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MT-CNC
Free Plane Selection and Lateral Cylinder Surface Machining V16

Application Manual

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Purpose of the document This document assists the machine manufacturer in implementing parallel axes and telescopic axes and in providing the lateral cylinder machining function.

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Contents

1 Introduction

Utilization

Free plane selection is chiefly used

- in large machining stations and handling systems for operation with parallel and telescopic axes;
- in turning and milling machines for lateral cylinder surface machining;
- in special machines for generating any (e.g. sinusoidal) movement s equences of any axes.

2 Basic Considerations

2.1 Axis Definition (Axis Functionality)

Definition

The axis definition characterizes the functionality of an axis. The table below provides a summary of the different combinations of axis definition and related axis functions that are available in each of the seven processes of the MT-CNC.

Axis definition	Symbol	No.	Axis position	Axis function
Feed axes (linear and rotary main and slave axes)	X Y Z U V W A B C	1 2 3 4 5 6 7 8 9	Abscissa Ordinate Applicate	**Functions of all feed axes:** • Absolute or incremental programming • Specification of the units • Reference point return • Zero offsets • Mirroring and scaling • Driving against hard stop • Low-lag interpolation • Speed-optimized block transition • Exact stop • Programmable path acceleration • Linear interpolation • Time programming • Velocity programming • Feed per revolution • Follower and Gantry axes
1. linear main axis 2. linear main axis 3. linear main axis	X Y Z	1 2 3	Abscissa Ordinate Applicate	**Functions of all linear main axes:** • Plane selection • Thread cutting • Tapping **Functions within the working plane:** • Circular interpolation • Tool radius compensation (R_{total}) • Tool length compensation ($L1/L2_{total}$) • Torsion • Transformation functions for facing and lateral cylinder surface machining **Functions of the axis that is perpendicular to the machining plane:** • Tool length compensation ($L3_{total}$) **Functions of the first linear main axis:** • Radius/diameter programming • Constant surface speed

Axis definition	Symbol	No.	Axis position	Axis function
1. linear or rotary secondary axis 2. linear or rotary secondary axis 3. linear or rotary secondary axis	U V W	4 5 6	any position and orientation	-
1. rotary main axis 2. rotary main axis 3. rotary main axis	A B C	7 8 9	rotates around abscissa rotates around ordinate rotates around applicate	**Functions of the rotary main axes:** • Effective radii
1. spindle 2. spindle 3. spindle	S1 S2 S3	10 11 12	parallel to the main axes	**Functions of the spindles:** • Speed specification • Position specification • Constant surface speed • Speed limitation • Selection of reference spindle • Thread cutting • Tapping • Feed per revolution • Gear shifting • Main spindle synchronization

Tab. 2-1: Axis definition and axis functionality

Note:

Using the axis parameter 'axis definition' (axis functionality) makes it possible to allocate one or more axis functionalities to any axis.

2.2 Working Plane

G17
G18
G19

The previous NC commands G17, G18 and G19 select the working plane and the axis that is perpendicular to the working plane within a cartesian coordinate system that consists of the axes designated X, Y and Z (axes that have the functionality of linear main axes).

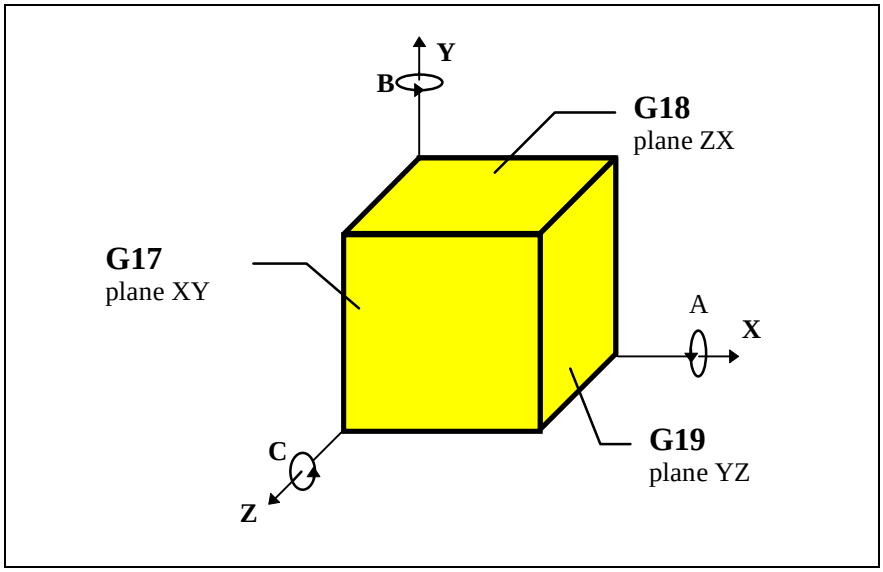


Fig. 2-1: G17, G18 and G19 working planes

G code	Definition of the 1st axis of the working plane	Definition of the 2nd axis of the working plane	Definition of the perpendicular axis
G17	X	Y	Z
G18	Z	X	Y
G19	Y	Z	X

Tab. 2-2: Axis definition

2.3 Using Parallel Axes for Machining

Definition

Parallel axes are axes that lie in parallel to the linear main axes (designated X, Y or Z). They are designated U, V or W.

Example

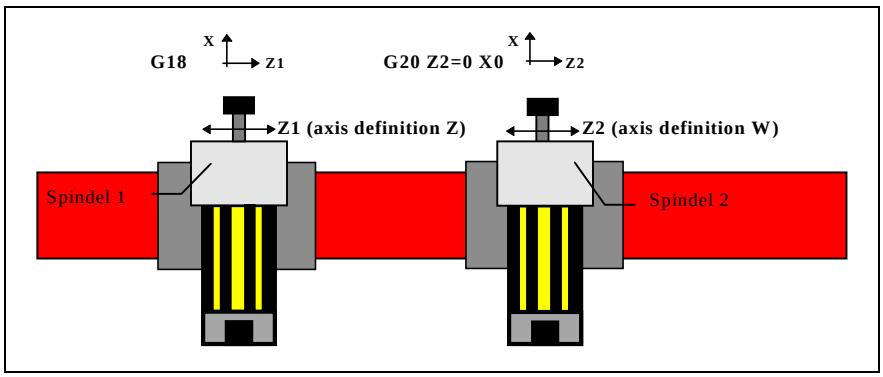


Fig. 2-2: Example: Using parallel axes for machining

Utilization

Parallel axes are not usually programmed within the NC program. Using the 'tracking' function, they are linked to the linear main axes.

Parallel machining requires the tools to possess the same dimensions, and the master and slave axes to return to their reference positions first. Merely the tool lengths in the direction of the master and slave axis may be different. They can be compensated by travelling to different start positions. Free plane selection significantly simplifies the approach to the tool correction positions. During machining, the NC only considers the tool data record of the active tool in the selected spindle.

In applications where the parts that shall be machined in parallel differ from each other (i.e. the axes must perform different tasks) or where the parallel axes are equipped with different tools, (e.g. due to a limited tool storage), free plane selection enables the parallel axes (axis definition U, V, W) to have the functionality of the linear main axes (axis definition X, Y, Z) allocated. Irrespective of the other axes, the parallel axes can perform the necessary machining tasks (such as circular movements that take the tool path correction into account).

2.4 Using Telescopic Axes for Machining

Definition

Telescopic axes are two or more axes that are mechanically coupled with each other such that their motion paths add or subtract. Usually, the travel range of one of the telescopic axes is larger (this axis is used for coarse positioning), and the travel range of the other one is smaller (used for fine positioning).

Example

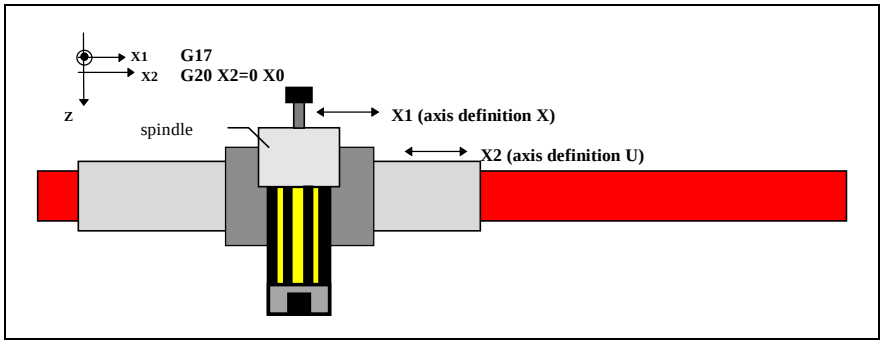


Fig. 2-3: Example: Using telescopic axes for machining

Application

The user programs the axis that is used for coarse positioning at the beginning of a new machining sequence and in exceptional cases only. This may be when circular movements, thread cutting or tapping movements shall be performed that are not possible due to the limited travel range of the fine positioning axis. Further reasons may be the mechanical structure if, for example, an angle head tool can only be moved in conjunction with the coarse positioning axis.

In power-on state, the fine positioning axes has the functionality of a linear main axis (axis definition X, Y or Z). The other one has the functionality of a slave axis (axis definition U, V or W). In the course of the machining process, the user may allocate the coarse positioning axis the axis definition X, Y, or Z, as required.

2.5 Lateral Cylinder Surface Machining

Definition

In lateral cylinder surface machining, the NC generates straight lines and circles according to the G00, G01, G02, and G03 blocks that are specified in the NC program. The straight lines and circles on the lateral cylinder surface may be programmed on the plane of the developed cylinder that is spanned by a linear axis and a rotary axis.

Example

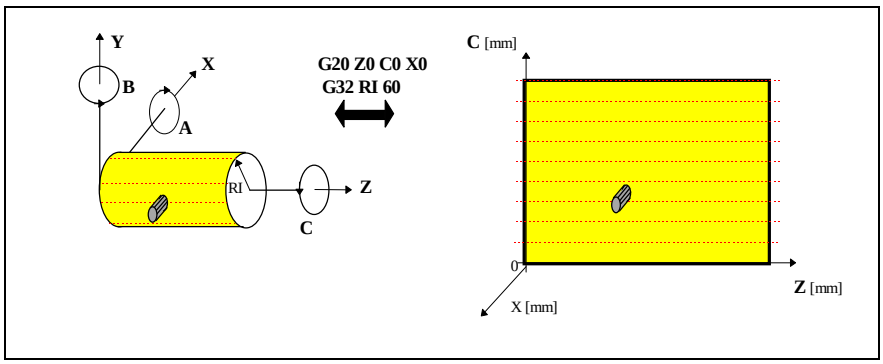


Fig. 2-4: Lateral cylinder surface machining

Application

In lateral cylinder surface machining, the participating rotary axis obtains the functionality of a linear main axis. This enables the user to use its functions (such as tool radius path correction and zero shifts including torsion) in the course of lateral cylinder surface machining.

Programming

The programming engineer may program the rotary axis that participates in lateral cylinder surface machining in [mm] or in [inch], like a linear axis (by specifying positions on the lateral cylinder surface).

2.6 Lateral Cone Surface Machining

Definition

If, in addition to the rotary and linear axes, there is another linear axis that performs an approach movement during the interpolation motion (3D linear interpolation or helical interpolation during lateral cylinder surface machining), straight lines and circles may also be generated on a lateral cone surface.

Programming

It must be observed that contour errors will manifest as the cone gradient increases (despite an average effective distance).

3 Free Plane Selection

3.1 Basics

Method of operation

Free plane selection enables

- the axes that make up the cartesian coordinate system to be selected, and
- to define the working plane and the axis that is perpendicular to the working plane within the coordinate system that is spanned by the linear main axes.

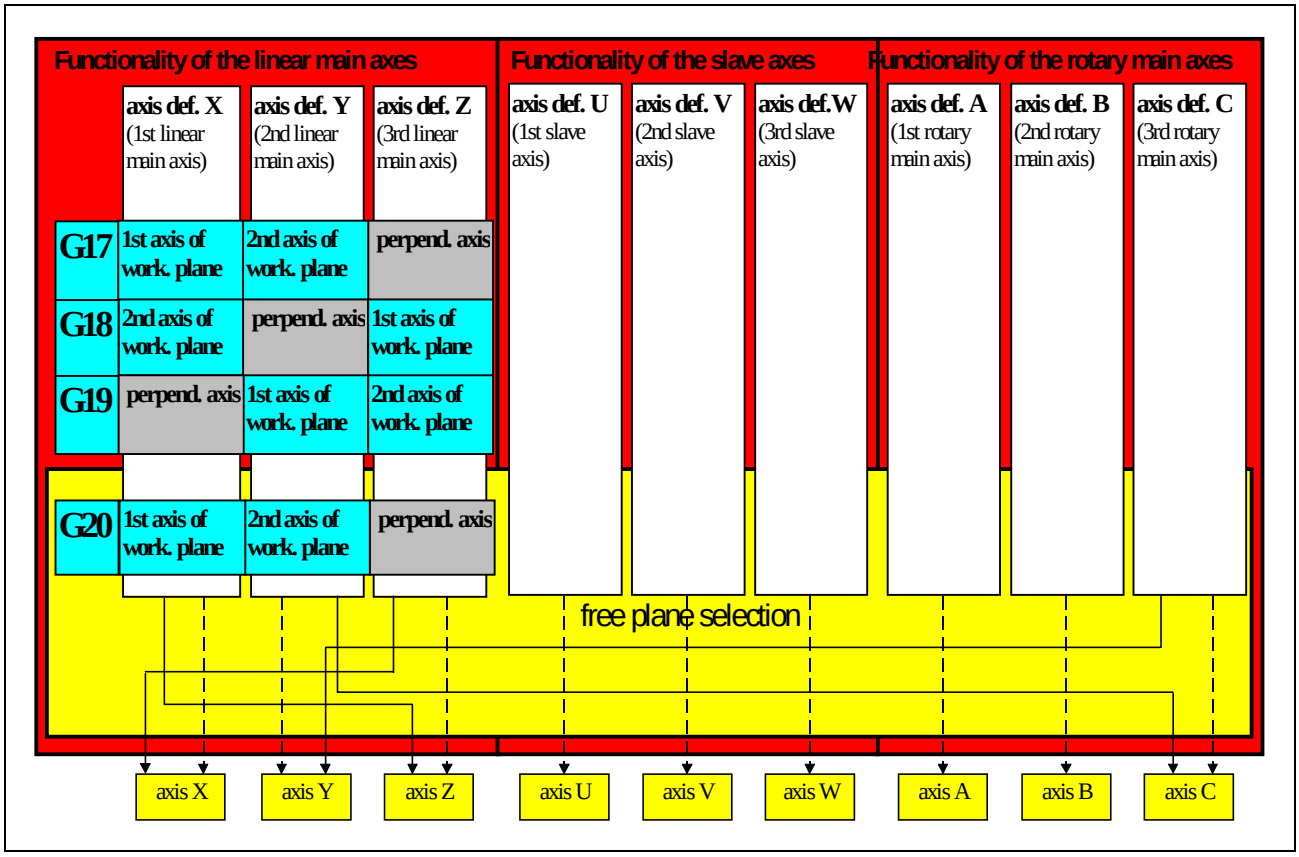


Fig. 3-1: Basic method of operation of the free plane selection
(example: lateral cylinder surface machining with G20 Z0 C0 X0)

Programming

Free plane selection employs G20. The user may, in succession, specify the axes that shall have the functionality assigned of the 1st axis of the working plane, of the 2nd axis of the working plane and of the axis that is perpendicular to the working plane.

3.2 Programming

Syntax

G20 [1st axis of the plane] [2nd axis of the plane] {perpendicular axis}

[ ]: Mandatory parameter of free plane selection
{ }: Optional parameter
1st axis of the plane, 2nd axis of the plane, and axis that is perpendicular to the plane:

Axis designation : = axis letter + axis index
Axis letter ∈ (X, Y, Z, U, V, W, A, B, C}
Axis index ∈ (‘ ‘, 1, 2, 3)

Boundary conditions

- An axis (axis designation) may only occur once within a G20 command.
- Tool storage axes and spindles are excepted.
- With G20, the user may program either two or three axes.
- The working plane can be spanned by up to two rotary axes.
- The third axis (that is perpendicular to the plane) must be a linear axis.
- If an NC block contains a G20 command, no further axis designations may be programmed in addition to the free plane selection.
- The NC automatically retains the current axis if the axis that is perpendicular to the working plane has not been specified.
- Each axis designation must have a '0' added.
- The commands G17 through G20 form a group (G code group 2).
- A change in the plane selection overwrites the previous plane selection, and has a modal effect.
- Upon the end of the program (BST, RET, JMP, M02 and M30), after control-reset, and in changeover to manual mode with the 'Manual axis jogging causes reset' process parameter being set, the NC selects the base coordinate system that has been selected in the parameters (axis parameter Css.053 'Axis defined in the RIGHT HAND COORD. System as ...') and selects the working plane that has also been defined there (process parameter Bxx.004 'Default interpolation plane').
- In the 'Axis definition (axis functionality)' axis parameters, the machine manufacturer must (for safety reasons) allocate the necessary axis functionality to the axes that are executed after the G20 command.

3.3 Example: Turning Centre

Description

Within a process, a turning centre has the following axes:

Axis designation	Axis name	Comment
X1	X	Turning slide
X2	W	Milling slide
Y	Y	For milling
Z	Z	For turning and milling
C	C	For lateral surface machining
B	B	Swivel axis for milling slide
U	U	Tailstock
S1	S1	Main spindle
S2	S2	Tool spindle for milling operation

Tab. 3-3: Axes within a turning centre (process 0)

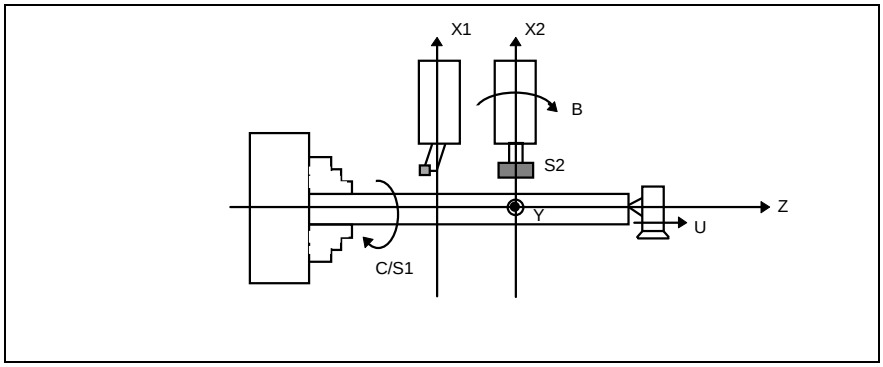


Fig. 3-2: Position of the axes in the turning centre

Selection and axis allocation

To perform the different machining tasks, the following planes are selected during machine operation:

G code	Linear main axes			Secondary axes			Rotary main axes			Work-ing plane	Perp. axis	Comments
	axis s. X	axis s. Y	axis s. Z	axis s. U	axis s. V	axis s. W	axis s. A	axis s. B	axis s. C			
G18	X1	Y	Z	U	-	X2	-	B	C	Z X1	Y	Turning (= power-up state)
G20 X2=0 Y0 Z0	X2	Y	Z	U	-	X1	-	B	C	X2 Y	Z	Milling (corresp. to G17 with X2)
G20 Z0 X2=0 Y0	Z	X2	Y	U	-	X1	-	B	C	Z X2	Y	Milling (corresp. to G18 with X2)
G20 Y0 Z0 X2=0	Y	Z	X2	U	-	X1	-	B	C	Y Z	X2	Milling (corresp. to G19 with X2)
G20 Z0 C0 X2=0 G32 RI=80	Z	C	X2	U	-	X1	-	B	C	C Z	X2	Lateral cylinder surface machin.

Tab. 3-4: Selection and axis allocation

When the coordinate system for the subsequent lateral cylinder surface machining is selected with ‘G20 Z0 C0 X2 0‘, a typical allocation of the axis names can be as follows:

- Starting from the allocations that have been defined in the axis parameters, axis Z has axis definition X allocated, and axis X1 axis definition Z.
- In the second step, axis C has axis definition Y allocated, and axis Y axis definition C.
- In the third step, the NC allocates axis X2 axis definition Z, and axis X1 axis definition W.

3.4 Example: Transfer Machine

Description

In normal operation of a transfer machine that features the axes X, Z1, Z2, S1 and S2 (see Fig 2-2), the working plane G18 (Z1 X) is active (power-up position) and the parallel axis Z2 is the slave axis. This enables the tool correction values to be correctly taken into account.

Selection and axis allocation

In the cases where the part that is to be machined by spindle 2 differs from the part that shall be machined by spindle 1, the slave compounds are de-activated and the NC command

G20 Z2=0 X0

is used for assigning axis definition Z to the parallel axis Z2 and for assigning axis definition Y to the X axis.

For the working planes that are required during operation, the following table shows the axes that span the individual working planes, and the allocation of the axes to the existing axis definitions.

G code	Linear main axes			Secondary axes			Rotary main axes			Working plane	Perp. axis	Comments
	axis s. X	axis s. Y	axis s. Z	axis s. U	axis s. V	axis s. W	axis s. A	axis s. B	axis s. C			
G18	X	-	Z1	-	-	Z2	-	-	-	Z1 X	-	power-up pos.
G20 Z2=0 X0	Z2	-	X	-	-	Z1	-	-	-	Z2 X	-	

Tab. 3-5: Selection and axis allocation

3.5 Zero Shifts

Selectable zero shifts

The structure of the zero shift table is oriented towards the axis definition. Within the table, there is a column for each axis definition that overwrites the user interface with the axis definition and with the axis designation of the allocated axis.

If, during program execution, free plane selection assigns axes functionalities (axis definition) that are different from the original ones, the user interface updates the axis designations above the columns.

Before free plane selection is invoked, the operator can use the additionally displayed axis definition to enter the zero points, that are required for future operation, in the table in a way that is oriented toward axis definition.

WARNING

⇒ The zero shift values must be entered in a way that is oriented toward the axis definition. In conjunction with G20, this means that a separate zero shift value must be entered for each G20 application (provided that zero shift is used for the axes whose axis definition is modified by G20).

3.6 NC Functions

Circle programming

When G20 is active in circle programming, the interpolation parameters I, J and K are allocated as in G17. The interpolation parameter (of the axis that is perpendicular to the working plane) may not be used.

Constant surface speed

The 'Constant surface speed' function belongs to the axis that has axis definition X.

Whenever G20 is used for allocating axis definition X to a different axis, this fact must be taken into account in free plane selection. If, for example, a user employs free plane selection to allocate axis definition X to a rotary axis, and if the 'Constant surface speed' function is active, the NC uses the current actual position of the rotary axis for computing the spindle speed.

Thread cutting, tapping, and feed per revolution

Thread cutting (G33), tapping (G63, G64 and G65) and feed per revolution (G95) are functions of the linear main axes. With the exception of rotary axes, that have axis definition X, Y or Z, all axes are able to perform these functions.

Tool corrections and D corrections

The NC always processes 'Tool cool corrections and D corrections' in the axes with axis definition X, Y or Z. Within the selected working plane (that is spanned by the axes with axis definition X and Y), the NC performs tool radius path correction (with the resulting radius R = R_tool_geometry + R_tool_wear + R_tool_offset + R_D_correction), and the tool length corrections L1 and L2 (with the resulting length values Li = Li_tool_geometry + Li_tool_wear + Li_tool_offset + Li_D_correction, $i \in \{1, 2\}$). In the axis that is perpendicular to the working plane (axis definition Z), the NC includes the tool length correction value L3 into computation (with the resulting length L3 = L3_tool_geometry + L3_tool_wear + L3_tool_offset + L3_D_correction).

If the user allocates a rotary axis the functionality of a linear main axis, the NC includes the tool correction values in the same way in the computation.

Driving against hard stop

The user may employ the 'Driving against stop' (G75) and 'Cancelling all axis pre-loads' (G76) functions even if he or she allocates the axis concerned a different axis definition (different from the first axis definition that has been stored in the axis parameters) via free plane selection.

3.7 Changes When Free Plane Selection is Activated/De-Activated

Constant surface speed

When free plane selection is activated via G20, the controller de-selects the 'Constant surface speed' (G96) function and activates the 'Spindle speed in rpm' (G97) function.

Linear interpolation

In addition, the controller activates linear interpolation (G1) when free plane selection is activated.

4 Lateral Cylinder Surface Machining

4.1 Basics

Method of operation

Lateral cylinder surface machining enables a rotary axis (taking the effective radius into account) to be programmed as a linear axis.

Programming

G32 de-selects lateral cylinder surface machining. The user must specify the effective radius RI on which machining is performed.

4.2 Programming

Syntax

G32 RI w or **G32 RI=w**

w : Value of the effective radius

Effective radius

- Specifying the effective radius RI is mandatory.
- Specifying an effective radius RI ≤ 0 is not permitted.
- The effective radius RI must not be changed when lateral cylinder surface machining is active (previous de-activation with G30 is required).
- If the machining plane is spanned by two rotary axes, the NC takes the effective radius RI for both rotary axis into account.

Note:

- The commands G30 (de-selecting the transformation function), G31 (facing), and G32 (lateral cylinder surface machining) form the 'Transformation function' G code group (No. 17).
- Upon the end of the program (BST, RET, JMP, M02 and M03), after control-reset, and in changeover to manual mode with the 'Manual axis jogging causes reset' process parameter being set, the NC de-selects lateral cylinder surface machining.

WARNING

⇒ Lateral cylinder surface machining (G31) must first be activated for rotary axes with axis definition X, Y or Z, that shall perform circular interpolation, tool length correction, tool radius path correction, or torsion.

⇒ At least one rotary axis must span the activated working plane before lateral cylinder surface machining is activated.

4.3 Rotary Axes

Rotary axis types

Rotary axes are subdivided into:

- Limited rotary axes ('rotary axis' axis type, and both travel limits are different from each other); and
- endlessly turning rotary axes
- endlessly turning rotary axes ('main spindle with rotary axis capability' or 'rotary axis' axis type, and the value '0' has been stored in the axis parameters for both travel limits).

Travel limits

During lateral cylinder surface machining, the NC monitors the limited rotary axes as in normal operation.

Unit

During lateral cylinder surface machining, rotary axes must be programmed in [mm] or in [inch].

Effective radius RI

- The NC employs the effective radius RI to convert the angle values into arc values.
- The effective radius RI has a modal effect. The NC retains the effective radius until lateral cylinder surface machining is de-activated.
- If the effective radius RI assumes the value

  $r = n/(2 * \pi)$ [mm] or [inch] n: division per revolution [units]

  the distance covered on the lateral cylinder surface corresponds to the covered angle. This value is known as the unit radius.

4.4 Changes When Lateral Cylinder Surface Machining is Selected/De-Selected

Diameter programming

When lateral cylinder surface machining is activated, the NC automatically switches over to radius programming (G15).

Upon de-selection, the NC restores the 'Radius programming' (G15) or 'Diameter programming' (G16) programming mode that has been stored in the process parameters.

WARNING

⇒ If 'Diameter programming' (G16) is selected during lateral cylinder surface machining, the NC interprets all position values of the axis with axis definition X as diameter values.

Zero shift

WARNING

⇒ The NC de-activates all zero shifts and sets G53 when lateral cylinder surface machining is selected or de-selected.

Note:
The zero shift values of a rotary axis with axis definition X, Y, or Z must be entered in [mm] or [inch] in the zero shift table.

The NC always interprets the programmable zero shifts of a rotary axis of axis definition X, Y or Z in [mm] or [inch].

4.5 Coordinate Systems and Direction of Rotation

Definition of the coordinate system for lateral cylinder surface machining

Below, the cases of machining before and after the rotation centre are shown for the two coordinate systems that are possible in a turning machine.

Starting from the machine coordinate system, the user employs G20 (for example: G20 Z0 C0 X0) to define the new coordinate system that is required for lateral cylinder surface machining, activates lateral cylinder surface machining, and uses the zero point shift values to move the new coordinate system that is required for lateral cylinder surface machining.

Provided that the machine manufacture has entered them, the NC employs 'axis designation 2' instead of 'axis designation 1' (that has been stored in the machine parameters) for the two axes that span the current working plane (in the example: for Z → Z1 and for C → Y1). This is done when lateral cylinder surface machining is activated.

Definition of the direction of rotation

Using the direction-of-rotation bit (axis parameter 'Direction of rotation for transformation'), the machine manufacturer may specify the positive sense of rotation during lateral cylinder surface machining (see Chapter 5.3).

Coordinate system I and machining before the rotation centre

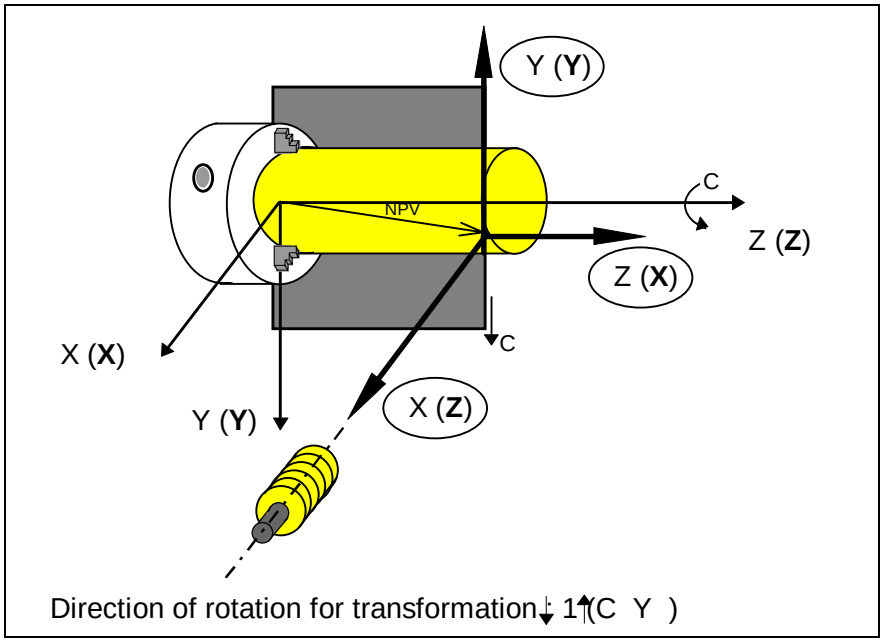


Fig. 4-1: Coordinate system I and machining before the rotation centre

Coordinate system I and machining after the rotation centre

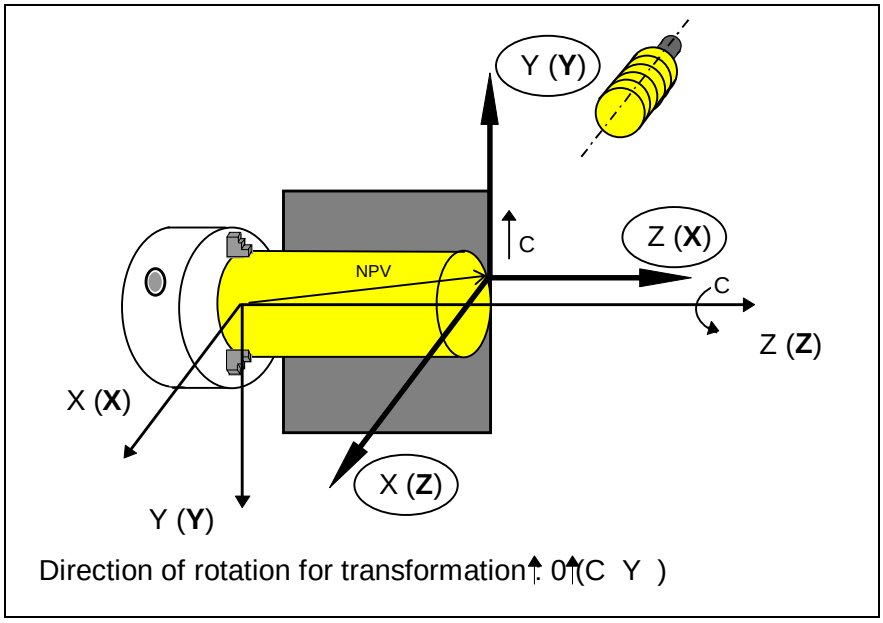


Fig. 4-2: Coordinate system I and machining after the rotation centre

Coordinate system II and machining before the rotation centre

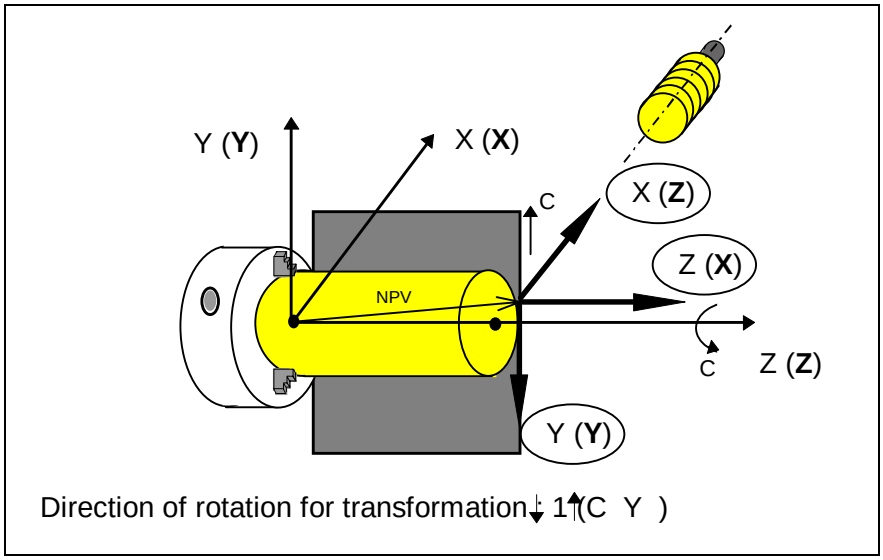


Fig. 4-3: Coordinate system II and machining before the rotation centre

Coordinate system II and machining after the rotation centre

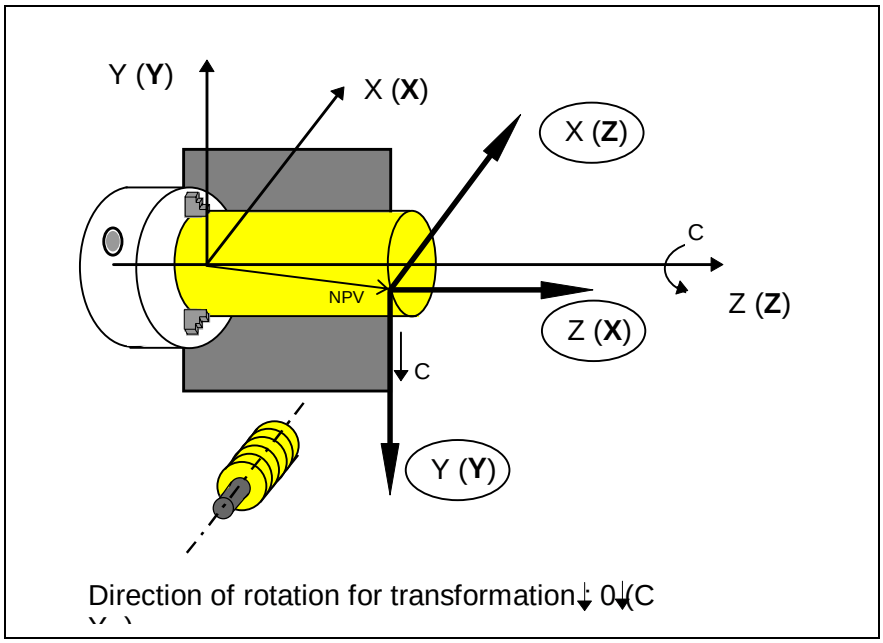
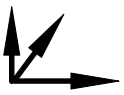


Fig. 4-4: Coordinate system II and machining after the rotation centre

Explanation of the figures



Coordinates or lateral cylinder surface machining (after G20, G32 and NPV)

(.)

Axis definition (neutral programming coordinate system)

Machine coordinates

5 Machine Parameters

5.1 Axis Definition (Axis Functionality)

Name Axis definition (axis functionality)

Number Cxx.053

Value range X, Y, Z, U, V, W, A, B, C, S (S1), S2, S3

Default value -

Unit -

From version 4.11

Dependency -

Axis parameter for
- digital and analog linear axes
- digital and analog rotary axes
- digital main spindles with rotary axis capability

Purpose The 'axis definition (axis functionality)' axis parameter enables the machine manufacturer to allocate each axis a specific axis functionality.

Explanation The axis definition characterizes the functionality of an axis. The table below summarizes the axis definition (axis functions) parameters that are available in each of the seven processes of the MT-CNC.

Axis definition	Symbol	No.	Axis position	Axis function
Feed axes (linear and rotary main and slave axes)	X Y Z U V W A B C	1 2 3 4 5 6 7 8 9	Abscissa Ordinate Applicate	**Functions of all feed axes:** • Absolute or incremental programming • Specification of the units • Reference point return • Zero offsets • Mirroring and scaling • Driving against hard stop • Low-lag interpolation • Speed-optimized block transition • Exact stop • Programmable path acceleration • Linear interpolation • Time programming • Velocity programming • Feed per revolution • Follower and Gantry axes

Axis definition	Symbol	No.	Axis position	Axis function
1. linear main axis 2. linear main axis 3. linear main axis	X Y Z	1 2 3	Abscissa Ordinate Applicate	**Functions of all linear main axes:** • Plane selection • Thread cutting • Tapping **Functions within the working plane:** • Circular interpolation • Tool radius compensation (R_{total}) • Tool length compensation ($L1/L2_{total}$) • Torsion • Transformation functions for facing and lateral cylinder surface machining **Functions of the axis that is perpendicular to the machining plane:** • Tool length compensation ($L3_{total}$) **Functions of the first linear main axis:** • Radius/diameter programming • Constant surface speed
1. linear or rotary slave axis 2. linear or rotary slave axis 3. linear or rotary slave axis	U V W	4 5 6	any position and orientation	-
1. rotary main axis 2. rotary main axis 3. rotary main axis	A B C	7 8 9	rotates around abscissa rotates around ordinate rotates around applicate	**Functions of the rotary main axes:** • Effective radii
1. spindle 2. spindle 3. spindle	S1 S2 S3	10 11 12	parallel to the main axes	**Functions of the spindles:** • Speed specification • Position specification • Constant surface speed • Speed limitation • Selection of reference spindle • Thread cutting • Tapping • Feed per revolution • Gear shifting • Main spindle synchronization

Tab. 5-6: Definition and functionality of axes

Besides the first axis definition, three more axis definitions may be entered in the axis parameter record. This permits additional planes to be defined. During operation, the user may select them via the G20 command (free plane selection). The additional axis definitions must be separated from each other by commas. They are used by the NC during the execution of the G20 command for checking illegal plane selections.

Based on the first axis definition, the NC allocates the axes their axis definition (axis functionality)

- upon power-up,
- after a control-reset,

- after the end of the program (RET, BST, JMP, M02, and M30),
- upon the first jogging operation in manual mode (if the 'Manual axis jogging causes reset' process parameter has been set), and
- when a plane is activated using G17, G18 or G19.

Subsequently, the axes with axis definition X, Y and Z span the base coordinate system.

5.2 Axis Designation 2

Name Axis designation 2

Number Cxx.075

Value range X, Y, Z, U, V, W, A, B, C, with or without index 1, 2, 3

Default value -

Unit -

From version 4.13

Dependency -

Axis parameter for
- digital and analog linear axes
- digital and analog rotary axes
- digital main spindles with rotary axis capability

Purpose Axis designation 2 defines the symbolic designators of the axes that span the fictitious working plane during facing (G31) and lateral cylinder surface machining (G32) .

Explanation During the execution of the transformation functions ‘G31’ and ‘G32’, the NC employs the designators that are stored here for the axes that span the fictitious working plane. Furthermore, the designator is used for displaying the fictitious axis.
Like for axis designation (1), the letters X, Y, Z, U, V, W, A, B, C with or without index 1, 2, 3 are available as symbolic designators.

Note:

Each axis designation may only be used once within a process.

Example In a turning machine that features a main spindle with rotary axis capability (S1/C), an X axis, a Y axis, and a PLC-controlled turret with driven tools (S2), the following parameter values are assigned to axis designations and axis definition:

Axis designation 1	Axis designation 2	Axis definition
S1/C	Y1	C, Y
X	X1	X, Z
Z	Z1	Z, X
S2	-	-

Tab. 5-7: Parameter values of axis designations and axis definition

During operation, the following axis designations shall be used in accordance with the machining task:

Machining task	G code	Axis designation to be used
Turning	G18	X, Z
Lateral cylinder surface machining	e.g.: G20 Z0 C0 X0 G32 RI 36	Z1, Y1 and infeed axis X
Facing	G31	X!, Y1 and infeed axis 2

Tab. 5-8: Utilization of the axis designations

5.3 Direction for Polar Coordinate Transformation

Name Direction for polar coordinate transformation

Number Cxx.076

Value range 0/1

Default value 0

Unit -

From version 4.13

Dependency -

Axis parameter for
- digital linear axes
- digital rotary axes
- digital main spindles with rotary axis capability

Purpose The 'Direction for polar coordinate transformation' parameter that is allocated to the digital rotary axes and digital main spindles with rotary axis capability enables the machine manufacturer to reverse the direction of rotation of the C axis in 'Facing' (G31) and 'Lateral cylinder surface machining' (G32).
The 'Direction for polar coordinate transformation' parameter that is allocated to the linear axes permits facing (G31) to be performed before the rotation centre (0: in the positive range) or after the rotation centre (1: in the negative range).

6 Machining Example

6.1 Contours that are to be Created on a Lateral Cylinder Surface

Using a turning machine that features a main spindle with rotary axis capability (S1/C), an X axis, a Y axis, and a PLC-controlled turret with driven tools (S2), the contours shown below shall be milled on the lateral cylinder surface of a turned part that is 170 mm long and has a diameter of 75 mm. The contours shall be machined with a width of 12 and/or 10 mm and a depth of 1.5 mm.

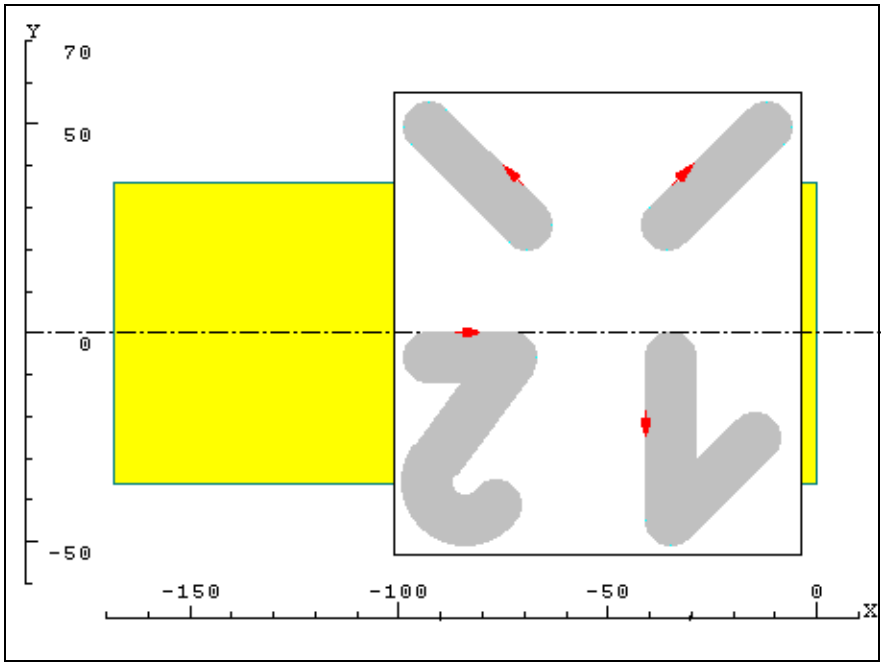


Fig. 6-1: Example: Contours that are to be created on a lateral cylinder surface

6.2 Required Tool Data

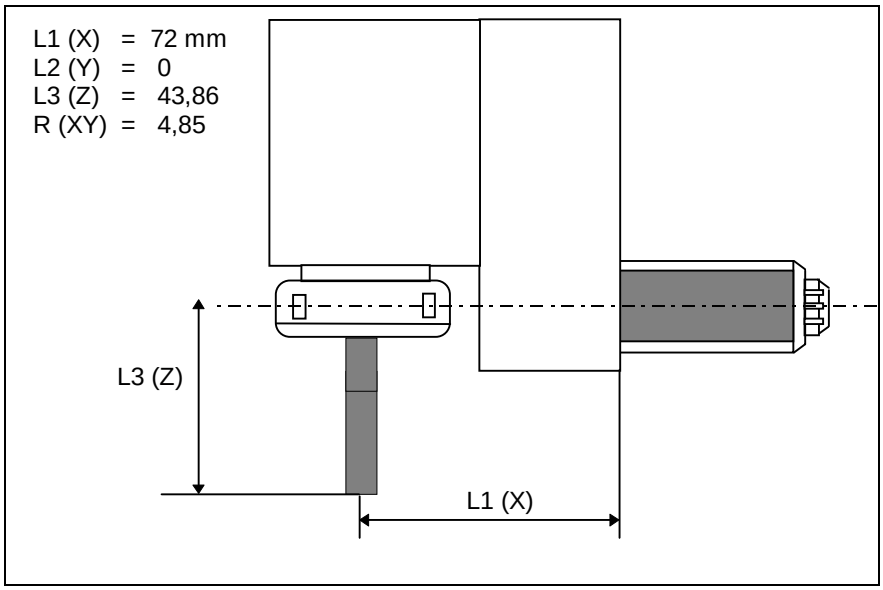


Fig. 6-2: Driven tool: Angle head with BNF D 9.7

6.3 Required Zero Shift

Storage A	X	Y	Z	
G52	0,0	0,0	0,0	
G54	0,0	0,0	267,85	⇐ for normal op.
G55	267,85	0,0	0,0	⇐ f. lat. cyl. sf. op.
G56	0,0	0,0	0,0	
G57	0,0	0,0	0,0	
G58	0,0	0,0	0,0	
G59	0,0	0,0	0,0	
gen. offset	0,0	0,0	0,0	
G50/G51	0,0	0,0	0,0	
total	0,0	0,0	0,0	

Tab. 6-9: Zero shift

6.4 NC Program

```
; ------------------------------------------------------------------------------------------
N0000 (lateral cylinder surface machining)
N0001 T7 BSR .M6
N0002 [TOOL: angle head with BNF D9.7]
N0003 G54 G15 G90 G71
N0004 M69                              ;chip conveyor ON
N0005 G92 S2 4000
N0006 BSR .M89                         ;engage driven tool
N0007 G0 C0
;
;milling  contour  'letter 1'
N0008 G55 G15 G94 G97 G6 G8 S2 3000 M203
N0009 G0 C0
N0010 G20 Z0 C0 X0                     ;free plane selection
N0011 G32 RI 36.5                      ;lateral cyl. surface mach. ON
N0012 G55 G48 Z1-36.15
N0013 Y1 25 Z1-36.15
N0014 X38
N0015 G1 X36 F150
N0016 G42 Y1 25 Z1-42 F297
N0017 Y1 50 Z1-42
N0018 G2 Y1 54.2426 Z1-30.7574 I-35 J50
N0019 G1 Y1 34.2426 Z1-10.7574
N0020 G2 Y1 25.7574 Z1-19.2426 I-15 J30
N0021 G1 Y1 36.5147 Z1-30
N0022 Y1 5 Z1-30
N0023 G2 Y1 5 Z1-42 I-36 J5
N0024 G1 Y1 25 Z1-42
N0025 G0 X38
N0026 G30                              ;lateral cyl. surface mach. OFF
;
;milling  contour  'letter 2'
N0027 G32 RI 36.5                      ;lateral cyl. surface mach. ON
N0028 G40 G55 G48 Y1 4.85 Z1-80
N0029 G1 X36 F150
N0030 G41 Y1 0 Z1-80 F297
N0031 Y1 0 Z-71
N0032 G3 Y1 10.2426 Z1-66.7574 I-71 J6
N0033 G1 Y1 29.1421 Z1-85.6569
```

```
N0034 G2 Y1 40.4558 Z1-74.3432 I-80 J34.799
N0035 G3 Y1 48.9411 Z1-65.8579 I-70.1005 J44.6985
N0036 Y1 20.6568 Z-94.1421 I-80 J34.799
N0037 G1 Y1 12 Z-85.4853
N0038 Y1 12 Z-94
N0039 G3 Y1 0 Z-94 I-94 J6
N0040 G1 Y1 0 Z-80
N0041 G0 X38
N0042 G30                          ;lateral cyl. surface mach. OFF
;
;milling  contour ‘inside groove’
N0043 G32 RI 36.5                  ;lateral cyl. surface mach. ON
N0044 G40 G55 G48 Y1 -36.5705 Z-26.5705
N0045 G1 X36 F150
N0046 G41 Y1 -40 Z-30 F297
N0047 Y1 -55 Z-15
N0048 G3 Y1 -46.5147 Z-6.5147 I-10.7574 J-50.7574
N0049 G1 Y1 -22.2721 Z-30.7574
N0050 G3 Y1 -30.7574 Z-39.2426 I-35 J-26.5147
N0051 G1 Y1 -40 Z-30
N0052 G0 X38
N0053 G30                          ;lateral cyl. surface mach. OFF
;
;milling  contour ‘outside groove’
N0054 G32 RI 36.5                  ;lateral cyl. surface mach. ON
N0055 G40 G55 G48 Y1 -43.4896 Z-71.6318
N0056 G1 X36 F150
N0057 G41 Y1 -40 Z-75 F297
N0058 Y1 -54.3171 Z-89.8331
N0059 G2 Y1 -45.6829 Z-98.1669 I-94 J-50
N0060 G1 Y1 -22.5179 Z-74.1669
N0061 G2 Y1 -31.152 Z-65.8331 I-70 J-26.835
N0062 G1 Y1 -40 Z-75
N0063 G0 X38
N0064 X60
N0065 G40
N0066 Z100
N0067 G30                          ;lateral cyl. surface mach. OFF
N0068 G18
N0069 M205                         ;driven tool OFF
N0070 M90                          ;disengage driven tool
N0071 G0 C0
N0072 M70                          ;chip conveyor OFF
N0073 M62                          ;door lock OPEN
N0074 G53 G90 G47 M5
N0075 M30 []
N0076 PROGRAMMENDE
```

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