Test and Measurement Conference

Evaluation of machines and CMMs using a laser tracer

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Outlook

This presentation will address the following questions.

• What is machine or CMM evaluation?
• Why is a machine or CMM evaluated?
• Which instruments are used during the evaluation and why?
• How do these instruments work?
• Conclusion
Machine or CMM evaluation

- It is a process where the performance condition of a machine or CMM is assessed against the manufacturer’s specification.
Reason for doing the evaluation

Machines (lathe, milling machine)

Machines are built with gears and belt which break and wear out. This affects the machine's ability to produce accurate parts. This is essential in industries such as production of parts or various components where high accuracy is required to ensure that the manufactured component will be fit for its purpose.

CMMs

CMMs contain bearings which in most cases run on air, they can easily be damaged by dust, oil or water. This can result in inaccurate measurement results.
Previously instrument(s)

Previously, NMISA was using a linear laser interferometer to perform evaluations of machines. This instrument can only do a single axis at a time.
New instrument

- Laser tracer

**mass and dimensions**
- mass of LaserTRACER-NG: approx 8.5 kg
- mass of Controller: approx 13.5 kg
- height of LaserTRACER-NG: 230 mm

**measuring range**
- range of elevation angle: -35° bis +85°
- range of azimuth angle: ±225°
- measuring range: 0.2 m bis 20 m

**accuracy**
- frequency stabilisation of laser 24 h: 2·10⁻⁸
- stability reference sphere: ±0.1 μm
- resolution of interferometer: 0.001 μm
- length measurement uncertainty (k=2): 0.2 μm ± 0.3 μm/m

120° CatEye: 0 – 20 m
Housing Ø 75mm
Weight 330g

160° CatEye: 0 – 5m
Housing Ø 35mm
Weight 140g
New instrument

• Laser tracer
Advantages of using a laser tracer

- Evaluation of linear axes (all component errors and squareness)
- Evaluation of rotary axes (all component errors and squareness)
- The evaluation is done according to ISO 10360
- No alignment is necessary, the laser tracks the reflector and does self-alignment
NMISA ZEISS CMM

- The CMM has an accuracy of 0,5µm
- Volume: (900x1300x650) mm
Evaluation of a ZIESS CMM using a laser tracer

• The Tracer covers systematic geometry deviations of a 3 axes machine, 21 parameters in total with the notation according to ISO 10360 (for CMMs) and ISO 230 (for machines)
Errors and their directions

Deviation from ideal motion

\[ x_{rx} \]
- error direction
- error type \((t=\text{translational}, r=\text{rotational})\)
- regarding axis

Deviation from ideal position

\[ x_{wy} \]
- regarding axis
- error type \((w=\text{angle})\)
- regarding axis
Results

Positions and volume evaluated
## Results

### Results table

<table>
<thead>
<tr>
<th>Group</th>
<th>Parameter</th>
<th>Deviation (range)</th>
<th>Umax (95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>xtx</td>
<td>2.1 µm</td>
<td>0.3 µm</td>
</tr>
<tr>
<td></td>
<td>yty</td>
<td>3.7 µm</td>
<td>0.4 µm</td>
</tr>
<tr>
<td></td>
<td>ztz</td>
<td>0.5 µm</td>
<td>0.5 µm</td>
</tr>
<tr>
<td>Straightness</td>
<td>xty</td>
<td>1.3 µm</td>
<td>0.2 µm</td>
</tr>
<tr>
<td></td>
<td>xtz</td>
<td>0.2 µm</td>
<td>0.3 µm</td>
</tr>
<tr>
<td></td>
<td>ytx</td>
<td>1.2 µm</td>
<td>0.3 µm</td>
</tr>
<tr>
<td></td>
<td>ytz</td>
<td>0.8 µm</td>
<td>0.3 µm</td>
</tr>
<tr>
<td></td>
<td>ztx</td>
<td>0.7 µm</td>
<td>0.1 µm</td>
</tr>
<tr>
<td></td>
<td>zty</td>
<td>0.4 µm</td>
<td>0.1 µm</td>
</tr>
<tr>
<td>Pitch / Yaw / Roll</td>
<td>xrx</td>
<td>1.9 µrad</td>
<td>0.4 &quot;</td>
</tr>
<tr>
<td></td>
<td>xry</td>
<td>0.9 µrad</td>
<td>0.2 &quot;</td>
</tr>
<tr>
<td></td>
<td>xrz</td>
<td>2.3 µrad</td>
<td>0.5 &quot;</td>
</tr>
<tr>
<td></td>
<td>yrx</td>
<td>10.5 µrad</td>
<td>2.2 &quot;</td>
</tr>
<tr>
<td></td>
<td>yry</td>
<td>1.8 µrad</td>
<td>0.4 &quot;</td>
</tr>
<tr>
<td></td>
<td>yrz</td>
<td>3.0 µrad</td>
<td>0.6 &quot;</td>
</tr>
<tr>
<td></td>
<td>zrx</td>
<td>22.7 µrad</td>
<td>4.7 &quot;</td>
</tr>
<tr>
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<td>zry</td>
<td>19.3 µrad</td>
<td>4.0 &quot;</td>
</tr>
<tr>
<td></td>
<td>zrz</td>
<td>14.6 µrad</td>
<td>3.0 &quot;</td>
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<tr>
<td>Squareness</td>
<td>xwy</td>
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<td>0.7 &quot;</td>
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<tr>
<td></td>
<td>xwz</td>
<td>5.3 µrad</td>
<td>1.1 &quot;</td>
</tr>
<tr>
<td></td>
<td>ywz</td>
<td>-21.8 µrad</td>
<td>-4.5 &quot;</td>
</tr>
</tbody>
</table>
Results

Results table
Conclusion

• The laser tracer is a useful instrument since it can evaluate all axes in a single alignment.

• The results show that the CMM requires calibration and/or adjustment.

• The squareness in the z-axis is shown to have a big deviation.

• Evaluation of CMMs and machines is essential because it provides information on whether the specific instrument is still within specification.
Thank You

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