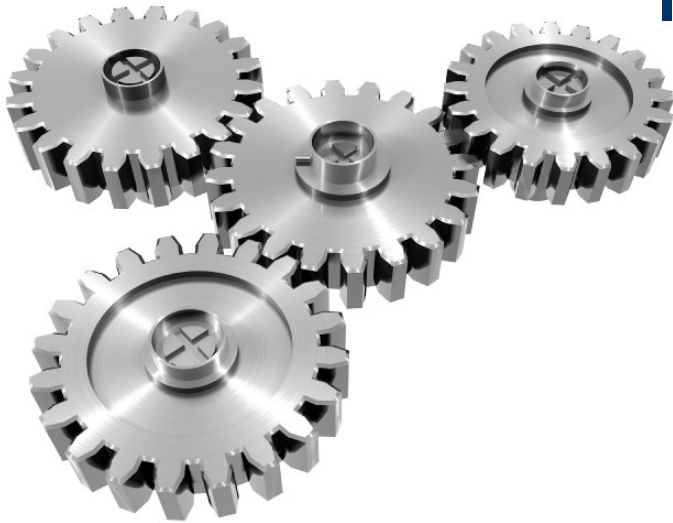


## Inspection Centre 5.0



*Evaluation of Gear Components, Tool  
Optimisation, And Virtual Testing From  
Measured Data*

17 December 2012

# Introduction

## The Need for Improvements to Gear Inspection

- *More comprehensive inspection to assess influence of machining process*
- *Improved versatility (3D surface) to assess operating characteristics*
- *Saving production time and capital expenditure through virtual testing*
- *Improved versatility (failure analysis, diagnostics, optimisation) through compatibility with other DS design and analysis modules*
- *Improved production efficiency*

# Introduction

## **BASIC**

- *Import / Export allows comprehensive surface definition (including root)*
- *Evaluation of 1D parameters (profile/flank/pitch)*

## **STANDARD**

- *2D & 3D Measurement*
- *Simulates physical tests to automate inspection procedures*
- *Statistical analysis of measurement data*

## **ADVANCED**

- *Creates virtual test rig for contact analysis*

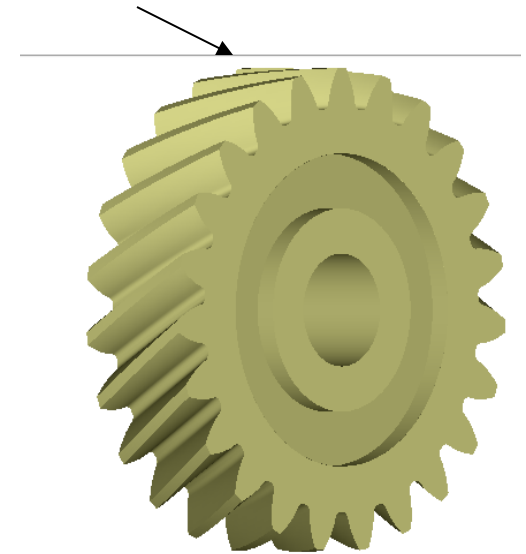
## Basic Level

**Surface Definition :** *Export / Import component 2D or 3D surface*

*Deifinition of Geometry, Inspection and Tolerances*

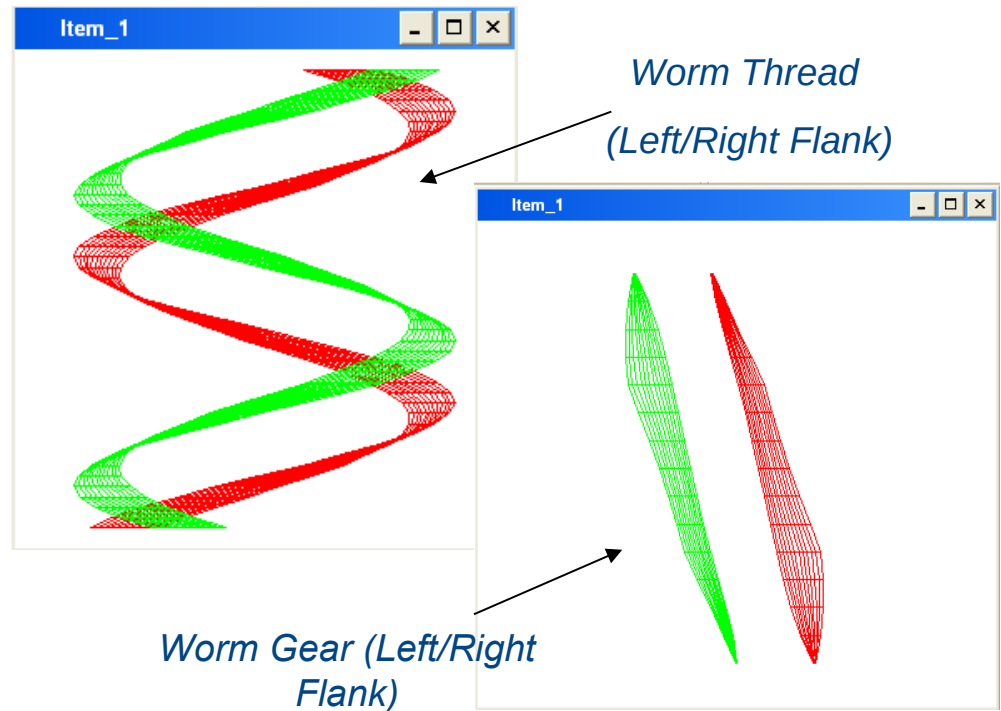
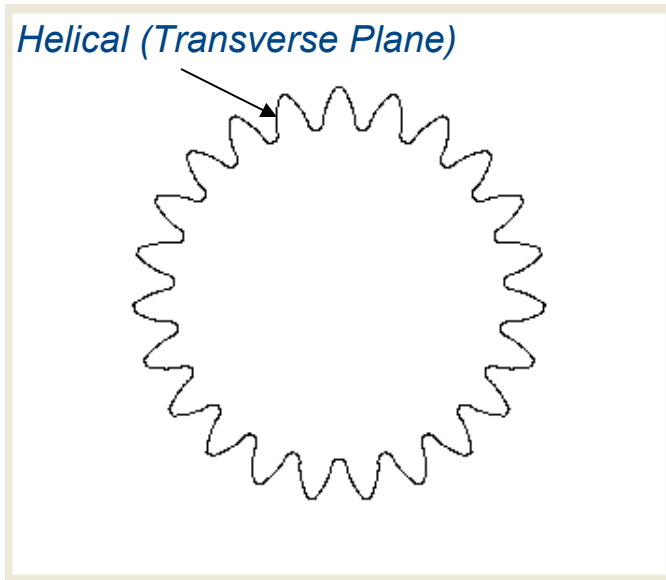
*Links to 3D Models*

The screenshot displays the 'Component Data' window for a gear component named 'M5230B30RH'. The 'Tooth Form' tab is active, showing various parameters for profile type, number of teeth, normal module, normal pressure angle, helix angle, face width, finished tooth thickness, tip diameter, and root diameter. A 'Text and Visual Report' window is overlaid on the main interface, showing a 2D profile of a gear tooth with various dimensions labeled:  $d_A = 187.000$  mm,  $LA = 186.750$  mm,  $d = 173.205$  mm,  $LE = 164.500$  mm,  $d_F = 162.000$  mm, and  $db$ . The 'Component' window also lists 'Basic Geometry' parameters such as Teeth (30), Normal module (5.0000 mm), Normal Pressure Angle (20.0000 °), Ref. helix angle (30.0000 °), Profile shift coefficient (0.00), Root Diameter (169.00), Tooth Height (9.00), Tooth Height / mm (1.80), Normal Tooth Thickness (7.85), Reference Data (Face width: 30.00, Tip Diameter: 187.00, Root Diameter: 169.00, Reference Diameter: 173.20, Base Diameter: 159.67), Finished Tooth Thickness (Dimension over balls: 2554.02, Ball diameter: 1183.51, Contact diameter: 354.43, Base tangent: 1191.39).



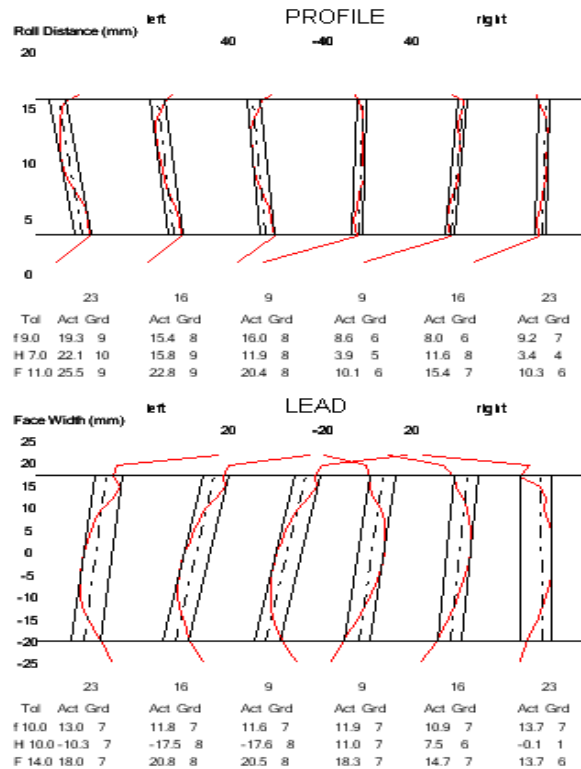
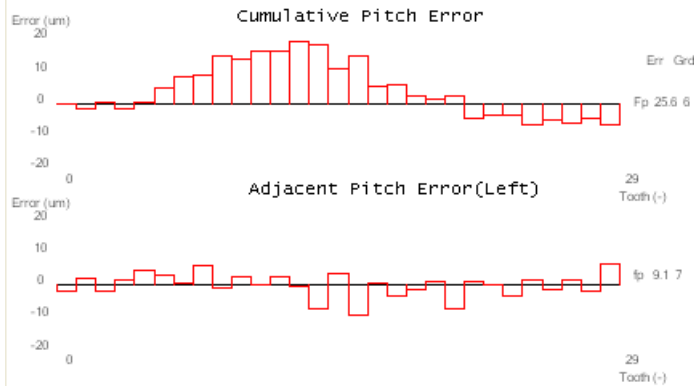
# Basic Level

**Surface Definition :** *Export / Import component 2D or 3D surface*



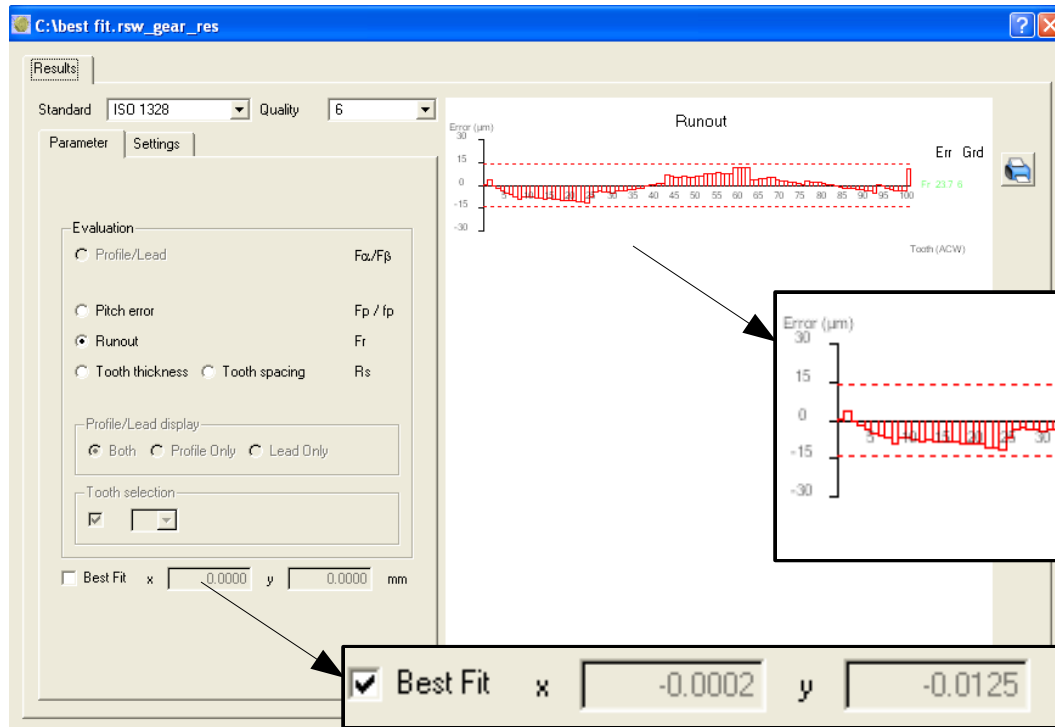
## Basic Level

ISO / DIN / AGMA Evaluation : *Profile, Helix, Pitch, Tooth Thickness, Run-Out*



# Standard Level

## Best Fit For Data



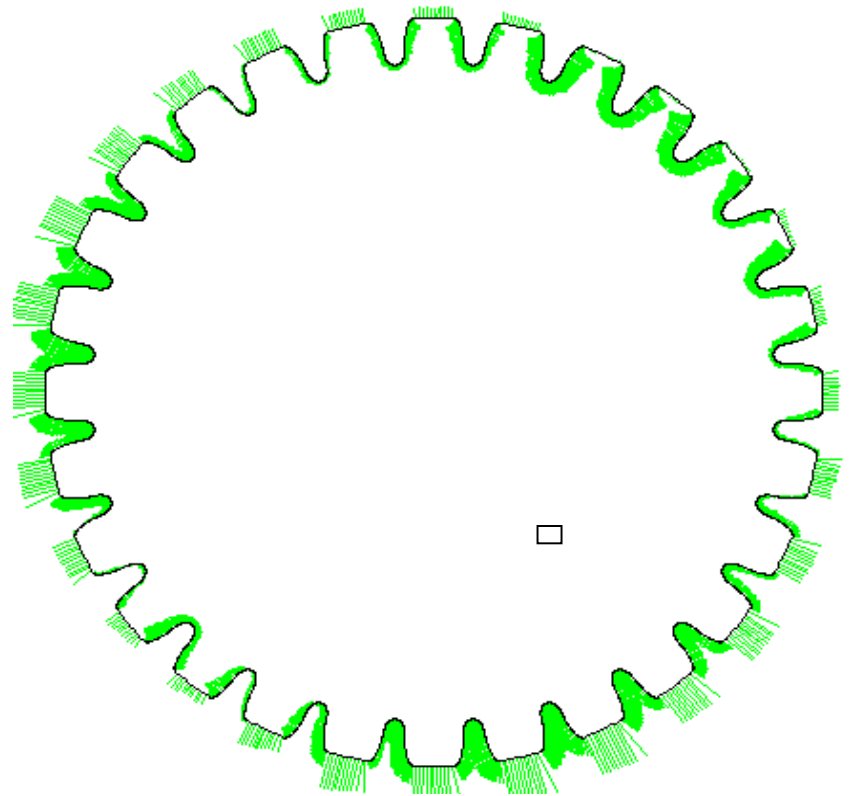
*run out minimised before evaluation*

*Shift in data recorded*

## Standard Level

### 2D scan measurement data -

- *Measured Data (Red) is compared to a Theoretical Tooth Form (Black)*
- *Scaled Errors (Green) illustrate deviation*
- *Error values can be calculated for profile, pitch, tooth thickness, and tip & root diameter*
- *Complete form check in transverse section including root/tip form generation*





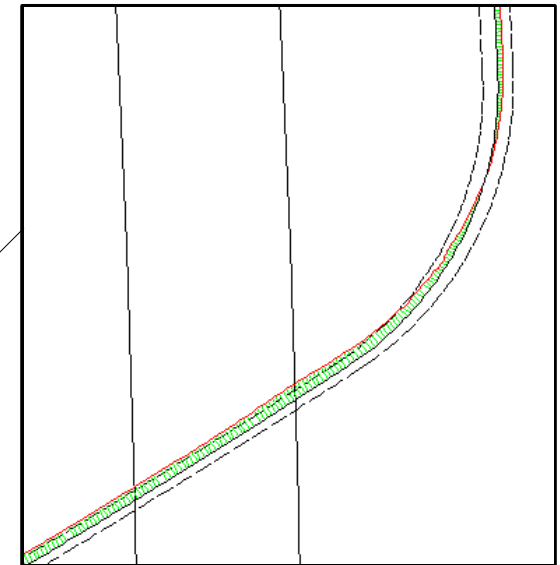
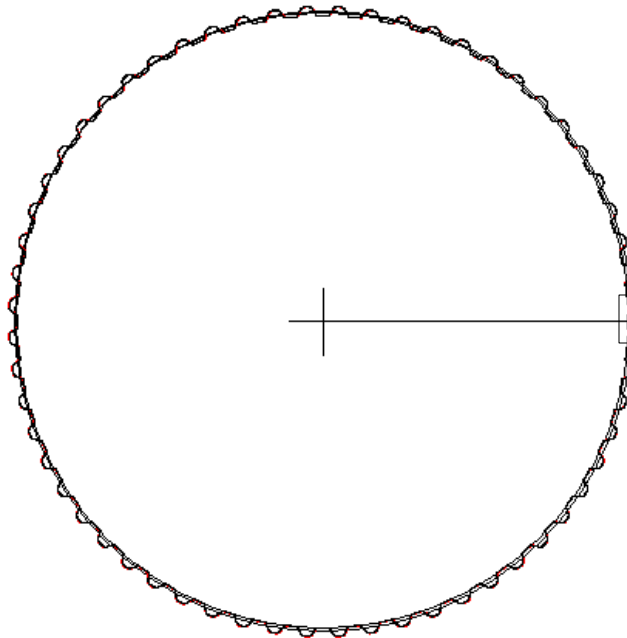
# Standard Level

## 2D scan measurement data -

	[Min]	Min	Max	[Max]	
Minor	[ -0.0020]	-0.0047	0.0230	[ 0.0020]	inch
Major	[ -0.0050]	-0.0043	0.0124	[ 0.0050]	inch

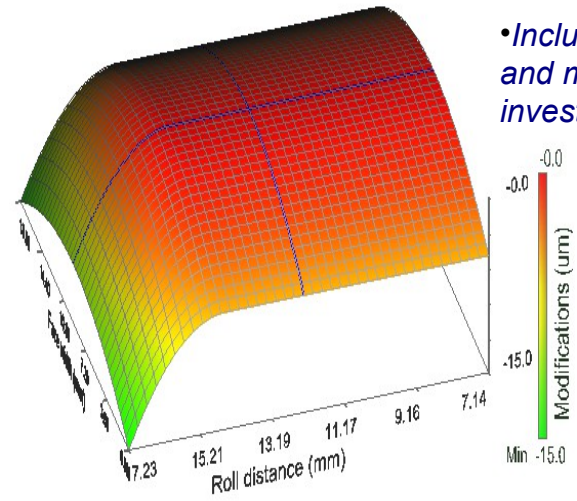
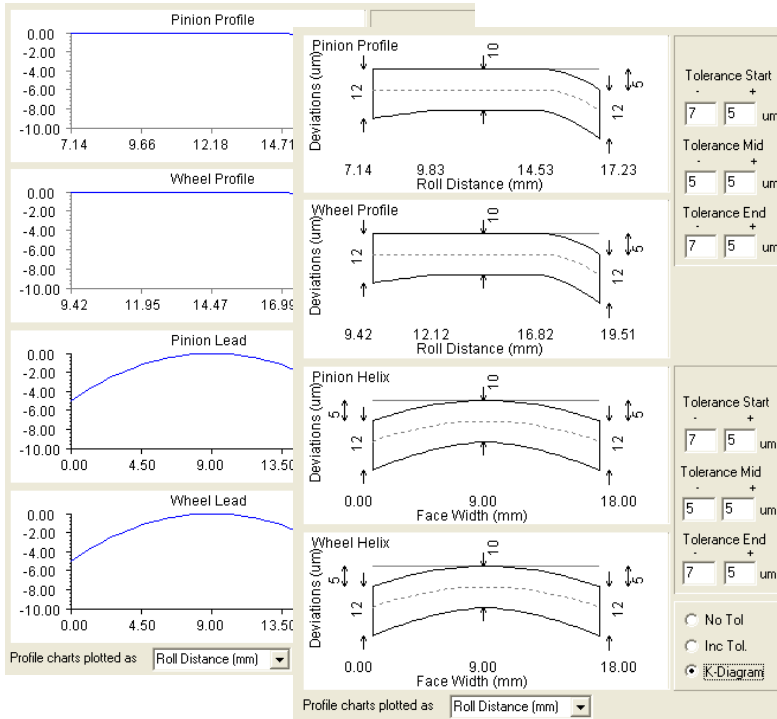
- *Tolerancing for max/min thickness, tip, root, and rounding can be assessed*

- *Simulate Go/No-Go Gauges in spline inspection*



# Standard Level

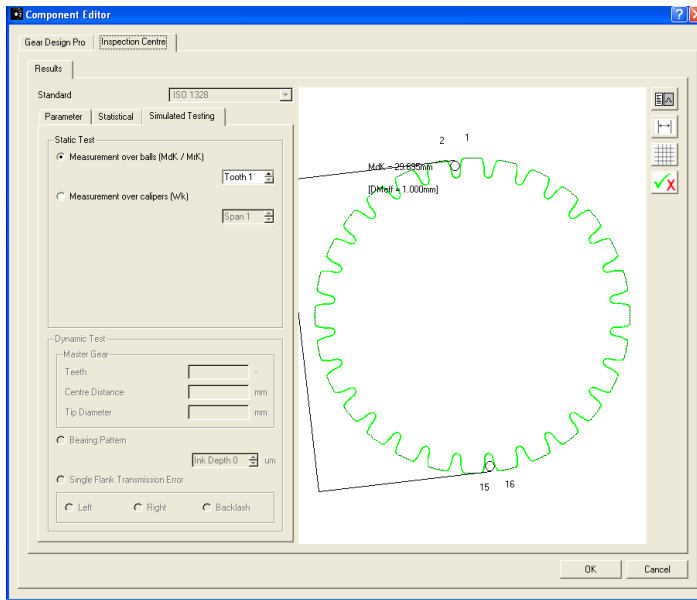
## Surface modification – 2D and 3D



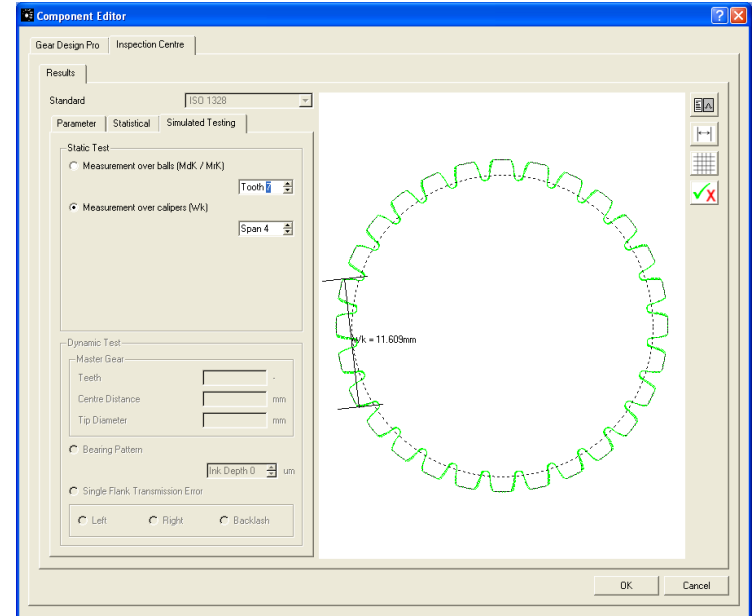
- Import/Export non-standard surface
- Asymmetric flanks
- Define 2D Profile/Lead including tolerance (K-Charts) or 3D surface modification
- Include influence of tooling and manufacturing to investigate process error

# Standard Level

**Virtual Testing (Static) :** *Simulation of physical measurement procedures*



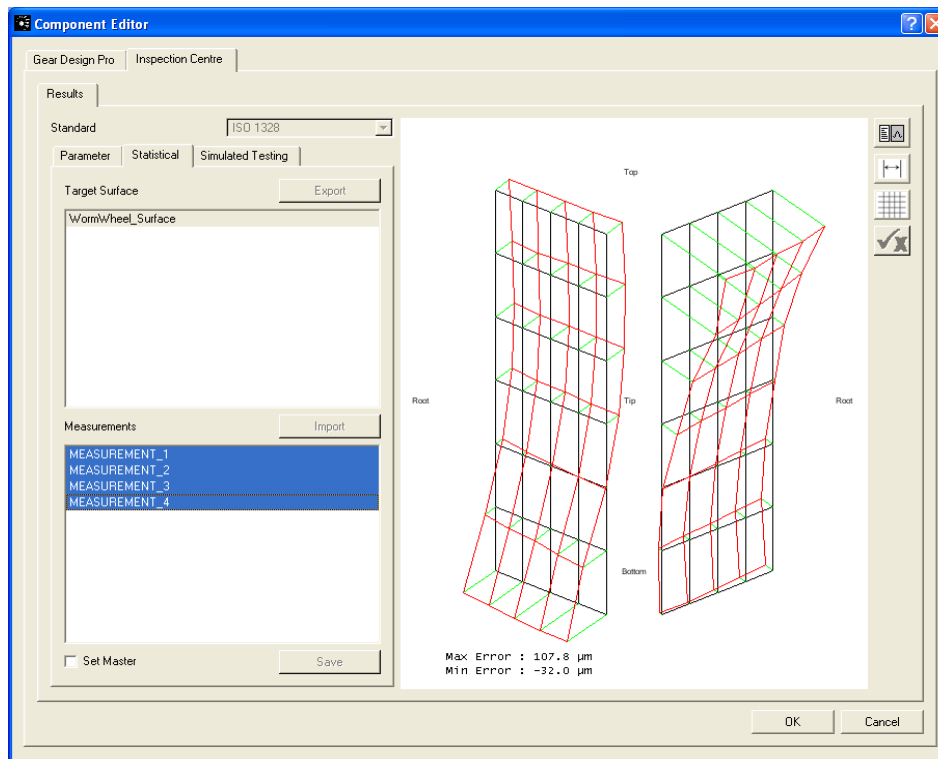
**Measurement Over  
Balls/Rollers**



**Calliper**

# Standard Level

## Statistical evaluation of measurements



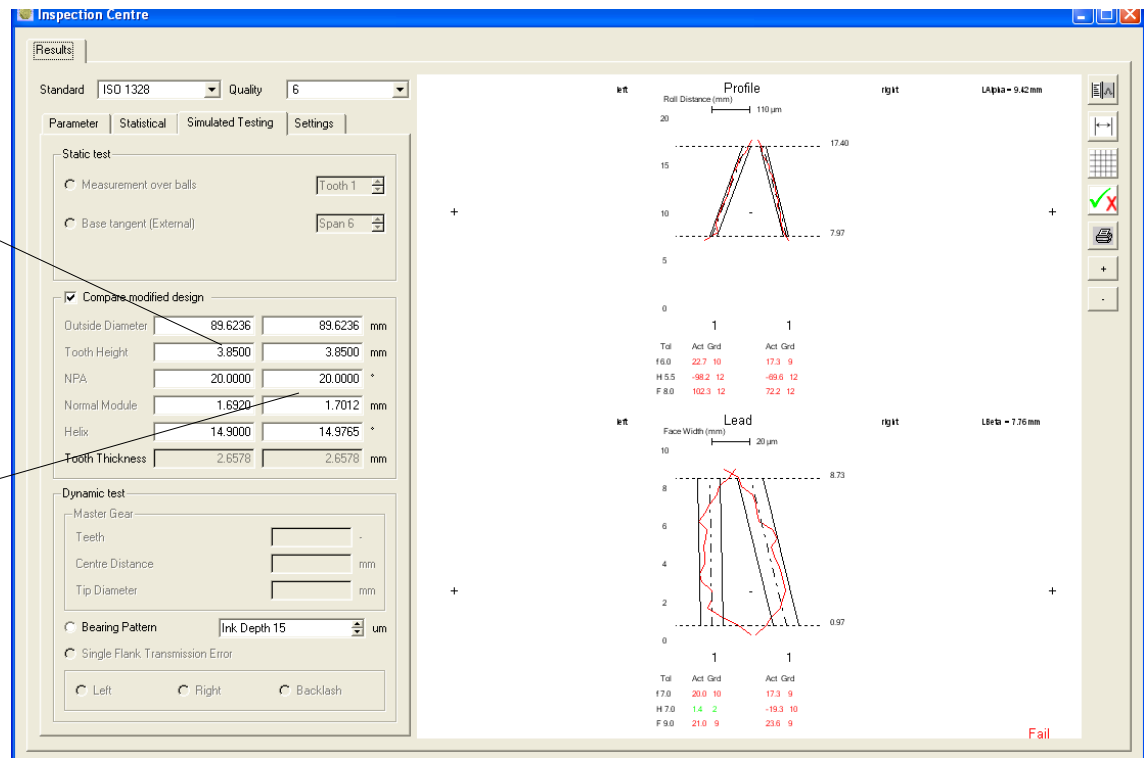
- Single or multiple measurements of one tooth, full section, or surface entered (red)
- Calculation of average form and maximum deviation
- Definition of statistical 'Master' surface for export

## Advanced Level

### - Diagnostics / Reverse Engineering

• *Small changes to the nominal gear design can be introduced and the measured data evaluated to the modified parameters*

• *Error values can be used to propose changes to nominal design parameters*



# Advanced Level

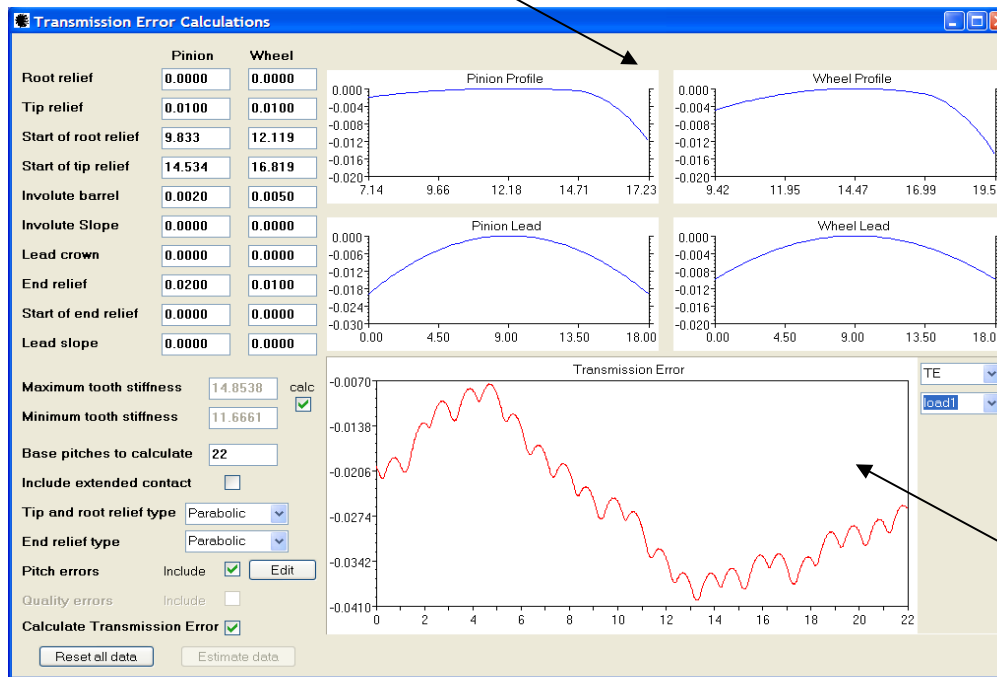
## Tooth Contact Model : *Specification of virtual master*

	SAMPLE	MASTER
No of teeth, z	29	87
Normal Module, mn	6.05	6.05
Ref Pressure Angle, $\alpha_n$	17.5°	17.5°
Ref. Helix Angle, $\beta_n$	28.7	28.7
Face Width, b	200	200
Ref. Diameter, d	199.946	599.839
Tip Diameter, $d_a$	222	612
Root Diameter, $d_f$	183.15	573.15
Centre Distance, a	400	400
Specified Accuracy ISO 1328-1/95 Grade	3	1

# Advanced Level

- Virtual Testing (Dynamic) : *Creating contact model*

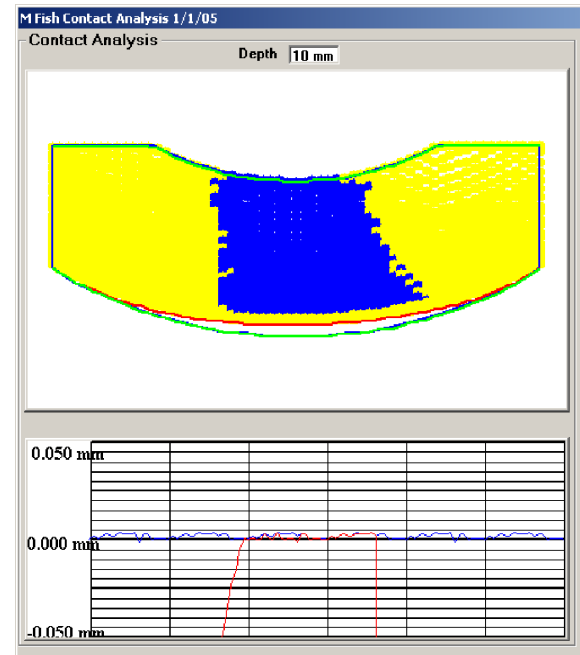
*Profile/Lead Modification (Simulated or Measured)*



*Pitch/Run-Out  
(Simulated or Measured)*

# Advanced Level

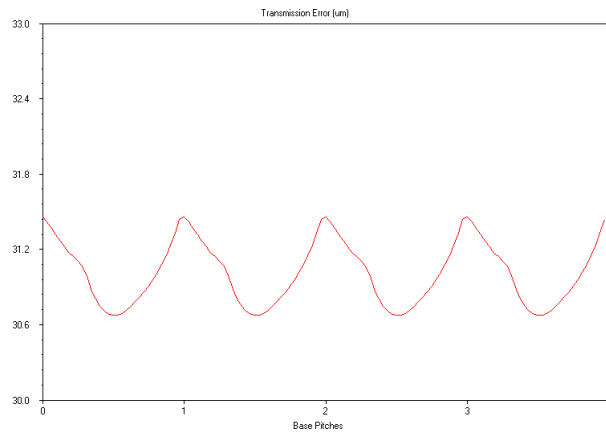
**Contact Characteristics** : *Simulated Transmission Error and Marking Pattern*



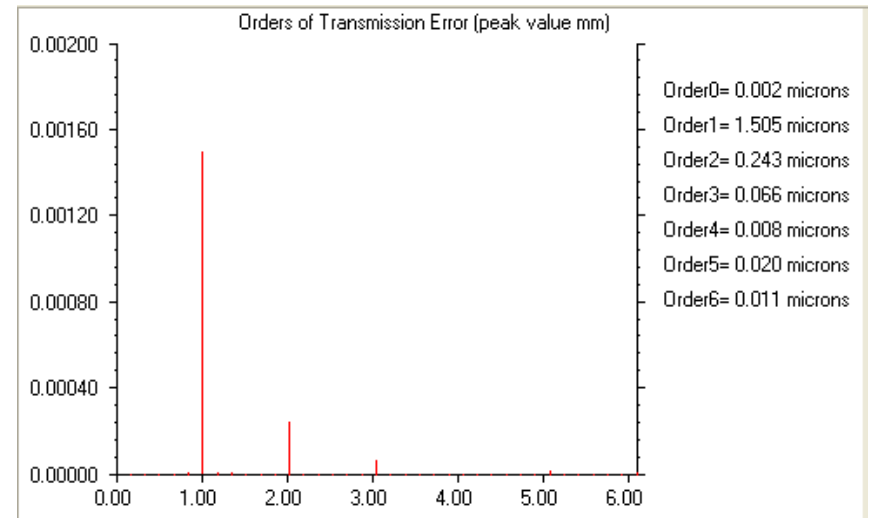


# Advanced Level

Contact Characteristics : *Fourier Transform from single flank test data*



**Detailed Tooth-To-Tooth**  
*(Plot can be used to derive FFT Spectrum)*



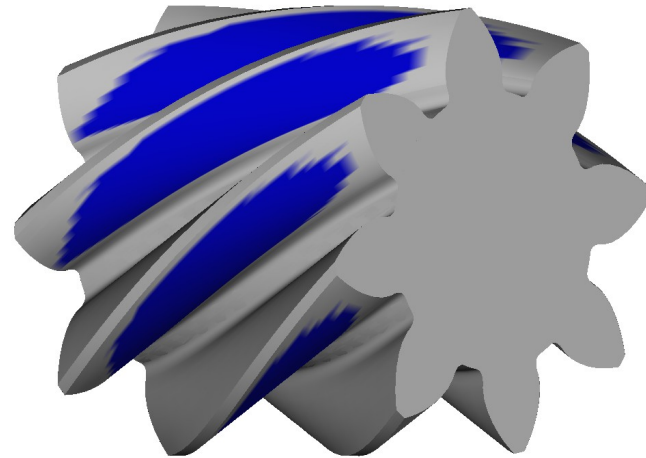
**Tooth-To-Tooth FFT**  
*(Amplitude/Frequency Spectrum)*

# Advanced Level

-Investigate changes In Design, Tooling and Machining



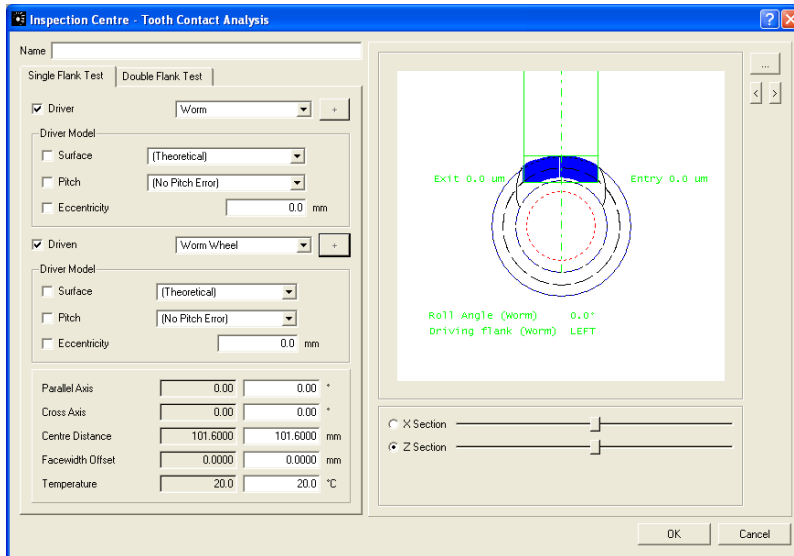
**Nominal Bearing  
Contact**



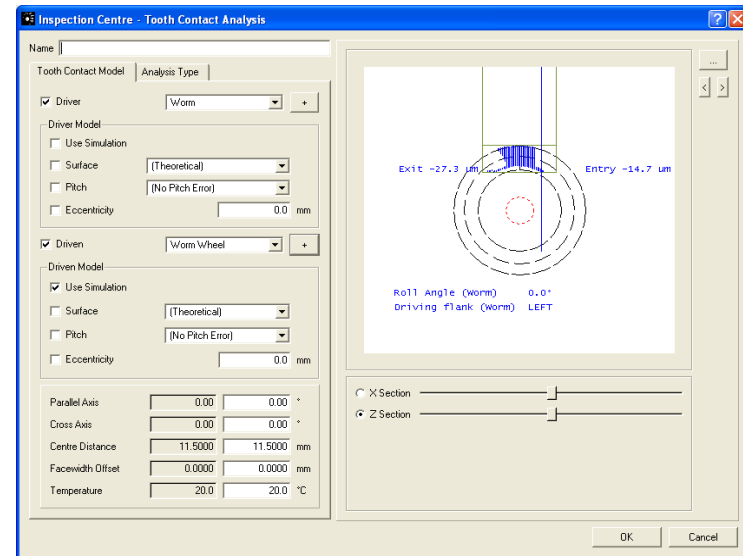
**With Additional Lead  
Crowning on Tool**

# Advanced Level

- Investigate Changes In Design, Tooling and Machining



**Nominal Worm Gear Contact**



**Contact Considering Tool and Machine Settings**

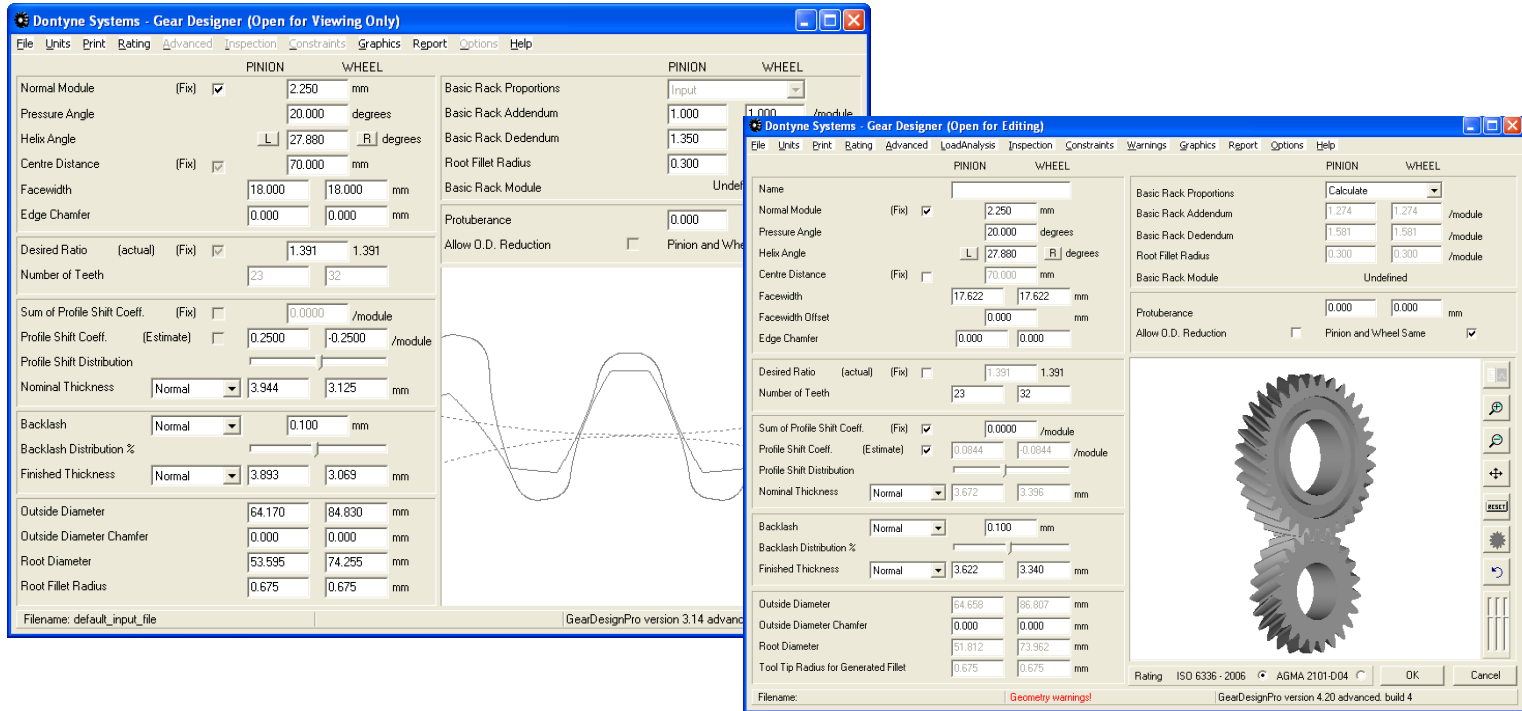
# Summary

The combined functionality and versatility of the Inspection Centre adds value to the standard quality evaluation process and enables large savings in cost and resources

- *Links to design software for surface definition*
- *Integration to existing metrology equipment*
- *ISO/DIN Evaluation of measurements*
- *Arbitrary gear form (segment, non-circular)*
- *Simulation of static and dynamic testing*
- *Diagnostic capability*
- *Practical development tool*

# Add On I

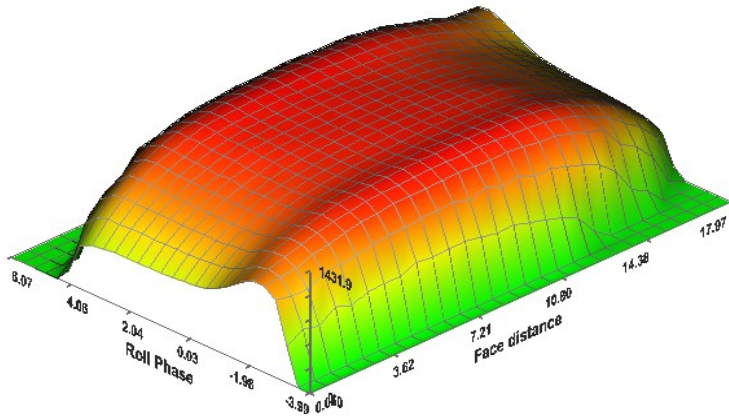
## Gear Design Pro Module : Design and Rating of gear pairs



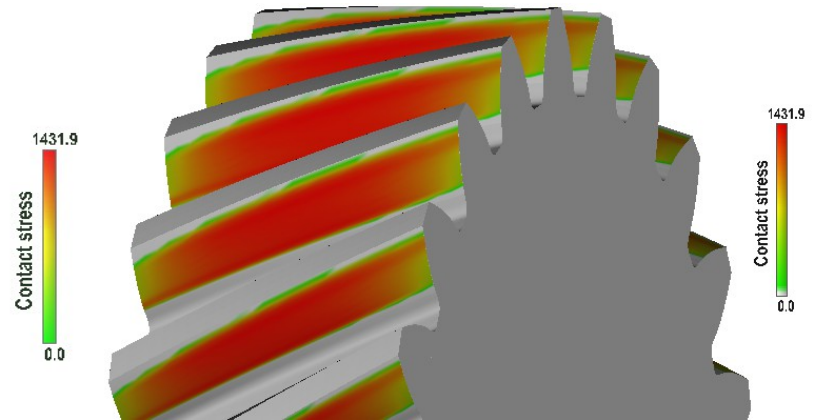
# Add On II

*Load Analysis Model Module : Calculation of contact including stress*

Contact Stress



**3D Mapped Surface**

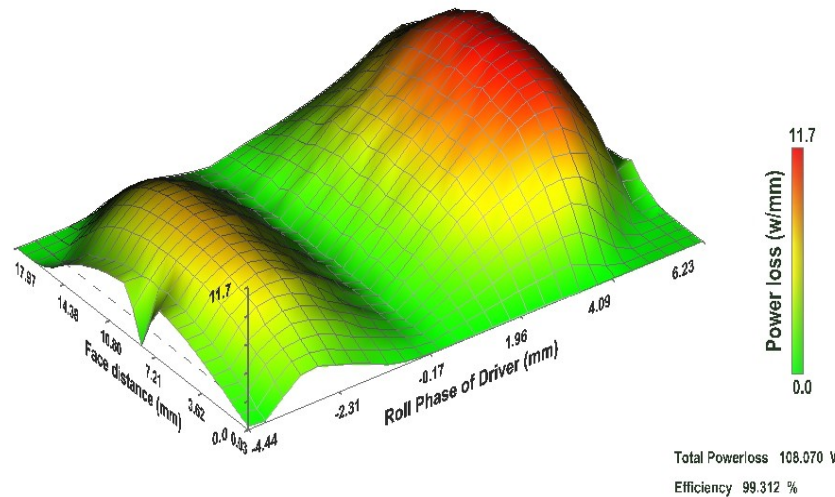


**3D Tooth Illustration**

# Add On II

*Load Analysis Model Module : Calculation of power loss on tooth (efficiency)*

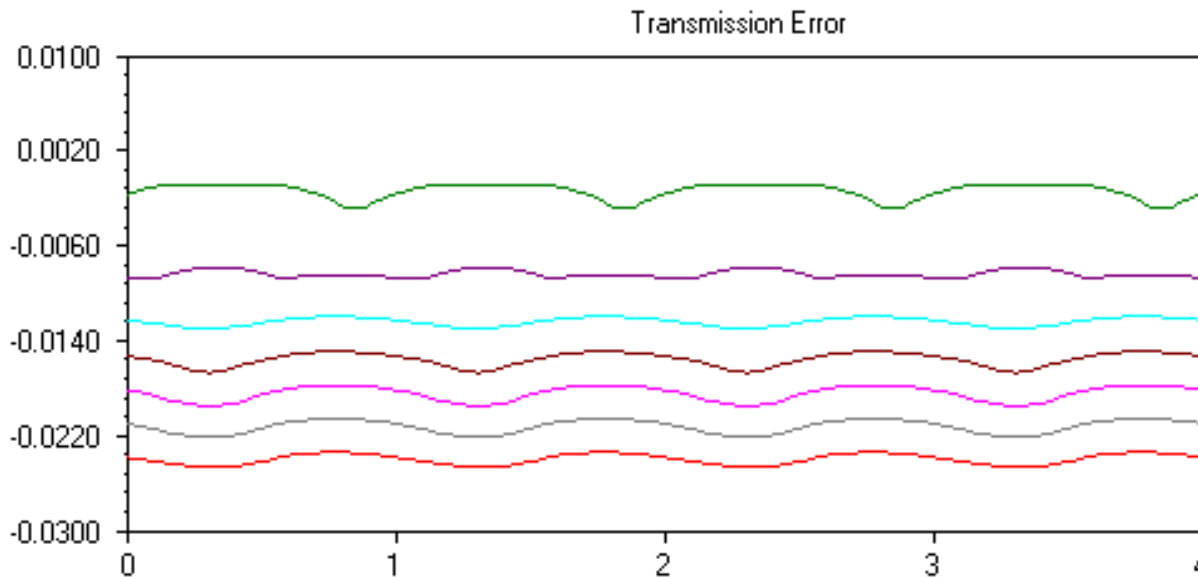
Power Loss



# Add On II

## *Load Analysis Model Module : Dynamic Testing*

*Predict transmission error under load for NVH analysis*



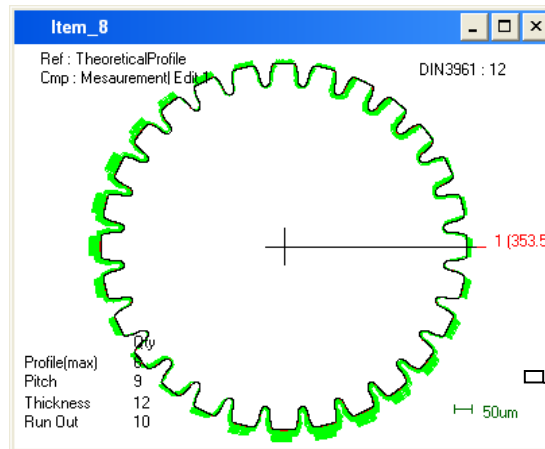
**Harris Map Plot**  
*(Illustrates Change in Amplitude through load to identify optimum operation)*



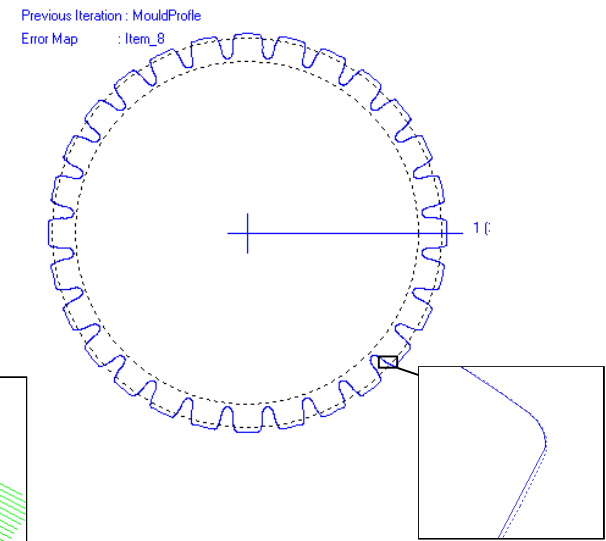
## Add On III

**Optimal Module : Corrective Action for Tool and Machine Settings**

(e.g. Wire Erosion used in Injection Mould, Forge, Extrude)



**Error Calculation**



**Tool Correction**

# Add On III

**Optimal Module** : *Corrective Action for Tool and Machine Settings*

**Other tooling processes available:**

- *Hobbing*
- *Shaving*
- *Shaping*
- *Dressing & Grinding*

# Contact Us

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[www.dontynesystems.com](http://www.dontynesystems.com)**