Application – eccentric turning of spindle nuts or other thread-type contours

Axis configuration

The machine should have the following axis configuration:

<table>
<thead>
<tr>
<th>No.</th>
<th>Axis name</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>Radial feed axis (real)</td>
</tr>
<tr>
<td>2</td>
<td>Z</td>
<td>Axial feed axis (real)</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
<td>Stroke axis, radial/parallel to the X axis (simulated)</td>
</tr>
<tr>
<td>4</td>
<td>C_REAL</td>
<td>Spindle 1 (real)</td>
</tr>
<tr>
<td>5</td>
<td>C_SIM</td>
<td>Spindle 2 (simulated)</td>
</tr>
</tbody>
</table>

Coupling structure required

The coupling structure shown here should implement two things:

- The stroke motion required to generate the eccentric contour must be superimposed on the motion of the real X axis.
- The eccentric contour must rotate around the spindle along the Z axis in order to realize the thread pitch.

To generate the eccentric contour, the X axis requires a stroke motion. This stroke motion is obtained from the contour of the thread and must be synchronized with the spindle. The stroke motion is generated using a master value coupling.

The stroke motion is superimposed on the motion of the real feed axis X via a simulated axis V and an electronic gear coupling.
Calculating the stroke table

The stroke table is calculated in the sub-routine COUP_ON from the transfer parameters. The transfer parameters are as follows:

- \_GewSteigung: Thread pitch
- \_GewHoehe: Thread height
- \_VerRadius: Rounding radius

(The contour used is intended for test purposes and is not intended to show a real template)

The eccentric contour is calculated in two steps:

Step 1:
The eccentric contour is described for at least one thread turn using straight lines and radii. This contour can be directly implemented in a table. In fact, it is even possible to calculate a cutting radius offset. The contour is, e.g., saved in Table 1.

The corresponding program section looks like this:

; Contour is stored in table 1
ttabdef(X,Z,1,0)
N105 G01 G40 Z=0                  X=\_GewHoehe  RND=0
N110 G01 G41 Z=0                  X=\_GewHoehe  RND=0
N115 G01 Z=0.125*\_GewSteigung X=\_GewHoehe  RND=\_VerRadius
N120 G01 Z=0.375*\_GewSteigung X=0          RND=\_VerRadius
N125 G01 Z=0.625*\_GewSteigung X=0          RND=\_VerRadius
N130 G01 Z=0.875*\_GewSteigung X=\_GewHoehe  RND=\_VerRadius
N135 G01 Z=1.000*\_GewSteigung X=\_GewHoehe  RND=0
N140 G01 G40 Z=1.000*\_GewSteigung X=\_GewHoehe  RND=0
ttabend

The cutting radius offset must be selected and de-selected in the table. It should be carefully ensured that for the equalization movement, the master value (axis Z) does not make a direction reversal. The tool length offset – that is naturally also taken into account in the table for an active tool - must be then eliminated again in a subsequent 2nd step. The rounding-off radii are also correctly calculated in this contour.

Step 2:
In order that the programmed contour corresponds to a thread revolution, the distance of a thread pitch must be converted into a spindle revolution (single thread). If you wish to generate a double thread, then a thread pitch must be converted to 180° of the spindle.
The corresponding program section looks like this:

N160 ctabdef(V,Z,2,1)
N165  FOR _NUM=0 to 360
; The contour must be corrected by the tool offset
N170     G53 G01 Z=_num
V=ctab(((_num* _GewSteigung/360)+Tool_OffsetZ),1,_dummy)-Tool_OffsetX
N175  ENDFOR
N180 ctabend

Switching the coupling in and out

COUP_ON:
Using the sub-routine COUP_ON.SPF, the stroke table is calculated in the part program and the couplings required are defined and activated. As described above, two couplings are required:

- Master value coupling: The stroke motion is derived – as described above – from the position of a simulated master spindle SP2 and traversed by the simulated axis V.
- ELG coupling 1: The programmed motion of axis X is superimposed on the stroke motion of axis V.
- ELG coupling 2: The rotation of the simulated master spindle SP2 is coupled 1:1 to the rotation of the real spindle SP1. In addition, the motion of the Z axis is taken into consideration in the coupling depending on the thread pitch. The sign of the differential coupling (Z→SP1) is used to make a differentiation between a right-handed and a left-headed thread.

If the feed using the X axis is to be programmed, then the interface signal of the following (slave) axis X must be enabled for the following axis superimposition (DB31.dbx26.4=1).

COUP_OFF:
All ELG and master value couplings are switched out and deleted by the COUP_OFF.SPF program.

Tangential synchronization

From the instant in time where the eccentric function is switched in, the motion of the X axis is superimposed on the stroke motion. If the Z axis is traversed by one spindle pitch, then the stroke cam must be shifted relative to the spindle position. The thread turn has now been machined on the workpiece if the offset is 360° (single thread). The reference point of the offset is always there where the Z axis is located at the instant in time that the gear coupling is switched in.

All couplings use the calculated setpoints of the axis motion and are therefore not subject to delays referred to an IPO clock cycle.