



DOCUMENTATION ISG-kernel

Functional description **Round/profiled tube processing**

Short Description:
FCT-M5

Preface

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<https://www.isg-stuttgart.de/produkte/softwareprodukte/isg-kernel/dokumente-und-downloads>

or (EN)

<https://www.isg-stuttgart.de/en/products/softwareproducts/isg-kernel/documents-and-downloads>

contains further information on messages generated in the NC kernel, online help, PLC libraries, tools, etc. in addition to the current documentation.

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Icons used and their meanings

This documentation uses the following icons next to the safety instruction and the associated text. Please read the (safety) instructions carefully and comply with them at all times.

Icons in explanatory text

➤ Indicates an action.

⇒ Indicates an action statement.



DANGER

Acute danger to life!

If you fail to comply with the safety instruction next to this icon, there is immediate danger to human life and health.



CAUTION

Personal injury and damage to machines!

If you fail to comply with the safety instruction next to this icon, it may result in personal injury or damage to machines.



Attention

Restriction or error

This icon describes restrictions or warns of errors.



Notice

Tips and other notes

This icon indicates information to assist in general understanding or to provide additional information.



Example

General example

Example that clarifies the text.



Programing Example

NC programming example

Programming example (complete NC program or program sequence) of the described function or NC command.



Release Note

Specific version information

Optional or restricted function. The availability of this function depends on the configuration and the scope of the version.

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1 Overview

Task

The functions permit a simplified programming for the surface machining of:

- round tubes,
- polygonal tubes (profiled tubes) and
- open polygonal tubes (L/U profiles)

Depending on the application, the geometry is specified as Cartesian either on the lateral surface projection or as a parallel projection onto the workpiece. Different machining variants are possible here on 3/4-axis or 5/6-axis machines.

Characteristics

The function can only be enabled exclusively for Cartesian and kinematic transformations.

Parametrisation

Specific kinematics with corresponding parameter sets are required for machining variants (see chapter Parameters [► 80]).

Programming

A kinematic transformation is actually selected by specific variants of the #CYL command. In this case, a kinematic is implicitly selected (#KIN ID [..]).



Notice

Transformations are additional options and subject to the purchase of a license.

Mandatory note on references to other documents

For the sake of clarity, links to other documents and parameters are abbreviated, e.g. [PROG] for the Programming Manual or P-AXIS-00001 for an axis parameter.

For technical reasons, these links only function in the Online Help (HTML5, CHM) but not in pdf files since pdfs do not support cross-linking.

2 Description

Classic lateral surface machining

Classic lateral surface machining of cylindrical workpieces typically takes place on machine structures that are designed and conceived for pure turning work. These machines have only 2 translatable tool axes Z, X and one rotary workpiece axis C.

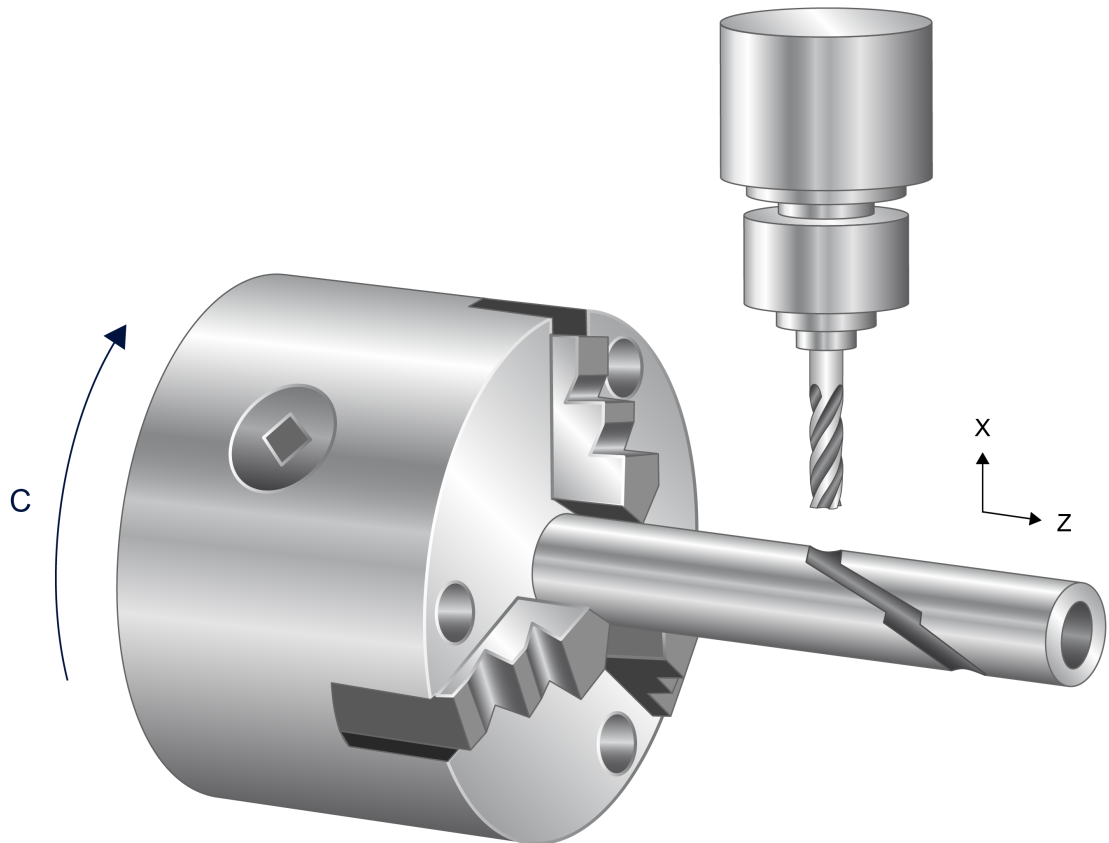


Fig. 1: Round tube lateral surface machining

Rotation-symmetrical workpiece

Besides its use in machining centres, this function is also used on other machine structures with 3 Cartesian axes X, Y, Z. With the aid of an additionally arranged rotary axis, e.g. A, these machines can also be used to machine rotation-symmetrical workpieces.

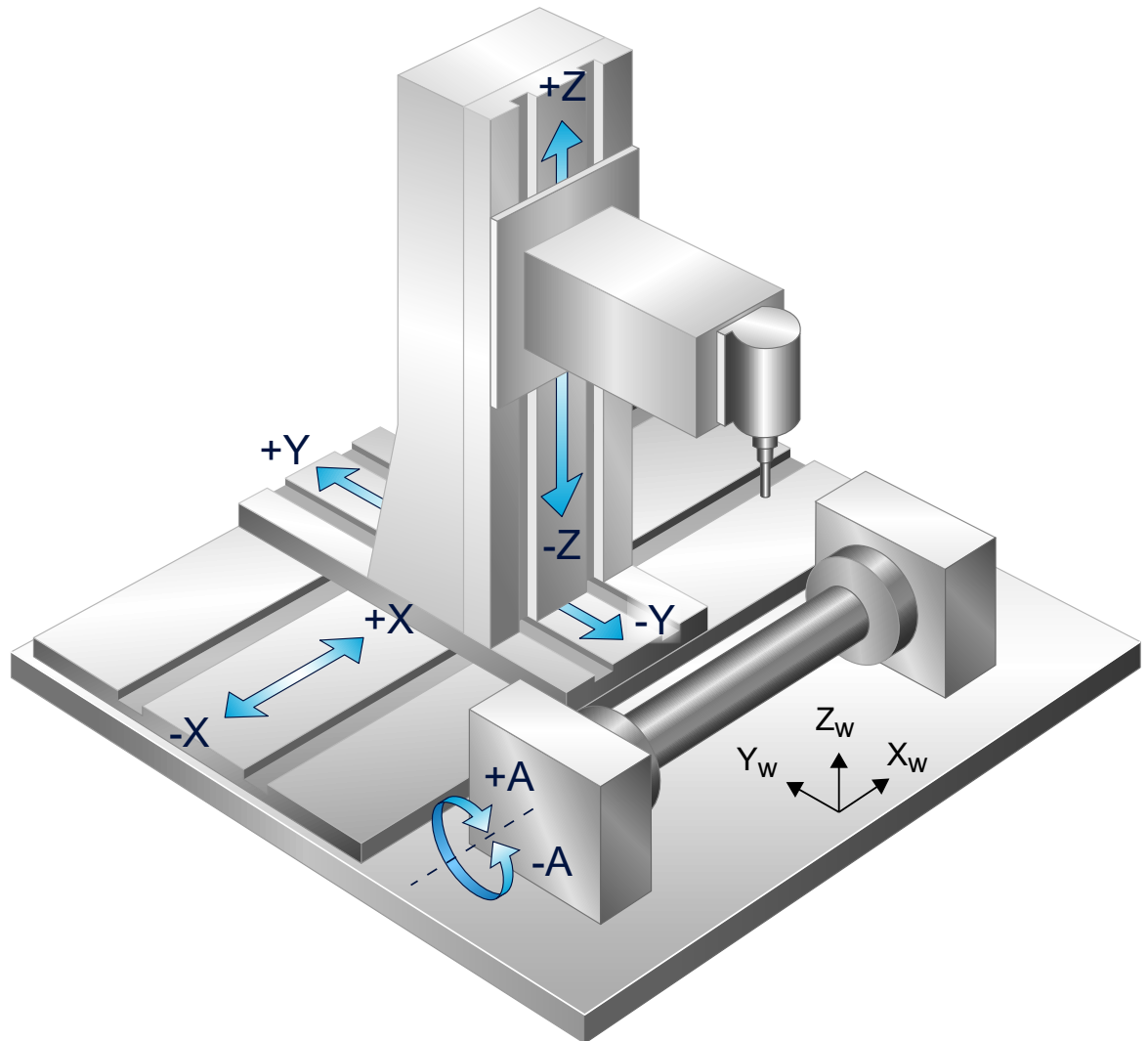


Fig. 2: Tube machining with Cartesian 3-axis machine

Besides round tube machining on the lateral surface, the functions for tube projection and profiled tube machining are described below.

Programming kinematic parameters

The kinematic parameters can be set in the channel parameters (kinematik[*].param[*] or trafo[*].*) or in the NC program by suitable V.G variables.



Release Note

Note on CNC Build up to V2.11.28xx and as of V3.00 and higher

Up to Build 2.11.28xx, parameterising the kinematics was only possible in the NC program. As of V3.00 the associated kinematic ID must be set in the channel parameters in P-CHAN-00262: e.g. trafo[0].id 15

As of Builds V3.00 and higher, the parameter P-CHAN-00262 is required for all subsequent transformations in pipe and profile tube machining operations.

Transformation ID	Description
15	Round tube, lateral surface (3/4-axis) [► 13]
78	Round tube, projection (3/4-axis) [► 18]
79	Polygonal tube, profiled tube (3/4-axis) [► 22]
90	Round tube, lateral surface (5/6-axis) [► 44]
93	Polygonal tube, profiled tube (5/6-axis) [► 74]



Programing Example

Channel parameter

Setting example (for CNC Builds up to V2.11.28xx):

```
...
# Parameterisation takes place in P-CHAN-00094
kinematik[15].param[0] 1230000 # P-CHAN-00094
kinematik[15].param[1] 0      # P-CHAN-00094
kinematik[15].param[2] 0
kinematik[15].param[3] 0
kinematik[15].param[4] 0
kinematik[15].param[5] 0
kinematik[15].param[6] 0
kinematik[15].param[7] 0
kinematik[15].param[8] 0
kinematik[15].param[9] 0
...
```

or

Setting example (for CNC Builds as of V3.00 and higher):

```
...
# Parameterisation takes place in P-CHAN-00262 and P-CHAN-00263
trafo[0].id          15          # P-CHAN-00262
trafo[0].param[0] 1230000 # P-CHAN-00263
trafo[0].param[1] 0      # P-CHAN-00263
trafo[0].param[2] 0
trafo[0].param[3] 0
trafo[0].param[4] 0
trafo[0].param[5] 0
trafo[0].param[6] 0
trafo[0].param[7] 0
trafo[0].param[8] 0
trafo[0].param[9] 0
...
```

NC program

Setting example in the NC program:

```
...
V.G.KIN[15].PARAM[0] = 123000
V.G.KIN[15].PARAM[1] = 0
V.G.KIN[15].PARAM[2] = 0
V.G.KIN[15].PARAM[3] = 0
V.G.KIN[15].PARAM[4] = 0
V.G.KIN[15].PARAM[5] = 0
V.G.KIN[15].PARAM[6] = 0
V.G.KIN[15].PARAM[7] = 0
V.G.KIN[15].PARAM[8] = 0
V.G.KIN[15].PARAM[9] = 0
...
```

3 Machining variants (3/4-axis)

A distinction is made between 4 different machining variants:

- Round tube, lateral surface [▶ 13]
- Round tube, projection [▶ 18]
- Polygonal tube, profiled tube [▶ 22]
- Open polygonal tube / profiled tube (L/U profiles) [▶ 34]

3.1 Round tube, lateral surface

3.1.1 Programming #CYL [..]

The path is programmed in Cartesian coordinates on the lateral surface projection in X and U where U is the rotary axis identifier. When selected, the reference radius R on the cylindrical workpiece must also be programmed.

The tool must be located above the centre of rotation when selected.

If required, PCS (Programming Coordinate System) modulo calculation can be activated by a kinematic parameter (see below Parameter HD10 in section Description [▶ 81]). In this case, the PCS U axis is treated as a rotary modulo axis. After it crosses the modulo limit of the rotary axis, the circumferential position is also corrected.

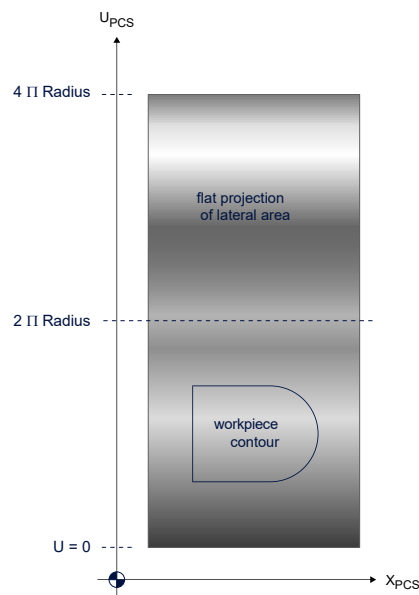


Fig. 3: Path programming on the lateral surface



Notice

In the case of absolute programming, a position on the tube's circumference is always moved to over the shortest distance. The section "Programming modulo axes" in [PROG] must be observed when programming the sign. This must also be taken into account for circular motion blocks (G02, G03) with absolute target point programming.



Notice

The kinematic parameters in ID 15 [► 81] must be set for this machining type.

Syntax to select lateral surface machining with round tube:

Lateral surface machining in G17

An axis configuration Z-C is formed by specifying the first and second main axes with #CYL [...]. This implicitly defines a main plane in G17. The reference radius must also be specified.

Syntax:

#CYL [<1st_main_axis_name>, <2nd main_axis_name>, <3rd_main_axis_name>..]

<1st_main_axis_name> Name of the first main axis according to the current main plane.

<2nd main_axis_name> Name of the second main axis according to the current main plane (virtual linear axis, development).

<3rd_main_axis_name>. Axis name of the third main axis according to the current main plane with specification of the reference radius in [mm, inch].

Syntax to deselect lateral surface machining with round tube

Syntax:

#CYL OFF

modal



Programing Example

#CYL [..]

```
(* Example with axis identifier U for 2nd main axis *)
N05 G00 Y0                      (tool over centre of rotation)
N10 G01 X60 U45 F5000
N20 #CYL [X, U, Z60]          (Select lateral surface, radius 60 mm)
N30 G00 G90 X0 U0              (X: 0mm U:0mm!)
N40 G01 U100 F500
N50 G02 X100 R50
N60 G01 U0
N70 Z0
N80 #CYL OFF
```

3.1.2 Axis configuration

The following axis configuration must be set in the NC channel.

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, U	
Axis index	0, 1, 2, 3	
Kinematic structure (ID 15)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z	U

Axis structure

The Z tool axis must intersect with the rotary axis U, i.e. the tool axis lies at the tube centre point. To achieve this, place the Y axis in the correct position before selecting the transformation.

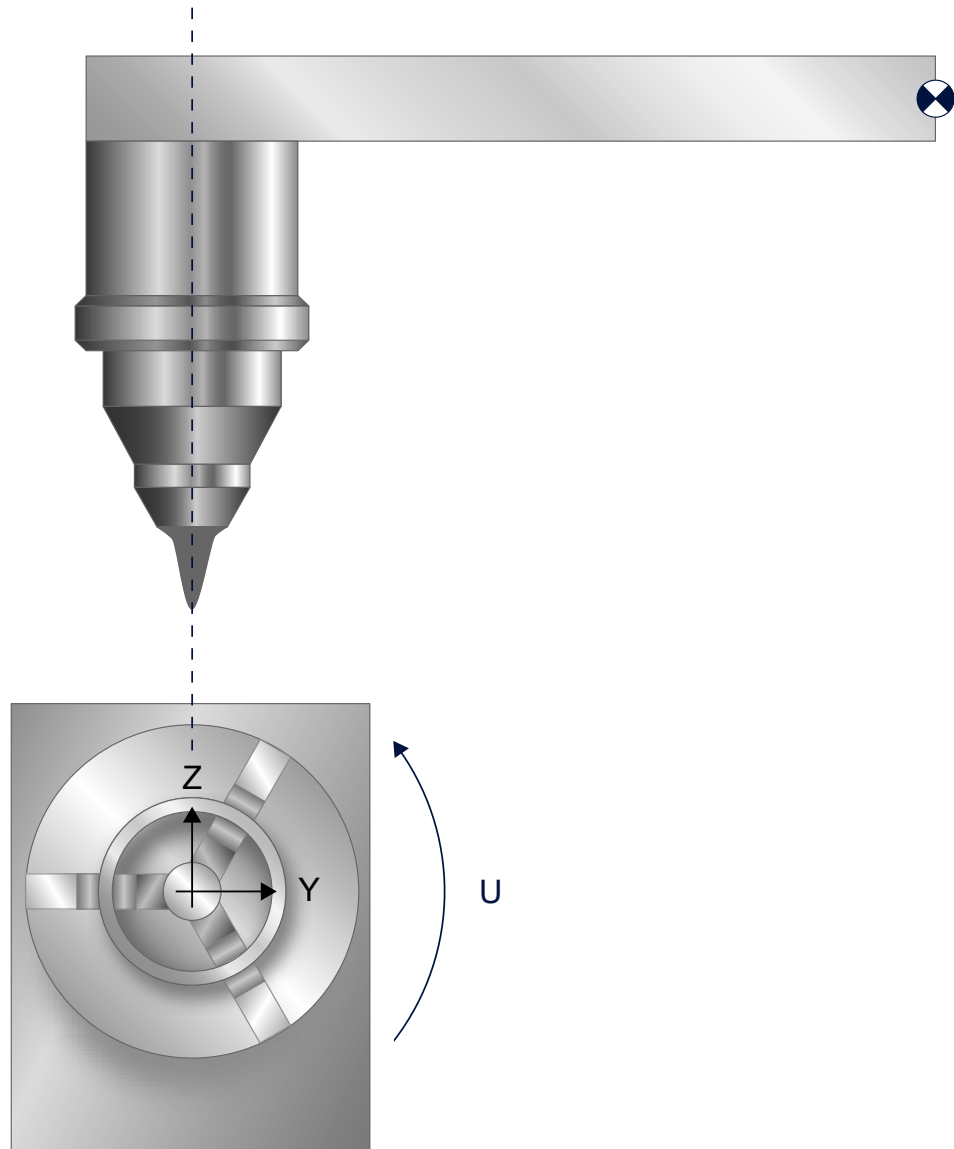


Fig. 4: Axis structure

Parameterisation: Round tube, lateral surface (kinematic ID 15) [► 81]

3.1.3

Path example



Programing Example

Lateral surface transformation

```

;Lateral surface transformation

N30 #SLOPE [TYPE=STEP]
N40 G00 X0 Y0 Z100 U0

N50 #CYL [X, U, Z35] ;Select lateral surface machining

N70 G01 G90 X0 U0 F5000
N80 G01 Z10 G90 F50000
N110 $FOR P2=1, 5, 1
N120   P3=P2*4
N130   P4=P3+2
N140   G01 G91 U-P3
N150           XP3
N160           U[2*P3]
N170           X-P3
N180 G90 U0
N190 G91 XP4
N190 $ENDFOR
N200 $FOR P2=1, 5, 1
N210   P3=P2*4
N220   P4=P3*2+2
N230   G90 G02 IP3
N240           G91 G01 XP4
N250 $ENDFOR

N290 #CYL OFF ;Deselect lateral surface machining
M30

```

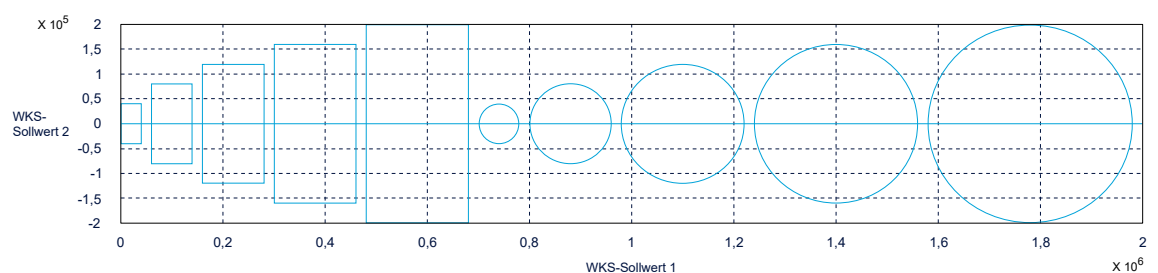


Fig. 5: X-U contour line projection

3.2

Round tube, projection

With projected round tube machining, the programmed X/Y path is mapped by parallel projection onto the lateral surface of a tube. The distance from the tube (Z height) is kept constant by transformation on the curved tube. If the distance is changed, a Z height change can be additionally programmed.

Machining is possible up to a programmable radius limit. This value is always less than the tube radius. Machining is aborted if a position outside this limit is programmed. This results in an error message.

Before selecting the transformation, the tube must be positioned so that the Y axis is within the set limit 'LIMIT' (see NC command #CYL [...]).

The specified feed rate refers to the original path programmed. Especially in the edge zone of the tube, the real feed rate of the tool in the round tube is higher.

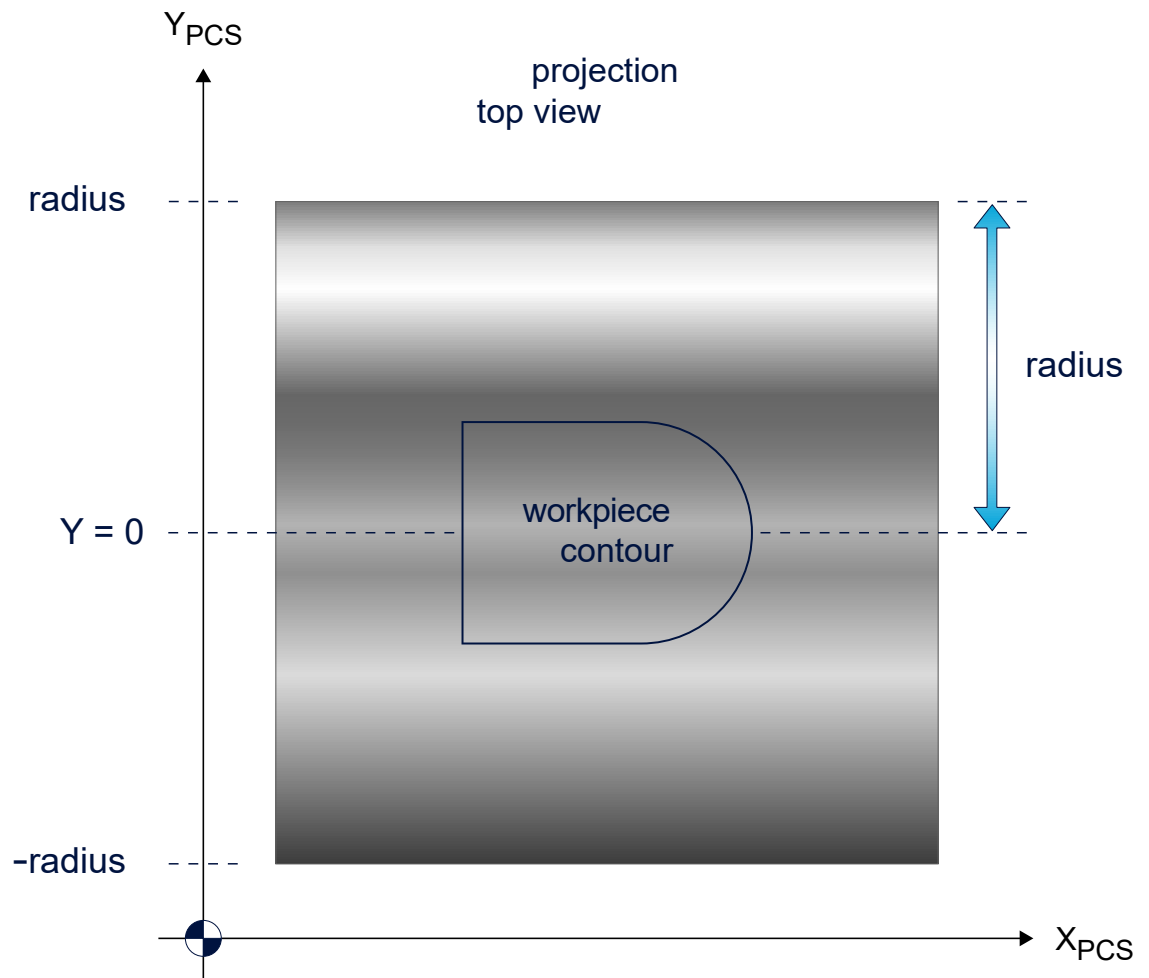


Fig. 6: Programming with path projection

3.2.1 Programming #CYL [RADIUS..]



Notice

The kinematic parameters in ID 78 [► 83] must be set for this machining type.

Syntax to select round tube projection:

Syntax:

#CYL [RADIUS=.. [LIMIT=..]]

modal

RADIUS=.. Radius of the round tube or of the lateral surface to be machined, [mm, inch]

LIMIT=.. Machining limit, symmetrically relative to the tube centre. [mm, inch]
If no limit is explicitly specified, $LIMIT = 0.25 \cdot RADIUS$ applies.

Syntax to deselect round tube projection:

Syntax:

#CYL OFF

modal



Programing Example

#CYL [RADIUS..]

```

N10 X0 Y-1000 Z100 U0
N20 # CYL [RADIUS=35 LIMIT=31] ;Select tube projection
N30 G01 G90 X0 Y0 F5000
N40 G01 Z10
N50 $FOR P1=1, 4, 1
N60 G00 G90 X0 Y0 U[P1*90]
N70 $FOR P2=1, 5, 1
N80 P3=P2*4
N90 P4=P3+2
N100 G01 G91 Y-P3
N110 XP3
N120 Y[2*P3]
N130 X-P3
N140 G90 Y0
N150 G91 XP4
N160 $ENDFOR
N170 $FOR P2=1, 5, 1
N180 P3=P2*4
N190 P4=P3*2+2
N200 G90 G02 IP3
N210 G91 G01 XP4
N220 $ENDFOR
N230 $ENDFOR
N240 #CYL OFF ;Deselect tube projection

```

3.2.2 Axis configuration

The kinematic structure consists of three translatory axes in the tool. The rotary workpiece axis is not changed by the transformation.

The following axis configuration must be set in the NC channel.

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, U	
Axis index	0, 1, 2, 3	
Kinematic structure (ID 78)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z	U

Axis structure

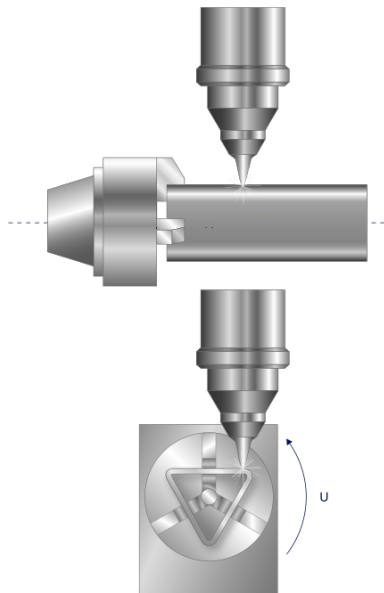


Fig. 7: Axis structure

Parameterisation: Round tube, projection (kinematic ID 78) [► 83]

3.2.3

Path example



Programing Example

Tube projection

```
(* Tube projection *)

#SLOPE [TYPE=STEP]
X0 Y-1000 Z100 U0

N50 #CYL [RADIUS=35 LIMIT=31]  (* Selecting tube projection*)

N70 G01 G90 X0 Y0 F5000
N80 G01 Z10 G90 F50000
N90 $FOR P1=1, 4, 1
N100 G00 G90 X0 Y0 U[P1*90]
N110 $FOR P2=1, 5, 1
N120   P3=P2*4
N130   P4=P3+2
N140   G01 G91 Y-P3
N150           XP3
N160           Y[2*P3]
N170           X-P3
N180 G90 Y0
N190 G91 XP4
N190 $ENDFOR
N200 $FOR P2=1, 5, 1
N210   P3=P2*4
N220   P4=P3*2+2
N230   G90 G02 IP3
N240           G91 G01 XP4
N250 $ENDFOR
N260 $ENDFOR

N290 #CYL OFF
M30
```

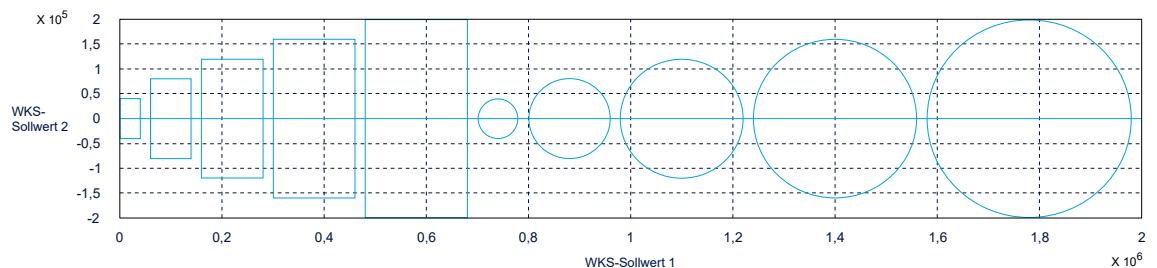


Fig. 8: X-Y contour line projection

3.3 Polygonal tube, profiled tube

This function places the programmed contour onto the projected lateral surface of a profiled tube.

The controller guides the workpiece during machining (Y deflection) so that the tool is always perpendicular to the workpiece surface. The distance from the workpiece (Z height) is kept constant without Z programming. A Z height can also be programmed. The programming coordinates of U, X and Z height of the TCP (Tool Centre Point) refers to the lateral surface.

With lateral surface machining, the path feed rate for round tubes refers to the programmed projected path.

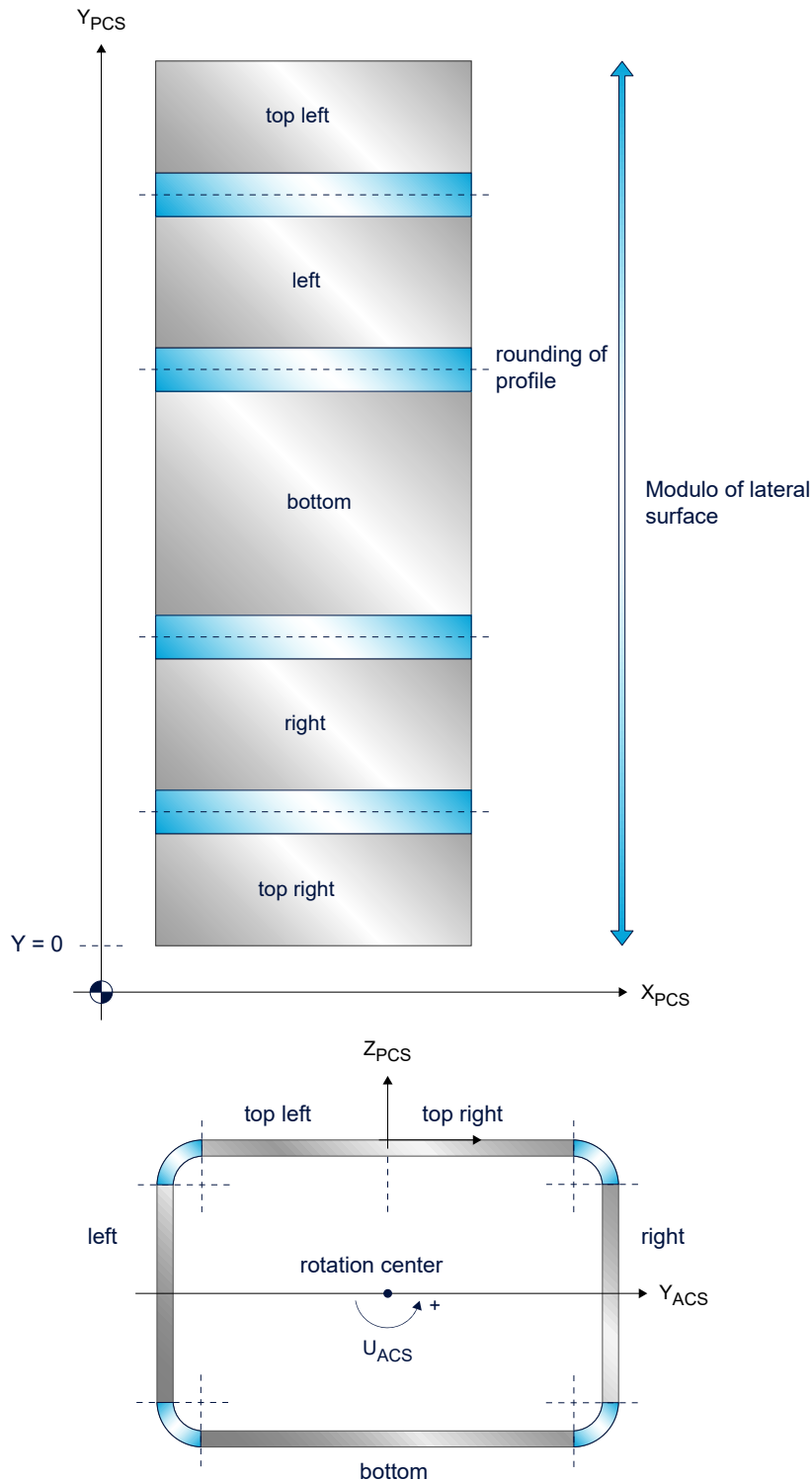


Fig. 9: Programming on the lateral surface

3.3.1 Programming #CYL [EDGES..]



Notice

The kinematic parameters in ID 79 [► 85] must be set for this machining type.

Syntax to select profiled tube machining:

Syntax:

#CYL [EDGES=.. ROUNDING=.. LENGTH1=.. [LENGTH2=..] modal
[VEL=..] [ACC=..]

EDGES=..	Number of edges (corners) of the profiled tube, positive integer The minimum number of corners on the profile is limited to 3 and the maximum number to 16.
ROUNDING=..	Edge rounding radius (corner radius), [mm, inch].
LENGTH1=..	Side length for symmetrical tubes or first side length for rectangular tubes, [mm, inch]
LENGTH2=..	Second side length for rectangular tubes, [mm, inch]
VEL=..	Path velocity on edge rounding [mm/min]
ACC=..	Path acceleration on edge rounding [mm/min ²]

Syntax to deselect profiled tube machining:

Syntax:

#CYL OFF modal



Programing Example

#CYL [EDGES..]

```
(Symmetrical square profile with 100 mm edge length)
(and 10 mm edge rounding radius)
N10 #CYL [EDGES=4 ROUNDING=10 LENGTH1=100]
...
(Asymmetrical square profile with edge lengths of 100 mm)
(and 80 mm and 15 mm edge rounding radius)
N10 #CYL [EDGES=4 ROUNDING=15 LENGTH1=100 LENGTH2=80]
...
(Reduced path dynamics on the profile rounding)
N10 #CYL [EDGES=4 ROUNDING=5 LENGTH1=50 LENGTH2=50
          ACC=1000000]
```



Attention

With relative programming, the number of profile rotations is limited for each block due to resources. An error message is generated if the maximum number is exceeded.



Programing Example

Tube profile machining

```
(* Tube profile machining *)
%main
N10 #SLOPE [TYPE=STEP]
N20 G90 X0 Y0 Z100 U0
N30 U0 X0
N40 #CYL[EDGES=4 ROUNDING=5 LENGTH1=20 LENGTH2=20]
N50 G01 G91 X10 F5000
N60 U50
N70 G03 U-100 I300 J-50
N80 #CYL OFF
N90 M30
```

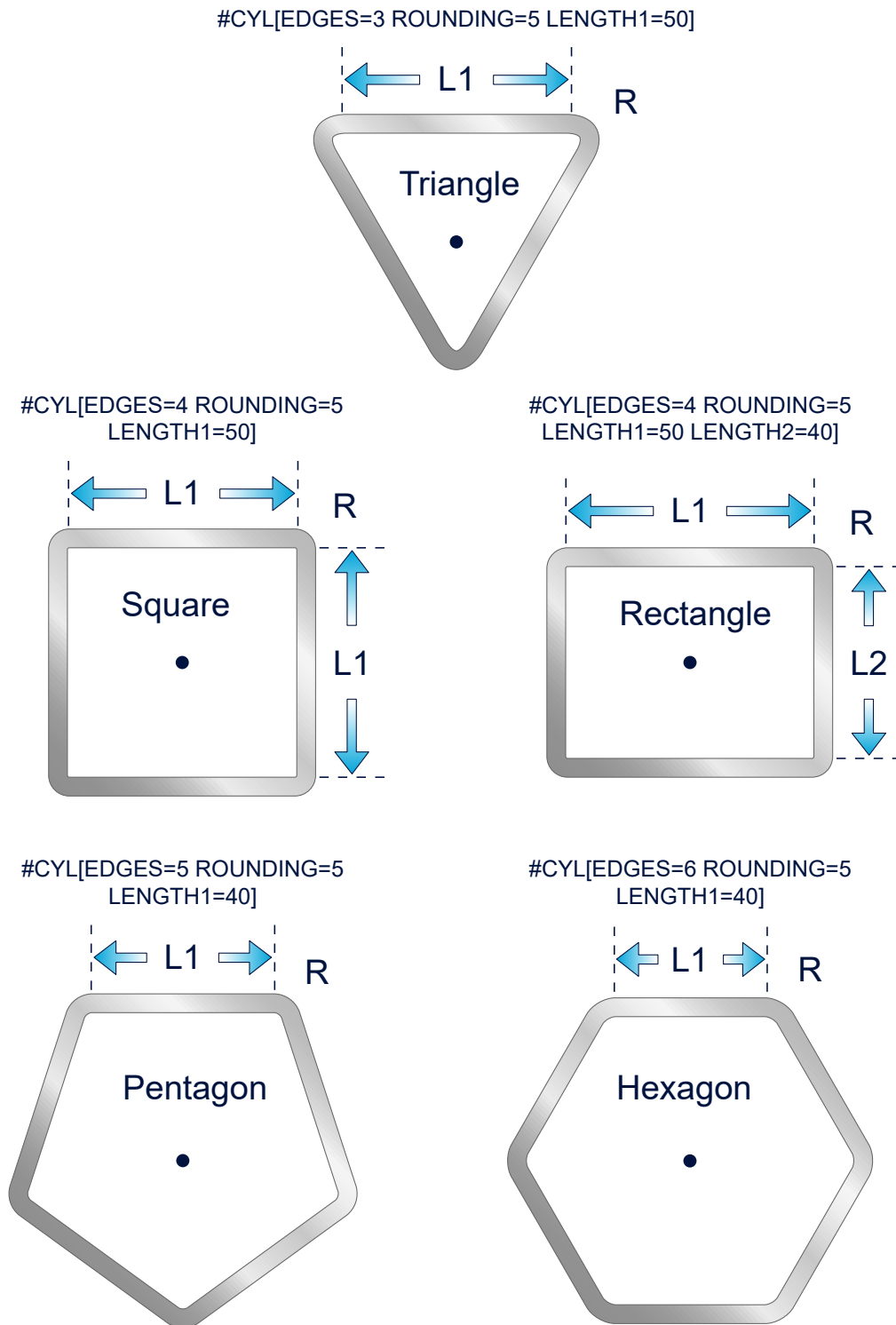


Fig. 10: Parameterisation examples for profiled tubes

Rectangular profile

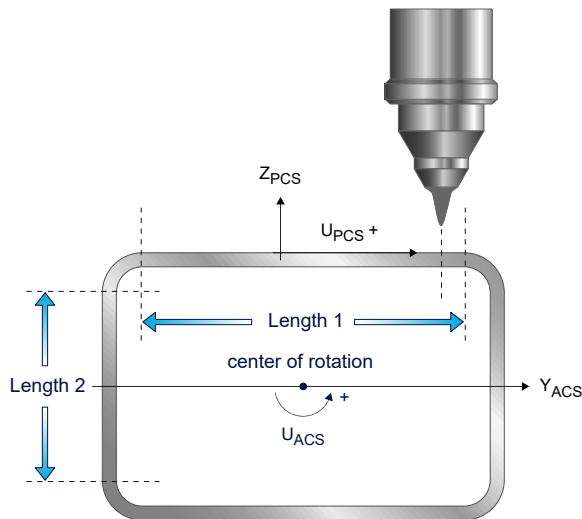


Fig. 11: Lateral surface coordinate system with rectangular profile

Activation condition

Default case: Selecting on plane surface

The transformation is selected when the workpiece is aligned flat. The angle of the U axis then displayed with horizontal workpiece alignment is set by means of a U offset (kinematic parameters).

When #CYL[...] is selected, the Y axis position of the tool is located within the plane surface of the workpiece (side length LENGTH1), otherwise an error message is output.

Special case: Selection on profile rounding

A U angle offset may possibly have to be set in the same way as described before.

The transformation should be selected on the profile rounding. This variant can be used when machining was stopped with active transformation on the profile rounding or a profile rounding position was approached using #PTP ON. The CNC checks whether selection is possible with the current active U and Y axis positions. An error message is generated if an axis position are invalid.



Notice

With G90 absolute programming, positioning on the circumference is always based on the "shortest path" without specifying the direction of rotation.

Please note the section "Programming modulo axes" in [PROG] when programming the sign for the direction of rotation.

This must also be taken into account for circular motion blocks (G02, G03) with absolute target point programming.

3.3.2 Axis configuration

The kinematic structure consists of 3 translatory axes in the tool and one rotary axis in the workpiece.

The following axis configuration must be set in the NC channel.

Axis configuration in the NC channel		
Axis identifier	X,Y, Z, U	
Axis index	0, 1, 2, 3	
Kinematic structure (ID 79)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z	U

Axis structure

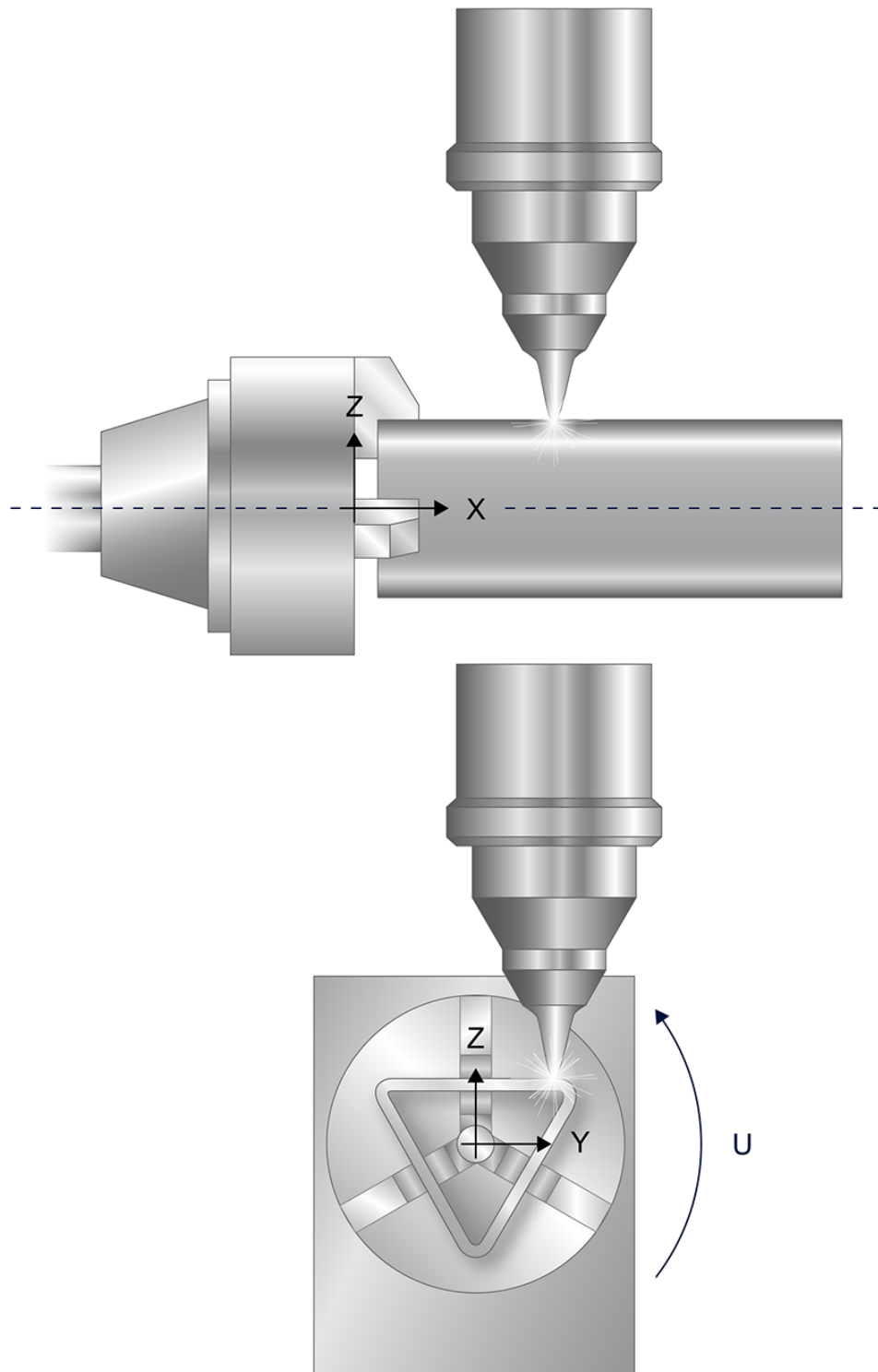


Fig. 12: Axis structure

Parameterisation: Polygonal tube, profiled tube (kinematic ID 79) [► 85]

3.3.3 Profile rounding, technology and dynamics during feed motion

Machining on profile roundings

In comparison to straight sections, there may be deviations in material characteristics (e.g. wall thickness) in the area of the profile roundings. When the limits to the profile roundings are crossed, this can be signalled by M/H functions. As a result, the process can be influenced by the PLC. The M/H functions are always of the MOS type (M functions without synchronisation).

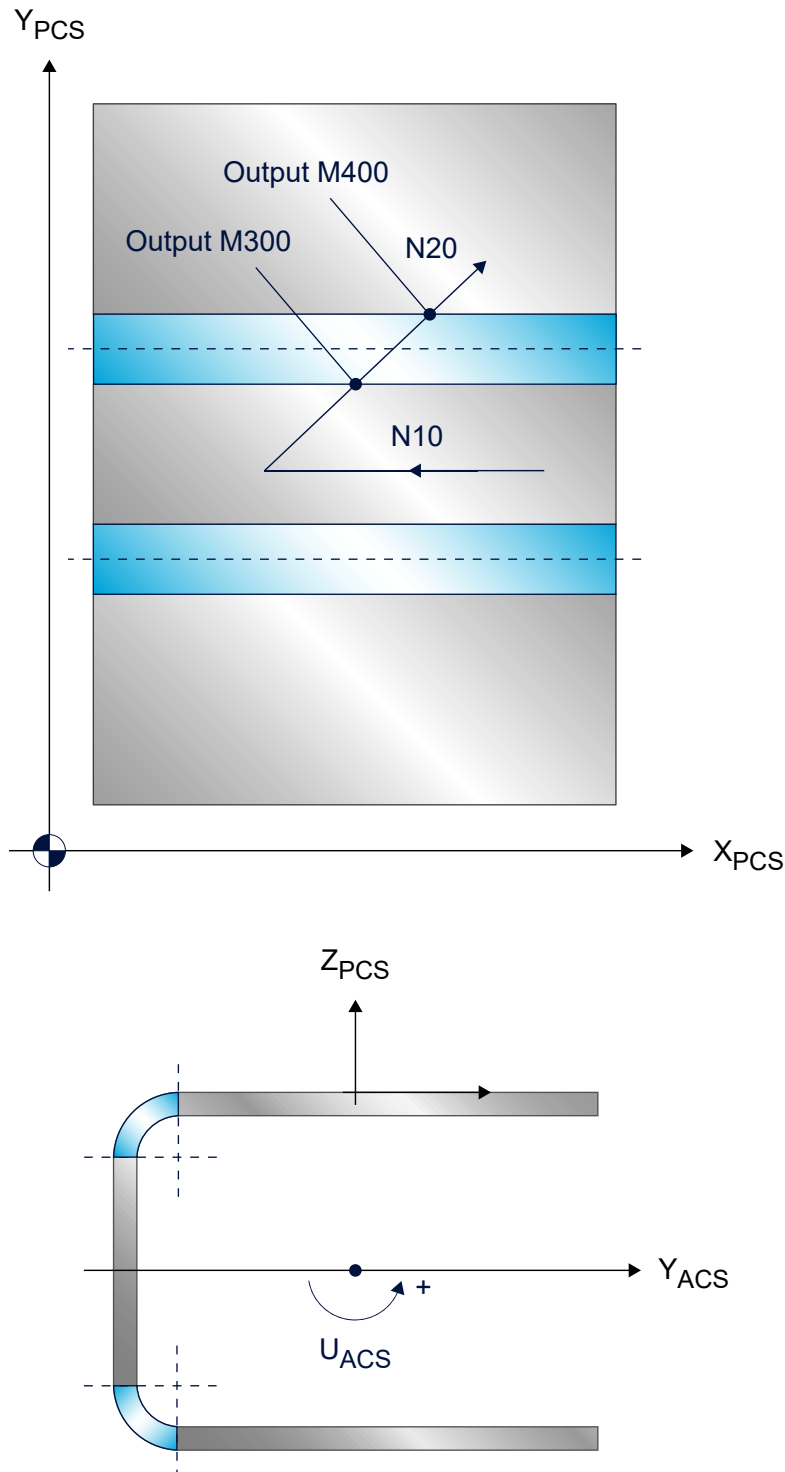


Fig. 13: Output of a technology function at a profile rounding

Dynamics in the profile rounding

At the transition points of the profile roundings, the CNC may possibly reduce the feed rate due to the acceleration of other axes depending on the parameterised axis dynamics of the participating axes.

The dynamics on the profile rounding can be influenced by parameters in the NC command `#CYL[...]`. In addition to the normal path velocity and acceleration limit (cf. `#VECTOR LIMIT[ VEL ACC]`), the values from the `#CYL[...]` command are also considered in the profile rounding.



Programing Example

Machining on profile roundings

```
#CYL[EDGES=4 ROUNING=5 LENGTH1=50 LENGTH2=50
      ACC=500000 VEL=1000]
```

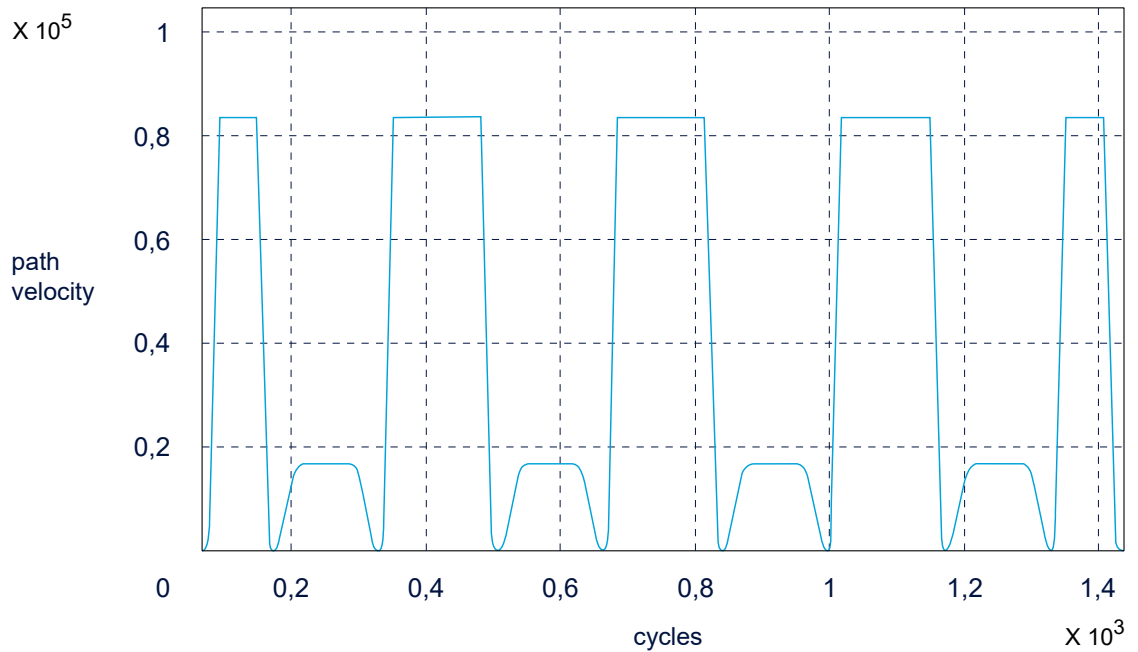


Fig. 14: Path dynamics adjustment on profile rounding

3.3.4

Path example



Programing Example

Polygonal tube transformation

```
(* Polygonal tube transformation *)

%L SUB_CONT
N[10+P30] G00 G90 X0 Z100 U0
N[20+P30] G162
P1=5    (* Radius inner circle *)
P2=25   (* Radius outer circle *)
P3=22.5
P4=2*P3
$FOR P10=0, 8 , 1
    P6=P10*P4
    P7=SIN[P6]
    P8=COS[P6]
N[40+P10] G01 X[P2*P8] U[P2*P7] F5000
    P20=SIN[P3 + P6]
    P21=COS[P3 + P6]
N[50+P10] G01 X[P1*P21] U[P1*P20] F5000
$ENDFOR
M29
%t_tube_prof.nc
N10 #SLOPE [TYPE=STEP]
N20 G00 X0 Y0 Z100 U0

N70 #CYL[EDGES=4 ROUNDING=5 LENGTH1=20 LENGTH2=20]
(* Profile circumference approx. 111.41592653589793 mm *)

P30=2000
N35 G92 X30 U30
N40 LL SUB_CONT
N45 G92 X-30 U30
N50 LL SUB_CONT
N60 G92 X30 U-[-30]
N70 LL SUB_CONT
N80 G92 X-30 U-[-30]
N90 LL SUB_CONT
N100 G92 X0 U0

N110 #CYL OFF
M30
```

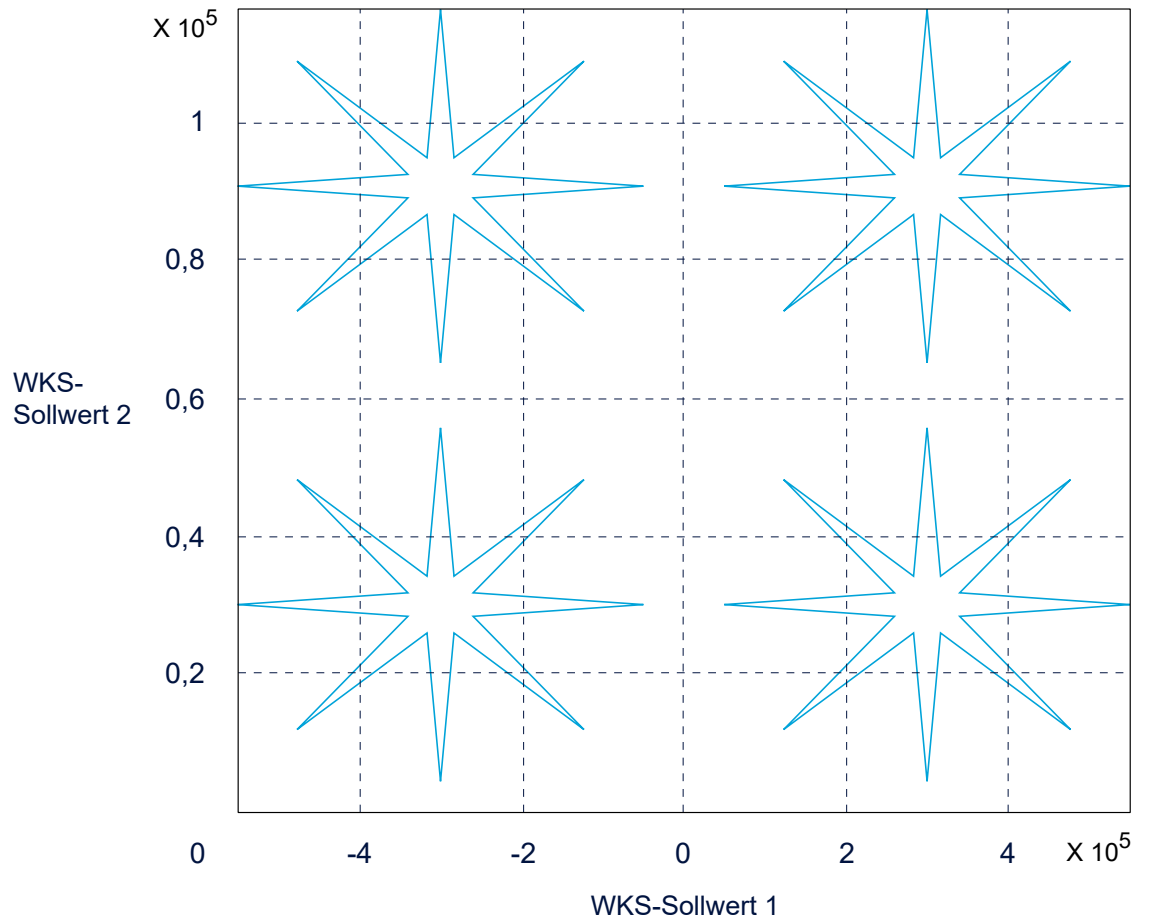



Fig. 15: X-U contour line projection

3.4 Open polygonal tube / profiled tube (L/U profiles)



Release Note

This function is available as of CNC Build

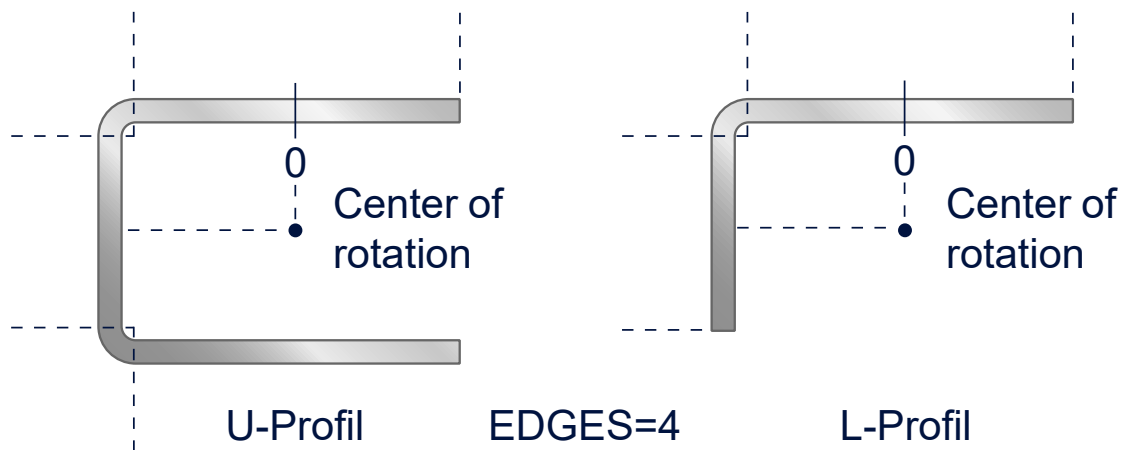
V2.11.2807.01 .

Characteristics

An extension of the definition permits the machining of **non-closed** profiles. An open profiled tube (L/U tube) is detected as a limited lateral surface.

There is no limitation of the path motion or modulo calculation of the PCS coordinate when "virtual edges" are crossed. For this reason, the coordinate system on a lateral surface is linear (see also linear coordinate system for round tube machining). Starting from the zero point, the lateral surface is divided into a positive and a negative direction.

Programming is always related to the closed edges of the tube profile. This means that it is possible to cross virtual edges when profile transformation is active but there is no rotation of the workpiece or Z height adjustment.



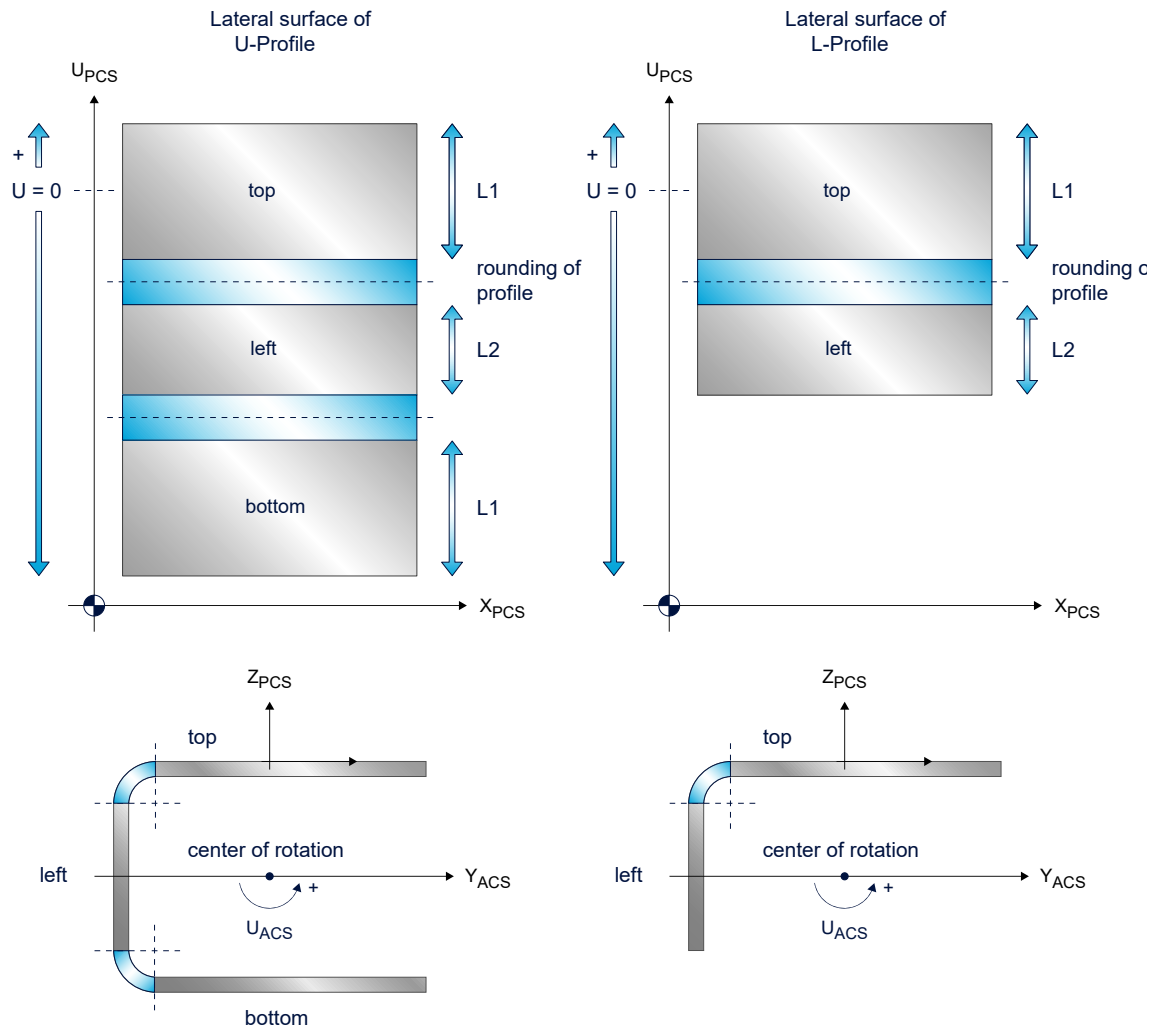


Fig. 16: Examples of open profiles, U and L profile

Clamping examples of open rectangular profiles:

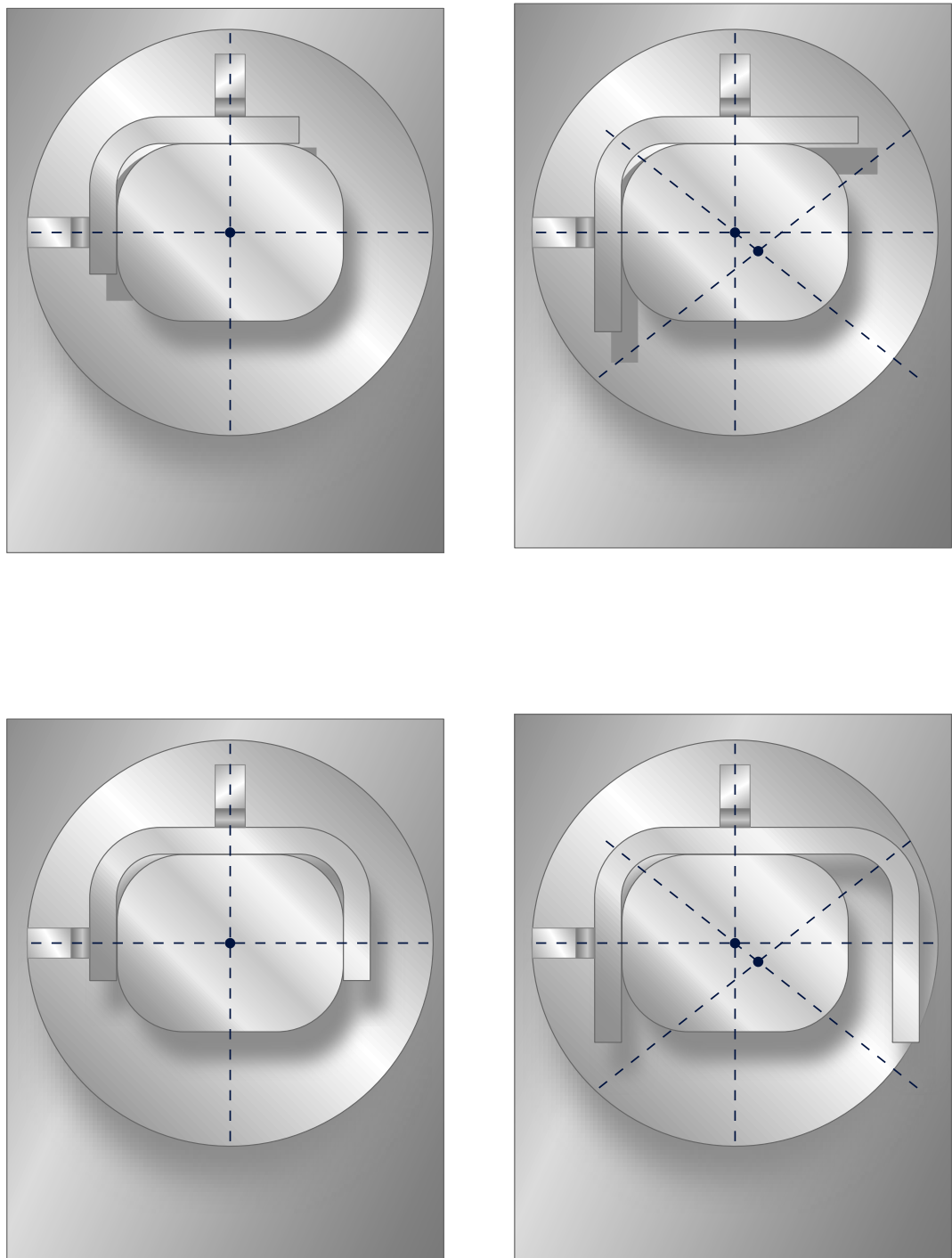


Fig. 17: Clamping examples

3.4.1 Programming #CYL [EDGES.. OPEN..]

Open edges

This extension permits the user to define 2 edges between which the profile is opened.

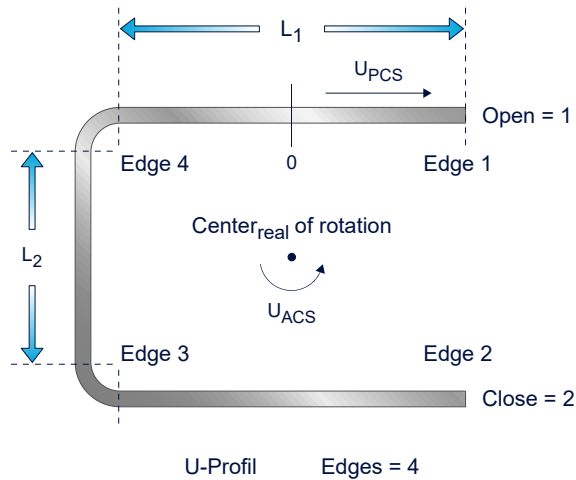


Fig. 18: Defining an open U profile specifying the open edges



Notice

The kinematic parameters in ID 79 [► 85] must be set for this machining type.

Syntax to select open profiled tube machining:

Syntax:

#CYL [EDGES=.. ROUNDING=.. LENGTH1=.. [LENGTH2=..]
[OPEN=.. CLOSE=..]]

modal

EDGES=..	Number of edges (corners) of the closed profiled tube, positive integer. The number of profile edges is limited to minimum 3 and maximum 16.
ROUNDING=..	Edge rounding radius (corner radius), [mm, inch].
LENGTH1=..	Side length for symmetrical tubes or first side length for rectangular tubes, [mm, inch]
LENGTH2=..	Second side length for rectangular tubes, [mm, inch]
OPEN=..	Number of the edge [1; <EDGES>] where the workpiece is open. Ascending number in lateral surface projection (positive U_{PCS} direction).
CLOSE=..	Number of the edge [1; <EDGES>] where the workpiece closes again (positive U_{PCS} direction).

Syntax to deselect open profiled tube machining:

Syntax:

#CYL OFF

modal



Programming Example

Programming #CYL [EDGES.. OPEN..]

```
...  
N3 U0 X0  
N4 #CYL [EDGES=4 ROUNDING=5 LENGTH1=60 LENGTH2=45 OPEN=1 CLOSE=2]  
N5 G01 G91 X10 F5000
```



Notice

To determine the edge numbers for 'OPEN' and 'CLOSE', start with '1 PCS' in the positive PCS direction (clockwise, CW) from 'OPEN' to 'CLOSE' across the profile. This ensures that all profiled parts between 'OPEN' and 'CLOSE' are in the open range.

OPEN=1 / CLOSE=2: -> U open right

OPEN=3 / CLOSE=4 -> U open left

OPEN=1 / CLOSE=3: -> L open right

OPEN=2 / CLOSE=4: -> L open right



Attention

It is only possible to select profile machining if a closed profile edge is orientated towards the tool when the rotating axis is in zero position.

For example the following command is not permitted:

#CYL [EDGES=4 ROUNDING=5 LENGTH1=60 OPEN=4 CLOSE=1]

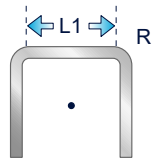


Notice

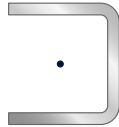
If it is necessary to cross an open profile edge to the adjacent surface (e.g. if the path to the new target position is shorter), deselect the profile transformation (#CYL OFF) or possibly retract the tool, reposition the rotating axis and repeat selection of the profile transformation with #CYL [EDGES...].

Examples of open profiles

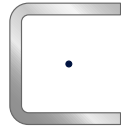
#CYL[EDGES=4 ROUNDING=5 LENGTH1=50]



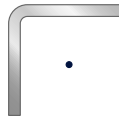
OPEN=2 CLOSE=3



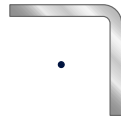
OPEN=3 CLOSE=4



OPEN=1 CLOSE=2

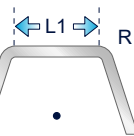


OPEN=1 CLOSE=3

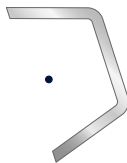


OPEN=2 CLOSE=4

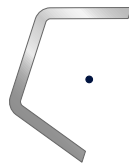
#CYL[EDGES=5 ROUNDING=5 LENGTH1=40]



OPEN=2 CLOSE=4



OPEN=3 CLOSE=5



OPEN=1 CLOSE=3



OPEN=2 CLOSE=5



OPEN=1 CLOSE=4

Fig. 19: Examples of programming parameters for open profiles



Programing Example

Profile transformation of square profile

```
(* Polygonal tube transformation, square tube, segmentation at circum-
ference, *)
(* Absolute programming *)
(* Open profile *)

%L SUB_CONT
N[10+P30] G00 G90 X0 Z100 U0
N[20+P30] G162
P1=20  (* inner circle radius      *)
P2=50  (* outer circle radius      *)
P3=22.5
P4=2*P3
G261
$FOR P10=0, 8 , 1
    P6=P10*P4
    P7=SIN[P6]
    P8=COS[P6]
N[40+P10] G01 X[P2*P8] U[P2*P7] F5000
    P20=SIN[P3 + P6]
    P21=COS[P3 + P6]
N[50+P10] G01 X[P1*P21] U[P1*P20] F5000
$ENDFOR
G260
M29

%prof_open_close.nc
N10 #SLOPE [TYPE=STEP]
N20 G00 X0 Y0 Z100 U0
N25 #CONTOUR MODE[DEV PATH_DEV 2]
N65 G00 G90 Y0 U0
N70 #CYL[EDGES=4 ROUNDING=5 LENGTH1=20 LENGTH2=20 OPEN=2 CLOSE=3]
P30=2000
N80 LL SUB_CONT
N90 #CYL OFF
M30
```

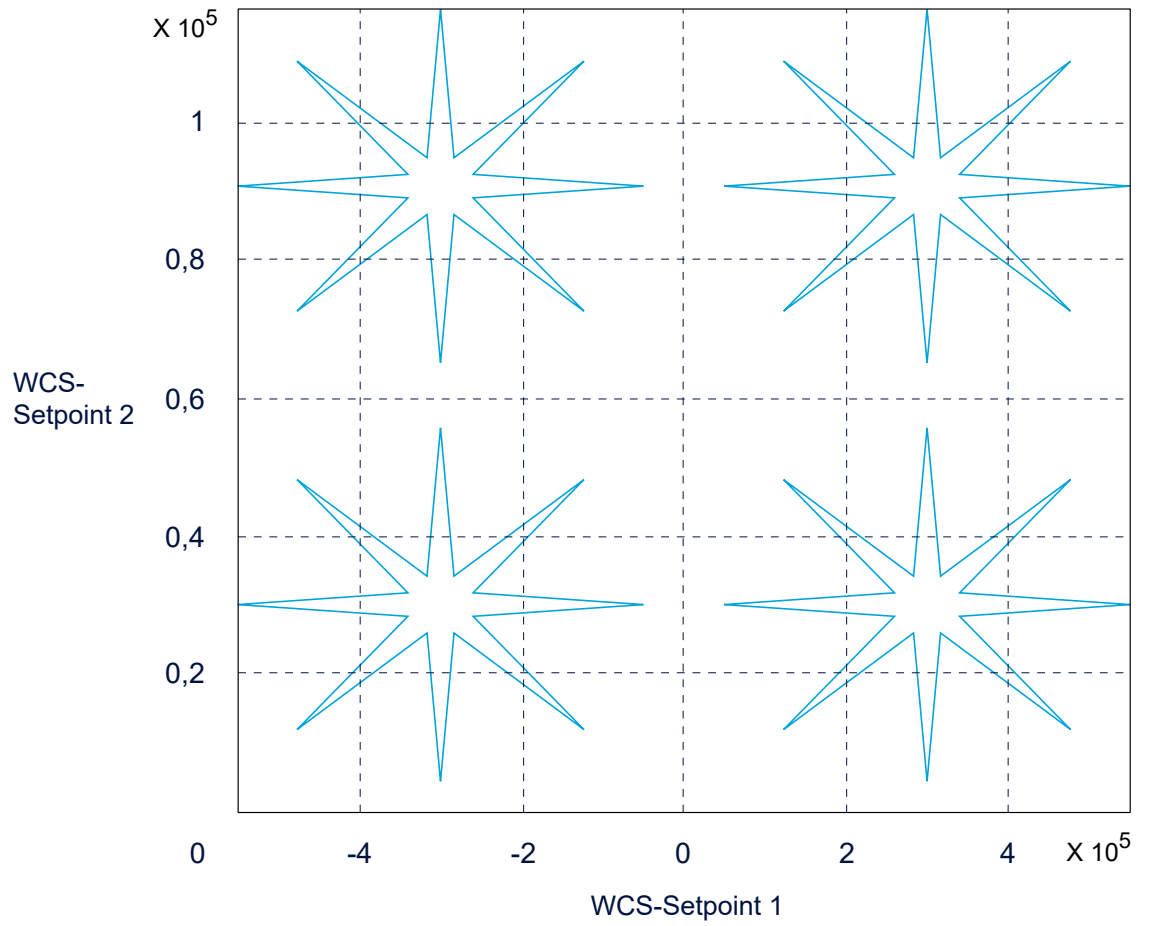



Fig. 20: X-U flat projection of geometry

3.4.2 Eccentric rotation centre point

Open edges

When the workpiece is not clamped centrally, it results in an offset between the workpiece centre point and the rotation centre. This offset can be additionally specified when it is selected.

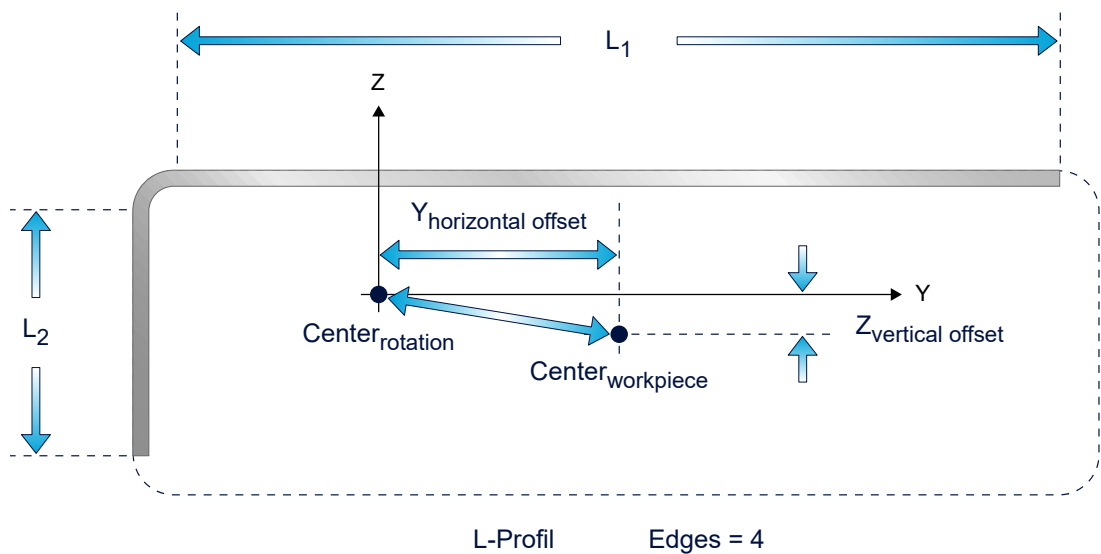
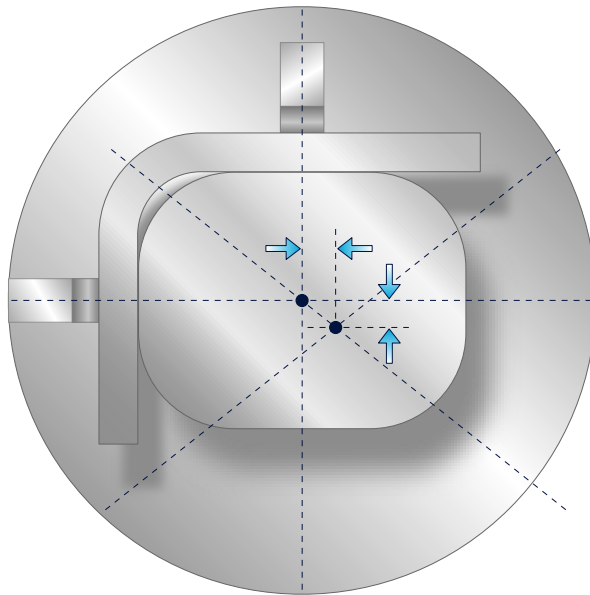


Fig. 21: Defining an open L profile with rotation centre point offset

Syntax to select open profiled tube machining with offset of rotation centre point:

```
#CYL [ EDGES=.. ... CLOSE=.. [ HOR_OFFSET=.. VERT_OFFSET=.. ] ]
```

EDGES=.. ... Syntax of profile description

CLOSE=..

HOR_OFFSET=.. Offset of the workpiece centre point in horizontal direction (Y here) towards the actual rotation centre point in [mm, inch].

VERT_OFFSET=.. Offset of the workpiece centre point in vertical direction (Y here) towards the actual rotation centre point in [mm, inch].

3.4.3 Axis configuration

The kinematic structure consists of 3 translatory axes in the tool and one rotary axis in the workpiece.

The following axis configuration must be set in the NC channel.

Axis configuration in the NC channel		
Axis identifier	X,Y, Z, U	
Axis index	0, 1, 2, 3	
Kinematic structure (ID 79)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z	U

Parameterisation: Polygonal tube, profiled tube (kinematic ID 79) [► 85]

4 Machining variants (5/6-axis)

A distinction is made between 2 different machining variants:

- Round tube, lateral surface [► 44]
- Polygonal tube, profiled tube [► 74]

4.1 Round tube, lateral surface

4.1.1 6-axis, 2 orientation axes in the tool head available



Release Note

This function is available as of CNC Build
V2.11.2019.00.

Combined machining of plate/round tube

The kinematics here consist of 6 axes and are intended for use on machine tools which have an optional tube axis in addition to the 5 axes of a classic plate machining machine.

The machining orientation is defined by the 2 rotation axes in the tool. To machine the tube, the TCP (tool centre point) and the X/Y axis remain positioned above the tube rotation axis. The X/Y position of the TCP remains at the top point of the tube during machining. The contour is programmed on the lateral surface by the axes U, Y and X, V. Orientation is programmed dependent on the axis structure present in the tool head:

- With the structure with machine angle A-B or B-A directly with the assigned angle values, or with the virtual angles C and A.
- With the head structure CA, CB, the programmings takes place directly using the angle values CA, CB. In these cases (virtual or real C axis) the bevel angle can be kept constant to the contour using the function "tangential tracking".

Set one of the following 6-axis configurations. Depending on the machine configuration, the tube axis lies parallel to the X or Y machine axis. This is controlled by the command **#CYL ORI LAT-ERAL[.].**

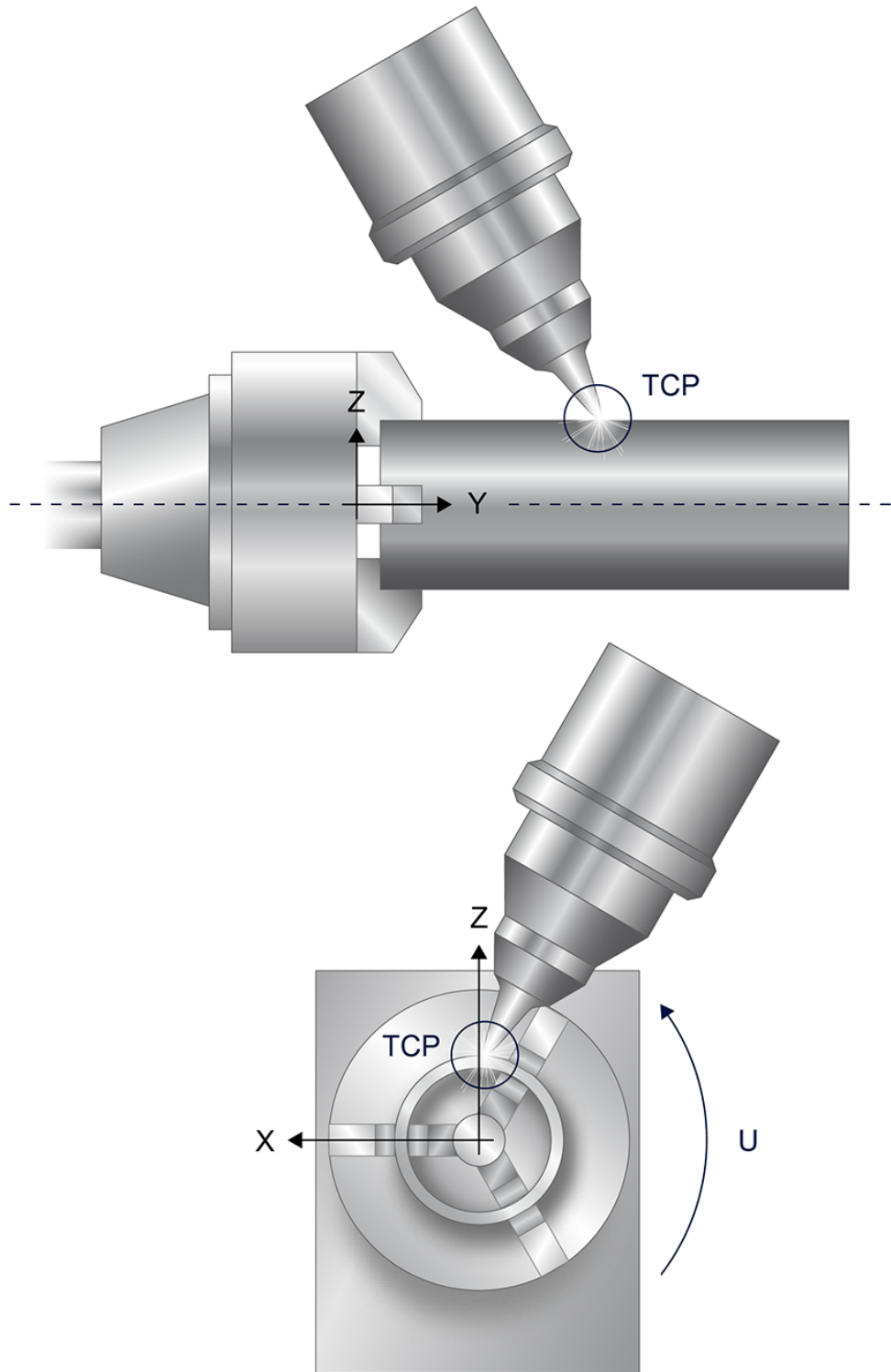


Fig. 22: TCP rotates about the tube centre axis, tube top point

4.1.1.1 Tube machining with AB orientation head

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, A/(C), B/(A), U/V	
Axis index	0, 1, 2, 3, 4, 5	
Kinematic structure (ID 90)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z, A/(C), B/(A)	U/V

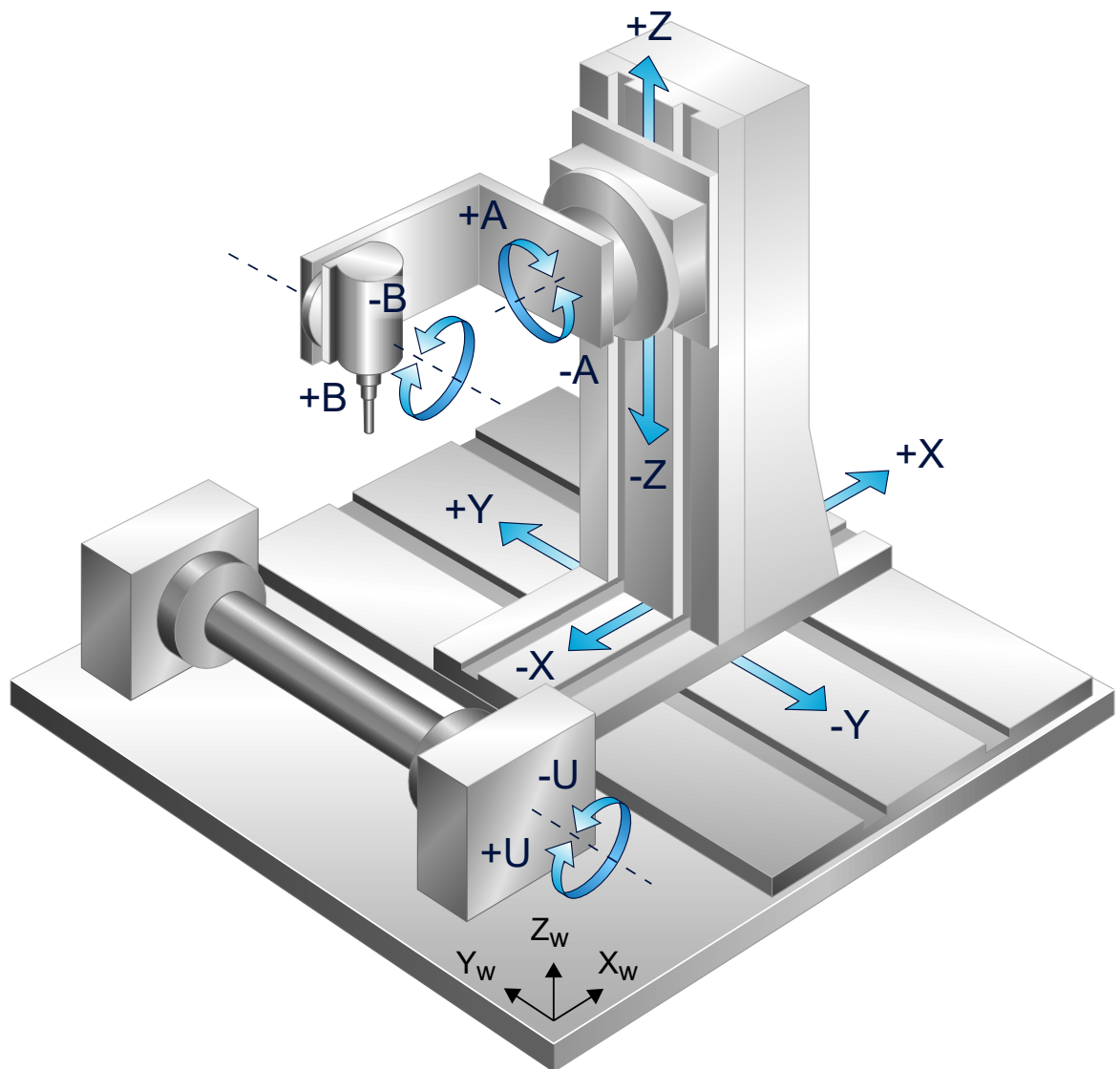


Fig. 23: Lateral surface machining with tube axis parallel to Y

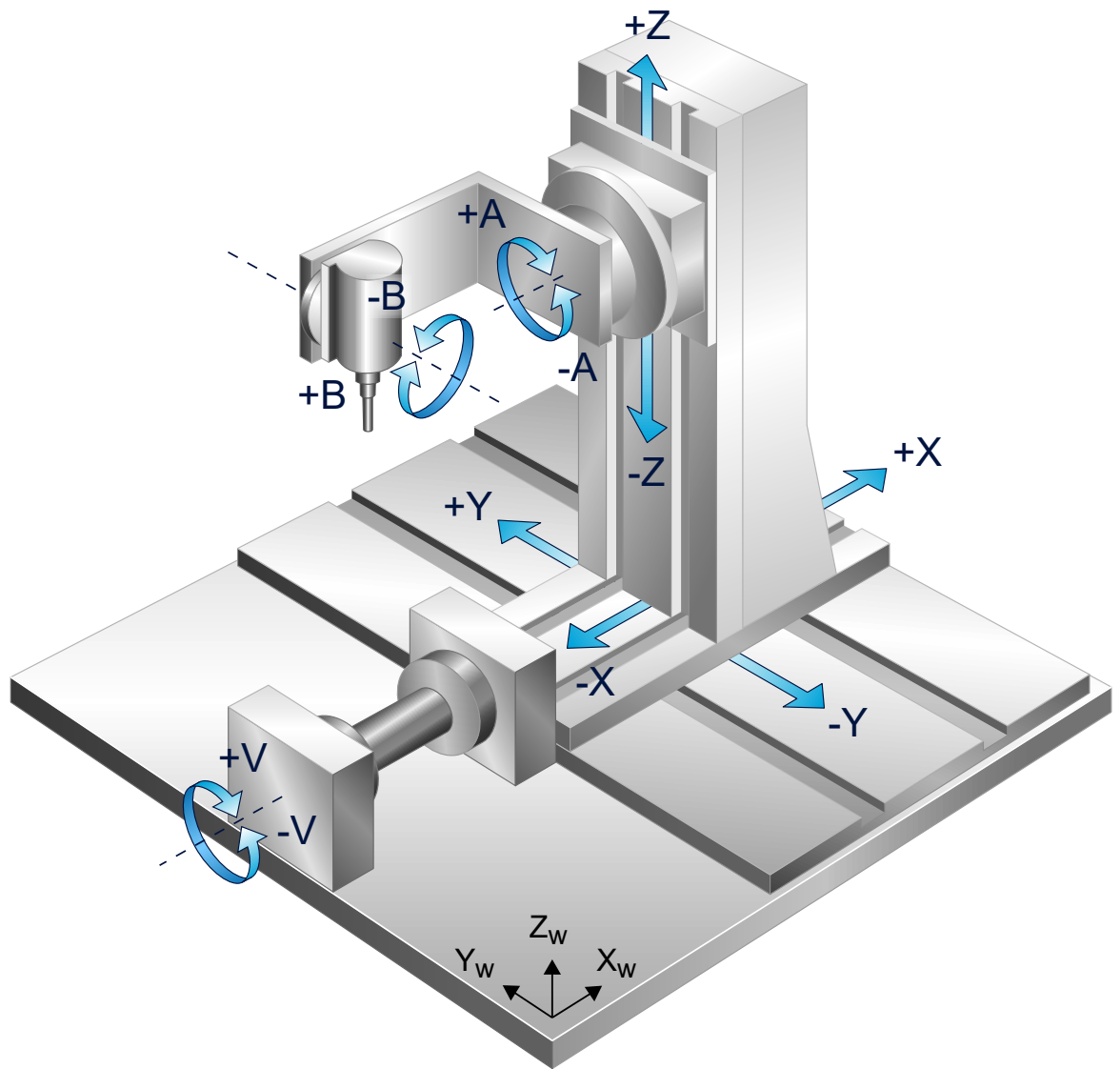


Fig. 24: Lateral surface machining with tube axis parallel to X

Parameterisation: Parameters for AB orientation head [► 91]

4.1.1.2 Tube machining with BA orientation head

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, B/(C), A/(A), U/V	
Axis index	0, 1, 2, 3, 4, 5	
Kinematic structure (ID 90)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z, B/(C), A/(A)	U/V

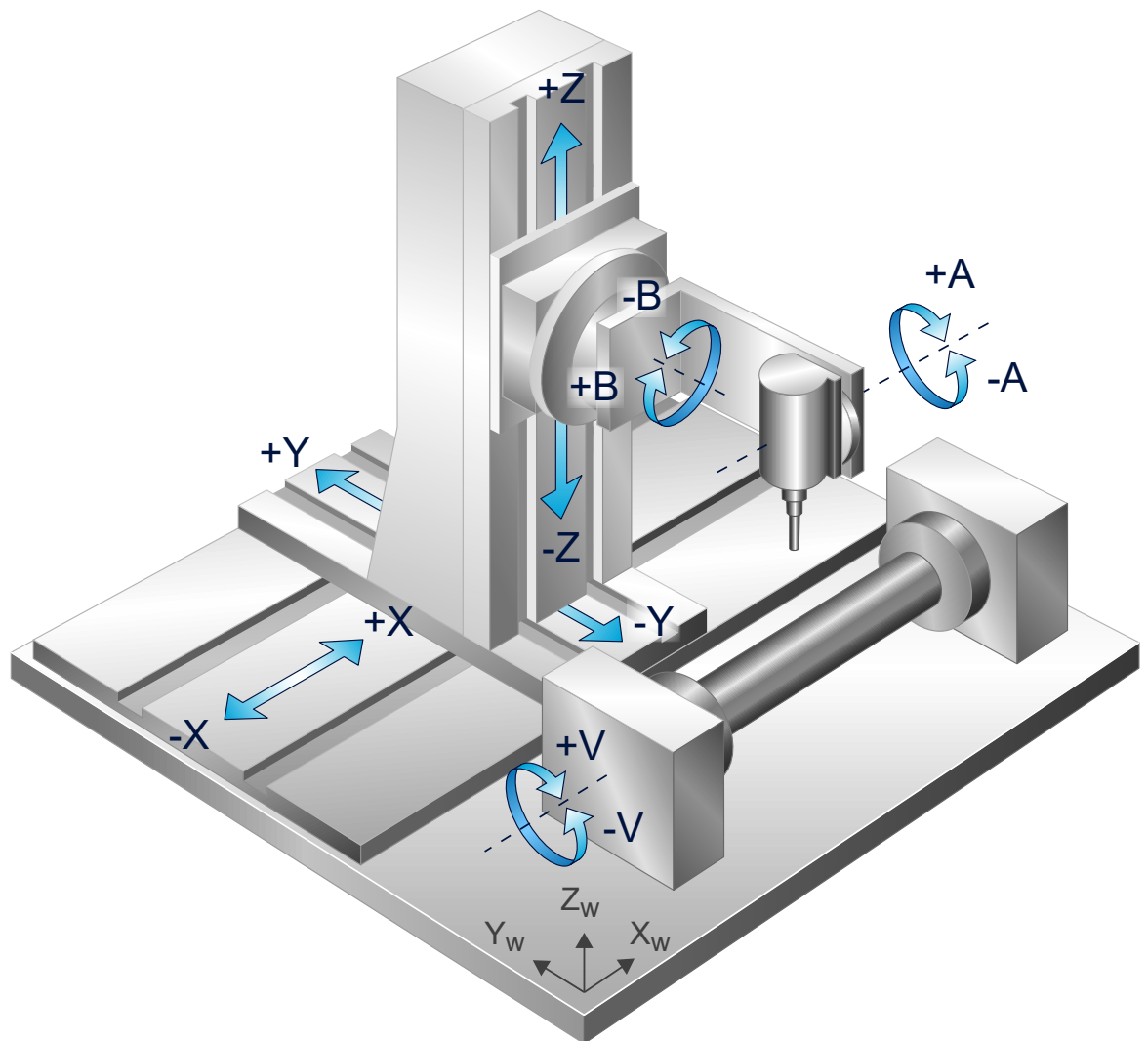


Fig. 25: Lateral surface machining with tube axis parallel to X

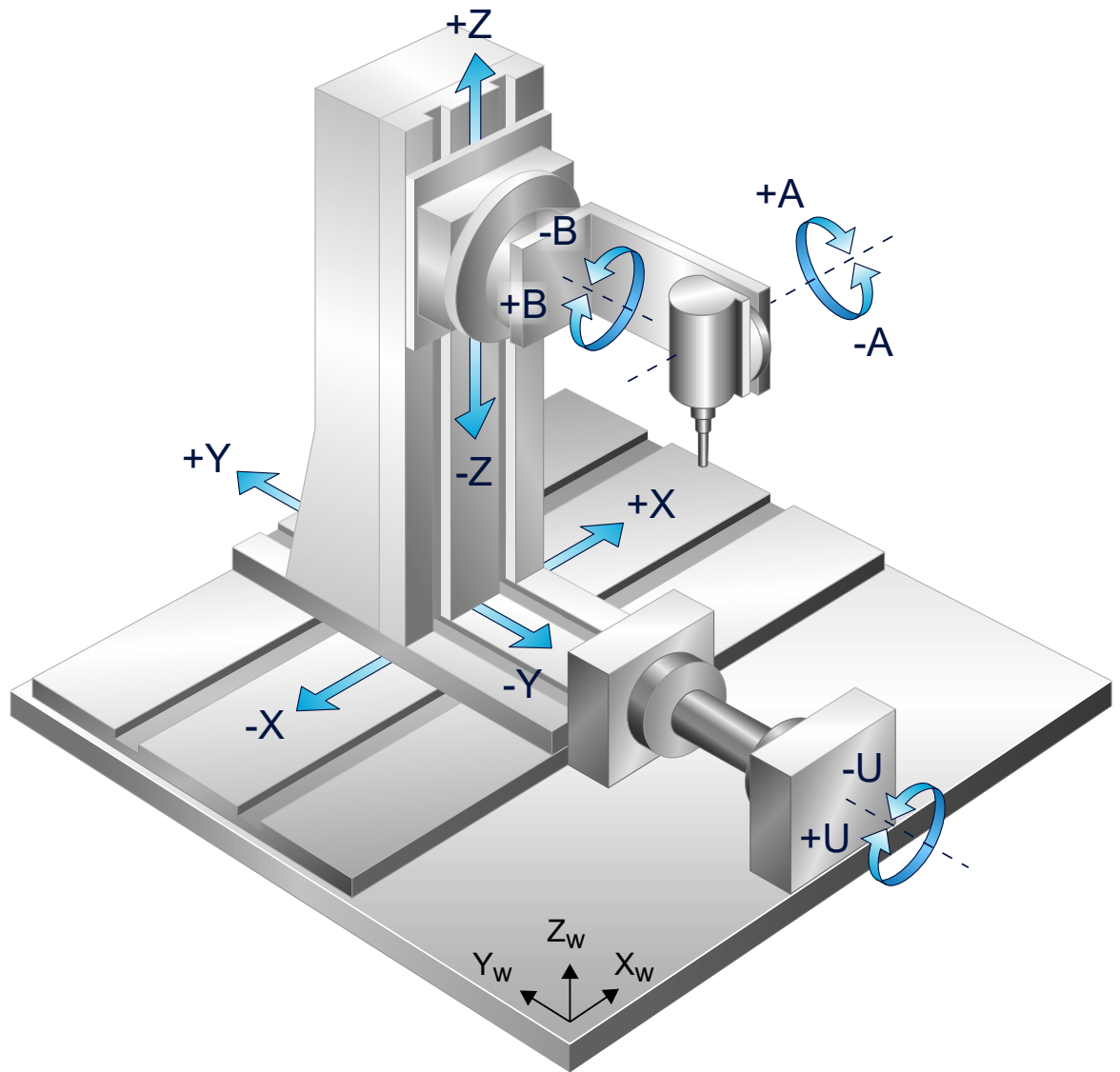


Fig. 26: Lateral surface machining with tube axis parallel to Y

Parameterisation: Parameters for BA orientation head [► 93]

4.1.1.3 Tube machining with CA orientation head

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, C, A, U/V	
Axis index	0, 1, 2, 3, 4, 5	
Kinematic structure (ID 90)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z, C ,A	U/V

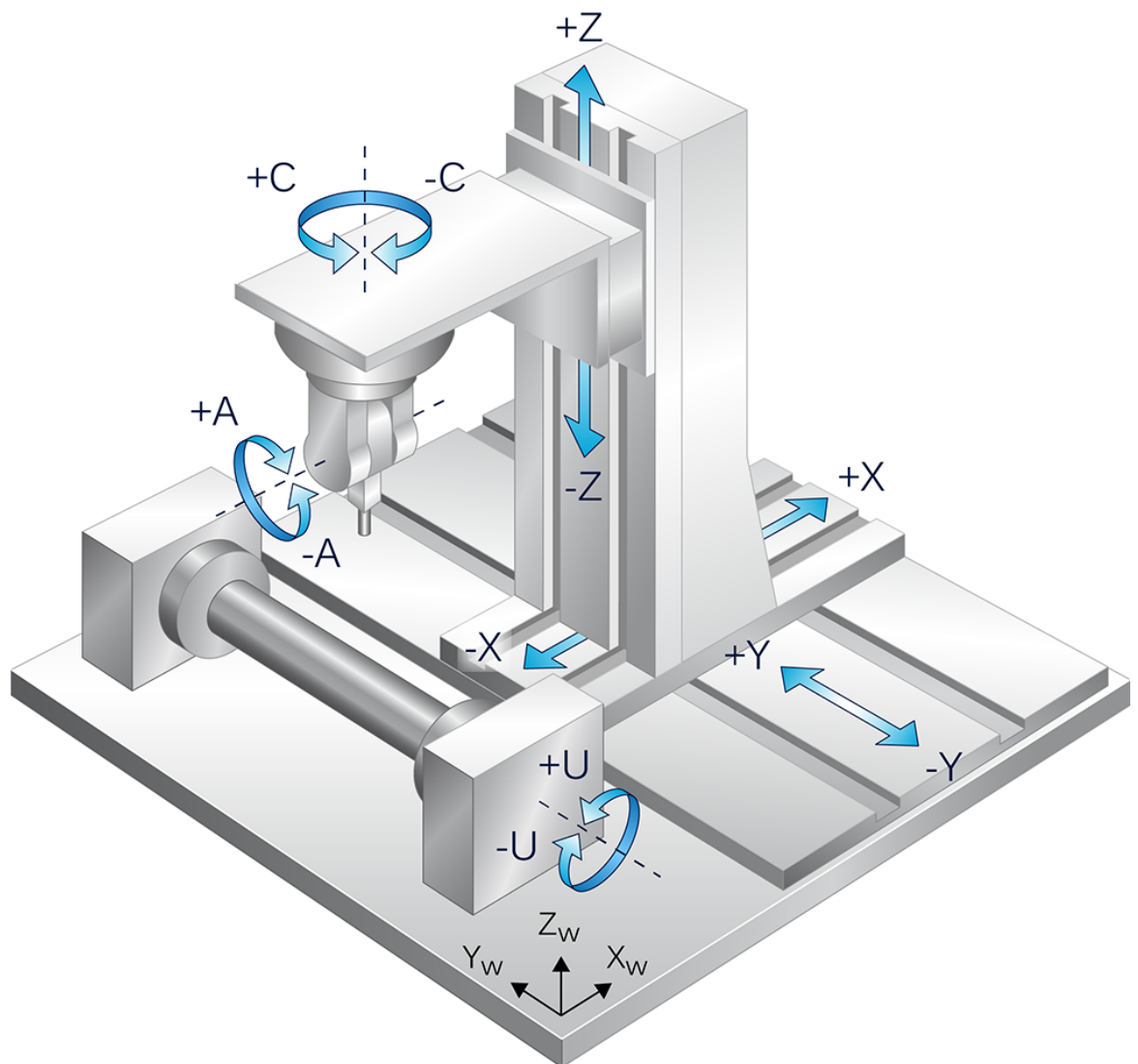


Fig. 27: Lateral surface machining with tube axis parallel to Y

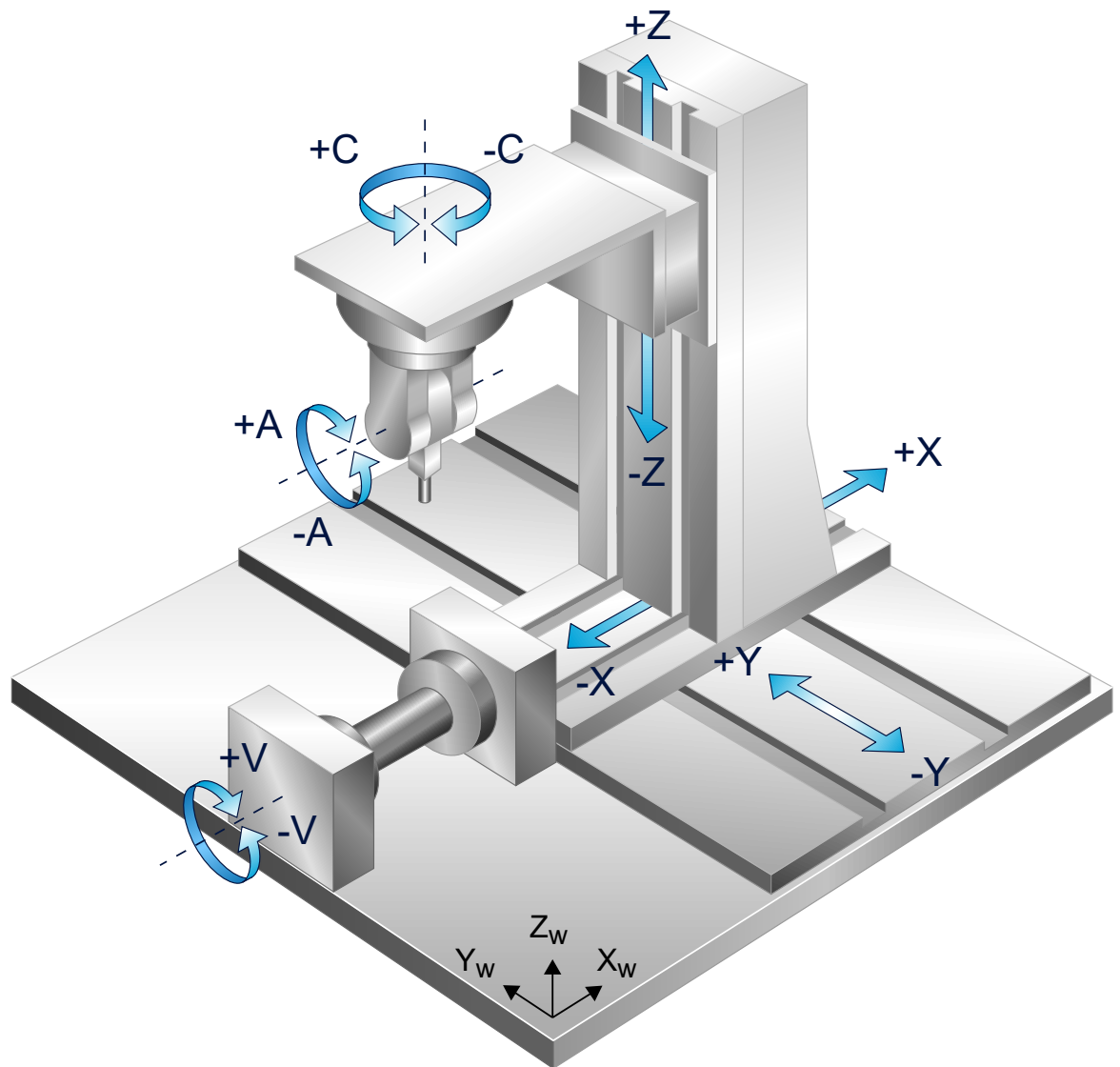


Fig. 28: Lateral surface machining with tube axis parallel to X

Parameterisation: Parameters for CA orientation head [► 95]

4.1.1.4 Tube machining with CB orientation head

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, C, B, U/V	
Axis index	0, 1, 2, 3, 4, 5	
Kinematic structure (ID 90)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z, C, B	U/V

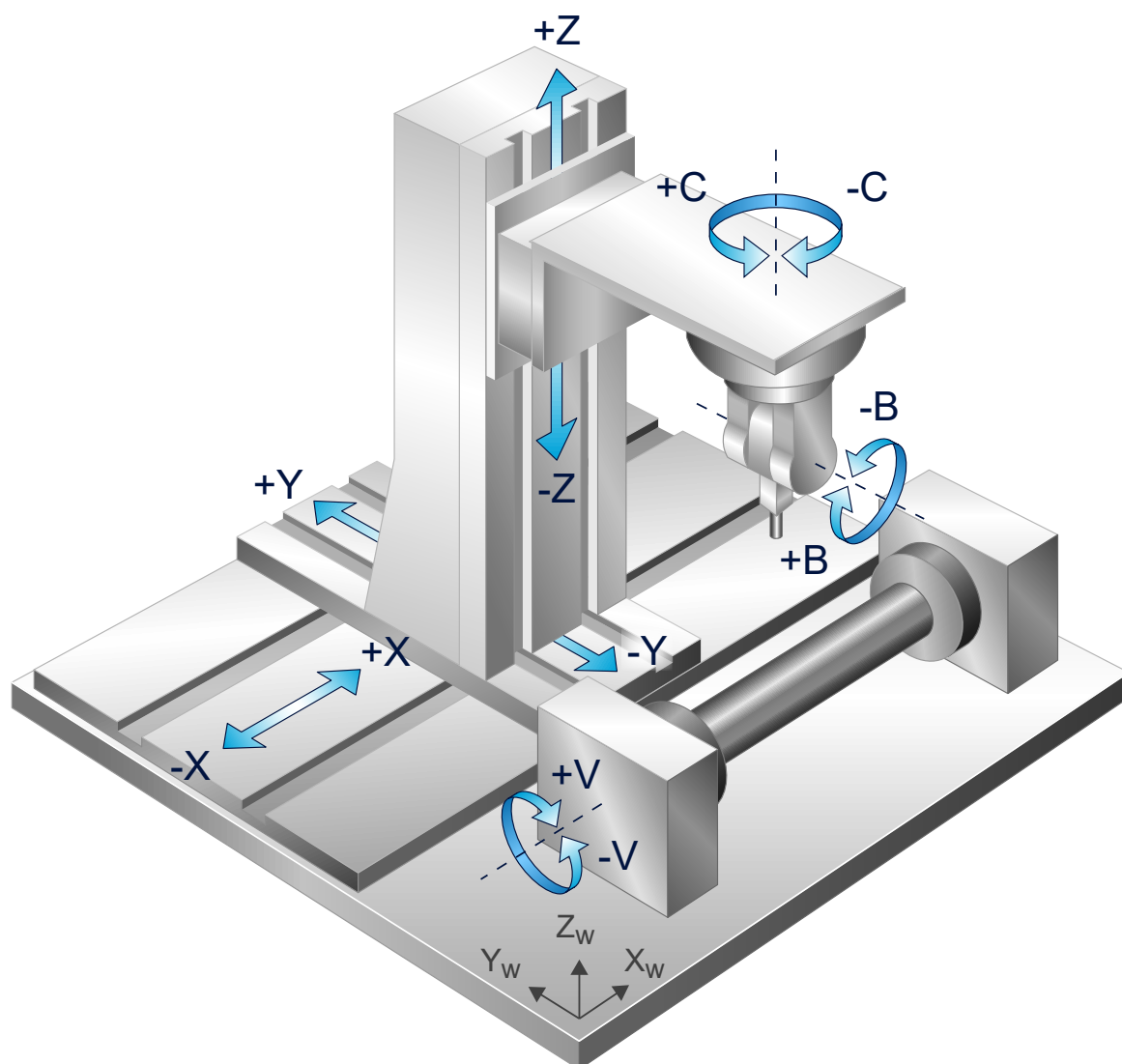


Fig. 29: Lateral surface machining with tube axis parallel to X

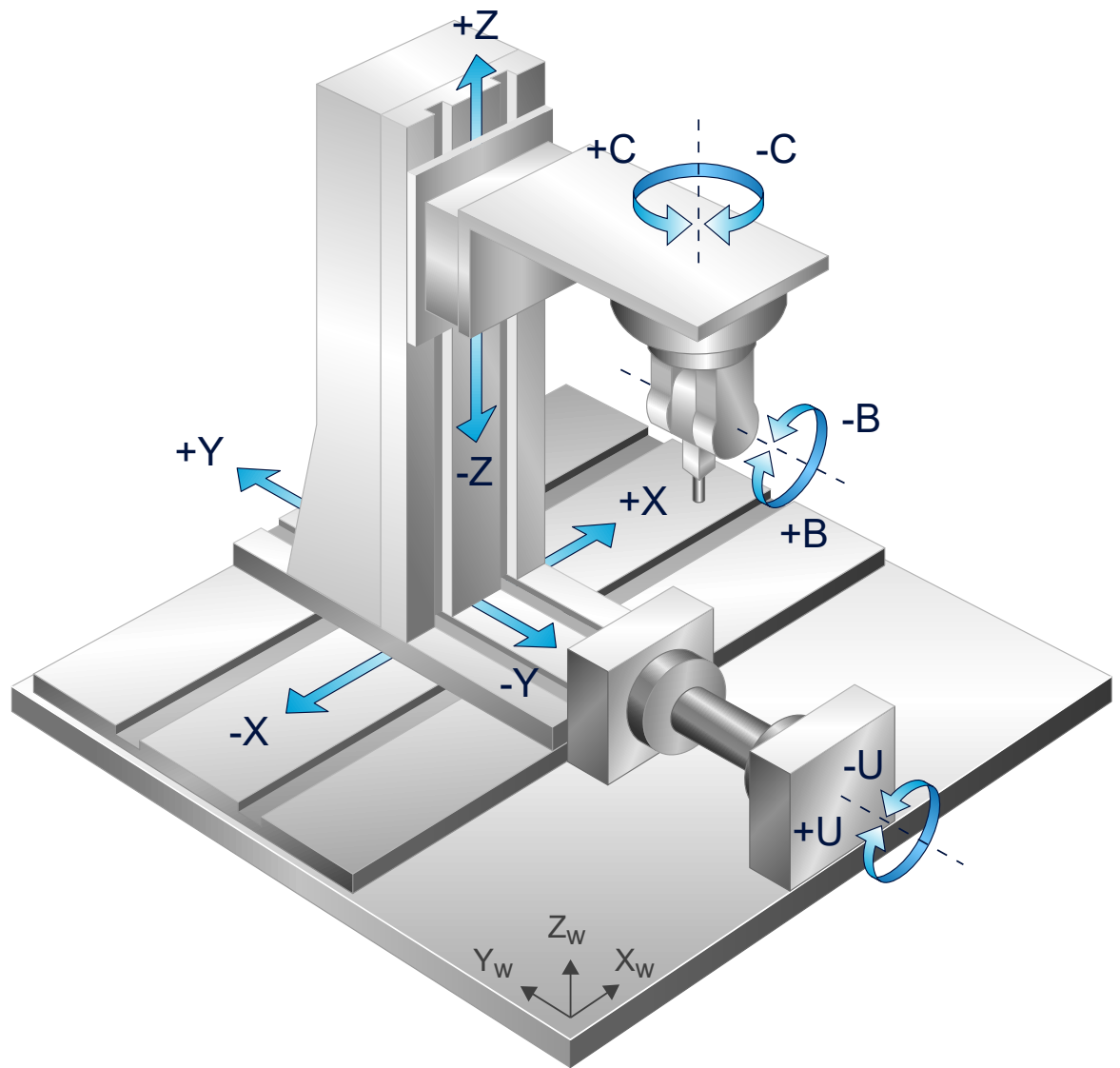


Fig. 30: Lateral surface machining with tube axis parallel to Y

Parameterisation: Parameters for CB orientation head [► 97]

4.1.1.5 Tube machining with CA cardanic orientation head

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, C, A, U/V	
Axis index	0, 1, 2, 3, 4, 5	
Kinematic structure (ID 90)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z, C, A	U/V

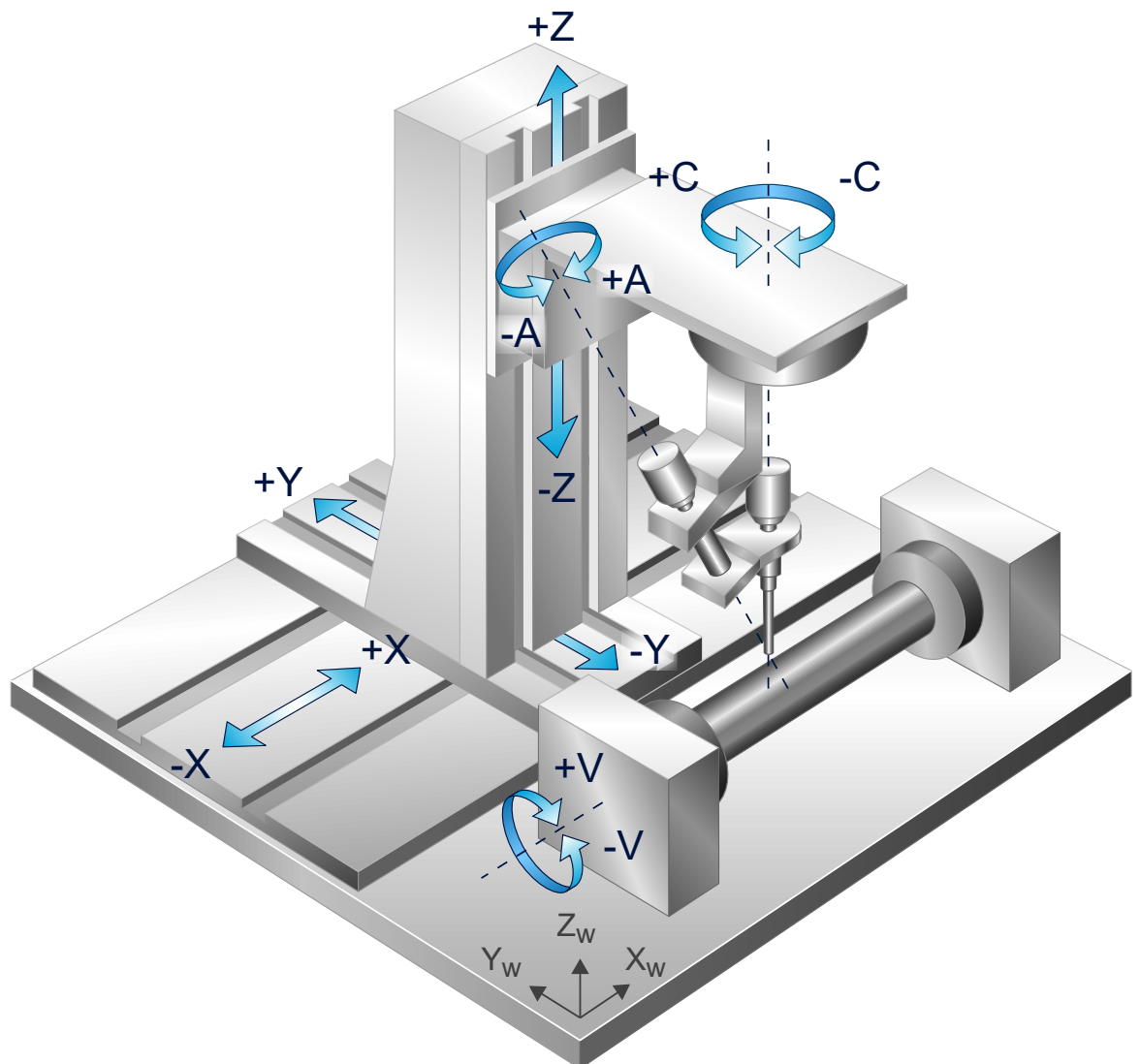


Fig. 31: Lateral surface machining with tube axis parallel to X

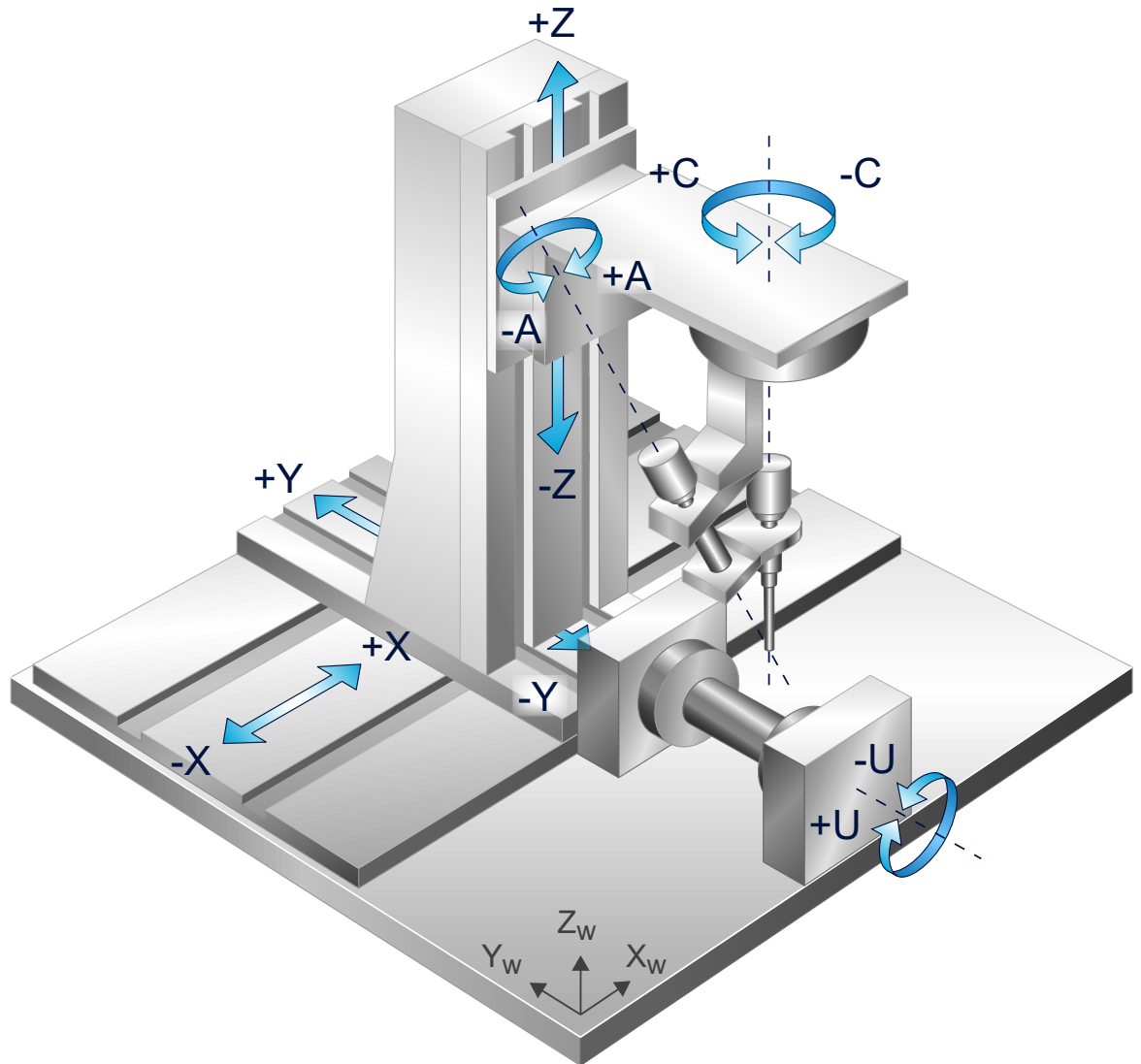


Fig. 32: Lateral surface machining with tube axis parallel to Y

Parameterisation: Parameters for CA cardanic orientation head [► 99]

4.1.2

5-axis, one orientation axis in both workpiece and tool



Release Note

This functionality has been available since CNC Build V2.11.2807.20.

Round tube machining

These kinematics are intended for machine tools with 5 machine axes which are specialised for tube machining only.

This requires a configuration of 5 real machine axes and one virtual axis or one simulation axis. The machining orientation is defined by one rotation axis in the tool and one in the workpiece.

The TCP is positioned for tube machining with the X/Y axis above the top point of the tube. As opposed to 6-axis kinematics [► 44] the TCP does not remain at the top point of the tube when there is a change in orientation but drifts along the surface of the cylinder. This must be considered to avoid collisions between the workpiece and the tool holder.

The path is programmed on the lateral surface by the axes U, Y and X, V. Orientation is programmed dependent on the existing kinematics.

- A-U or B-V structures are programmed directly using the assigned angle values A-B or B-A.
- When virtual axes CA are used for parametrisation, these angles are used for programming.

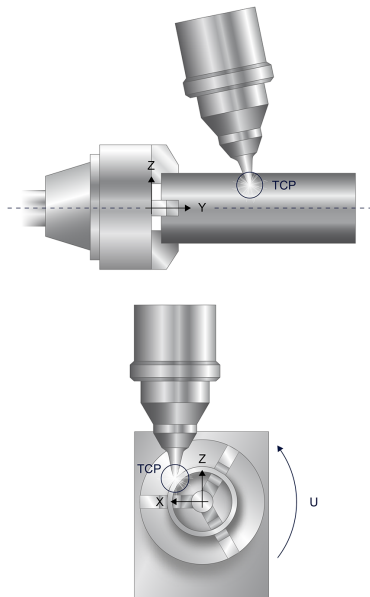


Fig. 33: TCP drifts along the XZ, YZ plane

4.1.2.1 Tube machining with AU kinematics

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, B*, A, U	
Axis index	0, 1, 2, 3, 4, 5	
Kinematic structure (ID 90)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z, B*, A	U

(*) Virtual axis or simulation axis

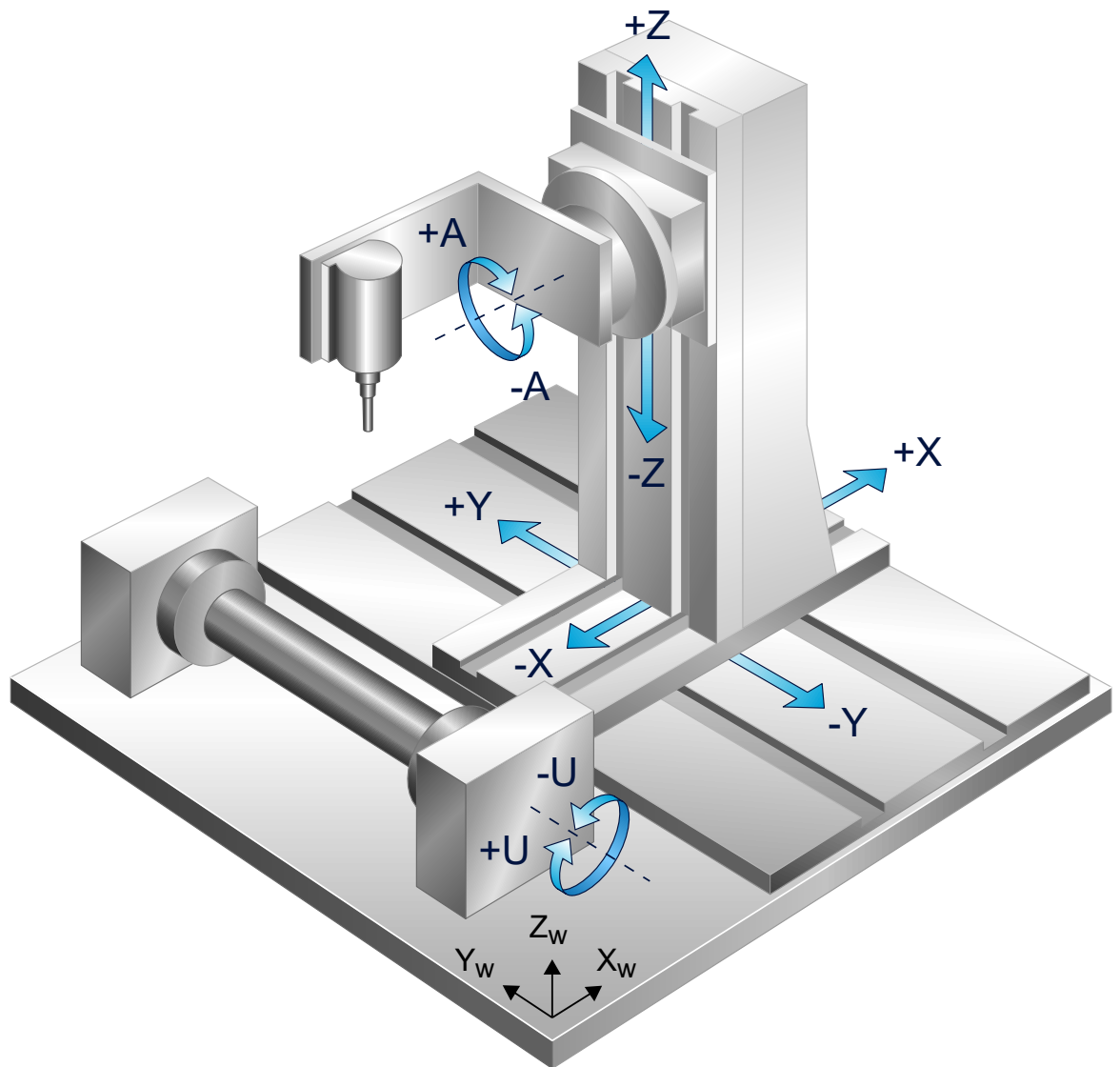


Fig. 34: Lateral surface machining with AU kinematics

Parameterisation: Parameters for AU kinematics [► 101]

4.1.2.2 Tube machining with BV kinematics

Axis configuration in the NC channel		
Axis identifier	X, Y, Z, A*, B, V	
Axis index	0, 1, 2, 3, 4, 5	
Kinematic structure (ID 90)		
	Tool axes	Workpiece axes
NC axes	X, Y, Z, A*, B	V

(*) Virtual axis or simulation axis

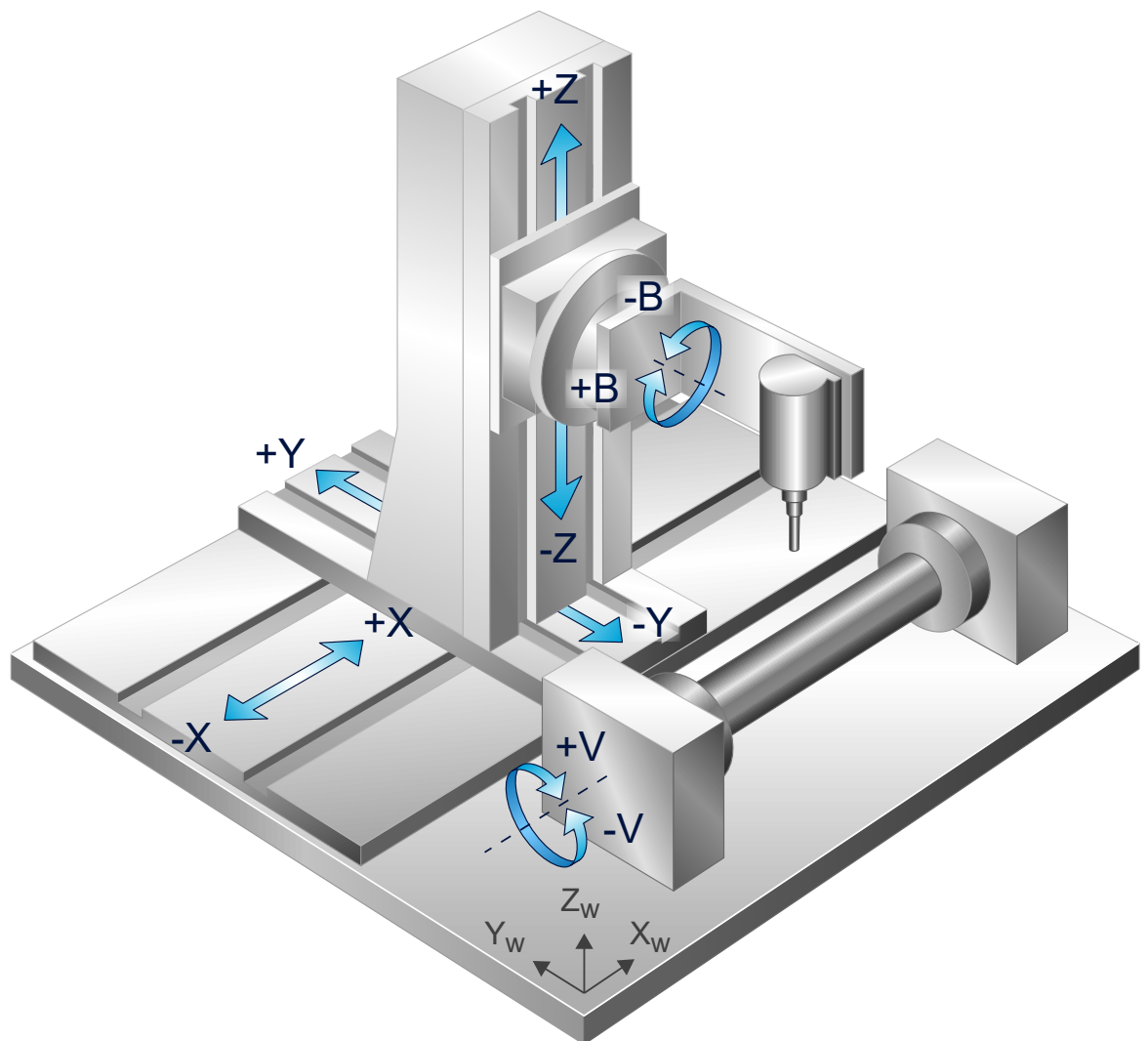


Fig. 35: Lateral surface machining with BV kinematics

Parameterisation: Parameters for BV kinematics [► 103]

4.1.3 Programming

Kinematic structure and axis identifiers

The U machine axis is normally an axis that rotates about the X axis, the V axis about Y and the W axis about Z. The configurations and programming examples deviate from this definition. The axis identifiers for the tube system are selected to achieve logical programming in a virtual right-handed **G17** lateral surface system. Therefore, tube machining is dependent on the orientation of the tube axis in the U-Y or X-V plane.

Of course, identifiers used in the NC program may also be the name of the rotary axis in **both** cases, e.g. U.

For tube machining the function is selected by the command **#CYL ORI LATERAL** [...]. The kinematic structure is then selected implicitly. A kinematic parameter defines which kinematic structure is activated in the tool head on selection. The sequence of axes during selection defines whether it is a U projection (tube axis is in Y direction) or a V projection (tube axis is in X direction).

The same kinematic can be used for plate machining. Selection takes place with the command **#KIN ID[90]**; the kinematic is activated by **#TRAFO ON**. The tube axis U can be programmed as tracking axis.

The programming variant with virtual C-A axis is only required for AB, BA head configurations if the application requires machining at a bevel angle to the path. In this case the tangential tracking function can be activated. For all other head configurations there is a real C machine axis.

4.1.3.1 Tube machining (#CYL ORI LATERAL)



Notice

The kinematic parameters in ID 90 [► 91] must be set for this machining type.

Syntax for selecting and parameterising, active as of the next motion block:

Syntax:

```
#CYL ORI LATERAL [ AX1<axis_name> | AXNR1=.. AX2<axis_name> | AXNR2=..
                  RADIUS=.. ]
```

AX1<axis_name>	Axis identifier of the first main axis (X or virtual linear axis U, flat projection)
AXNR1=..	Logical axis number of first main axis (X or virtual linear axis U, flat projection), positive integer
AX2<axis_name>	Axis identifier of the second main axis (Y or virtual linear axis V, flat projection)
AXNR2=..	Logical axis number of the second main axis (Y or virtual linear axis V, flat projection), positive integer
RADIUS=..	Tube (bending) radius, [mm, inch]

Syntax for deselection:

```
#CYL OFF
```

4.1.3.2 Plate machining

A general description is contained in the programming manual in Section *5-axis functionality* [PROG]:

N10 **#KIN ID[90]** (* Select kinematics *)

N20 **#TRAFO ON** (* Select kinematics *)

N30 G00 X100 Y100 Z10 (* Path sessions *)

.....
N100 **#TRAFO OFF** (* Deselection *)



Notice

For plate machining the tube rotary axis (e.g. U) must be located on index 5 in the axis configuration.



Notice

The tube rotary axis (e.g. U) is configured for C axis mode as a rotary modulo axis (operation mode 0x204, see P-AXIS-00015).
All kinematics with 2 rotary axes in the tool can be selected as listed under the 6-axis head structures. (AB, BA, CA, CB, CA cardanic head). The head structure is selected by the kinematic parameter HD13 as for tube machining.

4.1.4 Examples of tube machining (6-axis)

4.1.4.1 AB head, AB programming

```
%L SUB_1
N100 G01 G90 U50 F2000
N150          B15
N200          Y40
N250          B0    A-15
N300 G01          U[-40]
N350          B-15 A0
N400 G01 Y-40
N450          B0 A15
N500 G01          U40
N550          B15 A0
N600 G01 Y0
N700 G01 G90 U20 F2000
N1040 M29

%tube_5ax
V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 0    (* AB head *)
V.G.KIN[90].PARAM[13] = 0    (* AB programming *)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=TRAPEZ]
N20 #KIN ID[90]
N40 G01 X500 Y0 Z50 A0 B0 F2000
N50 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=30]
N40 G01 U0 Y0 Z30 A0 B0 F2000
N80 LL SUB_1
N110 #CYL OFF

M30
```

4.1.4.2 BA head, BA programming

```
%L SUB_1
N100 G01 G90 U50 F2000
N150          A15
N200          Y40
N250          A0    B-15
N300 G01          U[-40]
N350          A-15 B0
N400 G01 Y-40
N450          A0    B0
N500 G01          U40
N550          A15    B0
N600 G01 Y0
N700 G01 G90 U20 F2000
N1040 M29

%tube_5ax
V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 1    (* BA head *)
V.G.KIN[90].PARAM[13] = 0    (* BA programming *)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=TRAPEZ]
N20 #KIN ID[90]
N40 G01 X500 Y0 Z50 B0 A0 F2000
N50 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=30]
N40 G01 U0 Y0 Z30 B0 A0 F2000
N80 LL SUB_1
N110 #CYL OFF

M30
```

4.1.4.3 AB head, CA programming

```
%L SUB_1
N100 G01 G90 U50 F2000
N200      Y40
N300 G03 Y50 U40 I-10
N500 G01      U[-40]
N700 G03 Y40 U[-50] J-10
N900 G01 Y-40
N1100 G03 Y-50 U[-40] I10
N1300 G01      U40
N1500 G03 Y-40 U50 J10
N1700 G01 Y0
N1900 G01 G90 U20 F2000

N1040 M29

%tube_5ax

V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 0 (* AB head *)
V.G.KIN[90].PARAM[13] = 1 (* CA programming *)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=TRAPEZ]
N40 G01 X500 Y0 Z50 A0 B0 F2000
N45 #SET AX[X,1,0][Y,2,1][Z,3,2][C,4,3][A,5,4][U,6,5]
N50 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=30]
N40 G01 U0 Y0 Z30 C0 A15 F2000
N70 #CAXTRACK ON[ANGLIMIT 0.1]
N80 LL SUB_1
N90 #CAXTRACK OFF
N110 #CYL OFF

M30
```

4.1.4.4 BA head, CA programming

```
%L SUB_1
N100 G01 G90 U50 F2000
N200 Y40
N300 G03 Y50 U40 I-10
N500 G01 U[-40]
N700 G03 Y40 U[-50] J-10
N900 G01 Y-40
N1100 G03 Y-50 U[-40] I10
N1300 G01 U40
N1500 G03 Y-40 U50 J10
N1700 G01 Y0
N1900 G01 G90 U20 F2000

N1040 M29

%tube_5ax

V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 1 (* AB head *)
V.G.KIN[90].PARAM[13] = 1 (* CA programming *)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=TRAPEZ]
N40 G01 X500 Y0 Z50 A0 B0 F2000
N45 #SET AX[X,1,0][Y,2,1][Z,3,2][C,4,3][A,5,4][U,6,5]
N50 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=30]
N40 G01 U0 Y0 Z30 C0 A15 F2000
N70 #CAXTRACK ON[ANGLIMIT 0.1]
N80 LL SUB_1
N90 #CAXTRACK OFF
N110 #CYL OFF

M30
```


4.1.4.5 CA head, CA programming

```
%L SUB_1
N100 G01 G90 U50 F2000
N200 Y40
N300 G03 Y50 U40 I-10
N500 G01 U[-40]
N700 G03 Y40 U[-50] J-10
N900 G01 Y-40
N1100 G03 Y-50 U[-40] I10
N1300 G01 U40
N1500 G03 Y-40 U50 J10
N1700 G01 Y0
N1900 G01 G90 U20 F2000

N1040 M29

%tube_5ax

V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 2 (* CA head *)
V.G.KIN[90].PARAM[13] = 0
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=TRAPEZ]
N40 G01 X500 Y0 Z50 C0 A0 F2000
N45 #SET AX[X,1,0][Y,2,1][Z,3,2][C,4,3][A,5,4][U,6,5]
N50 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=30]
N40 G01 U0 Y0 Z30 C0 A15 F2000
N60 #CAXTRACK ON[ANGLIMIT 0.1]
N70 LL SUB_1
N80 #CAXTRACK OFF
N90 #CYL OFF

M30
```

4.1.4.6 CB Kopf, CB Programmierung

```
%L SUB_1
N100 G01 G90      U50 F2000
N200             Y40
N300 G03 Y50      U40      I-10
N500 G01          U[-40]
N700 G03 Y40      U[-50] J-10
N900 G01 Y-40
N1100 G03 Y-50    U[-40] I10
N1300 G01          U40
N1500 G03 Y-40    U50      J10
N1700 G01 Y0
N1900 G01 G90     U20 F2000

N1040 M29

%tube_5ax

V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 4      (* CA head *)
V.G.KIN[90].PARAM[13] = 0
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=TRAPEZ]
N40 G01 X500 Y0 Z50 C0 B0 F2000
N45 #SET AX[X,1,0][Y,2,1][Z,3,2][C,4,3][B,5,4][U,6,5]
N50 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=30]
N40 G01 U0 Y0 Z30 C0 B15 F2000
N60 #CAXTRACK ON[ANGLIMIT 0.1]
N70 LL SUB_1
N80 #CAXTRACK OFF
N90 #CYL OFF

M30
```

4.1.4.7 CA cardanic head, CA programming

```
%L SUB_1
N100 G01 G90 U50 F2000
N200 Y40
N300 G03 Y50 U40 I-10
N500 G01 U[-40]
N700 G03 Y40 U[-50] J-10
N900 G01 Y-40
N1100 G03 Y-50 U[-40] I10
N1300 G01 U40
N1500 G03 Y-40 U50 J10
N1700 G01 Y0
N1900 G01 G90 U20 F2000

N1040 M29

%tube_5ax

V.G.KIN[90].PARAM[0] = 0
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 450000
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 8 (* CA cardan head *)
V.G.KIN[90].PARAM[13] = 0
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=TRAPEZ]
N40 G01 X500 Y0 Z50 C0 B0 F2000
N45 #SET AX[X,1,0][Y,2,1][Z,3,2][C,4,3][A,5,4][U,6,5]
N50 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=30]
N40 G01 U0 Y0 Z30 C0 B15 F2000
N60 #CAXTRACK ON[ANGLIMIT 0.1]
N70 LL SUB_1
N80 #CAXTRACK OFF
N90 #CYL OFF

M30
```

4.1.5 Examples of plate machining (6-axis)

4.1.5.1 AB Kopf, CA Programming

```
%t_tube
V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 0    AB Kopf
V.G.KIN[90].PARAM[13] = 1    (* CA programming *)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N10 #SLOPE [TYPE=TRAPEZ]
N20 #KIN ID[90]
N30 G01 X0 Y0 Z0 A0 C0 U0 F2000
N40 #SET AX[X,1,0][Y,2,1][Z,3,2][C,4,3][A,5,4][U,7,5]
N45 #CONTOUR MODE[DEV PATH_DEV 0.1 TRACK_DEV 1]

N50 #TRAFO ON
N55 G01 U0 X0 Y0 Z0 C0 A45
N56 #CAXTRACK ON[ANGLIMIT 1]

N57 G261
N58 G01 G91 X50
N60 G90 G02 J-30
N61 G01 G91 X50
N62 G260
N63 #CAXTRACK OFF

N80 #TRAFO OFF

N90 M30
```

4.1.5.2 AB Kopf, AB Programming

```
%t_tube
V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 0    AB Kopf
V.G.KIN[90].PARAM[13] = 0    (* AB programming *)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N10 #SLOPE [TYPE=TRAPEZ]
N20 #KIN ID[90]
N30 G01 X0 Y0 Z0 A0 C0 U0 F2000
N40 #SET AX[X,1,0][Y,2,1][Z,3,2][A,4,3][B,5,4][U,7,5]
N45 #CONTOUR MODE[DEV PATH_DEV 0.1 TRACK_DEV 1]

N50 #TRAFO ON
N55 G01 U0 X0 Y0 Z0 A0 B45

N57 G261
N58 G01 G91 X50
N60 G90 G02 J-30
N61 G01 G91 X50
N62 G260

N80 #TRAFO OFF

N90 M30
```

4.1.6 Examples of tube machining (5-axis)

4.1.6.1 AU kinematics, BA programming

(* B is simulation axis *)

```
%L SUB_1
N570 G261
N580 G01 G90 Y50 B15
N600 G90 G02 J-30
N610 G01 G90 Y-50 B-15
N620 G90 G02 J-30
N630 G01 G91 Y50 B0
N640 G260
M29

%t_tube
V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 9 (* Kinematic 9: A WZ, U 10: B WZ, V *)
V.G.KIN[90].PARAM[13] = 0 (* Progr. orientation 0: same as Kin. 1: CA
*)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=STEP]
N10 #SET AX[X,1,0][Y,2,1][Z,3,2][B,4,3][A,5,4][U,6,5]

N20 G01 X0 Y0 Z150 A0 B0 U0 F2000
N30 #CONTOUR MODE[DEV PATH_DEV 0.1 TRACK_DEV 1]
N40 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=25]
N50 G01 U0 X0 Y0 Z30 A0 B0
N60 LL SUB_1
N120 #CYL OFF

M30
```

4.1.6.2 BV kinematics, AB programming

(* A is simulation axis *)

```
%L SUB_1
N570 G261
N580 G90 G01 X50 A15
N600 G02 J-30
N610 G01 X-50 A-15
N600 G02 J-30
N610 G01 X50 A0
N620 G260
M29

%t_tube
V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 10 (* Kinematic 9: A-U 10: B-V *)
V.G.KIN[90].PARAM[13] = 0 (* Progr. orientation 0: same as Kin 1: CA
*)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=STEP]
N10 #SET AX[X,1,0][Y,2,1][Z,3,2][A,4,3][B,5,4][V,6,5]
N20 G01 X0 Y0 Z150 A0 B0 V0 F2000
N30 #CONTOUR MODE[DEV PATH_DEV 0.1 TRACK_DEV 1]

N40 #CYL ORI LATERAL[AX1=X AX2=V RADIUS=25]
N50 G01 V0 X0 Y0 Z30 A0 B0
N60 LL SUB_1
N120 #CYL OFF

M30
```

4.1.6.3 AU kinematics, CA programming

(* C is simulation axis *)

```
%L SUB_1
N570 G261
N575          A15
N580 G01 G90 U50
N590          Y50
N600          U0
N610          Y0
N620          U[-50]
N630          Y-50
N640          U0
N650          Y0
N620 G260
M29

%t_tube
V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 9 (* Kinematic 9: A-U 10: B-V *)
V.G.KIN[90].PARAM[13] = 1 (* Progr. orientation 0: same as Kin. 1: CA
*)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=STEP]
N10 #SET AX[X,1,0] [Y,2,1] [Z,3,2] [C,4,3] [A,5,4] [U,6,5]
N20 G01 X0 Y0 Z150 C0 A0 U0 F2000
N30 #CONTOUR MODE[DEV PATH_DEV 0.1 TRACK_DEV 1]

N40 #CYL ORI LATERAL[AX1=U AX2=Y RADIUS=25]
N50 G01 U0 X0 Y0 Z30 C0 A0
N56 #CAXTRACK ON[AX=C ANGLIMIT 0.1]
N60 LL SUB_1
N70 #CAXTRACK OFF
N110 #CYL OFF

M30
```


4.1.6.4 BV kinematics, CA programming

(* C is simulation axis *)

```
%L SUB_1
N570 G261
N575          A15
N580 G01 G90 X50
N590          V50
N600          X0
N610          V0
N620          X-50
N630          V[-50]
N640          V0
N650          X0
N620 G260
M29

%t_tube
V.G.KIN[90].PARAM[0] = 1000000
V.G.KIN[90].PARAM[1] = 0
V.G.KIN[90].PARAM[2] = 0
V.G.KIN[90].PARAM[3] = 0
V.G.KIN[90].PARAM[4] = 0
V.G.KIN[90].PARAM[5] = 0
V.G.KIN[90].PARAM[6] = 0
V.G.KIN[90].PARAM[7] = 0
V.G.KIN[90].PARAM[8] = 0
V.G.KIN[90].PARAM[9] = 0
V.G.KIN[90].PARAM[10] = 0
V.G.KIN[90].PARAM[11] = 0
V.G.KIN[90].PARAM[12] = 10 (* Kinematic 9: A-U 10: B-V *)
V.G.KIN[90].PARAM[13] = 1  (* Progr. orientation 0: same as Kin 1: CA
*)
V.G.KIN[90].PARAM[14] = 0
V.G.KIN[90].PARAM[15] = 0
V.G.KIN[90].PARAM[16] = 0
V.G.KIN[90].PARAM[17] = 0

N05 #SLOPE [TYPE=STEP]
N10 #SET AX[X,1,0][Y,2,1][Z,3,2][C,4,3][A,8,4][V,7,5]

N20 G01 X0 Y0 Z150 C0 A0 V0 F2000
N30 #CONTOUR MODE[DEV PATH_DEV 0.1 TRACK_DEV 1]

N40 #CYL ORI LATERAL[AX1=X AX2=V RADIUS=25]
N50 G01 V0 X0 Y0 Z30 C0 A0

N56 #CAXTRACK ON[AX=C ANGLIMIT 1]
N60 LL SUB_1
N70 #CAXTRACK OFF

N80 #CYL OFF

M30
```

4.2 Polygonal tube, profiled tube

Machining with 5-axis head

The Kinematic 93 [► 105] is provided for profiled tube machining with 5-axis heads. It is activated implicitly when tube machining is selected. Its configuration is described in the section "Polygonal tube, profiled tube (5/6-axis) [► 105]".

5-axis heads supported

The Kinematic 93 [► 105] also supports all 5-axis heads described in the section "Round tube, lateral surface [► 44]".



Notice

One restriction is that the tube axis must always be parallel to the X axis. This explains why the command `#CYL ORI PROFILE [...]` has no options to specify the axes.

Parameterisation example: Parameters for AB and BV orientation head [► 105]

4.2.1 Programming (#CYL ORI PROFILE)



Notice

The kinematic parameters in ID 93 [► 105] must be set for this machining type.

Syntax for selecting and parameterising, active as of the next motion block:

Syntax:

#CYL ORI PROFILE [EDGES=.. ROUNDING=.. LENGTH1=.. [LENGTH2=..] modal
[VEL=..] [ACC=..]

EDGES=..	Number of edges (corners) of the profiled tube, positive integer The minimum number of corners on the profile is limited to 3 and the maximum number to 16.
ROUNDING=..	Edge rounding radius (corner radius), [mm, inch].
LENGTH1=..	Side length for symmetrical tubes or first side length for rectangular tubes, [mm, inch]
LENGTH2=..	Second side length for rectangular tubes, [mm, inch]
VEL=..	Path velocity on edge rounding [mm/min]
ACC=..	Path acceleration on edge rounding [mm/min²]

Syntax for deselection:

Syntax:

#CYL OFF modal



Programing Example

#CYL ORI PROFILE [..]

(Symmetrical square profile with 100 mm edge length)

(and 10 mm edge rounding radius)

```
N10 #CYL ORI PROFILE [EDGES=4 ROUNDING=10 LENGTH1=100]
```

...

(Rectangular tube with edge lengths of 100 mm)

(and 80 mm and 15 mm edge rounding radius)

```
N10 #CYL ORI PROFILE [EDGES=4 ROUNDING=15 LENGTH1=100 LENGTH2=80]
```

...

(Reduced path dynamics on the profile rounding)

```
N10 #CYL ORI PROFILE [EDGES=4 ... LENGTH2=50 ACC=1000000]
```

4.2.2 Program example with AB tool head configuration

This configuration contains 6 real axes.

```
N010 ; configuration of AB orientation head
N020 V.G.KIN[93].PARAM[0] = 1000000 ; Z offset to the tool fixing point
N030 V.G.KIN[93].PARAM[1] = 10000 ; X offset to the tool fixing point
N040 V.G.KIN[93].PARAM[2] = 20000 ; Y offset to the tool fixing point
N050 V.G.KIN[93].PARAM[3] = 30000 ; X offset rotation point A axis - rotation point
B axis
N060 V.G.KIN[93].PARAM[4] = 31415 ; Y offset rotation point A axis - rotation point
B axis
N070 V.G.KIN[93].PARAM[5] = 27181 ; Z offset rotation point A axis - rotation point
B axis
N080 V.G.KIN[93].PARAM[6] = -1234 ; X offset zero point - rotation point A axis
N090 V.G.KIN[93].PARAM[7] = 17 ; Y offset zero point - rotation point A axis
N100 V.G.KIN[93].PARAM[8] = 100 ; Z offset zero point - rotation point A axis
N110 V.G.KIN[93].PARAM[11] = 1000 ; angle offset U/V axis
N120 V.G.KIN[93].PARAM[12] = 0 ; 0 = AB head
N130 V.G.KIN[93].PARAM[13] = 0 ; 0 = PCS programming same as head
N140 V.G.KIN[93].PARAM[14] = 0 ; rotation direction AM positive
N150 V.G.KIN[93].PARAM[15] = 0 ; rotation direction BM positive
N160 V.G.KIN[93].PARAM[16] = 200 ; angle offset AM
N170 V.G.KIN[93].PARAM[17] = 100 ; angle offset BM
N200 ; configuration of profile tube
N230 V.G.KIN[93].PARAM[23] = 513 ; Z offset rotary axis U to machine zero point
N240 V.G.KIN[93].PARAM[24] = 1000 ; X offset rotary axis U to machine zero point
N250 V.G.KIN[93].PARAM[25] = -5000 ; Y offset rotary axis U to machine zero point
N260
N270 ; sort axes
N280 #SET AX [X, 1, 0][Y, 2, 1][Z, 3, 2][A, 4, 3][B, 5, 4][U, 6, 5]
N290
N300 ; move to zero
N310 G00 G90 X0 Y0 Z0 A0 B0 U0
N320
N330 ; select kinematic 93
N340 #KIN ID[93]
N350
N360 ; start processing
N370 G01 X500 Y0 Z50 A0 B0 F2000
N380 #CYL ORI PROFILE [EDGES = 4 ROUNDING = 10 LENGTH1 = 50]
N390 G01 X0 U0 Z30 A0 B0 F2000
N400 G01 G90 U50 F2000
N410 B15
N420 X40
N430 B0 A-15
N440 G01 U-40
N450 B-15 A0
N460 G01 X-40
N470 A15 B0
N480 G01 U40
N490 B15 A0
N500 G01 X0
N510 G01 G90 U20 F2000
N520 #CYL OFF
N530
N540 ; end program
N550 M30
```

4.2.3 Program example with BV configuration:

This configuration contains 5 real axes. The A axis included is a virtual simulation axis.

```
%L SUB_GEOM
N570 G261
N575          B=15 F200
N580 G01 G90 X50 F5000
N590          G91 U100
N600          G90 X0
N610          G91 U-100
N620          G90 X-100
N630          G91 U-100
N640          G91 U100
N650          G90 X0
N660          G90 B=0
N620 G260
M29

%t_edge_prof_5ax_BV.nc
N9 ;
N10 V.G.KIN[93].PARAM[0] = 1000000
N11 V.G.KIN[93].PARAM[1] = 0
N12 V.G.KIN[93].PARAM[2] = 0
N13 V.G.KIN[93].PARAM[3] = 0
N14 V.G.KIN[93].PARAM[4] = 0
N15 V.G.KIN[93].PARAM[5] = 0
N16 V.G.KIN[93].PARAM[6] = 0
N17 V.G.KIN[93].PARAM[7] = -942000
N18 V.G.KIN[93].PARAM[8] = 0
N21 V.G.KIN[93].PARAM[11] = 0
N22 V.G.KIN[93].PARAM[12] = 10 (* 10: B WZ, V *)
N23 V.G.KIN[93].PARAM[13] = 0
N24 V.G.KIN[93].PARAM[14] = 0
N25 V.G.KIN[93].PARAM[15] = 0
N26 V.G.KIN[93].PARAM[16] = 0
N27 V.G.KIN[93].PARAM[17] = 0
N33 V.G.KIN[93].PARAM[23] = 0
N34 V.G.KIN[93].PARAM[24] = 0
N35 V.G.KIN[93].PARAM[25] = 0

N10 #SET SLOPE PROFIL[1]
N20 G00 X0 Y0 Z250
N30 #CONTOUR MODE[DEV PATH_DEV 0.1 TRACK_DEV 1]

N40 #SET AX[X,1,0][Y,2,1][Z,3,2][A,4,3][B,5,4][U,6,5]
N50 G00 X0 Y94.2 Z250 A0 B0 U0
N60 #CYL ORI PROFILE[EDGES=4 ROUNDING=5 LENGTH1=50 LENGTH2=50]
(* Profile circumference approx. 231.41592 mm *)

N70 LL SUB_GEOM

N90 #CYL OFF
M30
```

5 Block search and profiled tube machining

Resuming path approach

Please note the following when path motion is resumed on profiled tubes with the block search function:

- The approach motion in an area with an active `#CYL [EDGES..]` or `#CYL ORI PROFILE [EDGES=...]` takes place on the **ACS plane**. To prevent any collision between tool and work-piece, position the tool at a sufficient safety height (U axis rotates without compensation motion of Z).
- The tool must be perpendicular to the profile surface and within the capture range of the profile (see figure below).
- The approach motion is executed in two steps:
 1. Approach motions without Z axis (e.g. U, Y, X)
 2. Approach motion of the Z axis

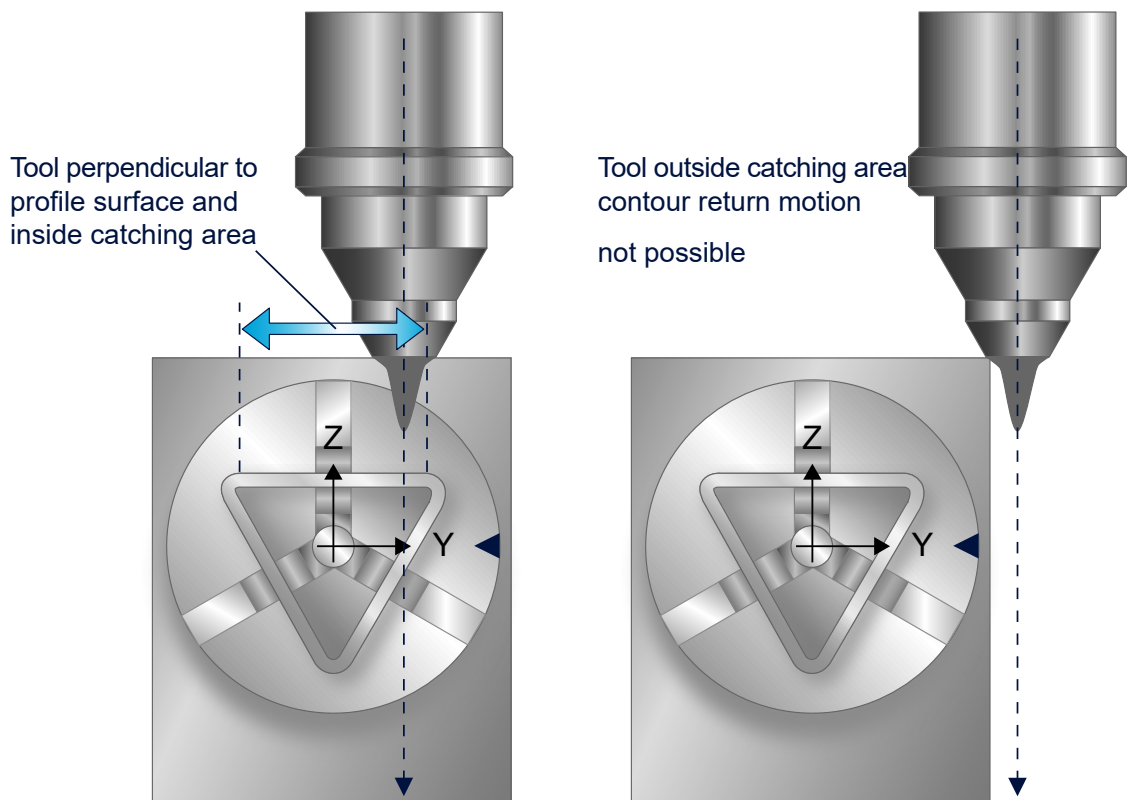


Fig. 36: Starting position for motion resumption

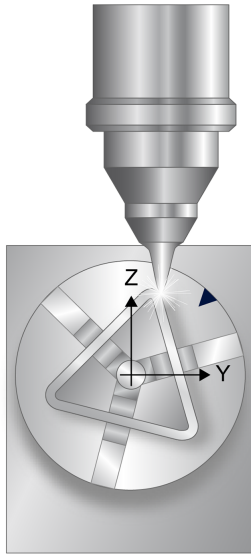


Fig. 37: Axis position after motion resumption

6 Parameter

Parameterisation

The workpiece parameters are defined in the NC program. The following parameters are offset values of the kinematic structure, parameters for the rotary axis and optionally applicable M/H codes.

6.1 Overview

6.1.1 Channel parameters

The following kinematic parameters must be assigned function-specific for machining variants.

ID	Parameter	Description
P-CHAN-00094	kinematik[i].param[j]	Kinematic offsets of the corresponding kinematics, CNC Build as of V3.00
P-CHAN-00262	trafo[i].id	Kinematics ID
P-CHAN-00263	trafo[i].param[j]	Kinematic offsets of the corresponding kinematics, CNC Build as of V3.00

The following parameters are optional for profiled tube machining. The M/H numbers are defined for output at the rounding transition of the profiled tube.

ID	Parameter	Description
P-CHAN-00249	tube_profile.techno_nr_rnd_on	M/H number, entering edge rounding
P-CHAN-00250	tube_profile.techno_nr_rnd_off	M/H number, leaving edge rounding
P-CHAN-00251	tube_profile.techno_type	0 = M, 1 = H

6.1.2 Axis parameters

The U rotary axis must be set by the following parameters.

ID	Parameter	Value	Description
P-AXIS-00015	axis mode	0x0000 0204	Axis defined as U rotary axis for lateral surface, projection and profiled tube machining.
P-AXIS-00126	moduloo	3600000	Definition of upper modulo limit
P-AXIS-00127	modulou	0	Definition of lower modulo limit

6.2 Description

6.2.1 Round tube, lateral surface (kinematic ID 15)

Parameters are defined under the ID 15 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

If required, PCS modulo calculation can be enabled by the parameter HD10.

HD offset	param[i]	Description	Unit
HD1	0	Z offset tool fixing point - Tool carrier reference point	1.0 E-4 mm
HD2	1	Angle offset of rotary axis	1.0 E-4°
HD3	2	X offset tool fixing point - Tool carrier reference point	1.0 E-4 mm
HD4	3	-	
HD5	4	Z offset of rotary axis U to machine zero point	1.0 E-4 mm
HD6	5	X offset of rotary axis U to machine zero point	1.0 E-4 mm
HD10	9	PCS modulo calculation 0: inactive 1: active	[-]

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

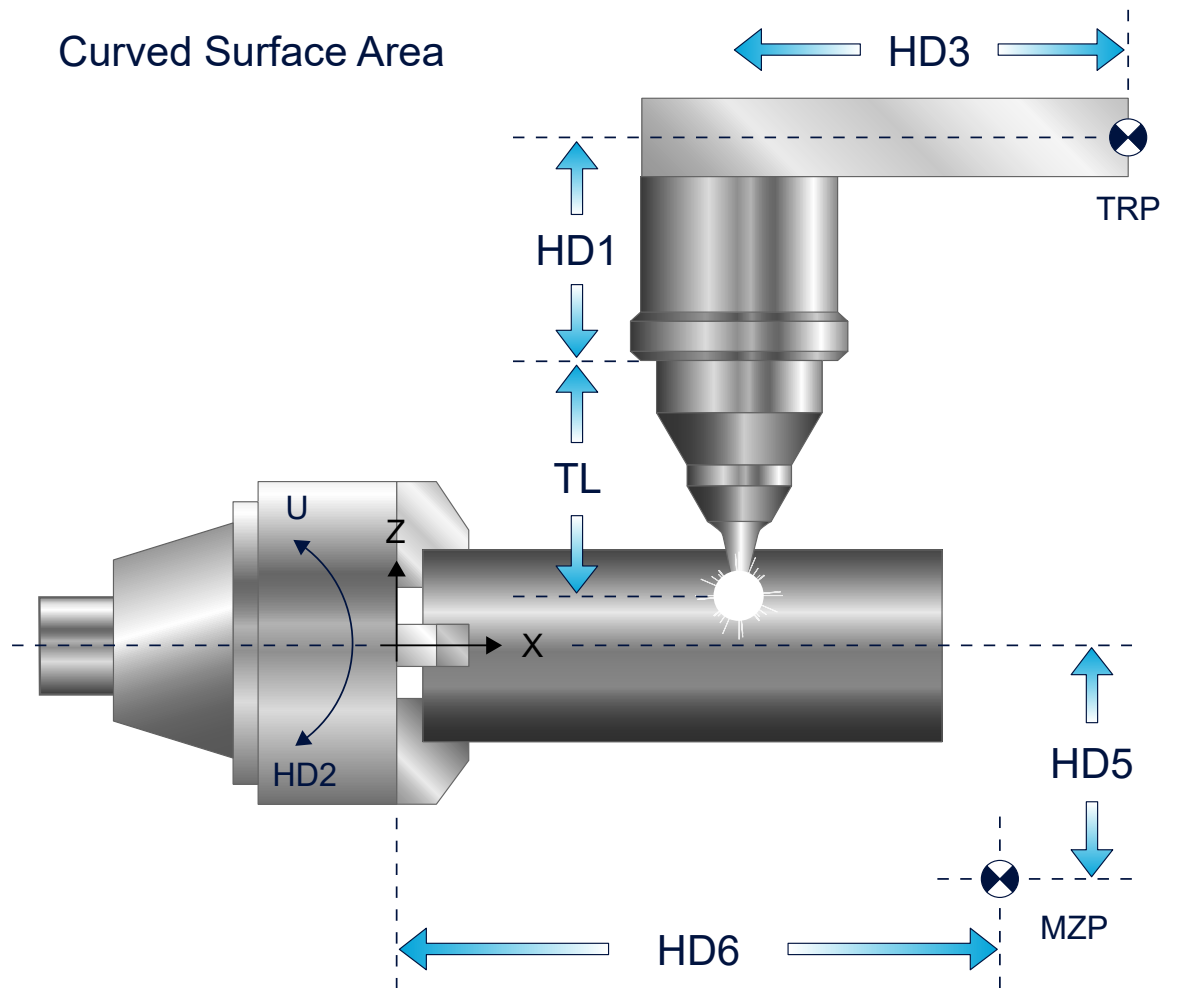


Fig. 38: Kinematic offsets for lateral surface machining

6.2.2 Round tube, projection (kinematic ID 78)

Parameters are defined under the ID 78 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	Z offset tool fixing point - Tool carrier reference point	1.0 E-4 mm
HD2	1	X offset tool fixing point - Tool carrier reference point	1.0 E-4 mm
HD3	2	Y offset tool fixing point - Tool carrier reference point	1.0 E-4 mm
HD4	3	-	
HD5	4	Z offset of rotary axis U to machine zero point	1.0 E-4 mm
HD6	5	X offset of rotary axis U to machine zero point	1.0 E-4 mm
HD7	6	Y offset of rotary axis U to machine zero point	1.0 E-4 mm

With regard to modulo calculation, the U axis is handled depending on the MDS setting in the axis.

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

Projection Tube Processing

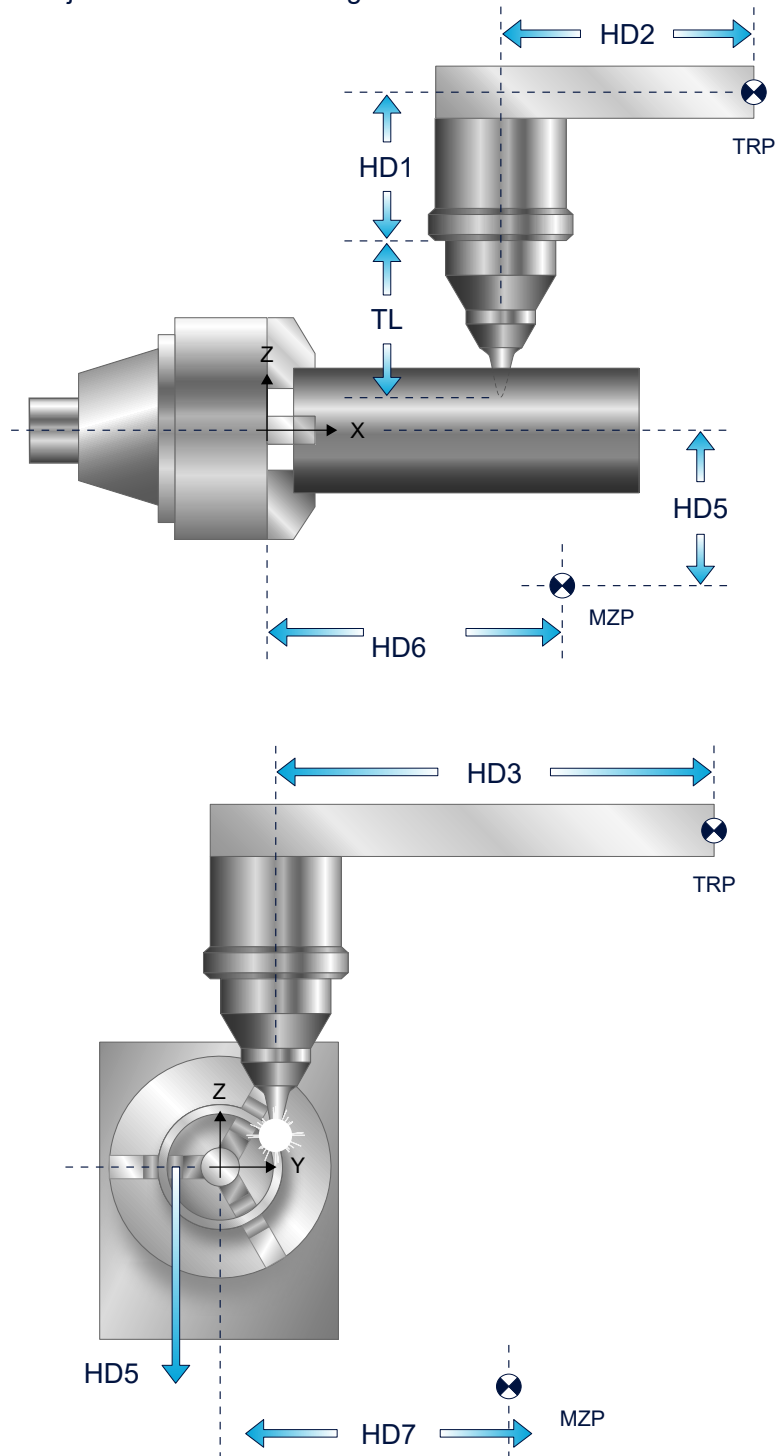


Fig. 39: Tube projection transformation kinematic offsets

6.2.3 Polygonal tube, profiled tube (kinematic ID 79)

Parameters are defined under the ID 79 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	Z offset tool fixing point - Tool carrier reference point	1.0 E-4 mm
HD2	1	X offset tool fixing point - Tool carrier reference point	1.0 E-4 mm
HD3	2	Y offset tool fixing point - Tool carrier reference point	1.0 E-4 mm
HD4	3	Z offset of rotary axis U to machine zero point	1.0 E-4 mm
HD5	4	X offset of rotary axis U to machine zero point	1.0 E-4 mm
HD6	5	Y offset of rotary axis U to machine zero point	1.0 E-4 mm
HD7	6	-	
HD8	7	Angle offset of workpiece clamp position	1.0 E-4°

A modulo compensation is always executed for the U axis.

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

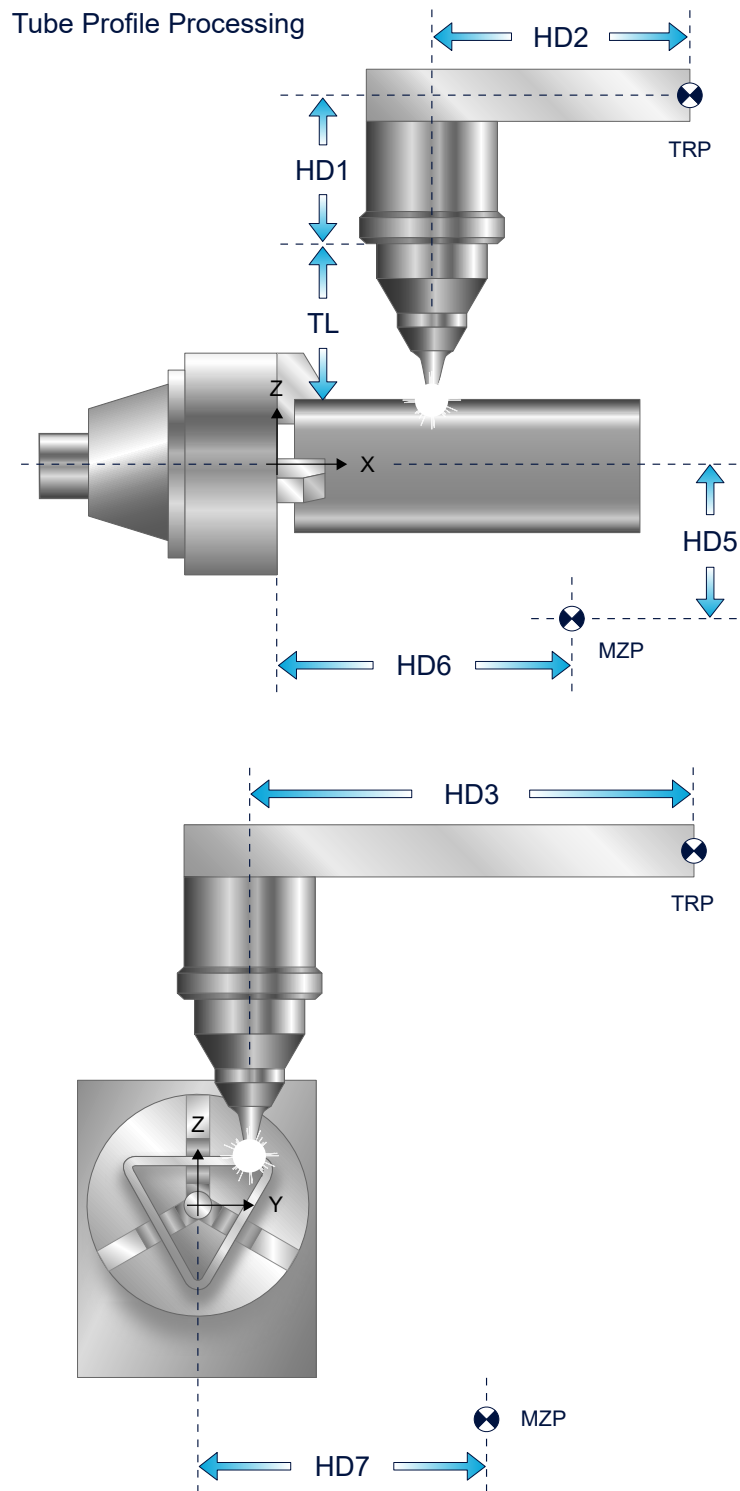


Fig. 40: Profiled tube transformation kinematic offsets

Tube Profile Processing

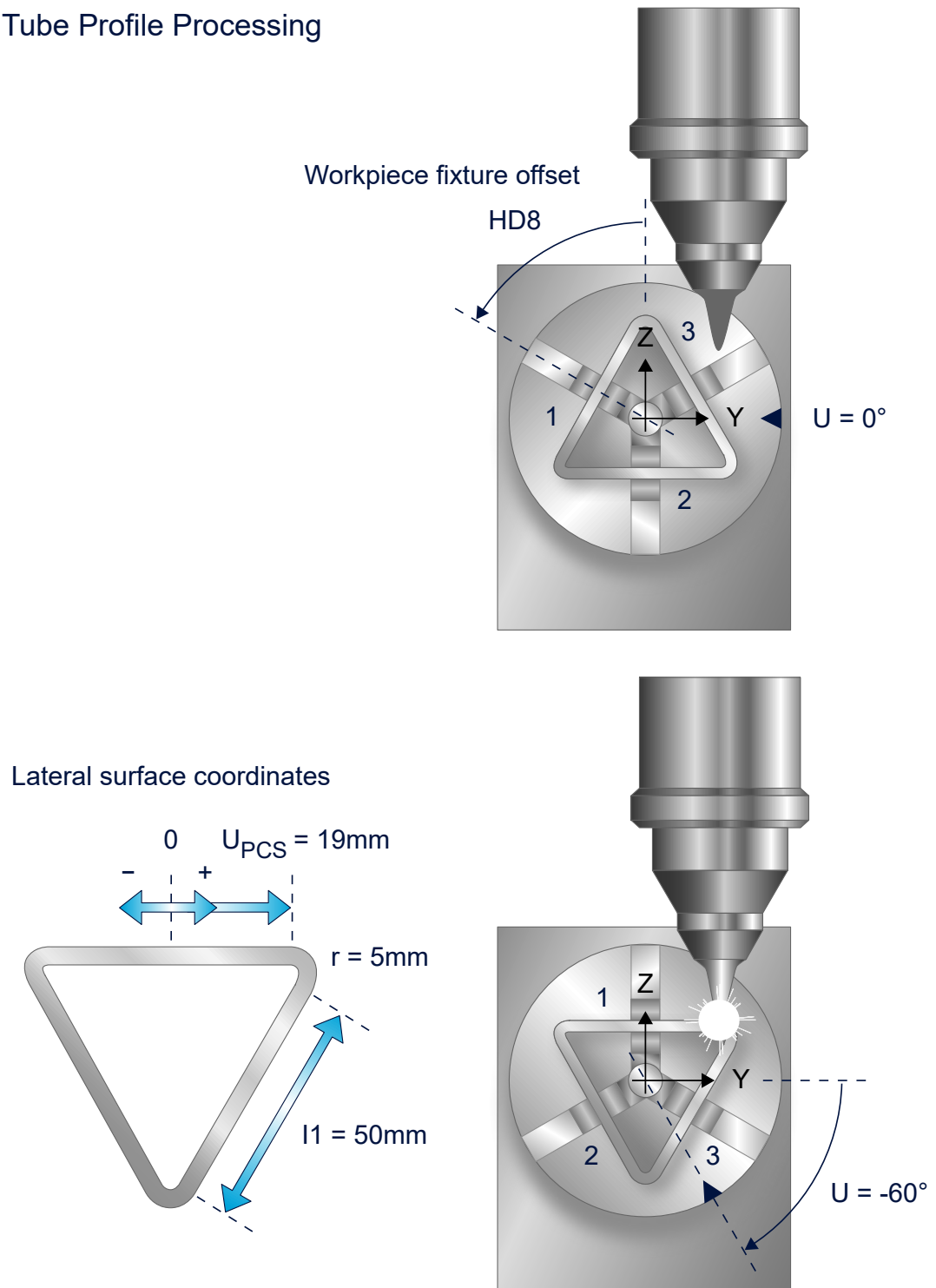


Fig. 41: Offset for workpiece clamp position

When the rotary workpiece axis is in zero position, the clamped workpiece is normally not in the specified basic orientation where the workpiece axis is perpendicular to the profile section. The kinematic parameter HD8 considers the clamp position of the profiled tube. In this case, the workpiece must be oriented above the rotary axis so that a plane surface of the profile is perpendicular to the tool. In the current example the U axis is moved to -60° ; the required offset setting is then $+60^\circ$.

In the above figure, the lateral surface system is then obtained after the transformation is selected according to following parameters #CYL[EDGES=3 ROUNDING=5 LENGTH1=50]. The zero point of the lateral surface system is located in the middle of lateral plane 1; the PCS start position of the TCP is $U_{PCS} = +19\text{mm}$.

Tube Profile Processing

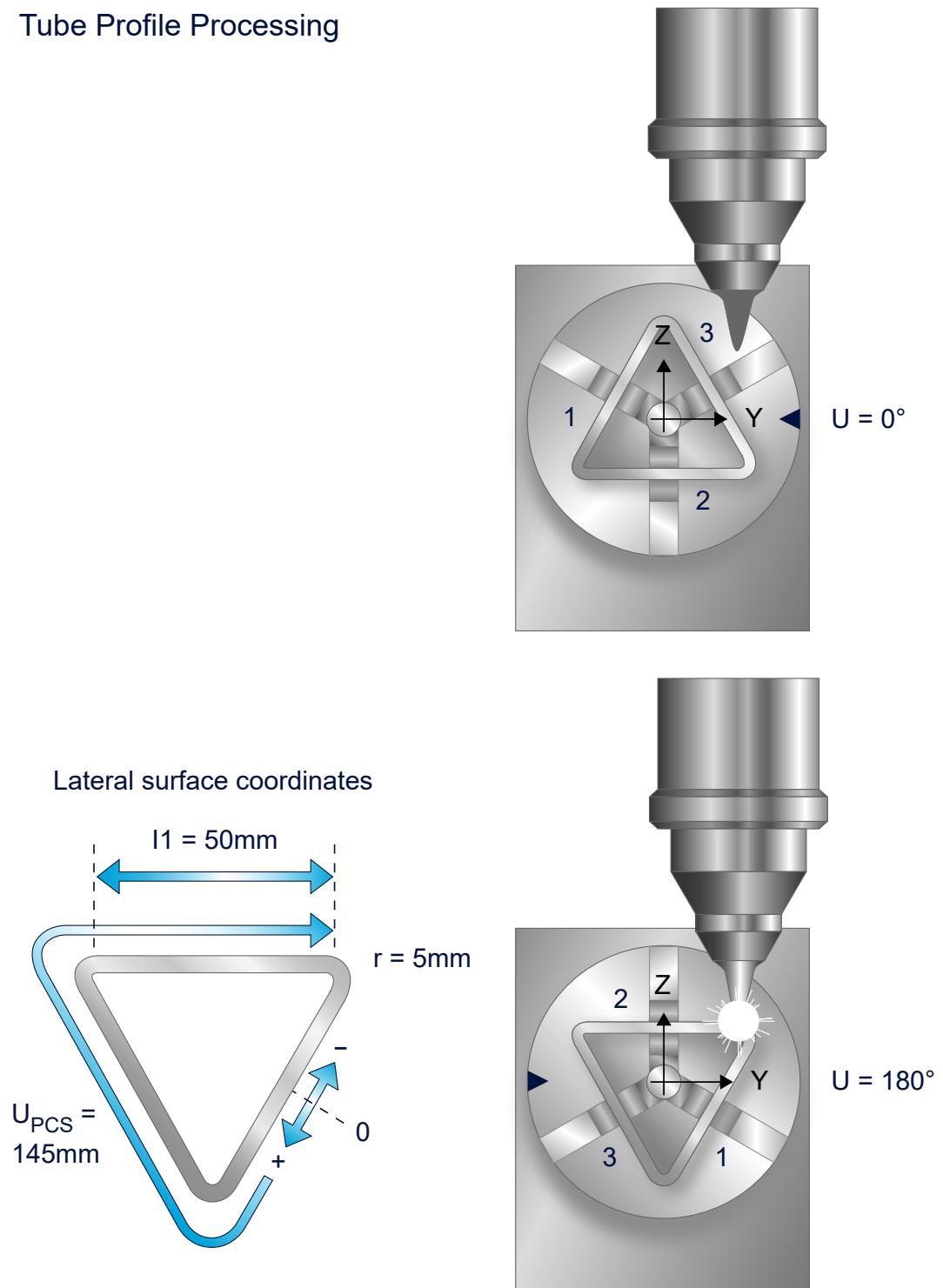


Fig. 42: Selection on the plane lateral surface

In the following case the transformation should be activated on the lateral surface 2. The clamping position and kinematic parameter HD8 correspond to the above example. The U axis is positioned at 180° before the transformation is selected so that the tool is perpendicular to the required plane surface.

In the above figure, the lateral surface system is then obtained after transformation is selected according to the following parameters #CYL[EDGES=3 ROUNDING=5 LENGTH1=50]. The zero point of the lateral surface system is located in the middle of lateral plane 1; in the lateral surface system, it is located at the start position $U_{PCS}=145\text{mm}$.

Tube Profile Processing

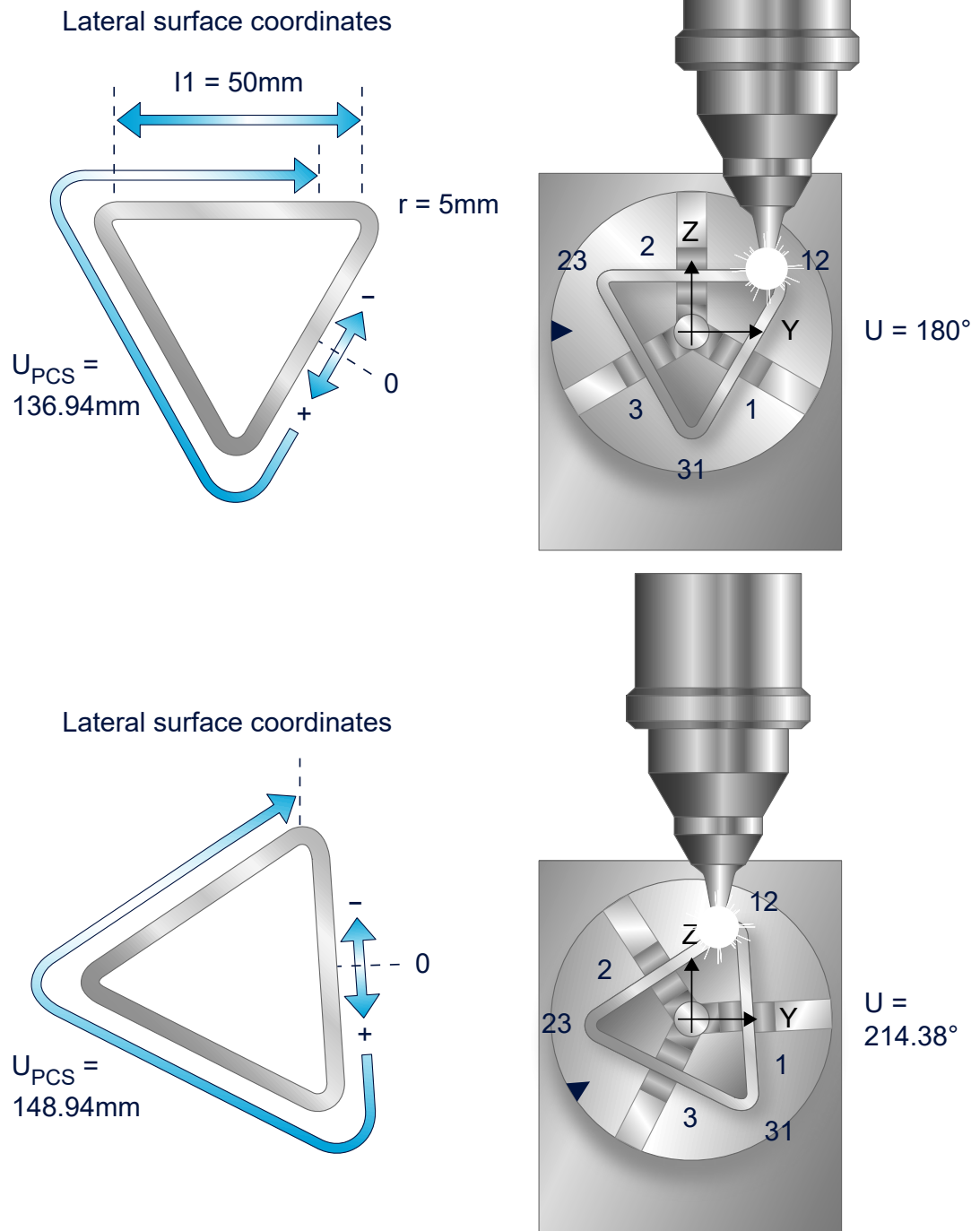


Fig. 43: Selection on profile rounding

In this case the transformation should be activated on the profile rounding 12. The clamping position and kinematic parameter HD8 correspond to the above example. The lateral surface system is obtained after transformation is selected as shown in above figure. The system is located at the start position $U_{PCS}=136.94\text{mm}$. The approach to the profile rounding at position $U_{PCS}=148.94\text{mm}$ is executed by positioning with the command #PTP ON.



Programing Example

Polygonal tube, profiled tube (kinematic ID 79)

```
N30 ...
N40 G0 G90 X0 Y=20 U=0 Z50
N50 #CYL [EDGES=3, ROUNDING=5, LENGTH1=50]
N60 #PTP ON
N70 G0 G90 U148.94 Z40
N80 #PTP OFF
N90 Z0
N100 G01 U150 X5
...
```

6.2.3.1

M / H SteuerCodes

The M/H functions described below can be used for process control on the profile rounding.

Variable name	Type	Permitted range	Dimension
tube_profile.techno_nr_rnd_on	SGN16	-1 ... [M/H_FKT_ANZ-1] Default: -1 = not used	---
tube_profile.techno_nr_rnd_off	SGN16	-1 ... [M/H_FKT_ANZ-1] Default: -1 = not used	---
tube_profile.techno_type	SGN16	0 : M numbers 1 : H numbers	----

Value M/H_FKT_ANZ	Meaning
application-specific	Maximum number of M/H functions



Attention

To activate the function, the M/H numbers of the two parameters must be ≥ 0 .

M/H numbers may not already be assigned by an application in P-CHAN-00041 (m_synch[...]) or P-CHAN-00027 (h_synch[...]).

Excerpt from the channel parameter list:

```
# Definition of M/H functions for profiled tube rounding technology
# =====
:
tube_profile.techno_type          1          Use of H numbers
tube_profile.techno_nr_rnd_on     300        H number, engage in rounding
tube_profile.techno_nr_rnd_off    400        H number, retract from rounding
#
```

6.2.4 Round tube, lateral surface (5/6-axis) (kinematic ID 90)

6.2.4.1 Parameters for AB orientation head

Parameters are defined under the ID 90 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	Z axis offset to the tool fixing point	1.0 E-4 mm
HD2	1	X axis offset to the tool fixing point	1.0 E-4 mm
HD3	2	Y axis offset to the tool fixing point	1.0 E-4 mm
HD4	3	X axis offset rotation point A axis to rotation point B axis	1.0 E-4 mm
HD5	4	Y axis offset rotation point A axis to rotation point B axis	1.0 E-4 mm
HD6	5	Z axis offset rotation point A axis to rotation point B axis	1.0 E-4 mm
HD7	6	X axis offset zero point to rotation point A axis	1.0 E-4 mm
HD8	7	Y axis offset zero point to rotation point A axis	1.0 E-4 mm
HD9	8	Z axis offset zero point to rotation point A axis	1.0 E-4 mm
HD10	9	n.a.	
HD11	10	n.a.	
HD12	11	Angle offset U/V axis	1.0 E-4°
HD13	12	Orientation head, sequence of rotary axes 0: AB 1: BA	[-]
HD14	13	PCS angle programming 0: same as orientation head 1: CA	[-]
HD15	14	Rotation direction AM 0: math positive 1: math negative	[-]
HD16	15	Rotation direction BM 0: math positive 1: math negative	[-]
HD17	16	Angle offset AM	1.0 E-4°
HD18	17	Angle offset BM	1.0 E-4°

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

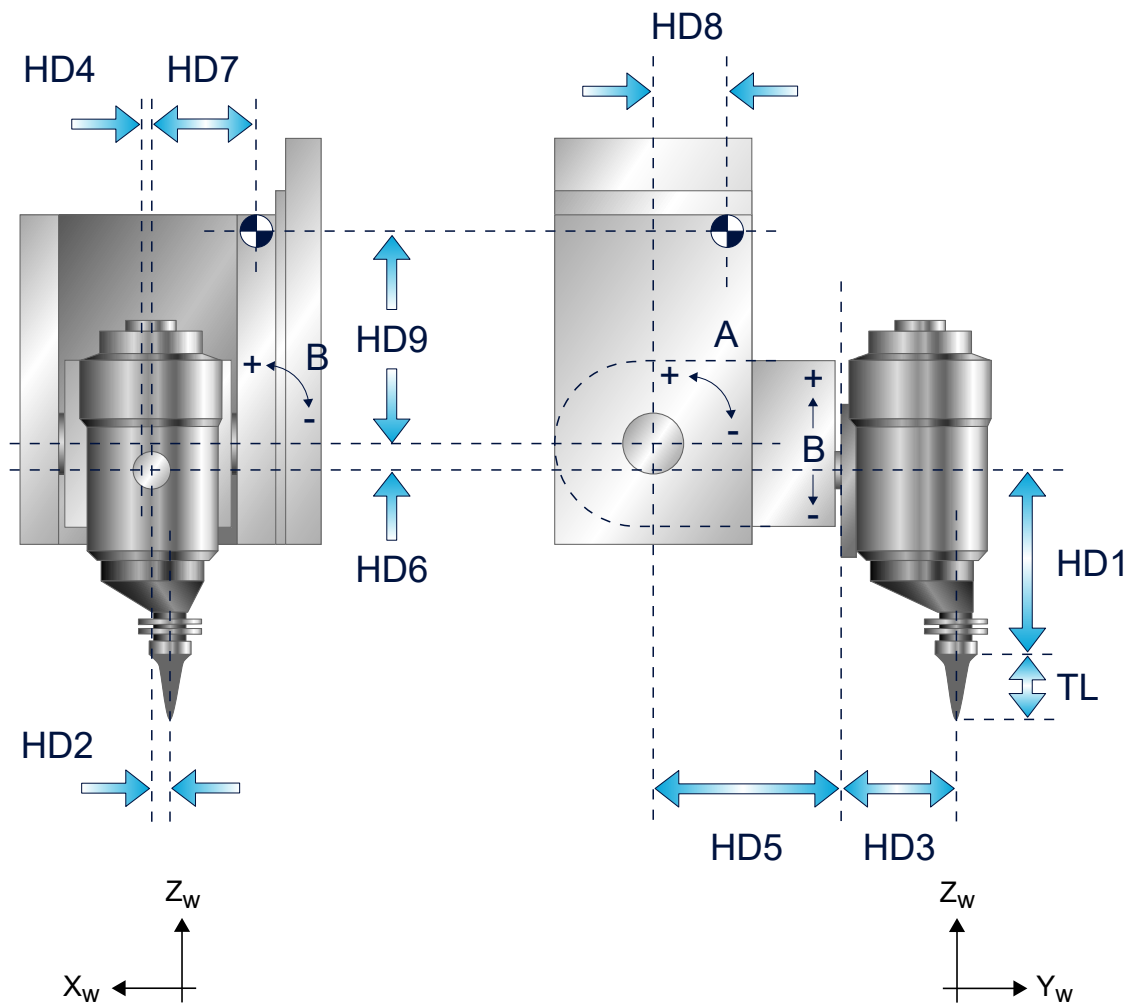


Fig. 44: Parameters of AB tool head

6.2.4.2 Parameters for BA orientation head

Parameters are defined under the ID 90 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	Z axis offset to the tool fixing point	1.0 E-4 mm
HD2	1	X axis offset to the tool fixing point	1.0 E-4 mm
HD3	2	Y axis offset to the tool fixing point	1.0 E-4 mm
HD4	3	X axis offset rotation point B axis to rotation point A axis	1.0 E-4 mm
HD5	4	Y axis offset rotation point B axis to rotation point A axis	1.0 E-4 mm
HD6	5	Z axis offset rotation point B axis to rotation point A axis	1.0 E-4 mm
HD7	6	X axis offset zero point to rotation point B axis	1.0 E-4 mm
HD8	7	Y axis offset zero point to rotation point B axis	1.0 E-4 mm
HD9	8	Z axis offset zero point to rotation point B axis	1.0 E-4 mm
HD10	9	n.a.	
HD11	10	n.a.	
HD12	11	Angle offset U/V axis	1.0 E-4°
HD13	12	Orientation head, sequence of rotary axes 0: AB 1: BA	[-]
HD14	13	PCS angle programming 0: same as orientation head 1: CA	[-]
HD15	14	Rotation direction AM 0: math positive 1: math negative	[-]
HD16	15	Rotation direction BM 0: math positive 1: math negative	[-]
HD17	16	Angle offset AM	1.0 E-4°
HD18	17	Angle offset BM	1.0 E-4°

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

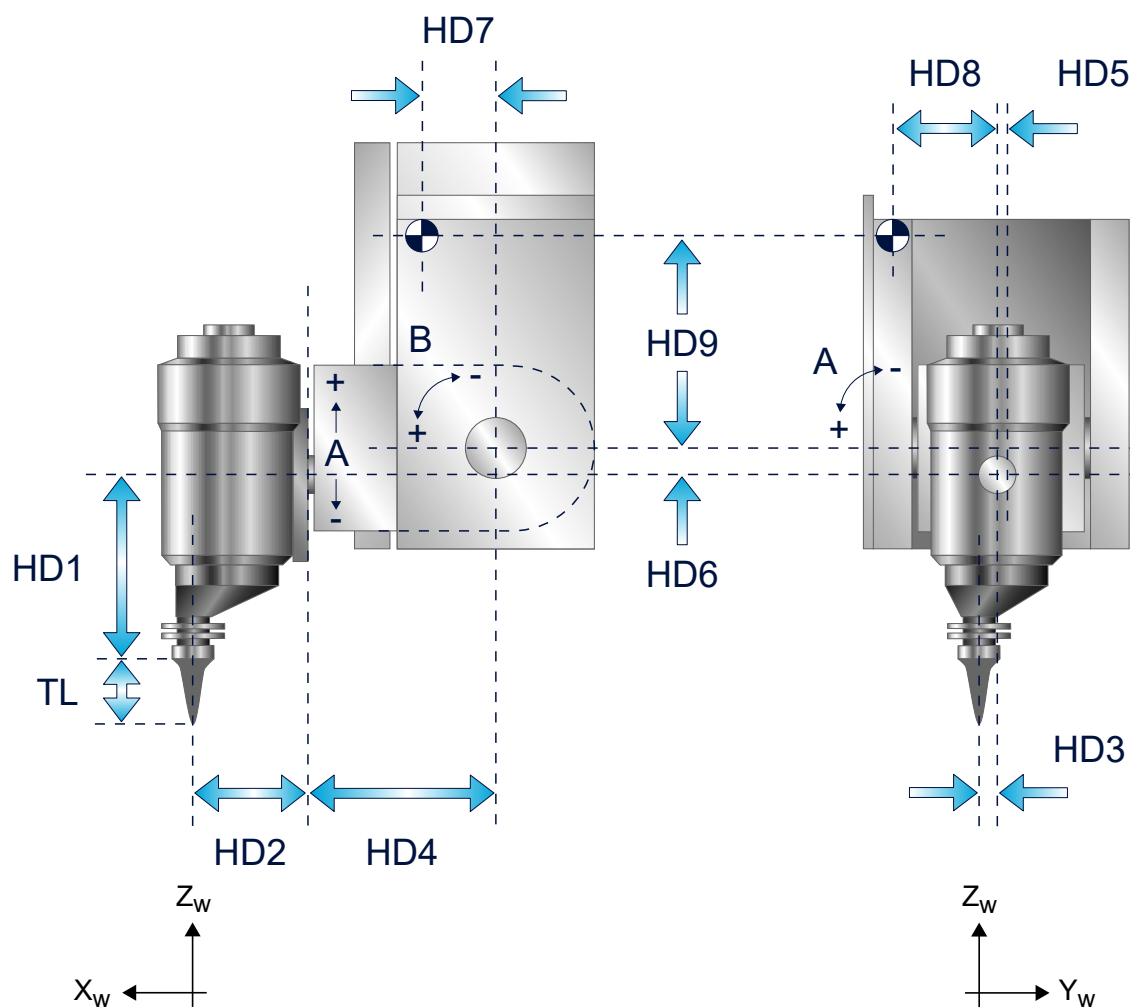


Fig. 45: Parameters for BA orientation head

6.2.4.3 Parameters for CA orientation head

Parameters are defined under the ID 90 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	Z axis offset to the tool fixing point	1.0 E-4 mm
HD2	1	X axis offset to the tool fixing point	1.0 E-4 mm
HD3	2	Y axis offset to the tool fixing point	1.0 E-4 mm
HD4	3	X axis offset rotation point C axis to rotation point A axis	1.0 E-4 mm
HD5	4	Y axis offset rotation point C axis to rotation point A axis	1.0 E-4 mm
HD6	5	Z axis offset rotation point C axis to rotation point A axis	1.0 E-4 mm
HD7	6	X offset reference point to rotation point C axis	1.0 E-4 mm
HD8	7	Y offset reference point to rotation point C axis	1.0 E-4 mm
HD9	8	Z offset reference point to rotation point C axis	1.0 E-4 mm
HD10	9	n.a.	
HD11	10	n.a.	
HD12	11	Angle offset U/V axis	1.0 E-4°
HD13	12	Orientation head, sequence of rotary axes 2: CA 4: CB	[-]
HD14	13	-	
HD15	14	Rotation direction CM 0: math positive 1: math negative	[-]
HD16	15	Rotation direction AM 0: math positive 1: math negative	[-]
HD17	16	Angle offset CM	1.0 E-4°
HD18	17	Angle offset AM	1.0 E-4°

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

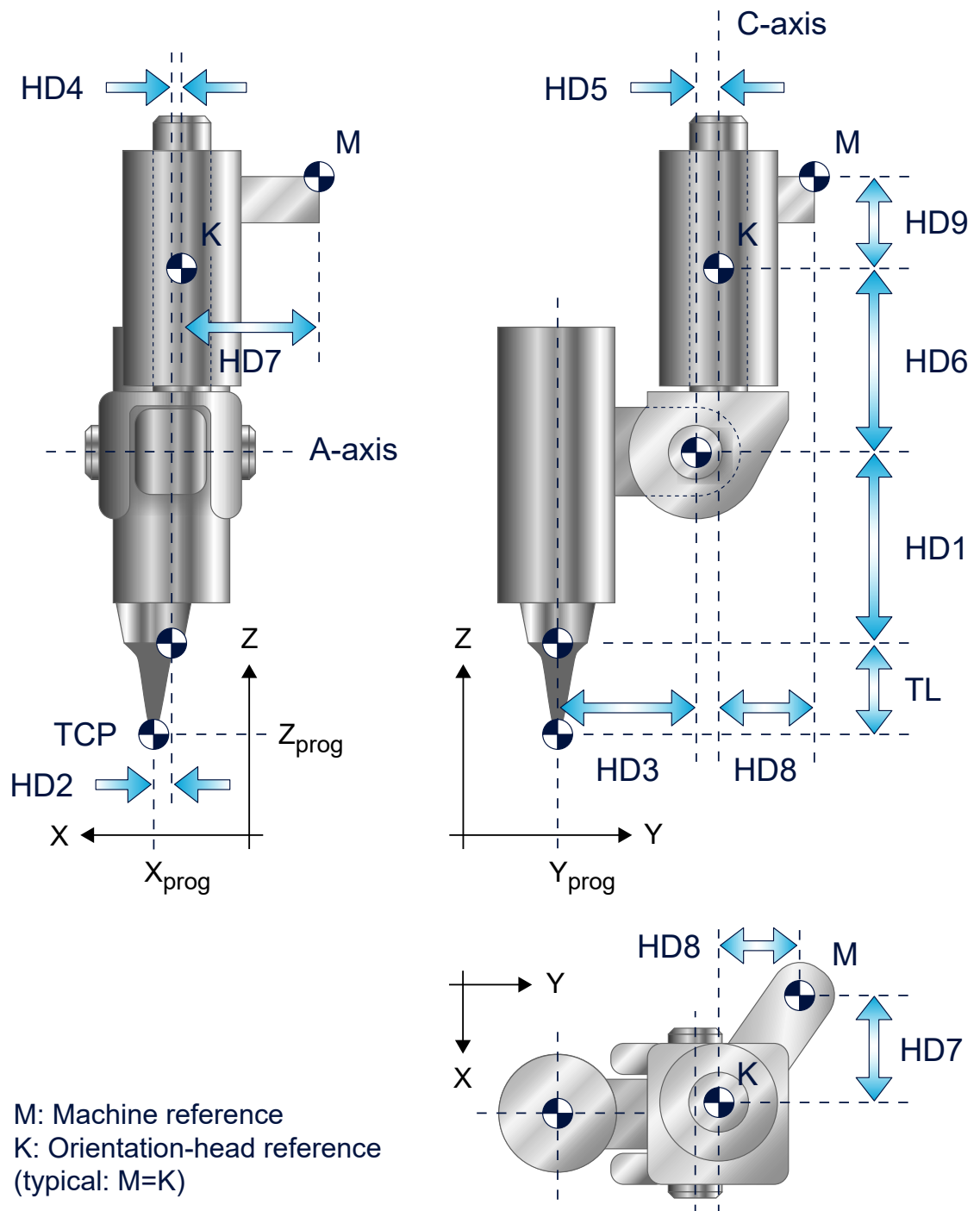


Fig. 46: Parameters for CA orientation head

6.2.4.4 Parameters for CB orientation head

Parameters are defined under the ID 90 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	Z axis offset to the tool fixing point	1.0 E-4 mm
HD2	1	X axis offset to the tool fixing point	1.0 E-4 mm
HD3	2	Y axis offset to the tool fixing point	1.0 E-4 mm
HD4	3	X axis offset rotation point C axis to rotation point B axis	1.0 E-4 mm
HD5	4	Y axis offset rotation point C axis to rotation point B axis	1.0 E-4 mm
HD6	5	Z axis offset rotation point C axis to rotation point B axis	1.0 E-4 mm
HD7	6	X axis offset zero point to rotation point B axis	1.0 E-4 mm
HD8	7	Y axis offset zero point to rotation point B axis	1.0 E-4 mm
HD9	8	Z axis offset zero point to rotation point B axis	1.0 E-4 mm
HD10	9	n.a.	
HD11	10	n.a.	
HD12	11	Angle offset U/V axis	1.0 E-4°
HD13	12	Orientation head, sequence of rotary axes 2: CA 4: CB	[-]
HD14	13	-	
HD15	14	Rotation direction CM 0: math positive 1: math negative	[-]
HD16	15	Rotation direction BM 0: math positive 1: math negative	[-]
HD17	16	Angle offset CM	1.0 E-4°
HD18	17	Angle offset BM	1.0 E-4°

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

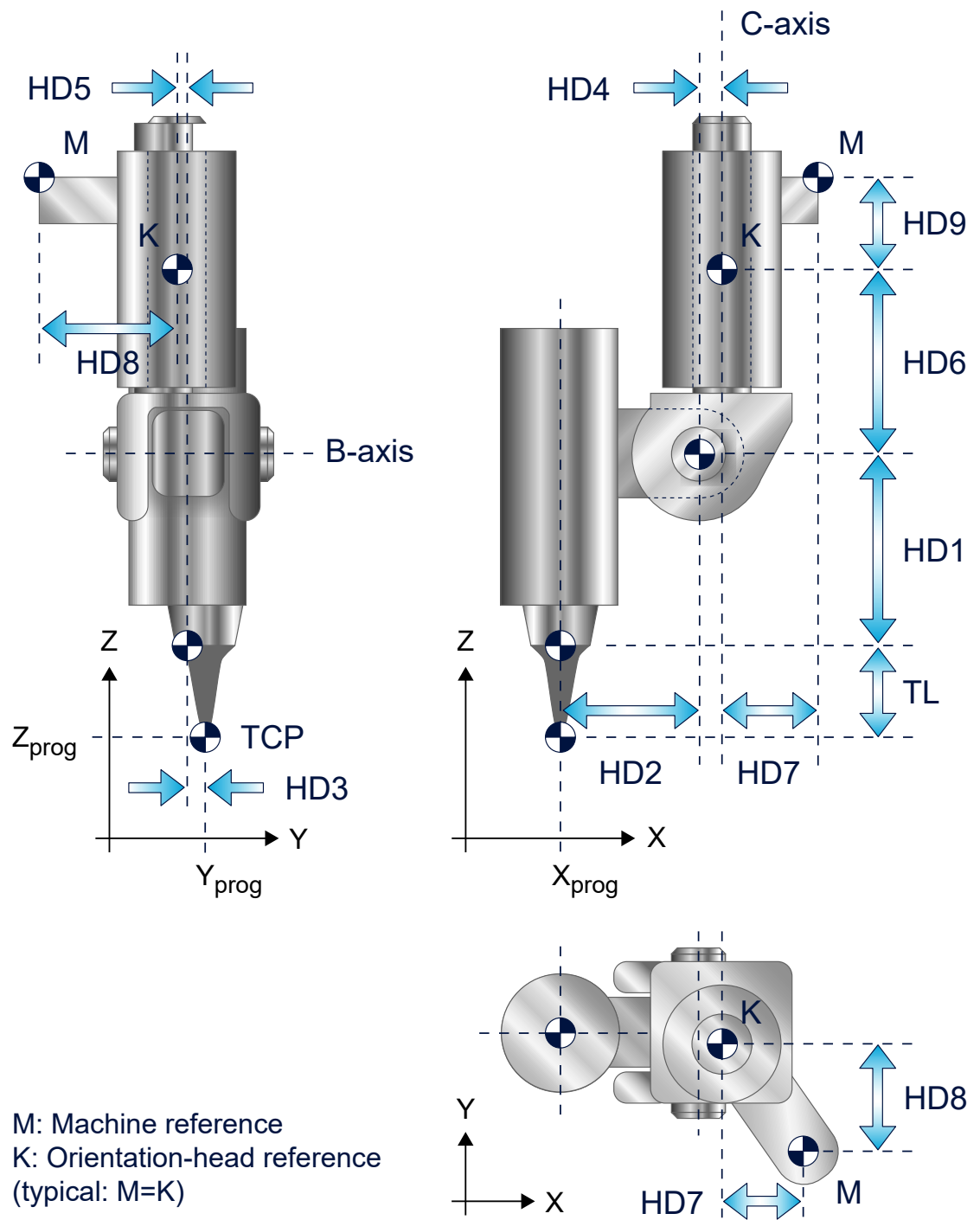


Fig. 47: Parameters for CB orientation head

6.2.4.5 Parameters for CA cardanic orientation head

Parameters are defined under the ID 90 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	n.a.	
HD2	1	n.a.	
HD3	2	Head angle	1.0 E-4°
HD4	3	n.a.	
HD5	4	n.a.	
HD6	5	Orientation C axis head; required if head has a 180° offset in zero position. 0: Default 1: 180 degree offset	[-]
HD7	6	X offset reference point to rotation point C axis	1.0 E-4 mm
HD8	7	Y offset reference point to rotation point C axis	1.0 E-4 mm
HD9	8	Z offset reference point to rotation point C axis	1.0 E-4 mm
HD10	9	n.a.	
HD11	10	n.a.	
HD12	11	Angle offset U/V axis	1.0 E-4°
HD13	12	Orientation head, sequence of rotary axes: 2: CA 8: CA cardanic	[-]
HD14	13	n.a.	
HD15	14	X offset to tool holding device	1.0 E-4 mm
HD16	15	Y offset to tool holding device	1.0 E-4 mm
HD17	16	Z offset to tool holding device	1.0 E-4 mm
HD18	17	X offset A axis to C axis	1.0 E-4 mm
HD19	18	Y offset A axis to C axis	1.0 E-4 mm
HD20	19	Z offset A axis to C axis	1.0 E-4 mm

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

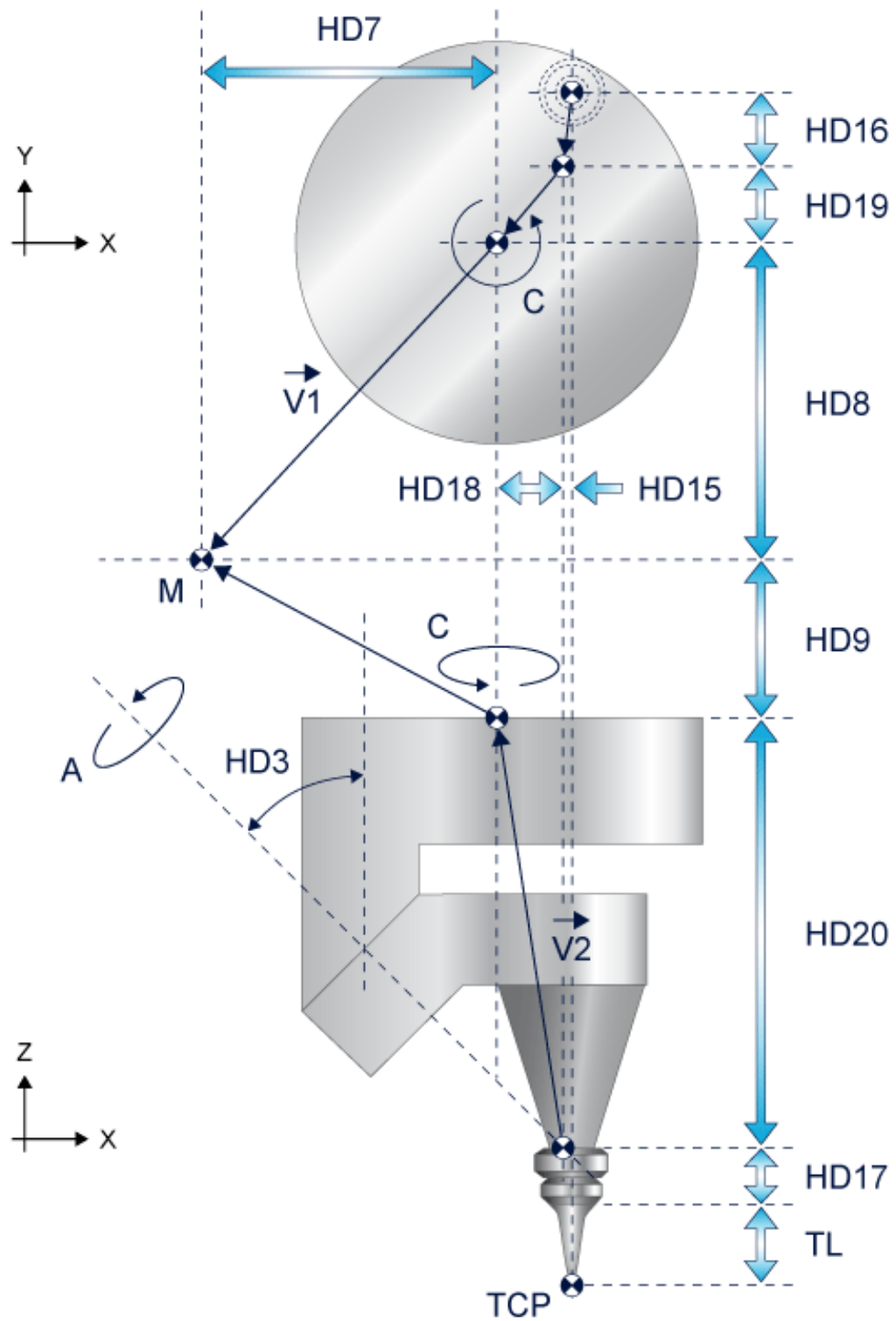


Fig. 48: Cardanic head in zero position, HD6=0

6.2.4.6 Parameters for AU kinematics

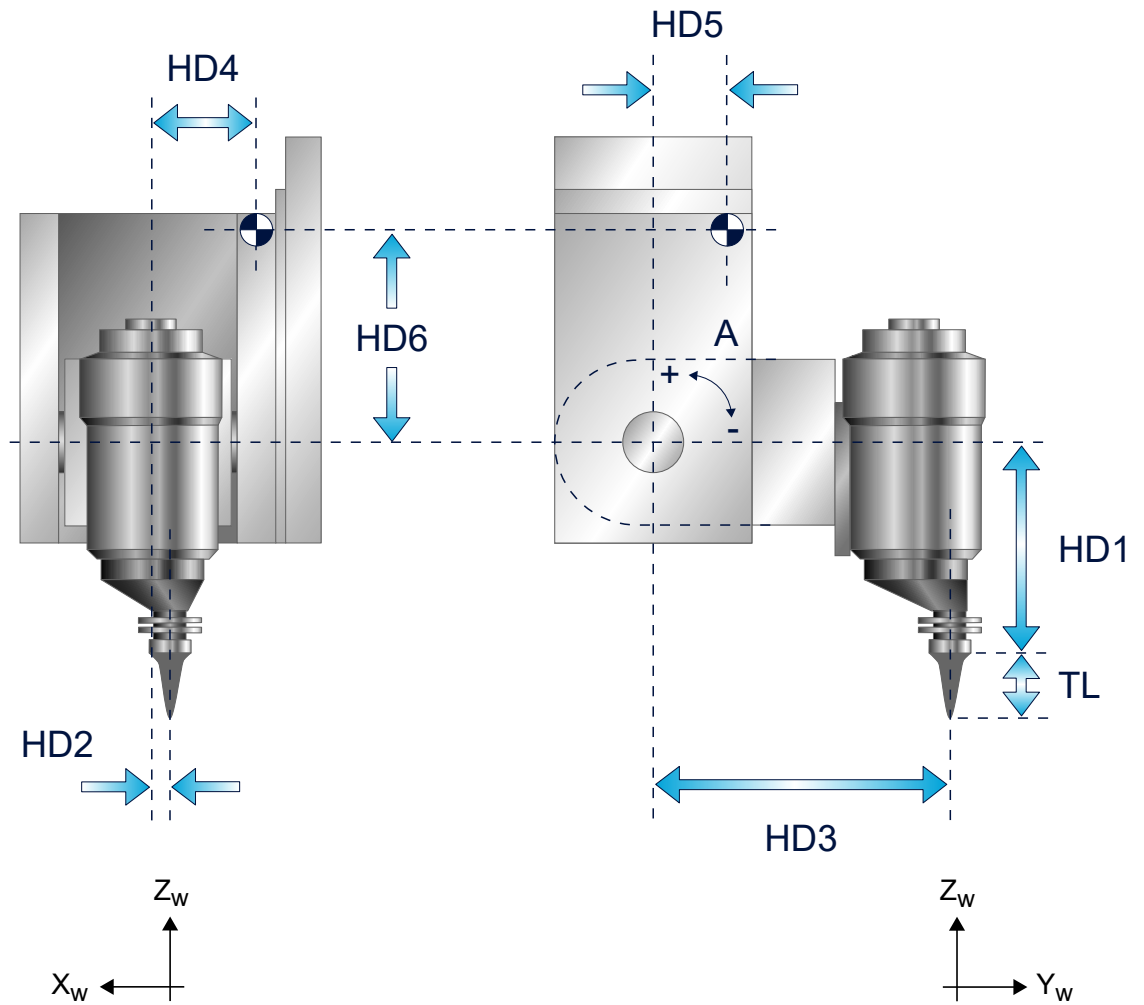


Fig. 49: Parameters of AU tool head

Parameters are defined under the ID 90 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	Z axis offset to the tool fixing point	1.0 E-4 mm
HD2	1	X axis offset to the tool fixing point	1.0 E-4 mm
HD3	2	Y axis offset to the tool fixing point	1.0 E-4 mm
HD4	3	X offset rotation point A axis to reference point tool slide	1.0 E-4 mm
HD5	4	Y offset rotation point A axis to reference point tool slide	1.0 E-4 mm
HD6	5	Z offset rotation point A axis to reference point tool slide	1.0 E-4 mm
HD7	6	X offset to machine origin	1.0 E-4 mm
HD8	7	Y offset to machine origin	1.0 E-4 mm
HD9	8	Z offset to machine origin	1.0 E-4 mm
HD10	9	n.a.	
HD11	10	n.a.	
HD12	11	Angle offset U/V axis	1.0 E-4°
HD13	12	Machine structure 9 : A U 10: B V	[-]
HD14	13	PCS angle programming 0: same as kinematic 1: CA	[-]
HD15	14	Rotation direction AM 0: math positive 1: math negative	[-]
HD16	15	Rotation direction BM 0: math positive 1: math negative	[-]
HD17	16	Angle offset AM	1.0 E-4°
HD18	17	Angle offset BM	1.0 E-4°

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

6.2.4.7 Parameters for BV kinematics

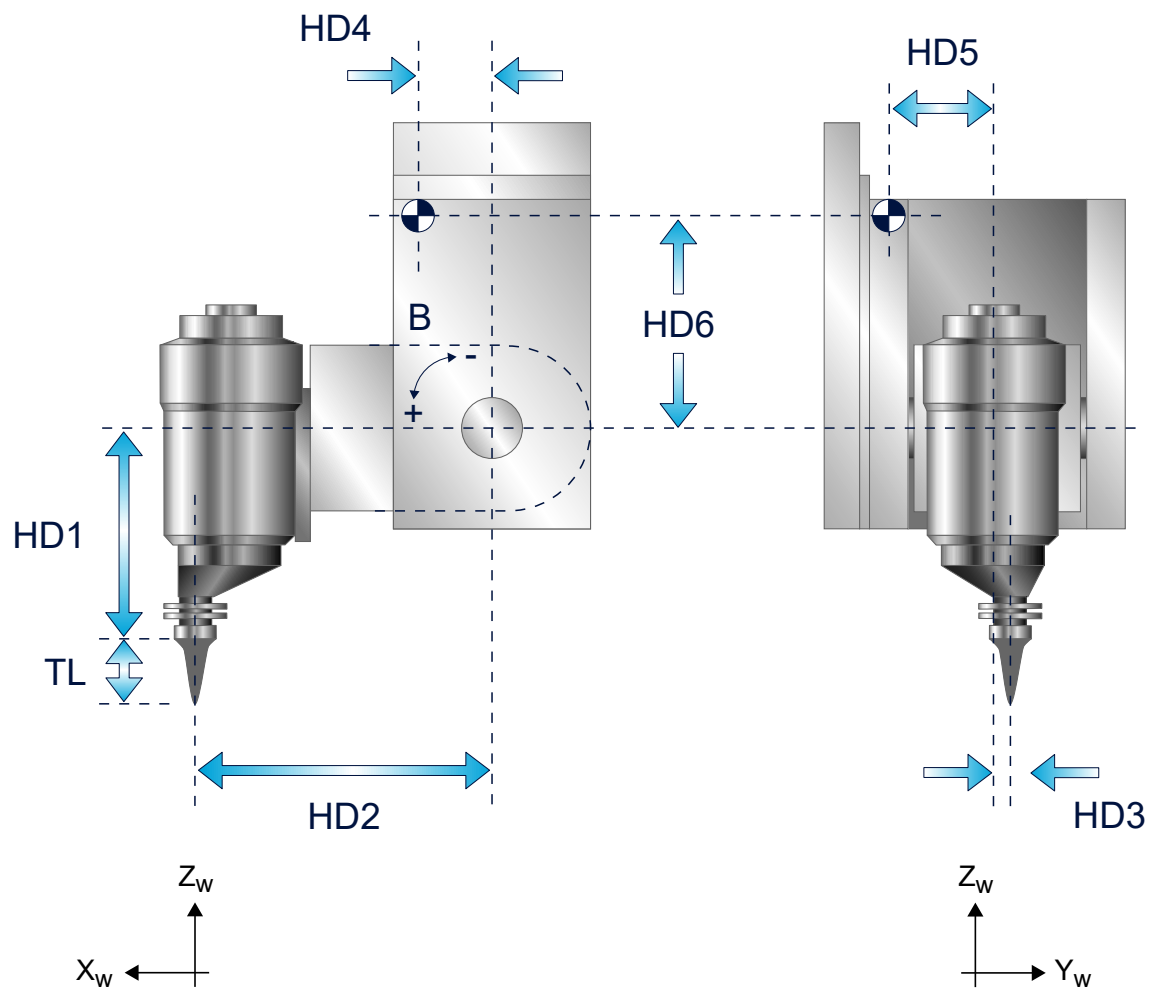


Fig. 50: Parameters of BV tool head

Parameters are defined under the ID 90 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

HD offset	param[i]	Description	Unit
HD1	0	Z axis offset to the tool fixing point	1.0 E-4 mm
HD2	1	X axis offset to the tool fixing point	1.0 E-4 mm
HD3	2	Y axis offset to the tool fixing point	1.0 E-4 mm
HD4	3	X offset rotation point B axis to reference point tool slide	1.0 E-4 mm
HD5	4	Y offset rotation point B axis to reference point tool slide	1.0 E-4 mm
HD6	5	Z offset rotation point B-axis to reference point tool slide	1.0 E-4 mm
HD7	6	X offset to machine origin	1.0 E-4 mm
HD8	7	Y offset to machine origin	1.0 E-4 mm
HD9	8	Z offset to machine origin	1.0 E-4 mm
HD10	9	n.a.	
HD11	10	n.a.	
HD12	11	Angle offset U/V axis	1.0 E-4°
HD13	12	Machine structure 9 : A U 10: B V	[-]
HD14	13	PCS angle programming 0: same as kinematic 1: CA	[-]
HD15	14	Rotation direction AM 0: math positive 1: math negative	[-]
HD16	15	Rotation direction BM 0: math positive 1: math negative	[-]
HD17	16	Angle offset AM	1.0 E-4°
HD18	17	Angle offset BM	1.0 E-4°

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

6.2.5 Polygonal tube, profiled tube (5/6-axis) (kinematic ID 93)

Configuration

Kinematic 93 is configured in analogy to kinematic 90 in section "Round tube, lateral surface (5/6-axis) [► 91]". In addition the user can specify kinematic parameters as of index 23. The parameters correspond to kinematic 79 described in section "Polygonal tube, profiled tube [► 85]" (i.e. Index 23 in kinematic 93 corresponds to Index 3 in kinematic 79 etc.).

As an example the configuration here is shown of an AB orientation head. Parameterisation is analogous for all other orientation heads.

Note: All offsets starting from Index 20 act as static offsets, i.e. they are not influenced by rotations within the head.

6.2.5.1 Parameters for AB and BV orientation head

Parameters are defined under the ID 93 of the kinematic offsets (P-CHAN-00263 and P-CHAN-00094).

The parameters in the AB and BV configurations only differ in the assignment of HD13.

HD offset	param[i]	Description	Unit
HD1	0	Z axis offset to the tool fixing point	1.0 E-4 mm
HD2	1	X axis offset to the tool fixing point	1.0 E-4 mm
HD3	2	Y axis offset to the tool fixing point	1.0 E-4 mm
HD4	3	X offset rotation point A axis to. rotation point B axis	1.0 E-4 mm
HD5	4	Y axis offset rotation point A axis to rotation point B axis	1.0 E-4 mm
HD6	5	Z axis offset rotation point A axis to rotation point B axis	1.0 E-4 mm
HD7	6	X axis offset zero point to rotation point A axis	1.0 E-4 mm
HD8	7	Y axis offset zero point to rotation point A axis	1.0 E-4 mm
HD9	8	Z axis offset zero point to rotation point A axis	1.0 E-4 mm
HD10	9	n.a.	
HD11	10	n.a.	
HD12	11	Angle offset U/V axis	1.0 E-4°
HD13	12	Orientation head, sequence of rotary axes 0 : AB 10: BV	[-]
HD14	13	PCS angle programming 0: same as orientation head 1: CA	[-]
HD15	14	Rotation direction AM, , 0: math positive 1: math negative	[-]
HD16	15	Rotation direction BM 0: math positive 1: math negative	[-]
HD17	16	Angle offset AM	1.0 E-4°
HD18	17	Angle offset BM	1.0 E-4°
HD19	18	n.a.	
HD20	19	n.a.	
HD21	20	n.a.	
HD22	21	n.a.	
HD23	22	n.a.	
HD24	23	Z offset of rotary axis U to machine zero point (MNP)	1.0 E-4 mm
HD25	24	X offset of rotary axis U to machine zero point	1.0 E-4 mm
HD26	25	Y offset of rotary axis U to machine zero point	1.0 E-4 mm
HD27	26	-	
HD28	27	Angle offset of workpiece clamp position	1.0 E-4°

The general description is contained in the channel parameter list under P-CHAN-00263 and P-CHAN-00094.

7 Appendix

7.1 Suggestions, corrections and the latest documentation

Did you find any errors? Do you have any suggestions or constructive criticism? Then please contact us at documentation@isg-stuttgart.de. The latest documentation is posted in our Online Help (DE/EN):



QR code link: <https://www.isg-stuttgart.de/documentation-kernel/>

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