Inspection Centre 4.7

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

23 July 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

- Definition of Geometry, Inspection and Tolerances
- Links to 3D Models
- Text and Visual Report

![Image of gear and chart](image-url)
Basic Level

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

- *Helical (Transverse Plane)*
- *Worm Thread (Left/Right Flank)*
- *Worm Gear (Left/Right Flank)*
Basic Level

ISO / DIN / AGMA Evaluation: Profile, Helix, Pitch, Tooth Thickness, Run-Out
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
• Root form generation error can be assessed
• Average tooth form and Symetric average calculation available
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

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

<table>
<thead>
<tr>
<th>Specification</th>
<th>SAMPLE</th>
<th>MASTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of teeth, z</td>
<td>29</td>
<td>87</td>
</tr>
<tr>
<td>Normal Module, mn</td>
<td>6.05</td>
<td>6.05</td>
</tr>
<tr>
<td>Ref Pressure Angle, αn</td>
<td>17.5°</td>
<td>17.5°</td>
</tr>
<tr>
<td>Ref. Helix Angle, βn</td>
<td>28.7</td>
<td>28.7</td>
</tr>
<tr>
<td>Face Width, b</td>
<td>200</td>
<td>200</td>
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<tr>
<td>Ref. Diameter, d</td>
<td>199.946</td>
<td>599.839</td>
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<tr>
<td>Tip Diameter, da</td>
<td>222</td>
<td>612</td>
</tr>
<tr>
<td>Root Diameter, df</td>
<td>183.15</td>
<td>573.15</td>
</tr>
<tr>
<td>Centre Distance, a</td>
<td>400</td>
<td>400</td>
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<tr>
<td>Specified Accuracy ISO 1328-1/95 Grade</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
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

With Additional Crowning
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**

![Power Loss Graph](image)
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
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