Bevel Gear Production Software

For Use With 5-Axis Machines For Low-Cost, Efficient, and Flexible, Production As Part of Industrial Revolution 4.0

Dontyne Systems Limited is a company registered in England and Wales with company number 05973058. Registered office: Rotterdam House, 116 Quayside, Newcastle Upon Tyne , ENGLAND, NE1 3DY. VAT Registration Number: 902 9027 45

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Presentation Contents

- Overview the DS Bevel software
- Current Software preview
  - Gear Design Pro - Bevel
  - Load Analysis Model – Bevel
  - Machine Centre (Manufacturing Simulation 5 Axis / G-Code)
  - Inspection Centre
  - Optimal Calculation
- Development of a Heat Treatment Model

Overview of Dontyne Systems Bevel Software

- The Gear Design Pro has ISO/AGMA calc for sizing while Generic bevel gear design option produces the complex gear tooth surface data including micro-geometry
- The Load Analysis Model shows contact region of the gear pair under no load and transmission error under load
- The Machine Centre can design tooling and calculate machine path G-code for 5-axis as well as hobbing, grinding, shaping, shaving and even
- Measured data can be evaluated by Inspection Centre module
- Measured data can be used for tool optimisation by Optimal calculation

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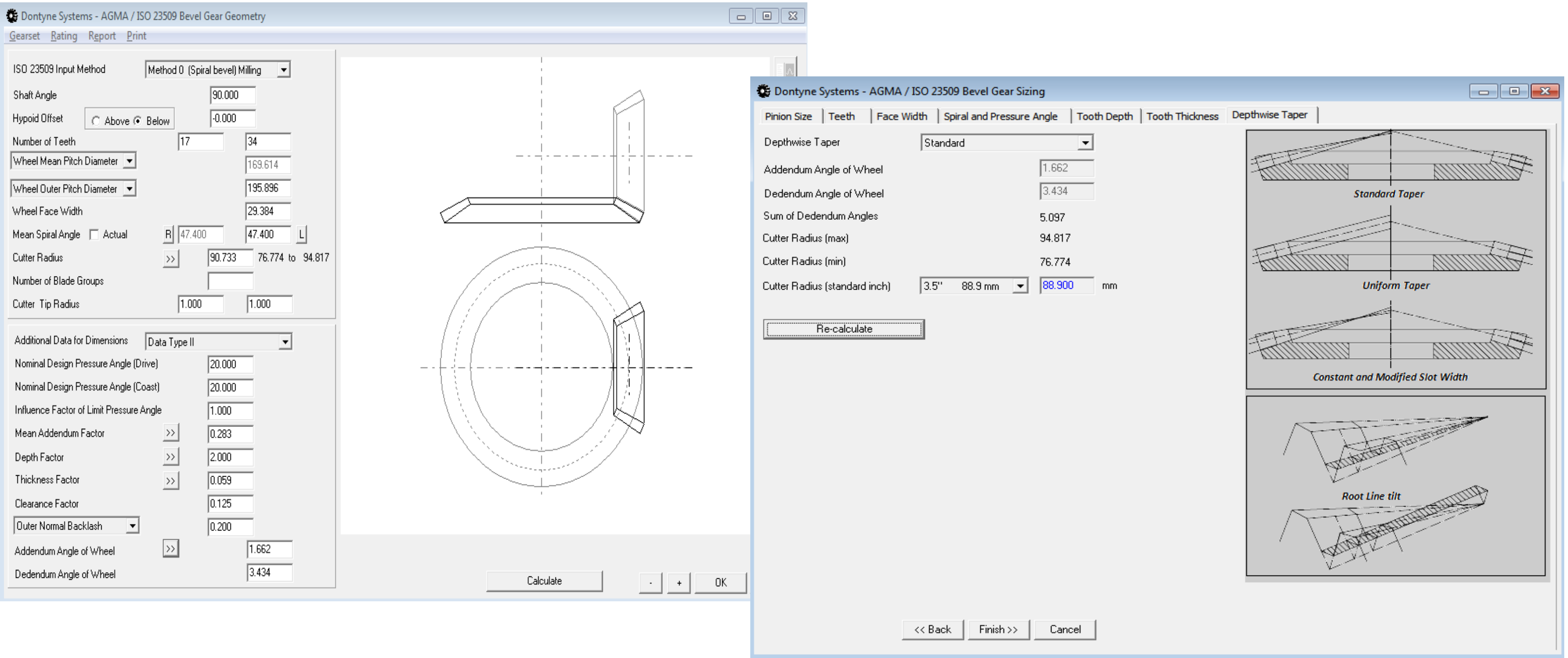
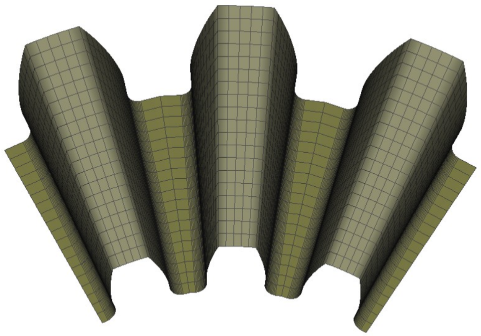
Gear Design Pro - ISO/AGMA Design and Rating

Types Milled, Hobbed, Gleason, Klingelnberg, and Oerlikon can be sized and rated

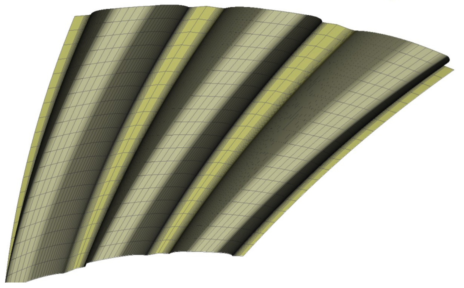


Types of Gear That Can be Exported

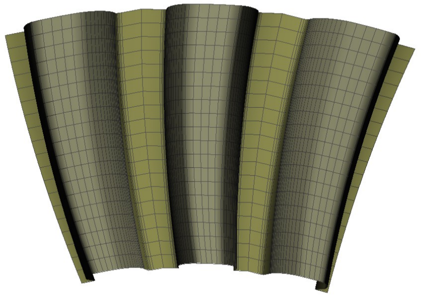
Straight bevel



Spiral Bevel

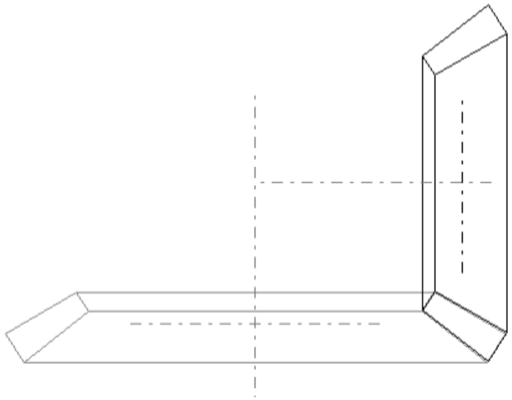


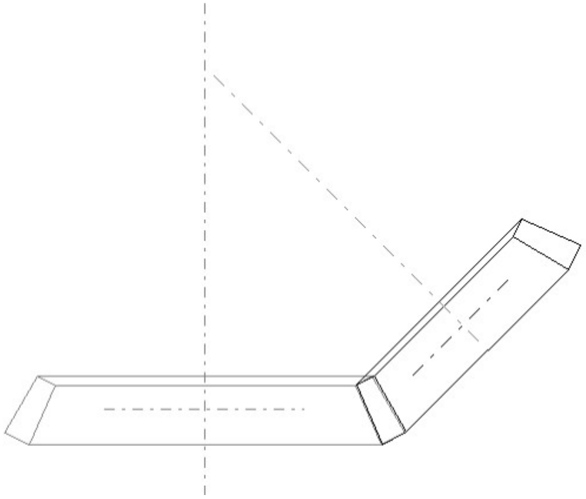
Zerol Bevel



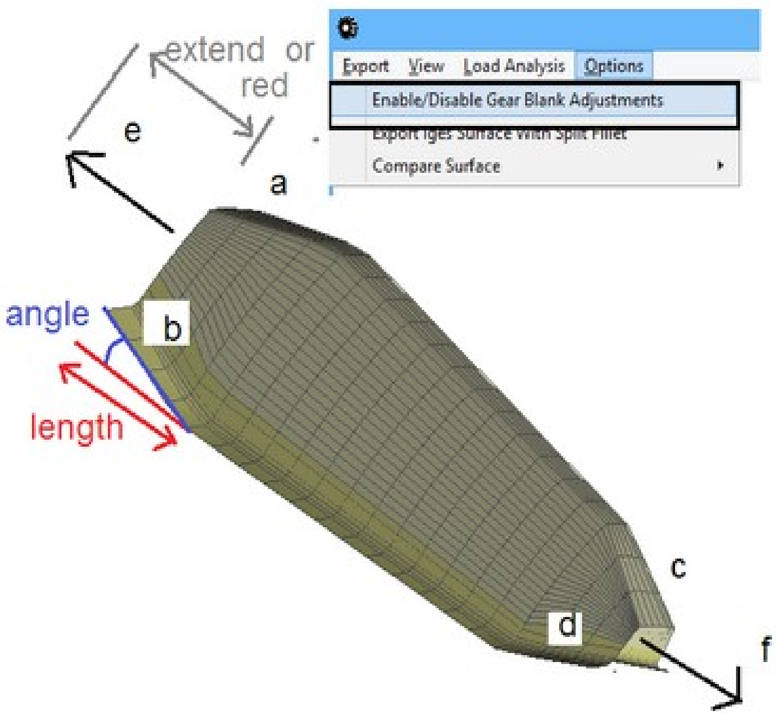
Types of Gear That Can be Exported

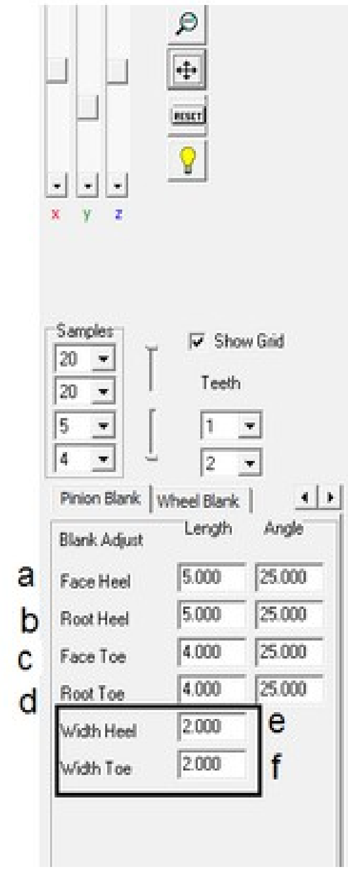
90 degree shaft angle or other





Gear Design Pro





Design tooth can be cropped (a,b,c,d) or extended at toe or heel in Gear Production Suite pair editor reducing potential for error after reworking in export to CAD

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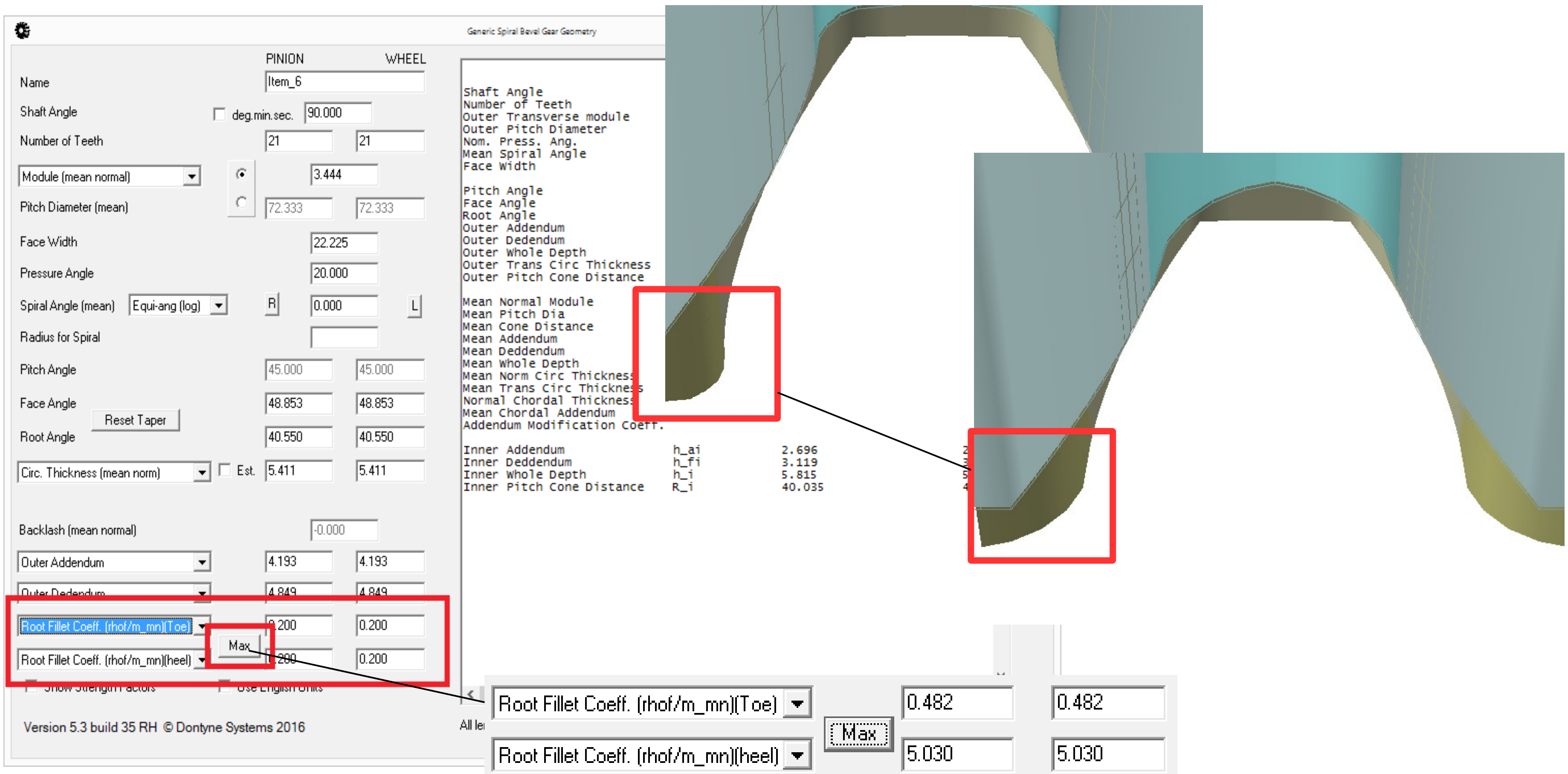
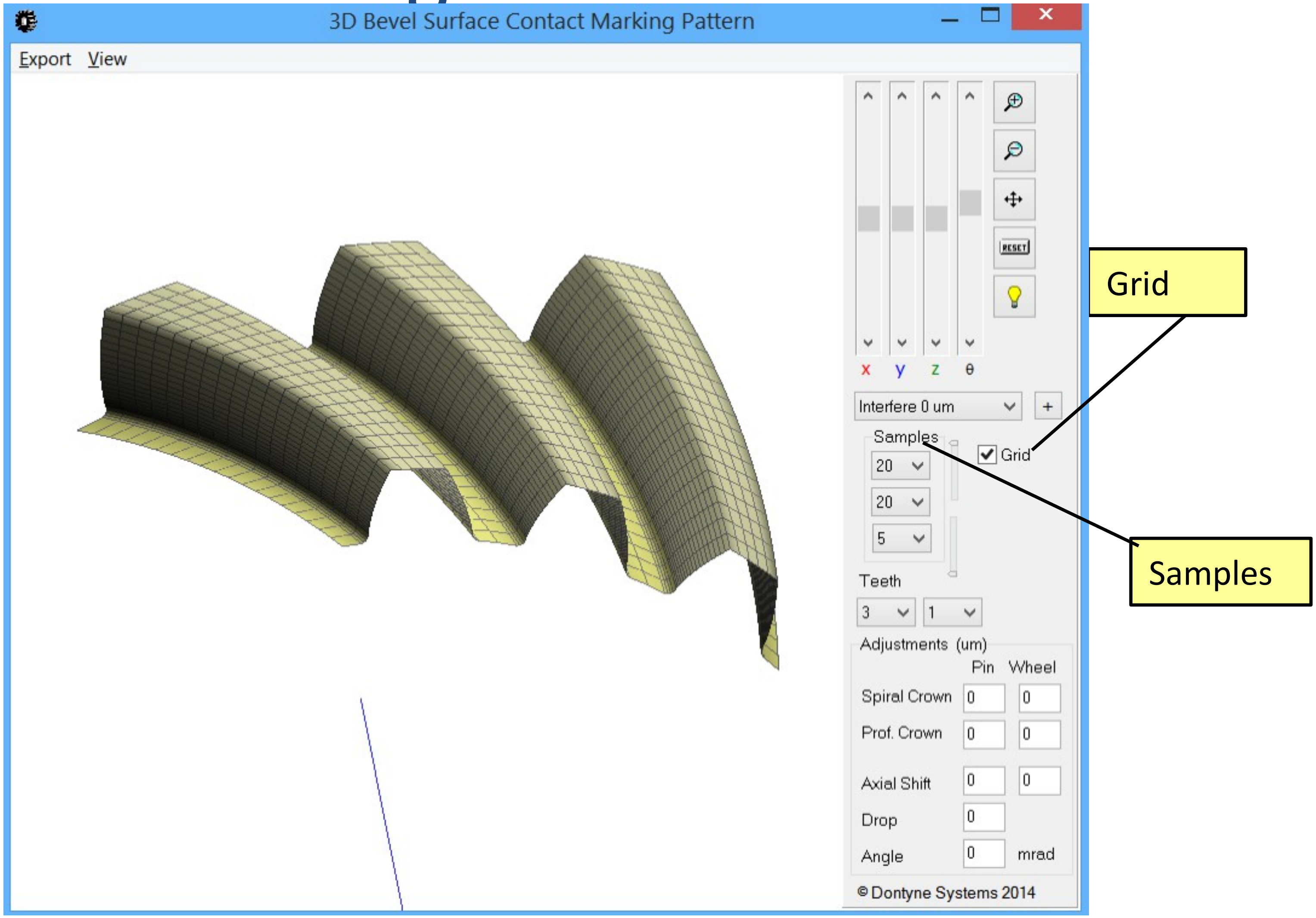
Gear Design Pro

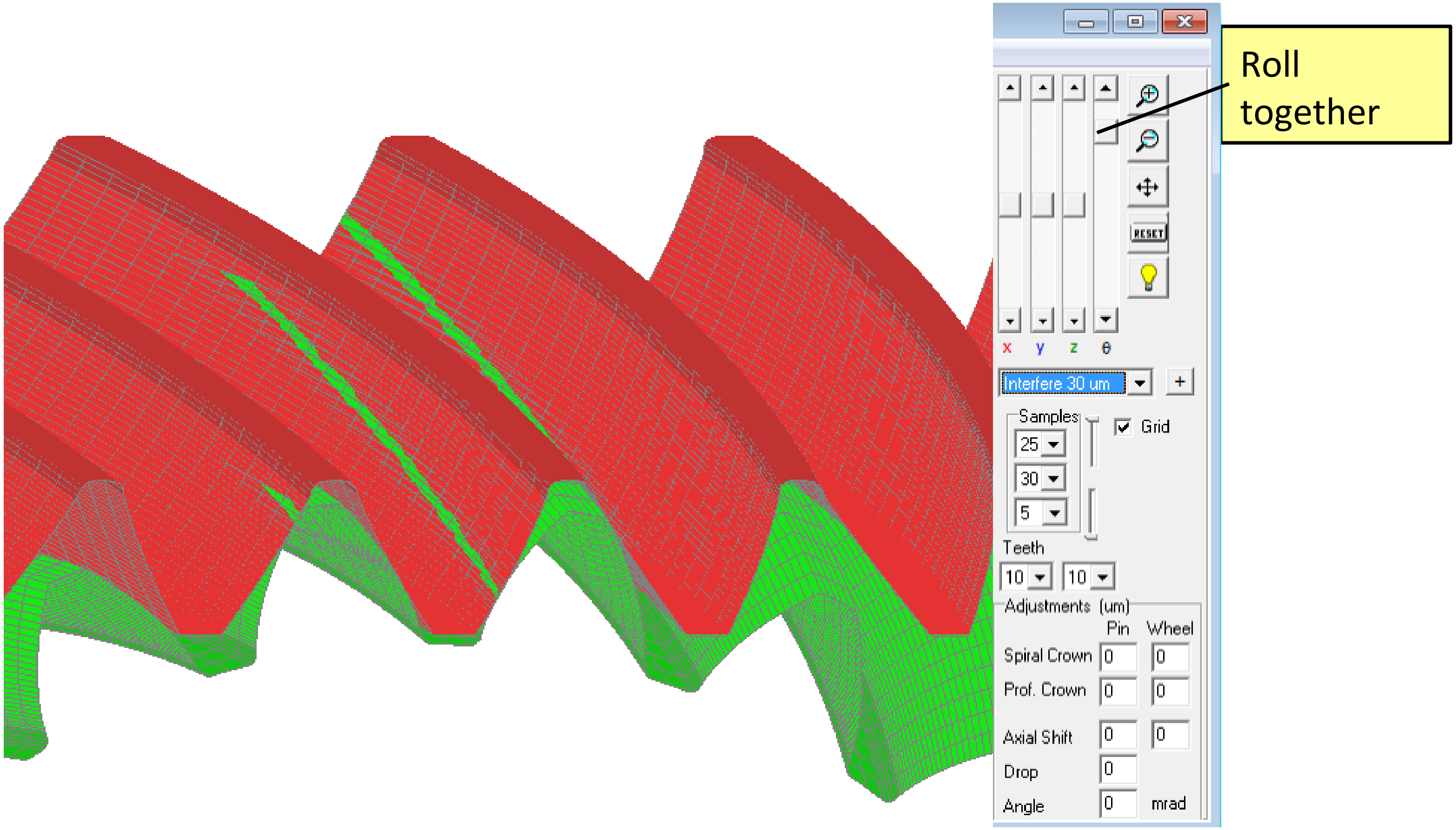


Gleason Strength Factors included in report - Flexible root design for optimum root strength – constant or variable from toe to heel

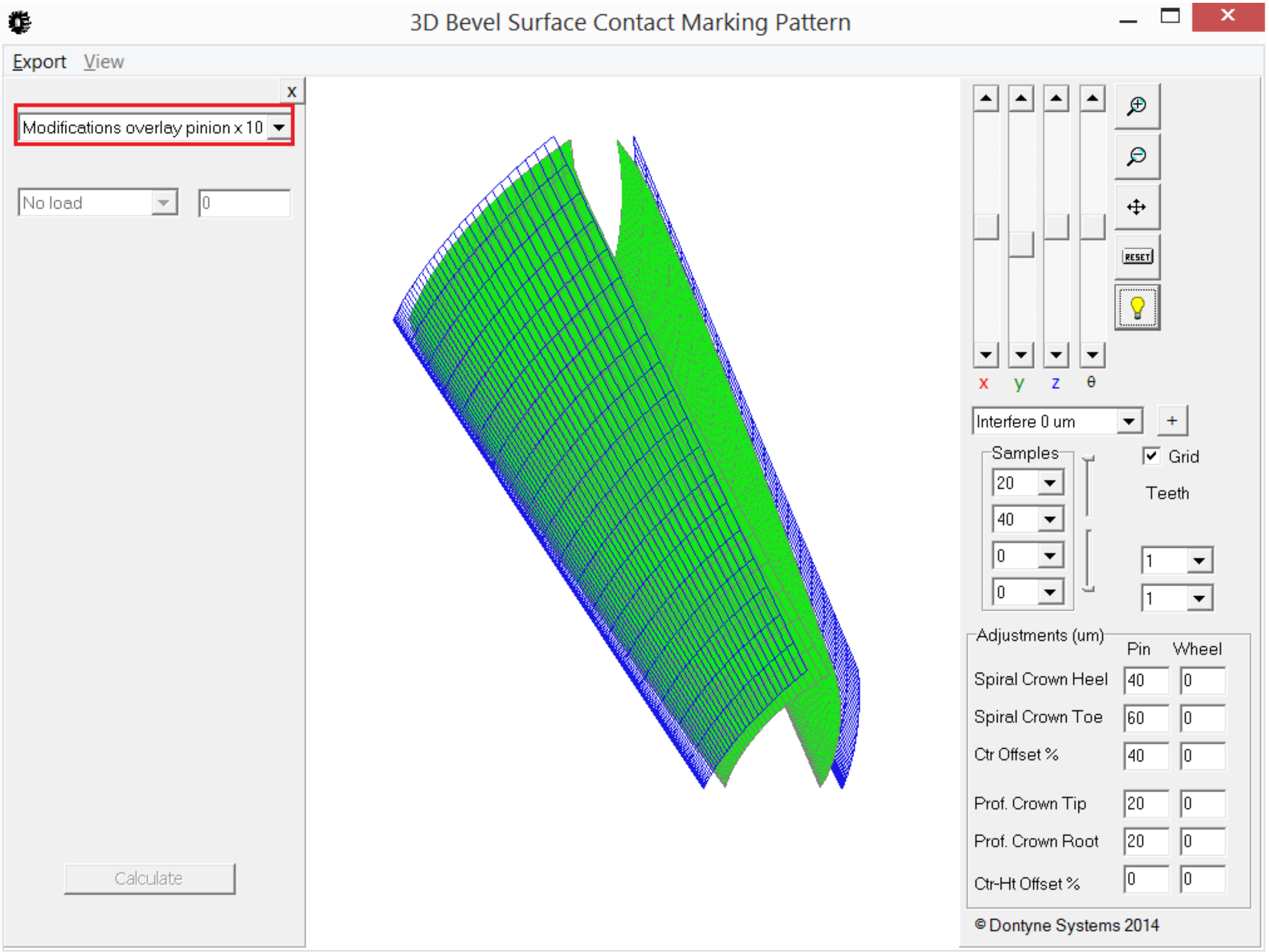
Gear Design Pro - Generic



Gear Design Pro - Generic

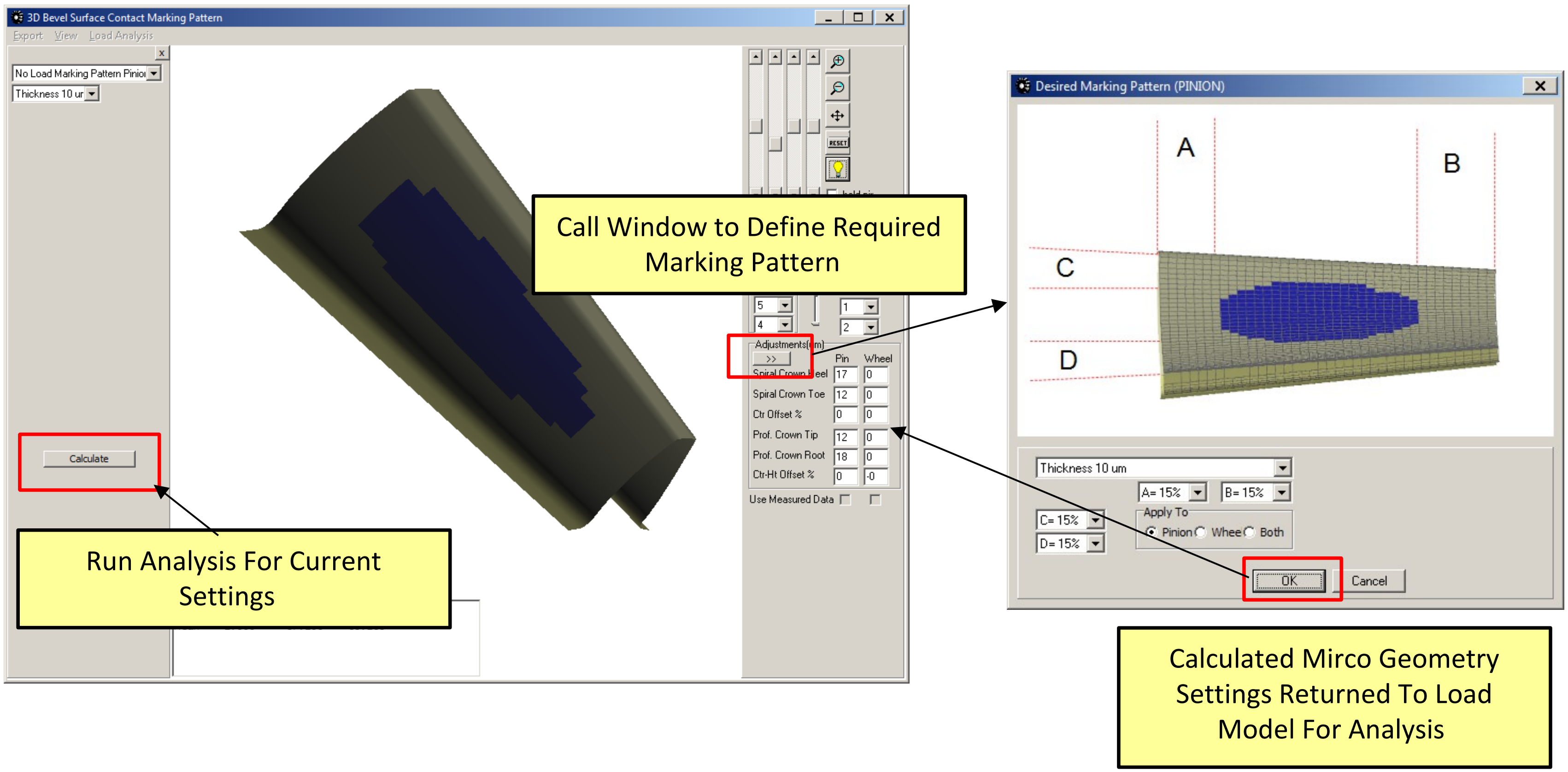


Gear Design Pro – Micro Geometry

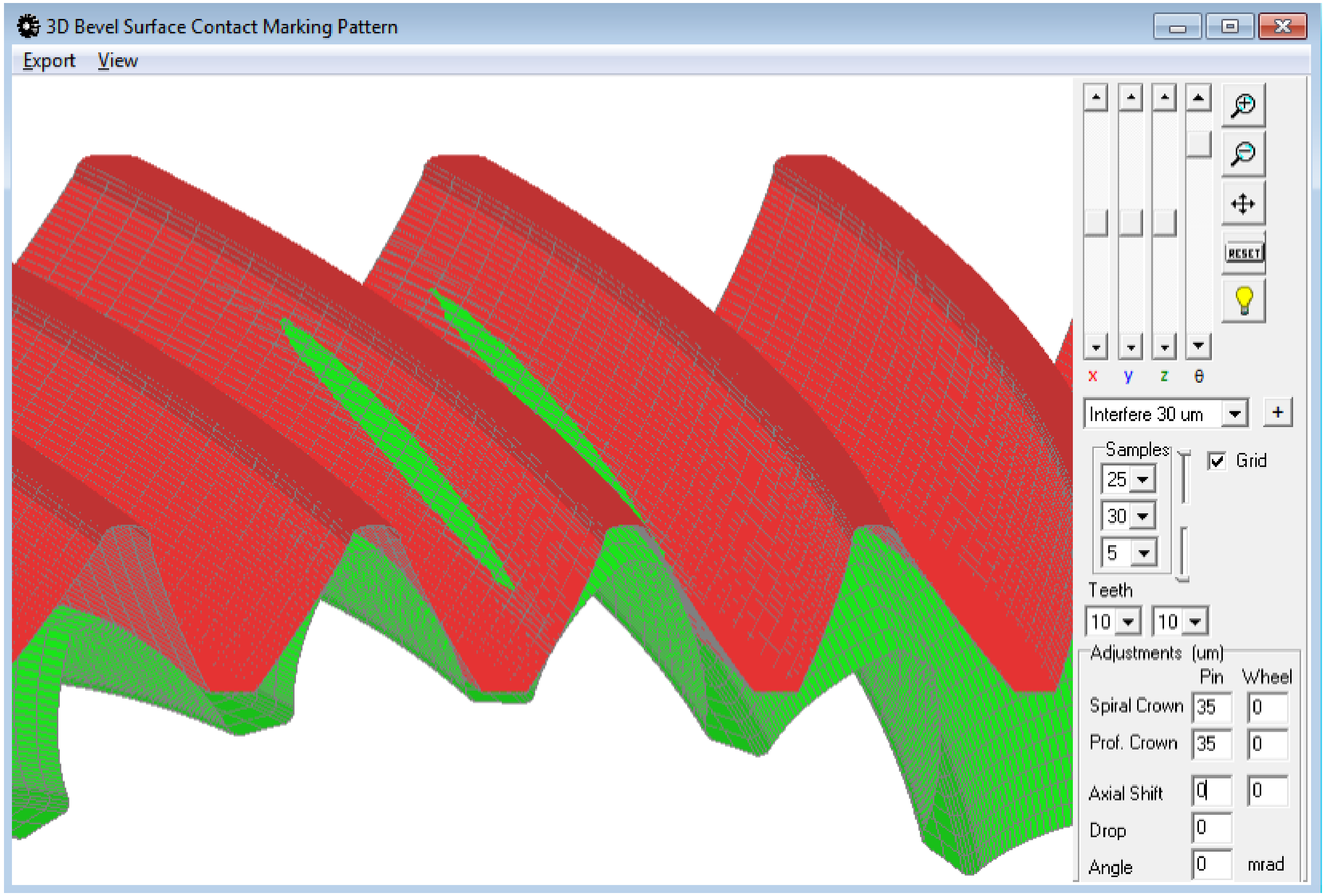


Gear Design Pro – Micro Geometry

Calculate mirco-geometry values from definition of required marking

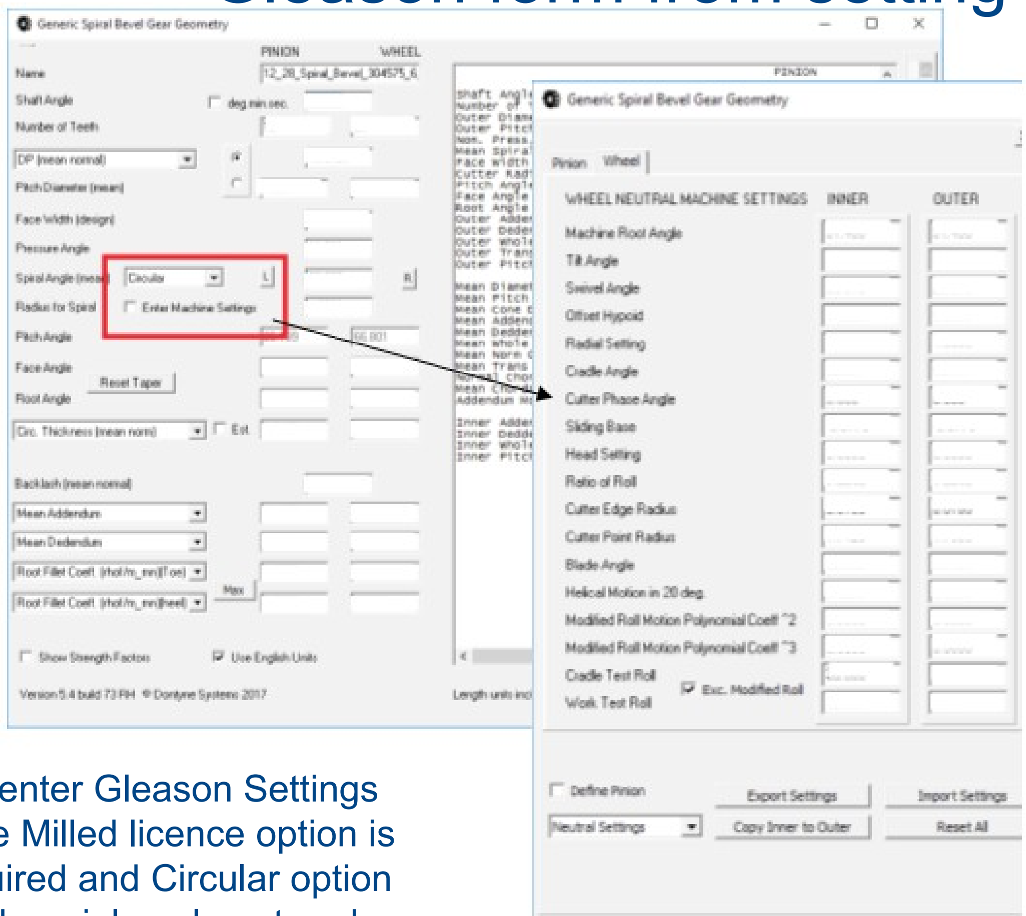


Gear Design Pro – Micro Geometry



Gear Design Pro – Micro Geometry

Gleason form from setting sheet



To enter Gleason Settings Face Milled licence option is required and Circular option with sprial angle entered

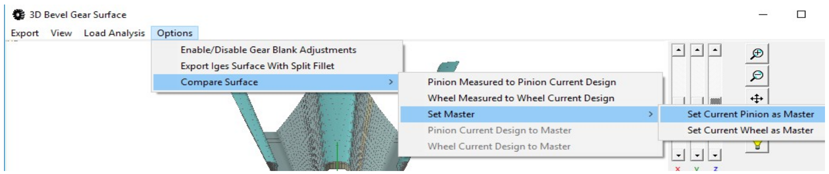
IMPORTANT!

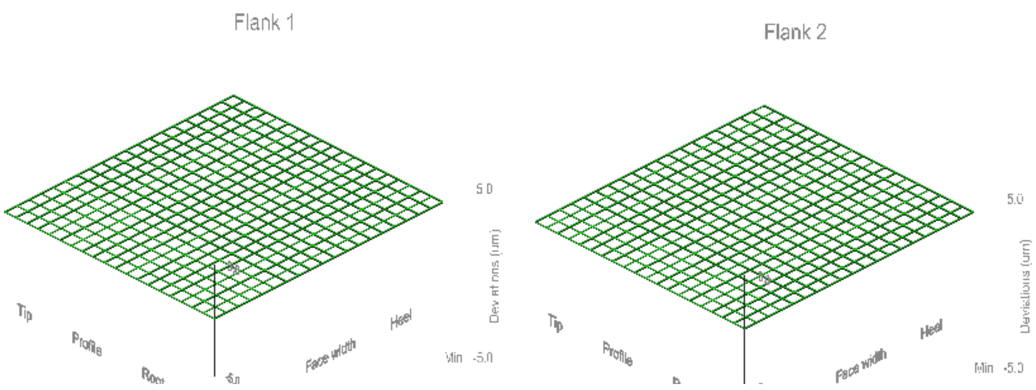
1. The software does not calculate settings required to achieve a design, but calculates tooth form based on parameters entered

2. The nominal values are often changed from those the issued documents by production to achive specific customer contact condiitons

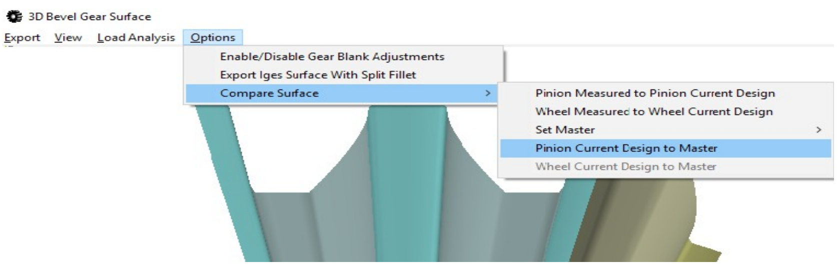
Gear Design Pro – Micro Geometry

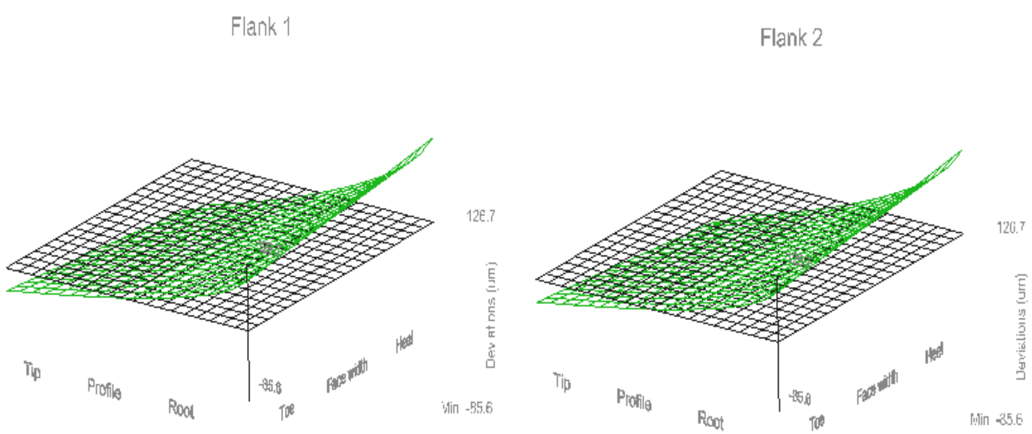
Determine changes due to changes in design or machine settings





Choose the set as master from the menu to set current design or measured surface as reference





Any changes in micro-geometry due to design, machine settings, and measured data relative to stored reference can be viewed

Tooth Contact Analysis

- No-Loaded and Loaded tooth contact analysis
- Transmission error calculations
- Alternative root fillet shapes other than circular
- Consideration of tooling
- Direct links measurement data

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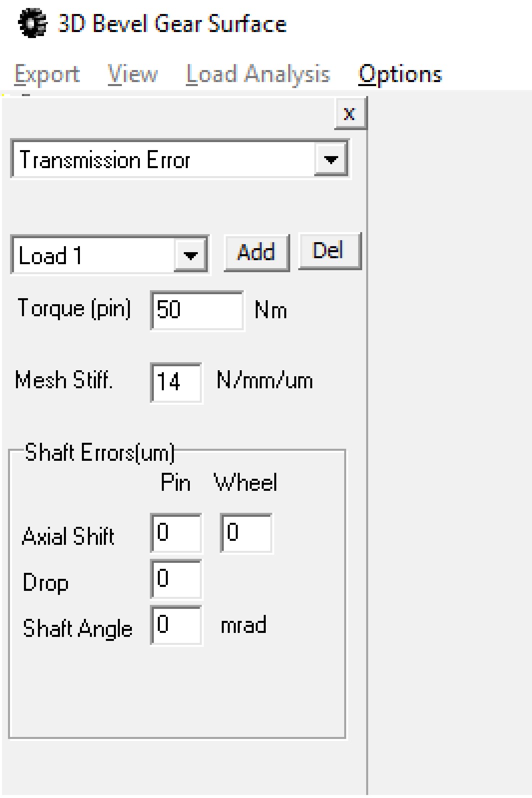
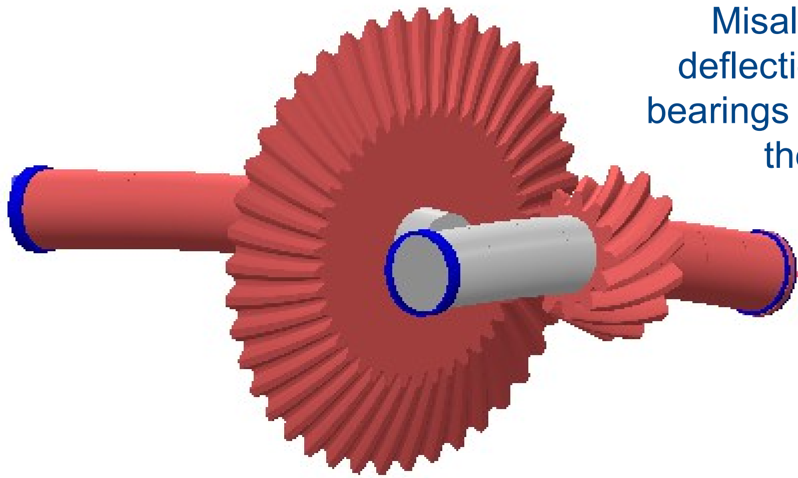
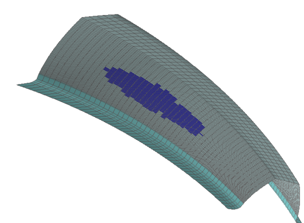
Tooth Contact Analysis





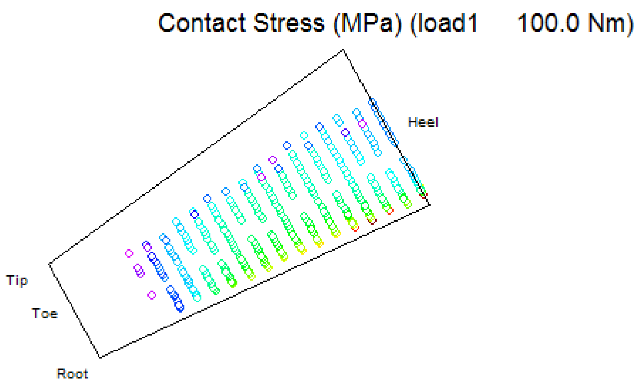
Misalignment is caused by deflection in casing, shaft, and bearings as well as deformation of the tooth under load



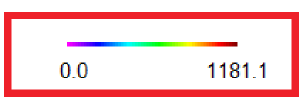
Load Analysis (Standard) can model deflections in 4 axes at several different load cases

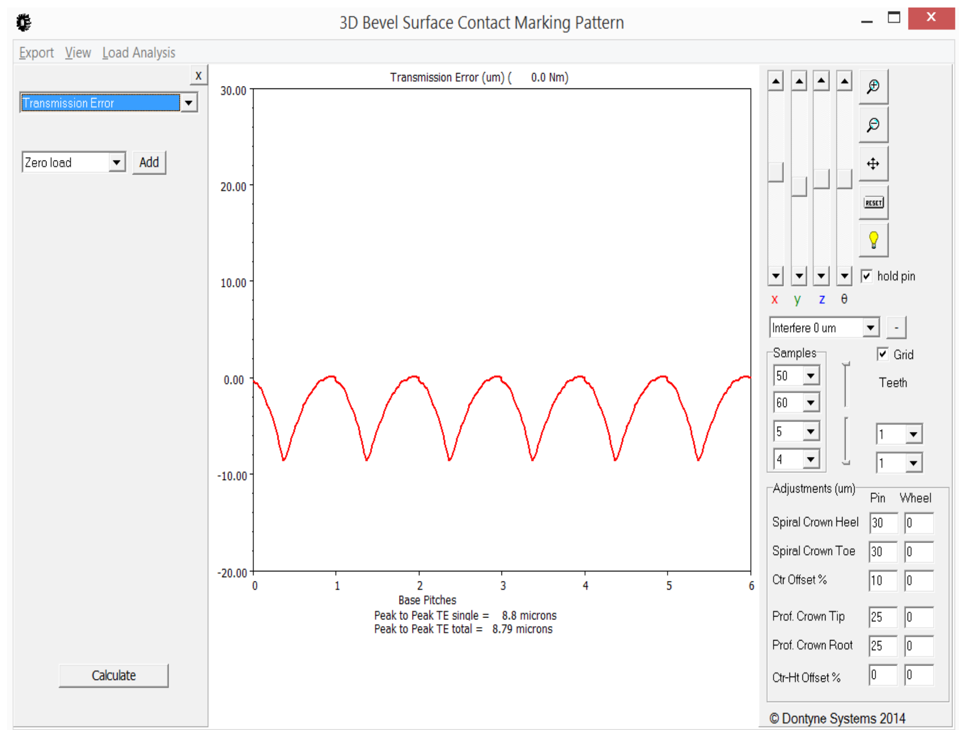
Micro-geometry (small changes to the theoretical surfaces) are designed to avoid tooth edge contact or noise and vibration otherwise due to deflection under load

Tooth Contact Analysis



Efffect of Shaft alignment on loaded stress results





Contact Stress

Transmission Error

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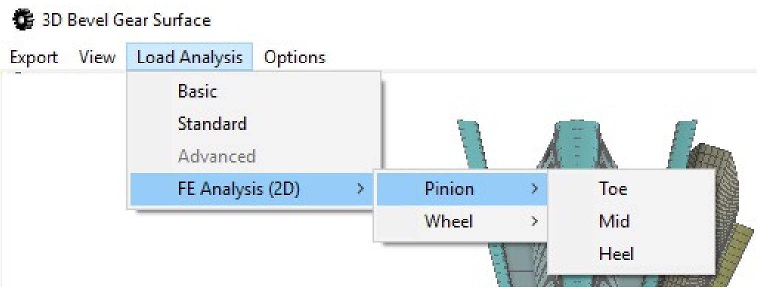
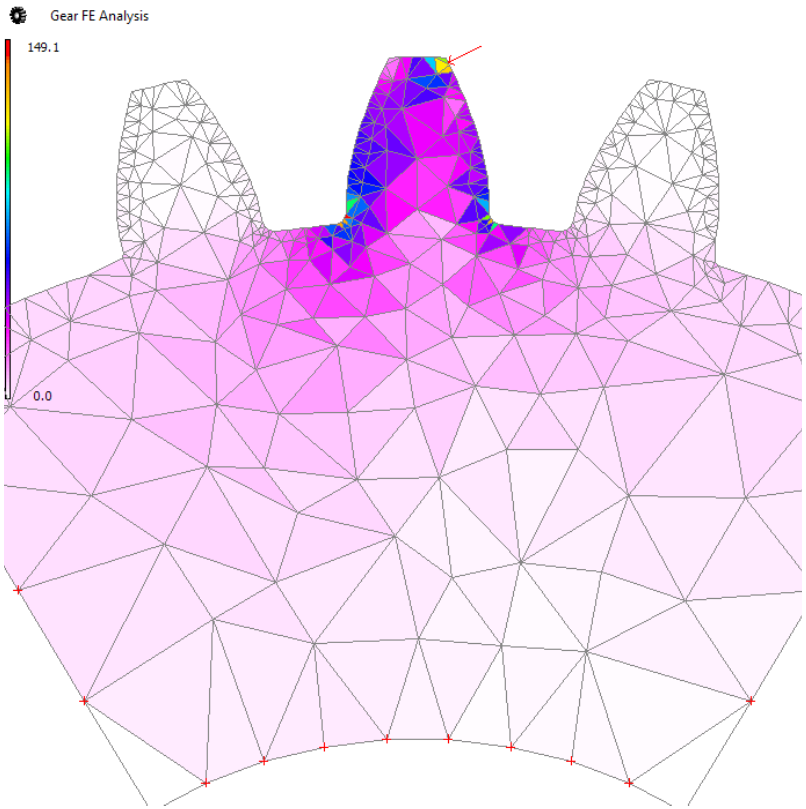
Tooth Contact Analysis





Bending Stress can be analyzed in normal plane through toe, middle, or heel (straight bevel only)

Gear Design Pro - Data Export

DXF 3D line grid

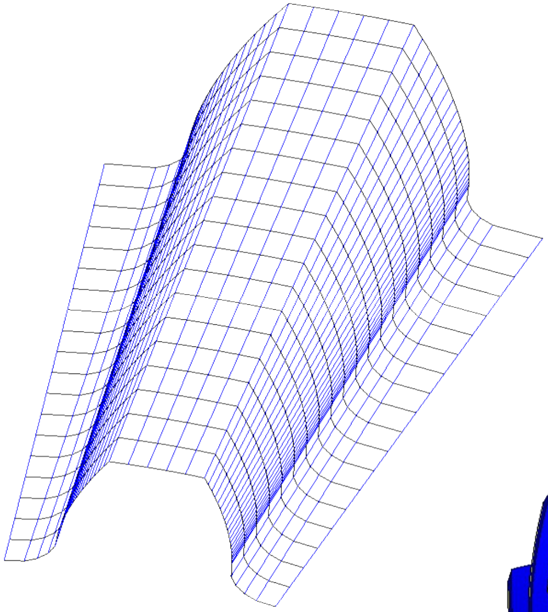
ASCII X,Y,Z N

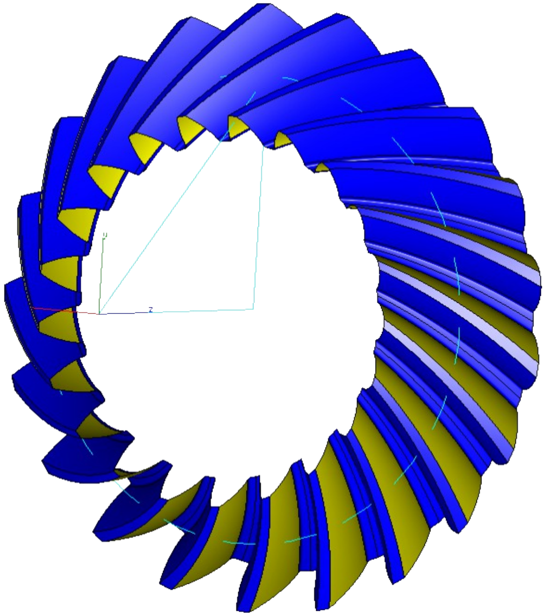
IGES Bspline surface

G-Code (Mazak, Okuma, Makino, etc)

Inspection Systems CMM (Carl Zeiss, Mitutoyo, IMS, Renishaw, etc)

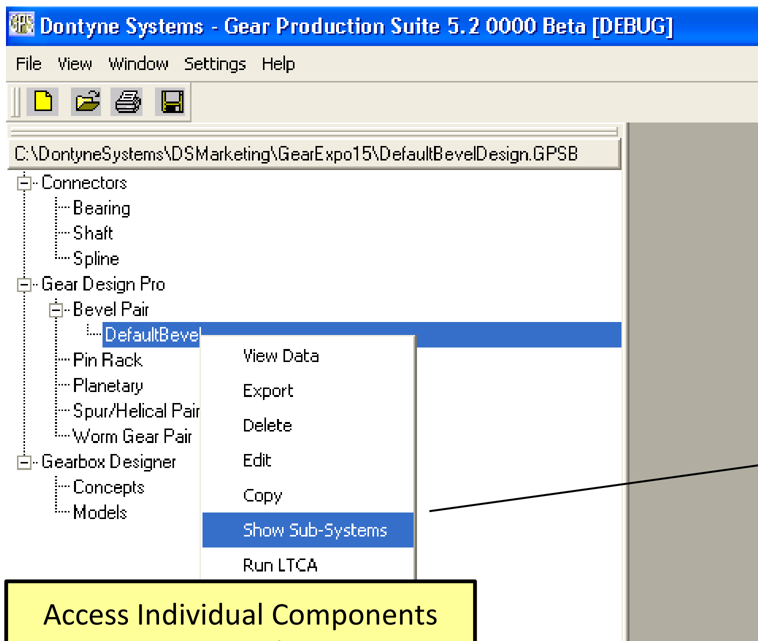
Gear Checker (Osaka Seimitsu, Klinglenberg)



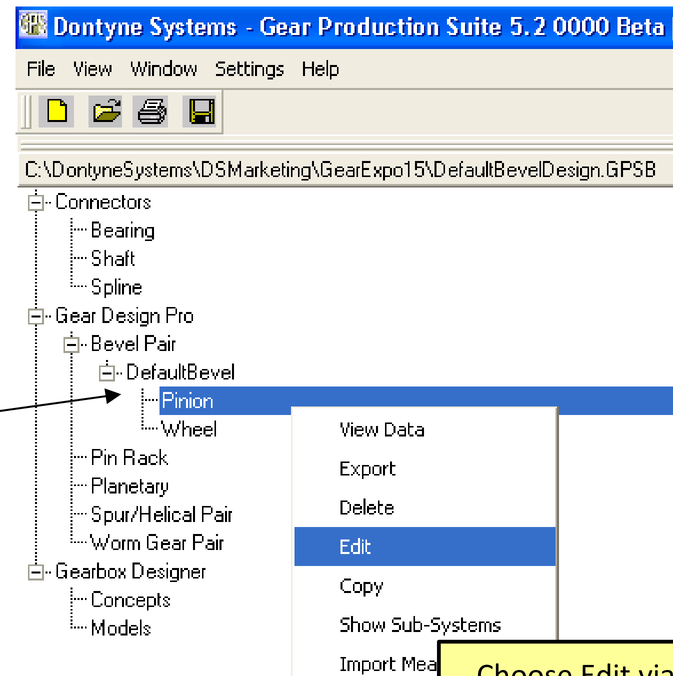


Tool Design

Die tool for forging - Tool Definitions can be derived from gear



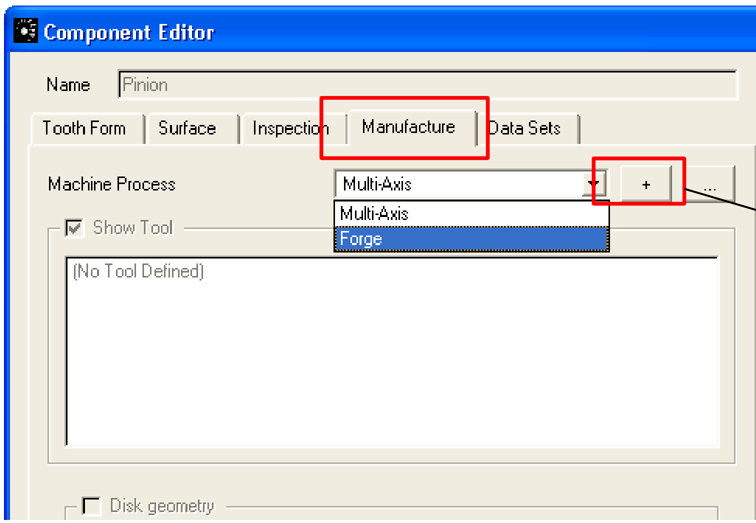
Access Individual Components via Context Menu (Right Mouse Click)

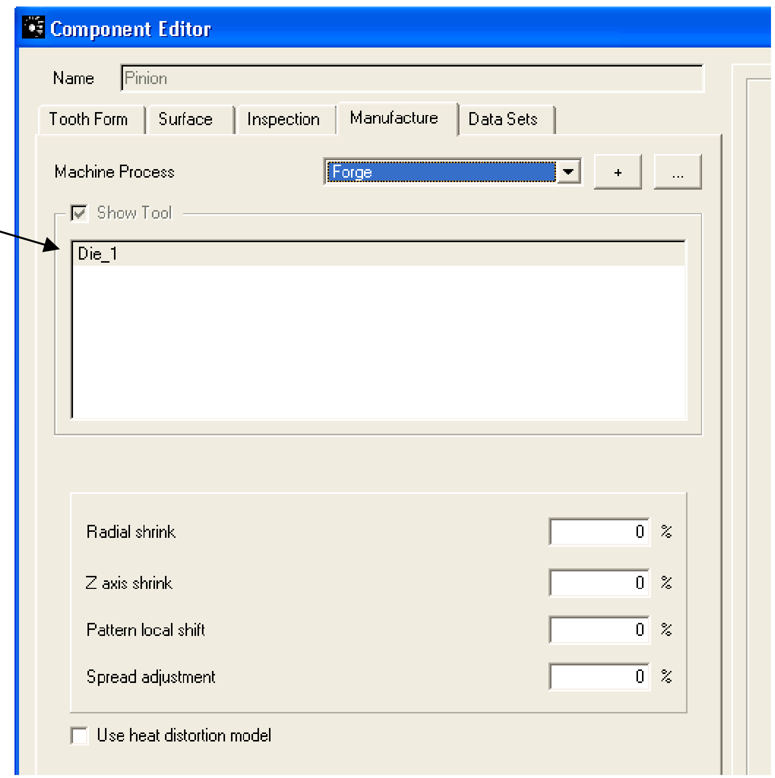


Choose Edit via Context Menu (Right Mouse Click) To Access Component Details

Tool Design

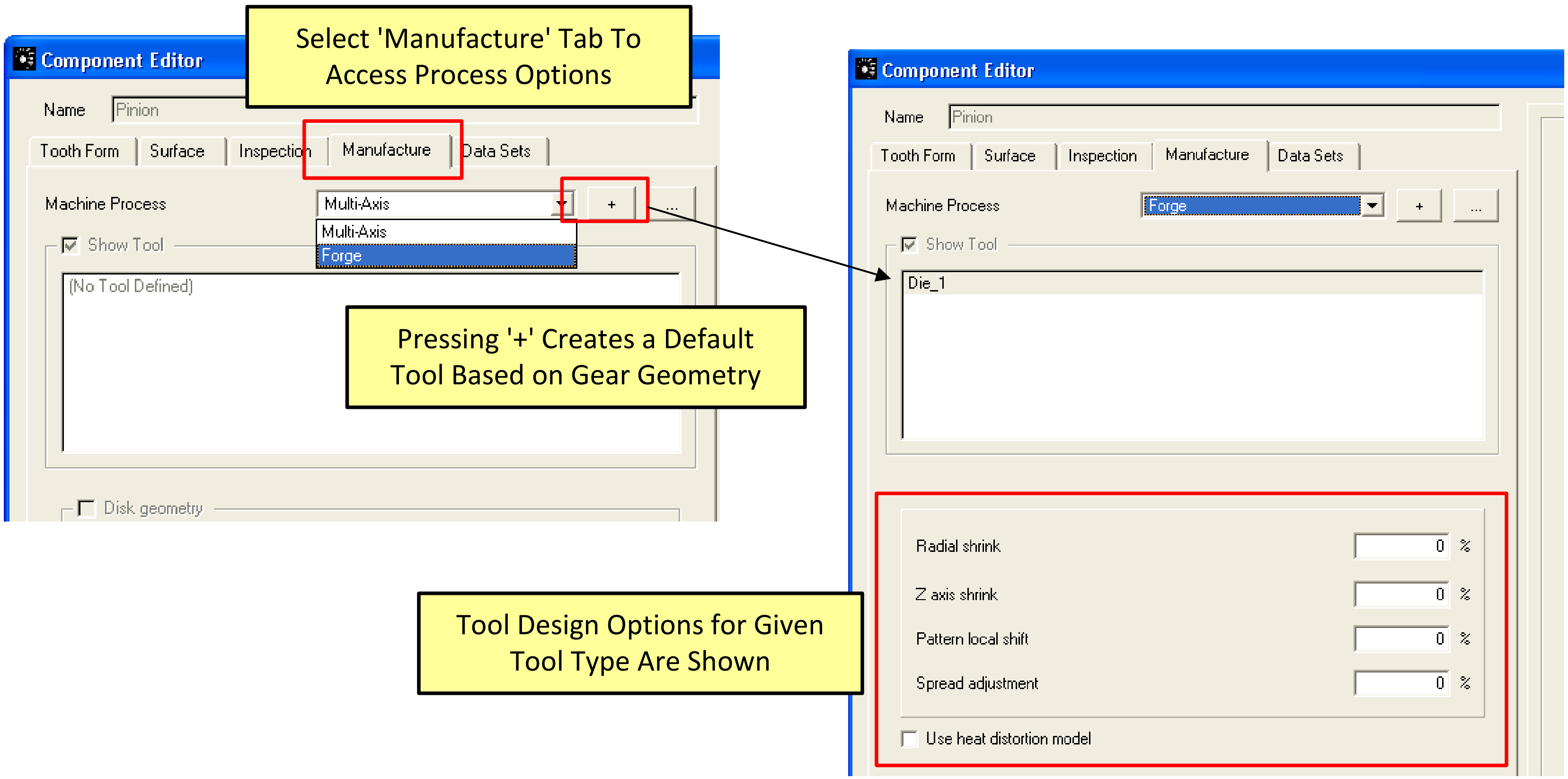
Choose process available for gear type and create tool





Tool Design

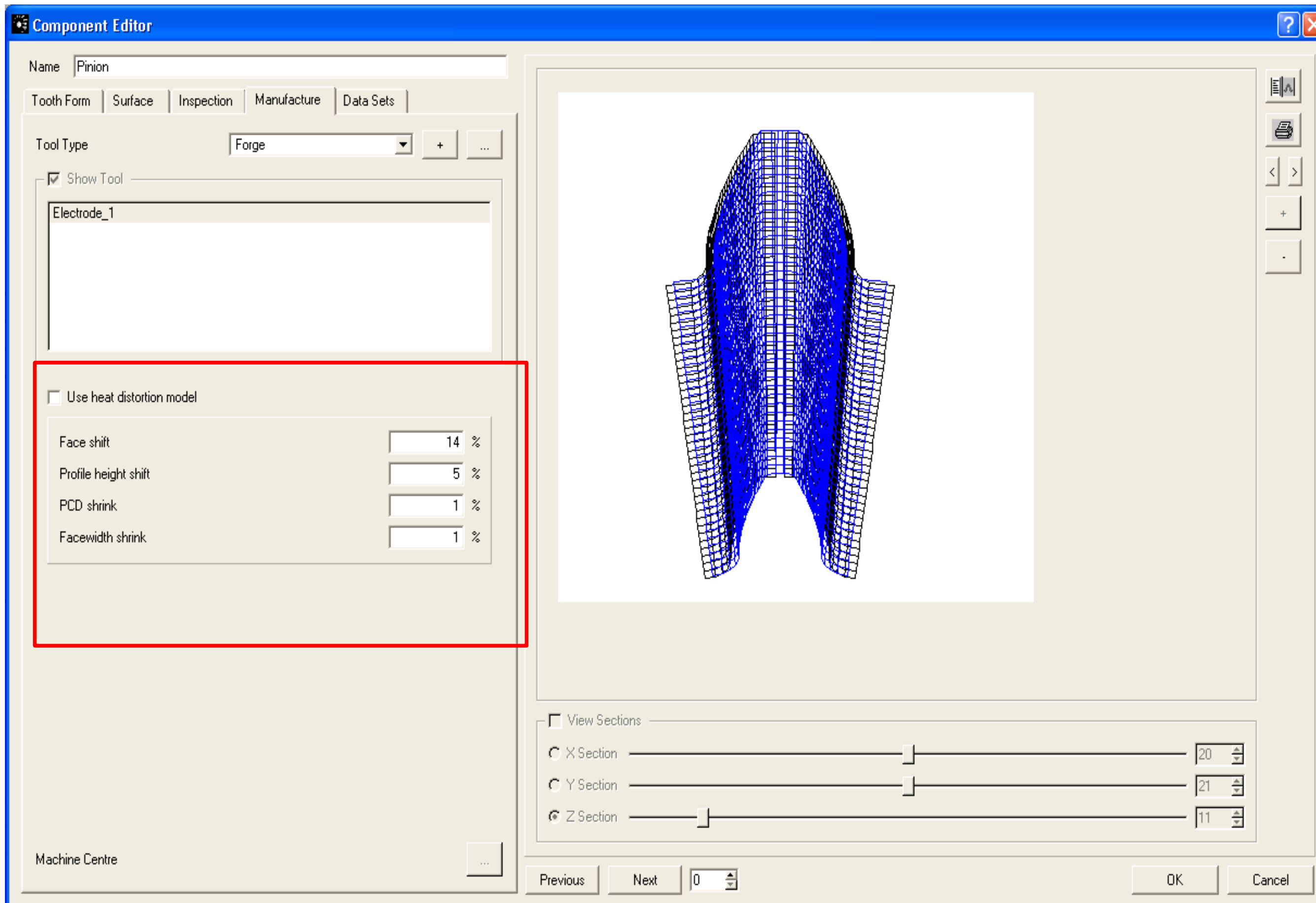
Choose process available for gear type and create tool



Tool Design

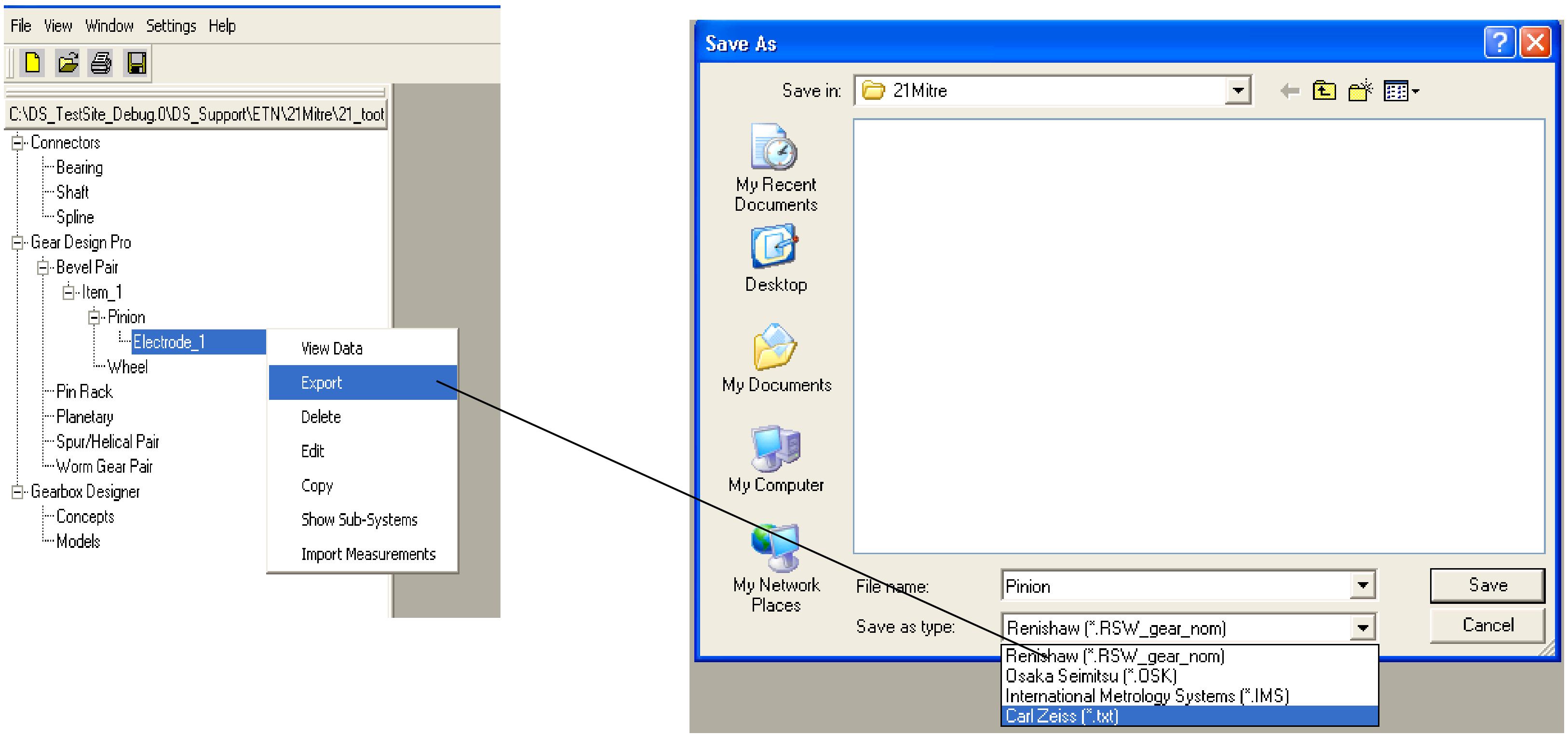
Die tool for forging - tool definitions can be derived from gear

Factors applied to gear form to define die which can also compensate for heat shrinkage



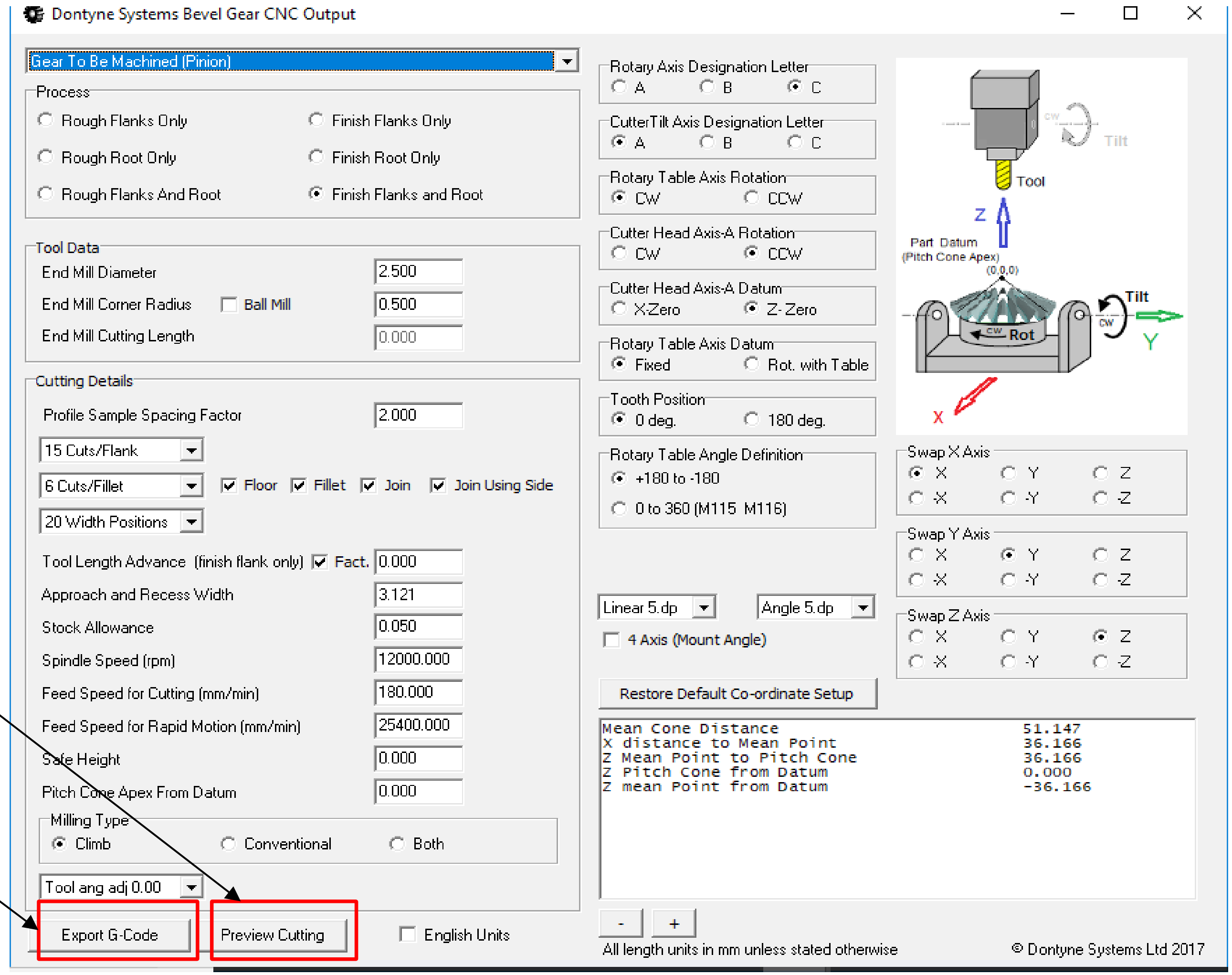
Tool Design

Tool can be exported from different formats



Gear and tool data can be exported to various inspection machines

Machine Centre



Virtual 5-Axis simulation defines various machines, tools, and cutting options

Simulation of 5-Axis process to cut tooth using end mill, fast flexible production of prototypes and small batch

Export G-Code to file

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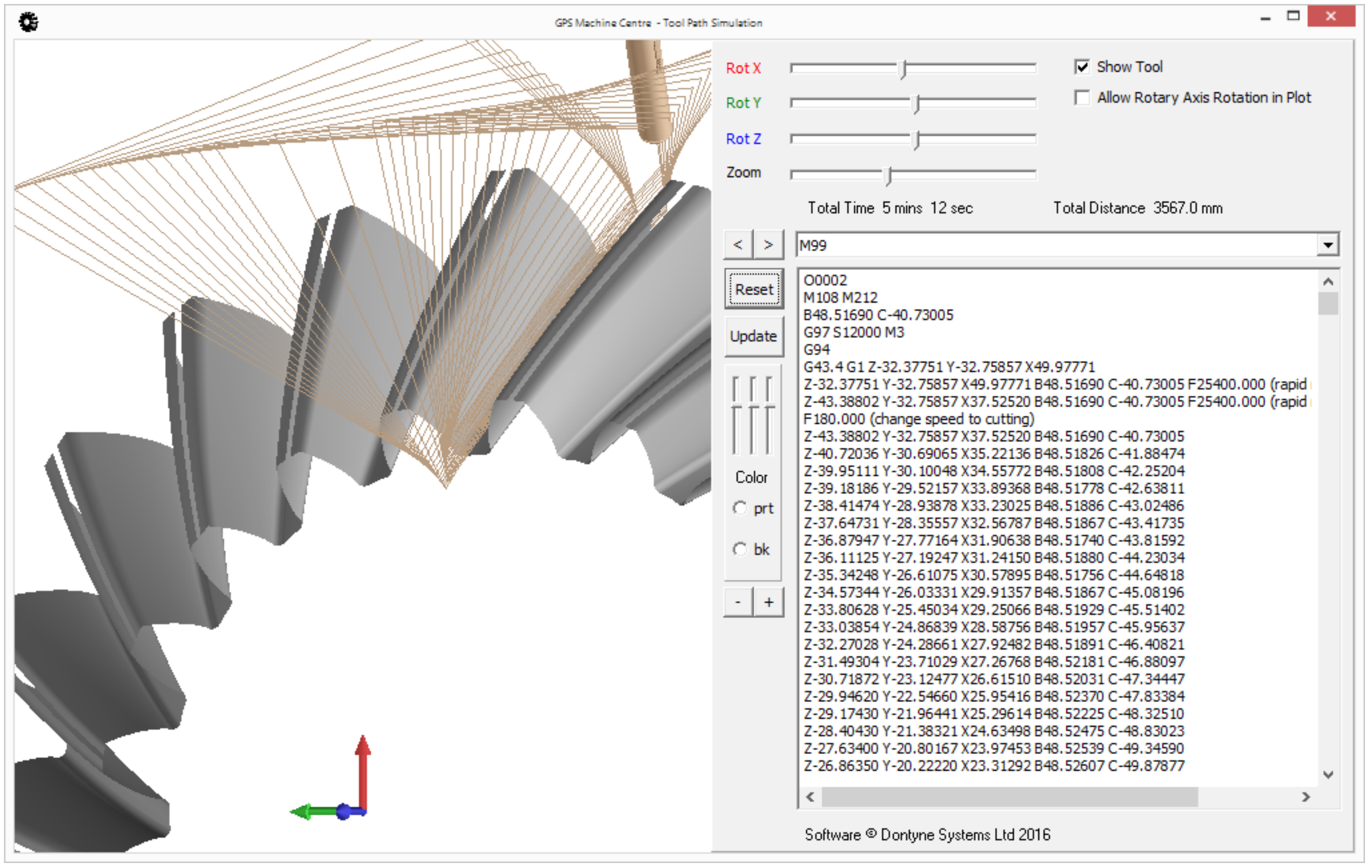
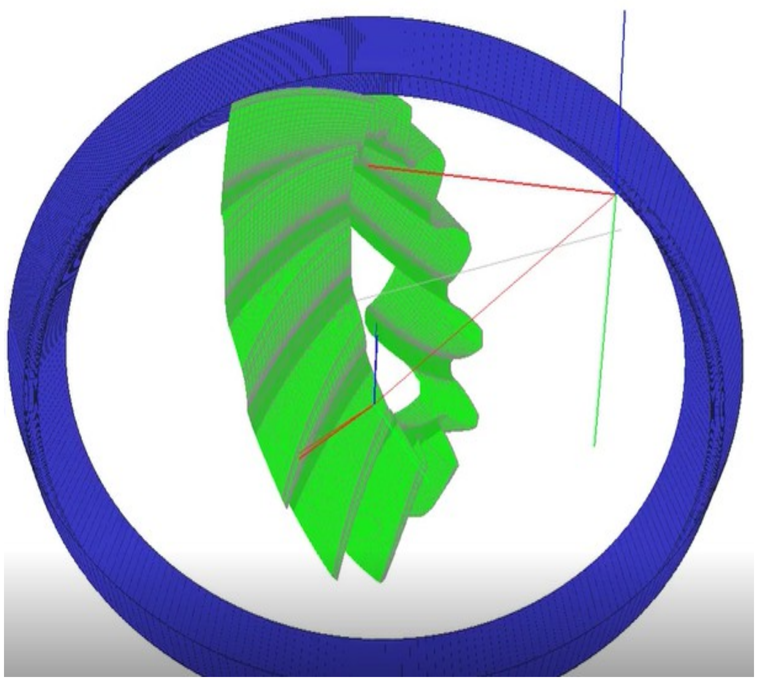
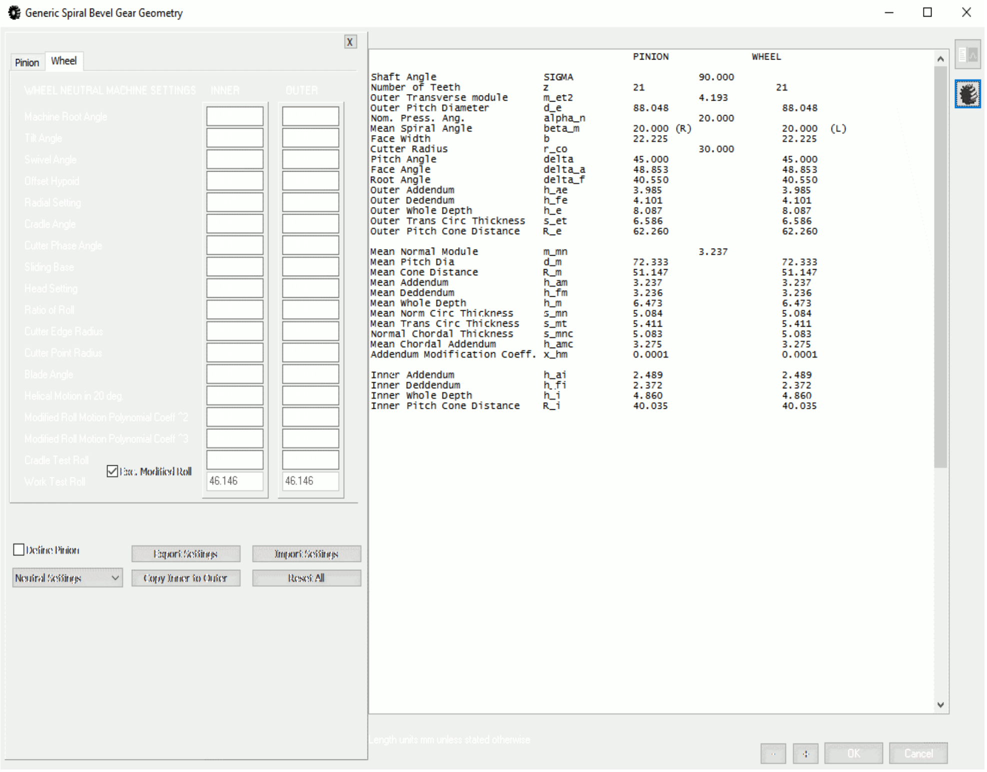
Machine Centre



G-Code Calculation can be exported to *.EIA file

Machine Centre





Face Milled option calculates tool form and G-code for production on 5-axis for medium and large batch sizes

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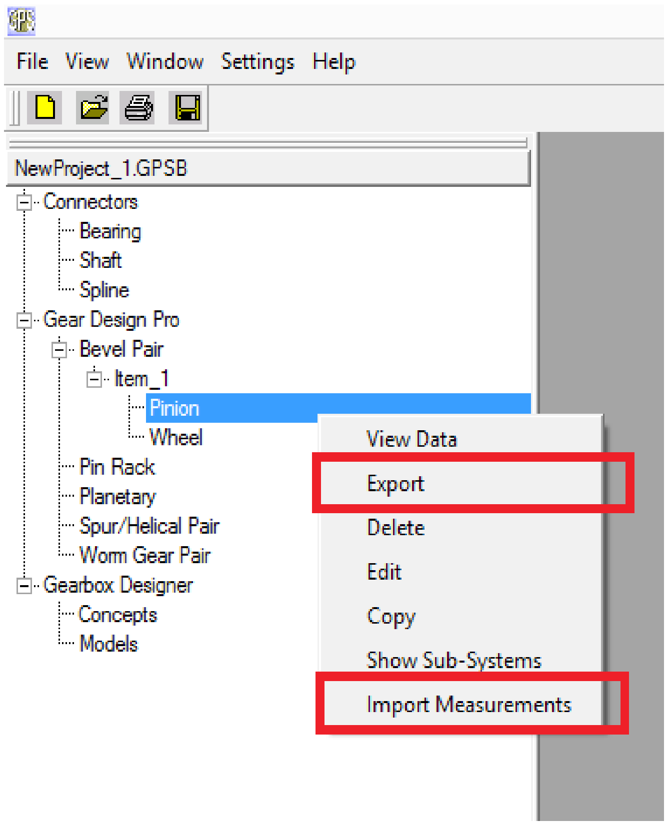
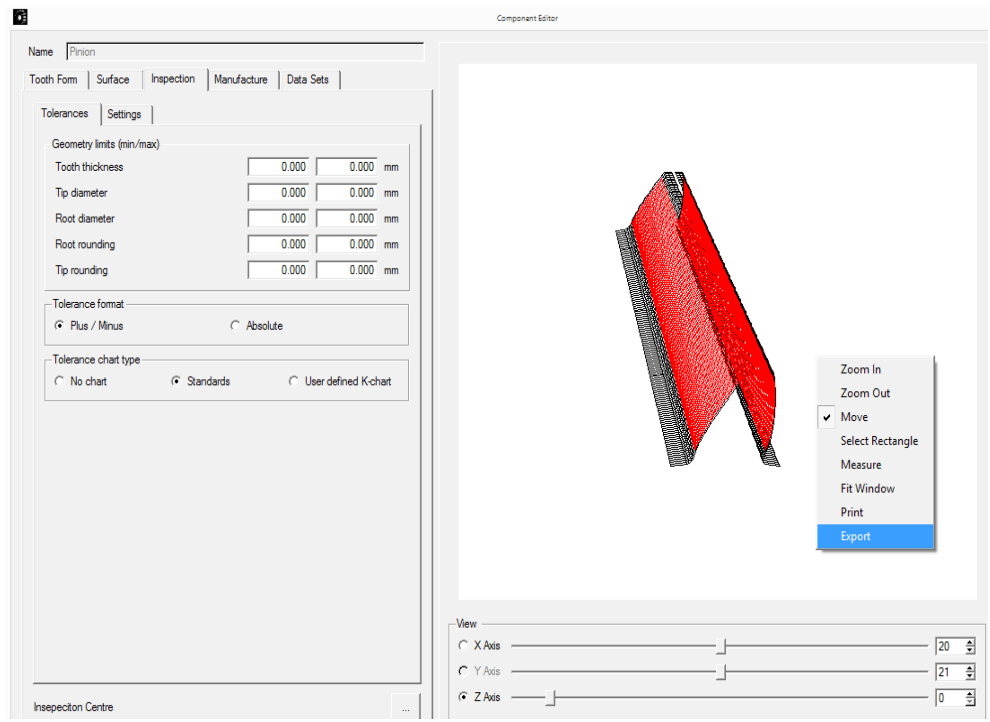
Inspection Centre

Export Target Data / Import Measurement File

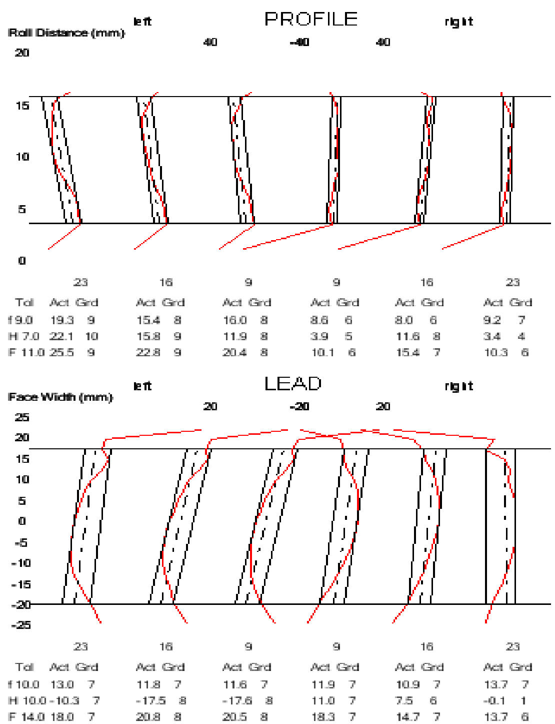


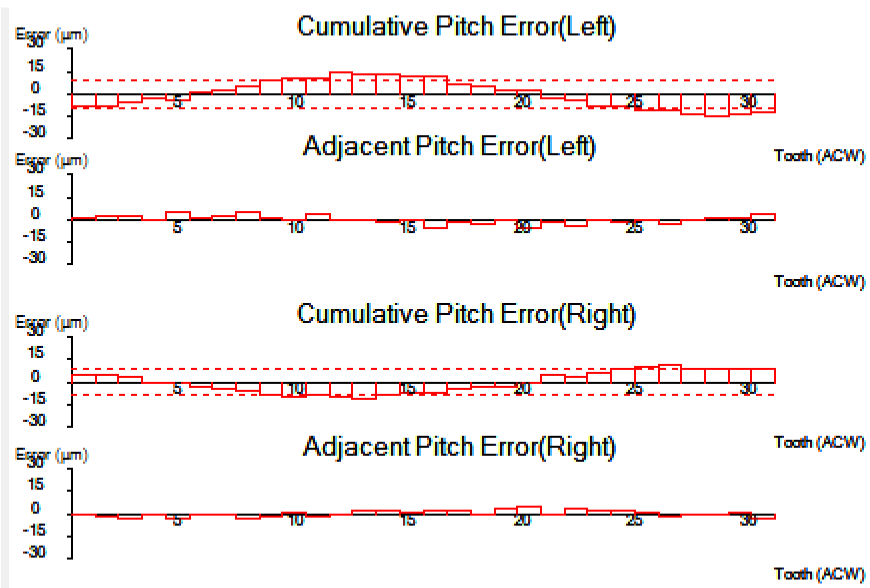


Inspection tab on single component window can be used to select inspection range even on cropped teeth and adjust reference plane with inspection machine datum

Inspection Centre

Measured data can be imported and evaluations of profile, flank line, pitch, thickness and run-out to ISO and AGMA



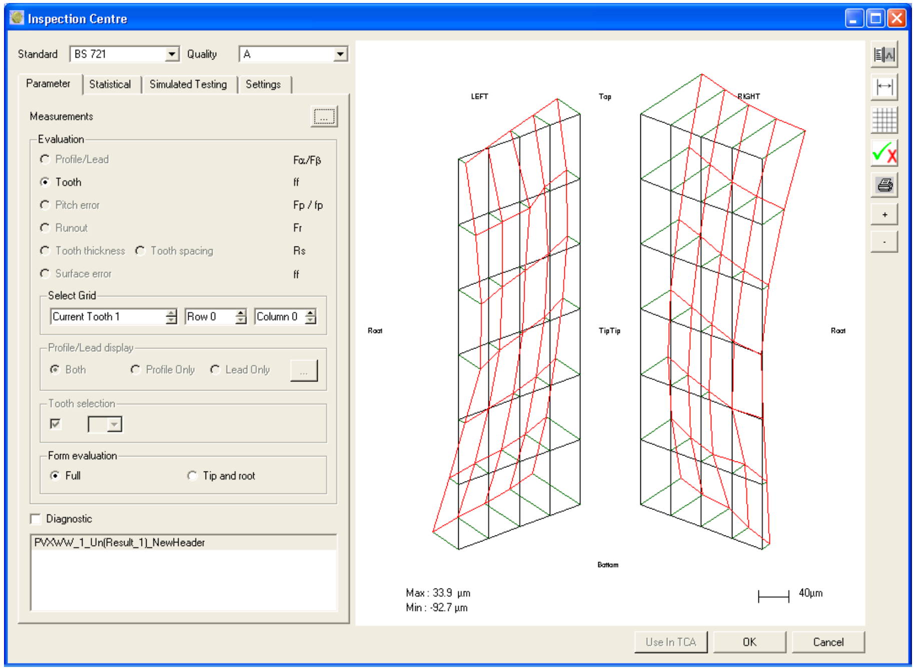


Inspection Centre

Tooth Surface Measurements

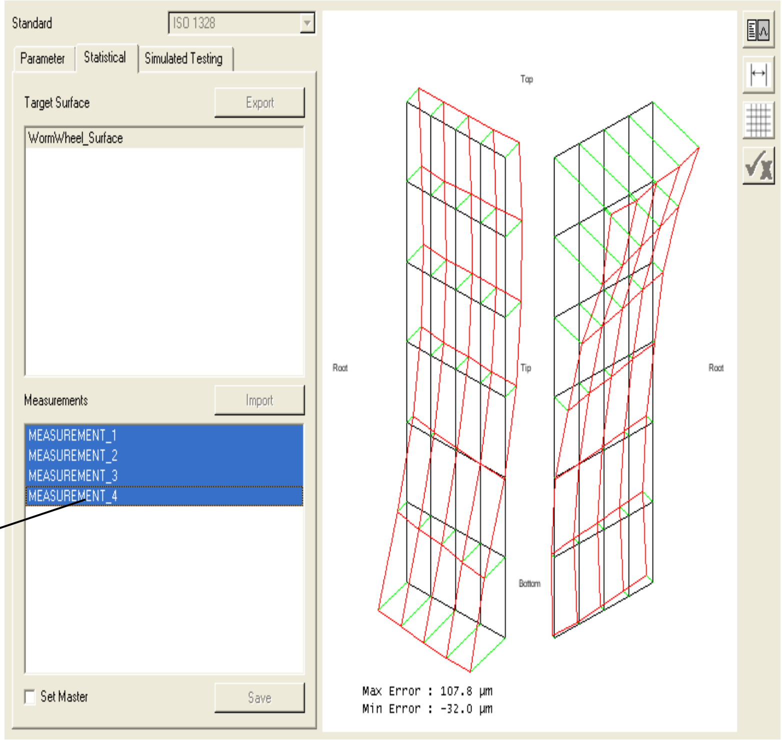
Data can be imported and used for:

Statistical analysis of several teeth
Creating master tooth form
Tooth contact analysis
Tool and process correction



Inspection Centre

Import and evaluate tooth measurement data for a component or tool



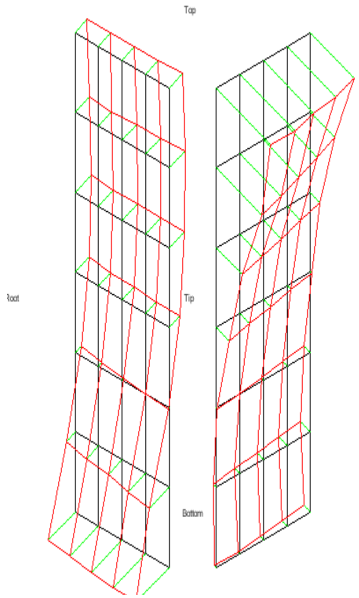
Several measurement files can be imported into Inspection Centre

Create Average from Multiple Measurements

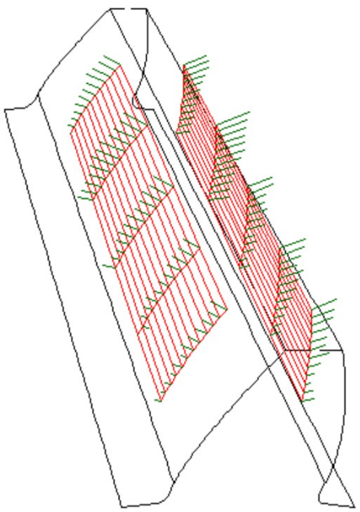
Inspection Centre

Import and evaluate tooth measurement data for a component or tool

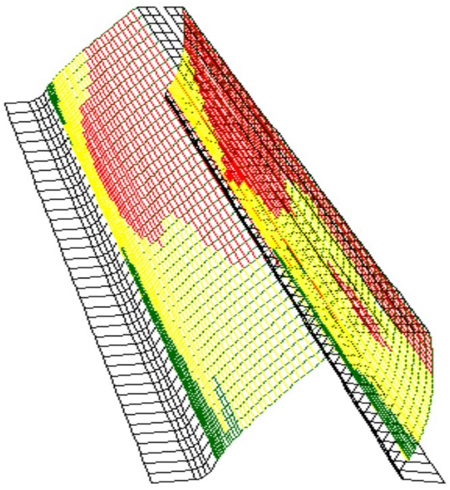
Isometric Projection



Surface Projection



Heat Map



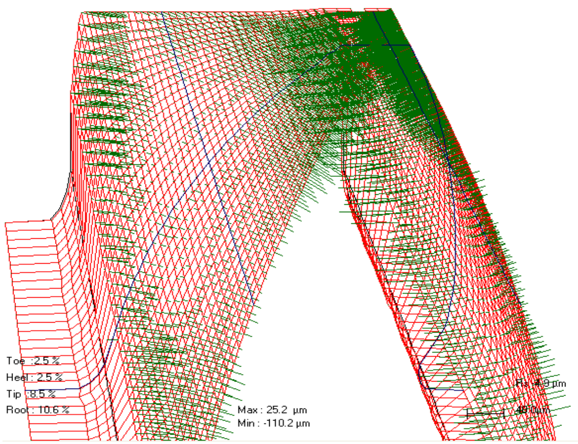
Different formats for surface display

New Heat-Map format showing areas of correct form to given tolerance (green) marginal (yellow) and error (red)

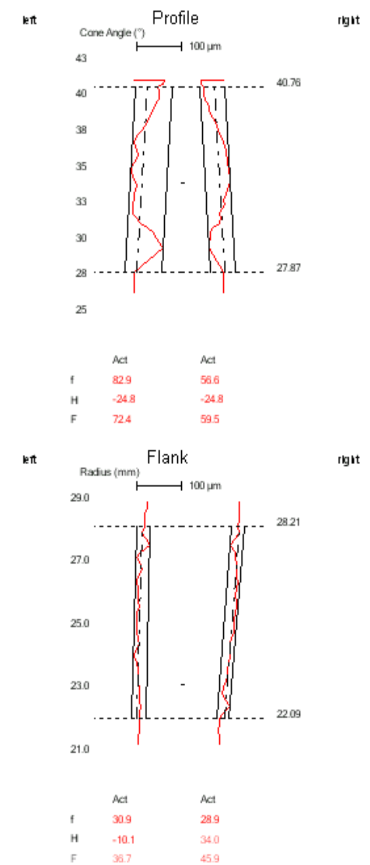
Inspection Centre

Import and evaluate tooth measurement data for a component or tool

Twist Pattern



Current Profile/Flank selection indicated in blue



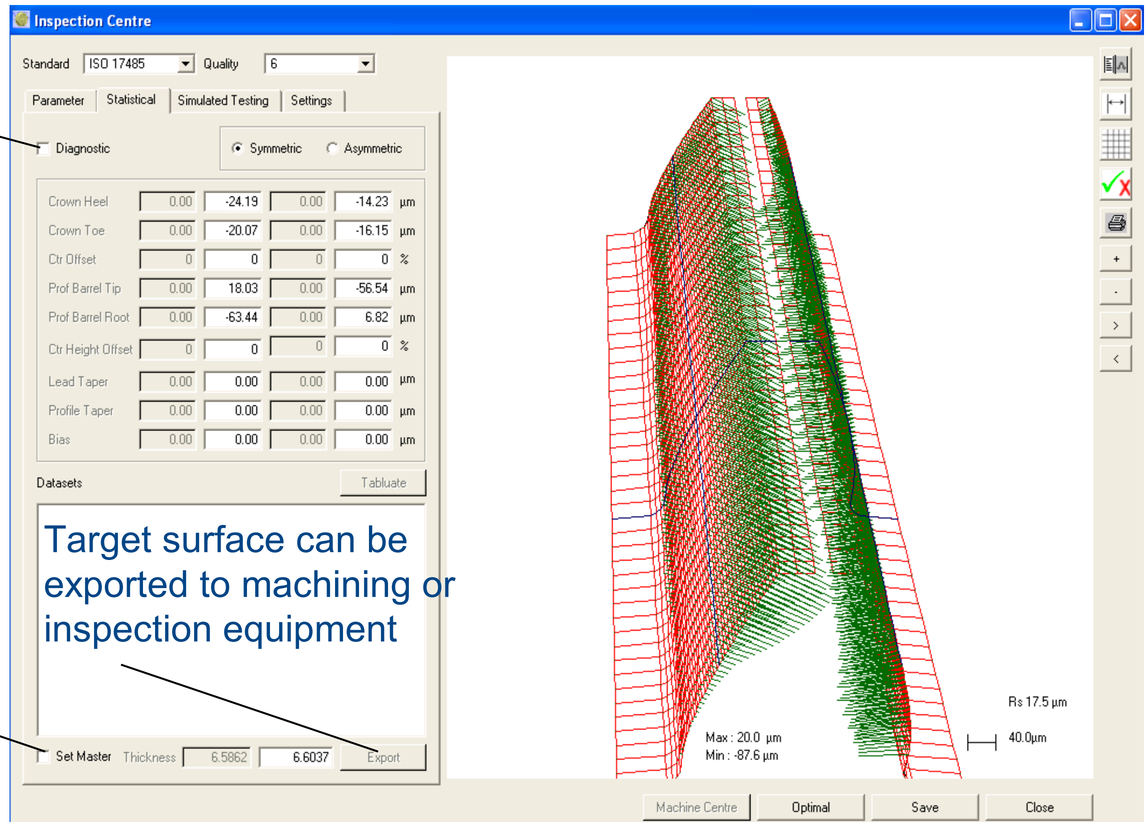
Different formats for surface display

Inspection Centre

Import and evaluate tooth measurement data for a component or tool

Target surface can be smoothed to make generation by 5-axis possible

Select “Set Master” to create a surface definition for comparison

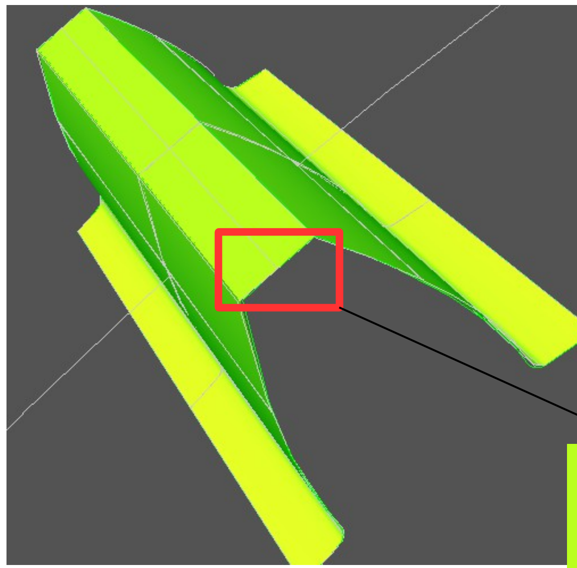


Target surface can be exported to machining or inspection equipment

Create Target Surface For Future Production

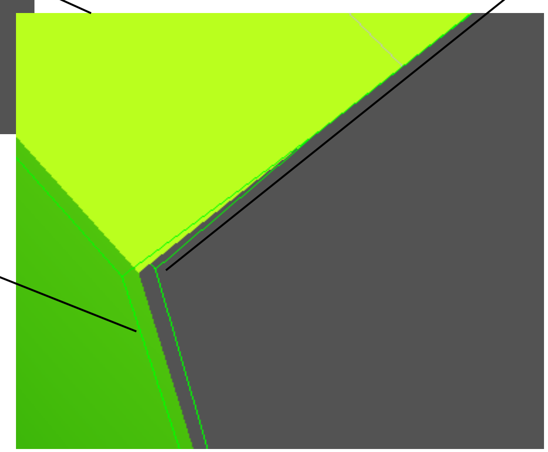
Inspection Centre

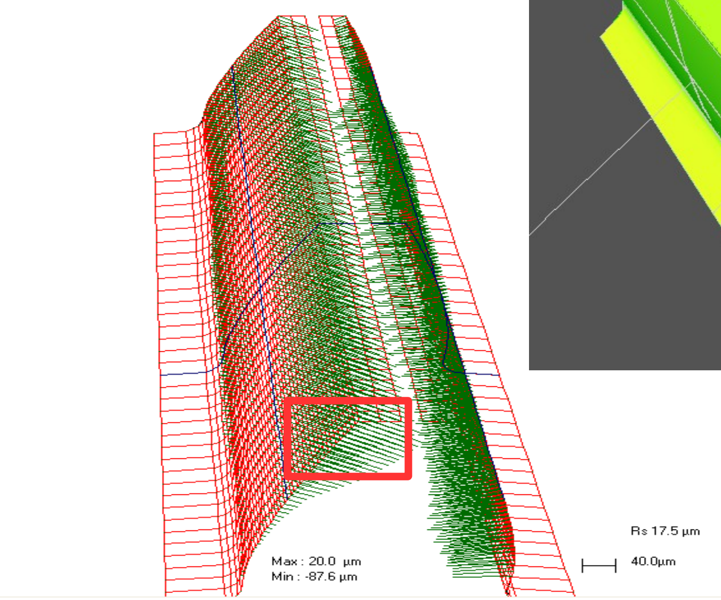
Create Master Or Optimised Surface



Solid surface is nominal tooth form

Select “Set Master” to define a surface as new nominal which can be exported in IGES or G-Code, and Inspection file formats



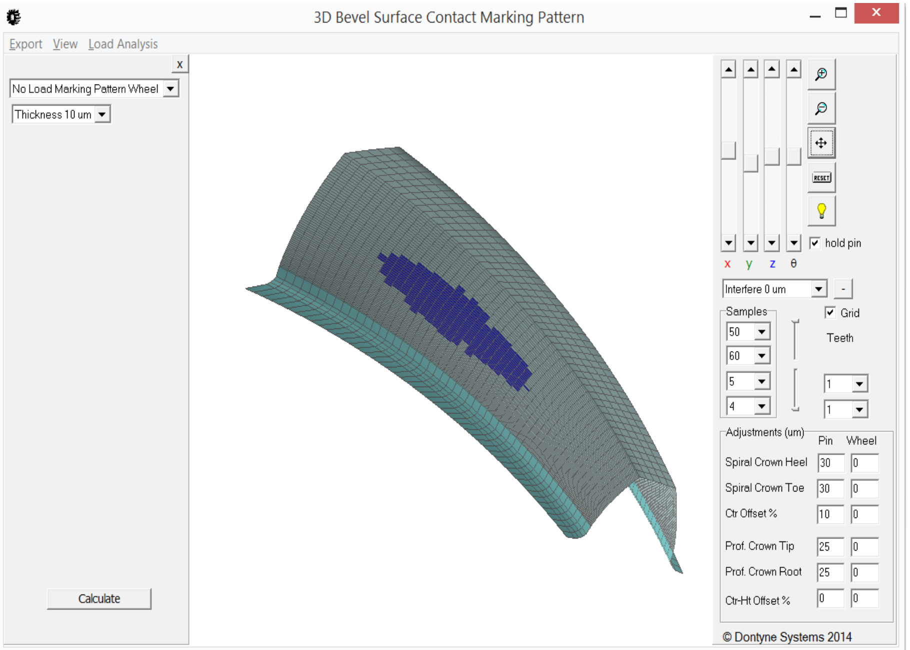


Region shows minus metal

Optimal exports surface with opposite deviations to measured

Inspection Centre

Tooth measurement data can be used to simulate a marking pattern



Simulation of marking pattern using measurement data on one or both components

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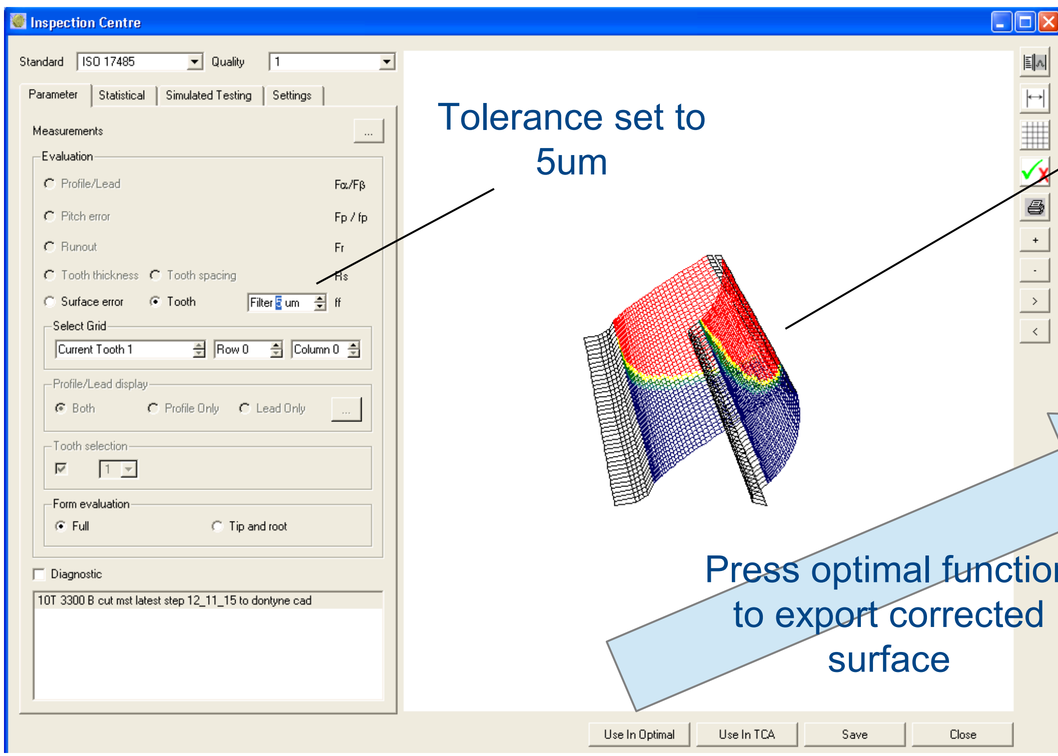
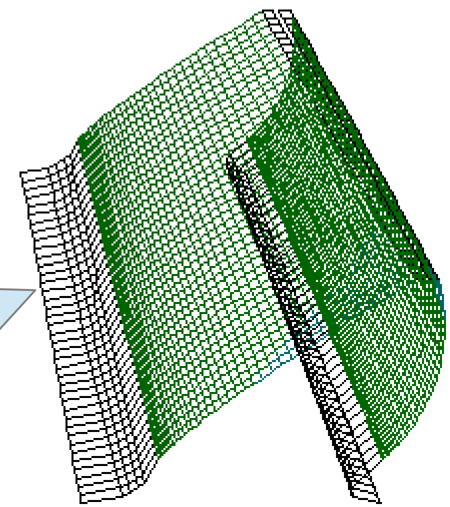
Optimal - Tool Optimisation Using Measured Data



Tolerance set to 5um

Press optimal function to export corrected surface

First attempt indicates small area within 5um tolerance (red and blue outside plus and minus material respectively)



Most areas of gear now show within 5um tolerance (green) after re-machining

Future Development

- Full 3D FE of tooth form
- Efficiency in Load Model
- Database for heat distortion

Deformation Model For Heat Treatment Compensation

- Appropriate for pre-finished form and for die production in forging and injection moulding
- Factors such as design parameters, material, force, and temperature will form model
- Requires contribution from customer to develop initial model based on experience
- Model will be compared to existing data for validation (propose correct 50% as initial target)
- Considerable savings in time if avoidance of iteration to tool surface

Thank You