 1
;TOOL DIAMETER     : 12.00[mm]
;TOOL LENGTH       : 30.00[mm]
;*****

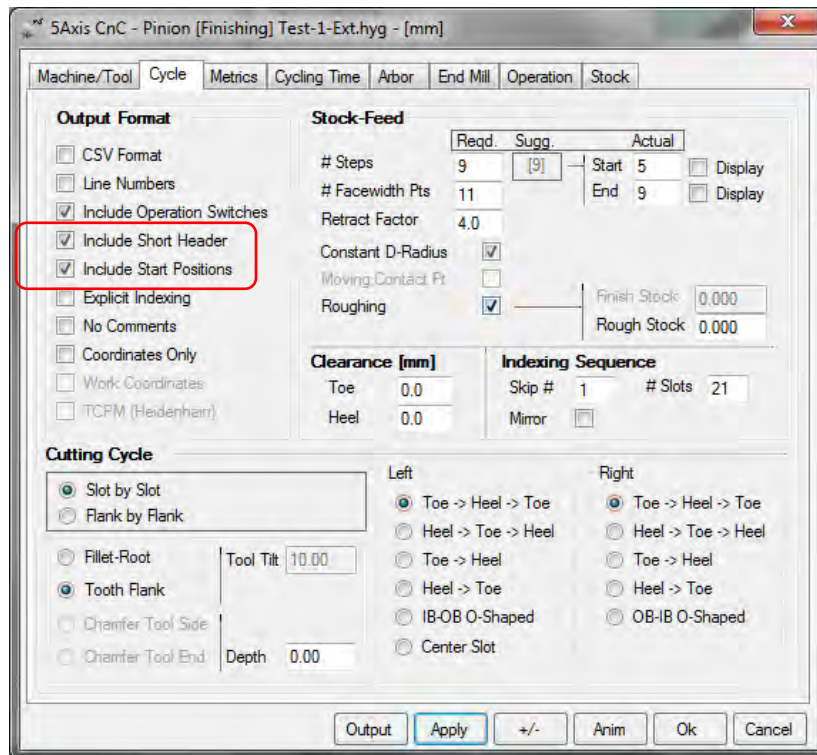
```

- The “Start Positions” provide several variables with the X, Y Z, A, B and C initial values which can be used by special cycles:

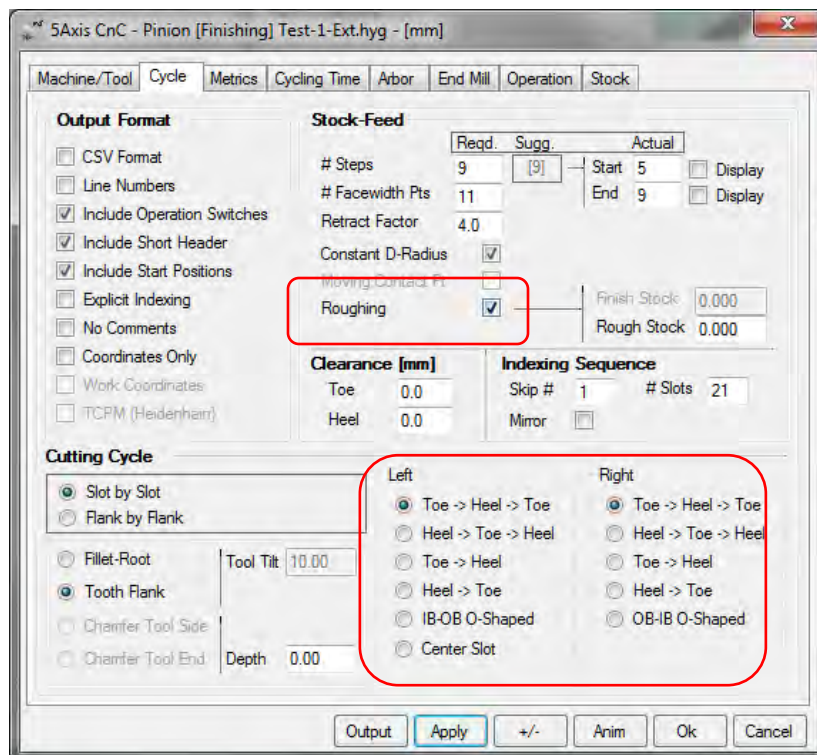
```

; ----- Begin Start Positions -----
DEF REAL HYG_POSX = 9.03501
DEF REAL HYG_POSY = 0.00000
DEF REAL HYG_POSZ = 245.35820
DEF REAL HYG_POSA = 90.000013
DEF REAL HYG_POSC = 185.877469
; ----- End Start Positions -----

```

14) In 5Axis, Roughing the tooth flank with an End Mill or a Ball Mill can now be done in all of the Finishing cutting cycles as shown below. The “Rock Me (Babe)” Cycle is replaced by “Center Slot” which was the original cycle for Roughing.

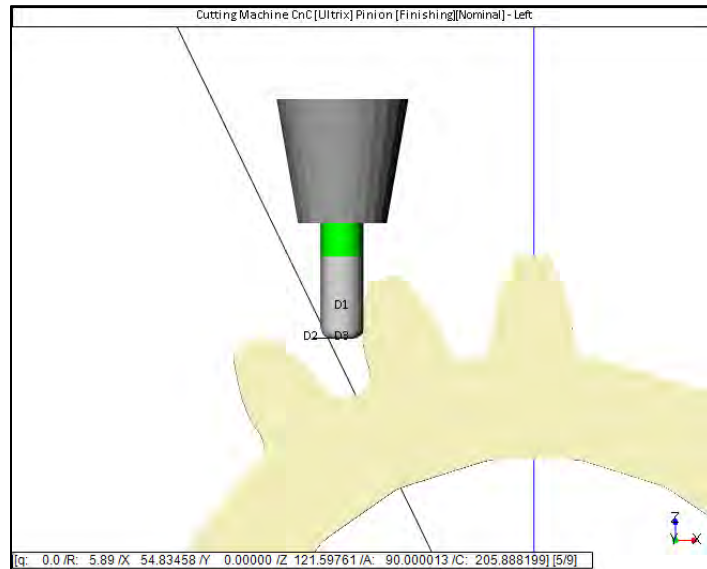


Additionally, the tools are orientated perpendicularly to the OD of the part, such that End Mills with replaceable insert can be used without any risk of damage when the tool is tilted relative to the surface.

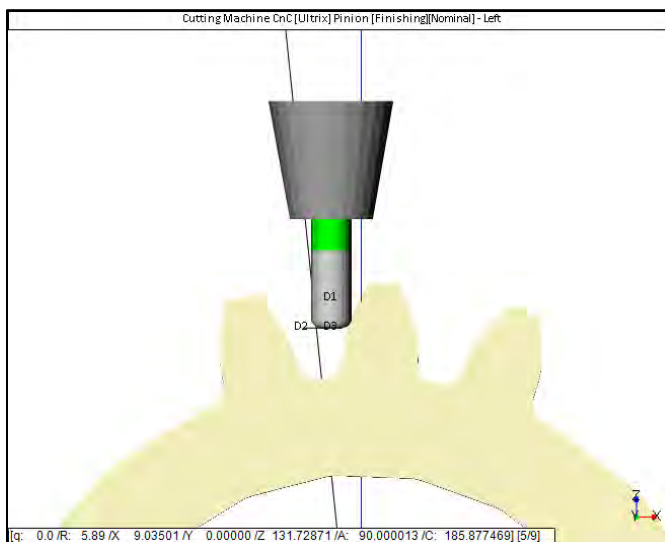
One consequence of roughing this way is that the profile will be cut in a step-wise manner; thus, a rather large number of steps may be needed to provide an acceptable surface whereas in Finishing mode, the tool being tangent to the surface, tooth profile is acceptable even with a low number of steps.



End Mill with replaceable inserts



End Mill in Finishing orientation – tangent to the tooth flank

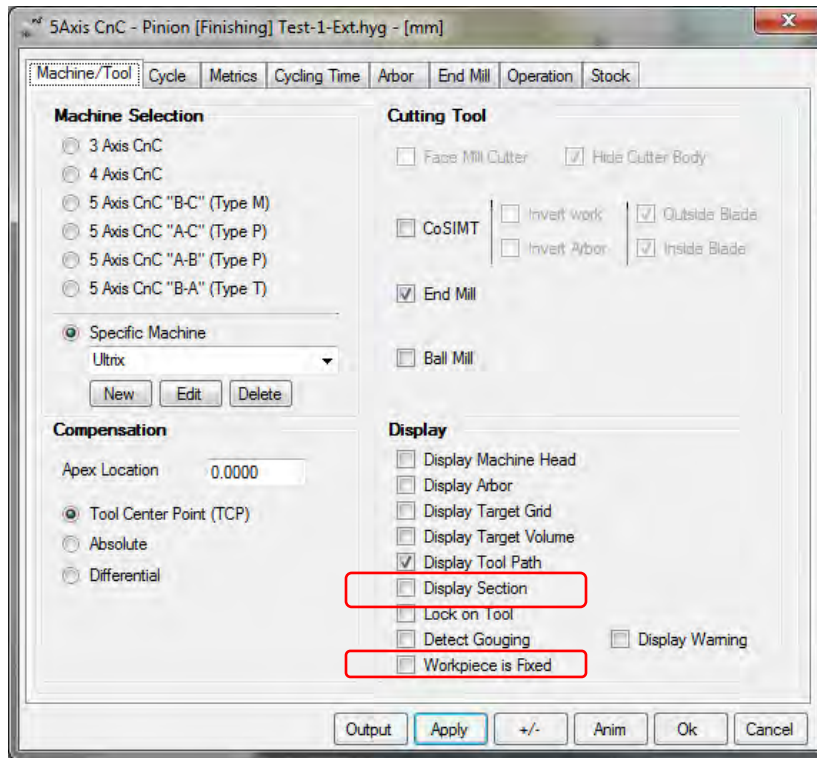


End Mill in Roughing orientation – Perpendicular to the OD

15) In 5Axis, addition of 2 new Display Switches on the Machine/Tool tab:

- Display Section: shows a section of the tooth in the Normal plane; useful when cutting in 3Axis mode and one desires to see the spatial relation between the tooth profile and the tool axis;

- Workpiece is Fixed: the work piece does not rotate any more, but the tool is rather pivoting about the tooth. Useful to limit the movements of the part and tool when looking in high zoom modes; it also allows to better visualize the tool to work movements. Gouging detection is automatically disabled when selecting “Workpiece is Fixed”.



16) Addition of the Start and End Cradle angles of the cutting cycle to the Machine Settings section of the Summary output.

17) Expansion of the SPA import function such as to calculate the FApXp and RApXp of spiral bevel gears as those are normally provided only for hypoid gears.

18) In the edition of a spiral bevel or hypoid Summary (“Pin” or “Gea” function buttons), when changing the Cutter Gaging entry in the Cutter data page and clicking on the “Apply” button, HyGEARS will now calculate and apply the changes in machine settings needed to accommodate the requested gaging value; the Machine page is then updated to reflect the new machine settings.

19) In 5Axis, it is now possible to have a Moving Contact Point with a Ball Mill tool on the tooth flank. When instructed, HyGEARS will impose the given Tool Tilt to the tool at the OD, and progressively decrease the Tilt until zero at the Fillet line, thus avoiding any possible collision with the opposite tooth flank.

20) In 5Axis, when a Toe or Heel clearance is needed, HyGEARS now attempts to have a more continuous extension of the tooth, including a continuous rotation of the work piece as the tool moves out of the tooth gap. This is especially useful when using a CoSIMT as if the outside angle of the tool is negative, damage could occur to the convex flank of the teeth.

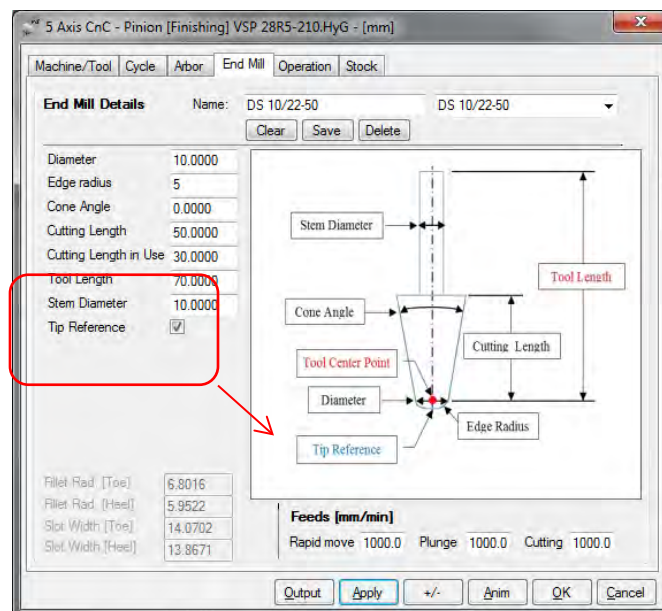
21) In 5Axis, for the roughing operation using a CoSIMT, the tool now follows the points comprised in the Toe and Heel clearances.

HyGEARS update – 09 March 2015 - Build 404.30 - 457

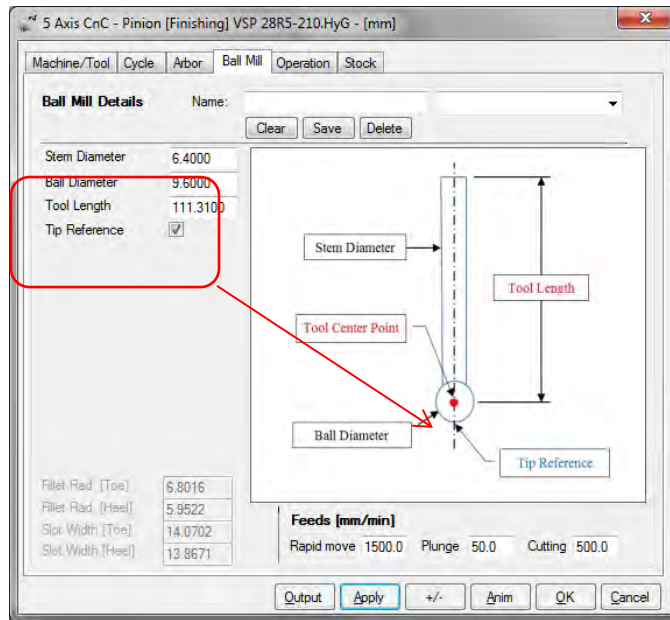
1) When installing HyGEARS, the Setup program, which must be “Run as Administrator” since components must be registered with the system, now creates a folder called HyGEARS40 in the path “c:/user/MyDocuments” where all tool, configuration, registration, machine, oil, material and other support files that are accessed during the use of HyGEARS are now stored. This folder is not protected, and therefore, HyGEARS does not need to be “Run as Administrator” anymore (that is, from Build 404.30).

Existing support files will be searched in previous installations, and if found, the user is notified of the files found which are then copied to folder “c:/user/MyDocuments/HyGEARS40”.

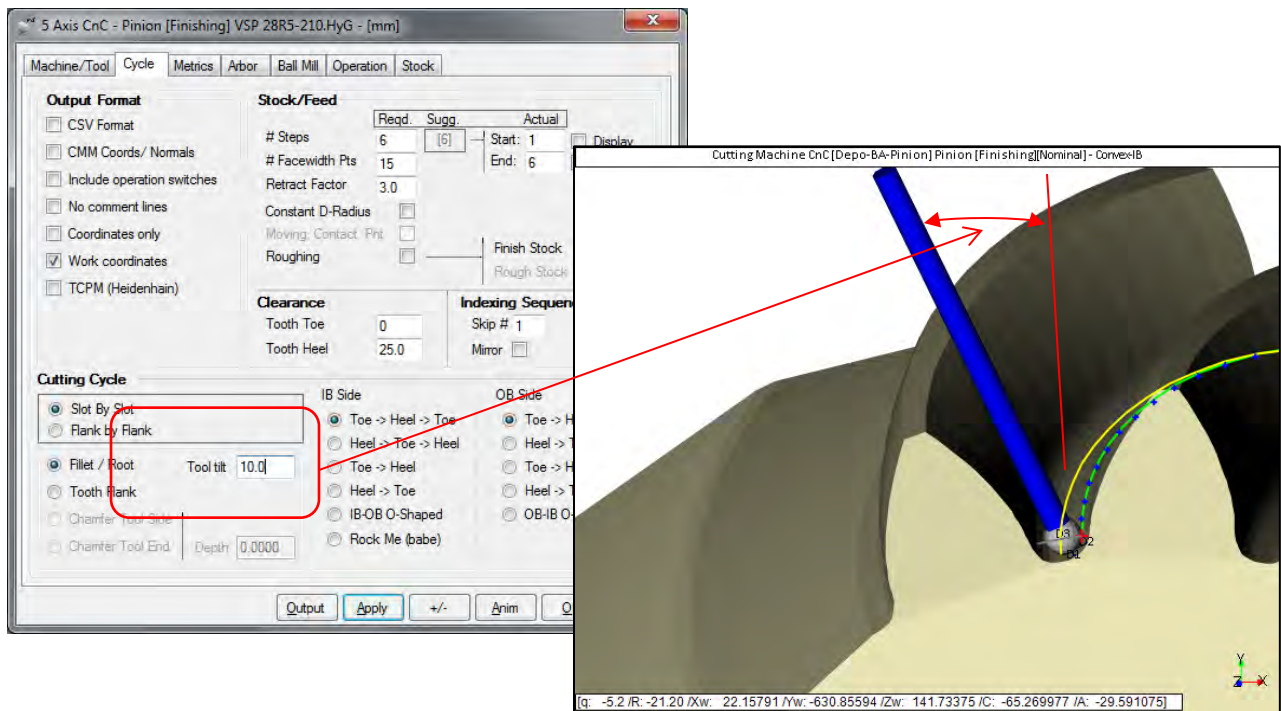
2) In 5Axis, addition of the “Tip Reference” check box to the End Mill tool. When this option is selected, the tool coordinates are given in reference to the tool tip rather than the HyGEARS usual Tool Center Point (TCP). Thus, machine operators do not have to enter a tool length change in the controller to account for the fact that the ref. point is the TCP. [Requested by A. Pfitzer, Voith Turbo Schneider GmbH].



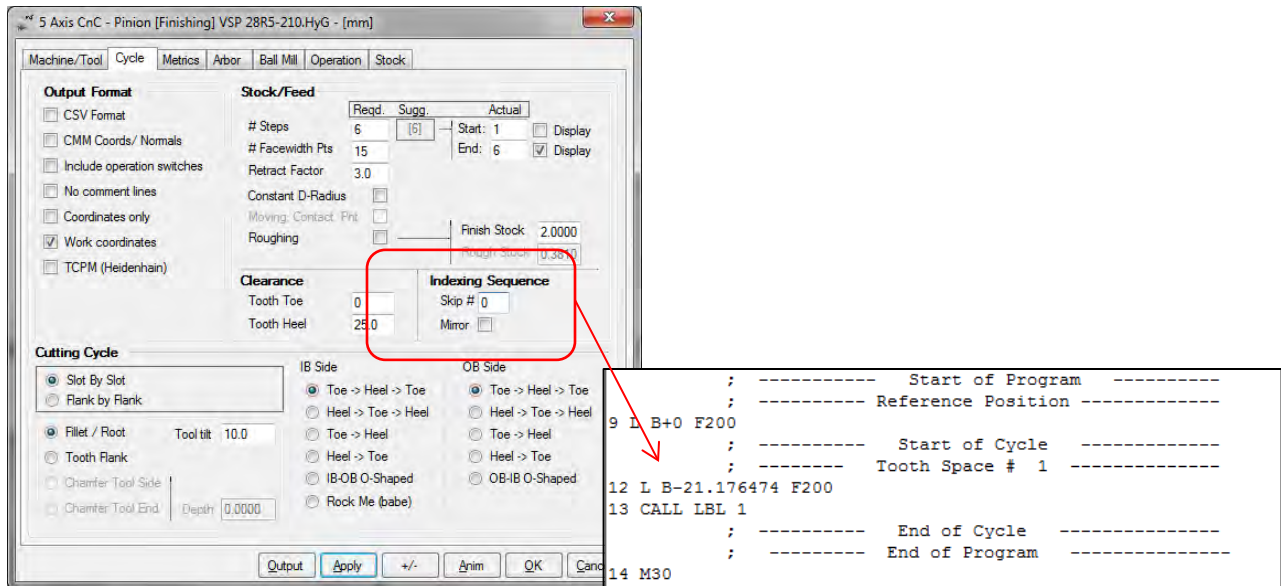
3) In 5Axis, addition of the “Tip Reference” check box to the Ball Mill tool. When this option is selected, the tool coordinates are given in reference to the tool tip rather than the HyGEARS usual Tool Center Point (TCP). Thus, machine operators do not have to enter a tool length change in the controller to account for the fact that the ref. point is the TCP. [Requested by A. Pfitzer, Voith Turbo Schneider GmbH].



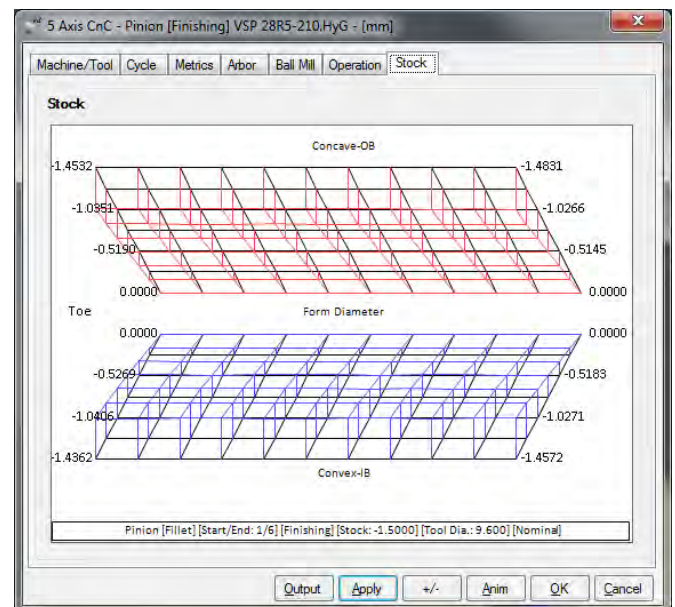
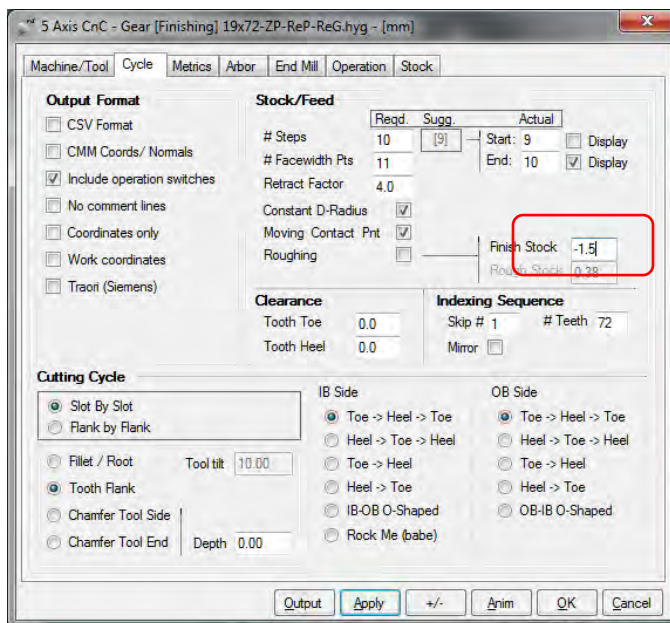
4) In 5Axis, when the Fillet Cutting Cycle is chosen, the “Tool Tilt” angle can now be selected freely. Tool Tilt in the Fillet is used to tilt the tool away from the considered tooth flank such that no interference occurs between the tool shaft and the considered tooth flank when cutting near the Fillet line. At the Fillet line, the entered Tool Tilt value is fully used; as the cutting point moves away from the Fillet line towards the bottom of the tooth gap, Tool Tilt decreases progressively to become null at the bottom. Default value is 10 degrees. [Requested by A. Pfitzer, Voith Turbo Schneider GmbH].



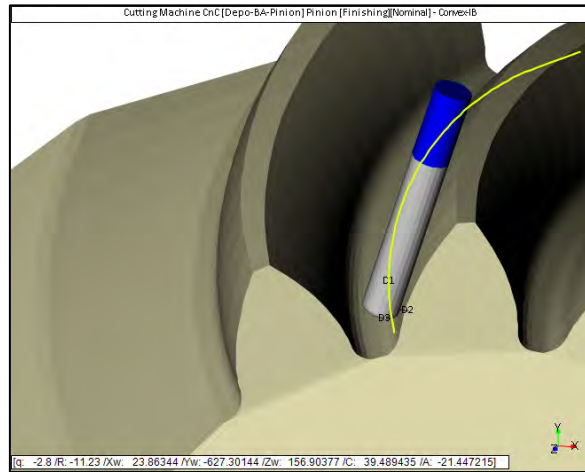
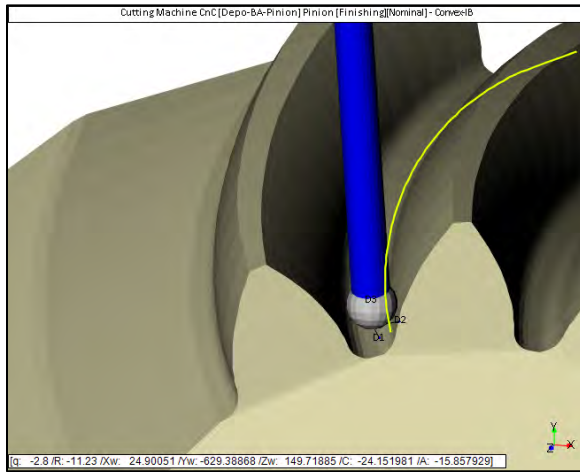
5) In 5Axis, when the “Skip #” of the Indexing Sequence is zero, the cutting cycle of the Part Program comprises only 1 tooth gap. This is done to simplify the job of CnC machine programmers which already have “canned” cycles to cut gear tooth gaps.



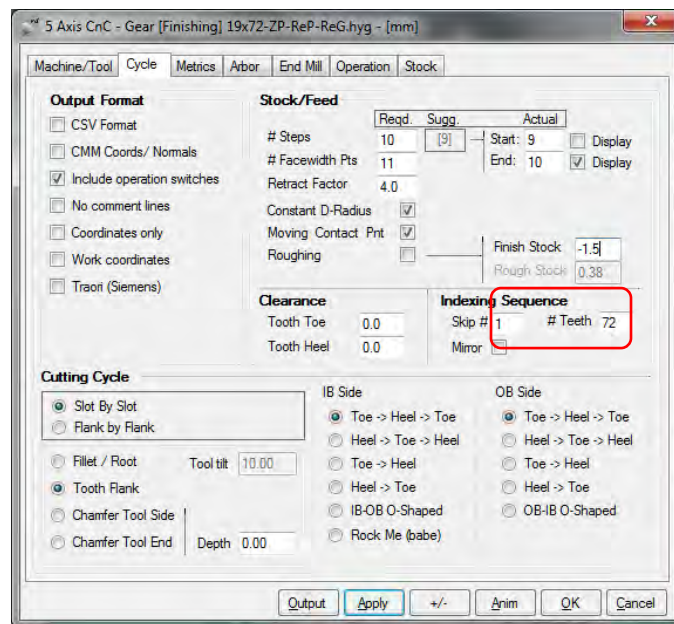
6) In 5Axis, when the “Finish Stock” is negative for the “Fillet / Root” Cutting Cycle, HyGEARS now imposes the Stock to be zero at the Fillet line (or Form Diameter), and to progressively decrease to the requested value when reaching the bottom of the tooth gap. This ensures that any negative protuberance imposed in the fillet area does not mutilate the fillet in the immediate vicinity of the fillet line.



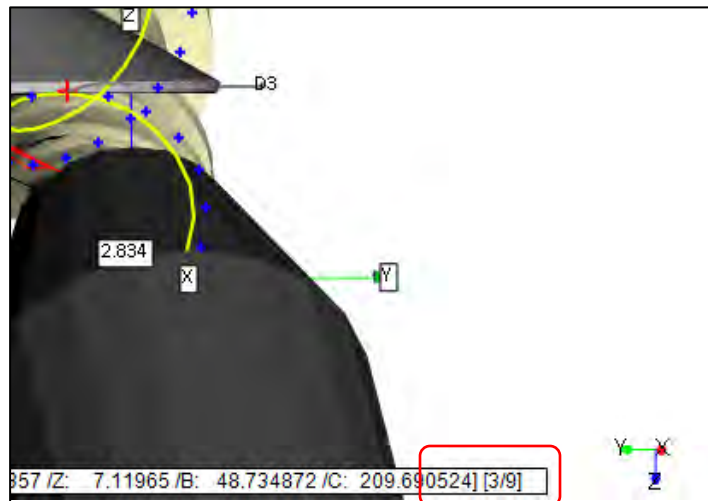
7) In 5Axis, when changing tool type for a given machine, the display projection is not reset anymore such that the selected view is maintained for an improved user comfort when considering different tools in a given situation.



8) In 5Axis, addition of the “# Teeth” to the “Indexing Sequence”, Cycle Tab. The # Teeth is the actual number of teeth which will be treated in the part program. Minimum is 1, maximum is the tooth number of the target part. [Requested by S. Kauranen, Kumera Drives].

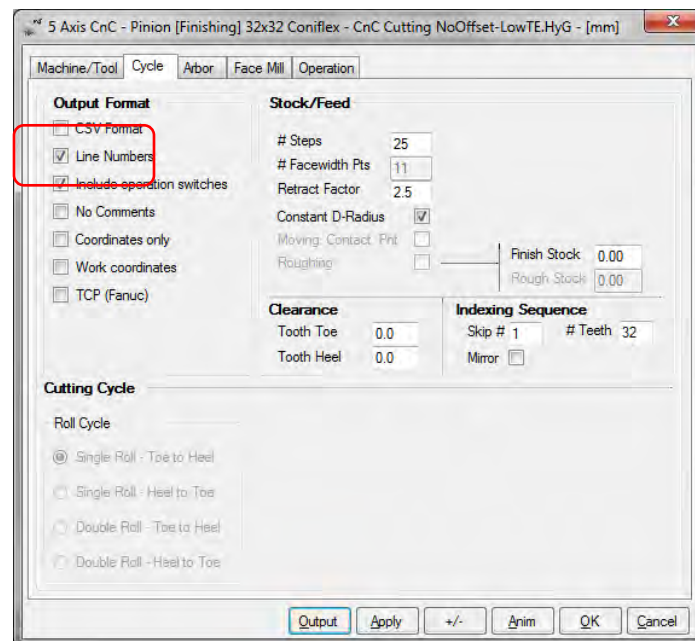


9) In 5Axis, addition of the “Step Number / End Step Number” to the Child Window Display of the XYZ and ABC coordinates. This is presented in the form [x/y] where “x” is the current depth wise step, and “y” is the current number of the end depth wise step. This can be especially useful when identifying at what depth wise step Gouging begins.

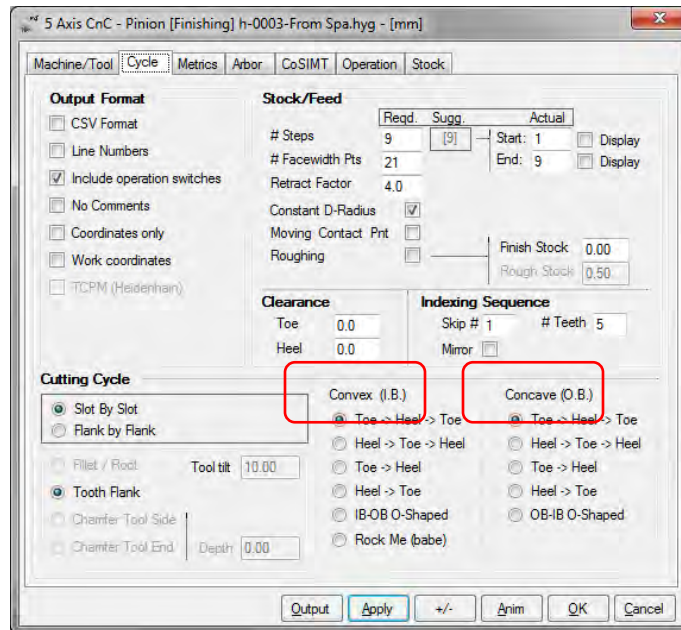


10) In 5Axis, addition of the “Line Numbers” switch which instructs HyGEARS to include/exclude the line numbers in the part program. Given most controllers can provide their own numbering once the part program has been read, by default this option is not set.

If the “CSV Format” output is selected, then the line numbers are never added, no matter whether the “Line Numbers” option has been selected or not.



11) In 5Axis, for spiral bevel type gears, the IB side is now renamed “Convex (I.B.)” and the OB side is renamed “Concave (O.B.)” in order to help those users not familiar with the IB and OB acronyms.

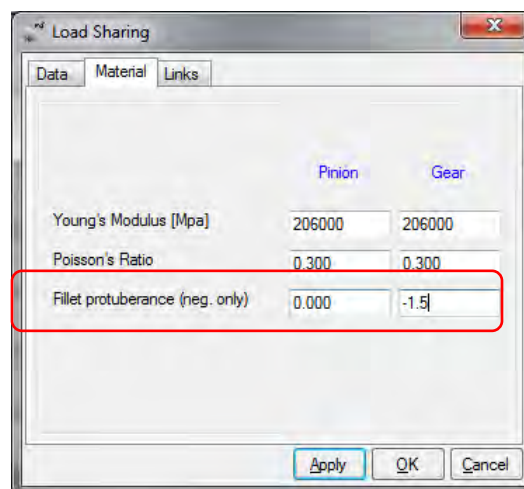


12) In 5Axis, machine axes X, Y, Z and rotation angles A, B, C can now comprise up to 3 characters such that rotation axis “C_1” can be used.

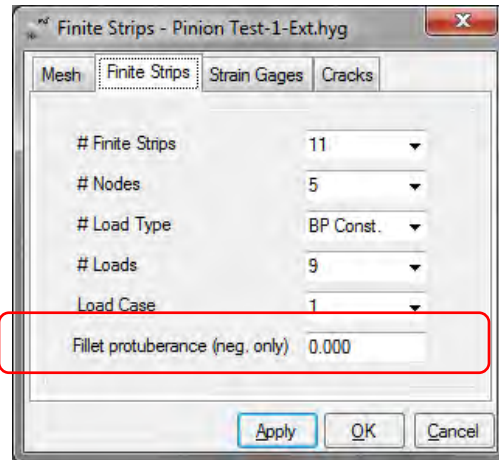
13) In 5Axis, when the Roughing cycle is turned on, the default IB and OB cycles now revert to Toe-Heel-Toe.

14) In 5Axis, when the “Rock Me (babe)” cutting cycle has been selected, the maximum # of Toe and Heel clearance points is limited to 4.

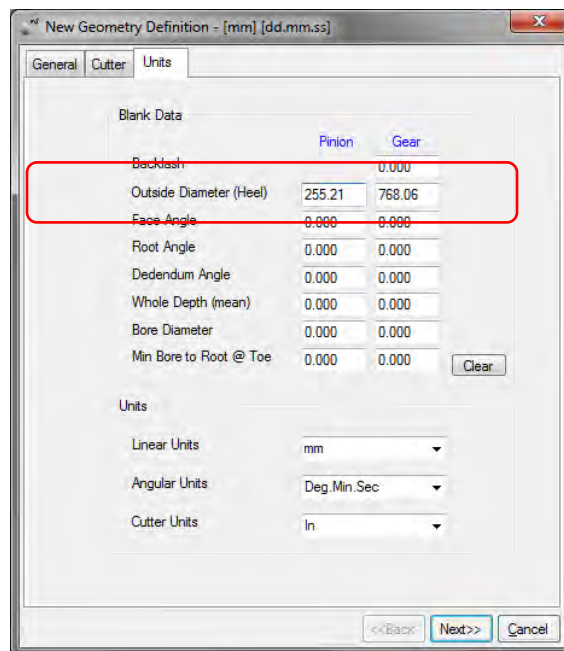
15) When calling the LTCA “Load” input form (“Load” function button), the “Material” tab now includes an entry for “Fillet Protuberance”. This is the same protuberance as that used in 5Axis for the fillet; it can only be negative to be used. This allows the estimation of the effect a protuberance will have on bending stresses. It is applicable to both Pinion and Gear. By default, the value is always zero; to see the effect, a negative value must be entered and the “Apply” button clicked. Clicking on “Ok” or “Cancel” returns the geometries to null protuberances. [Requested by A. Pfitzer, Voith turbo Schneider GmbH].



16) In Finite Strips, when calling the “Mesh” input form (“Mesh” function button), the “Finite Strips” tab now includes an entry for “Fillet Protuberance”. This is the same protuberance as that used in 5Axis for the fillet; it can only be negative to be used. This allows the estimation of the effect a protuberance will have on bending stresses. It is applicable to the current member only. By default, the value is always zero; to see the effect, a negative value must be entered and the “Apply” button clicked. Clicking on “Ok” or “Cancel” returns the geometries to null protuberances.



17) When creating a new Spiral Bevel/Zerol/Hypoid gear geometry, the OD of the Pinion and Gear can be imposed if known. HyGEARS now imposes that this OD be specified at the same position the Gleason Dimension Sheet uses, i.e. at the end of the tooth whose Back angle is equal to the Pitch angle. Therefore, if the known values match this condition, or if the Gleason Dimension Sheet values are available, then an imposed OD can be entered safely; otherwise, this value should be left blank.

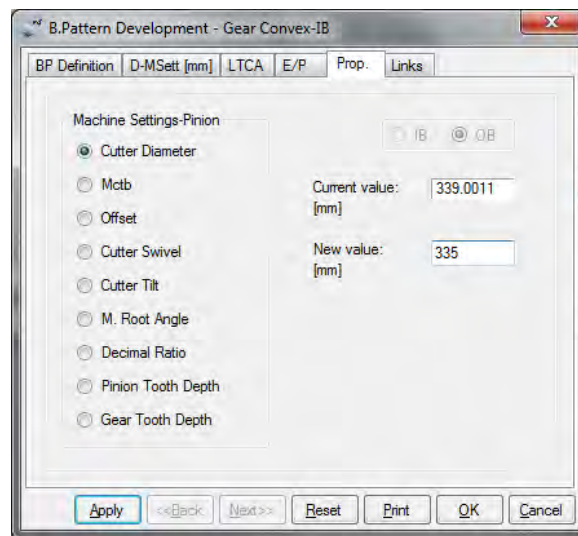


18) When selecting a CMM output file using the “XYZ” function button, the X, Y and Z conversion factors, which were set to “Auto” by default, have been removed since they were no longer needed. The “CMM File” selection field has been enlarged to allow seeing better large file names.

HyGEARS update – 08 February 2015 - Build 404.20 - 457

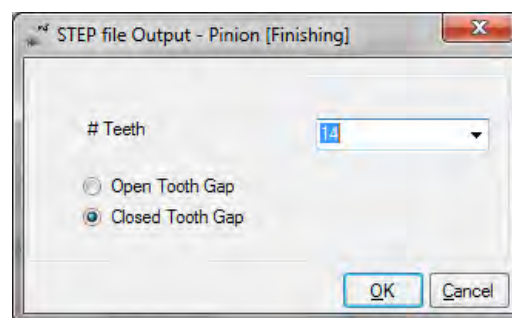
1) The Updates file (this document) is now provided as a Pdf document which allows better formatting than Notepad text files, and especially allows the incorporation of images to support the text. The file is also built in reverse order, from the most recent to the oldest.

2) In BP Development ("BPat" function button), the pinion Cutter Diameter can now be modified proportionally for both Completing and Fixed Setting cycles.



3) Addition of the "116CNC" machine. The #116CNC machine is a Gleason #116 that uses an electronic gearbox. Therefore, the angular values are given in Deg.Dec format rather than in DD.MM.SS format, and the machine is Higher Order capable, i.e. it can use Higher Order changes for Modified Roll and Helical Motion.

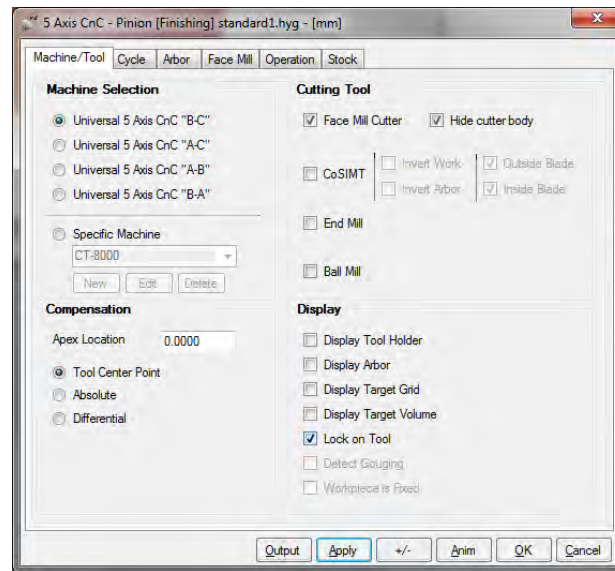
4) Improved the STEP file output. The STEP function now creates a Solid Body; the number of teeth exported can be chosen; and the tooth gap, at the bottom of the fillet, can be closed (default) or not.



5) Removed the "Dxf" export from the Tooth ChildWindow as it is now superseded by the STEP output which is much superior.

6) In 5Axis, addition of the "Lock on Tool" switch to the Display section (Machine/Tool page). This switch maintains the tool centered in its set position when either animating ("Anim" button) or single stepping

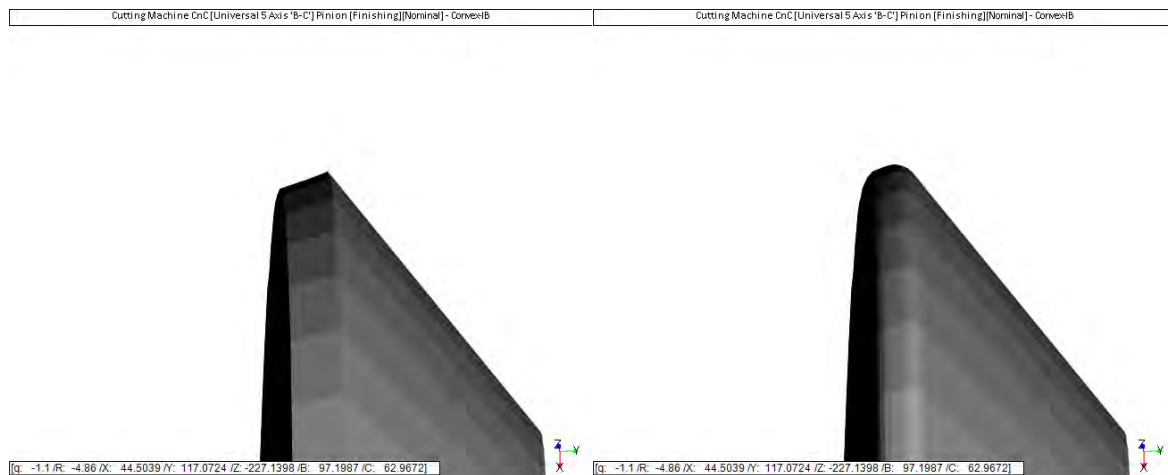
("+/-" button) the cutting movement in order to prevent the tool from going out of the display window for better tracking. [Requested by P. Koenen, EMCO Gears]



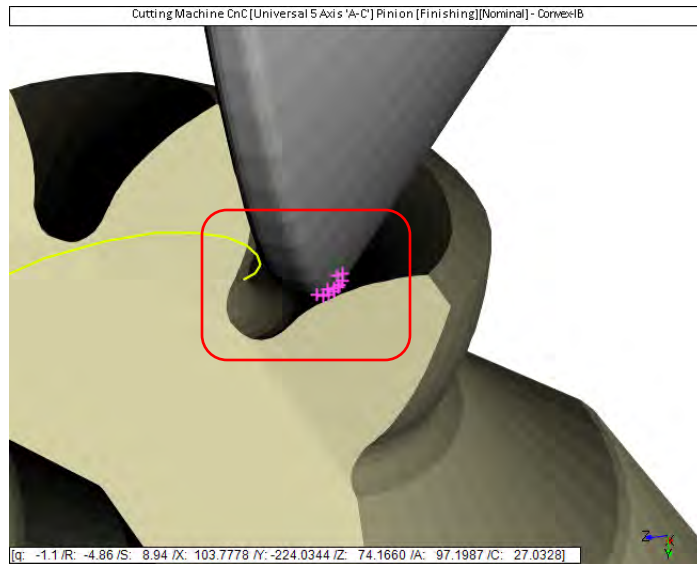
7) In 5Axis, the Edge Radius of the CoSIMT is now displayed.

Before

Now



8) In 5Axis, addition of the "Detect Gouging" switch to the Display section (Machine/Tool page). This switch instructs HyGEARS to check for "back tool interference" or Gouging caused by the tool to the opposite tooth flank, at each position along the tool path. The Edge Radius and the bottom of the tool cutting edge are tested. For each hit, a pink cross is displayed.



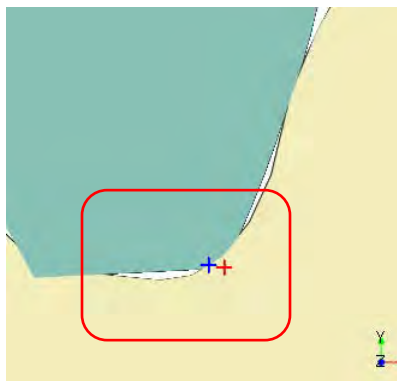
9) In 5Axis, addition of the # Points used for the Toe and Heel clearances in the Header section of the part program. This is noted on the same line as the clearance values and within brackets such as: "Toe Clear. [#pts] : 5.250 [3]". [Requested by P. Koenen, EMCO Gears]

```
( Toe Clear.  [#pts] :                10.000[3] )
( Heel Clear. [#pts] :                10.000[3] )
```

10) Modification to the way the tip to root clearance is calculated for cylindrical gears: the actual operating C.Distance. is now used rather than the theoretical C.Distance.

11) Modification to the SPA import: when cutters with curved blades are present, the TopRem values read from the SPA file are too large, and often lead to waviness of the tooth flank near the fillet, if not divergence. Therefore, the TopRem is now disabled at import time for curved blades. Values can be edited manually as desired. [Reported by Xin Guohua, SEW-Eurodrive, Tianjin]

12) In the TCA Pre-defined mode, addition of the "NoIn" / "Intr" function buttons to instruct HyGEARS to test for Tip to Fillet interference for the Full Model Child Window. The function button appears in the TCA pre-defined mode. Initially, the function button is in the "NoIn" state. When clicked, the Full Model Childwindow



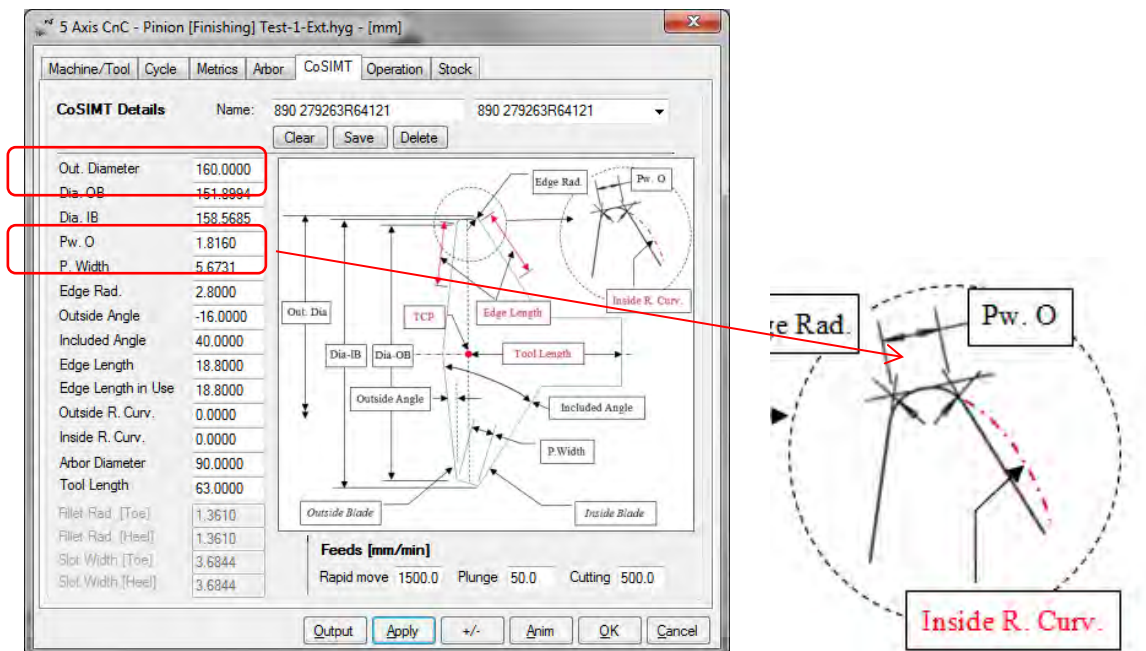
is activated, the function button toggles to "Intr" and for each contact position, Tip to Fillet interference is checked for the given operating conditions.

The "+/-" function button is used to single step forward and backward through contact. The tip points where interference occurs are displayed in Red, while the fillet points where interference occurs are displayed in Blue. Interference check is disabled when the display is animated ("Anim" function button).
[Requested by B. Wisbey, Drive System Design, UK]

13) Addition of the Cyclo-Palloid (Z-P, or Zyklo-Palloid in German) spiral-bevel gear type to the list of HyGEARS supported gear types. Sold as an Optional cutting process. This gear type is a de-factor standard in the marine industry. It can be created and developed in HyGEARS, meaning that the machine settings for a Phoenix type machine will be obtained. When developing a Z-P gear set through the "BPat" function button, the Vertical Position of the BP is ignored for the time being; Bias is replaced by Crowning (lengthwise) which directly influences the Bias anyway. Reverse Engineering and Corrective Machine Settings (Closed Loop) are also applicable. Finally, 5Axis cutting is also supported by all tools except for the reference Face Hobbing cutter as 6 simultaneous axes are required.

14) Addition of a BECAL Import/Export function for Cyclo Palloid (Zyklo Palloid) gears. HyGEARS will read the BECAL file, generate the geometry and display it on screen. The geometry is then ready to be saved as a regular .HyG file. The usual Becal file extension is ".kgd".

15) In 5Axis, added 2 new values to the definition of the CoSIMT: the Out. Diameter, i.e. the actual outside diameter of the tool, as opposed to the outside diameter of the IB and OB blade cutting edges, as was the case before, and the Pw.O value which is the Point Width at the Outside Diameter; Pw.O. is calculated by extending the IB and OB cutting edges until they intersect the tangent to the OD flat between the IB and OB edge radii. To update the "Out. Diameter" and "Pw.O" values, add a zero at the end of either the Dia. OB or Dia. IB entries.



16) Addition of the Leitz CMM to the list of HyGEARS supported CMMs.

HyGEARS update - 07 Dec 2014 - Build 404.10 - 457

1) Correction, in 5Axis where, when the Start and End Steps were 1, a division by zero would occur.

[Reported by P. Koenen, EMCO Gears]

2) Correction, in 5Axis where, for Ball Mill Finishing, the Stock would give a non zero value at Tip when the Start and End steps are equal to zero, even if the stock value was zero. [Reported by P. Koenen, EMCO Gears]

3) Additional flexibility in Corrective Machine Settings / Reverse Engineering ("Corr" and "RE" function buttons, "Corr-RE" pre-defined mode):

- For Fixed Setting gears: the Profile Curvature control parameter can now be chosen as either Blade Curvature or Work Offset;
- For Formate gears: 2nd Order is now offered in Reverse Engineering (not for Correction); the control parameter is Cutter Diameter; this can be very useful when Reverse Engineering an unknown existing gear set and trying to identify the actual cutter used.
- For Generated completing cycles: in 2nd order, the Lengthwise Crowning control parameter can now be chosen; when a single control parameter is selected (either "Cutter Diameter" or "Offset"), the average IB+OB Crowning is considered as the target; when combination parameters are used ("Offset + Tilt"), Crowning is corrected individually on each tooth flank. Usually, the best combination is "Cutter Tilt + Decimal Ratio" for pressure angle correction and "Offset" for Crowning correction.
- For Duplex Helical completing cycles: Bias can be Corrected/RE.
- For Spread Blade completing cycles: Bias cannot be Corrected/RE.
- Addition of 2 switches:
 - o *Maintain Tooth Thickness*: when selected, it excludes Tooth Thickness correction, and the actual tooth thickness is maintained;
 - o *Maintain Tooth Depth*: when selected, Point Width is modified to correct/maintain tooth thickness and tooth depth is not modified; when unselected, Point Width is maintained, and tool depth is used to to correct/maintain tooth thickness in completing cycles.

4) Corrective Machine Settings and Reverse Engineering can now be done either in Finishing or Roughing modes. The "Fin" / "Roug" function buttons toggle the Finishing / Roughing modes.

5) CMM Nominal Data can now be created either for the Finishing or Roughing tooth. The "Fin" / "Roug" function buttons toggle the Finishing / Roughing modes.

6) 5Axis Part Programs ("5Axis" function button) can now be done either in Finishing or Roughing modes. The "Fin" / "Roug" function buttons toggle the Finishing / Roughing modes. The "Sele" function button used to select the appropriate Summary version is aware if the Correction was done in Finishing or Roughing mode and will toggle the display to the appropriate mode.

7) in 5Axis, addition of the "Include operation switches" to the Output Format options on the Cycle Page. When this is selected, the values for:

- Units: [In] or [mm]
- Tool ID
- Coolant On/Off
- Spindle CW/CCW and RPM

are included in the Part Program header. Otherwise, they are omitted. The default value is "Selected".

8) Addition of the "Sele" function button to the "Geometry" pre-defined display. This allows visualizing the rootline after any Corrective Machine Settings iteration. When the desired Summary is selected, both the Tooth and Blank windows are redisplayed.

9) Addition, in the Blank ChildWindow, of the "... [Actual]" output for bevel gears, where "..." stands for "Root Angle". This output calculates the actual root angle of the tooth and is displayed below the theoretical value, for comparison purposes. The Actual value is calculated at the 2nd point from Toe, and 2nd to last point to Heel along the facewidth, where 2nd is in reference to the # of points used to display the tooth.

10) In the Geometry pre-defined display, addition of the "Depth" function button which allows the modification of the tooth depth, either Pinion or Gear, depending on the button group, without changes to the BP or kinematics, as opposed to what is done in the Prop page of the BP Development (BPat function button). The current Tooth depth at heel is displayed and a new value is expected. This function can be especially useful when Reverse Engineering an existing gaset for which the Summary is not known but the blank dimensions, including tooth depth, are known.

11) In 5Axis, the Operations now support and "remember" Start and End Steps = 0. [Requested by P. Koenen, EMCO Gears]

12) In 5Axis, for Face Milling of spiral-bevel gears, the starting location of the cutter can now be chosen outside of the blank, at Toe or Heel, such that the tool Plunge can be made full speed without the cutter making contact with the work at the end of the Plunge, and then cutting per se can be started with the tool at its desired level and feed. The extension of the tool path using the Toe and Heel clearances now avoids undercutting at Toe and excessive spiral angle at Heel.

13) In 5Axis, for CoSIMT, End Mill and Ball Mill tools, when positive (i.e. outside of the tooth) Toe and/or Heel clearances are specified, rather than extending the tooth at digitization, the tooth flank coordinates are extrapolated to the given clearance while the roll angle is maintained at that at Toe for Toe clearance and at that at Heel for Heel clearance. Therefore, when the tool is going through the target points outside of the tooth, the work piece stops rolling and actual rolling occurs only when the tool is within the boundaries of the tooth. This should eliminate any digitization error happening when the tooth was extended at Toe beyond the undercutting limit and at Heel beyond an acceptable spiral angle. The actual "# Facewidth Pts" specified along the tooth facewidth does not include the points outside of the tooth boundaries unless the current 199 point limit is exceeded; when this happens, the #Facewidth points on the tooth itself is reduced to allow Toe and Heel clearances.

14) The Vertical and Horizontal Scroll bars, which would appear when the Parent window would be reduced, are now gone. To do this, a Windows function is called from the User32.dll library as setting the

scroll bar visible property is not accessible directly from Visual Studio. This should help having a more pleasant display in resolutions such as 1366x768 and 1024x768.

HyGEARS update - 12 Nov 2014 - Build 404.00 - 457

1) In 5Axis, modification to the Oper/Process Tab; the Processes are moved to a separate Tab, not yet completed; the Operation Tab now adds several switches as follows:

- Tool ID: a number is expected;
- Coolant On/Off Switch: the appropriate codes are expected;
- Spindle CW/CCW Switch: the Spindle RPM is expected;
- Return Trip Switch: the Return Trip is a series of steps from the retracted position at the end of the cycle to the retracted position at the beginning of the cycle; this is sometimes necessary to force the controller to go through a given path rather than letting it decide of the "best" course;
- Rapid Move speed: when the tool is modified, the default value assigned in the specific tool tab is copied, and this is the actual value used in the Part Program;
- Plunge speed: when the tool is modified, the default value assigned in the specific tool tab is copied, and this is the actual value used in the Part Program;
- Cutting speed: when the tool is modified, the default value assigned in the specific tool tab is copied, and this is the actual value used in the Part Program;

2) Added a short header paragraph which goes at the very beginning of each Part Program; this header allows the identification of what follows, and is added to the Part Program whatever the Output Switch choices. The short header appears as follows, and is preceded/followed by the appropriate comment character:

```
*****  
  
PROGRAM NAME      : User entered on the CnC machine  
  
PROGRAM DATE      : 11-09-2014  
  
TOOL ID           : 1  
  
TOOL DIAMETER     : 14.70[in]  
  
TOOL LENGTH       : 40.57[mm]  
  
*****
```

3) In the BP Development window ("BPat" function button), on the "Prop" Tab, when either the Pinion or Gear tooth depth is selected, 2 switches are shown allowing the specification of the new tooth depth either at Mid-Face or at Heel. This stems from the fact that blank drawings do not always give tooth depth at the same position along the face width.

- 4) In the BP Development window ("BPat" function button), on the "Prop" Tab, when either the Pinion or Gear tooth depth is selected, the Finishing tooth depth is modified as requested and the Roughing tooth depth is now adjusted to match that of the Finished tooth.
- 5) Revision of the fonts displayed in each window as in some Asian variants of Windows 7, some HyGEARS forms would not show correctly.
- 6) In 5Axis, revision of the behavior of the function buttons of the Gear group (of the Parent Window), such that whenever a button belonging to the Gear group is clicked, the Gear machine Childwindow comes to front if it is hidden by the Pinion Childwindow. The same applies to the behavior of the Pinion group buttons when the Gear Childwindow is hiding the Pinion Childwindow.
- 7) When using the "File -> Input Existing Summary" function, HyGEARS now requires that a geometry be resident in memory in order to provide default values. The "Input Existing Summary" function is now defined only to manually input a Face Hobbed gear set, either hypoid, spiral bevel or zerol, where the gear member can be either Generated or Non-Generated.
- 8) When creating a new spiral-bevel, Zerol or hypoid gear set, the radius of circular profiled blades can now be inputted in the New Geometry window, and are used when the new gear set is initially developed. This often results in significantly enhanced gears in terms of kinematics. These gears can be cut on 5Axis CnC machines using regular straight edge CoSIMT and End Mill tools and Ball Mill tools. The Face Mill tool used to cut these gears on 5Axis CnC machines needs that the cutter edge be exactly that of the design in terms of cutting edge profile curvature.
- 9) In 5Axis, CoSIMT, corrected the fact that the Edge Radius of the CoSIMT was limited to " $PWidth / 2$ " rather than " $PWidth / 2 / \cos(IncludedAngle / 2)$ ". No incidence since the value is used nowhere at this time. [Reported by P. Koenen, EMCO Gears]

HyGEARS update - 23 Oct 2014 - Build 403.90 - 457

1) In 5Axis, addition of the "Op/Process" Tab, where operations and processes can be defined. Only Operations are defined at this time.

An Operation is the complete definition given by all the Selections and Values done in the 5Axis window. An Operation is saved in the "Operations.Fil" file, which is stored in the folder of the current geometry. Therefore, an Operation strictly belongs to a specific geometry.

Operation names can be up to 50 characters long.

- the "Save" button adds the current definition, under the entered name, to the Operations.fil file; if the content of the 5Axis window has been changed after an operation has been saved, and the Save button is clicked with the same operation name, the older definition is overwritten after user confirmation.
- the "Delete" button removes the currently selected Operation; a confirmation message is displayed;
- the "Import" button imports the Operations file of another geometry; in this case, the imported and current files are scanned for redundancy in Operations names and only the unique operations names are imported from the selected file, irrespective of their definition (i.e. only the name of the operation is checked);
- the "Output" button in the Operation section generates the CnC part program as per the data contained in the selected operation; the display is updated prior to generating the part program, even if the "Apply" button has not been pressed; therefore, it acts only when an operation is selected and is ignored when no Operation is selected, or when the selected Operation is different from that in the Name field.
- the "STEP" button appears when the STEP option has been purchased. It allows to generate a STEP file based on 2 operations: one Flank operation and one Fillet operation. The STEP output will appear in a Text Results window. This function can be useful to visualize the shape of the tooth when, say, the tooth flank is finished with Zero stock while the fillet is cut with negative stock such as what a tool protuberance will produce. It can also be useful to assess the tooth dimensions after a Roughing operation.

Note 1: the tools used in each operation MUST be NAMED for the operations to work correctly since only the tool name is saved in the Operations file.

Note 2: the "Output" button at the bottom of the 5Axis window will generate the CnC part program as usual, i.e. even if an operation is not selected; the content of the 5Axis window is read, the display is updated, and the part program is generated.

2) In 5Axis, modified a condition where, when deleting a tool from the Face Mill, CoSIMT, End Mill or Ball Mill files, if the name of the deleted tool was a substring of the name of any other tool, then the other tool would be deleted as well.

3) For FH and Cyclo Palloid gears, addition of the "Module Mean-Normal" and "# Blade Groups/Blade per Group" to the Blank output of the Summary.

4) Addition of the BP Development ("BPat" function button) for Coniflex straight bevel gears. The Horizontal and Vertical positions of the contact pattern, which may be different for the Left and Right tooth flanks, the total Crowning (i.e. the sum of Pinion and Gear Crowning as created by the combination of the cutter Dish angle and Tilt) and the Backlash and Transmission Error may all be imposed. For the Horizontal position and the Backlash, the machine settings - Offset, Ratio of Roll Setting / Ratio of Roll) - of the conventional Coniflex machine such as Gleason 102, 104, 114 and 134, are modified, and the cutting Summaries are still applicable to conventional mechanical machines.

However, if the Vertical position of the Contact Pattern, Crowning and Transmission Error are imposed, or if the horizontal position of the BP on the Left and right tooth flanks are different, then Cutter tilt may be changed, Modified Roll may be introduced, and different machine settings may be changed on each tooth flank and thus, the conventional machine becomes an "NC" machine; the machine number becomes "102-NC", "104-NC", etc; and it is assumed that the parts will be cut on a 5Axis CnC machine.

5) In 5Axis, when the Toe and/or Heel clearances are too large in Spiral Bevel gears, undercutting can result at Toe and too large a Spiral angle can result at Heel, both an indication that the tooth is beyond its limits. If this situation occurs, a message is now displayed hinting the user to modify the appropriate value till the message disappears.

6) In 5Axis the units function buttons "mm" and "In" are now responsive when the 5Axis window is displayed; when the units button is clicked, HyGEARS reads the 5Axis window in the current units and redisplay all values in the new units.

7) In 5Axis, the Target Grid and Target Volume now account for the Edge Radius / Ball Diameter when establishing the Fillet grid.

8) In 5Axis, addition of the "Stock" tab. The "Stock" tab displays the distribution of material between the target tooth flank, i.e. that produced by the reference generating process, and what the tool movement will leave in the slot. This is especially useful when roughing (which is currently single pass), or when finishing the fillet with a Ball Mill or a Bull Nose End Mill and going into negative stock. The following rules are applied:

- Fillet roughing : the Start/End Steps have no influence on the display
- Fillet finishing : the Start/End Steps are accounted for in the calculation and display
- Flank roughing : the Start/End Steps are accounted for in the display
- Flank finishing : the Start/End Steps are accounted for in the display

9) In 5Axis, the small RGB ref. frame displayed at the bottom right of 3D ChildWindows has been reviewed to be consistent with the rotation buttons. Therefore, rotations about the X, Y and Z axes now (mostly) agree with the X, Y and Z directions displayed by the RGB ref. frame. Exceptions arise when the Y or X axis are perpendicular to the screen and, in this case, a rotation about the X or Y axis is the same as a rotation about the perpendicular to the screen. The workaround to this situation is to rotate the other axis, Y or X axis until the X or Y axis is no more perpendicular to the screen and is seen in true dimension. This situation

is of general knowledge and is called "Gimbal Lock" where a 3DoF Gimbal loses one DoF when 2 axes are aligned.

10) In 5Axis, the default projections for the machines have been revised. Successively keying the ^J (or Ctrl J) keyboard combination cycles through each of the 5 default projections:

- Top View;
- Front View;
- Right Side View;
- Left Side View;
- Automatic View (where the machine is seen at an oblique angle)

When either the machine or tool is changed, clicking on the Apply button resets the current display to its default view.

11) In 5Axis, moved the "Roughing" check box and the "Finish Stock" and "Rough Stock" entries from the "Machine/Tool" Tab to the "Cutting Cycle" Tab, "Stock/Feed" section, as it appears more logical to have them there with the other Cycle parameters.

12) Extension of the list of previously opened HyGEARS files from 8 to 12 ("File" menu in the Parent Window).

13) In 5Axis, the "Const D-Radius" option now applies only to the tooth flank. It is ignored for the Fillet since, because of the circular nature of the fillet, constant radial point spacing is very difficult to maintain near the bottom of the tooth.

14) In the "BPat" function, the Transmission Error (TE) can now be imposed individually to each tooth flank. This applies to Spiral Bevel, Straight Bevel and Coniflex gears. [Requested by P. Koenen, EMCO Gears]

15) In the 2DGraph Window, when the Pinion or Gear Bending Stress is displayed, the Max value is now displayed where the max value occurs. [Requested by P. Koenen, EMCO Gears]

HyGEARS update - 29 August 2014 - Build 403.80 - 456

- 1) After a new installation following a new HyGEARS Build, the several messages indicating that a HyGEARS Reference file had been carried over from the previous installation are now replaced by 1 message giving the full list of Reference files.
- 2) The Backlash is now outputted both in linear and angular values (gear rotation) in the format: "B: x.xxx [mm]/ y.yyy [deg.]" . [Requested by N. Meixel, Neugart GmbH]
- 3) Addition of the "Loads" entry to the Pre-defined display mode Quick tool bar on the Parent window. The "Loads" Pre-defined mode displays 4 Child windows, 2 for the Pinion and 2 for the Gear, respectively to the Left and Right of the Parent Window; for each member, three teeth are displayed in Top view in the Top ChildWindow, and Front view in the Bottom Childwindow. Clicking on the "Con" / "Cvx" or "Left" / "Right" function buttons toggles the display. The usual Summary Editor, Units and Summary Output buttons are available. The displayed loads are calculated at mid-facewidth and mid-tooth depth and are consistent with those given in the Strength Calculations section of the Graphics Summary ["GSum" function button].
- 4) Addition of the "Tooth Loads" entry to the GSum choices. The "Tooth Loads" selection adds the display of the Axial, Radial and Tangential loads at mid-tooth, for the Convex/Left and Concave/Right tooth flanks of the Pinion and Gear. For each display, three teeth are displayed in Top view in the Top row, and Front view in the Bottom row, such that the Loads can be clearly visualized. The displayed loads are calculated at mid-facewidth and mid-tooth depth and are consistent with those given in the Strength Calculations section of the Graphics Summary ["GSum" function button]. [Requested by N. Meixel, Neugart GmbH]
- 5) Significant improvement in the calculation speed of a) the tooth digitization, b) the kinematics and c) the LTCA thanks to the migration of the simulation engine to a highly optimized DLL.
- 6) Improved rendering of the graphics in the Graphics Summary ("GSum" function button), where the jagged lines which would be displayed on screen (but not at printing time) are now much smoother. One consequence is that the size of the "GSum" Pdf output file is reduced by 90%.
- 7) In the Graphics summary ("GSum" function button) the "Strength Calculation" is now selected by default. [Requested by N. Meixel, Neugart GmbH]
- 8) When in LTCA pre-defined mode, clicking the "Str-C" button now adds the FFT-LTCA (Square window) display to the existing sequence [currently made of
 - a) Compressive Stresses,
 - b) Bending Stresses c) Efficiency].
- 9) For the Grids of 2D Graphs, extended the output to include "FFT LTCA" when this is the currently displayed choice. The Grid then gives a good idea of the mesh harmonics as a function of say the Torque, or the E-P location of the gear set.
- 10) In 5Axis, Cutting Cycle Page, addition of the "Indexing Sequence" option. The Indexing Sequence is the sequence in which tooth slots will be cut. It can be used to favourably spread thermal load and tool wear over tooth slots which are not consecutive.

- A value of 1 (default) means that each tooth slot 1, 2, 3, ... is cut in sequence;
- A value of 2 means that tooth slots 1, 3, 5, ... will be cut in sequence, thereby leaving 1 empty tooth slot between each cut; when the last tooth slot is reached, the cycle starts anew and then tooth slots 2, 4, ... will be cut.
- The Mirror check box means that the center tooth is taken as a reference, and then the specified tooth slots are counted on each side of the ref. tooth using the specified indexing value.

11) In 5Axis, for the Fanuc controller, if the Indexing sequence is 1, and Mirroring is Off, the Tooth Space logic is used; otherwise, the more usual internal subroutine call is used to follow the imposed sequence.

12) In 5Axis, addition of the Feeds (in mm/min or in/min) used in the part programs. Feeds are for 1) Rapid Move 2) Plunge and 3) Cut. The Feeds are specific to each tool and in consequence, must be added at tool creation time. Default values of 1500, 50 and 500 mm/min are provided.

13) In 5Axis, the Feeds are defined as variables at the beginning of each part program and can thus be easily changed by the user at the top of the part program, rather than having to hunt for them. Applies to Fanuc, Heidenhain and Siemens controllers.

14) In 5Axis, addition of the "Face Mill" tab where the actual shape of the Face Mill cutter used on a 5Axis machine can be defined, in order to ease the detection of potential collisions. The Face Mill cutter is now displayed with a green body and metal grey blades. Face Mill cutters can be created at will, and are stored in a user-owned file called FaceMill.fil which is imported from the latest to the newest HyGEARS installation. The dimensions are Body Diameter, Body Height, Blade Depth and Number of Blades.

15) In 5Axis, addition of the "Display Target Grid" option in the Miscellaneous section of the Machine/Tool Tab. The "Target Grid" is the actual tooth flank or fillet, as described by the Stock Feed and Clearance parameters in the Cutting Cycle Tab. It is displayed in amber color, as a wireframe mesh which allows appreciating the actual envelope the tool will cover in reference to the final tooth.

16) In 5Axis, addition of the "Display Target Volume" option in the Miscellaneous section of the Machine/Tool Tab. The "Target Volume" is the portion of the tooth gap, as described by the Stock Feed, Clearance, Start and End Steps parameters in the Cutting Cycle Tab. It is displayed in Cyan color, as a volume which allows appreciating the actual volume the tool will cover in reference to the final gap. At this time, the volume used by the Edge Radius is neglected.

17) In 5Axis, when cutting a spiral bevel gear with a Face Mill cutter, the starting and ending roll angles are now those defined by the Toe and Heel clearances (or tooth extensions) which can be appreciated using the above "Display Target Grid". In this manner, if say the Heel clearance is 30 mm on a Heel to Toe roll, the plunging part will be done partially outside the actual tooth heel (depending on tooth size) such that progressive in feed occurs in order to reduce wear on the cutter.

The same happens if a Toe to Heel roll is selected, and a sizeable Toe clearance is imposed.

Note: there is a limit to the Toe and Heel clearances since at Toe, undercutting eventually occurs, preventing the digitization of the tooth, and at Heel the spiral angle may become too important to allow convergence. Any such problem can be detected by selecting "Display Target Grid" on the Machine / Tool tab; if the grid does not display properly, then the Toe and/or Heel clearances may be too large and need be diminished until no display error is evident.

18) In 5Axis, when cutting Spur/Helical/Straight Bevel/Coniflex/Face Gears with a CoSIMT, the Inside or Outside cutting blade can now be imposed. This can be useful to prevent excessive A or B angles for example which are out of the machine range. The Outside Blade is that opposite the arbor, while the Inside Blade is that on the side of the arbor. Inverting the arbor does not change the definition in that the reference Arbor side is that of the un-inverted arbor. When only 1 blade is used, the cutting cycle switches automatically to Flank by Flank, and the tool is withdrawn in the Z+ direction by the sum of the CoSIMT radius and face width in order to avoid collisions when switching tooth flanks.

19) In the Blank display, addition of the Ht (or whole depth) output. For Bevel gears, it is calculated at heel.

20) When creating a New Geometry, or importing from a SPA or ND file, the file name is not added to the list of Recently Opened/Saved (File menu, Parent window) files until the new file is actually saved to disk. This is to prevent cluttering the Recently Opened/Saved list when doing several trial new geometries.

HyGEARS update - 22 July 2014 - Build 403.70 - 455

1) In 5Axis, for the Siemens controller, the program structure has been revised and now incorporates a loop to cut all tooth slots rather than an enumeration with calls to a subroutine within the same program. This makes for a more compact program.

2) In 5Axis, when in "Machine coordinates", "Work Coordinates", "Traori" (Siemens), "TCPM" (Heidenhain), "TCP" (Fanuc), the ref. roll angle, used to decrement the work piece rotation angle in order to balance the C angle values between toe and heel has been replaced by a function always returning an angle between 0 and 360 degrees, for consistency since in "work coordinates", "Traori", "TCPM" or "TCP", the machine controllers link the X and Y positions of the tool to the rotation of the work piece.

This has no consequence in "machine coordinates".

Therefore, the work piece angles in part programs generated before 403.70 will be different from those generated from now on. However, the range of values for each cutting cycle remains the same when the same conditions are used.

3) In 5Axis, the progress bars indicating the % accomplishment of the CnC program generation, now accurately reflect the evolution. The previously erratic display was caused by a bug in the progress bar control which requires an additional call for a proper display.

4) In 5Axis, for End Mills, when the Stem diameter is different from the End Mill diameter, the stem is now tapered rather than a constant cylinder such as to better render the actual shape.

5) In 5Axis, when editing a machine, the "Mach. Preamble" tab has been added. The Preamble tab contains 2 sections: the Program Preamble and Program Trailer, which are section of code specific to a machine, for the selected controller, that are added respectively at the beginning and end of the part program.

6) In 5Axis, the "Tool Holder" tab has been added to the machine definition; this allows to define the shape of the tool holder in up to 5 successive Diameter/Length steps such that potential interference with the work piece can be visualized. A check box allows specifying that the holder is square rather than cylindrical.

7) In 5Axis, addition of the "OBIB-O Shaped" cutting cycle, where the concave flank is cut first, and then cutting switches to convex all the way to the fillet. This is the opposite of the "IBOB-O Shaped" cycle where cutting rather starts on the convex flank, switches to concave, and so on.

8) In 5Axis, the "IBOB-O Shape" and "OBIB-O Shape" processes are now defined for the fillet.

9) In 5Axis, addition of the "Coordinates only" switch which allows the output of only the coordinates and axis angles or tool vector. This can significantly reduce the amount of edition required from the operator.

10) The STEP file output has been adjusted such that the axis of rotation of the exported tooth is Z, and the apex is at X Y Z = 0. The STEP file axes thus now matches those of CAD softwares.

11) In 5Axis, for Face Milling cutters, the Double Roll Toe-Heel and Heel->Toe is now available for Completing cycles. In this case, the cutter is progressively plunged from the start of the cycle while generating along the forward roll until full depth, and on the return roll generation proceeds full depth.

This allows for a less aggressive engagement of the cutter in the work piece when compared to single roll where the cutter is first plunged full depth from whence generation proceeds.

12) In 5Axis, the Toe and Heel clearances are now used for Face Mill cutters, such as to allow starting and ending the generation beyond the Toe and Heel boundaries of the tooth and thus avoid potential gashes at tooth end when the cutter retracts.

13) When calculating bending stresses by the conventional methods, the geometry factor J in the AGMA model, which uses the full facewidth, is now an average of the IB and OB sides for Hypoid gears, even though these normally have different pressure angles. This ensures better compatibility with existing methods such as the output on the Gleason Summaries.

14) Addition of Corrective Machine Settings (Closed Loop) and Reverse Engineering (RE) for Coniflex Gears. Only 1st order changes are allowed at this time. The Pressure angle, Helix angle and Tooth thickness can be corrected using respectively Ratio of Roll, Cutter offset and Space angle. Corrections are applied with respect to a reference machine (Gleason 102, 104, 114, 134) and to individual tooth flanks, i.e. it is assumed these gears are cut on 5Axis CnC machines on which tooth flanks are independent.

15) For bevel gears, addition of the Mounting Distance (MD) to the display of the Blank.

16) Addition of the Ratio of Roll to the Machine Settings output of #16, 26, 102, 106, 108, 116, 118 Gleason machines. [Requested by G.B. Ricambi]

17) On the Blank output of Spiral Bevel gears, the Face, Pitch and Root angles now come out in DD.MM.SS format for mechanical machines and in Deg.Dec format for CnC machines such as the Phoenix.

18) In 5Axis, addition of a Spherical CoSIMT where the Inside and Outside Cutting Edges can be an arc of circle extending from the start to the end of the cutting edge. This cutter type allows cutting Face Gears even if the tooth profile curvature is negative (concave).

19) In 5Axis, addition of the BA type architecture where the cutter head can tilt about axis Y (B angle) and swivel about axis X (A angle). The workpiece is fixed, i.e. does not rotate, and all tool orientation is done by the tilting and swiveling cutter tool.

20) Addition of the Gleason 122 machine to the list of the HyGEARS supported machines.

21) Addition of Spiral Face Clutch gear type (optional). The Spiral Face Clutch set is made of one "pinion" and one "gear" with the same tooth number; the Shaft angle is 180 deg. The single contact point is centrally located lengthwise and profile wise. Both the pinion and gear are generated. The Spiral Face Clutch is used as a self centering coupling capable of transmitting large torque. It can be cut using Face Mill, CoSIMT, End Mill and Ball Mill cutters; Face Mill cutters can be used on dedicated gear cutting machines, or 5Axis CnC machines; CoSIMT, End Mill and Ball Mill cutters are to be used on 5Axis machines.

22) For the Klingelnberg P machine CMM Target file, addition of the GeomPin and GeomGear output [Requested by R. Richardt, PTR-TEC]

23) When Developing a spiral bevel gear set ((BPat function button), in the Prop tab, when the tooth depth is changed, the Point Width of the cutter was modified such as to maintain slot width. This behavior is now removed and no change is applied to the cutter. [Requested by N. Meixel, Neugart GmbH]

HyGEARS update - 01 June 2014 - Build 403.60 - 454

- 1) Corrected a sign inversion in 5Axis, for Tip Deburring - Tool End, in spiral bevel gears, where the tilt of the tool axis would be inverted for a RH gear set. [Reported by P. Koenen, EMCO Gears]
- 2) For Spur, Helical, Beveloid and Straight Bevel gears, the "Stock" Pre-Defined mode changes to "Modifications" where the imposed profile and crowning deviations are plotted in 2D Graphs, for each the Left and Right tooth flanks. By default, the display is for the Pinion. The "->G" toggles the display to that of the Gear. The "->P" toggles the display back to that of the Pinion.
- 3) In 5Axis, for a specific machine, the machine X, Y and Z axes can now be renamed freely. Thus, from the basic architecture of a given 5Axis milling machine, i.e. "AC" or "BC", the kinematics of any specific machine can be reproduced. For example, machine axis X can be renamed Z, machine axis Y can be renamed X and machine axis Z can be renamed Y.
- 4) In 5Axis, for a specific machine, the Work X, Y and Z axes can now be renamed freely.
- 5) Removed the "Invert XY" option from the definition of specific BC machines as this is now superseded by 3) above.
- 6) Introduction of the "Tilt Offset" value in the definition of specific 5Axis machines. This value adds / subtracts, depending on the sign, to either the A angle in "AB" and "AC" machines or the B angle in "BC" machines. The Tilt Offset is useful when the tool spindle axis of a 5Axis machine, for example some Depo machines, is not as per the basic architecture. In the Depo machine, basically a "BC" machine, the tool spindle is horizontal for a zero B angle; to match the definition of the HyGEARS BC machines, 90 degrees must be subtracted from the calculated B angle, hence the Tilt Offset is -90 degrees.
- 7) Addition of "Herringbone Gears" (optional) to the list of supported gear types. Herringbone gears are analyzed like spur and helical gears. They can also be machines on 5Axis machines using the same tools as spur and helical gears.
- 8) In 5Axis, increased the # decimal places when editing tools (CoSIMT, End Mill, Ball Mill) in order to limit precision loss when changing units. [Requested by P. Koenen, EMCO Gears]
- 9) In 5Axis, for CoSIMT, End Mill and Ball Mill tools, corrected a switch which would cause only the IB to be outputted when generating the CnC program for non generated gears ("Output" button).
- 10) Changed the order in which the Interference limit (undercutting limit, Cyan line) and Fillet limit (green line) are displayed such that the Interference limit is displayed on top of the Fillet limit rather than the other way around. This way, if the Interference limit is coincident with the Fillet limit, only the Interference limit is visible and it is deducted that the Fillet limit is underneath.
- 11) The cutter blade angles for the Gleason Phoenix machine are now given in Deg.Dec format in the Summary Editor, Cutter Data page, and in the Machine Settings output, to be more consistent with the summaries outputted by CAGE.
- 12) In 5Axis, the distance between the origin of the ref. frame attached to the work piece hub and the pitch cone Apex is now displayed.

13) In 5Axis, the distance between the machine origin and the origin of the ref. frame attached to the work piece hub is now displayed. It is equal to the difference between the Apex Location and the distance between the origin of the ref. frame attached to the work piece hub and the pitch cone Apex (12 above).

14) In 5Axis, for the Siemens controller, when either Traori or Work coordinates are selected, the program output is in the Sinumerik language and now built such as to be executable in 1 single file. When in Machine coordinates, the G291 code, selecting ISO mode GCodes, is added and the controller is expected to behave in standard GCodes mode.

HyGEARS update - 18 May 2014 - Build 403.50 - 454

1) When using the rotation buttons on the Parent window, while clicking on the desired rotation axis,

- pressing the Shift key will divide the rotation angle by 10
- pressing the Ctrl key will multiply the rotation angle by 5.

Thus, quick (using Ctrl) and slow/precise (using Shift) rotations can be achieved without changing the rotation increment.

2) Addition of the Tip to Root clearances to the 2D - PoC Childwindow, when both the Pinion and Gear are displayed. The 2D-PoC Childwindow appears at the bottom right of the TCA pre-defined mode. [Suggested by P. Koenen, EMCO Gears].

3) For Spiral bevels, at geometry creation time, addition of a checking function to determine whether the IB and OB Edge radii overlap in the root of the tooth. If so, then the Edge radii are reduced to avoid this situation. Overridden if the Edge radii are imposed. [Suggested by P. Koenen, EMCo Gears]

4) In the Bearing Pattern Development ["BPat function"], addition of a checking function to determine whether the IB and OB Edge radii overlap in the root of the tooth. If so, then the Edge radii are reduced to avoid this situation. [Suggested by P. Koenen, EMCo Gears]

5) In 5Axis machining, for Roughing using a COSIMT, the Stock is now respected and is calculated from the bottom of the tooth slot.

6) In 5Axis machining, refined the way the location of the COSIMT is located when roughing in order to have even material distribution on each side of the tool.

7) Whenever a 3D Childwindow is right-clicked, a small tool bar containing the rotation buttons is now displayed at mid-height and to the right of the Childwindow, in order to facilitate rotations by not having to navigate with the mouse to the controls on the Parent window. The tool bar is floating, and can be deleted using the [x] button, but will be shown whenever a 3D Childwindow is right-clicked.

8) In 5Axis machining, addition of the Siemens controller to the list of machine controllers (GCodes, Heidenhain, Siemens). The controller is specified when Editing a specific machine.

9) In 5Axis machining, Machine and Work axes can now be edited individually. The Work axes are used in the Siemens Traori and Heidenhain TCPM transformations.

- Machine axes are conventionally named X, Y and Z, and their signs can be changed.
- Work axes can be edited by clicking on the "Work" button in the "XYZ Signs" section of the machine editor. Work axes are named X, Y and Z by default,

but can be renamed at will depending on the machine kinematics. The Ref. Axis is the conventional orientation of the X, Y and Z axes; the ID Letter is the new identity given to the X, Y and Z axes; only X, Y and Z can be used, and only one of each can be used. When this is satisfied, the help display is updated to reflect the selection.

10) Addition of the Siemens Traori transformations. This is selected from the 5Axis window, GCodes Tab, when the specific machine has a Siemens controller.

When in Traori mode, the CnC output program is given in work piece coordinates, and the orientation vector of the tool axis is given as A3 B3 C3.

The X, Y and Z values, and therefore the associated A3 B3 C3 values, can be renamed at will from the machine editor. Siemens recommends 5 to 6 decimal places for the tool axis orientation vector, which is selected with the Angle Decimals entry.

Traori mode is selected from the 5Axis window, GCodes page, and is accessible only when a Siemens controller is selected.

11) Addition of the Heidenhain TCPM transformations. This is selected from the 5Axis window, GCodes Tab, when the specific machine has a Heidenhain controller.

When in TCPM mode, the CnC output program is given in work piece coordinates, and the orientation vector of the tool axis is given as Tx Ty Tz.

The X, Y and Z values, and therefore the associated Tx Ty Tz values, can be renamed at will from the machine editor.

TCPM mode is selected from the 5Axis window, GCodes page, and is accessible only when a Heidenhain controller is selected.

12) Addition of the "Outp" button to the TE-P2V Childwindow (accessible in User mode), which outputs the contents of the display window in a Text Results window. [Requested by P. Koenen, EMCO Gears]

13) Upon installation, the HyGEARS executable is now tagged as "Run as Administrator" in order to allow copying support files between installation directories.

HyGEARS update - 15 April 2014 - Build 403.40 - 454

- 1) In TCA predefined mode, the E/P function is now available for Straight Bevel (Generated, Net Shape) and Coniflex gears, thereby allowing the estimation of the sensitivity of the gear set to E and P changes.
- 2) In the Graphics summary selection window (GSum function button), the TCA can now be analyzed and displayed for the Drive and Coast sides at Toe and Heel for Straight Bevel (Generated, Net Shape) and Coniflex gears
- 3) Corrected a sign inversion, for spiral bevel pinion fillet roughing using either End Mill or Ball Mill tools, where the tool would show inverted. [reported by P. Koenen, EMCO Gears]
- 4) In 5Axis, for specific BC machines, the X and Y axis directions can now be inverted such that the X axis replaces the Y axis and vice-versa. The +/- signs apply when X and Y are inverted. [based on Sandvik test case with DMF260]
- 5) In 5Axis, when using an End Mill tool in the Fillet finishing operation, added a condition to detect when the last line of the Fillet is being cut to ensure that the effects of an Edge Radius less than half the End Mill diameter do not displace the tool sideways.
- 6) When creating a new spiral bevel or hypoid gear geometry, the Root and Dedendum angles of the pinion and gear can now both be specified. When both values are entered, preference is given to the Root angle.
- 7) When creating a new spiral bevel or hypoid gear geometry, the Whole Depth is now given at mid face and is thus the Mean Whole Depth.
- 8) In BP Development ("BPat" function button), added protections when calculating the proportional changes to detect if circular arc cutters are used and if so, temporarily disable them to prevent divergence occurring in some [rare] cases. [Based on 8x30 spiral-bevel, Sandvik Austria]
- 9) In BP Development ("BPat" function button), when "Curvature" is used to control the TE, if the radius of curvature becomes negative, i.e. a convex blade edge rather than a concave blade edge, the request is cancelled and the cutter edge reverts to straight in order to avoid divergence occurring in some [rare] cases.
- 10) Inverted the display of the Ease Off in order to better convey the relationships between the location, size and sensitivity of the BP and the shape of the Ease Off.
- 11) When developing the BP, HyGEARS ensures that the root radius on the pinion IB and OB remain constant at mid-facewidth. However, for pinions with an outer transverse module larger than 10 mm, because there may be a difference in fillet radius at mid-facewidth, the IB and OB root radii are now read at toe to ensure that no lip is formed between the IB and OB.
- 12) Advancements to Straight bevels gears:

- a) they can be developed on screen; BP development includes crowning, TE, axial and radial location of the mean point, Bias and backlash. Bias is more effective when a helix angle is present.
- b) they can be Reverse Engineered
- c) they can be "Corr M/C", or corrected in Closed Loop

13) The 1st time a new installation is started, HyGEARS searches for existing reference files. Now, if such a file is found, a message is displayed to inform the user. This will normally happen only the 1st time HyGEARS is started after a new installation.

HyGEARS update - 26 March 2014 - Build 403.30 - 453

1) For 5Axis CnC machining, CoSIMT, End Mill and Ball Mill tools can now be defined and saved in dedicated tool files. There is one file for each tool type; tool files are saved in the HyGEARS installation directory and are respectively called "CoSIMT.fil", "EndMill.fil" and "BallMill.fil".

The interface consists of one File Name field, one Drop Down List box in which the currently defined tools are displayed, and three buttons.

- the "Clear" button clears all input fields for the current tool, including the Name field; the Drop Down list is not cleared;
- the "Save" button adds the currently defined tool to the tool box; if the tool exists, its current values are overwritten; if the tool does not have a name, it cannot be saved; when a tool is saved, the Drop Down list box is updated and the saved tool becomes the current tool;
- the "Delete" button deletes the current tool - it is known by its name.

As usual, for the tool to be displayed, the "Apply" button must be clicked.

The tool files are user-defined, i.e. no tool file is included in the HyGEARS installation. The files are created when needed. When a new installation is done, HyGEARS searches the previous installation directories for the tool files, from the last installation to the 1st, until a tool file is found, which is then copied to the current installation.

The current tool names, for CoSIMT, End Mill and Ball Mill are saved separately for the pinion and gear in the geometry data file.

2) For the generation of the fillet, the max. S angle in the fillet is increased from 80 to 87 deg. in order to bring the end point of the fillet closer to the root and thus allow the user to select as large a fillet radius as practical to reduce bending stresses while avoiding an overlap of the root lines between tooth flanks. This is especially significant when cutting the fillet with End Mill or Ball Mill cutters in 5Axis CnC. [Based on test case by P. Koenen, EMCO Gears]

3) The Parent window can now be resized without having to un-check the "Control Panel -> Performance Information and Tools -> Adjust Visual Effects -> Show window contents while dragging" setting, which prevents firing the Paint event while the Parent Window is resized. To resize the Parent Window, the lower right corner must be dragged for HyGEARS to catch the resize event.

4) For Face Gear members, addition of the Mounting Distance to the Other Data Page of the Geometry Summary Editor, and to the Blank output. The MD is now outputted as well in the Zeiss GPro CMM target files. [Requested by E. Steinwider, Sandvik Austria]

5) Addition of the "Rock Me (babe)" cutting cycle to the 5Axis list of tooth flank cutting cycles. In the "Rock Me (babe)" cycle, the workpiece rotates back and forth between tooth flanks as the tool moves along the face width. The tool starts at tooth tip - Toe either on the Pinion IB or Gear OB, runs down along the tooth profile till the fillet, shifts to the opposite tooth flank at fillet, rises till tooth tip, and then increments along the tooth face width to start anew the same cycle, but in the opposite direction, i.e. from tooth tip, on the Pinion OB or Gear IB, running down along the tooth profile till the fillet, and rising back to tooth tip on the

opposite tooth flank. This cycle may allow increased feed speeds and results in less back and forth movements on the machine for spiral bevel gears. The Metrics tab reflects, in the Face Width direction, the fact that using this cycle creates scallops in the profile direction.

6) Addition of the "LTCA" Tab to the BP Development Window ("BPat" function button). This should ease development work since the user does not have to exit/re-enter the BPat function in order to check what a change in TCA kinematics entails on the LTCA. Available only if the LTCA option has been purchased.

The "LTCA" tab displays, for the selected gear tooth flank, IB or OB, either the Contact stresses on the Gear tooth flank, or a 2D Graph with the Contact, Pinion Bending and Gear Bending stresses, for the current geometry definition. The pinion torque can be modified.

The "Apply" button instructs HyGEARS to calculate the LTCA and display the requested result. The "Next>>" and "<<Back" buttons allow moving between the different BP development iterations, without having to click on the "Apply" button. However, if the tooth flank is changed from IB to OB or vice-versa, the "Apply" button must be clicked. If the "E/P" positions have been changed on the "E/P" tab, clicking the "Apply" button on the "LTCA" tab updates the display for the current E-P-G values.

7) In 5Axis CnC cutting, when selecting a Flank by Flank cutting cycle, only the Toe-Heel-Toe sequence would be respected when generating the CnC program. This is now corrected. [Reported by E. Steinwider, Sandvik Austria]

8) In 5Axis CnC, for the "Moving Contact Point" along the Tooth Flank, addition of a protection such that when the bottom cutting line does not reach the fillet line, the contact point on the tool edge is at the bottom of the cutting edge when at the lowest selected cutting line, and is progressively rising to the Cutting Length when cutting the 1st Step. [Reported by P. Koenen, EMCO Gears]

9) In 5Axis CnC, for the CoSIMT, addition of the "Edge Length in Use" which represents the part of the Edge Length of the tool which will be actually used in the cutting process. This way, the tool may be displayed in its true shape, but the actual part of the tool used in cutting may be limited.

10) In 5Axis CnC, for the End Mill, addition of the "Cutting Length in Use" which represents the part of the Cutting Length of the tool which will be actually used in the cutting process. This way, the tool may be displayed in its true shape, but the actual part of the tool used in cutting may be limited.

11) In 5Axis CnC, when using a Face Mill cutter, the maximum #Steps is now increased from 121 to 1000. [Requested by N. Meixel, Neugart GmbH]

12) In 5Axis CnC, the Metrics tab now covers Roughing cuts and Fillet cuts for the CoSIMT, End Mill and Ball Mill tools.

- When Roughing, only the Profile Wise or Fillet Wise data is given (no Length wise data); Step#, Slot Width and Step Depth are given at Toe and Heel; since Flat Width and Flat-Prof. are not significant in Roughing mode, they are omitted;
- When in Fillet, the "Profile Wise" data is replaced by the "Fillet Wise" Data; the Peak-Fill. value, i.e. the height above the fillet where the Edge Radius intersects for 2 consecutive points in the depth direction, replaces the Flat-Prof value normally given for the profile part of the tooth.

13) In 5Axis CnC, GCodes Tab, the Start and End Steps can now be selected such that cutting may be initiated and ended at any of the defined steps.

14) For Straight Bevel Gears (Generated), the Transmission Error (TE) value entered when creating the gear set is now calculated at the Transfer Points of the TE curve. The TE is controlled by Modified Roll, if a positive value is given; if zero is given, then the TE request is ignored and Modified Roll is not used.

15) In 5Axis CnC, there is now the possibility to use 2 controllers for the machines: GCodes and Heidenhain. Both are of limited extent, but offer anyway the fundamental commands in the desired language. The controller is selected by editing the desired machine.

HyGEARS update - 21 Feb 2014 - Build 403.20 - 452

1) Addition of a "Metrics" tab to the 5Axis CnC machine interface. The "Metrics" tab displays, for tooth slots cut by CoSIMT, End Mill and Ball Mill tools, for the tooth flank either in roughing or finishing mode, the following information in a table:

Profile wise:

Step#: 1, 2, 3 ... /Max requested

Slot Width : in the normal direction;

Step depth : @ mid slot; the Total is given at the bottom of the column;

Flat width: distance along the profile between 2 points which are based on the # steps

Flat-Prof: distance along the tooth flank normal between the line joining 2 points along the profile - which are based on the # Steps -

 and the actual profile; this gives a measure of the "flattening" of the profile with a decreasing #Steps

Length wise:

Point#: 1, 2, 3 ... /Max requested

Flat Length: distance along the tooth face between 2 points which are based on the # Points requested; the Total is given at the bottom of the column;

Flat-Prof: distance along the tooth flank normal between the line joining 2 points along the face width - which are based on the # Points -

 and the actual profile; this gives a measure of the "flattening" of the face width with a decreasing #Facewidth Points.

[Requested by E.Steinwiddler, Sandvik, and P. Koenen, EMCO Gears].

2) Added the display of the cutting steps to the 5Axis CnC machine interface. The steps appear as grey lines at Toe and Heel, and do not to interfere with other displayed elements. The display can be toggled On/Off from the 5Axis window, GCodes Tab, to the right of the #Steps (in the Display check box).

3) Added the display of the #Facewidth Points to the 5Axis CnC machine interface. The Points appear as blue crosses at the current cutting depth; the current point is displayed in red. The display can be toggled On/Off from the 5Axis window, GCodes Tab, to the right of the #Facewidth Points (in the Display check box).

- 4) Corrected a situation where when in Roughing mode, for CoSIMT, End Mill and Ball Mill, the 1st tooth slot cut would not correspond to the 1st tooth slot cut when in finishing mode. [Reported by P. Koenen, EMCO Gears].
- 5) Added the "Tool Holder Diameter" to the Miscellaneous section of the 5Axis input window, Machine Tab. This value is used in combination with the Tool Holder Length to display the machine chuck at the end of the tool in order to allow collision detection.
- 6) Improved the display of the CNC machine Tool Holder, or chuck; the color is now greyish, to be somewhat similar to steel; the diameter of the chuck can now be set (see 5) above) and the # facets is increased from 5 to 24 to enhance the display. [Requested by P. Koenen, EMCO Gears].
- 7) Changed the color of the CoSIMT arbor in order to facilitate visualizing the arbor from above when checking for interference between the tool arbor and the work. The CoSIMT is green while its arbor is dark green. [Requested by P. Koenen, EMCO Gears].
- 8) Changed the display of the Topland in the Tooth Childwindow (visible, for example, in the "Geometry" Pre-defined mode). The Topland is now given in the transverse plane at Toe and Heel, and in the Normal plane at mid-facewidth, in order to facilitate verifications after cutting where using a caliper, it is easier to measure the transverse value on spiral bevel gears.
- 9) Added the output of the transverse Topland at Toe and Heel to the Blank output of the Summary.
- 10) Added the display of the coordinates (in the work ref. frame) of the center of the Ball when it is contacting the 2 tooth flanks in the Dia. over Balls ChildWindow. The axial coordinate is given in ref. to the Crossing Point (Xp) for hypoid gears, and in ref. to the pitch apex for other bevel gears. [Requested by P. Koenen, EMCO Gears].
- 11) For the End Mill cutter, if the user enters an Edge Mill radius larger than the End Mill radius for a cylindrical End Mill, or larger than the End Mill radius divided by the cosine of the End Mill cone angle, the entered value is overwritten by the maximum allowed value, which is displayed in red. [Requested by P. Koenen, EMCO Gears].
- 12) When entering the #Facewidth Points or the #Steps, if the entered value is below the lower limit, or above the upper limit, then the entered value is replaced by the appropriate limit which is displayed in red to alert the user (when the Apply button has been clicked). [Requested by P. Koenen, EMCO Gears].
- 13) In 5Axis CnC Roughing when using a CoSIMT, corrected a situation where the CoSIMT would be closer to the IB side than the OB side at Heel for spiral bevel gears with large spiral angle.
- 14) In the Machine section of the CnC Output program, added the distinction between the stock left at Finishing and that left at Roughing.
- 15) Corrected a switch which would make the 5Axis input window to lose the Invert Arbor check box when changing from CoSIMT to another tool such as an End Mill.
- 16) Changed the way the Ref. C angle (B angle for AB machines) is calculated since when using different tools, for example a cylindrical End Mill and a tapered End Mill of the same diameters, the calculated work piece angle (C or B) would be different for the same fillet line at toe position, and therefore, if one finished

the tooth flank with say a Tapered end Mill and the fillet with a Bull Nose End Mill, the phase angle of the work would be lost. [Reported by P. Koenen, EMCO Gears].

17) In 5Axis CnC, when cutting the tooth flank, the 1st pass (which is empty anyway) is now removed such as to improve process speed. [Requested by P. Koenen, EMCO gears].

18) Added the possibility to specify the default rotation direction of the A angle in AC and AB machines; this can be achieved when editing a specific machine, where +A and -A can be selected or not; if both are selected, the work can be tilted both directions; when only +A is selected, then the coordinates will be converted such that A is always +; same for -A, which is often the preferred way since most AC machines have the work tilted towards the operator for -A.

19) Improved the consistency of the convergence for large diameter gears in 5Axis CnC; to create a tool path, the tooth is digitized such that the tooth flank points are spaced at regular radius increments. For large diameter gears, some points could diverge, especially so where the fillet is close to, or at, the undercutting limit. [Reported by E. Steinwider, Sandvik Austria].

20) In 5Axis, in the GCodes data page, the #Steps required is now followed by a number within brackets "[x]" giving the recommended number of steps to cut without interference on the opposite tooth flank and based on the Slot width, the stock left on the flank, and the tool dimension. The bracketed number "[x]" is then followed by an input field where the user can override the recommended #Steps by entering any number between 1 and the requested #Steps; this number is the actual #Steps which will be used to generate the CnC program. The user can thus tailor the #Steps as a function of tool dimension and slot width. [Requested by P. Koenen, EMCO Gears]

21) Addition of the "Constant D-Radius" switch to the Stock Feed section of the GCodes data page in the 5Axis input window. The Constant D-Radius instructs HyGEARS to spread at equal radial intervals the lines defining the tooth flanks; therefore, when this switch is checked, the cutting Steps will be of almost equal depth. *A contrario*, when unchecked, HyGEARS spreads the lines defining the tooth flanks based on equal roll angle increments; in this case, at the OD, the steps will be deeper than those at the fillet. The advantage of equal roll angle increments is that the Profile to Flat distance is also reduced and thus, a lesser number of steps may be used to achieve the same surface finish (especially visible on large diameter gears).

22) For Straight Bevel gears, added the "Minor Diameter (Heel)" entry to the Straight Bevels data page when creating a New Geometry. This allows HyGEARS to replicate exactly the root diameter at heel of an existing gear. If left blank, then it is ignored.

23) Straight Bevel Gears [Generated] can now be created with an helix angle - they are thus helical bevel gears. The Helix angle is entered in the Cutter data page of the "New Geometry" definition window.

24) It is now possible to specify the Transmission Error that a Straight Bevel gear set will exhibit. The desired value is entered in the "T. Error" field of the Cutter data page of the New Geometry definition window. If zero, then no attempt is made to attain a given value. If non zero, then HyGEARS will attempt to reach the given value at contact entry, i.e. at the beginning of the TE curve rather than at the transfer point.

25) Addition of the #decimal places used to display/output the CnC program. By default, linear and angular values present 4 decimals, and this applies to the 3 default Universal CnC machines. For specific machines, the #decimal places can vary from 1 to 8, for linear and angular values. [Requested by P. Koenen, EMCO Gears]

26) When the ^J keyboard shortcut is pressed, HyGEARS cycles through the pre-defined projections for any 3D ChildWindow. However, the rotation buttons about X, Y and Z now remain active such that the user can use the shortcut to quickly select an appropriate projection, and then simply make a few rotations to reach the desired viewpoint. [Requested by P. Koenen, EMCO Gears]

27) In the 5Axis input window, GCodes data page, the "Moving Contact Pnt" switch has been added to allow the user selecting if the contact point on the tool is always at the same position or is rather moving along the edge of the tool in a manner similar to Face Mill or Rack cutters. When roughing, since material is to be removed from the outside, this option is not available; however, when pre-finishing, or when finishing the tooth after hardening, it is important to allow the contact point to move along the edge of the tool such as to distribute the generated heat and wear more evenly, thus increasing tool life and improving surface finish. Applicable only to CoSIMT and End Mill tools in finishing mode. Ignored in Fillet mode.

28) Addition of the Angular Thickness to the Tooth Thickness section of the Blank in a Summary. The Angular Thickness is the angle between the IB and OB tooth flanks at the Mean Point, i.e. mid-face width on the Pitch cone. [Requested by P. Koenen, EMCO Gears]

29) Addition of the "Edge Length" to the definition of a CoSIMT. This value allows HyGEARS to display the CoSIMT with the given Edge Length in a greyish color similar to that of steel. The same Edge Length is assumed for each cutting side of the CoSIMT. When a "Moving Contact Pnt" is selected, if the Edge Length is less than that required to fully cover the tooth depth, the edge Length is used as the maximum value.

30) Addition of the display of the Mean Point - in pinkish color - in the CMM NOminal Child Window, such as to give a reference where thickness values are given in the Summary.

31) Inverted the sign of the Y and Ny components for the Zeiss GPro CMM target of hypoid, spiral bevel and Zerol gear members. [Reported by P. Koenen, EMCO Gears]

32) Modified the rotation of the Ref. frames in the Dia. over Balls ChildWindow for the X1X2X3 and Y1Y2Y3 coordinates to match the display.

33) When in 5Axis Mode, ^R now toggles On/Off the display of the Pinion/Gear ref. frame. [Requested by P. Koenen, EMCO Gears]

34) In 5Axis, the tools - CoSIMT, End Mill, Ball Mill - now comprise all their dimensions, including the Tool Length which has been moved from the Machine Data Page to the appropriate tool data page.

35) In 5Axis, specific machines now include the dimensions of their tool holder, i.e. diameter and length, and in the case of BC machines, the B Axis offset.

36) In 5Axis, in the Misc. section of the Machine Data page, 2 switches were added to toggle On or Off the display of a) the Tool Holder and b) the work piece arbor.

37) In 5Axis, for End Mill tools, the tool now comprises a Cutting Length, which is the part of the tool doing the actual cutting.

38) In 5Axis, for CoSIMT, End Mill and Ball Mill tools, the cutting section is now displayed in light grey, the stem or arbor in green, and the tool holder in dark grey.

HyGEARS update - 10 Jan 2014 - Build 403.10 - 451

- 1) Inverted an ill-behaved switch in the LTCA that determines which of the AGMA-Mod and AGMA models is used for Bending stresses.
- 2) Added support for High Ratio Hypoid gears (HRH) and Super High Ratio Hypoid gears (SRH). Such gear sets can be in the range from 6:60 to 1:100, pinion to gear transmission ratio. The Fixed Setting and Duplex Helical processes, generated and non generated, can be used. For higher ratios (15:1 and above), the Fixed Setting gives better results because of its greater flexibility.
- 3) Added the display of the Pinion and Gear complete models to the Blank page of the Graphics Summary ("GSum" function button). This gives users a better idea of the final part.
- 4) In the GCodes selection window ("5Axis" function button), when editing a specific machine, the machine can now be told whether negative C angles (for AC and BC machines) or B angles (for AB machines) are accepted by the controller. When accepted, typical C values can change in the following sequence C+3, C+1, C-1, C-3, When not accepted, C values rather change as C+3, C+1, C+359, C+357, ... Similarly for B angles in AB machines.
- 5) When creating a new Zerol, spiral-bevel or hypoid gear set, the "Units" data page now offers to describe the blank with the following data input, such that existing blanks may be used with improved facility:
 - required Backlash
 - Outside Diameter
 - Face Angle
 - Dedendum Angle
 - Whole Depth
 - Bore Diameter
 - Min Bore to Root @ Toe
 -

14 Jan 2014 - Build 403.10A - 451

Note: this is an extension to 403.10 because of last minute requests by a user.

- 1) Added control to detect the "Stop" button was pressed when animating a Spur/Helical gear from the 5Axis GCodes input window. To stop the animation, one had to click twice on the "Anim" button of the Tool Bar on the Parent Window.
- 2) Corrected the sign and value of the A angle for AC and AB machines when using a CoSIMT as tool.
[Reported by P. Koenen, EMCO Gears]
- 3) Added, to the display of the 5Axis CnC machine, the Fillet line (in green) and the lower limit till where the tool will cut (in yellow). The Fillet line is given as a reference. The cutting limit (in yellow) is given to inform the user how deep any given tool will reach in the tooth slot. When in fillet/root cutting cycle, the yellow line is at the bottom of the tooth; when in Tooth Flank cycle, the yellow line is at the depth where the tool

will stop, and will not go below the fillet line (in green); when in Tip deubrring cycle, the yellow line is along the tooth tip [requested by P. Koenen, EMCO Gears]

4) Added a protection such that the Edge rad of the End Mill cannot be larger than 50% of the End Mill diameter.

5) Added the display, in the End Mill and Ball Mill tabs, of the min. fillet radius at Toe and Heel. The fillet radius is taken on each tooth flank and the minimum value is kept for reference [requested by P. Koenen, EMCO Gears]

6) Now, when the Anim button is clicked, the tool starts where it is and continues its motion, which is pre-defined from the selection made in GCodes. If the Stop button is clicked during animation, the motion stops. If Anim is clicked again, motion continues from where it was.

7) Single Stepping in 5Axis mode: If the [+/-] button is clicked, the motion will move UP or DOWN on the same tooth flank from where it was when stopped. The + button (left mouse button) moves UP on the tooth depth; the - button (right mouse button) moves DOWN in the tooth depth.

Stepping will not retract the tool. Keeping the [+/-] button depressed (left mouse button = +; right mouse button = -) makes a continuous movement. It will stay on the same tooth flank and go back and forth when reaching either the tip or fillet if the + or – button keeps on being depressed.

HyGEARS update - 05 Dec 2013 - Build 403.00 - 451

- 1) Duplex Helical hypoid gears, generated and non-generated, are now responsive to tooth taper (which can be chosen as Standard, Duplex and Tilted Root Line) and Depth / Addendum factors, such as to allow control of tooth dimensions.
 - 2) Modified a switch to rotate the -1 tooth flank when calculating tooth stiffness in the LTCA. When using "reasonable" torque values producing contact stresses of 2 GPa or less, this switch has no perceptible effect. However, with large torque values where contact stresses approach 3 GPa, its effect on tooth stiffness, and thus on the TE under load and the contact stresses, becomes significant. [Reported by E. Steinwider, Sandvik].
 - 3) Added the Toe and Heel clearances to the 5Axis CnC machine window. The Toe and Heel clearances are used to force the tool to get out of the actual tooth before actual cutting. The values are maintained in the geometry data file. [Requested by popular demand ! - EMCO and Sandvik].
- Note: Care must be used for Face Gears, at Toe, since in most cases, the fillet reaches more than 50% of tooth height; in this condition, there is no margin for Toe clearance, and results will not be correct - one must verify visually the cutting cycle ("Anim" button) to ensure adequate movements at Toe before generating the CnC program.
- 4) Addition of the Addendum and Dedendum outputs which were missing from the Blank Output for Straight Bevel gears. [Reported by P. Koenen, EMCO Gears]
 - 5) When editing the Summary for a Straight Bevel pinion or gear, modifying the Major Diameter (OD) now changes the needed FApXp, just like for Spiral Bevel gears.
 - 6) Modified several conditions when creating a Straight Bevel gear set to ensure that the requested Face and Root Angles and Major Diameter are met. [Reported by P. Koenen, EMCO Gears]
 - 7) Added support to calculate Tooth Thickness Error, and thus account for it in the Corrective Machine Settings and RE, for the GAGE output such as found on a Wenzel CMM. [Requested by N. Meixel, Neugart GmbH]
 - 8) Added support to calculate Tooth Thickness Error, and thus account for it in the Corrective Machine Settings and RE, for the Zeiss GPro output
 - 9) Inverted the sign of the Tooth Thickness Error. Positive when the actual tooth is thicker than the simulation, and vice-versa.
 - 10) Disabled the "Thickness Error" entry field when converting either a GAGE or Zeiss GPro CMM file since the information is contained in the output file.
 - 11) For 5Axis CnC "BC" type machines, the B Axis rotation can be limited to Positive or Negative values, such as to support machines such as the Mazak Integrex which can operate only from above, i.e. with Positive B Axis values. The Positive/Negative capabilities are set by clicking on the "Edit" button in the Machine tab from the 5Axis Input window. [Requested by E. Steinwider, Sandvik].

HyGEARS update - 29 Nov 2013 - Build 402.90 - 450

- 1) For Face Gears, cutting cycles for the tooth flank and the fillet can now be either Slot by Slot or Flank by Flank. [Requested by E. Steinwider, Sandvik]
- 2) In the creation of Spur/Helical/Face/Beveloid gears, the Blade Edge Radius (BERad) is calculated as "Fillet Factor * module"; the active profile below the Pitch circle is now calculated as the difference in tooth depth between the Pitch and Root circles, based on the Dedendum factor and $BERad * (1 - \sin(\Phi))$ where Φ is the blade angle.
- 3) Added to 5Axis CnC machines the Roughing cycle to the CoSIMT, End Mill and Ball Mill tools, for all geometries. The Roughing cycle runs the tool in the middle of the tooth slot without generating motion. The cycle can be visualized like the other cutting cycles. The Roughing cutting cycle is Slot-by-Slot, Toe-Heel-Toe, and goes into the slot till there is no more space for the point width (CoSIMT) or diameter (End Mill, Ball Mill) of the tool, plus 2 times the Roughing Stock.
- 4) For Face Gears (gear member), when the Face Width is changed, the OD is adjusted from the sum of the $(ID + 2 * \text{Face Width})$.

HyGEARS update - 16 Nov 2013 - Build 402.80 - 450

1) Improved the way rotations on the screen are done using the mouse; a hand now appears when rotating, and the border between rotation about axis X and Y is better defined such that a slightly slanted line followed by the cursor results in a constant rotation about the X or Y axis.

2) Modified the Blank display for Spur/Helical gears. The display now shows the contour of two teeth and displays:

- O: Outside Diameter
- P: Pitch Diameter
- F: Form or Start Active Profile Diameter
- B: Base Diameter
- R: Root diameter.

along with the Face Width, Addendum, Dedendum and Helix Angle in text. [Requested by E. Steinwider, Sandvik GmbH].

3) In the comparison of the CMM and Nominal data Child Window, the 1st order surface statistics (fa = pressure angle error, fb = helix/spiral angle error) are now displayed shown at the right of the display Child window.

4) Normalized the tool definition for Spur and Helical gears. Whereas previously the tool addendum and dedendum were modified to reflect the desired profile shift factor, these are now set as per the addendum and dedendum factors and the profile shift factor actually displaces the tool, as is the case in the real machine.

5) Corrected an ill stated condition for the generation and conversion of CMM target files for the Zeiss GPro CMM, where the 1st tooth flank to be measured, and converted after measurement, would be inverted between pinion and gear. [Reported by E. Steinwider, Sandvik GmbH].

6) Corrected a display condition for the AB type 5 Axis CnC machine where the arbor would not show at the right place when the Apex Location value is different from zero.

7) Addition of an interface to define specific 5 Axis CnC machines based on the AC, AB or BC type Universal machines already defined in HyGEARS.

The [New] and [Edit] buttons on the GCodes window give access to the interface where the signs of the X, Y Z, A, B and C axes on the actual machine can be defined in relation to the selected basic machine.

8) Addition of a Deburring cycle for the End Mill tool. Deburring is normal to the tip edge, therefore at and angle half way between the top land and the tooth flank at tip. Deburr depth and the number of passes needed to reach that depth are both editable. Deburring can be done using the Tool Side, or the Tool End, the latter providing A angle values (for AC and AB machines) or B angle values (for BC machines) usually less than or equal to 90 degrees, whereas the former often exceeds the 90 degree mark.

9) Added a condition to detect, in the BP TCA Child window, if a spiral bevel gear set or spur/helical/straight bevel/face gear set is displayed, in order to identify correctly the Gear Right and Left tooth flanks which were opposed.

HyGEARS update - 29 Oct 2013 - Build 402.70 - 449

1) In the Zeiss Gear Pro CMM target file, the Facewidth for bevel gears now describes the distance along the axis of rotation between the backing face and the front crown of the tooth.

2) The End Mill tool is now generalized as a conical End Mill. Its action stops at the Start of Active Profile; this is to say that if there is no edge radius on the End Mill, there will be no fillet generated and a Ball End Mill will need to be used to generate the fillet.

3) Corrected a condition on the Graphics Summary where the BP Ltca would not display properly when a Grid was requested. [Reported by P. Koenen, EMCO Gears].

4) For Zerol, Spiral-Bevel and Hypoid gears, in the Summary Editor, when the OD is changed, the FApXp is now updated to provide the requested OD.

5) Updated the Balance Strength switch when creating a new Zerol, Spiral Bevel, or Hypoid gear set. Now works for Completing and Fixed setting cycles.

This averages the Bending strength on both tooth flanks with the load applied at 67% of tooth height, at mid-facewidth; the BP is centered before this can proceed.

6) Addition of an AB 5 Axis CnC machine. The AB machine is based like an AC machine with a trunnion, but the A axis is // to the Y axis, and the work piece axis is called the B axis. It is based on the Haas VF3 machine.

7) Addition of the Ball Mill tool, which is made of a sphere at the end of a stem. The ball works on its bottom half only. It can be used to either cut the tooth flank or the fillet area.

8) Addition of a cutting cycle to finish the fillet area of the tooth. This can be done using either a Ball Mill or an End Mill with sufficient edge radius.

9) Spiral bevel gears, when cut with a Face Mill tool, can now be cut in 3 different cycles:

- Single Roll - Toe to Heel (for Completing cycles)
- Single Roll - Heel to Toe (for Completing cycles)
- Double Roll - Toe to Heel on IB, Heel to Toe on OB (for Fixed Setting)

10) In the Bearing Pattern Development window ("BPat" function button) from the "TCA" pre-defined mode, the "Prop" tab (or Proportional changes) is now displayed for every gear type. When the pinion is Fixed Setting, the Point Diameter for the IB and OB can be changed independantly.

The Pinion and Gear Tooth Depth can also be changed (it was rather "Pinion Profile Shift" only before).

HyGEARS update - 19 Oct 2013 - Build 402.60 - 448

- 1) In Pre-defined modes, the Interpolation order is now set as that selected by the user, whereas before, it was imposed as Linear.
- 2) When in the Load Sharing editor window (Load function button), clicking on Apply would not update the upper left BP LTCA window. This is now corrected.
- 3) In the Summary Editor, if the Apply button is clicked while the "Operating" data page is displayed, the bending and contact stresses are now calculated and displayed. One can therefore modify the application factors and torque and have an immediate feel for the effects on the geometry.
- 4) The file system now makes the difference if the gear machine is a generator or non generator and accordingly stores the gear corrective machine settings in the appropriate stream.
- 5) In the contact stress calculations as per the standards, a distinction is made if the pinion has less or more teeth than the gear member; if the pinion has the lesser teeth, then the contact stresses are calculated at the LPSTC; otherwise, they are calculated at the HPSTC; for helical gears, the contact ratio is accounted for in the calculation of the effective length of the line of contact.
- 6) Inverted the CoSIMT tool flank on which the tool cuts Face Gears in order to reduce interference possibilities between workpiece and tool spindle. [Requested by E. Steinwider, Sandvik].
- 7) Added the Fixed Setting process to the list of gear cutting processes. This can be used to grind Cyclo Palloid pinion and gears since the lengthwise curvature is not very different. Tooth taper defaults to Uniform. It is available only for spiral bevel gears when the pinion is cut by the Fixed Setting process.
- 8) Corrected a condition where when generating the Corrective Machine Settings Summary, at the end of a Correction calculation, the pinion or gear datastructure could be polluted.
- 9) Corrected the behavior of the tooth display in the Stock Pre-Defined mode, when Stock distribution optimization is requested ("Stock" button).
- 10) Addition of the Changes in Machine Settings, and Surface Statistics before and after correction, to the Pdf Correction Summary which is issued automatically after calculating Corrective Machine Settings.
- 11) In the "5Axis" (GCodes) and the "Anim" windows, the Arbor tab now allows to define an arbor behind and in front of the workpiece such as to check for collisions between the tool and the machine / workpiece. The Toe arbor can be up to 3 segments long, that at the Heel can be up to 5 segments long.
- 12) Added control to prevent starting an animation from the Parent Window ("Anim" function button) when the GCodes window is present.
- 13) Change to the behavior of the Graphics menu: whenever "Pinion", "Gear" or "Pinion and Gear" the selection request is accounted for and the menu is redisplayed immediately for the user to select the desired graphic function.

14) Added control to detect that the Child window being Zoomed is not linked to the current display list; when this occurs, the display list is refreshed and zooming can proceed directly.

HyGEARS update - 04 Oct 2013 - Build 402.50 - 447

- 1) For Straight Bevel and Coniflex Gears, the Blank Summary now states that tooth thickness is given at Heel on the Pitch Cone.
- 2) End Mill dimensions used for 5 Axis CNC machining are now stored in the geometry data file.
- 3) For Face Gear CNC machining on an AC 5 Axis machine, the cutting cycle is changed; the left tooth flank for all teeth is cut 1st; then the right tooth flank is cut. This is in order to avoid shifting from one side of the machine to the other between tooth slots.
- 4) The CNC Output now includes the Apex Location as entered in the GCodes input window.
- 5) In CNC GCodes generation, instead of Roll Angle and Face Angle increments, the # Passes DepthWise and then # of Points along the facewidth are now specified as they are more intuitive than angles in specifying the finish coarseness.
- 6) Addition of the Beveloid gears to the list of gears cut using 5 Axis CNC machines. Valid for both AC and BC type machines.
- 7) Addition of the Zeiss Gear Pro CMM to the list of supported CMMs.
- 8) For the wheel of Face Gear sets, when defining the CMM Target file, the sign of the tooth root clearance is changed to be consistent with the sign for other gear types.
- 9) For 5 Axis CNC machining, Cutting cycles now include [Requested by E. Steinwiddler, Sandvik GmbH]:
 - 1- Toe -> Heel -> Toe; i.e. constant back and forth on one tooth flank, starting at toe
 - 2- Heel -> Toe -> Heel; i.e. constant back and forth on one tooth flank, starting at heel
 - 3- Toe -> Heel: cut from toe to heel, retract and return to toe for another pass
 - 4- Heel -> Toe: cut from heel to toe, retract and return to heel for another pass
 - 5- O-Shaped: cut toe to heel on flank 1, switch to tooth flank 2, cut from heel to toe, switch back to flank 1, take another pass, and so on.

Cycles 1 to 4 can be either :

- a- Slot by Slot, i.e. cut one side then the other, and then index to next slot, or
- b- Flank by Flank, i.e. cut all tooth flanks on one side, then all tooth flanks on the other side.

5 is a Slot by Slot process by definition.

- 10) The CoSIMT is redefined and now replicates the Sandvik Gear Milling tool: about any practical blade angle can be used on the side opposite the arbor;
 - when 0, one gets a standard CoSIMT (as per PTR-TEC);
 - it can be negative, although applications will be limited;
 - it can also be 20 degrees, with an included angle of 40 degrees, such as to replicate a standard spur gear rack; etc.

[Requested by E. Steinwider, Sandvik GmbH]

11) Corrected a display error in 5 Axis CnC machining mode, where a hypoid pinion would not be displayed at its proper location in relation to the cutting machine.

12) In the Blank Contour Child window, for bevel gears, added the axial distance between the Front Crown and the end of the hub at the root-heel location. Useful when preparing blanks.

13) In 5 Axis CNC Output, added control for the C angle to avoid toggling to complement 360 degrees when either switching tooth flank or retracting the tool. [Based on 19x22 Coniflex, GMC]

14) In the Animation of the 5 Axis CNC cutting, the paths of the tool and work piece are now segmented between two end points such that possible interferences can be visualized.

15) In the GCodes input window, the "Retract Factor" is used to determine by how much the tool is to be retracted between 2 end points; the Retract Factor multiplies the tooth depth at the Heel to determine how much the tool is retracted.

16) Corrected a condition where, in files older than June 2013, the higher-order parameters for modified roll (in Phoenix machine) would not be recalled when a data file is read.

17) Corrected a condition when editing the gear member of a Helical Face Gear set, where the sign of the helix angle would be inverted.

18) Inverted the "Net Shape" straight bevels ID with the "Generated" straight bevels ID and vice versa to avoid confusion.

19) Added conditions when applying Stock Distribution optimization to detect that the Jacobian Matrix had not been calculated.

20) Increase of the #digits in the Blank display. [Requested by P. Koenen, EMCO Gears]

21) Corrected a ref. point for hypoid pinions that would cause the OD to come out slightly smaller than the actual value. [Reported by P. Koenen, EMCO Gears]

22) In the 2D Graphs, for Profile Deviation, added a call to recalculate the sin and cos of the deviation angles, which would cause the display not to recalculate the profiles and thus display would not show the actual deviations.

HyGEARS update - 04 Sept 2013 - Build 402.40 - 444

- 1) Corrected a sign error for Gleason machine 16 where the sign of the cradle angle for the gear had to be inverted.
- 2) When the Corr-RE display page is clicked, if a measurement data file is in memory after loading a file from the disk, the display would be wrong because the conversion factor would not be reset. This is now corrected.
- 3) when creating a new hypoid gear set, the imposed Face angles for the pinion and gear are now considered and if possible, the blank geometry is adjusted to satisfy these.
- 4) Inverted the column order in the GAGE CMM target files, starting from root rather than from tip. [Requested by N. Meixel, Neugart GmbH].
- 5) Correction to Conflex design where, in the case of miter gears, the pinion and gear machine settings are made identical at pre-development time. [Based on 32x32 case from Neugart GmbH].

HyGEARS update - 24 June 2013 - Build 402.30 - 442

- 1) In BP Development ("BPat" function button), when the "2nd-3rd" option for TE control is selected, the correction is now extended to 5th order such as to control not only TE depth, but also the fact that the contact entry and exit branches are at the same level as long as the requested lengthwise location of the Mean Point is situated between 40% and 60% of tooth facewidth.
- 2) Corrected a display bug where, in Bearing Pattern Development ("BPat" function button), cycling through the "Next" and "Back" buttons would not yield the appropriate BPs and TE curve although machine settings were correct.
- 3) Changed the behavior of the Grid button in the BP TCA Pre-defined display: If the BP Child window is active, then Grid is for BPs; otherwise, it is for 2D-Graphs.

HyGEARS update - 10 June 2013 - Build 402.20 - 441

- 1) Added support for GAGE CMM Target files and Result output conversion to HyGEARS [requested by B. Cihlar, Neugart GmbH].
- 2) Modification to the default tool for the pinion of a Face Gear set: this is now a Rack rather than a shaper.
- 3) Modification to the crowning of the Pinion in a Face Gear set: now, crowning is provided by using a shaper (for the Gear) which has 1 tooth more than the tooth number of the Pinion. [Suggested by E. Steinwider, Sandvik]
- 4) At design time, Face Gears now go through the following:
 - a. basic tool and blank dimensioning;
 - b. calculation of a default X Factor for the pinion, if needed and none entered;
 - c. calculation of the needed X Factor for the gear to ensure adequate backlash;
 - d. calculation of the needed gear shaper center distance to center the BP on the tooth flank.
- 5) When creating a new Zerol/Spiral Bevel/Hypoid gear set, the "Sum of Pressure Angles" could be ignored and default to 40 degrees. This is now cured and is valid from 30 to 50 degrees.
- 6) When digitizing cylindrical gears using a Shaper as the tool, the OD would come out too small and necessitated a larger Addendum factor. The condition causing this is now corrected.
- 7) When using a Shaper as the tool for Cylindrical / Face gears, the X-Factor - or Profile Shift factor - now modifies the tooth thickness of the shaper and the Tool Center Distance modifies the location of the tool in relation to the workpiece.
- 8) For cutting processes using a shaper tool, the max. tool OD is now calculated to avoid pointed teeth, and the min. ID (thus the blade dedendum) is limited to the Base circle.
- 9) For very small module SimplexT spiral bevel gears, the default cutter diameter could be too large which caused divergence. A smaller default value is now used.
- 10) Corrected a situation where, for cylindrical gears, when giving profile deviations as a function of the workpiece diameter, requested values would sometimes be ignored because of a divergence when searching the correspondance between the specified diameter and the point on the blade edge.
- 11) The GCodes interface is now accessed through the "5Axis" function button in the Machine Child Window, or "Machine" Pre-defined display.

The interface allows selection of the machine and tool, and visualization of the entire cutting process as the tool follows the digitized tooth profile.

Single stepping is enabled through the "+/-" button. While the "5Axis" window is displayed, there is access to all function and rotation buttons in

the Parent window and therefore, the user can modify the viewpoint at all times. The "Output" button generates the CNC program and displays it in a Text Results window.

- 12) Introduction of a 5 Axis CNC "AC" machine to the list of offered CNC machines.
- 13) Added support for CNC machining for all currently supported gear types in HyGEARS with a CoSIMT: Straight Bevels, Coniflex, Zerol, Spiral-Bevel, Hypoid, Spur, Helical, Beveloid, and Face Gears.
- 14) Added support to cut all gear types using an End Mill cutter. This specific cutter works on its shank rather than its end, allowing for longer tool life.
- 15) Added a "Roughing" mode for CoSIMT and End Mill tools in 5 Axis CNC machining.
- In Roughing mode, the cutter starts at the outside of the blank and progressively moves in toward the root of the tooth. A "Stock" dimension moves the tool away from the finished tooth profile by the given value.
 - In Finishing mode, the tool mimicks a standard tool and therefore assumes that the tooth gap is already almost totally free of material.
- 16) The Parent Window can now be minimized in all modes, i.e. User and Pre-defined. However, it cannot be maximized.
- 17) Update to the User Documentation and Context Sensitive Help (F1 Key) to reflect changes since January 2013.

HyGEARS update - 11 April 2013 - Build 402.10 - 440

- 1) Increased the size of the Display List from 96,000 facets to 192,000 facets.
- 2) Improved the speed of graphics display.
- 3) Improved the speed of Finite Strips calculations.
- 4) Improved the speed of the LTCA calculations.
- 5) In the Summary, Page #1, Tooth Data, specification that the Normal Thick. is either @ Mean Point or at Mid-Height. Both are at mid-face.
- 6) Corrected a condition where the transverse tooth thickness at the Mean Point would be calculated in the wrong direction, resulting in an erroneous value. [reported by J. Thomas, Voith GmbH].
- 7) Added a condition when using the "Opp" Function button (which inverts the tooth hand) where after clicking on the button, one had to edit both the pinion and gear through the Summary Editor (Pin and Gea function buttons) to have the teeth to digitize properly.

HyGEARS update - 04 March 2013 - Build 402.00 - 440

1) When the Graphic Parent window is displayed, it occupies a pre-defined space. Since users may want to run HyGEARS on screens 1024x768 pixels, the Pre-defined modes become too high for the screen height. HyGEARS now resizes the Parent window to fit within the screen area, and the Parent window itself can be resized at will. [Requested by J. Lamprecht, Bosch GmbH].

2) When creating a new Spiral-Bevel or Zerol gearset, the desired Backlash can now be entered on the Units Data Page. When the Module or Diametral Pitch is changed, the Backlash is modified on the Units Data Page to reflect the normally recommended values as per AGMA; this value can be modified prior to clicking on the Ok button to start calculating the new geometry.

3) When creating a new Spiral-Bevel or Zerol gearset, the desired Whole depth of the gear member can now be entered on the Units Data Page. HyGEARS will attempt to reach this value,

- a. preventing possible Undercutting by shifting out the cutter if needed (which will reduce the tooth height) and
- b. maintaining a minimum Topland by modifying the FApXp value.

[Requested by J. Lamprecht, Bosch GmbH].

4) Enabling of higher order Modified Roll and Helical motion for the gear member [Disabling reported by J. Thomas, Voith GmbH].

5) Improvement in the digitization of Spiral-bevel/Zerol teeth when heavy undercutting is present. All tooth flank points in the undercut area are now brought out to the undercutting limit. [Based on test case 9x43 Stihl]

6) Improved graphic rendering of the cutter body and blades in the Cutting Machine Child window.

HyGEARS update - 08 Feb 2013 - Build 401.90 - 440

1) for TCA and LTCA analyses, Beveloid gears are now considered as Point contact profiles (as opposed to Line contact for Spur/Helical gears) and therefore the results of TCA and LTCA differ slightly from 401.80 and earlier HyGEARS releases.

2) For Spur/Helical/Beveloid gears, the Helix angle can now be edited.

3) For all gears, access to the Corr-RE Pre-defined display is now possible in order to access the CMM results. Corrective Machine Settings and Reverse Engineering are possible only for Zerol, Spiral bevel and Hypoid gears.

4) Modified a condition such that for Spur/Helical gears, profile modification can start from the root to the tip by entering a zero value for "Tooth Addendum Relief Start" and a non-zero value for the "Tooth Addendum Relief Angle"

5) When creating a Zerol/Spiral-bevel/Hypoid gearset, it is now possible to enter values for Cutter Blade Profile Curvature for both the Pinion and Gear IB and OB. These values can be positive (concave curvature; increases Bias and TE) or negative (convex curvature, decreases Bias and TE).

They are very effective to control Bias and TE. Typical values are in the range of 20 to 60 [in] / 500 to 2400 [mm].

6) Corrected the effects of rotation buttons about Y and X on the Parent window as they were inverted [Reported by J. Lamprecht, Bosch GmbH]

7) For Zerol, Spiral-bevel and Hypoid gears, when developing the BP (BPat function button), TE may now be controlled in 3 manners:

- when "2nd-3rd" is checked, 2nd and 3rd order Modified roll is used to balance TE between the IB and OB, and reach the requested value;
- when "Curvature" is checked, Profile Curvature on the blade edges is used to balance TE between the IB and OB, and reach the requested value;
- when nothing is checked, the generating gears is modified to balance TE between the IB and OB, and reach the requested value.

8) For Spur/Helical/Beveloid/Straight Bevel gears, the Graphics Summary (GSum button) now contains 1 additional page with plots of the deviations of the standard tooth (i.e. no profile, helix and crowning modifications) against the topography of the actual tooth (i.e. which includes all the modifications). This allows to appreciate what are the effects of the modifications in relation to the standard teeth.

9) Corrected a mis-behavior, in the BP LTCA Pre-defined Display, where if the user selected the Finite Strips for the Bending Stiffness model, or the Contact Elements for Hertz Stress, the selection would disappear and the display would revert to the default Roark / Westinghouse models. [Reported by J. Thomas, Voith GmbH]

10) Added a control loop, when creating a Hypoid gearset, to ensure the Path of Contact covers entirely the gear tooth, i.e. from toe to heel on both sides.

HyGEARS update - 25 Jan 2013 - Build 401.80 - 439

- 1) When selecting a measurement data file of the Klingelnberg-P type, either Nominal or Actual, HyGEARS now automatically complements the 2nd file name to be provided since in the Klingelnberg-P system, the IB and OB are provided in separate file with always the same names. [Requested by J. Thomas, Voith GmbH].
- 2) For Straight Bevel and Coniflex gears, modified a condition in the generation of the tooth fillet area where divergence could occur for certain combinations of blade edge radius, blade angle and modified roll. While not affecting the TCA analysis, the displayed teeth would appear wrong.
- 3) Added a protection when elliptic blade edge radius is entered to prevent zero radius.
- 4) In the Summary Editor, for Straight-Bevel Gears, added testing to enable/disable the "Forged Fillet" on the Cutter Data Page - [Net Shape] can have the fillet Forged or Generated; [Generated] can only have Generated fillet.
- 5) In the Diameter over Balls calculation, the Jacobian is now calculated at each pass to improve convergence with Zerol, Spiral-bevel and hypoid gears with a large pitch cone angle (typically the gear member).
- 6) Improved the default values for the Diameter Over Balls function, such that the sphere lies close to tooth center and the sphere is an integer value in [mm].
- 7) Updated Context sensitive Help (F1 key).
- 8) In the Blank Childwindow, display of the radial distance between the Bore and the root ID at toe - important for small gears. [Suggested by J. Lamprecht, Bosch GmbH].
- 9) In the Blank Childwindow, addition of display of the Face, Pitch and Root angles. PApxXp, FApxXP and RApxXp (in text).
- 10) Improvement in the graphic rendering of the Blank Childwindow.
- 11) Modifications to the Beveloid simulation:
 - the calculation of the PoC is based on tooth separation, to be in better agreement with the Ease Off;
 - crowning on the pinion is doubled (when compared to equivalent spur gears) to better center the BP;
 - crowning is not centered on the tooth but a 3/4 of facewidth to better center the BP;
 - crowning is Imposed rather than obtained by machine vertical movement for better control of backlash;
 - correction of the gear grid which would overflow at tip with edge reduction = 0 [Reported by J. Thoms, Voith GmbH]

12) For Zerol, Spiral Bevel and Hypoid gears, in BP development (BPat function button, TCA predefined Mode or BP Development ChildWindow), the TE can now be imposed. The algorithm will a) balance the TE between the IB and OB and b) aim for the requested TE level. If the starting point is far from the desired result, several requests (Apply button) may be necessary. For Fixed Setting and Modified Roll, changes are applied to the pinion machine settings only; for completing cycles, both the pinion and gear are modified. Higher order changes are not used at this time.

13) For Hypoids gears, a more explicit message is given when the Input Data provided by the user is not satisfactory to create a geometry. It now refers to the inputted Cutter Diameter (if any), Spiral Angle (if any) and Offset (must be given).

14) Addition of the preselection of tooth taper for Straight bevel gears:

- [Net Shape] is Standard Taper (Duplex can be used);
- [Generated] is Duplex Taper (imposed; Standard taper causes an error).

15) For Coniflex gears, increased the speed of creation by modifying the partial derivative for backlash calculation.

16) Modified a conditional statement when creating Generated Duplex Helical hypoids, where the solution would not converge for some combinations of cutter diameter, offset and spiral angle.

17) In the Full Model ChildWindow, added the [+/-] function button to single step through meshing. The right mouse button does the [+], the left mouse button does the [-]. [Requested by J. Lamprecht, Bosch GmbH]

18) In the BP TCA predefined display, the [+/-] button defaults to the Path of Contact Childwindow; however, when the Full Model Childwindow has the focus, then the [+/-] function button steps the pinion and gear teeth through mesh. [Requested by J. Lamprecht, Bosch GmbH]

19) HyGEARS now installs in a different directory for each release. This allows multiple releases to coexist. As such, all support controls are installed as system/shared, and at the time of Uninstalling HyGEARS, the user is requested to confirm the removal of each support control when no other application appears to be using it. The existing configuration contained in the configur.inv file is transferred from the previous installation directory, if it exists and is found, on the condition that HyGEARS is installed in the proposed directory.

HyGEARS update - 11 Jan 2013 - Build 401.70 - 439

- 1) Addition of "elliptic blade edge radii". Using Elliptic edge radii on the cutter can significantly decrease the fillet stresses. In the Summary Editor, the Elliptic Edge radius is entered as "aa.aaa/bb.bbb" where aa.aaa is the value of the edge radius at the limit between the active blade profile and the edge radius, and bb.bbb is in a direction perpendicular to aa.aaa (thus in a direction parallel to the active blade profile). aa.aaa can be larger or smaller than bb.bbb. [Requested by C. Whirth, ZG GmbH].
- 2) In the HyGEARS Configuration window, Colors Tab, addition of the [Reset] button which resets the colors to their default values.
- 3) In the HyGEARS Configuration window, Colors Tab, when the Apply button is clicked, the newly chosen colors are now displayed [Requested by J. Lamprecht, Bosch GmbH].
- 4) Added warning messages for the Depth and Addendum factors in hypoid and spiral bevel gears. When either factor is below or above the AGMA recommended values, a warning message is issued.
- 5) Addition of "Toast Slice" messages, which are displayed in the bottom right corner of the Desktop when HyGEARS is going through a procedure that can be long, such as Creating a New Geometry, LTCA, and other tasks. Each message is displayed for a fixed amount of time. The message can be closed by clicking on the [x] button in the upper right corner.
- 6) Introduction of the Proportionality Constants, which are the changes in machine settings needed for one specific operation, such as displacing the contact along and across the tooth on the IB and/or the OB or modifying the Bias. These constants are calculated on the fly when going through the BP Development process, and are stored in the geometry datafile such that do not need to be calculated again for later use. The Reset button in the BP Development window (BPat function button) resets these constants. These constants allow much faster and reliable BP Development.
- 7) Corrected a call in the tip-to-root clearance calculation for Zerol and Spiral-bevel which caused the values to return negative.
- 8) Added a test in the display of 2D Graphs to detect the presence of splines, in which case the X Axis is artificially extended in order to display the results. (Since there is no relative rotation between the pinion and gear in splines, there is no value on the X Axis.)
- 9) Added the calculation of the Diameter over Balls for internal spur/helical/spline gears.
- 10) Added a test and associated message for the Shaft angle in External Spur/Helical gears which should not exceed 60 degrees.
- 11) Improved algorithm for the "Balance Strength" option when developing a Bearing Pattern (BPat function button).

HyGEARS update - 08 Dec 2012 - Build 401.60 - 437

- 1) HyGEARS 4.0 updates now posted on the www.hygears.com - Downloads website page. User only has to click on the desired Update link to download it, and then install the update. Customer must either be within the 1st year free included support, or have paid for the support, for the installed HyGEARS update to run. If these conditions are not met, an error message is displayed and HyGEARS terminates.
- 2) When creating a Spline, corrected the calculation of the topline which would cause the hourglass to appear and HyGEARS to block.
- 3) Corrected the default value of the Shaft Angle for Spur/Helical gears which would default to 90 deg. rather than 0 deg. [Reported by J. Thomas, Voith].

HyGEARS update - 30 Nov 2012 - Build 401.50 - 437

- 1) When creating an Internal Spur/Helical gear set, corrected the calculation of the topline which would cause the hourglass to appear and HyGEARS to block. [Reported by J. Thomas, Voight GmbH]
- 2) When creating either External or Internal Spur/Helical gear sets, improved the default values for profile modification such that maximum contact stress occurs at tooth center, away from contact entry. These values can be modified later through the Summary Editor.
- 3) For GCodes - CoSIMT tool - Completing cycles, reverted to the HyGEARS 3.0 algorithm, where the IB and OB tooth flanks are treated separately, machining starting with the IB side. In the HyGEARS 4.0 algorithm, the tooth was "extended" such that roll angles on the extended IB side would cover both the IB and OB of the actual tooth, thereby resulting in a single pass machining operation and saving cutting time. [Requested by R. Richardt, PTR-TEC].

HyGEARS update - 20 Nov 2012 - Build 401.40 - 437

1) Added support for several features when importing a geometry from a SPA file:

- for Zerol, the Helical motion is imported
- for Zerol and Spiral-Bevel, the Pinion and Gear OD are read, and the FApXp is modified to suit the inputted OD

[From DSD test case 26x69]

2) Modified a constant from which Zero tilt was considered: was 0.0001 Rad; now is 0.000001 Rad. [From DSD test case 26x69]

3) For cutters with circular edge, corrected a ref. value that was calculated with the abs value of the circular edge radius, rather than with the actual sign. This caused at times the profile to be digitized in the opposite direction (complement solution). [Reported by J. Thomas, Voith GmbH]

HyGEARS update - 10 Oct 2012 - Build 401.30 - 437

1) Upgrade to new definition in Hardlock key.

HyGEARS update - 02 Oct 2012 - Build 401.20 - 437

- 1) When Corr M/C or RE 2nd Order, default pressure angle control is now Blade Angle for Completing Cycles.
- 2) Added an additional pressure angle control loop when importing Face Hobbed from a Gleason SPA file as the SPA file seems not to contain the needed data to convert the given Blade Angle into the actual Pressure Angle needed by HyGEARS for proper simulation.
- 3) Improved the calculation of the sensitivity factor to helical motion - 1st order - to control BP Bias. Especially visible in small module gearsets.
- 4) Changed the ref. side to display the BP on Coniflex gears, as nothing would be displayed in the TCA and LTCA Pre-Defined modes.
- 5) Removed a condition that would toggle Off Modified Roll for Straight Bevel gears if the loaded datafile was older than the default version of the current HyGEARS build.
- 6) Improved the development of Coniflex gears. Coniflex pairs can now:
 - use cutters different from Gleason's 4.25" diameter
 - use cutters with different dish angle than Gleason's 4 deg.
 - use cutters with different point width/edge radius from Gleason's default values.Using a dish angle smaller than 4 deg. allows the increase of the BP Width and tooth coverage.
- 7) Corrected a display factor for the pinion/gear Blank where the Front and Back angles did not show in true dimension.
- 8) Modified a condition when RE - Corr M/C that would cause the solution to diverge for Spread Blade in 2nd order mode. [Reported by I. Massenrati, MdM]
- 9) Expanded Coniflex designs to support Gleason machines #104, 114 and 134, and default cutters 9" and 15".

HyGEARS update - 18 August 2012 - Build 401.10 - 434

- 1) Added, to the Blank section of the Summary, the Ratio of Involute to Outer Cone Distance, as it is a metric frequently referred to by Hypoid gear manufacturers for lapping.
- 2) Added "Profile" to the list of Corr M/C - Reverse Engineering options which can be controlled. When either the IB or OB blade is of circular shape, the "Profile" option is enabled. If selected, then the Radius of Curvature of the desired blade is modified to control profile error. If a straight edge blade exists, then no change occurs. Corr M/C - Reverse Engineering then operates in Manual Damping mode.
- 3) Improved Bias control for Completig cycles in Corr M/C - Reverse Engineering when in 2nd order.
- 4) Ensured that the default interpolation method is Linear for TCA and LTCA analyses (2nd Order Regression was the default interpolation). Linear Interpolation is the fastest and follows accurately the Residual Error surface.
- 5) For non-generated Face Hobbed gears, added a conversion of the cutter radii when using RE or Corr M/C. Without this needed conversion, a small amount of Crowning would appear after RE or Corr M/C.

HyGEARS update - 13 August 2012 - Build 401.00 - 434

- 1) Corrected a condition where the cutter edge type (Circular or Straight) would not be saved for generated Spiral-Bevel, Zerol and Hypoid gears.
- 2) Improved the digitization of heavily undercut Spiral-bevel, Zerol and Hypoid gears with circular edge cutters.
- 3) Added "Align", i.e. Alignment Error, to the RMC input form ("RMC" function button, 2D Graphs).
[Requested by A. Tylee-Birdsall, DSD]
- 4) Enabling of the "Text" output option to the RMC input form ("RMC function button, 2D Graphs). When this option is checked, output will be directed to both Graphic display and a Text window, in which the results of all requested cases will be displayed in tabular form.

HyGEARS update - 06 August 2012 - Build 400.90 - 432

- 1) Added control of tooth Topland for cylindrical gears (including Beveloid gears) to avoid pointed teeth.
- 2) Corrected a condition where adjustment of the operating center distance, for Beveloid gears, would result in divergence.
- 3) Added a control condition in the calculation of LTCA TE specific to exclude non-bevel gears in the smoothing of the TE values.
- 4) For Spur/Helical/Beveloid gears, modified a condition that would shift the fillet profile radially.
- 5) Corrected a mis-behavior of Spur/Helical/Beveloid gears which would exhibit inverted TE after creation. To cancel this behavior, one had to go through the Summary Editor once, which was annoying.
- 6) Improved the initial values of S for circular edged cutters with negative values.

HyGEARS update - 01 August 2012 - Build 400.80 - 432

- 1) Corrected a data file read when the data file contained Corrective Machine data (uninitialized data structures). [Reported by R. Richardt, PTR-TEC]
- 2) Added support for separate cutter edge profiles, i.e. Straight and Circular, on the same cutter. Valid for Spiral-Bevel, Hypoid and Zerol gear types.

HyGEARS update - 31 July 2012 - Build 400.70 - 431

1) Added support to extract tooth thickness info from Klingelnberg P-Machine actual data.

2) Added support for 2nd Order Corr M/C - RE for completing cycles. When Blade Angle or Decimal Ratio is selected for pressure angle error control, Cutter Diameter and Cutter Tilt are used to control Crowning; when Decimal Ratio + Cutter Tilt are used for pressure angle error control, then Cutter Diameter is used to control the average crowning error.

3) Addition of the RMC Function - or Run Multiple Cases. The function is accessible in User Mode, from the 2D Graphs Child Window, through the "RMC" function button.

Up to 20 combinations of Torque, E, P, G, Shaft angle error can be inputted for each tooth flank; Output includes:

- TCA TE,
- FFT TCA,
- LTCA TE
- FFT LTCA,
- Contact Stress
- Bending Stress - Pinion
- Bending Stress - Gear
- BP TCA (on the gear tooth flank)
- BP LTCA (on the gear tooth flank)

For all display choices (except BP TCA), up to 3 rows by 3 columns are created per display page, thus a maximum of 9 results per display page.

For BP TCA, up to 5 rows by 4 columns can be displayed on a display page, thus up to 20 results.

If more than one display page is needed, then all results are embedded in a Pdf document, which can then be saved in as many Jpg files as there are pages using Adobe Acrobat. [Requested by A. Tylee-Birdsall, DSD]

HyGEARS update - 17 July 2012 - Build 400.60 - 430

- 1) Corrected a mis-reference for the Root Apex for Uniform depth teeth, which would result in a mis-placed pitch point in the Blank display for Spiral-bevels.
- 2) Added smoothing to the LTCA TE curve to improve repeatability [requested by A. Tylee-Birdsall, DSD].
- 3) Increased the number of mis-convergence when comparing CMM measurement data to the simulated model such that when CMM or theoretical points lie in the fillet area (such as Kimos nominal data), HyGEARS does not issue a warning and exit the comparison function.

HyGEARS update - 11 July 2012 - Build 400.50 - 430

- 1) Corrected the import of a gearset through Klingelnberg ND where the shaft angle was assumed as 90 degrees, rather than its actual value.
- 2) Added the display of the Cutting Machine to the Pre-defined mode for Straight Bevel gears.
- 3) Modified the KIMOS import to account for Neutral Data presence rather than assuming Gleason Basic data only.
- 4) Modified a condition that prevented the control of tooth depth when RE Face Hobbed non generated gears [reported by A. Tylee-Birdsall, DSD].

HyGEARS update - July 05 2012 - Build 400.40 - 430

- 1) When outputting the contents of the 2D Graphs ("Outp" Function button) , the LTCA Transmission Error is now centered about its mean value such that the TE values can be used in a FFT [requested by Alex T.Birdsall, Drive System Design].
- 2) In 2D Graphs, the FFT of the LTCA TE is now using the TE centered about its mean value.
- 3) Introduction of 2 new processes: Beveloid gears and Straight Bevel (generated). Contrary to the Straight Bevel (Net) gears which are intended for injection or forging, The Straight Bevel (generated) gears can be cut using a one bladed cutter or a CoSIMT (Conical Side Milling Tool).
- 4) Addition of the Klingelnberg P machine output for CMM Nominal ("Ram" function button). The pinion output will be sollmes1.dat and sollmes2.dat, while the gear's will be sollmes3.dant and sollmes4.dat.
- 5) In LTCA analysis, the "AGMA-Mod' model for bending stress is now the default model. The actual facewidth used to compute the bending stress is the smaller of 2 values:
 - 125% of the instant line of contact uner load;
 - 35% of the facewidth projected in the direction of the helix/spiral angle.
- 6) Corrected a problem that would occur in FH gears when calculating R.E. or Corrective Machine Settings with the Blade Angle as the parameter to control Pressure Angle errors.
- 7) When calculating R.E. or Corrective Machine Settings, all the allowed correccions (Pressure Angle, Spiral Angle, Taper, etc.) for a given order (1 or 2) are now automatically selected.
- 8) When using a Phoenix machine, the Modified Roll and Helical Motion parameters (up to 6th order) are now displayed in the Hi-Order Data Page next to the Machine Data Page.
- 9) Gleason SPA files and Klinglenberg ND files can now be opened directly through the File -> Open menu just like HyGEARS files. The files are converted and displayed immediately.

For Klingelnberg ND files,

- selecting either pgo____nd.dat implies ggo____.dat and vice versa, such that only 1 of 2 files must be selected.
 - HyGEARS checks if sollmes1, 2, 3 and 4 are present and converts them if available; the converted files become the reference CMM data once converted
 - HyGEARS checks if istmess1, 2, 3 and 4 are present and converts them if available; the converted files become the reference CMM data once converted and override the converted sollmes files.
- 10) The default extension for HyGEARS files is now ".HyG" in order to differentiate them from the data files used by many other softwares. [Requested by J. Lamprecht, Bosch GmbH]

June 1st 2012 - Pre-release of HyGEARS 4.0
