Machine-integrated workpiece measurement for 3-axis milling

Principle and application with SINUMERIK Operate
# Machine-integrated workpiece measurement for 3-axis milling

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Measuring the workpiece is used to define the position and alignment of the workpiece in the machine coordinate system.

Workpiece measurement can take place in two modes:

- **JOG**
  - Setup mode
- **AUTOMATIC**
  - Process measuring

Measuring cycles are used in various measuring tasks. The measuring cycle for the measuring task is configured by setting various parameters in the input screen.
Automated and repeated execution of workpiece programs requires the definition of **reference points**:

**Machine zero point**
- Located in the MCS machine coordinate system and defined by the machine manufacturer
- Cannot be changed from end-user
- Reference point for internal measuring systems in the machine
- Limits the machine's working area

**Workpiece zero point**
- The basis of the WCS workpiece coordinate system
- Zero point of the workpiece
- Can be freely selected by the end-user
- Is often positioned on a corner or in the center of the workpiece, a hole, a pin (to suit workpiece machining)

Adaptation of MCS to WCS i.e. transformation of the machine zero point to the workpiece zero.
### Measuring instruments for measuring workpieces

#### Manual contacting / scratching

- The operator manually moves an edge finder or a rotating tool to the workpiece
- The operator determines the current position on the basis of visual signals
- The operator confirms the touching via a softkey
- The workpiece zero point is automatically saved by the CNC

#### Manual probe

- The measuring instrument is located in the spindle, which has its probe length and diameter stored in the tool offset
- The operator determines the current position of the spindle center above an edge using a scale
- The operator confirms the touching via a softkey

#### Switching probes

- The operator positions a previously calibrated probe in the vicinity of the desired measuring object
- The cycle is selected and the measurement is started via NC-Start
- The desired position is automatically determined and saved by the CNC
### Measuring instruments for measuring workpieces

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#### Switching probes
- The machine must be prepared on both the HW and SW side for the use of switching probes!
1.2 Measuring accuracy
Calibration, the key factor in accurate measurements

Calibration = calibration of the probe before use
- Set the radial eccentricity of the probe, see manufacturer’s specifications
- Radius alignment with calibration
- Length alignment with internal or external length measuring device
→ Determination of individual switching points (trigger points) in reference to the spindle center of each direction of the axis (e.g. +X, -X, +Y, -Y, -Z)

Measurements must be made under the same conditions as for the calibration
- Calibrations and measurements should be done in the same planes (G17, G18, G19).
- The measuring feed must correspond to the calibration feed
- At the start of the measurement, the probe should be located approximately in the center of the calibration ring (by eye)
- In the best case, the probe will always be calibrated in the spindle (clamping tolerance)
Measuring precision
Influencing factors and measuring inaccuracies

The following lead to measuring inaccuracies:

- Geometric errors in the machine axes
- Radial eccentricity of the spindle
- A faulty calibration process (e.g. feedrate must be 100%!)
- A faulty or dirty probe sphere
- A dirty surface of the measuring object (e.g. due to chips)
- Temperature fluctuations during the measurement

The obtainable measuring precision that can be obtained is dependent on the following factors:

- Accuracy of the machine
- Measuring precision of the calibrated probe
When measuring workpieces, a measuring instrument similar to a tool is moved to the clamped workpiece. These measuring tasks can take place in two modes:

<table>
<thead>
<tr>
<th>JOG (set-up mode)</th>
<th>AUTOMATIC (in-process measurement)</th>
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<tbody>
<tr>
<td><img src="image" alt="JOG" /></td>
<td><img src="image" alt="AUTO" /></td>
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</table>

- To prepare the machine for processing
- The determination of the position and alignment of a workpiece
- Definition of the zero point position of the workpiece in the machine space
- Quality assurance in the machining process
- For the correction of work offsets
- Correction of thermally influenced changes to the machine
- The creation and provision of measurement reports

Partially automatic measurement, as interactive operation in the set-up mode of the machine

- Fully automatic measurement by calling measuring cycles in the CNC machining program
2.1 Workpiece measurement / Setup in the JOG mode
Overview of the measurement functions

Selecting the desired measurement functions

<table>
<thead>
<tr>
<th>Edge</th>
<th>Align edge</th>
<th>Rectangular corner</th>
<th>1 hole</th>
<th>Rectangular pocket</th>
<th>2 holes</th>
<th>3 holes</th>
<th>4 holes</th>
</tr>
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<tbody>
<tr>
<td><img src="image1" alt="Edge diagram" /></td>
<td><img src="image2" alt="Align edge diagram" /></td>
<td><img src="image3" alt="Rectangular corner diagram" /></td>
<td><img src="image4" alt="1 hole diagram" /></td>
<td><img src="image5" alt="Rectangular pocket diagram" /></td>
<td><img src="image6" alt="2 holes diagram" /></td>
<td><img src="image7" alt="3 holes diagram" /></td>
<td><img src="image8" alt="4 holes diagram" /></td>
</tr>
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</table>

Distance 2 edges | Any corner | 1 circular spigot | Rectangular spigot | 2 circular spigots | 3 circular spigots | 4 circular spigots | Plane
| ![Distance 2 edges diagram](image9) | ![Any corner diagram](image10) | ![1 circular spigot diagram](image11) | ![Rectangular spigot diagram](image12) | ![2 circular spigots diagram](image13) | ![3 circular spigots diagram](image14) | ![4 circular spigots diagram](image15) | ![Plane diagram](image16) |

Measuring variants for **manual measuring instruments**

Measuring variants for **switching probes**
2.1 Workpiece measurement / Setup in JOG mode
Aligning the workpiece on the workpiece edge

Alignment on the workpiece edge

- Saving the axis position in the rotary part of the zero point FRAME.
- The **twisting of the workpiece** is compensated by rotating the coordinates of the workpiece coordinate system.
### Workpiece measurement

<table>
<thead>
<tr>
<th>... with correction of the work offset</th>
<th>... with correction of the tool geometry</th>
<th>... measuring only</th>
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<td>Checking the current clamping situation</td>
<td>Ensuring the adherence to workpiece tolerances</td>
<td>Measurement of workpiece geometries for individual reuse</td>
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<tr>
<td>Correction of the workpiece zero point offset resulting from the manual or automatic feeding of workpieces</td>
<td>Continuous correction of the tool wear or thermal expansions that occur during machining</td>
<td>Display of the workpiece geometry</td>
</tr>
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2.2 Workpiece measurement in AUTOMATIC mode
Overview of the measurement functions

Measuring variants only for **switching probes**

<table>
<thead>
<tr>
<th>3D probe</th>
<th>Mono probe</th>
<th>L probe</th>
<th>Star probe</th>
</tr>
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</table>

**Special tools**

- 710 - 3D-Messtaster
- 711 - Kantentaster
- 712 - Monotaster
- 713 - L-Taster
- 714 - Sterntaster
- 725 - Kalibrierwerkzeug

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SINUMERIK makes a distinction between two kinds of measuring reports:

- **User measuring report** (user-defined formatting of the contents)
- **Standard measuring report** (pre-formatted form for each automatic measuring cycle)

Creating measuring reports

Quality transparency can be achieved using standard reports.
Practical part: SINUMERIK measuring cycles in the application
Summary

User benefits

- Time savings thanks to reduction in setup times
- Increased process reliability due to cycle-driven applications
- Integrated input support in ShopMill and programGUIDE workstep programming
- Realistic display of the measuring process in the SINUMERIK simulation
- Easy creation and output of measuring reports

The multi-faceted application area of the SINUMERIK measuring cycles and measurement functions make it possible to cover nearly all measuring tasks involving milling technology.
Thank you for your attention

Digital Experience and Application Center Erlangen

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