CNC - BASIC PROGRAMMING COURSE

Fig. 1. Optional control panel for SinuTrain

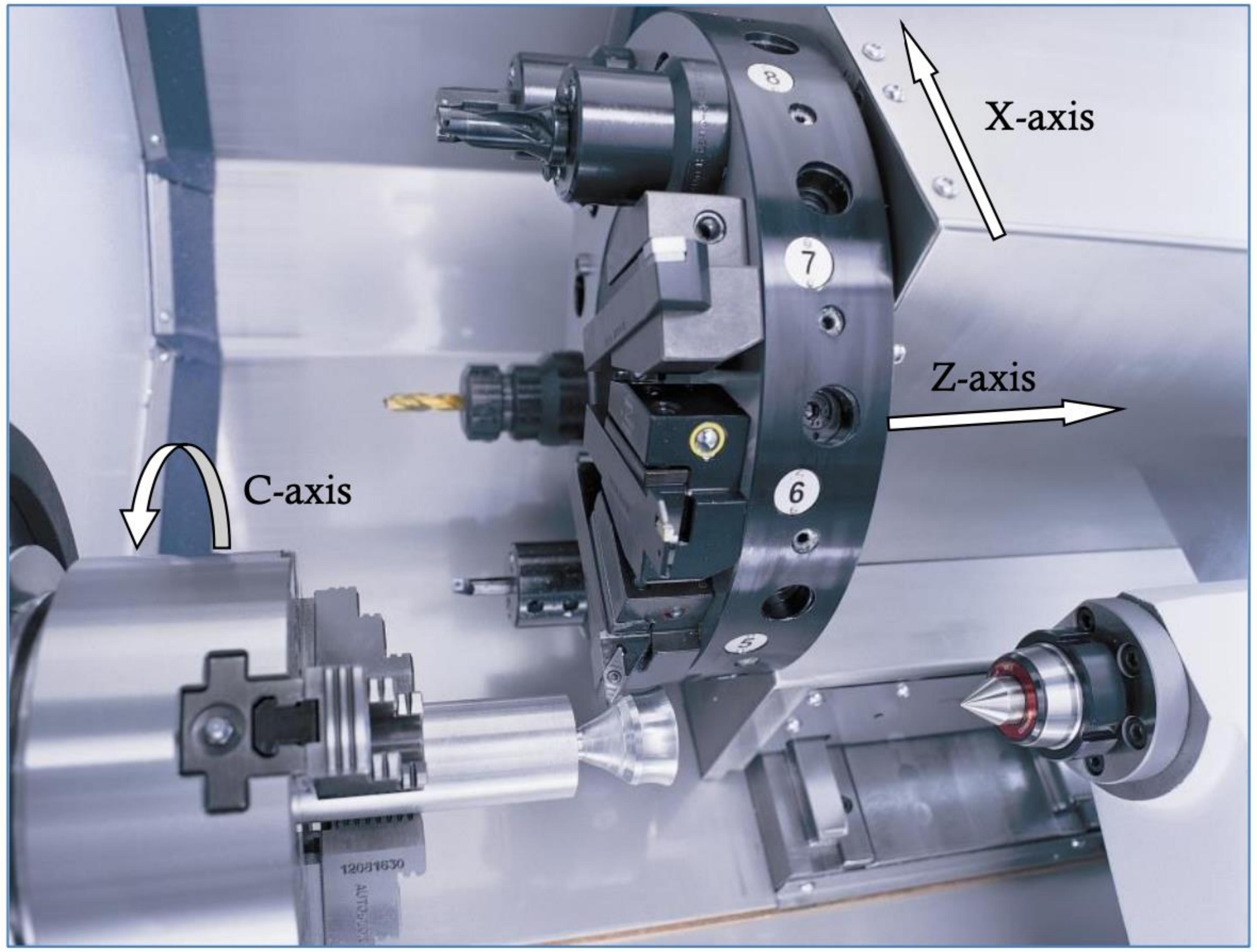


Fig. 2. Lathe with 3 axes and driven tools

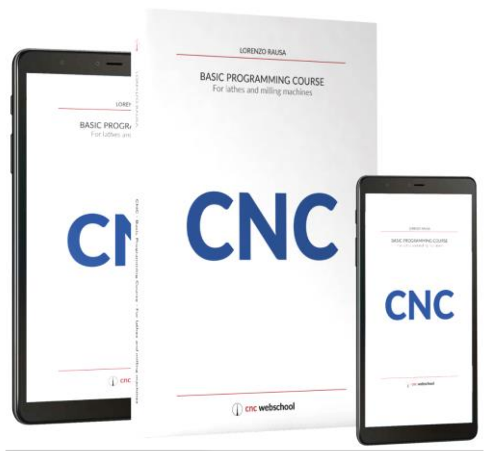
Fig. 2.1 Milling machine with 3 axes

Hardware:	Processor 2 GHz, RAM 4 GB, Internet connection, USB data port
Disc Capacity:	Approx. 3.3 GB for full installation
Operating System:	Windows 7 SP1 (32 and 64 Bit) (no: Starter, Web Edition, Embedded) Windows 8.1 (32 and 64 Bit) (no: RT) Windows 10 (64 Bit) (no: Mobile, Mobile Enterpr.)
User Settings:	PC administrator rights required for installation and use
License:	The machines examined in the course (DEMO-Lathe and DEMO-Milling Machine) do not require any license

Fig. 3. Minimum PC requirements

Username:	Password:
……………………………………	……………………………………

Fig. 4. Personal access data to Siemens website



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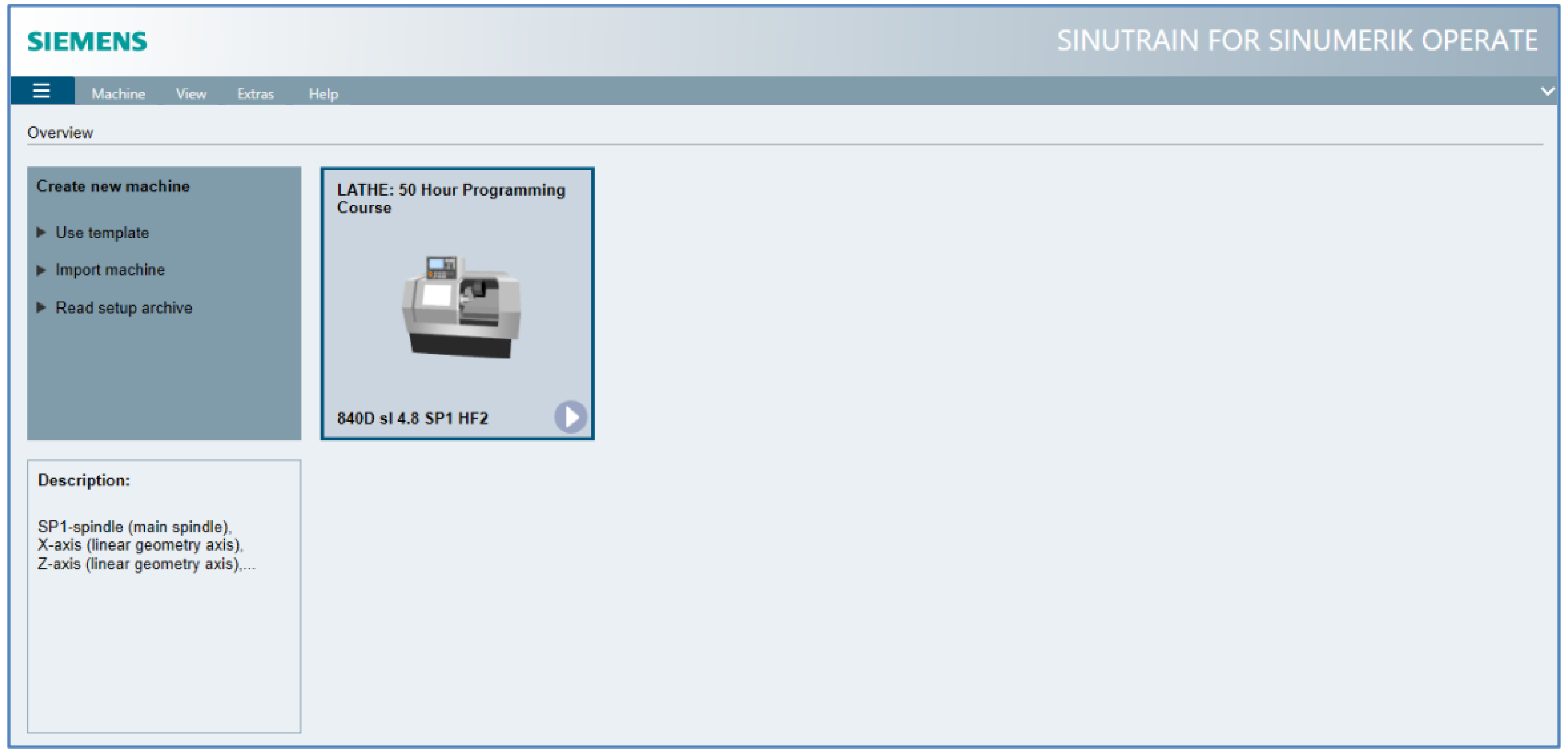


Fig. 5. Starting window of the simulation program

Fig. 6. Buttons for the selection of the operating environments

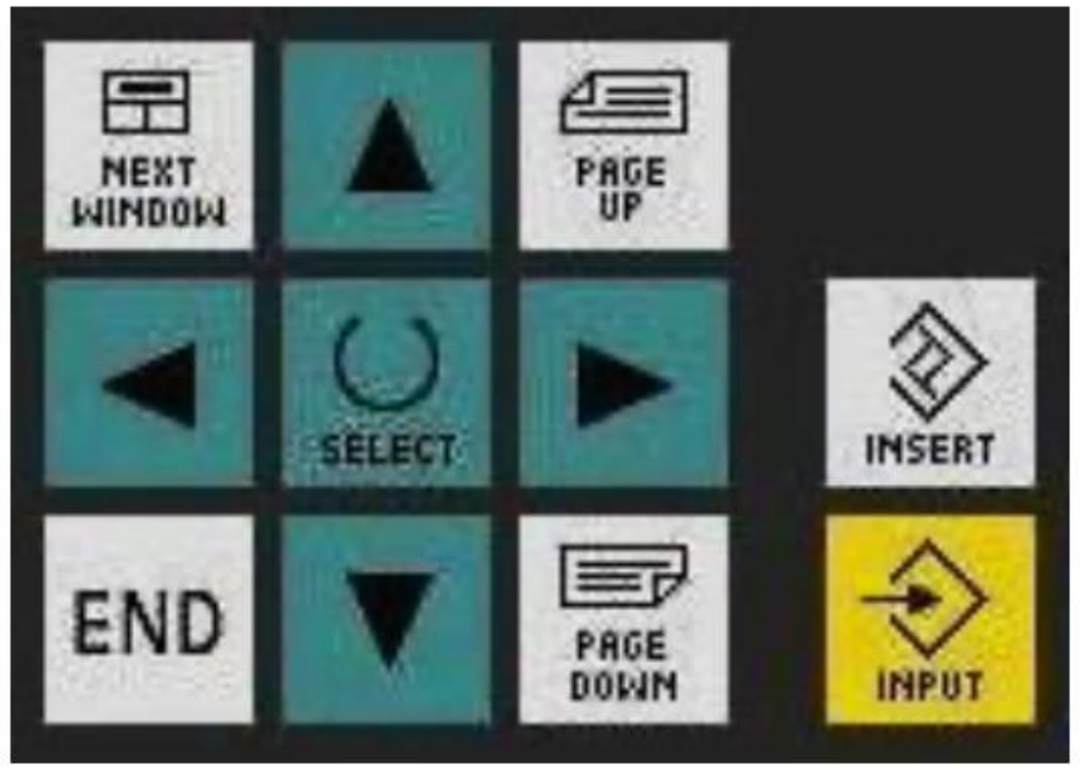
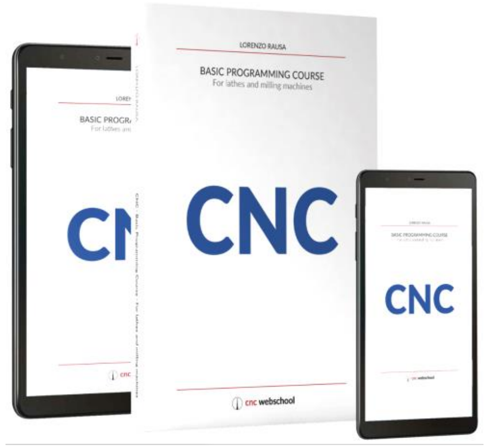


Fig. 7. Buttons for cursor movement and data entry



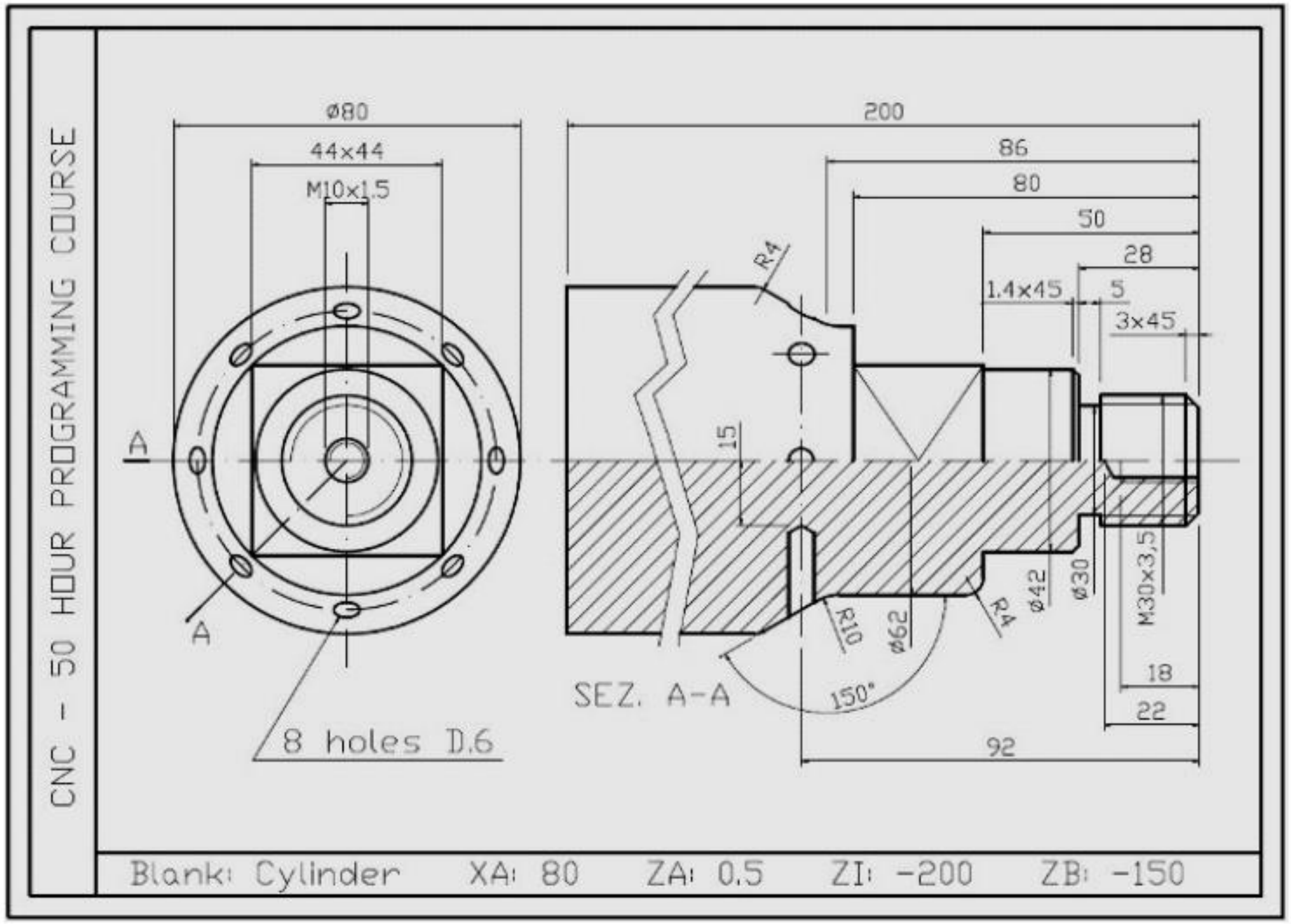
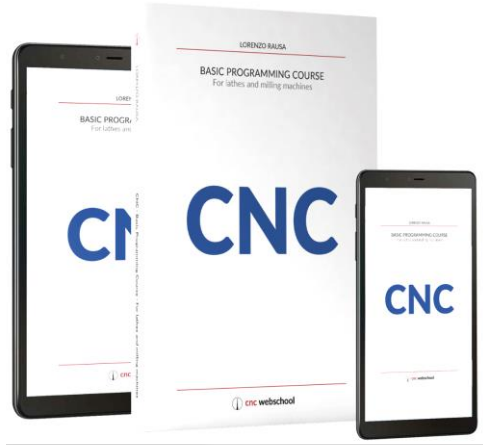


Fig. 8. Technical drawing of the introductory workpiece of the course



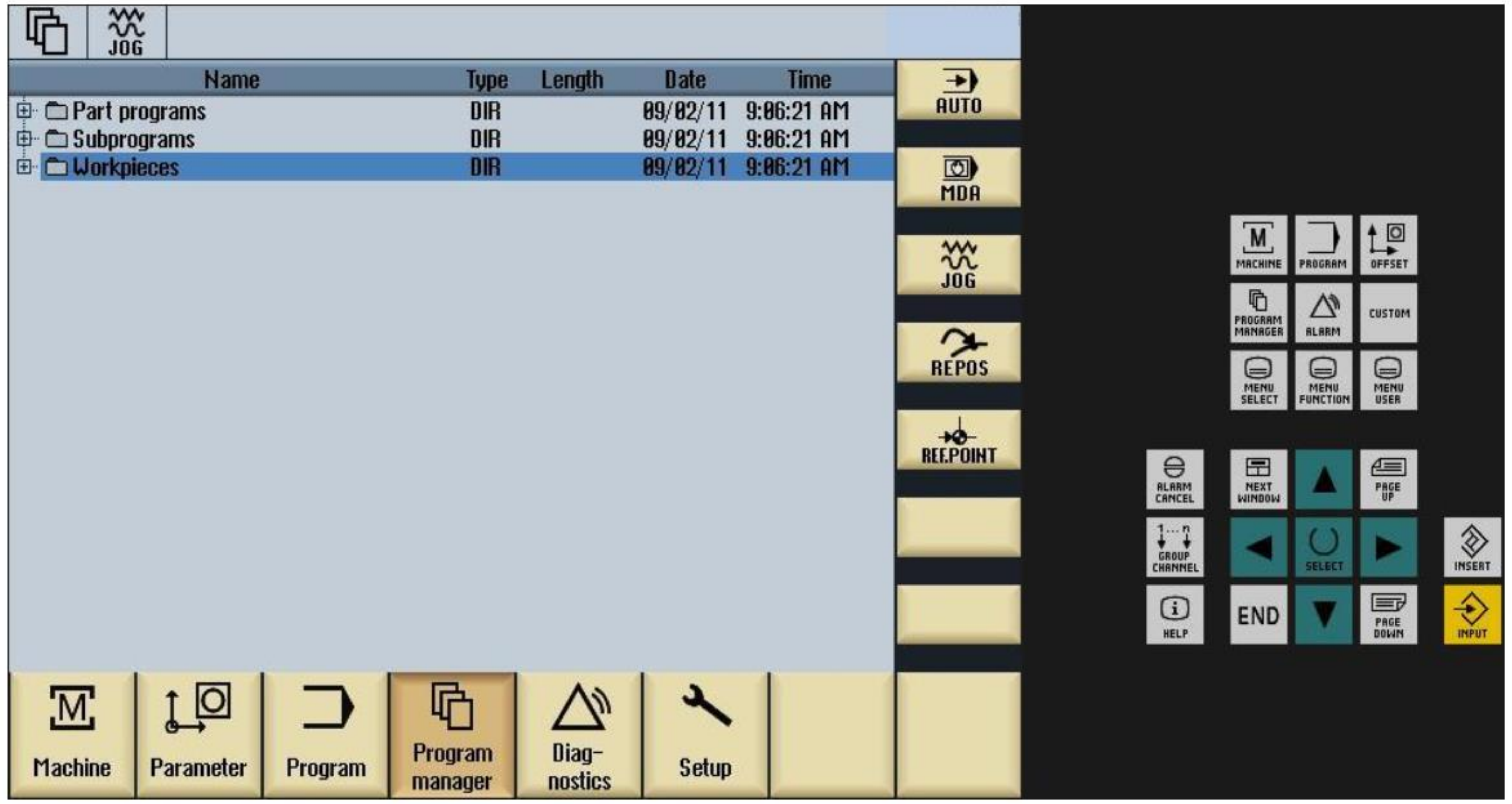


Fig. 9. Organization of the programs on the PROGRAM MANAGER page

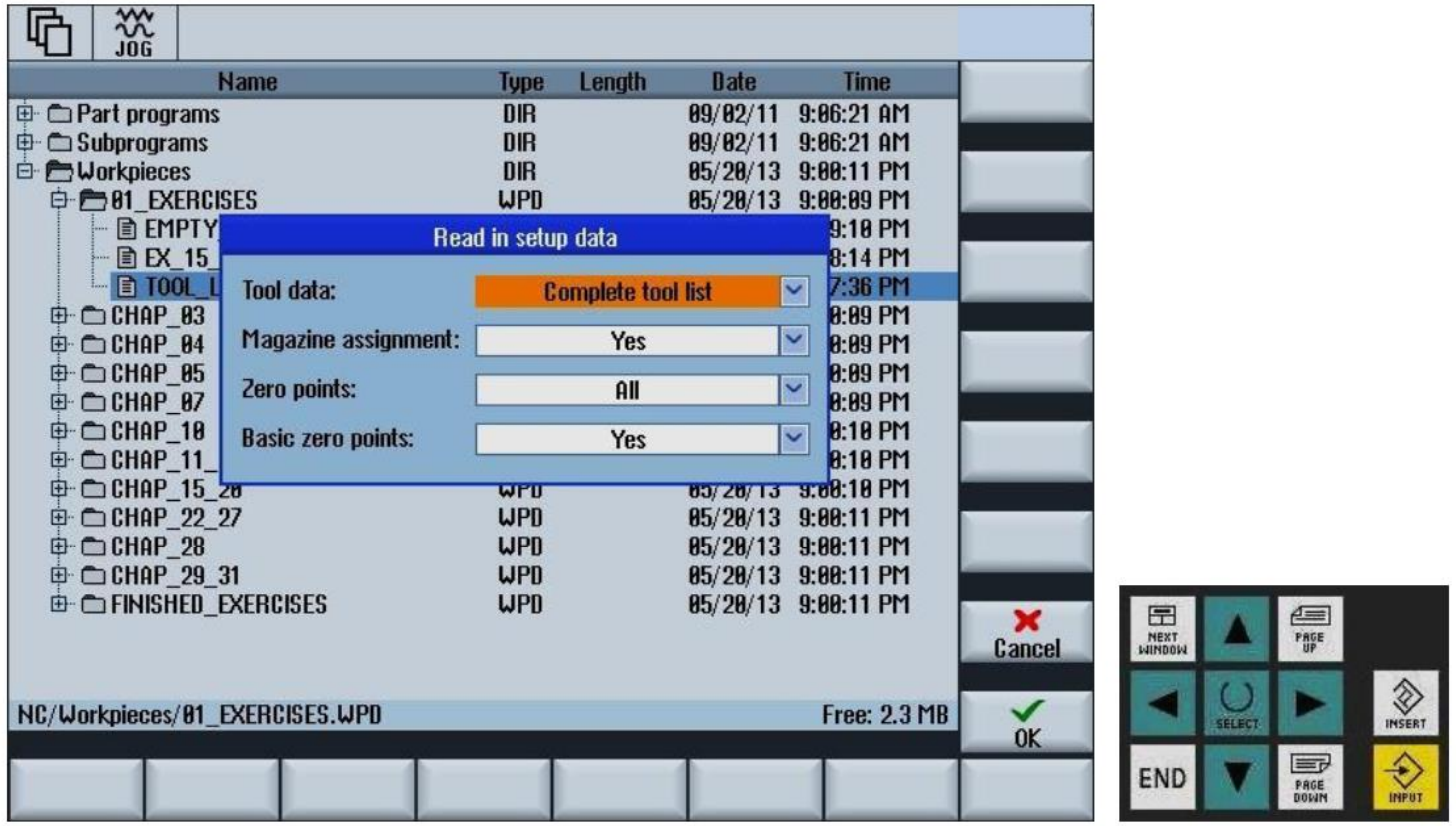
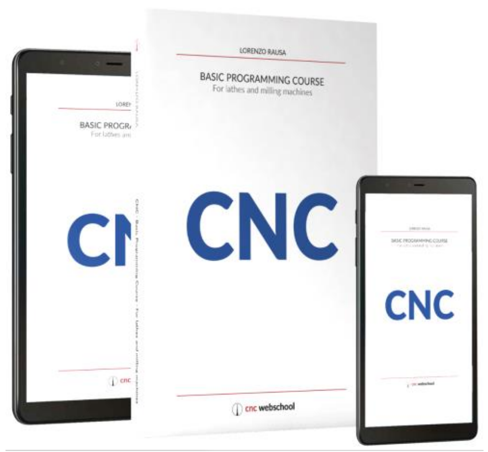


Fig. 10. Dialog box for the import of tooling data



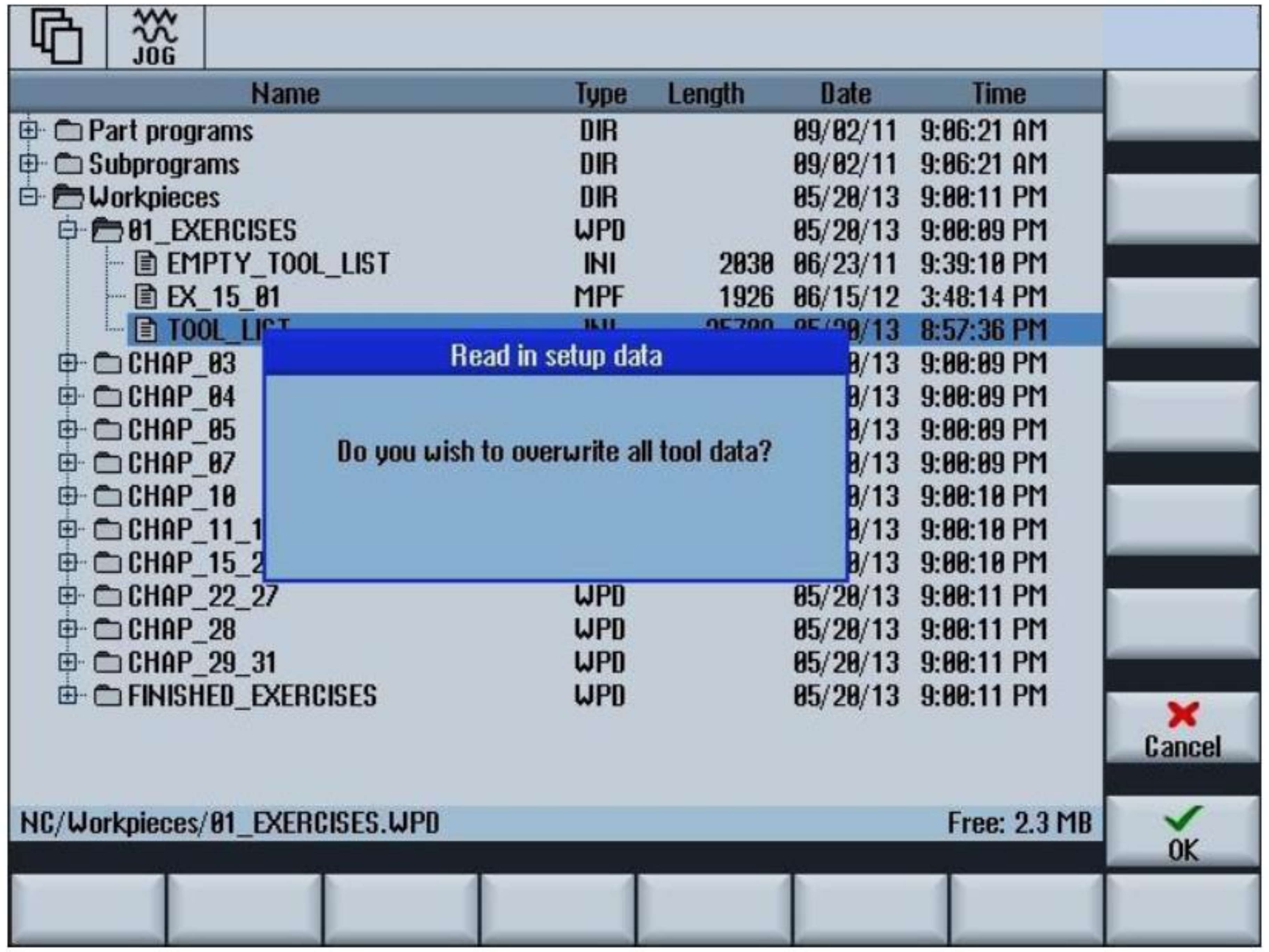
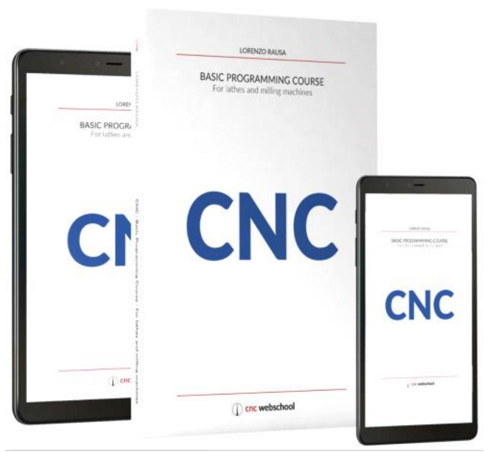


Fig. 11. Window for the confirmation and overwriting of the tool data

Blank part:	Shape of the blank part (e.g. cylinder)
XA:	External diameter of the blank part (e.g. 80 mm).
ZA:	Value of the machining allowance on the front face of the blank part (e.g. 0.5 mm).
ZI:	Length of the blank part. If by pushing SELECT you select ABSOLUTE (recommended), the length refers to the part zero point, if INCREMENTAL, the length refers to the front face of the part, machining allowance included.
ZB:	Extension of the face of the blank part from the jaws of the chuck. For the selection of absolute or incremental the same applies as for ZI.

Fig. 12. Description of the blank part dimensions



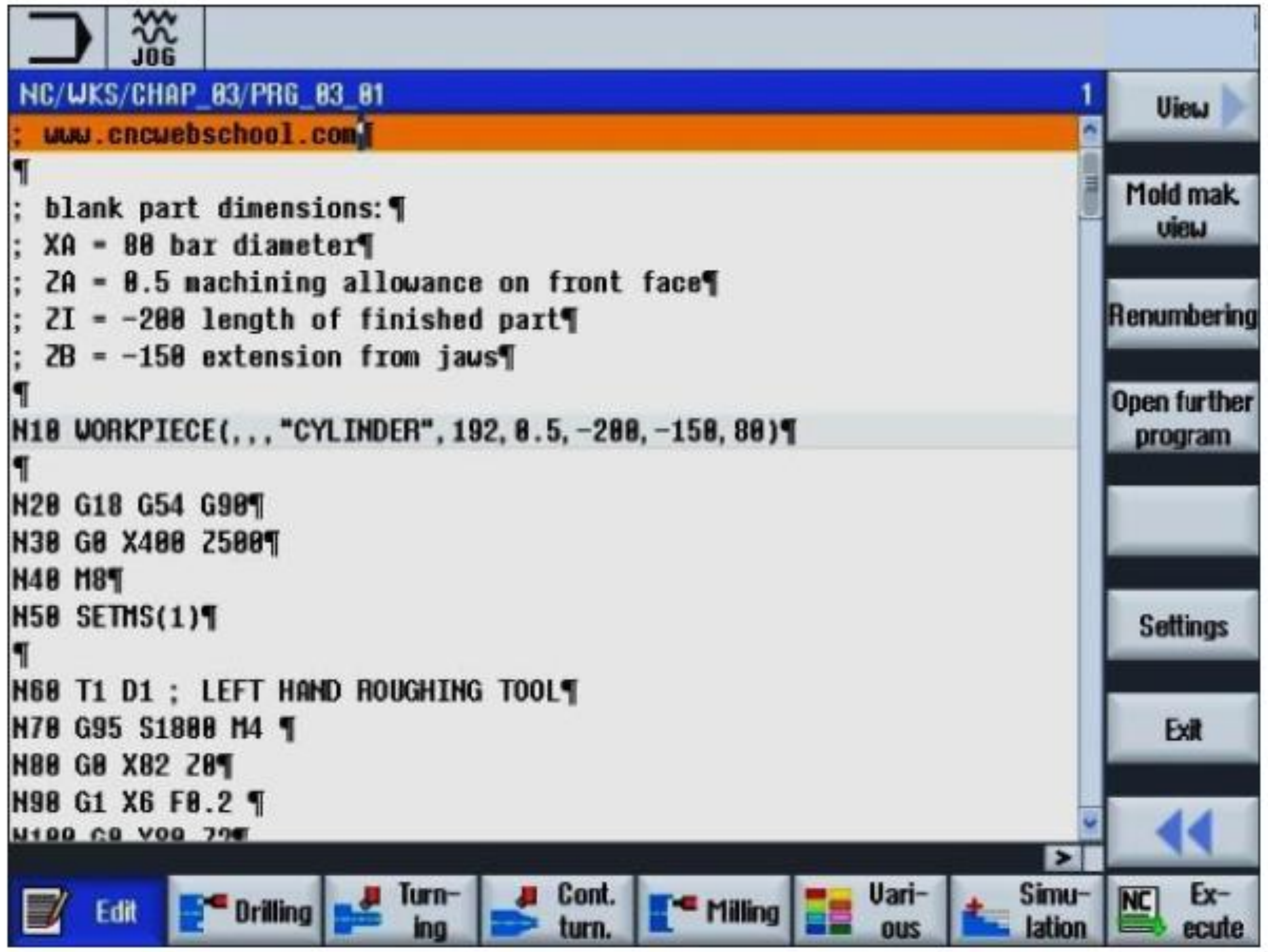


Fig. 13. Program opened and ready for simulation

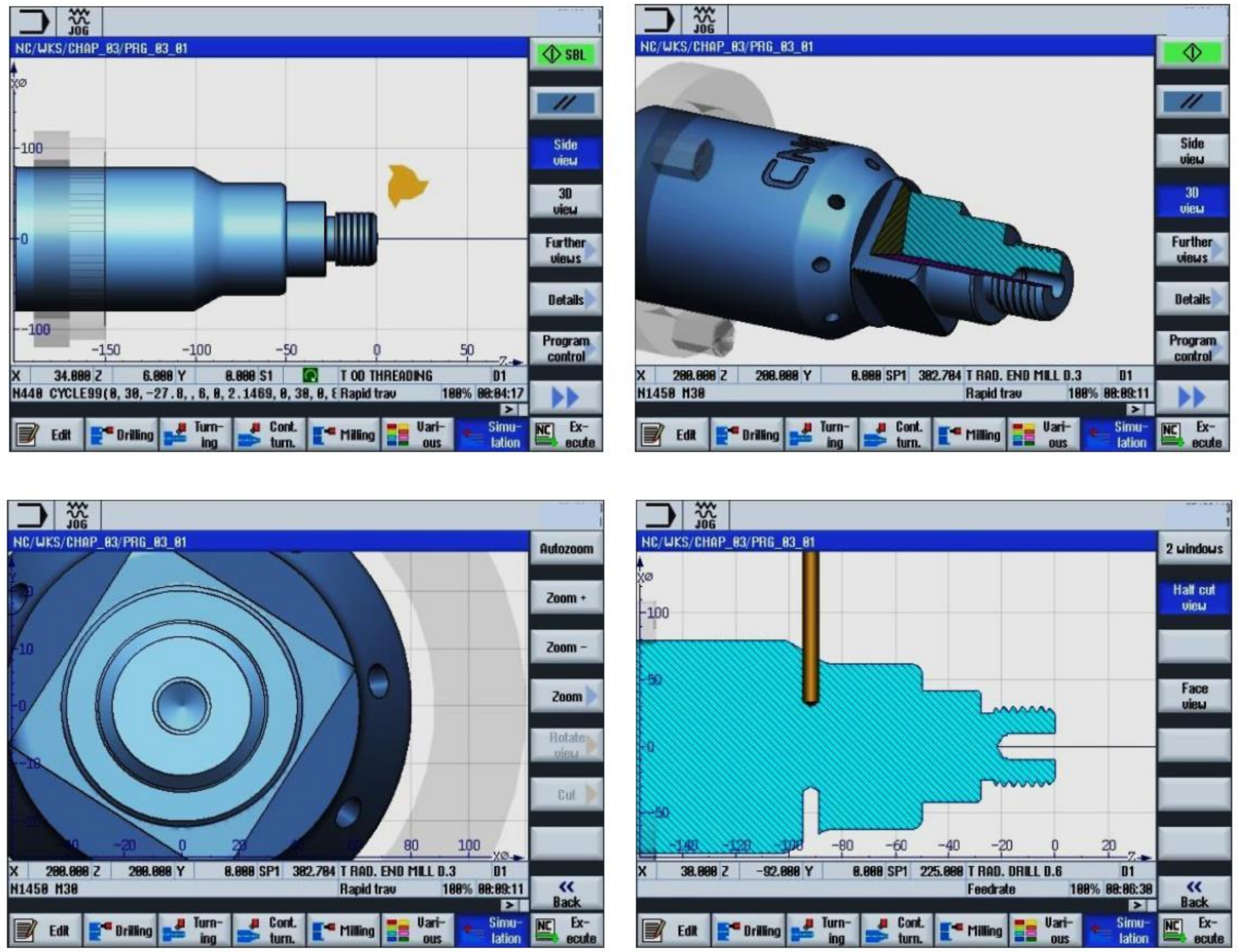
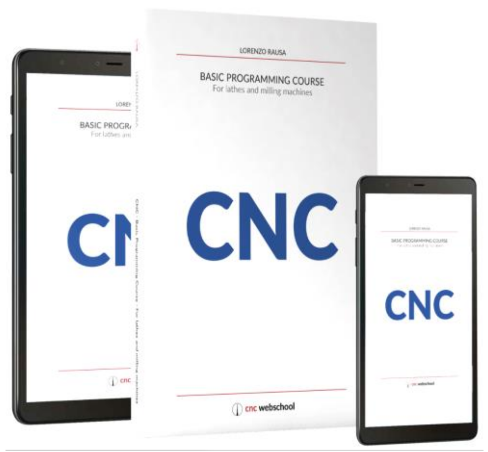


Fig. 14. Display options for the workpiece



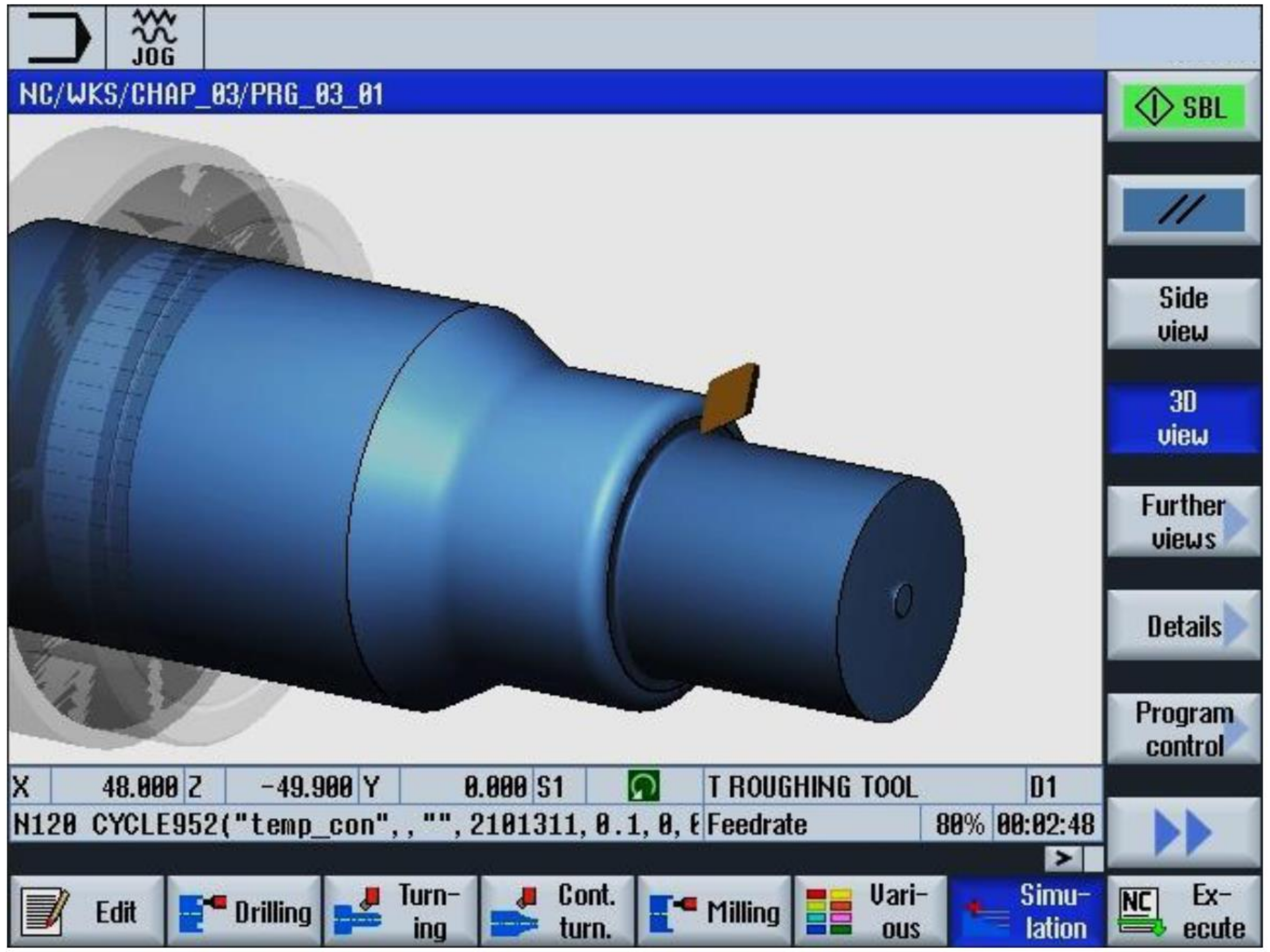


Fig. 15. Execution of the graphic simulation in single block mode

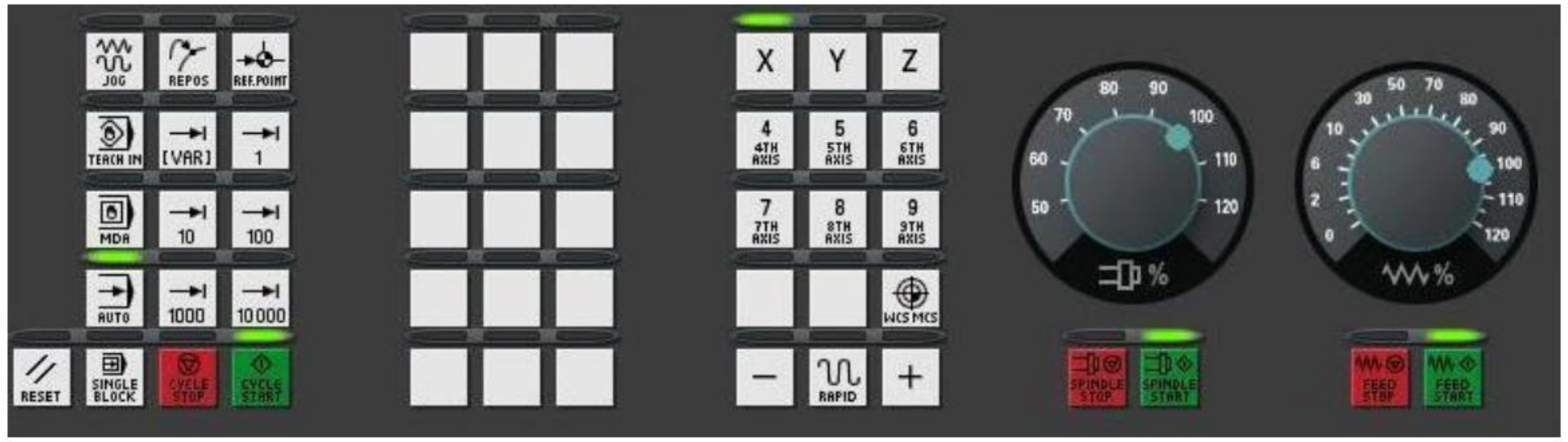
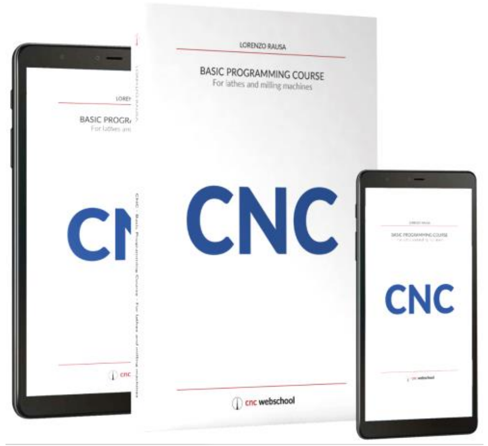


Fig. 16. Activation and setting of the potentiometers for the execution of the program in automatic cycle



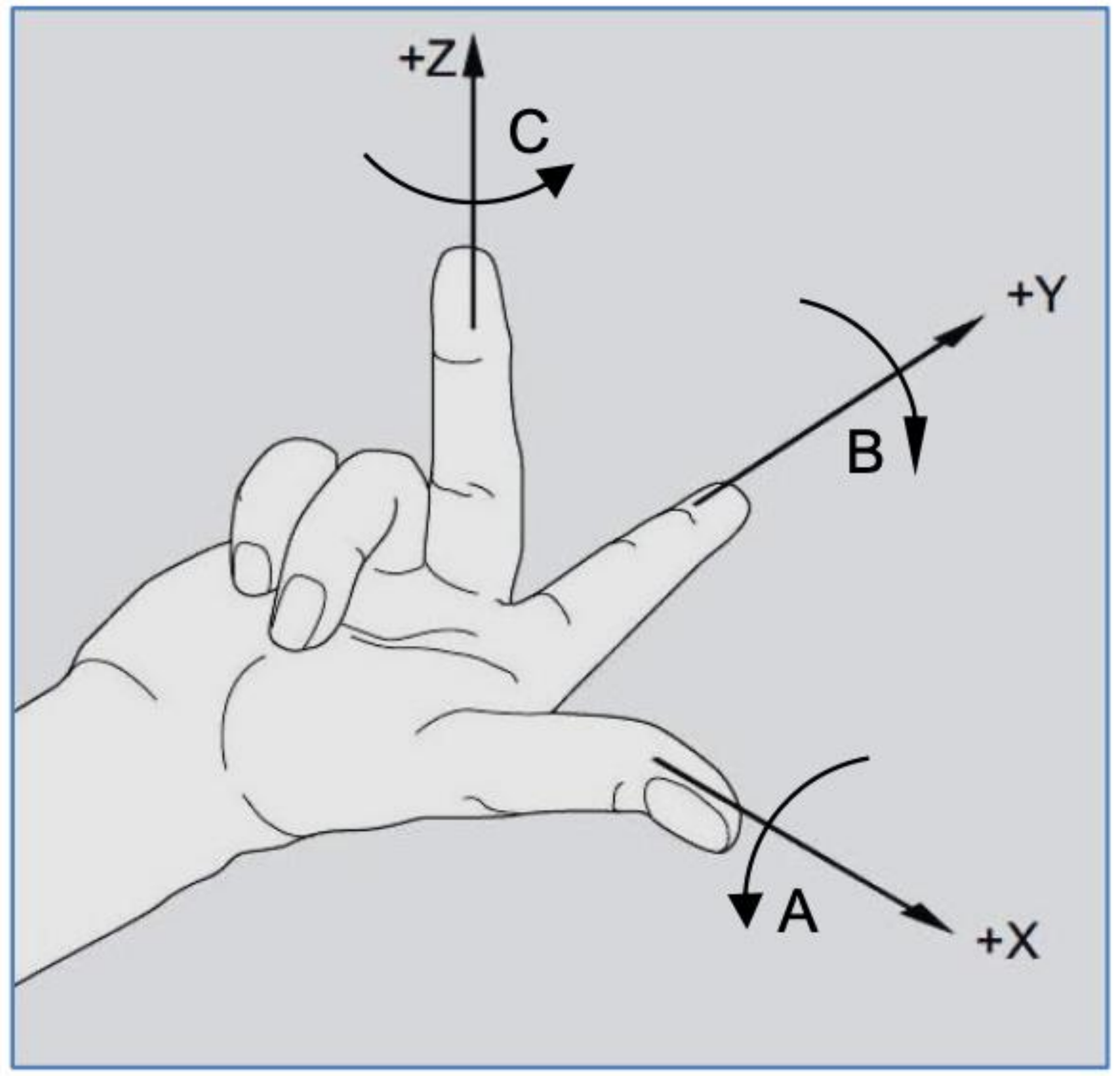


Fig. 17. Right-hand rule: definition of the axes and their positive motion according to ISO Standards. The positive motion is always determined in relation to the moving path of the tool on the workpiece.

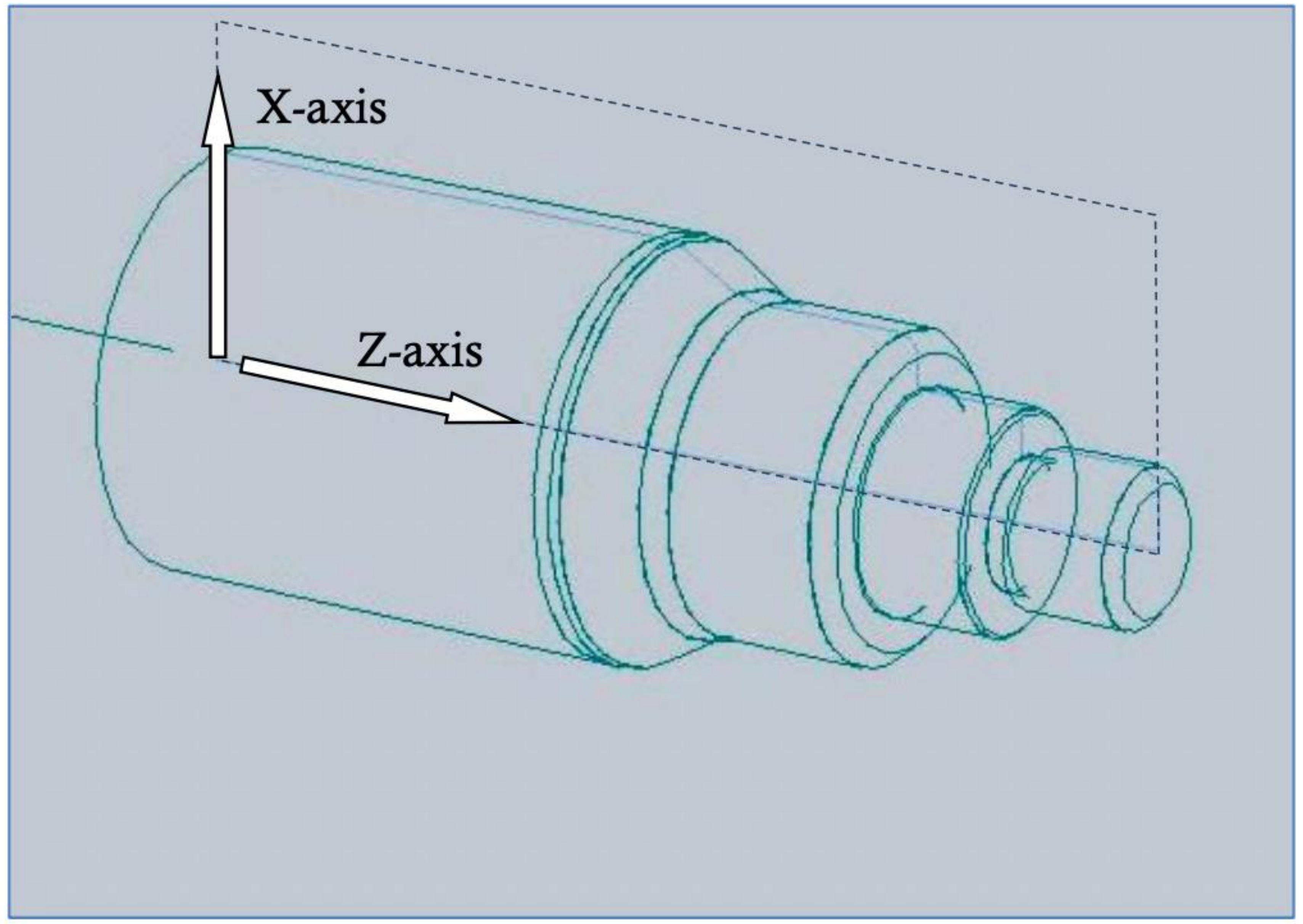


Fig. 18. Solid of revolution around the Z-axis of the profile described on the plane X-Z

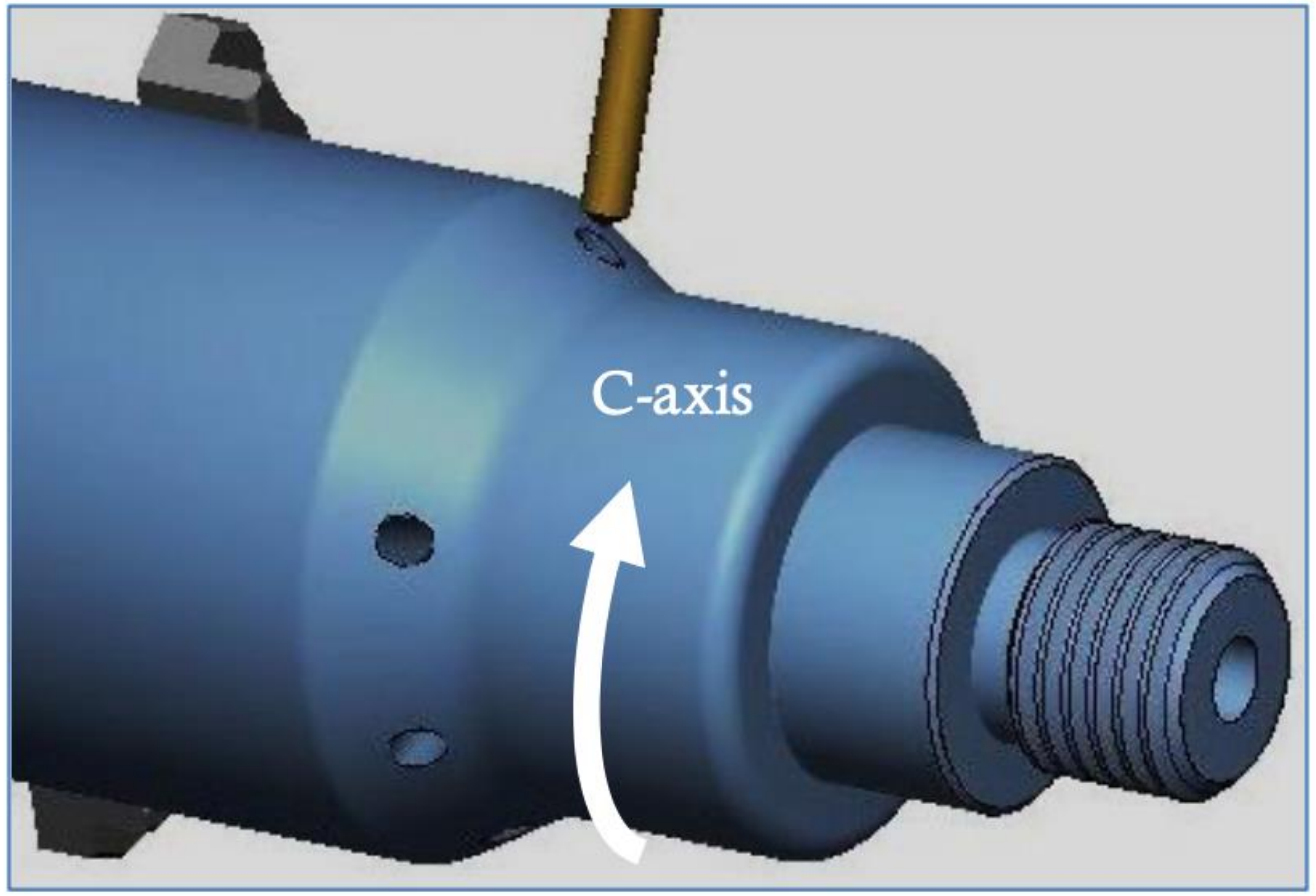


Fig. 19. Angular orientation of the spindle for the creation of radial holes

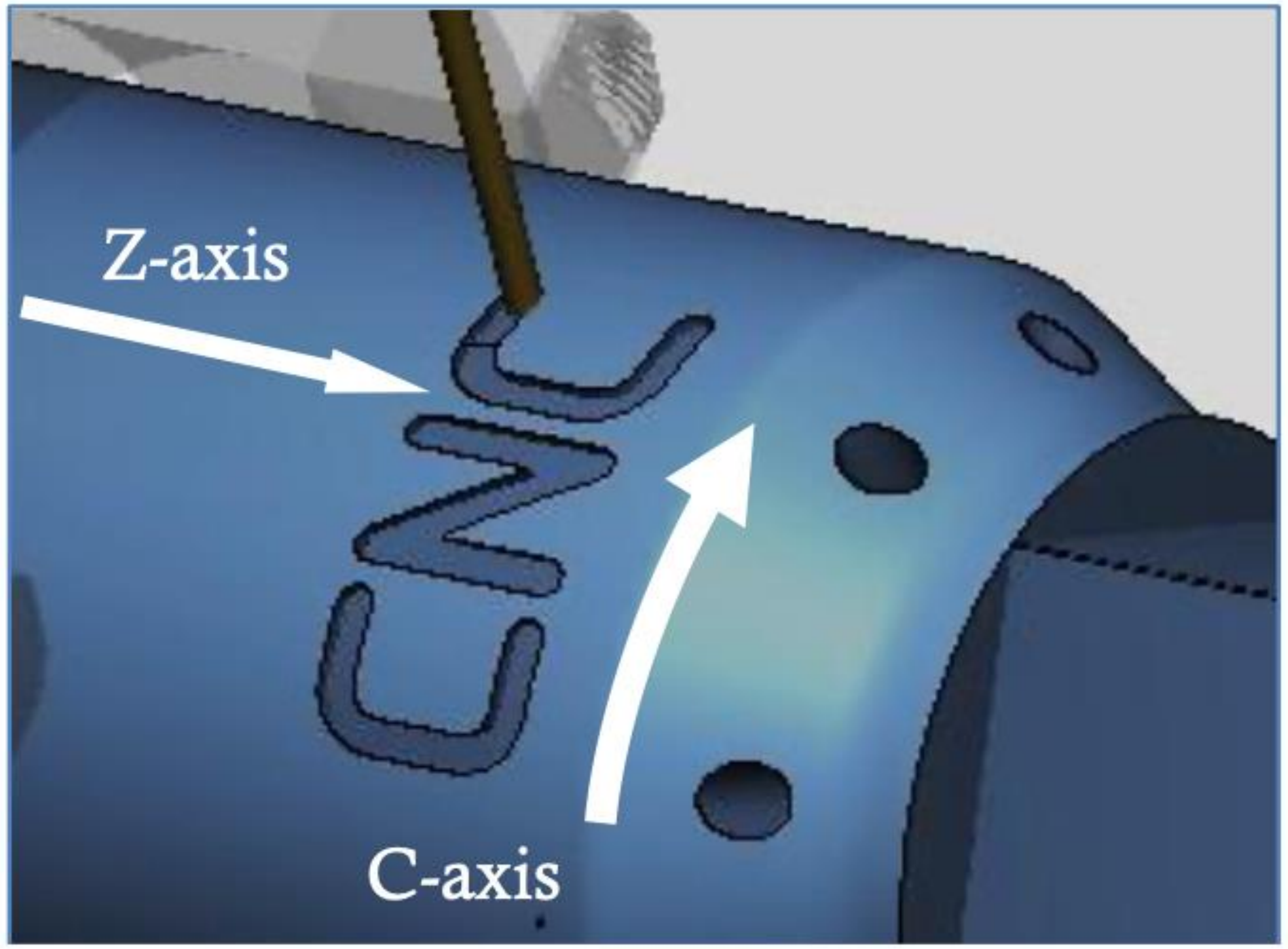


Fig. 20. Example of a cylindrical interpolation C-Z

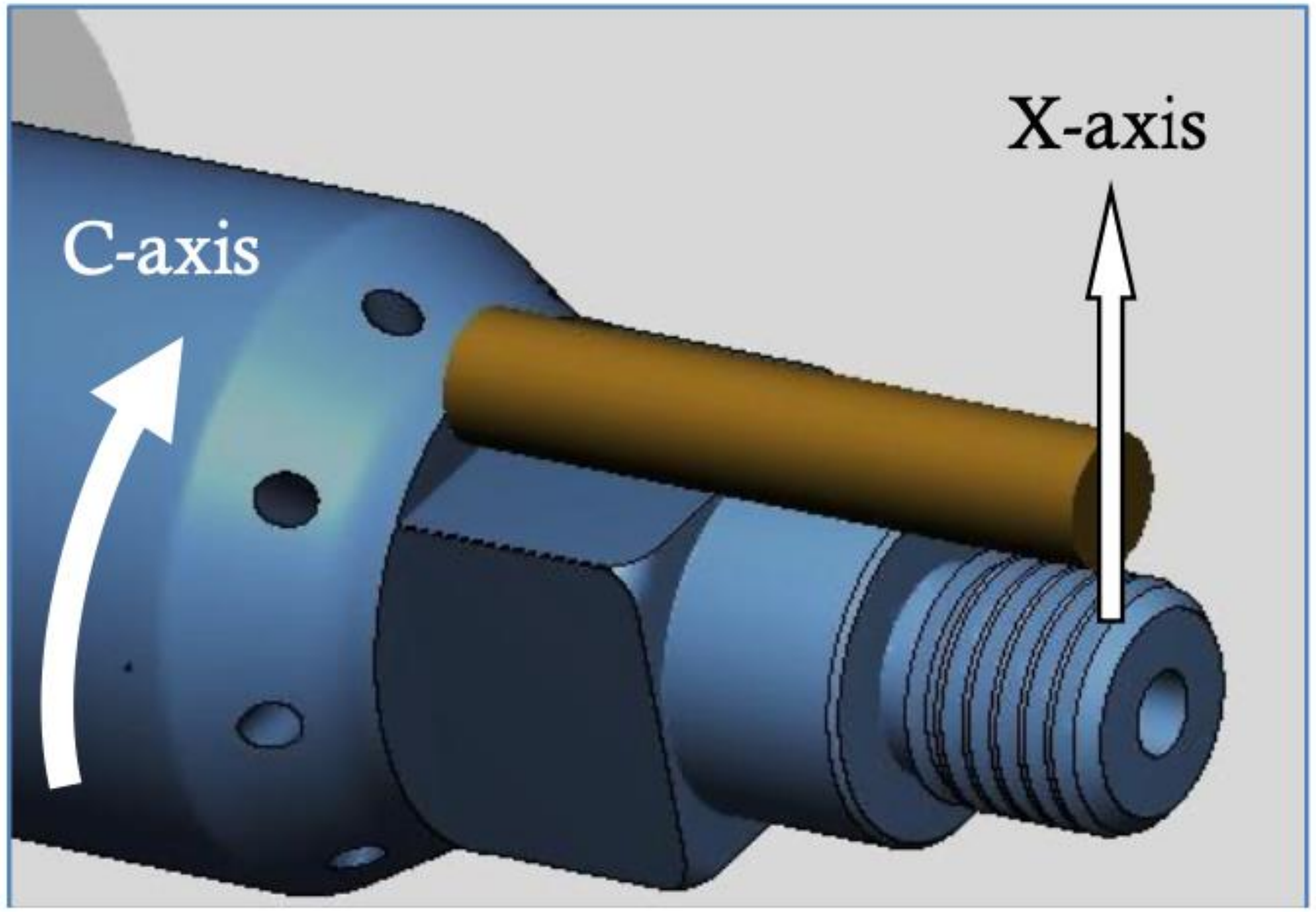


Fig. 21. Example of a frontal interpolation C-X

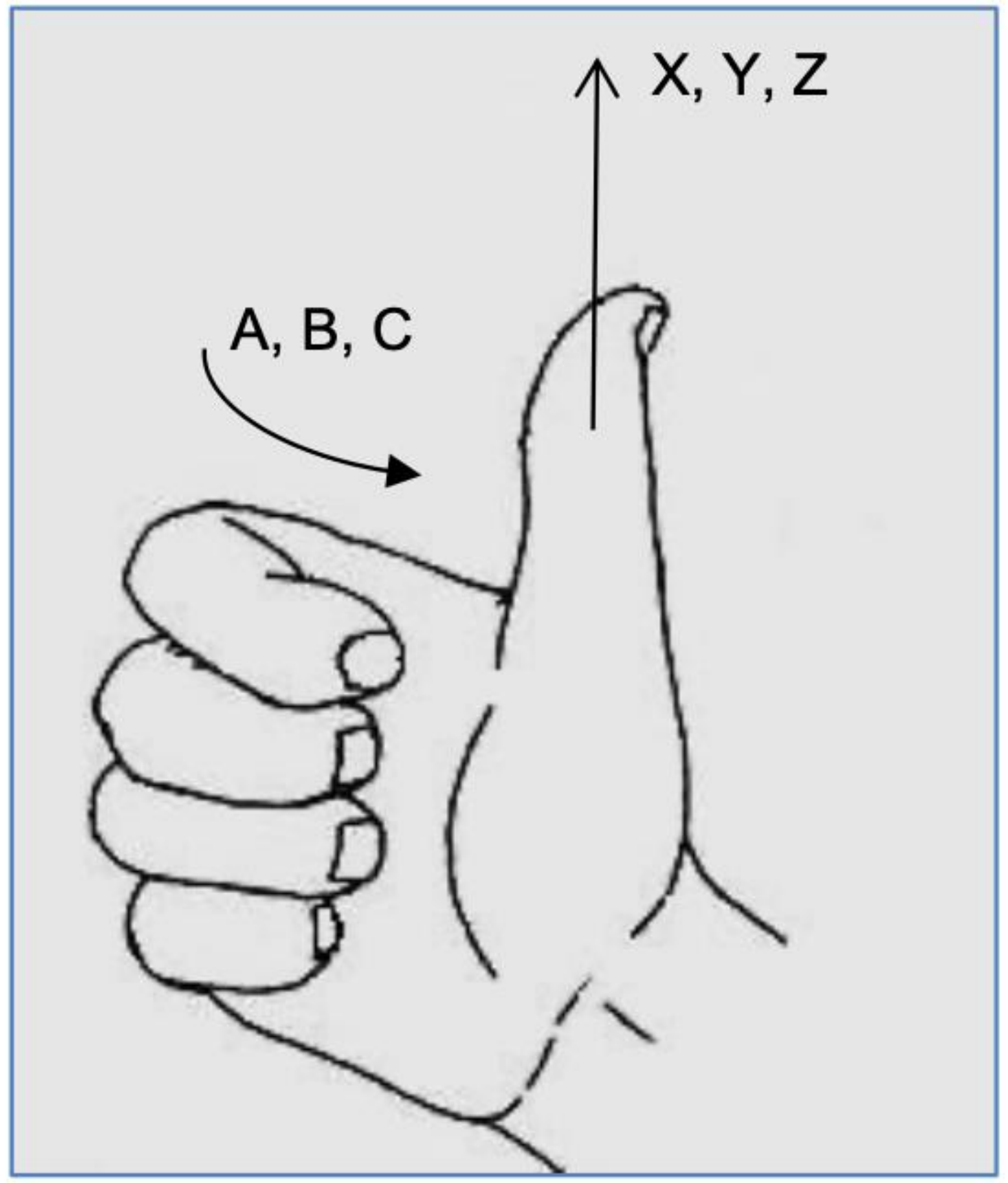


Fig. 22. Right-hand rule to determine the positive motion of the rotating axes

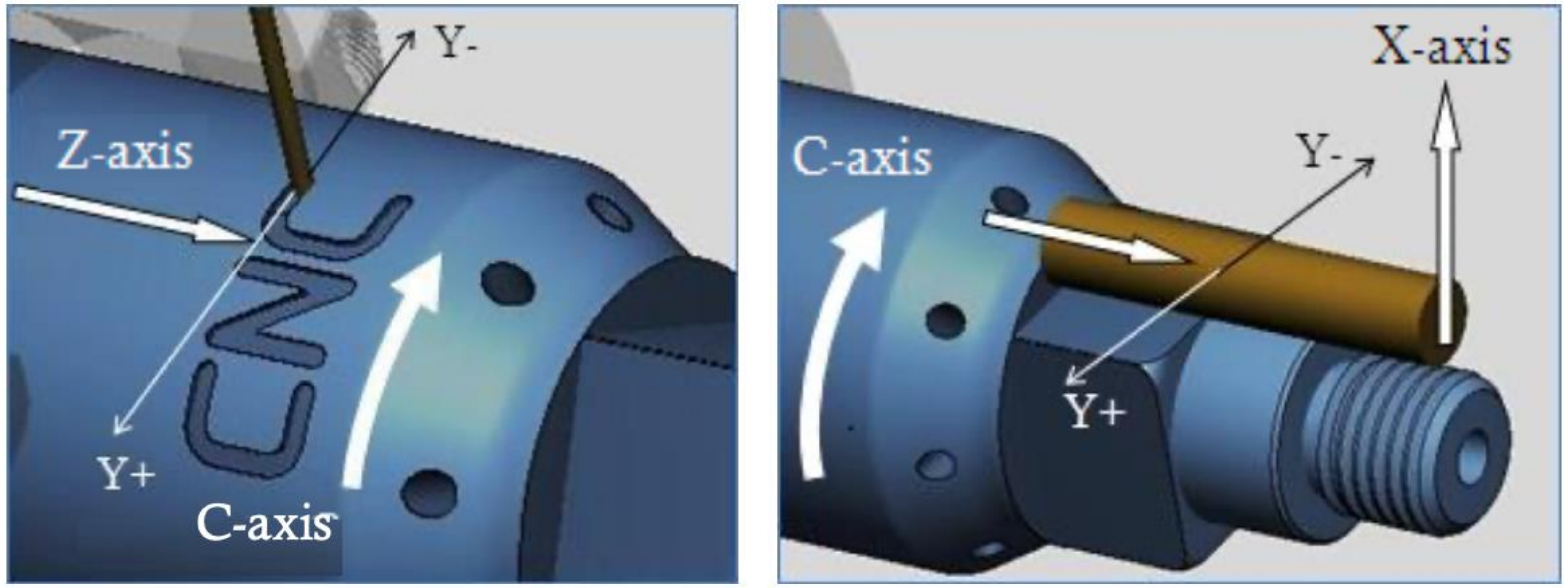


Fig. 23. C-axis positive programming direction and real movement of the workpiece

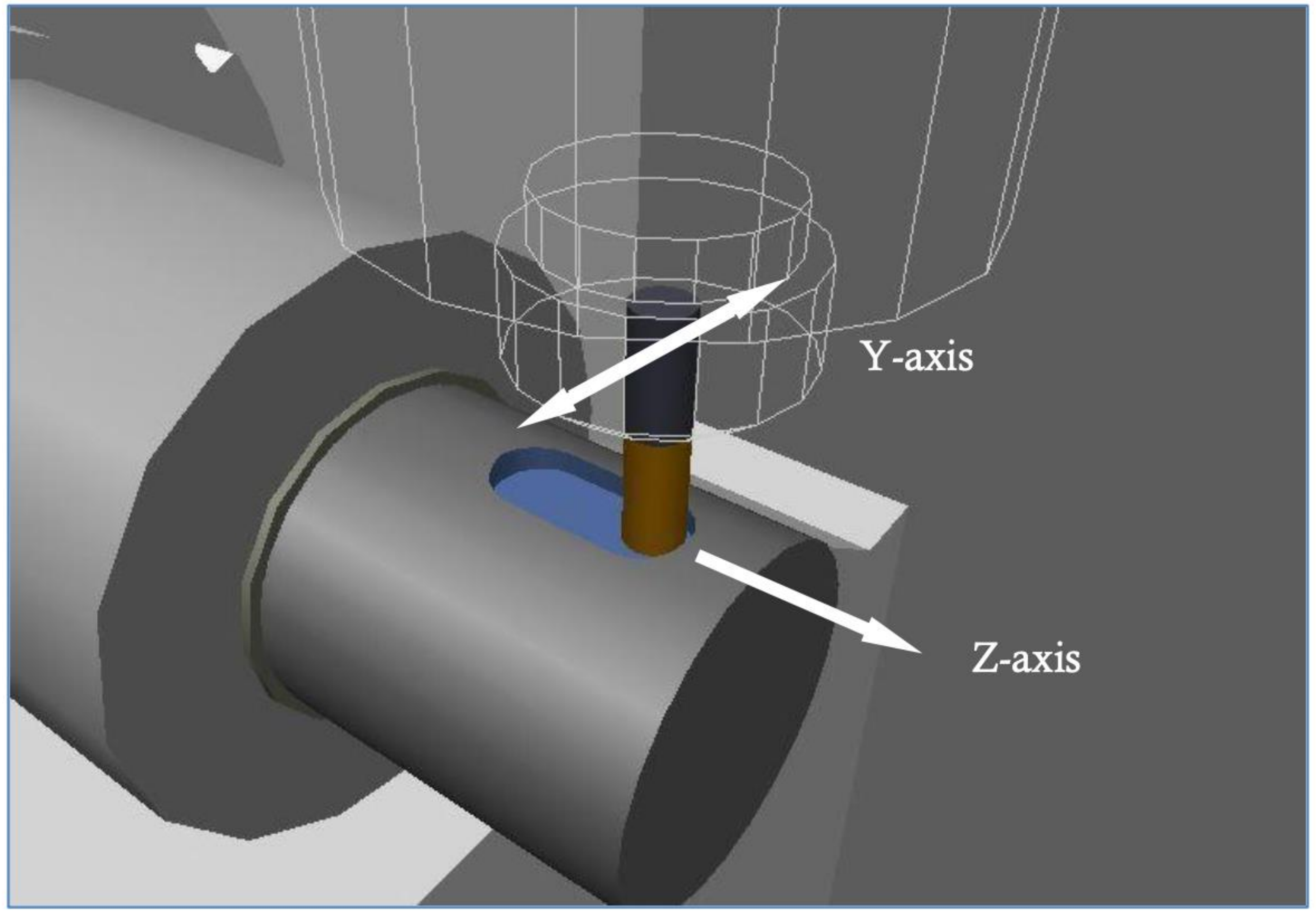
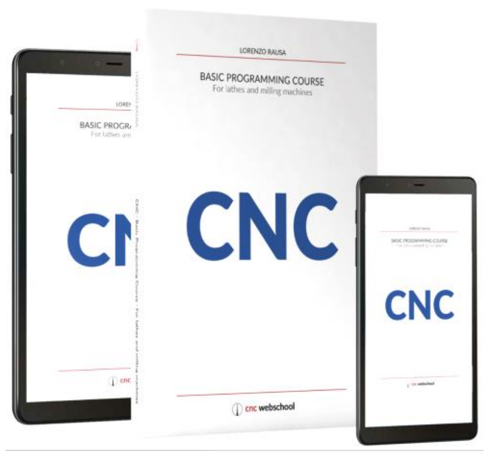


Fig. 24. Milling of a key using the real Y-axis



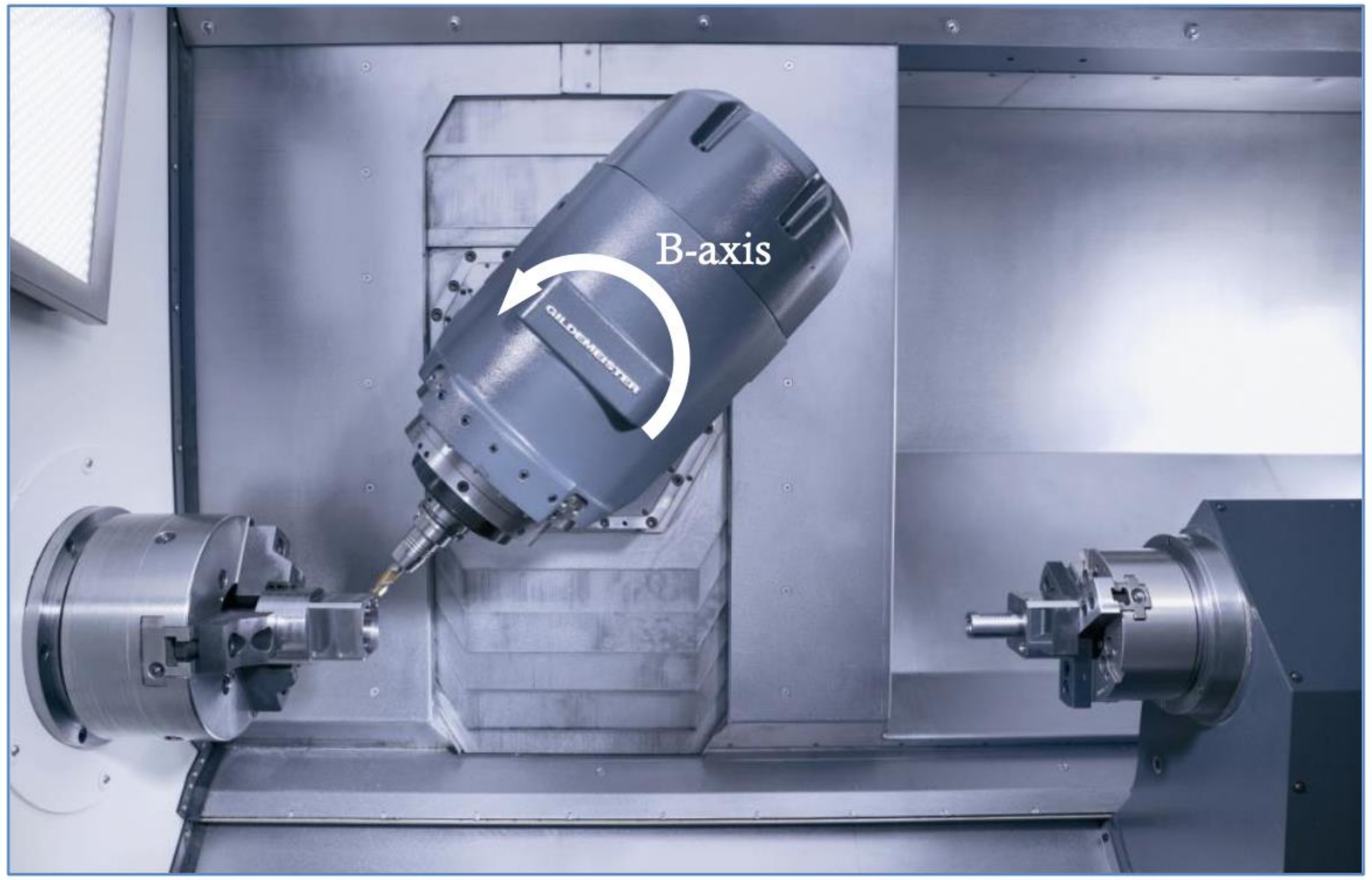


Fig. 25. Universal lathe with B-axis

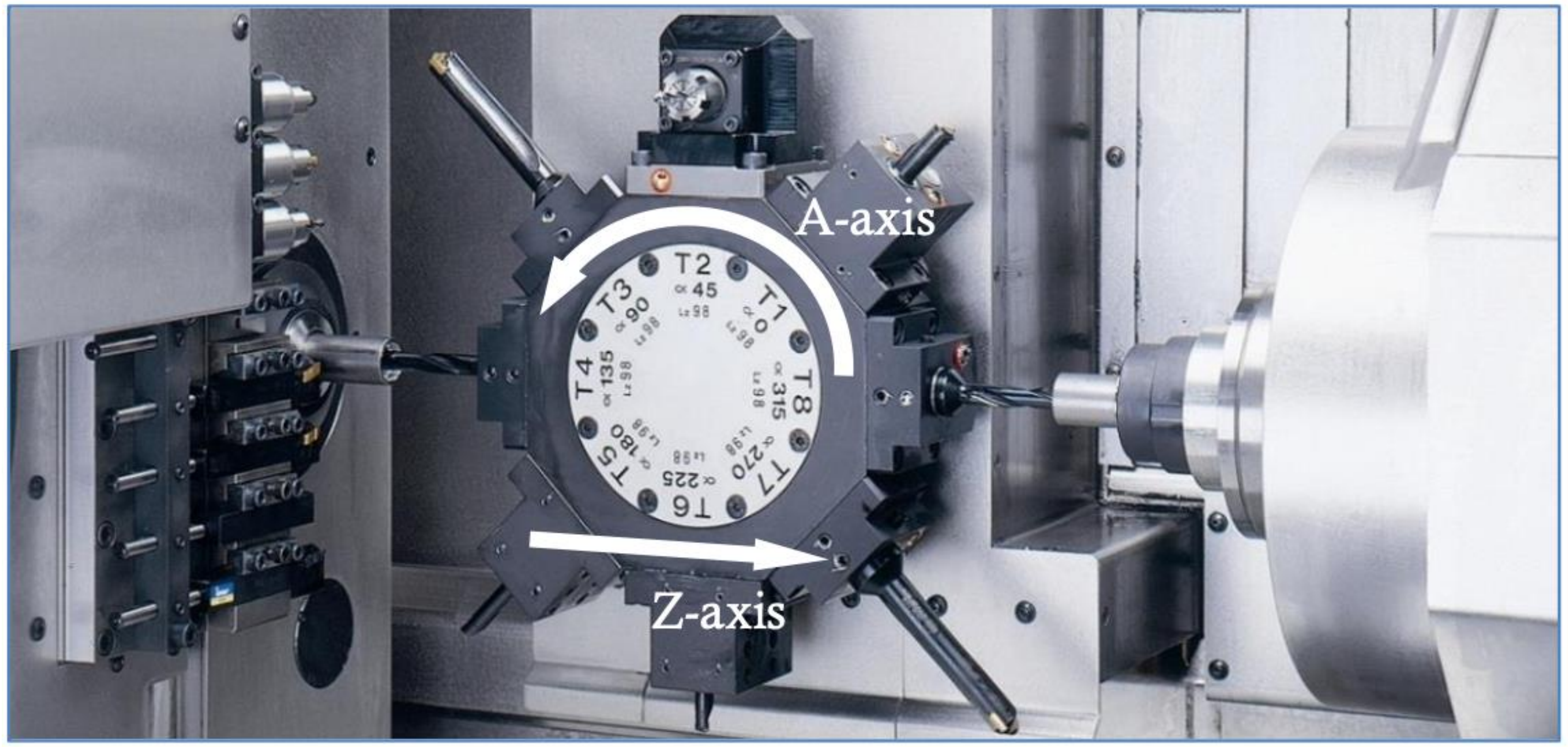


Fig. 26. Lathe with A-axis

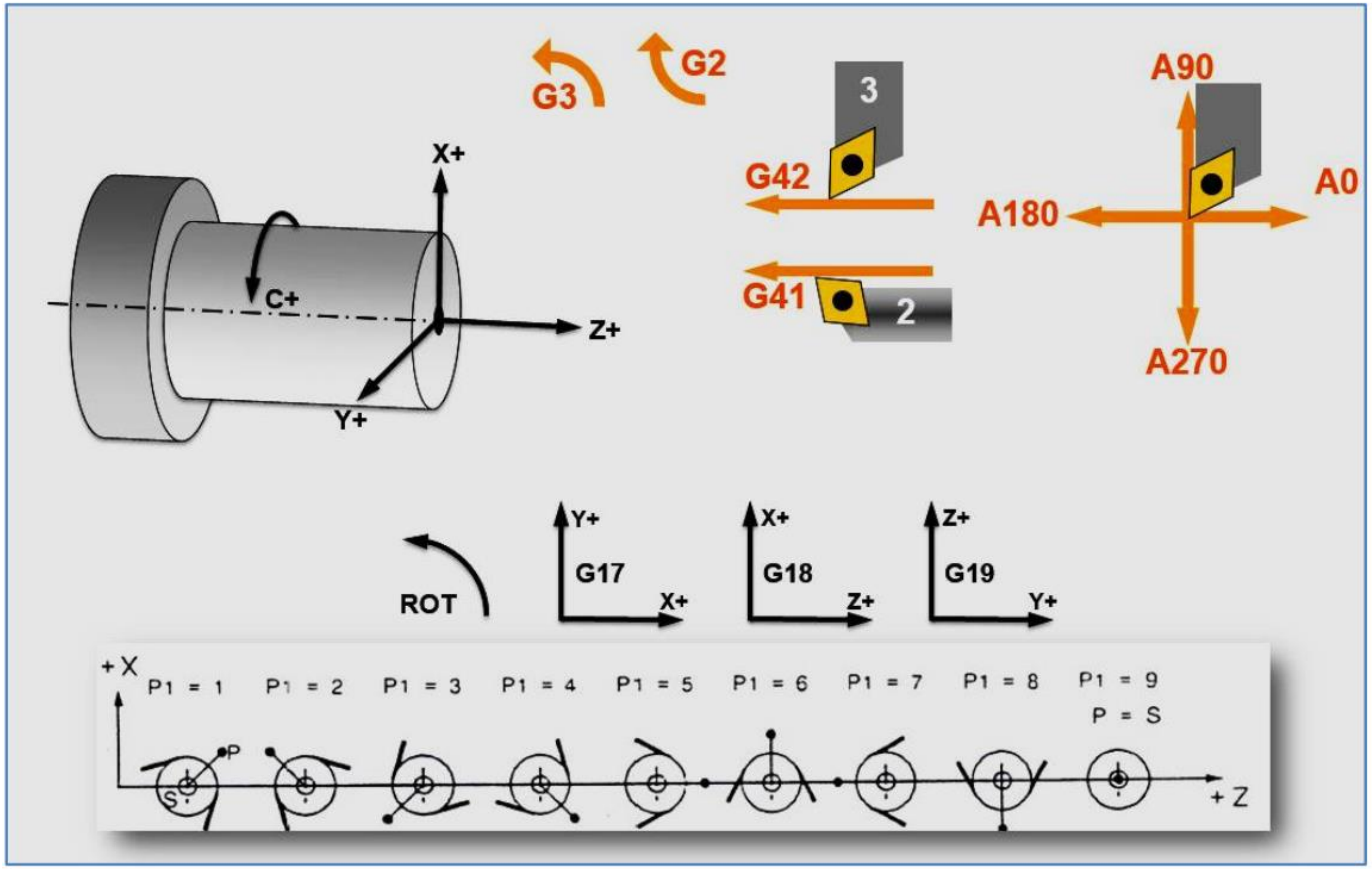


Fig. 27. Programming scheme

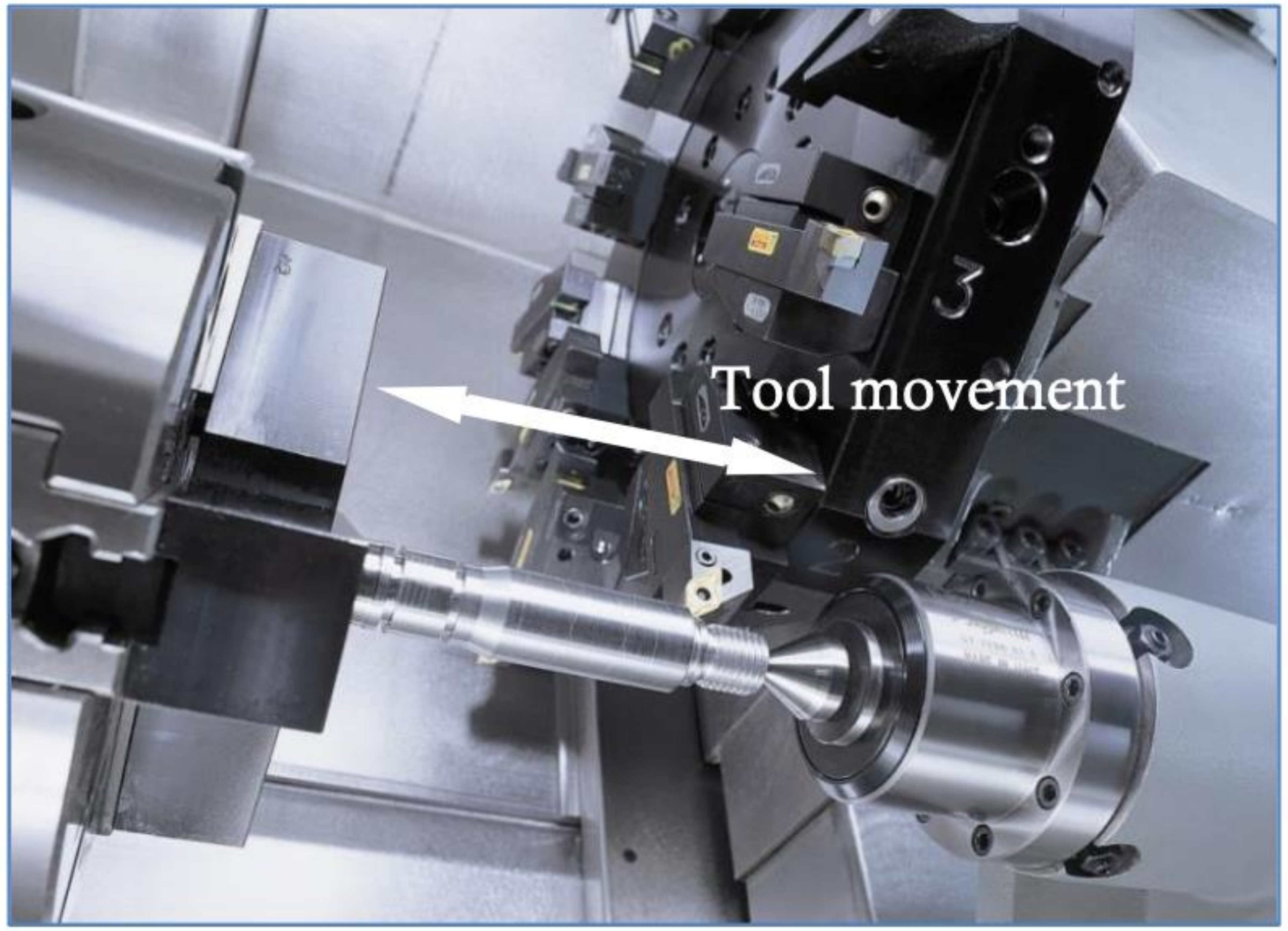


Fig. 28. Traditional lathe where the tool moves on the workpiece

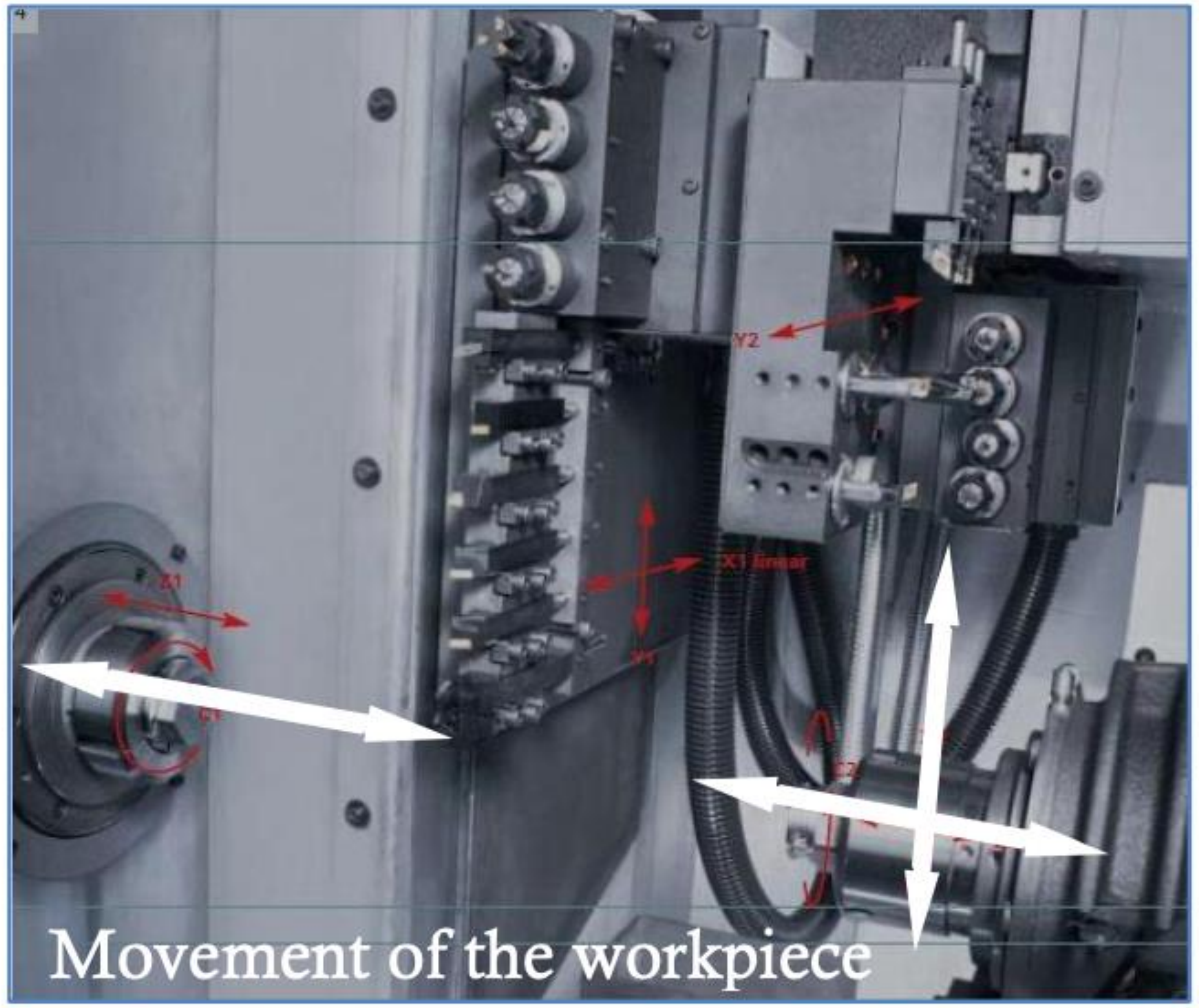


Fig. 29. Lathe with real movement of the Z-axis and of the X-axis on the workpiece

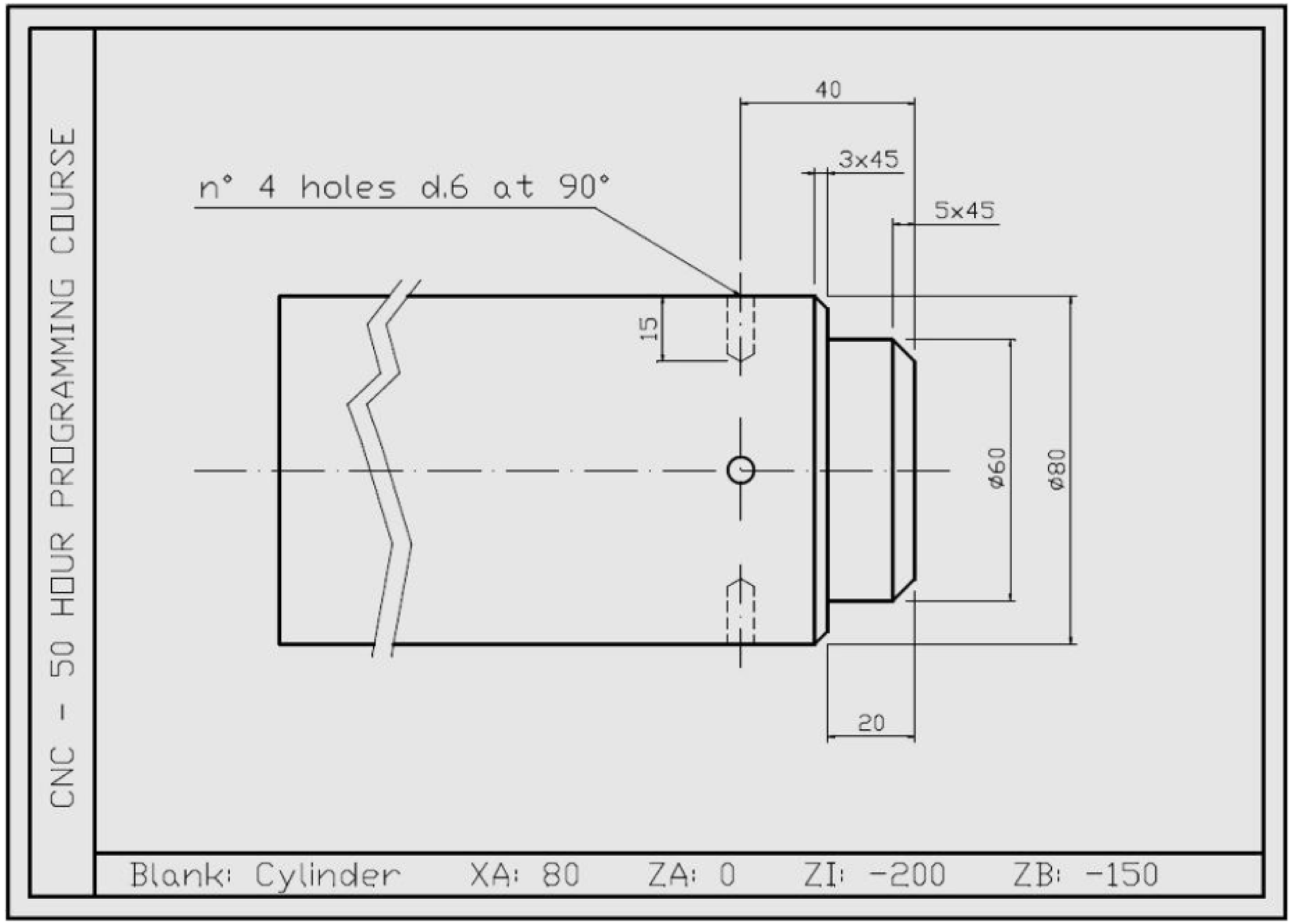


Fig. 30. Technical drawing created by the program PRG_04_01

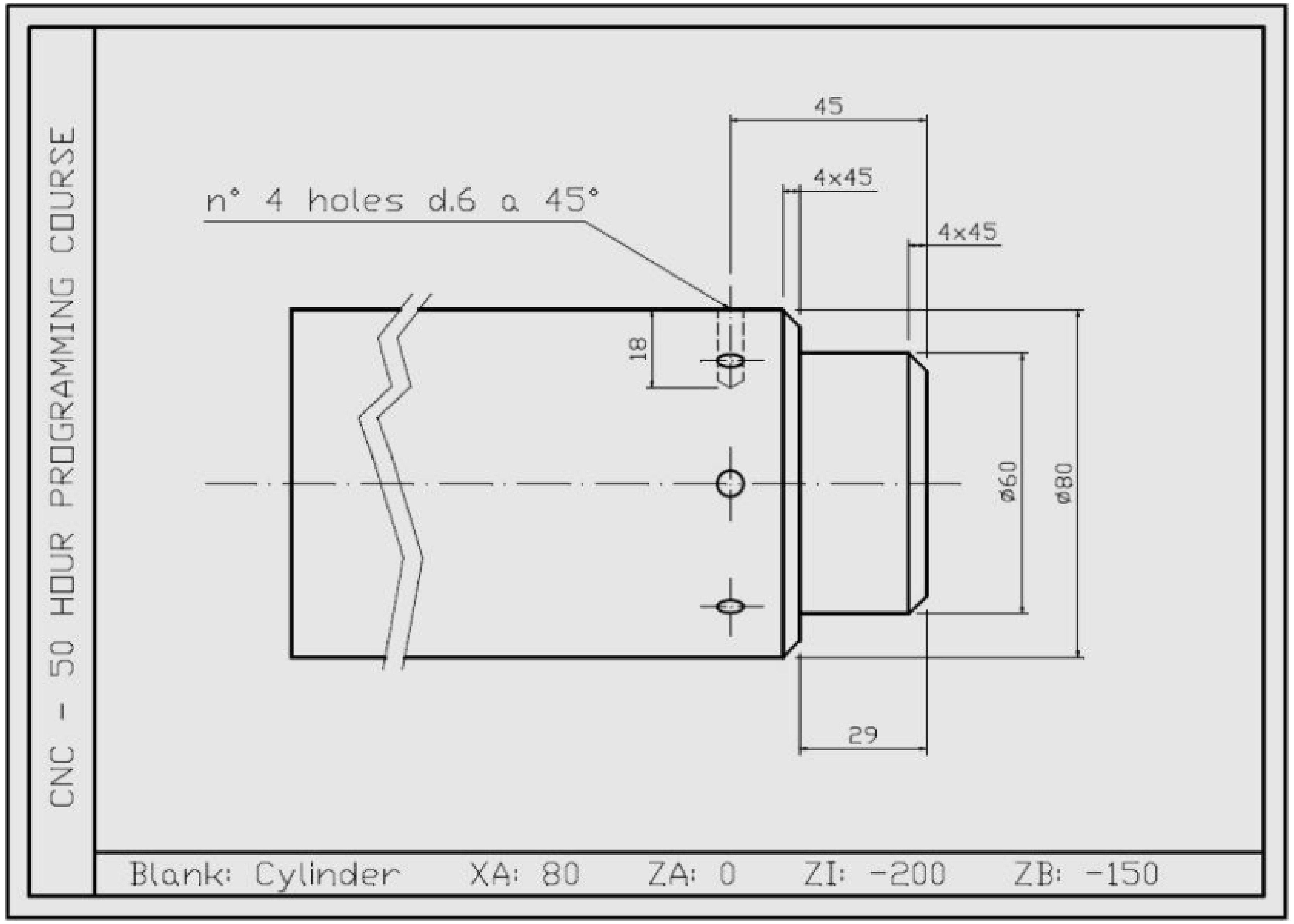
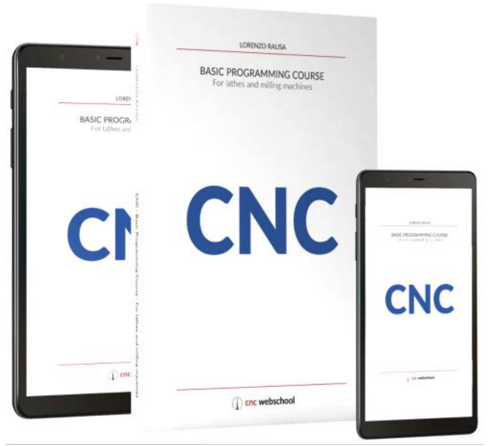


Fig. 31. Technical drawing of the part to create in program EX_04_01



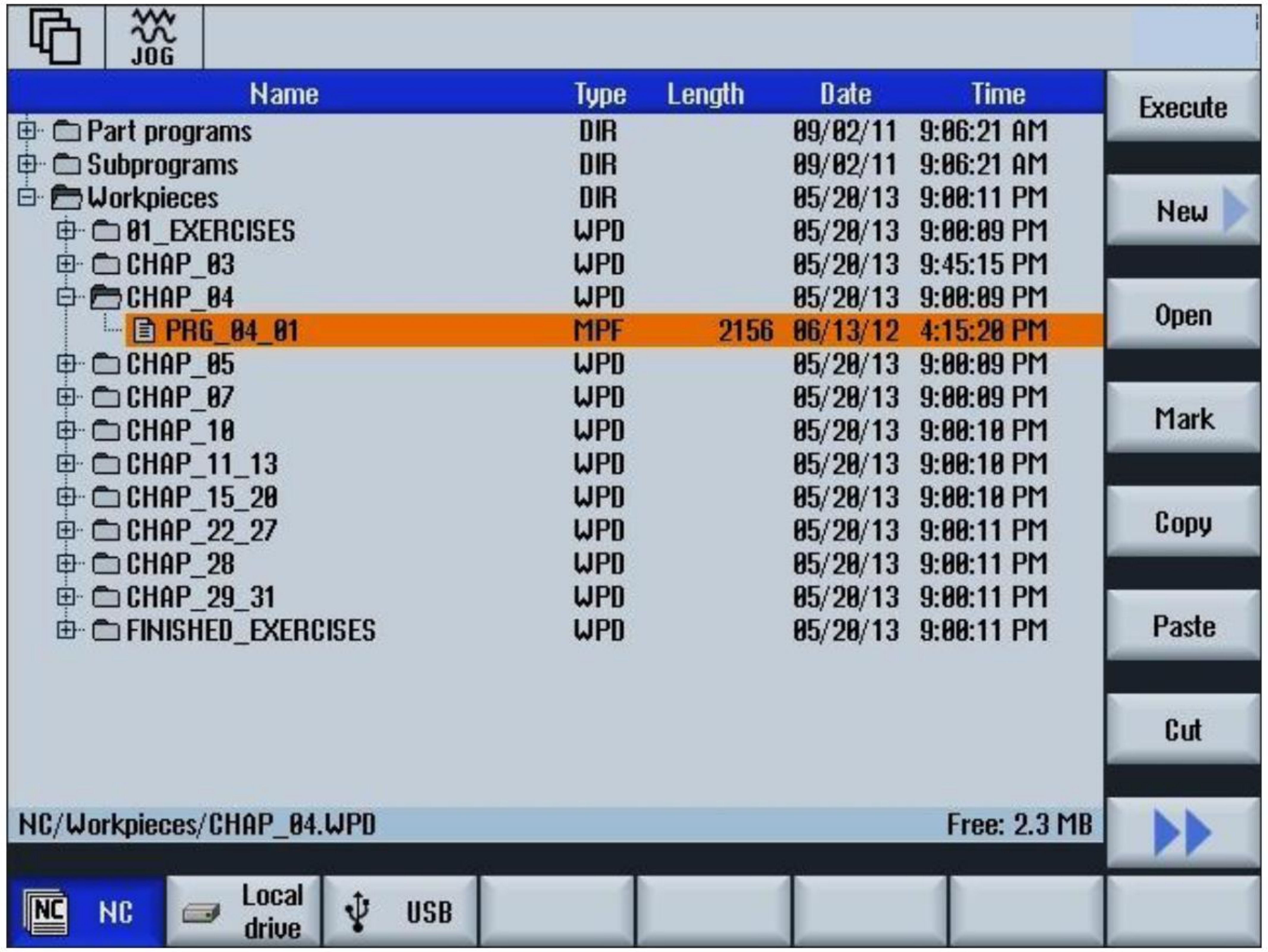


Fig. 32. Display of the PROGRAM MANAGER

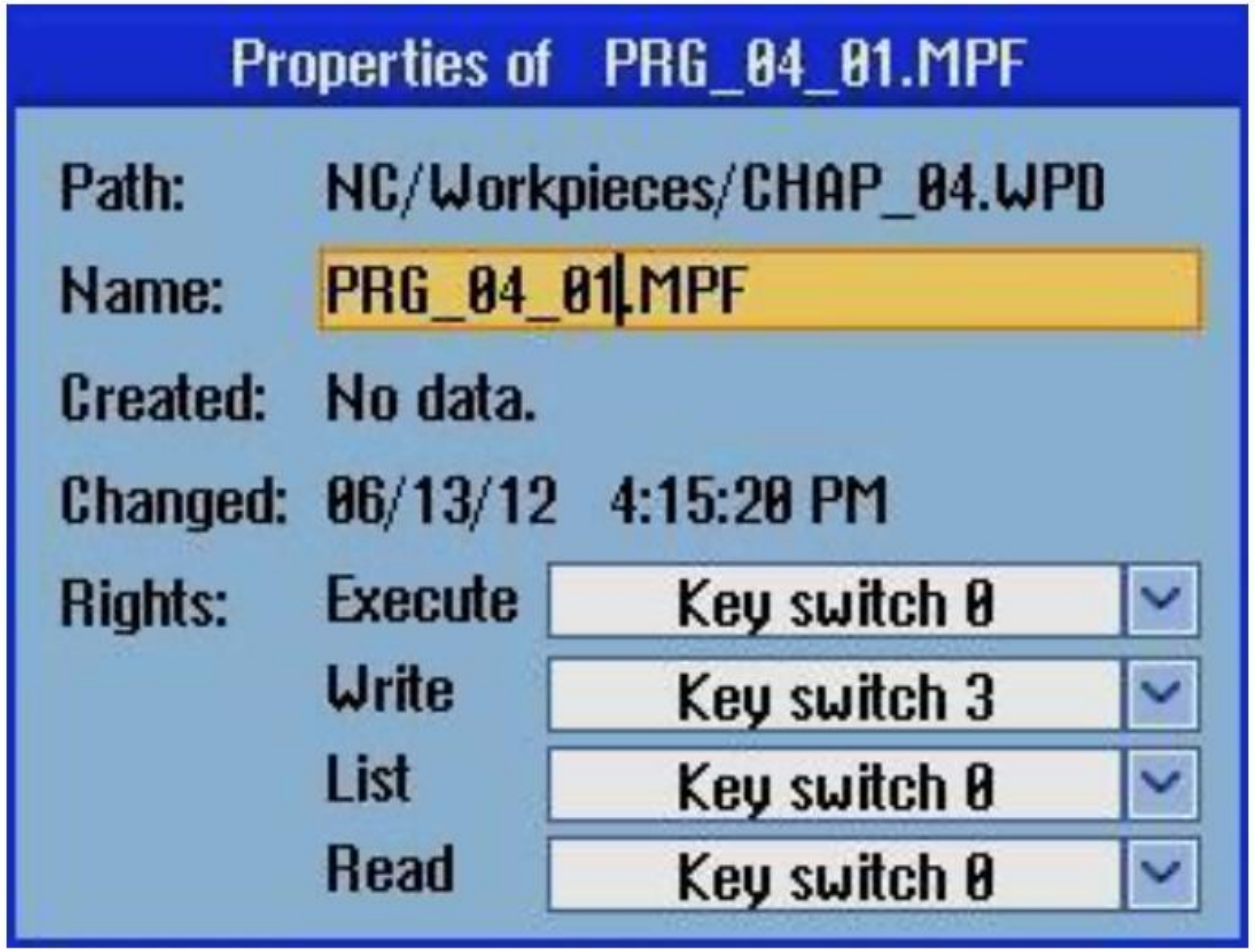
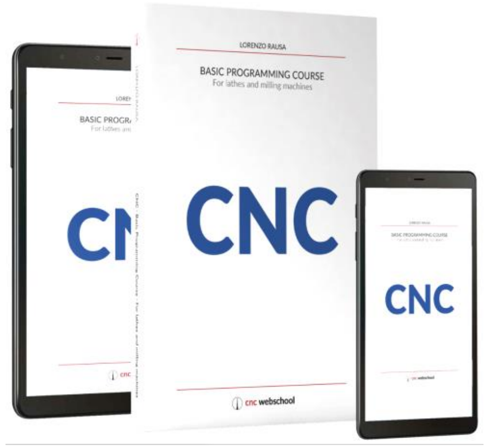


Fig. 33. File properties window



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Block	Word	Word	Word	; Comment
Block	N10	G0	X20	; First block
Block	N20	G2	Z37	; Second block
Block	N30	G91	…	…
Block	N40	…	…	
Block	N50	M30	…	; End of program

Fig. 34. Name of the elements constituting the program

Address	**Meaning**
N	Address of block number
10	Block number
G	Preparatory function
X, Y, Z	Path information
F	Feed rate
S	Number of revolutions or cutting speed
T	Tool position
D	Number of tool corrector
M	Auxiliary function

Fig. 35. Meaning of some addresses

Name	**Meaning**
G0	Rapid traverse motion
G1	Linear interpolation
G2	Circular interpolation clockwise
G3	Circular interpolation counterclockwise
G33	Thread cutting with constant lead
G331	Rigid tapping
G332	Return (rigid tapping)
G34	Thread cutting with variable lead
G35	Thread with decreasing lead

Fig. 36. Group 1: Motion commands

Name	**Meaning**
G17	Plane selection 1st - 2nd geometry axis (X-Y)
G18	Plane selection 3rd - 1st geometry axis (Z-X)
G19	Plane selection 2nd - 3rd geometry axis (Y-Z)

Fig. 37. Group 6: Plane selection

Name	**Meaning**
G40	Deactivation of the tool radius compensation
G41	Activation of the tool radius compensation left of contour
G42	Activation of the tool radius compensation right of contour

Fig. 38. Group 7: Tool radius compensation

Name	**Meaning**
G500	Cancel all adjustable frames G54 - G57 if no value in G500
G54	Settable zero offset
G55	Settable zero offset
G56	Settable zero offset
G57	Settable zero offset

Fig. 39. Group 8: Settable zero offset (frame)

Name	**Meaning**
G60	Velocity reduction, precise stop
G64	Continuous path mode

Fig. 40. Group 10: Precise stop – continuous path mode

Name	**Meaning**
G70	Selects English units (inches and feet)
G71	Selects metric units (millimeter and meter)

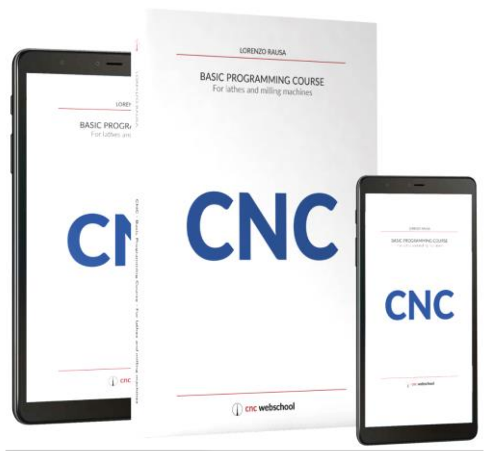
Fig. 41. Group 13: Workpiece dimensioning inch/metric

Name	**Meaning**
G90	Absolute coordinate system
G91	Incremental coordinate system

Fig. 42. Group 14: Absolute/incremental coordinate system

Name	**Meaning**
G94	Linear feed mm/min or inch/min
G95	Rotational feed in mm/rev or inch/rev
G96	Constant cutting speed in m/min or feet/min
G97	Constant number of revolutions in rev./min

Fig. 43. Group 15: Feed rate and rotation type

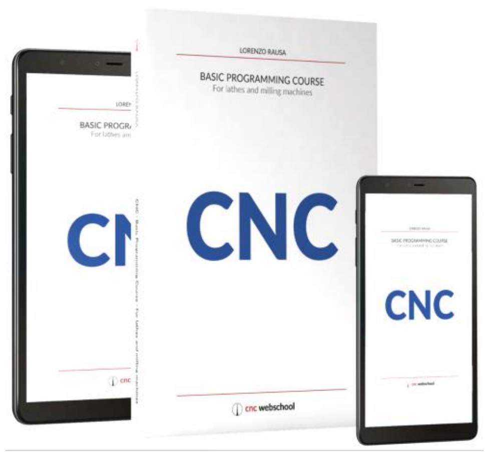


Name	Meaning
G4	Dwell time preset
G9	Exact stop only in the block where it is programmed
G53	Suppression of current frame

Fig. 44. Self-deleting instructions

Name	Meaning
M0	Programmed stop
M1	Optional stop activated by the control panel
M3	Spindle clockwise
M4	Spindle counterclockwise
M5	Spindle stop
M6	Tool change (if provided)
M8	Cooling liquid activation
M9	Cooling liquid stop
M30	End of program and return to beginning
M17	End of subroutine and return to main program
M40	Automatic gear change (when provided)
M41	Gear stage 1 (if provided)
M42	Gear stage 2 (if provided)
M43	Gear stage 3 (if provided)
M44	Gear stage 4 (if provided)
M45	Gear stage 5 (if provided)
M70	Spindle with transition to functioning as an axis

Fig. 45. Auxiliary or miscellaneous functions



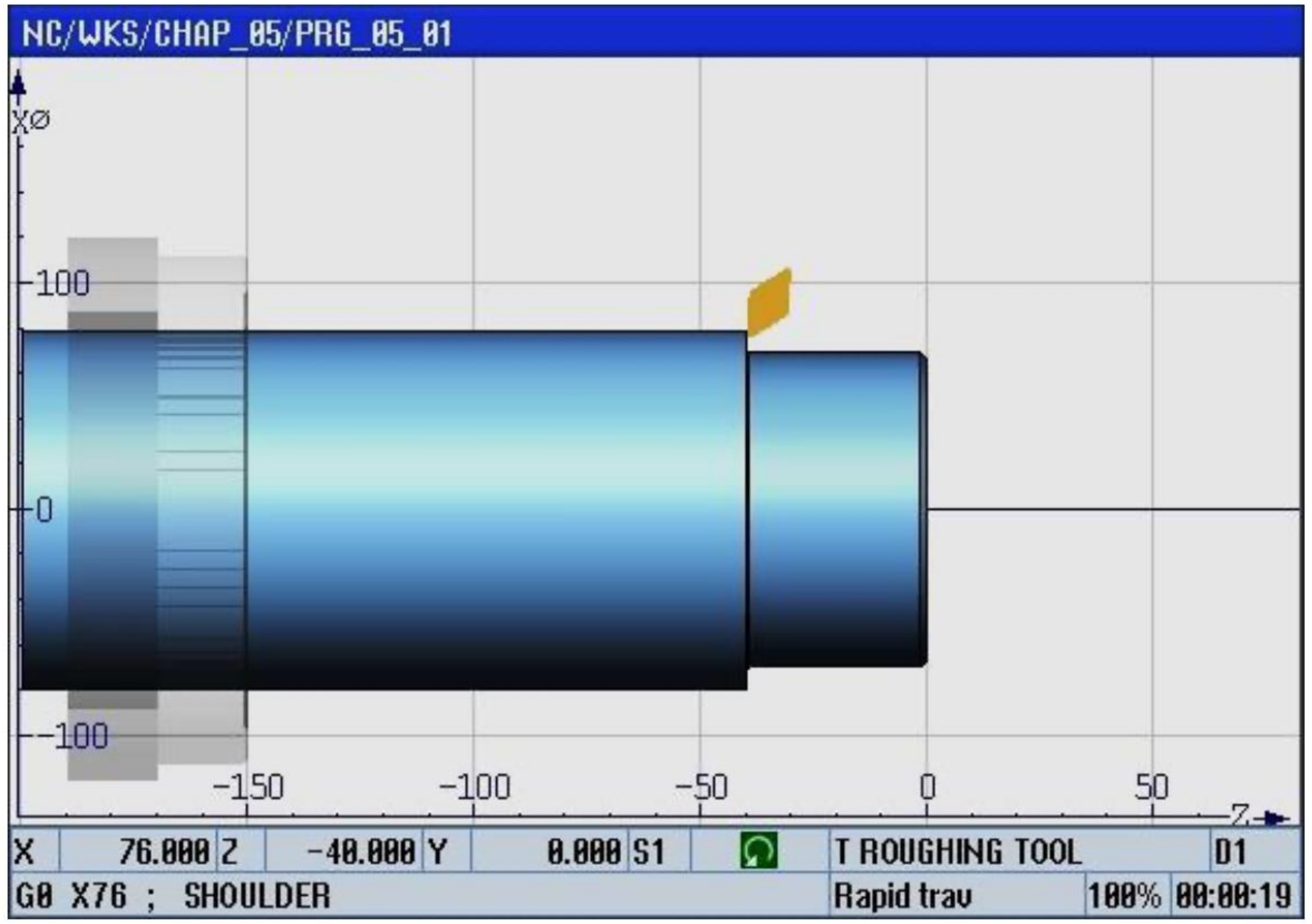


Fig. 46. Start of the simulation in order to analyze the program

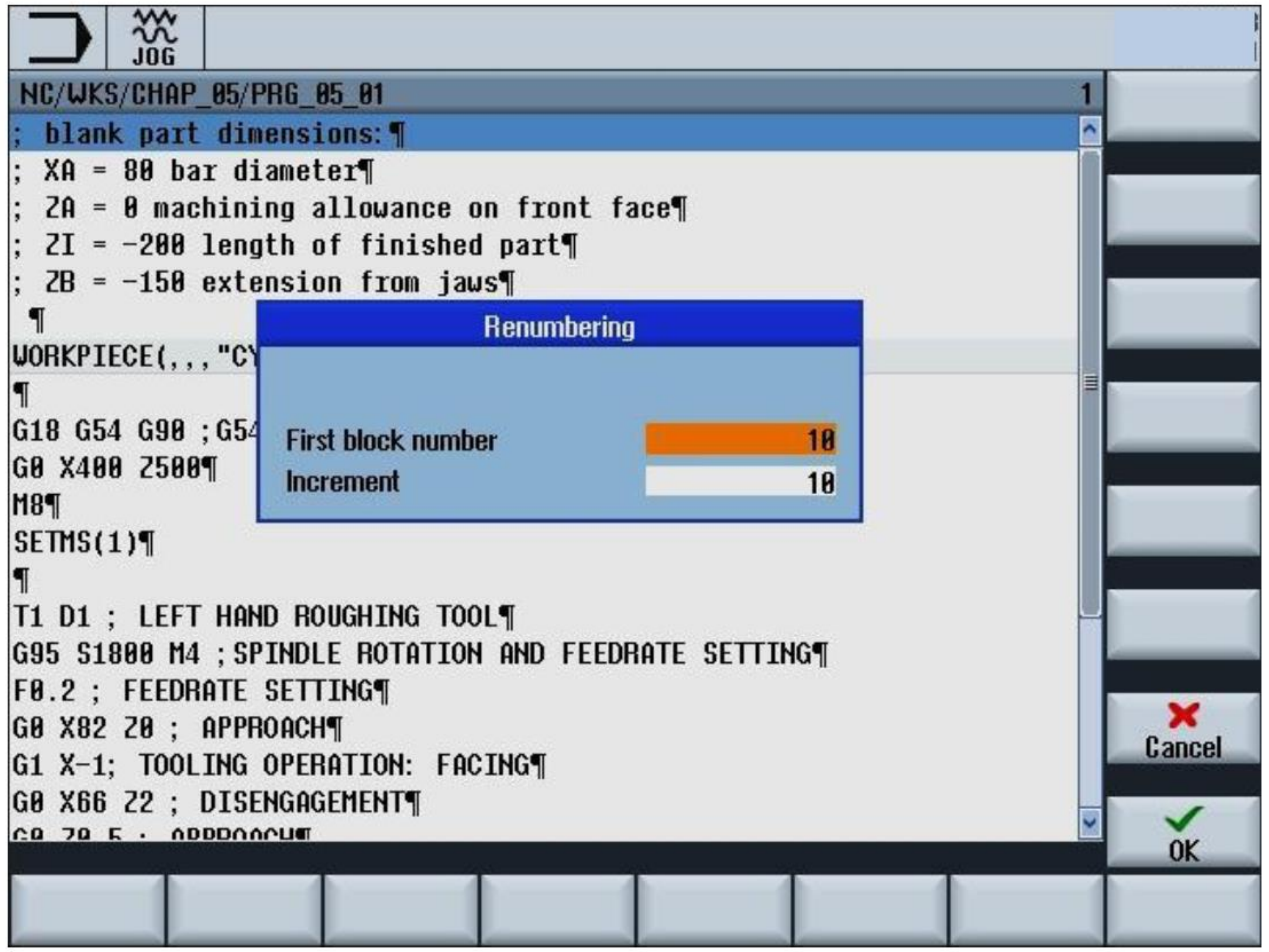


Fig. 47. Automatic block numbering screen

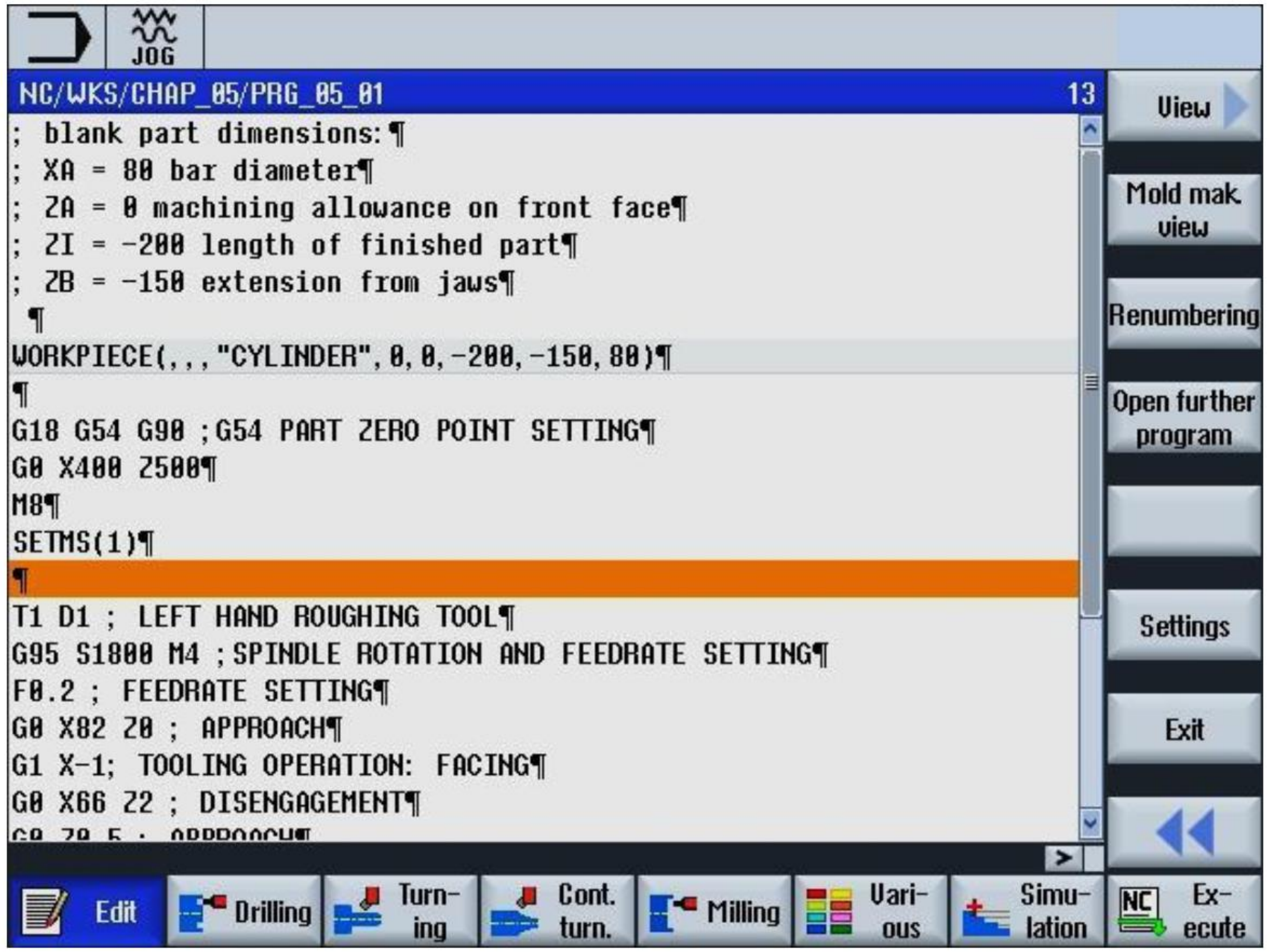


Fig. 48. Program without block numbers

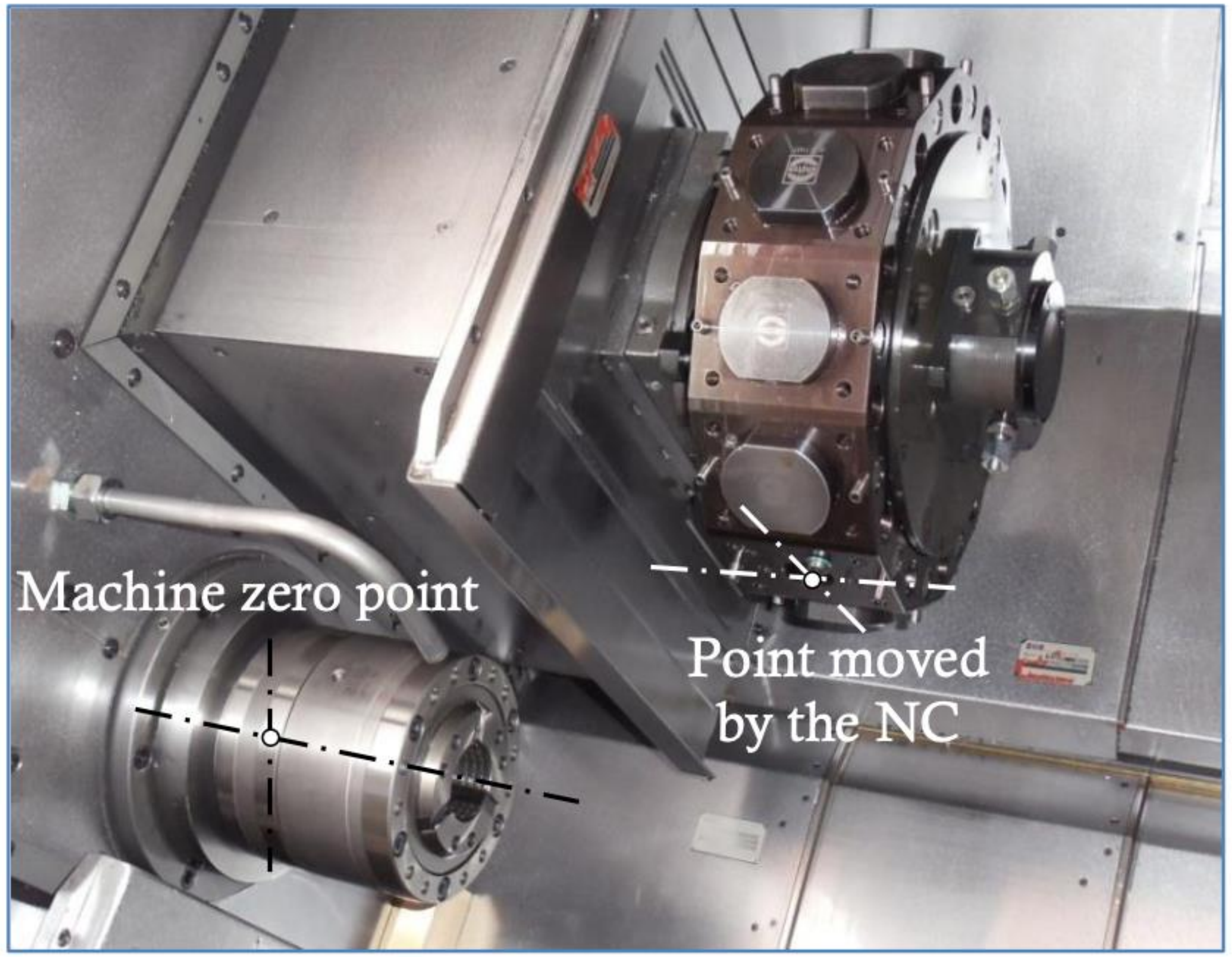
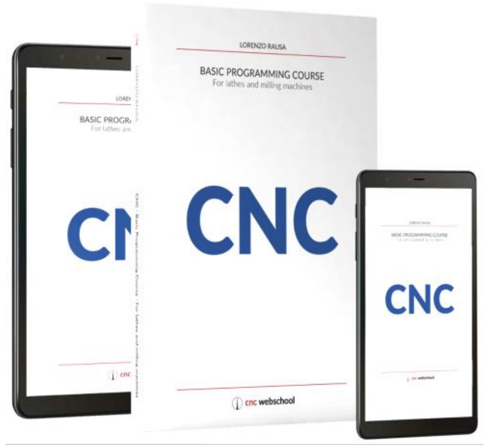


Fig. 49. Machine coordinate system: point moved by the NC referring to the machine zero point



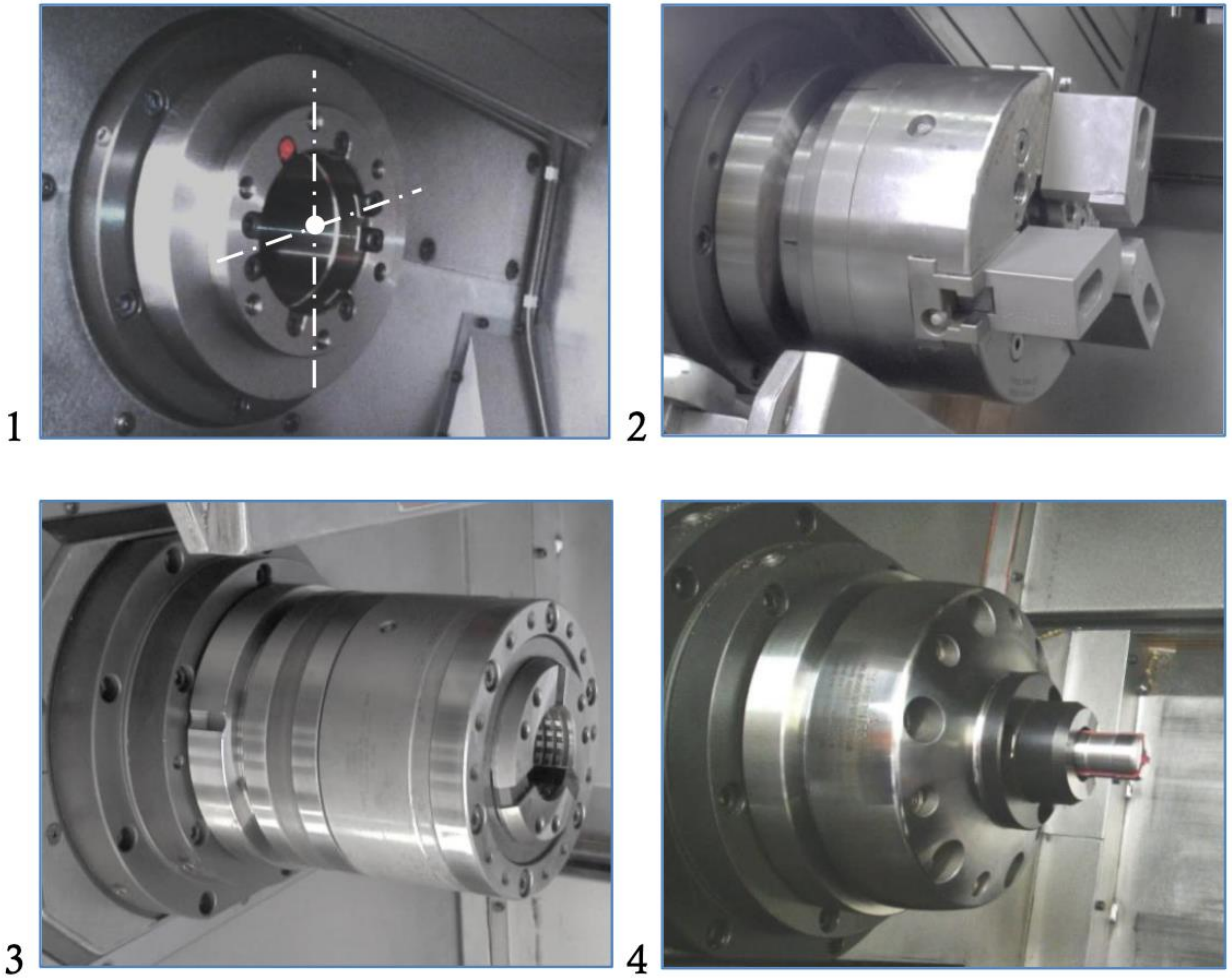
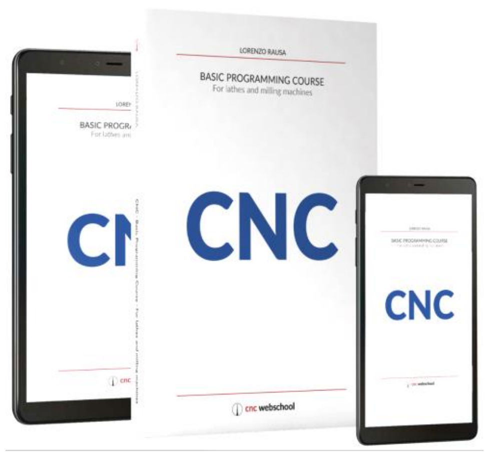


Fig. 50. 1: Spindle nose ; 2: chuck with three jaws ; 3: Elastic collet for external hold;
4: Elastic expansion collet for internal hold of the workpiece



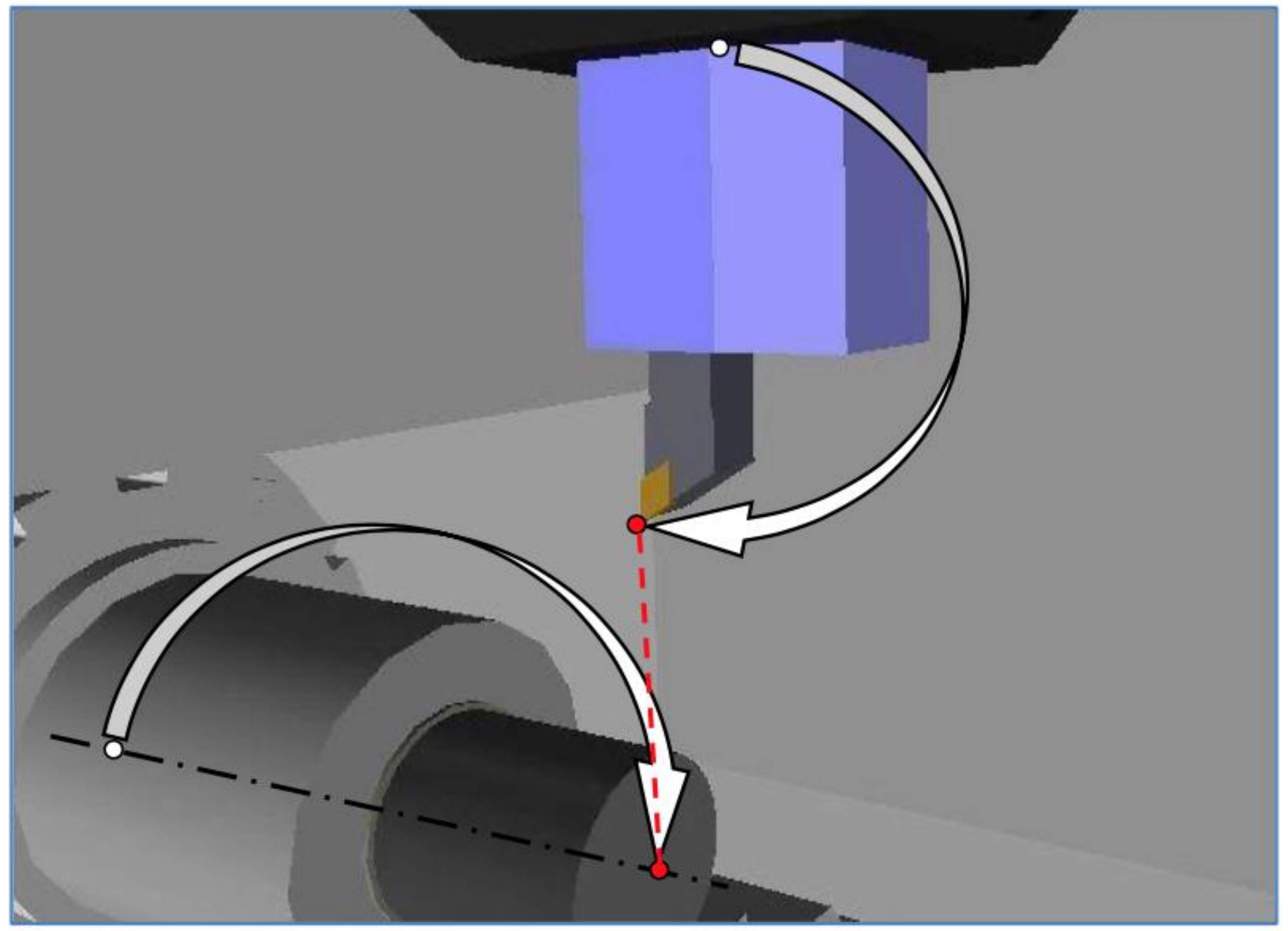


Fig. 51. Workpiece coordinate system: tool tip referring to the part zero point

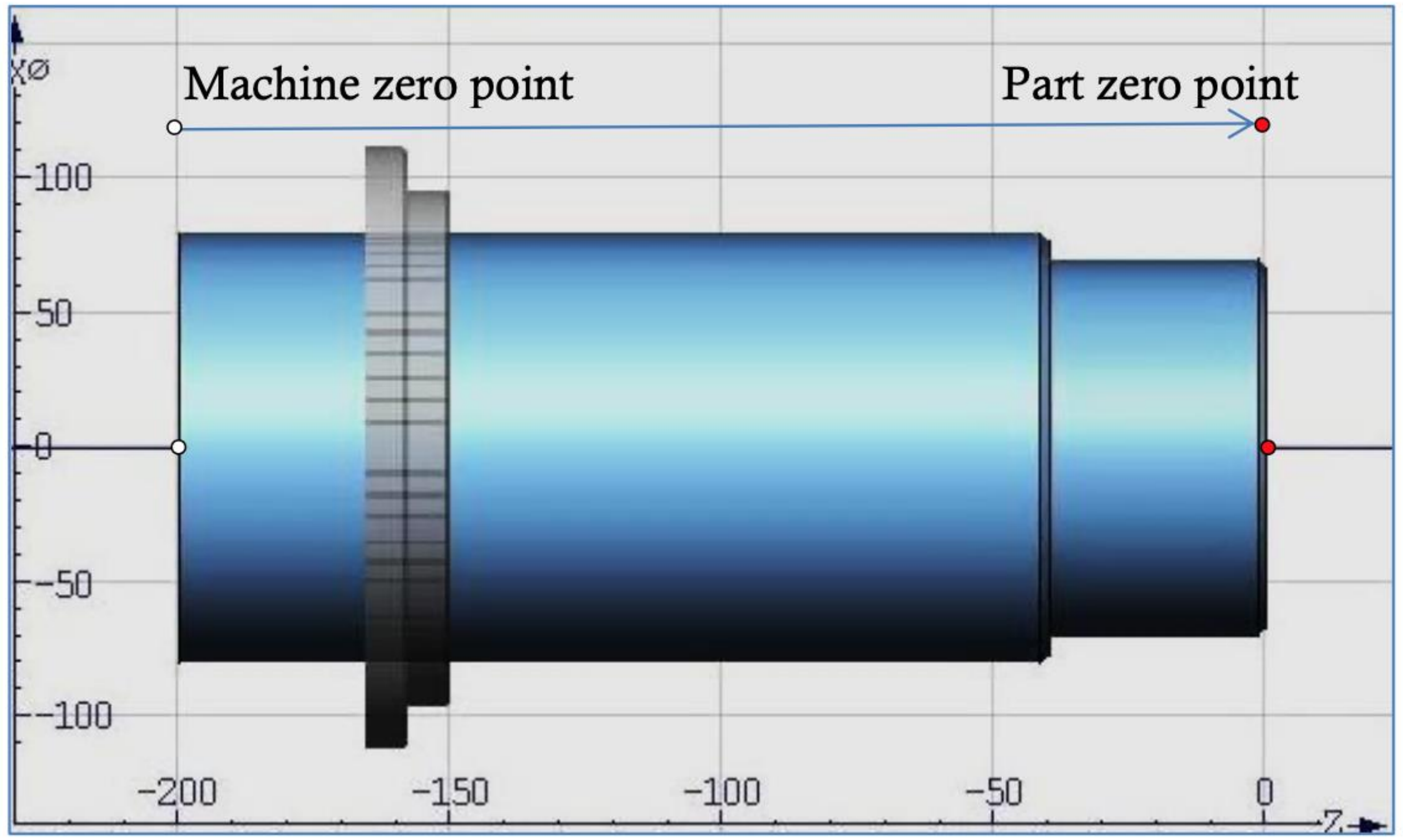
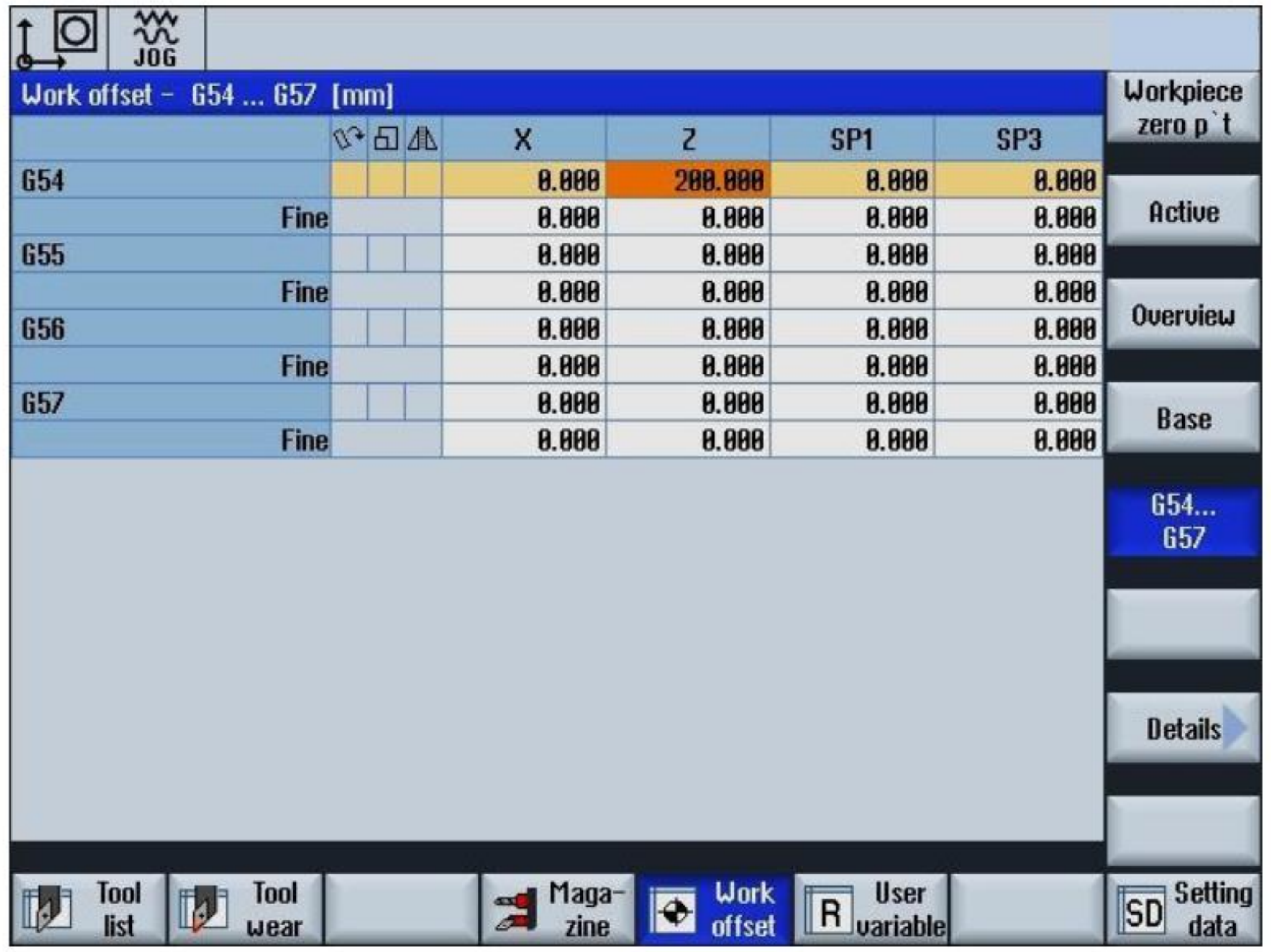


Fig. 52. Definition of the part zero point



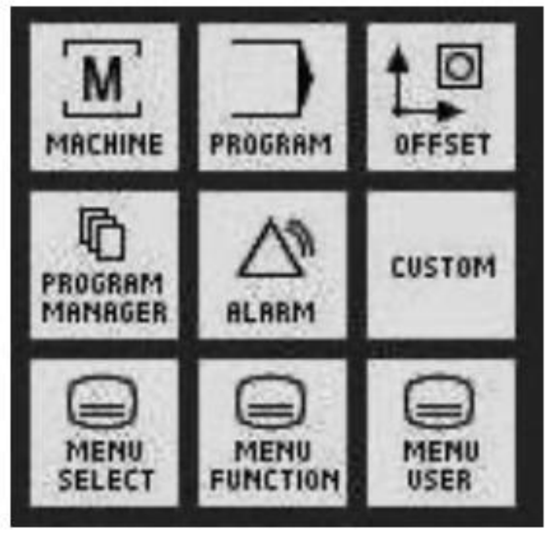


Fig. 53. Table of work offsets

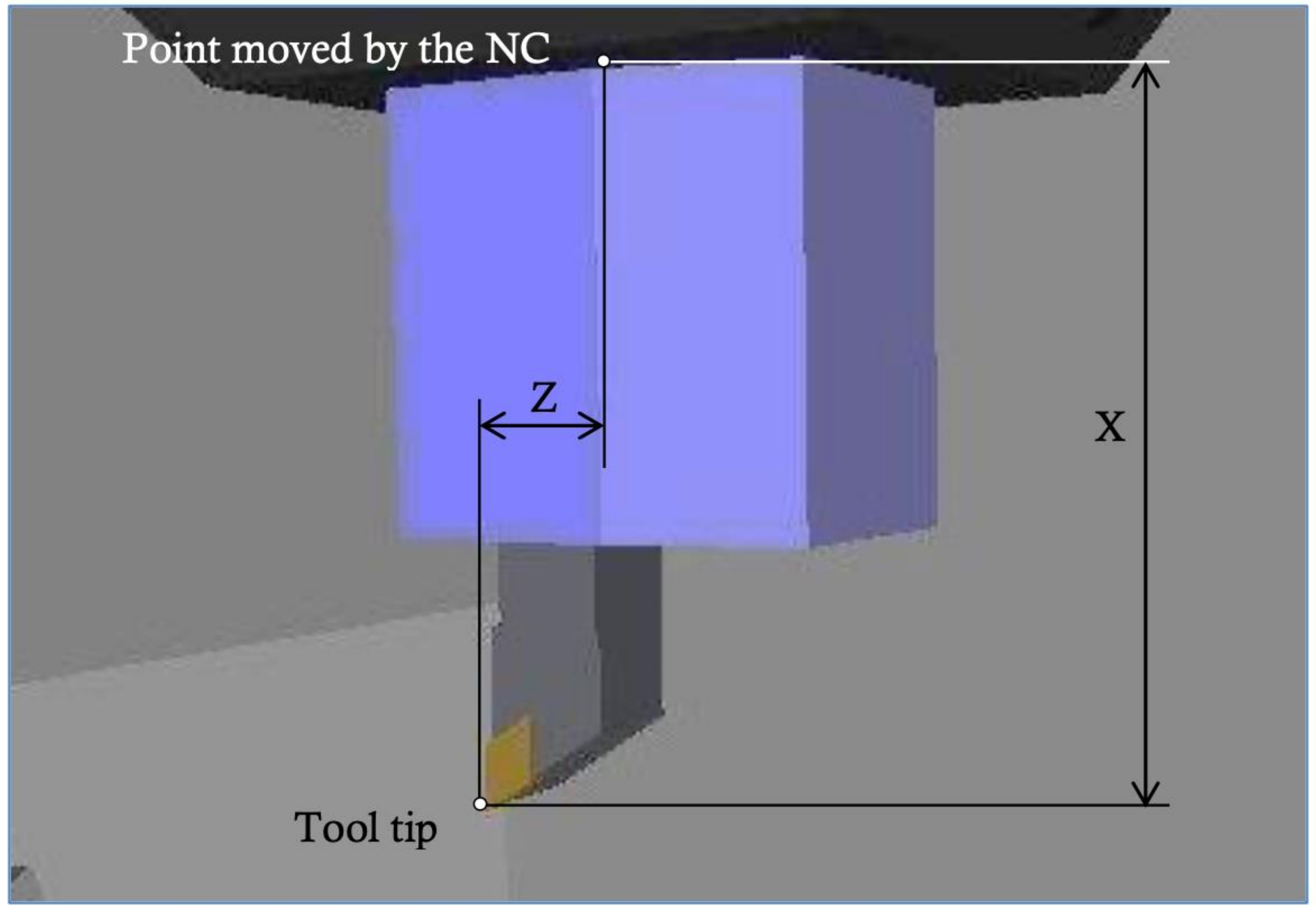
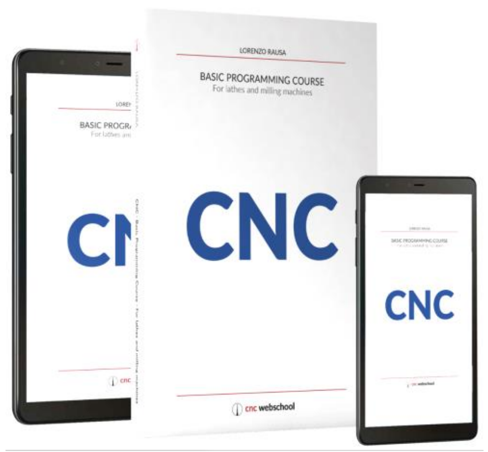


Fig. 54. Tool offset values



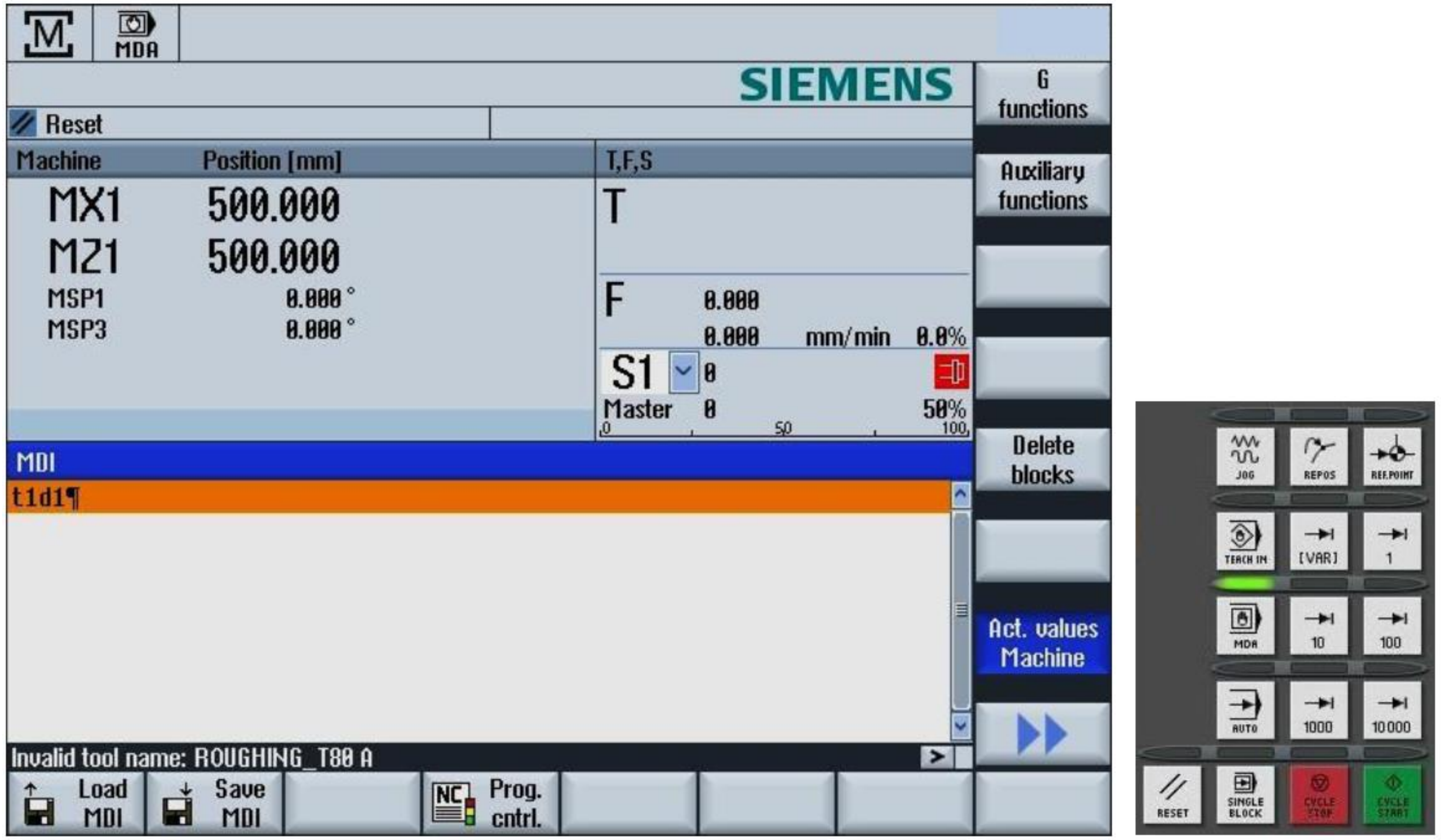


Fig. 55. Page for manual data entry

Fig. 56. Buttons for the selection of the continuous manual feed

Fig. 57. Buttons for the selection of the manual feed by incrementation

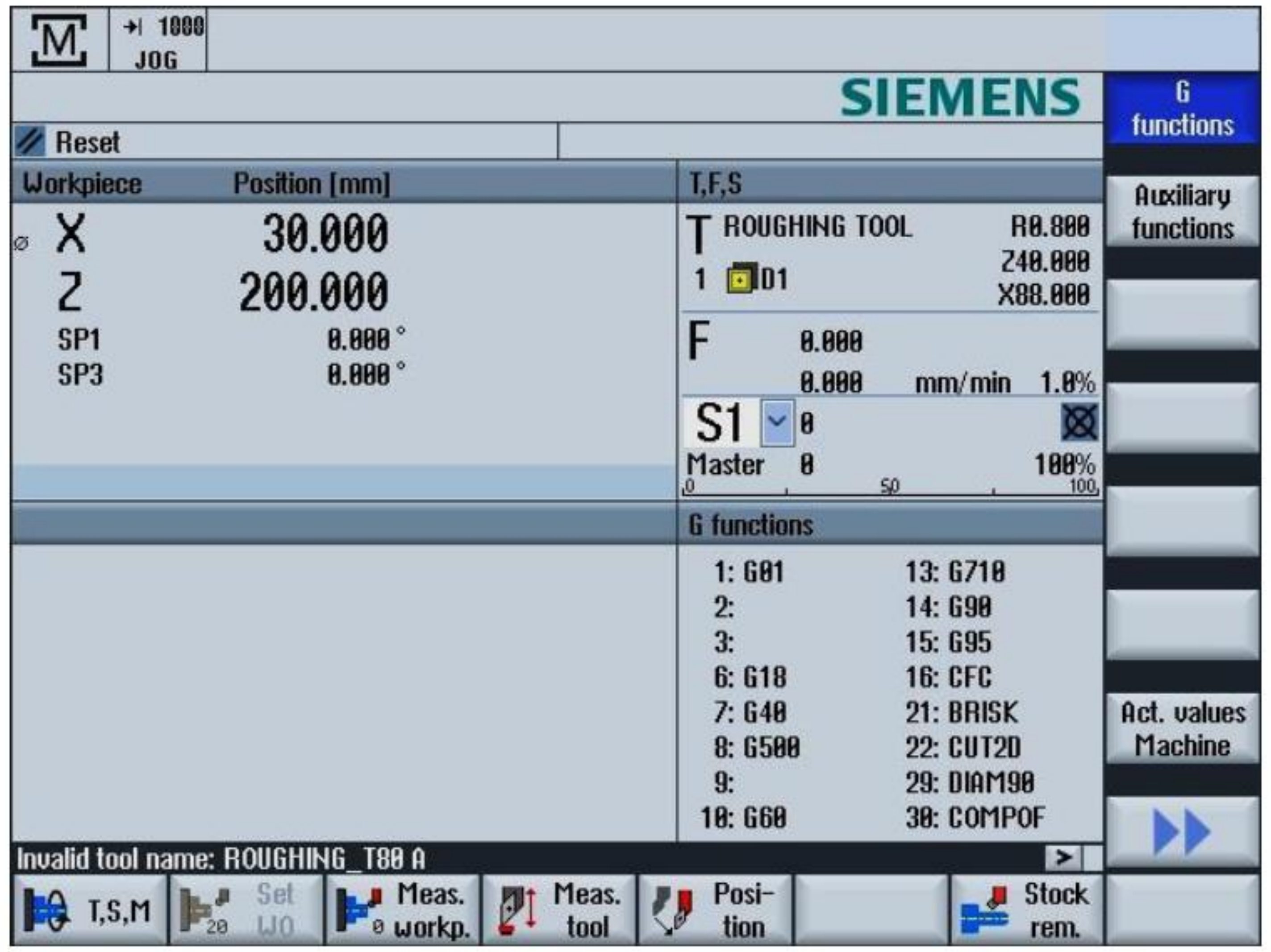
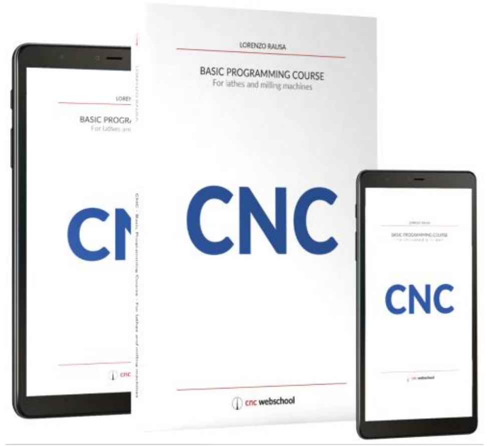


Fig. 58. Touch-off position of the part face in the workpiece coordinate system



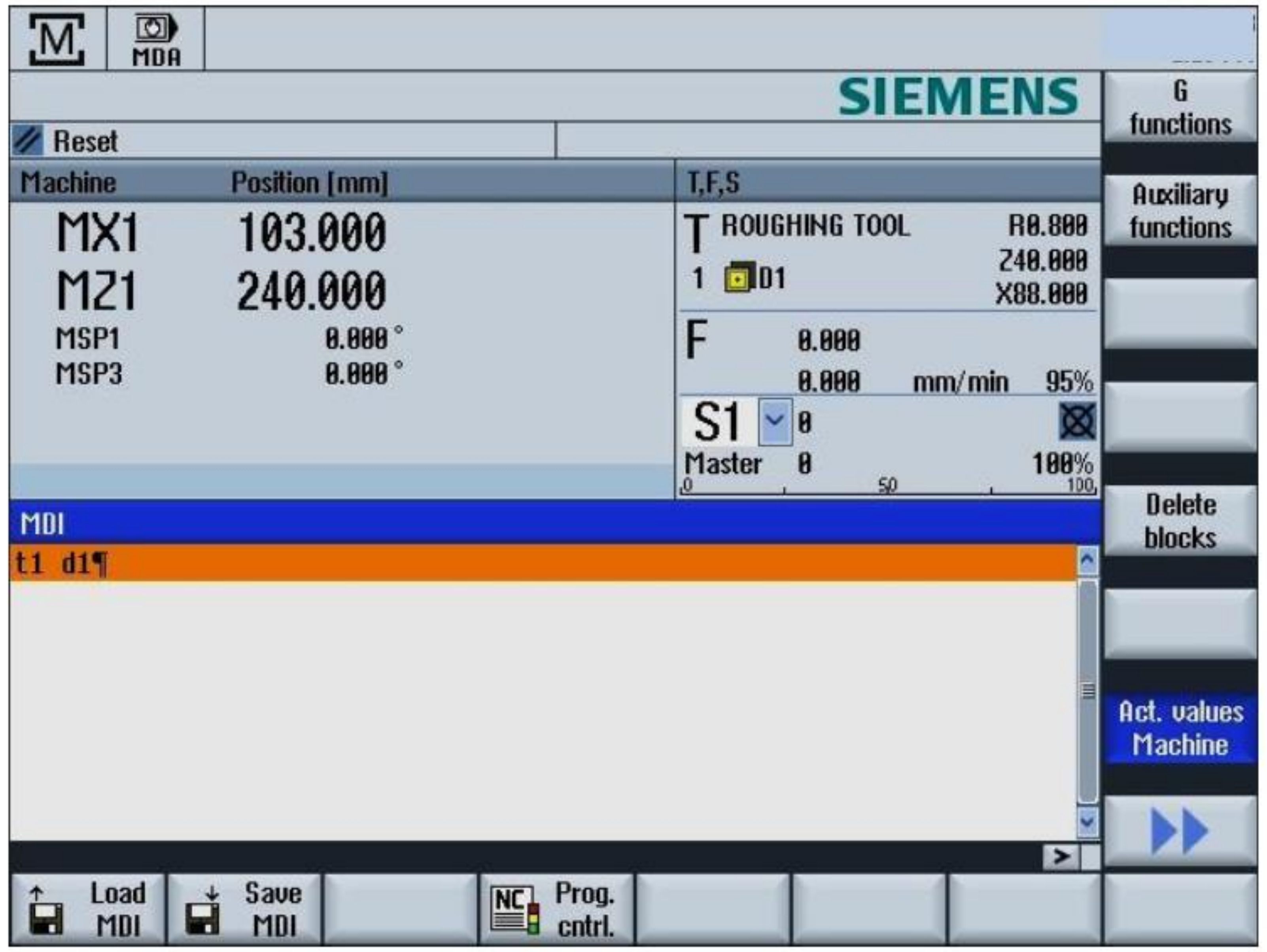


Fig. 59. Touch-off position of the part face in the machine coordinate system

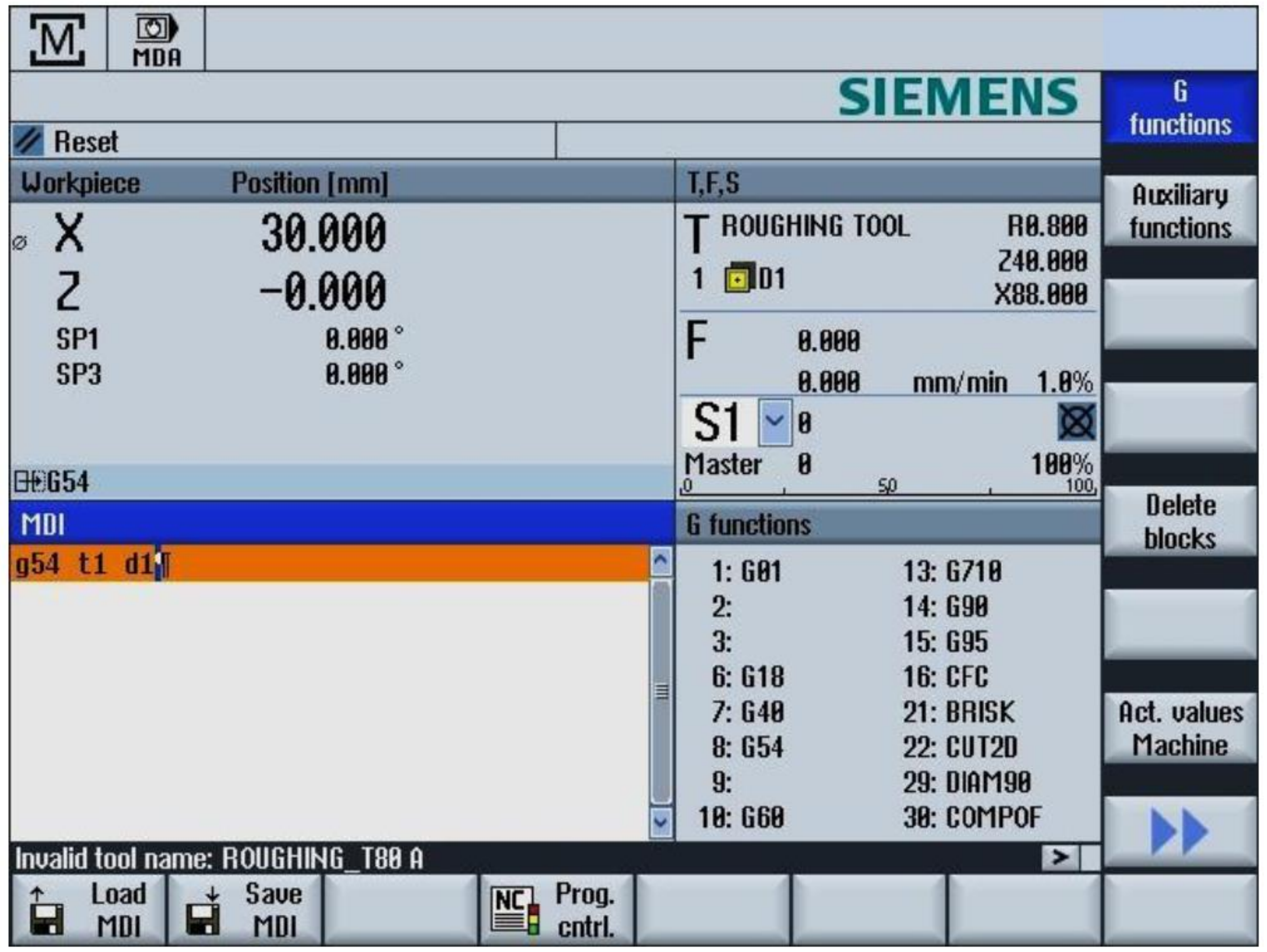
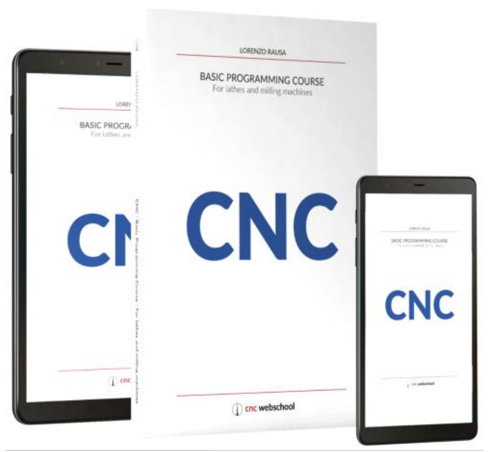


Fig. 60. Current position of the tool after activation of the workpiece coordinate system programmed in MDA



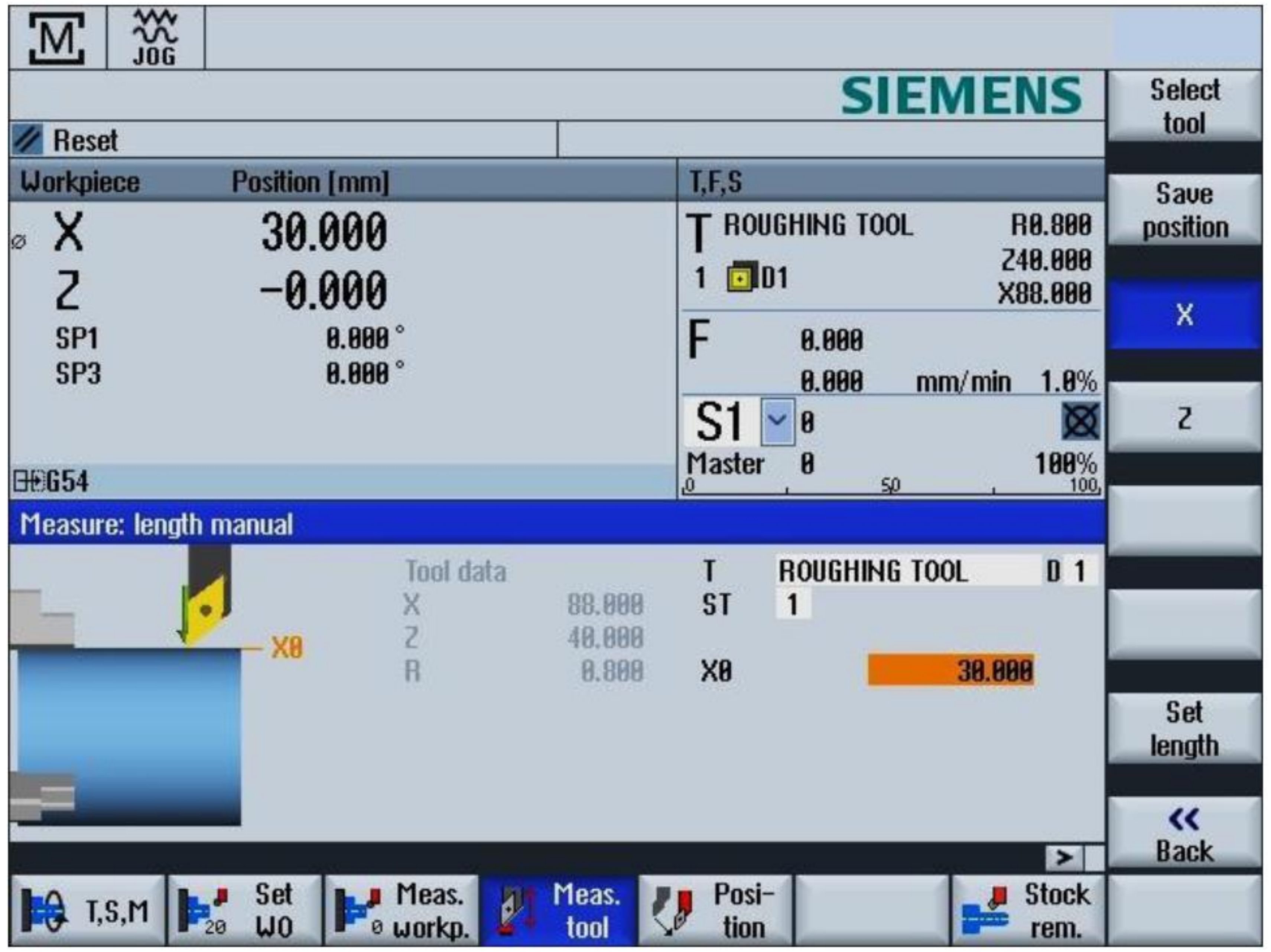
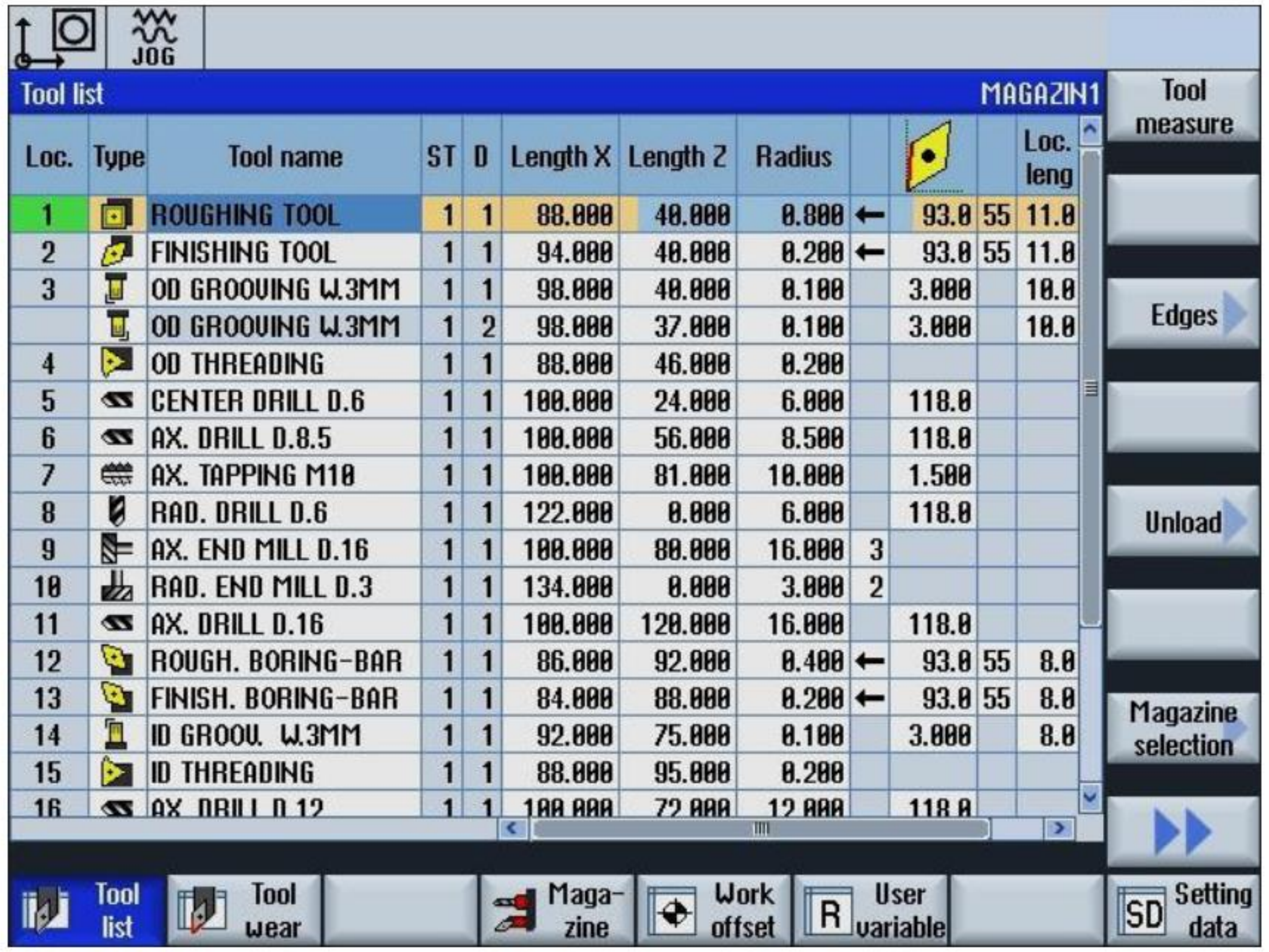


Fig. 61. Page for the automatic offset by touching the workpiece



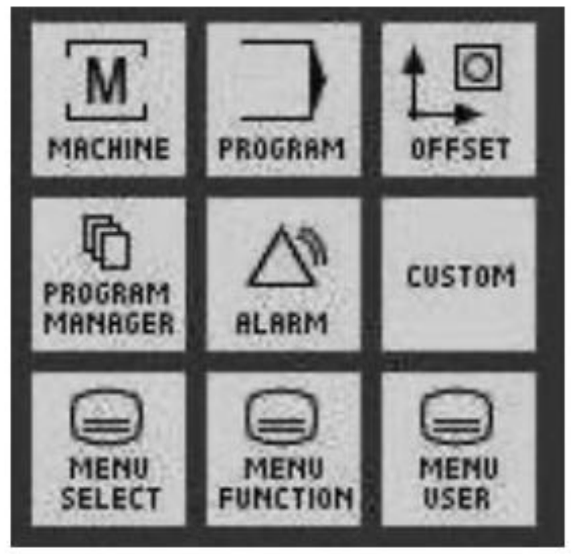
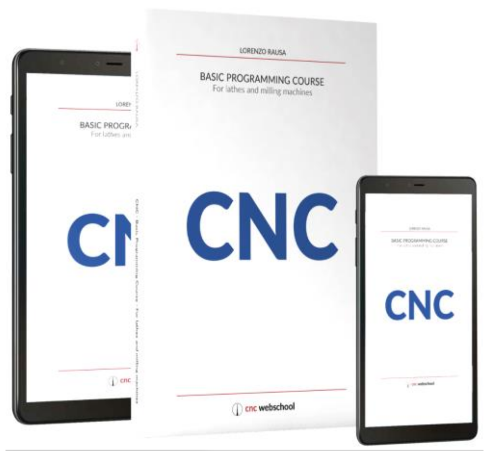
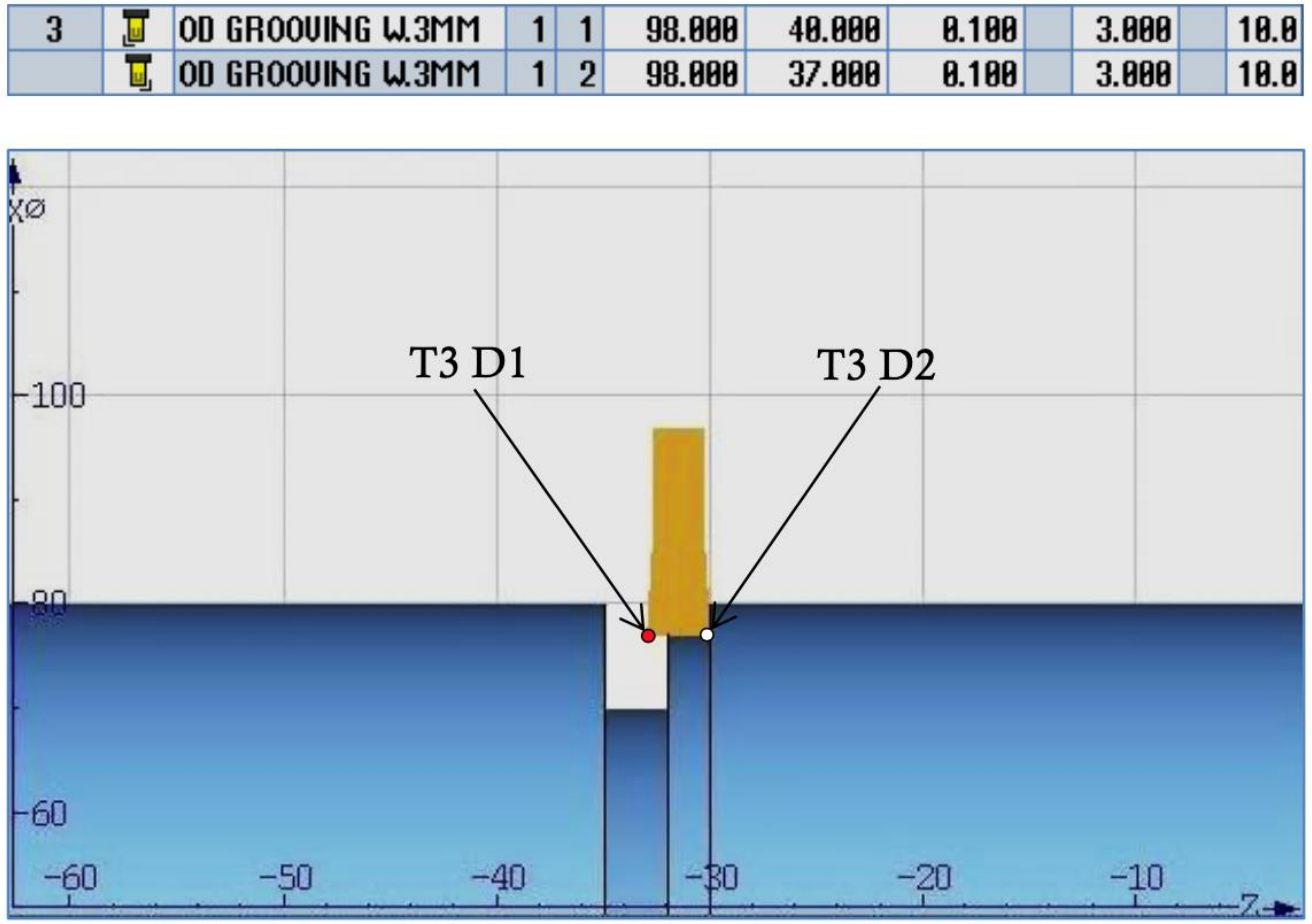


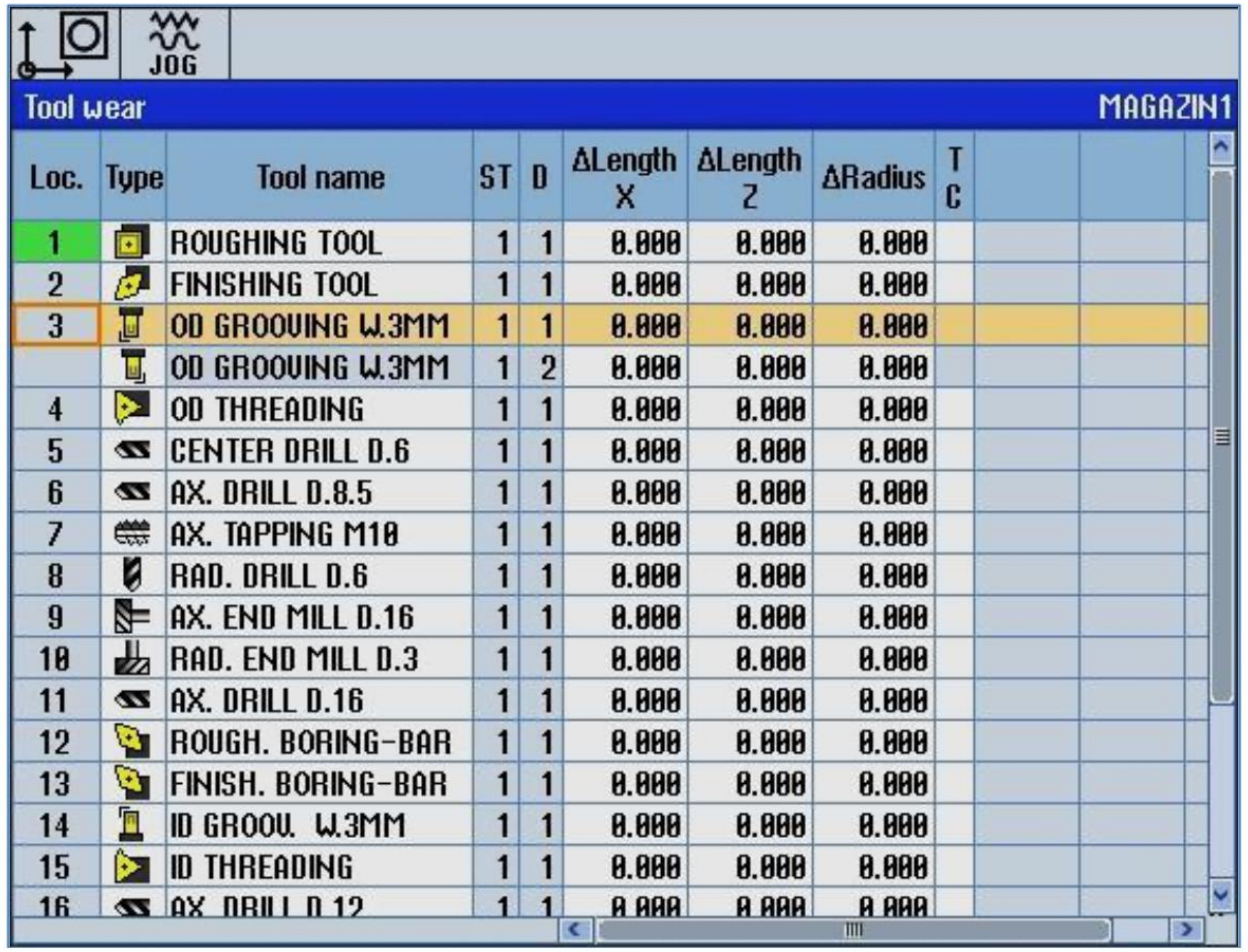
Fig. 62. Tool list page





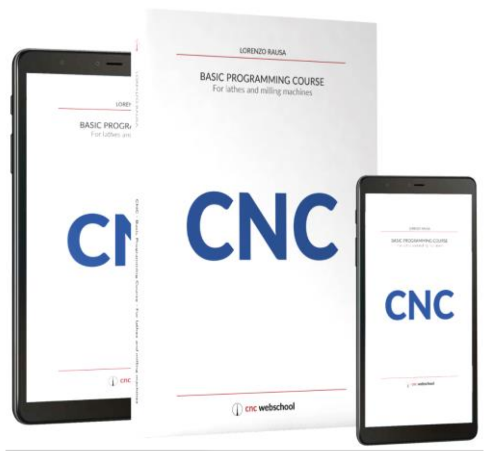
3		OD GROOVING W.3MM	1	1	98.000	40.000	0.100	3.000	10.0
		OD GROOVING W.3MM	1	2	98.000	37.000	0.100	3.000	10.0

Fig. 63. Double corrector used for a 3 mm grooving tool



Loc.	Type	Tool name	ST	D	ΔLength X	ΔLength Z	ΔRadius	T C
1		ROUGHING TOOL	1	1	0.000	0.000	0.000	
2		FINISHING TOOL	1	1	0.000	0.000	0.000	
3		OD GROOVING W.3MM	1	1	0.000	0.000	0.000	
		OD GROOVING W.3MM	1	2	0.000	0.000	0.000	
4		OD THREADING	1	1	0.000	0.000	0.000	
5		CENTER DRILL D.6	1	1	0.000	0.000	0.000	
6		AX. DRILL D.8.5	1	1	0.000	0.000	0.000	
7		AX. TAPPING M10	1	1	0.000	0.000	0.000	
8		RAD. DRILL D.6	1	1	0.000	0.000	0.000	
9		AX. END MILL D.16	1	1	0.000	0.000	0.000	
10		RAD. END MILL D.3	1	1	0.000	0.000	0.000	
11		AX. DRILL D.16	1	1	0.000	0.000	0.000	
12		ROUGH. BORING-BAR	1	1	0.000	0.000	0.000	
13		FINISH. BORING-BAR	1	1	0.000	0.000	0.000	
14		ID GROOV. W.3MM	1	1	0.000	0.000	0.000	
15		ID THREADING	1	1	0.000	0.000	0.000	
16		AX. DRILL D.12	1	1	0.000	0.000	0.000	

Fig. 64. Tool correction page



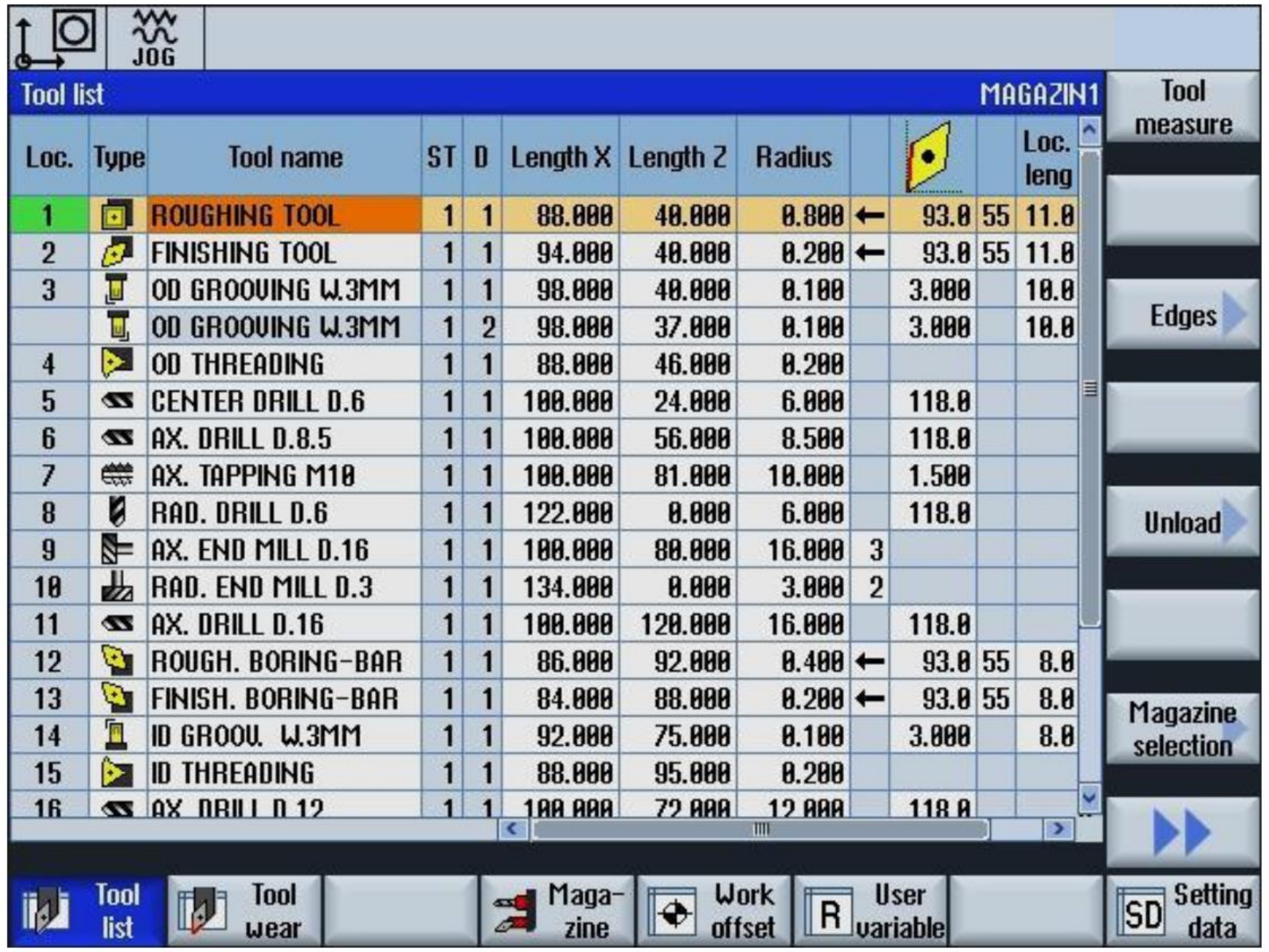


Fig. 65. Impossible to create a new tool when an already existing tool is selected

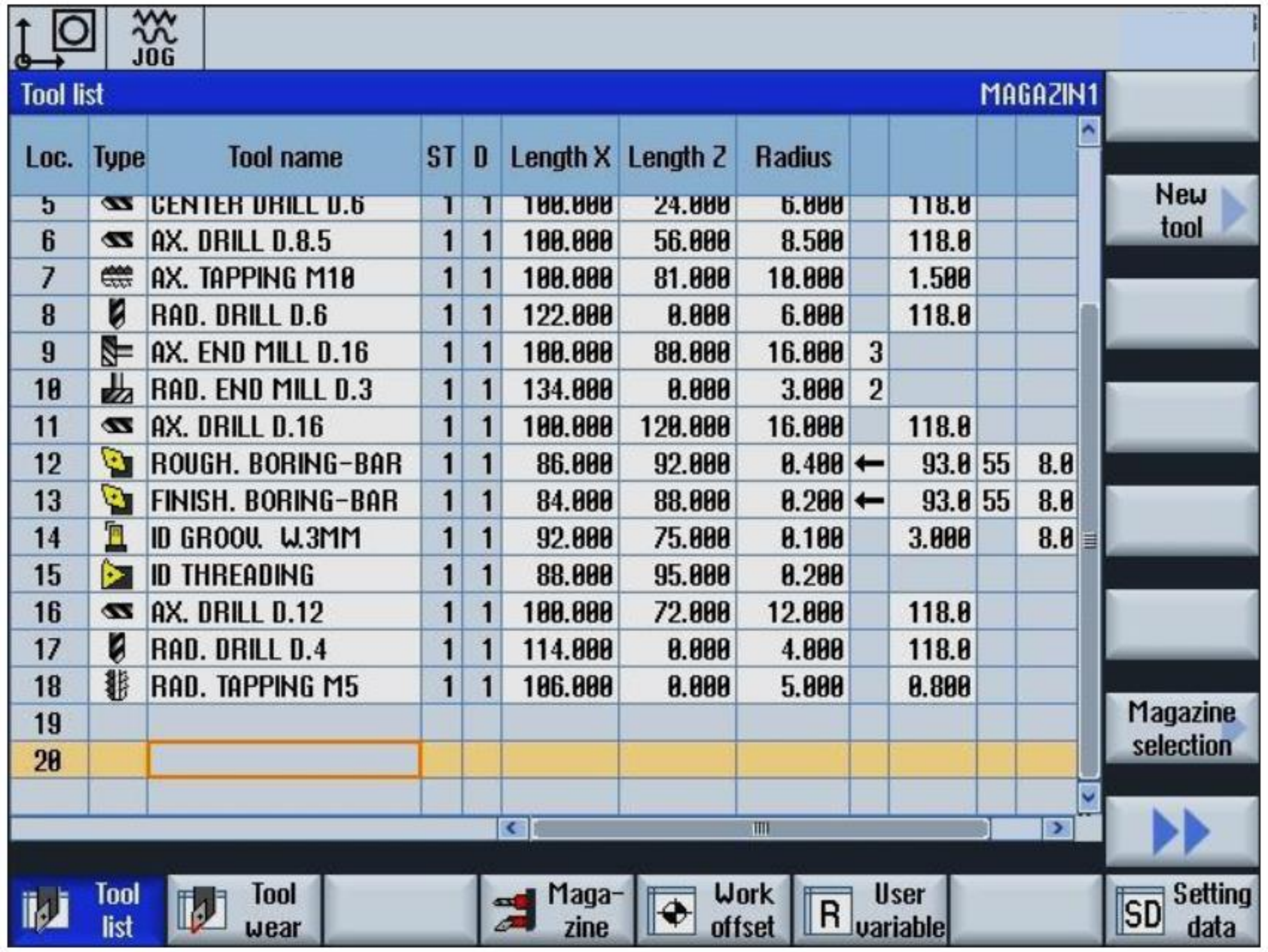
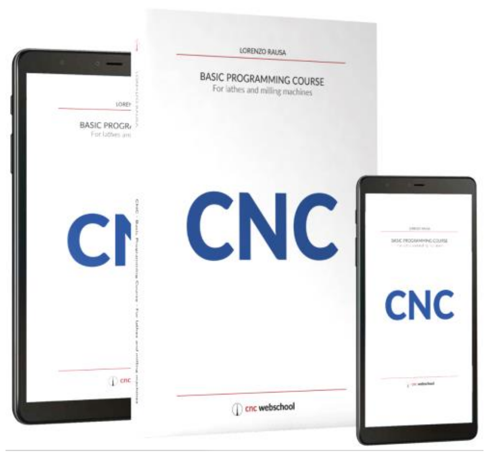


Fig. 66. Selection of an empty location for the creation of a new tool

Fig. 67. Selection of the type of new tool to be created and position of the cutting edge

Fig. 68. Creation of a new tool



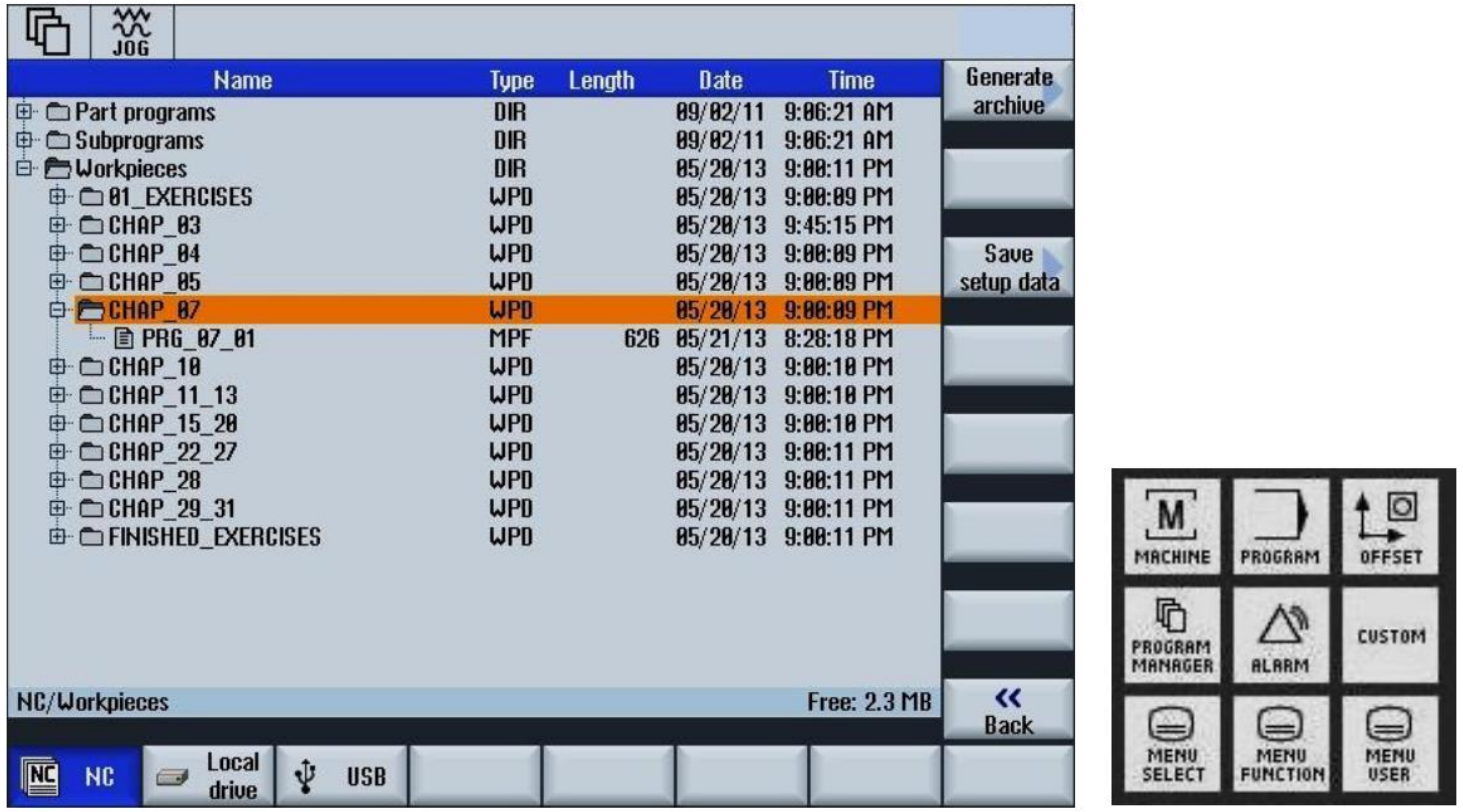


Fig. 69. Saving of tooling data

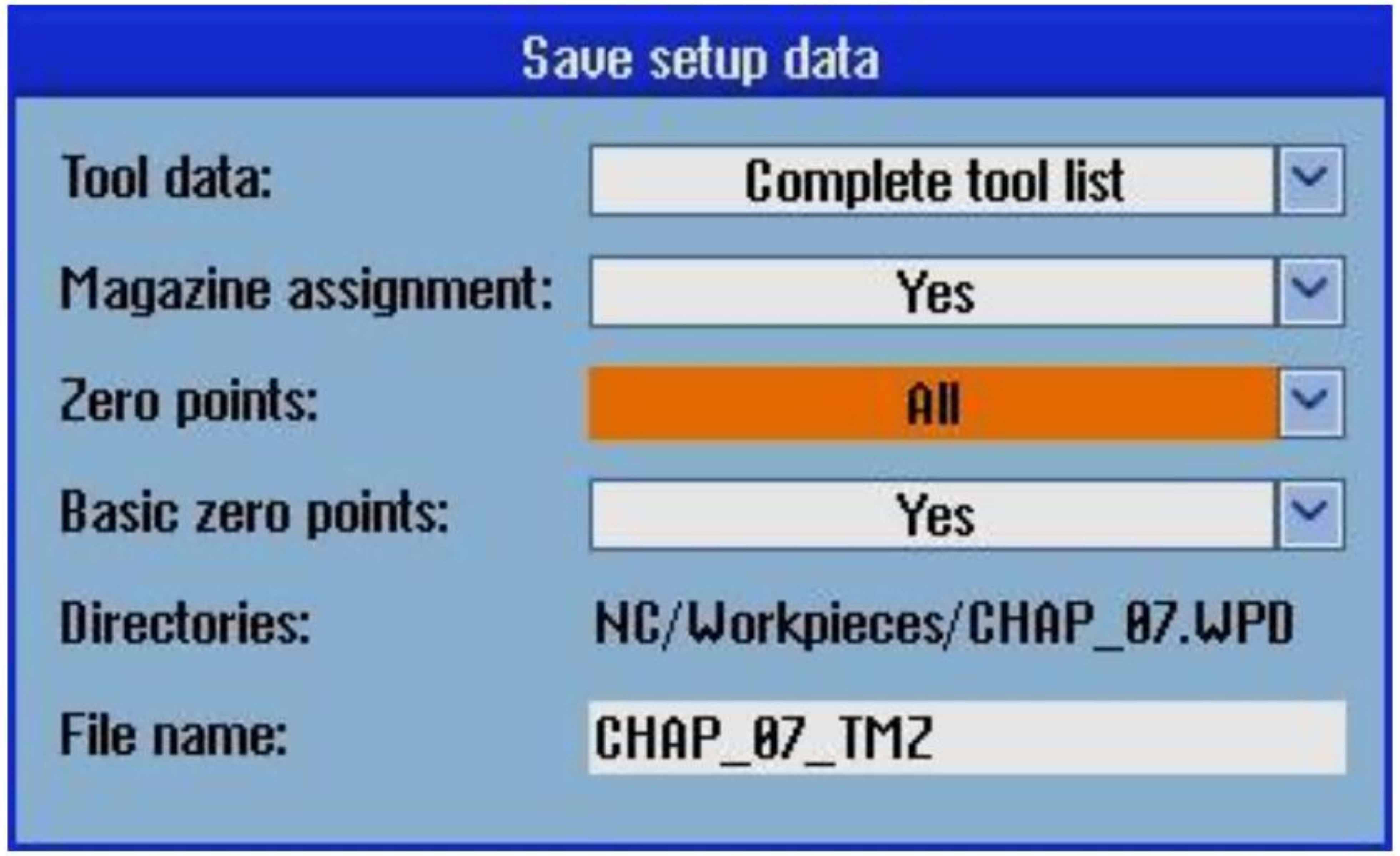
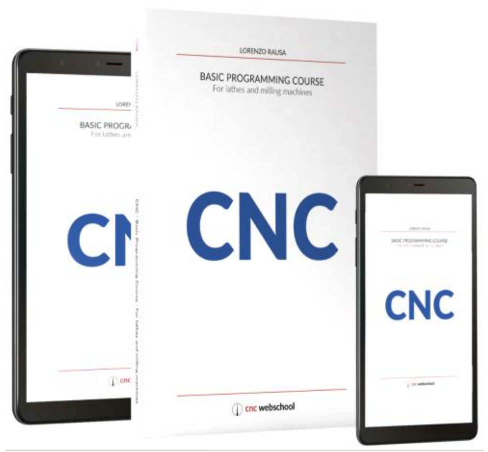


Fig. 70. Window for the saving of tooling data



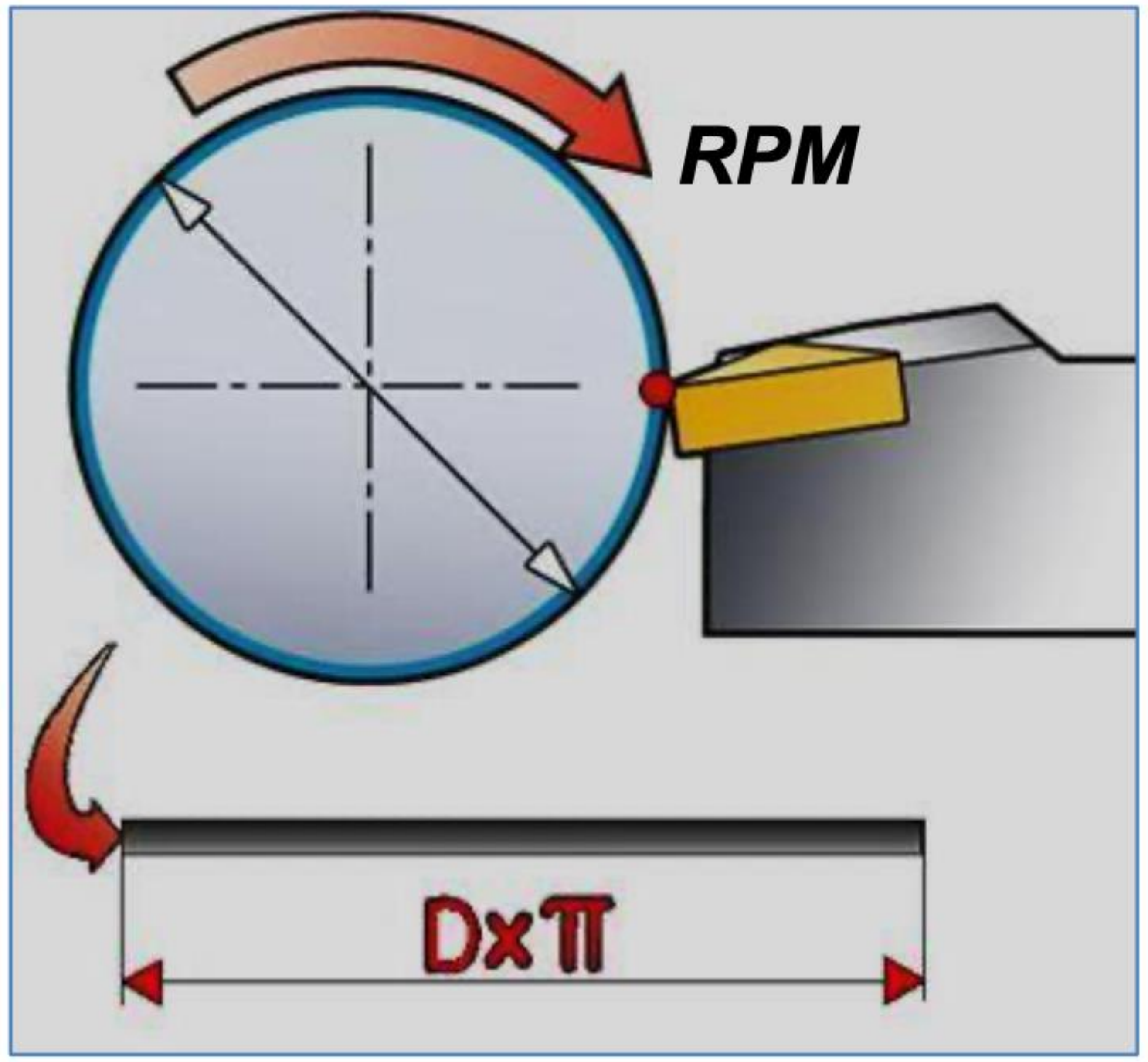


Fig. 71. Distance traveled by the tool in one revolution

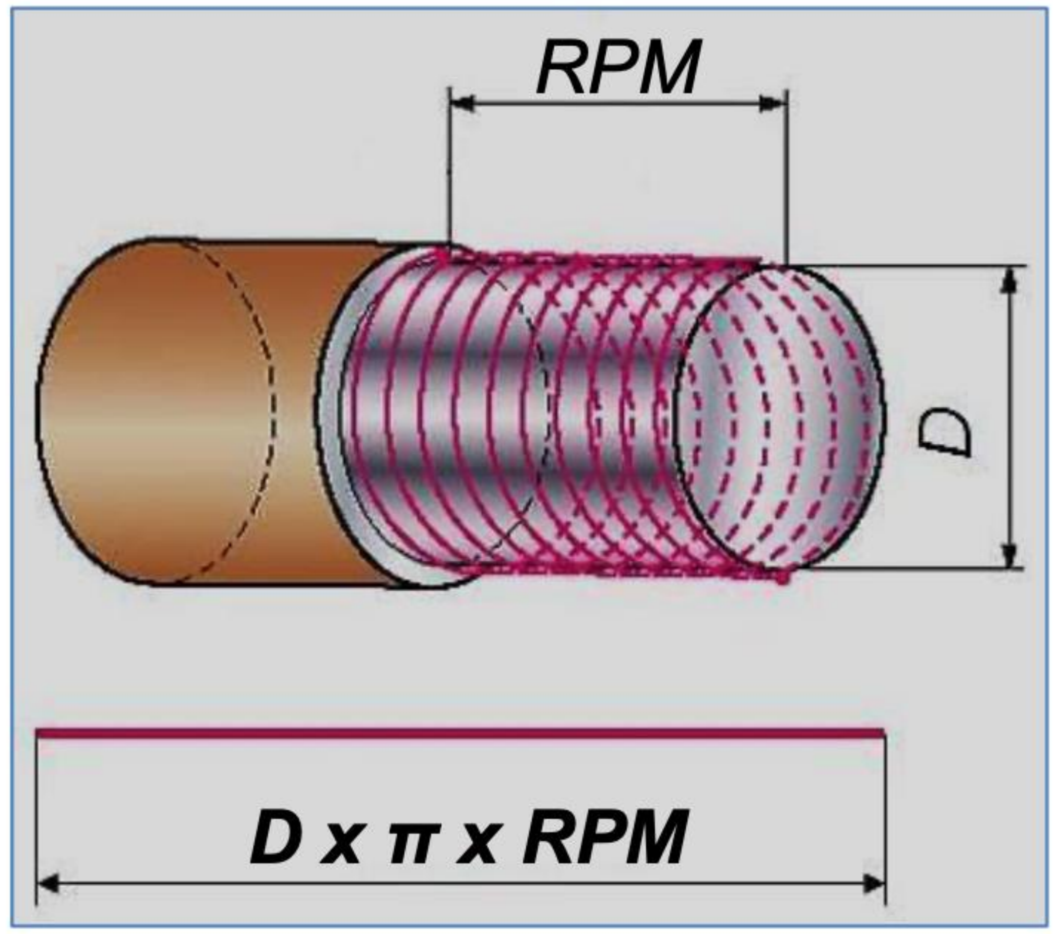
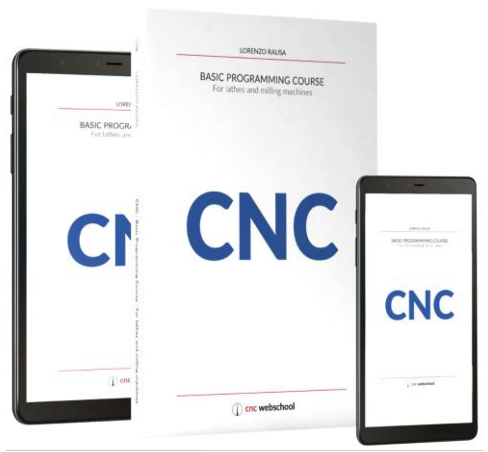


Fig. 72. Distance traveled by the tool in one minute with rotating workpiece

$$C_s = \frac{D \times \pi \times RPM}{1000} \quad \frac{m}{min}$$

Fig. 73. Formula for the calculation of the cutting speed



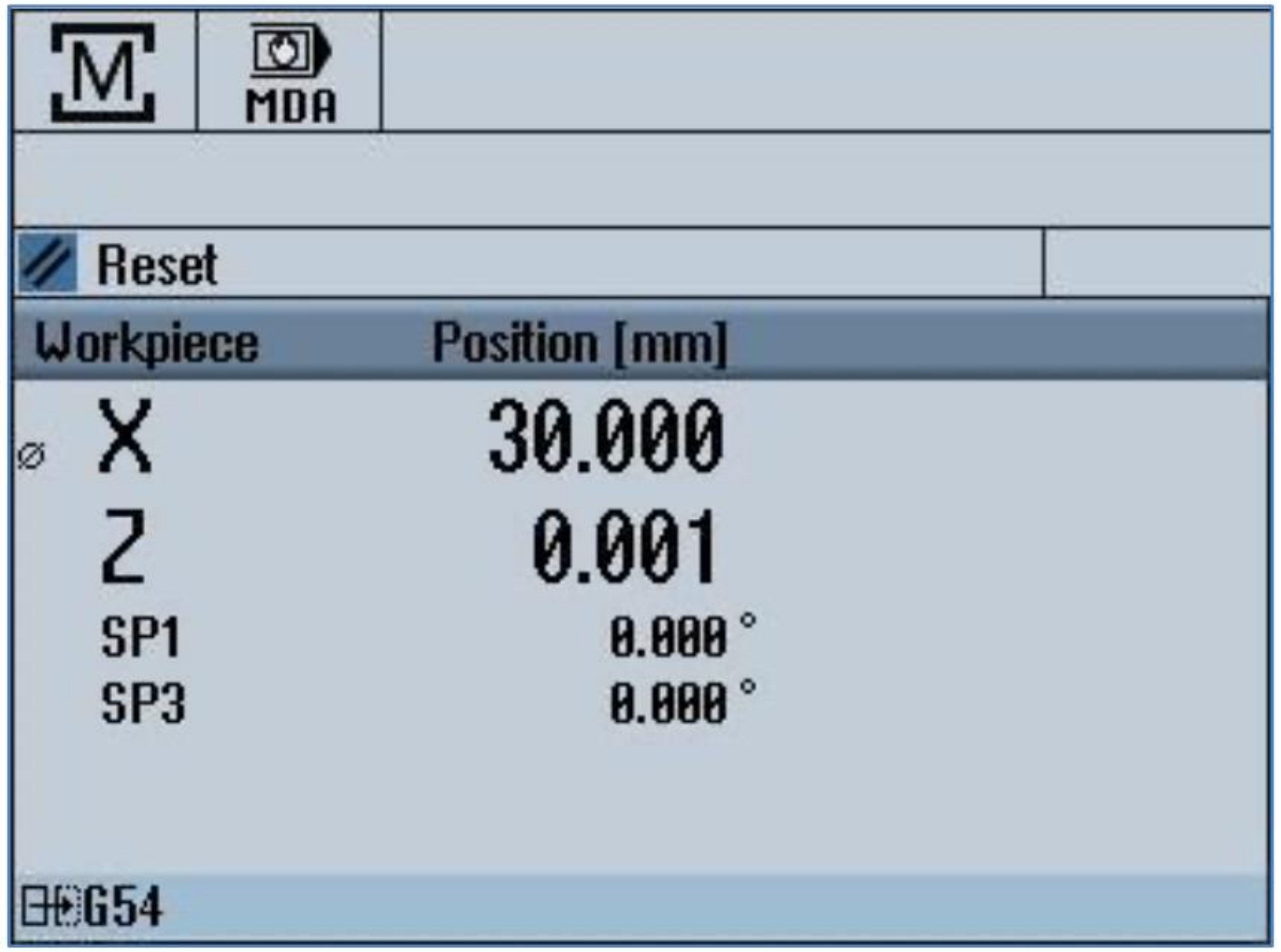


Fig. 74. Name of the spindles shown on the "current position" page

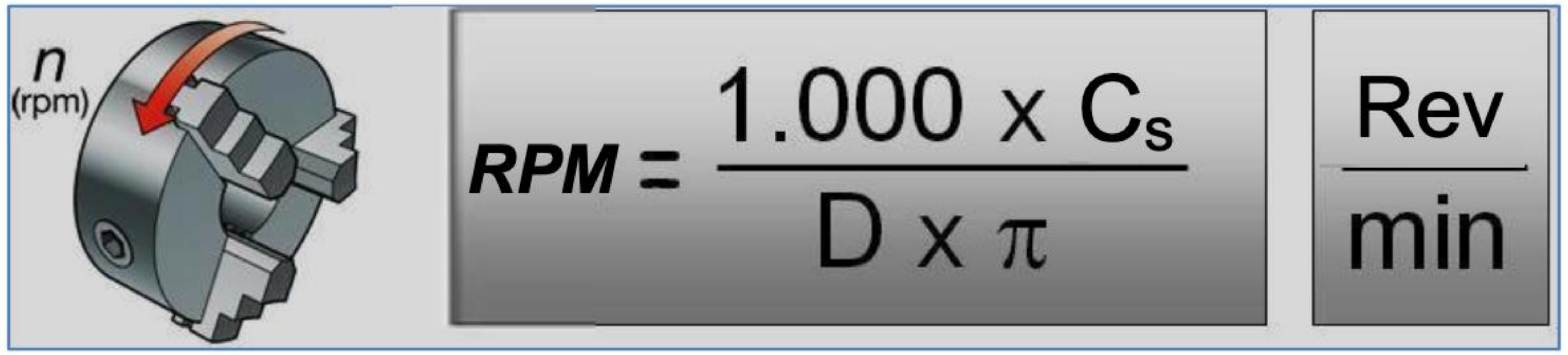


Fig. 75. Inverse formula for the calculation of the number of revolutions

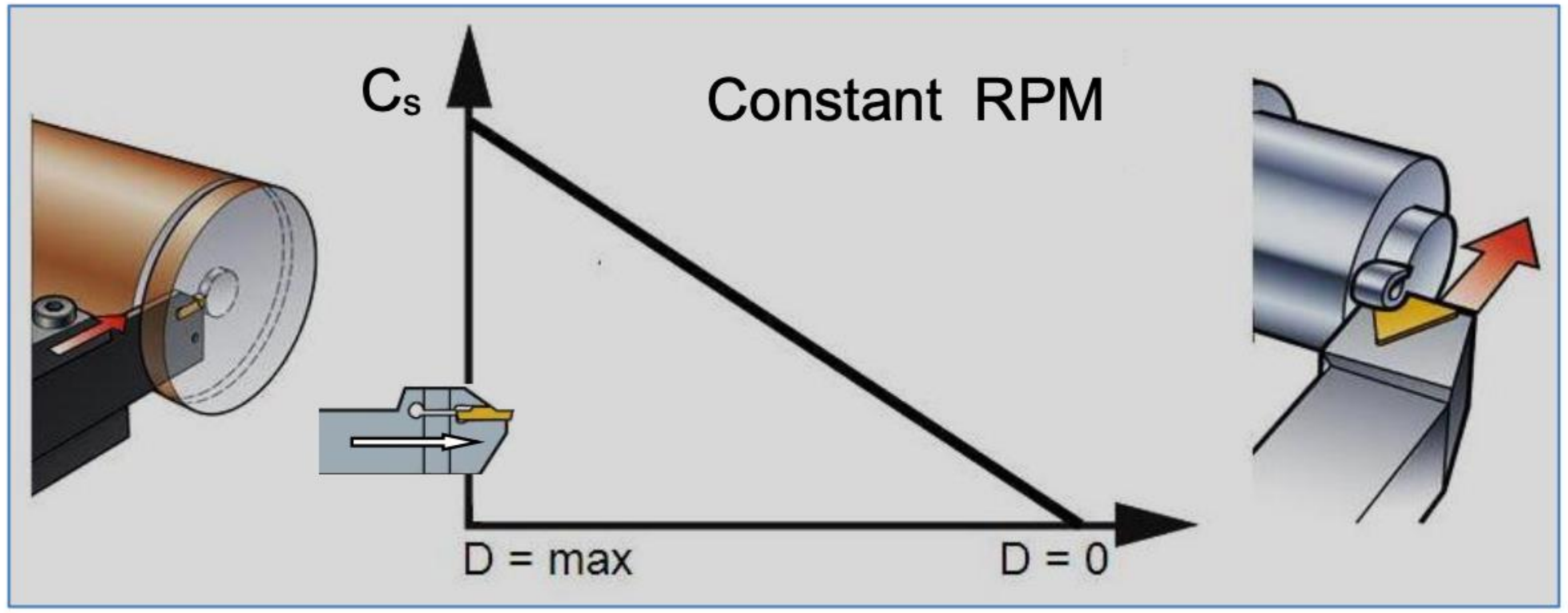


Fig. 76. Graph for the evolution of cutting speed at variation of working diameter, at constant number of revolutions

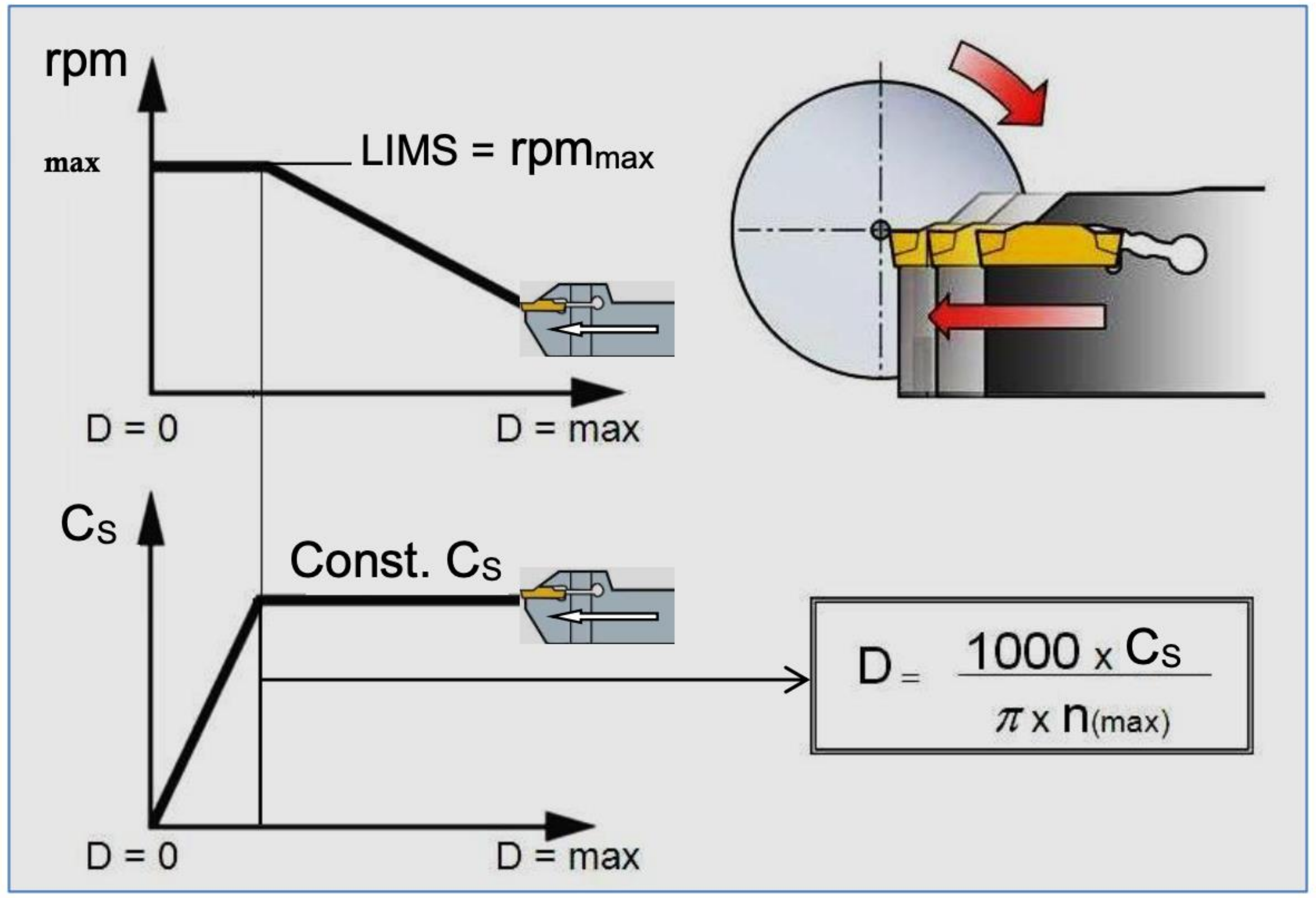


Fig. 77. Graph for the cutting speed trend beyond the number of revolutions threshold

Working diameter (mm)	Number of revolutions (r/min)	Cutting speed (m/min)
50	764	120
62	………………………	140
19	………………………	85
5	………………………	100
55	1200	………………………
8	1200	………………………
62	650	………………………
………………………	4500	100
………………………	2000	40
………………………	2000	220

Fig. 78. Exercise for the calculation of the cutting speed, the number of revolutions and the diameter from which the cutting speed begins to decrease

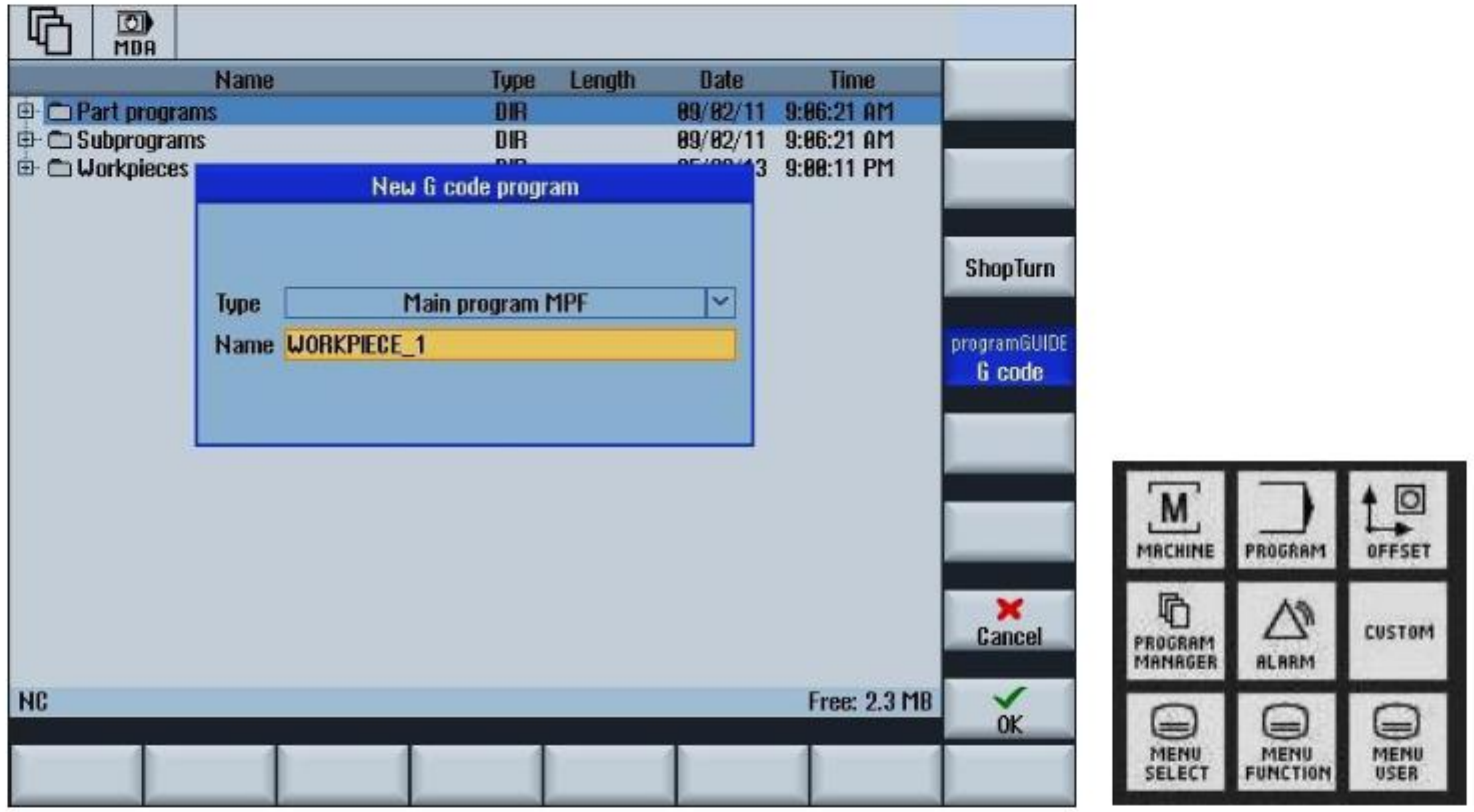
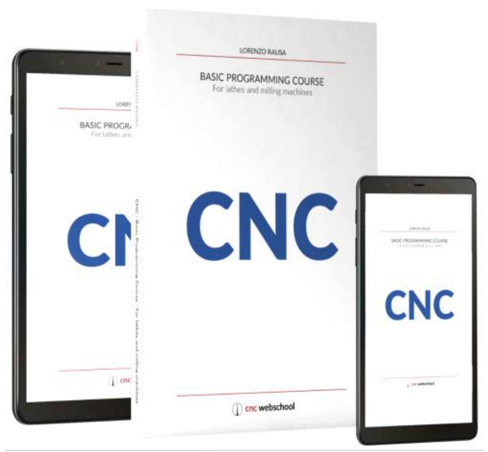


Fig. 79. Creation of a new program



Cut length (mm)	Feed rate (mm/rev)	Number of revolutions (rpm)	Time necessary (seconds)
60	0.3	840	....
60	0.12	1100	....
24	0.1	1260	....
18	0.06	780	....
22	0.14	1530	....
80	0.18	2100	....
66	0.05	1400	....
43	0.25	600	....

Fig. 80. Calculation exercises for the time needed for the tool to execute a pass

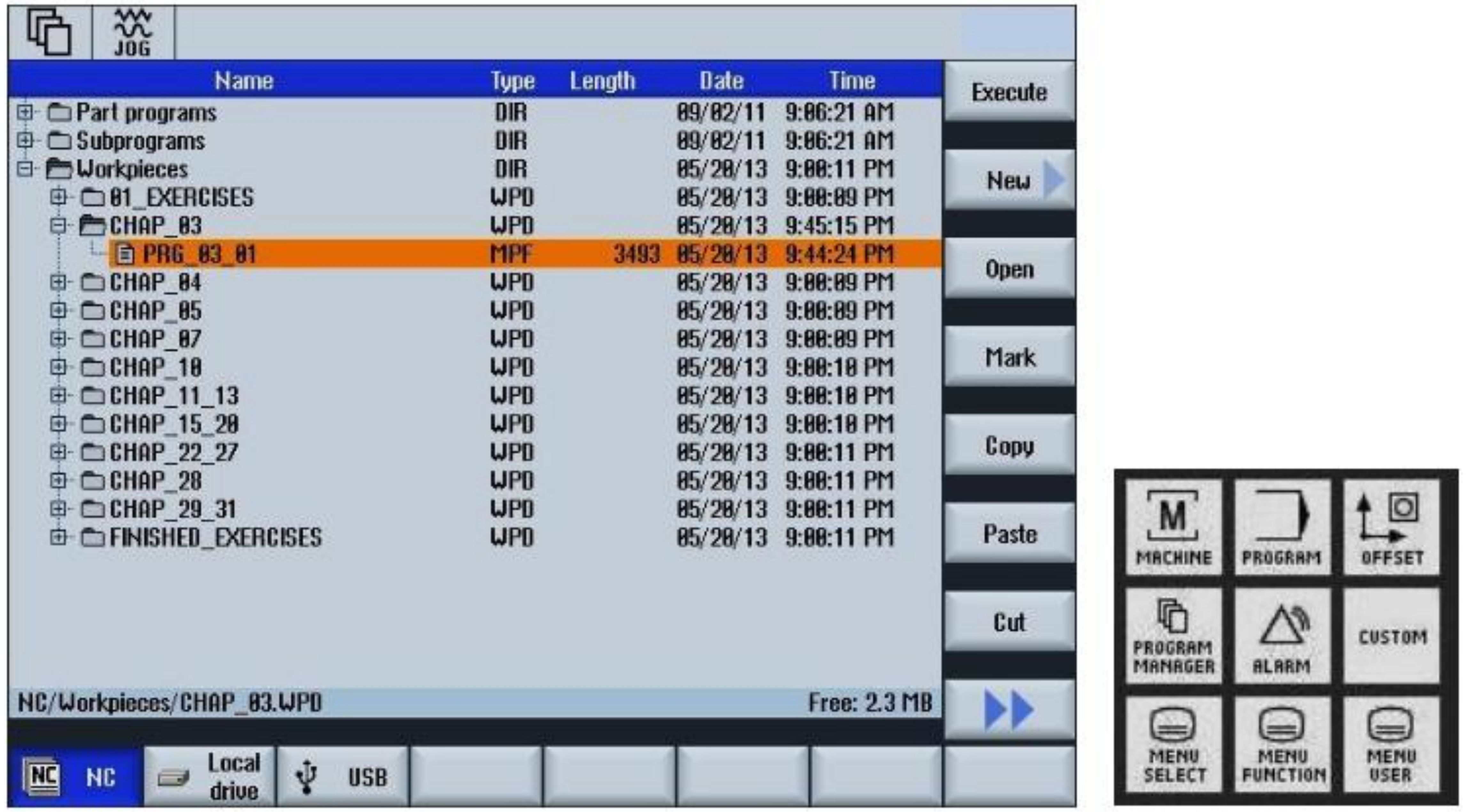
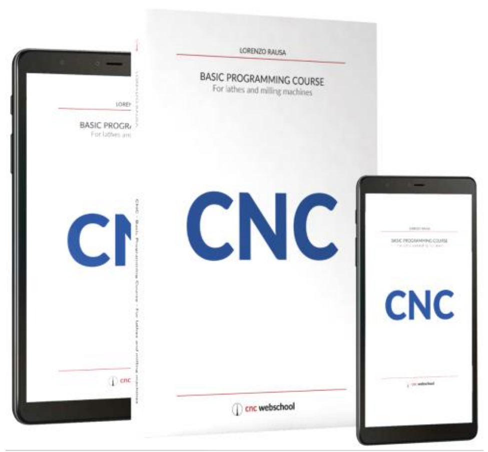


Fig. 81. Saving of folders and programs in an external memory



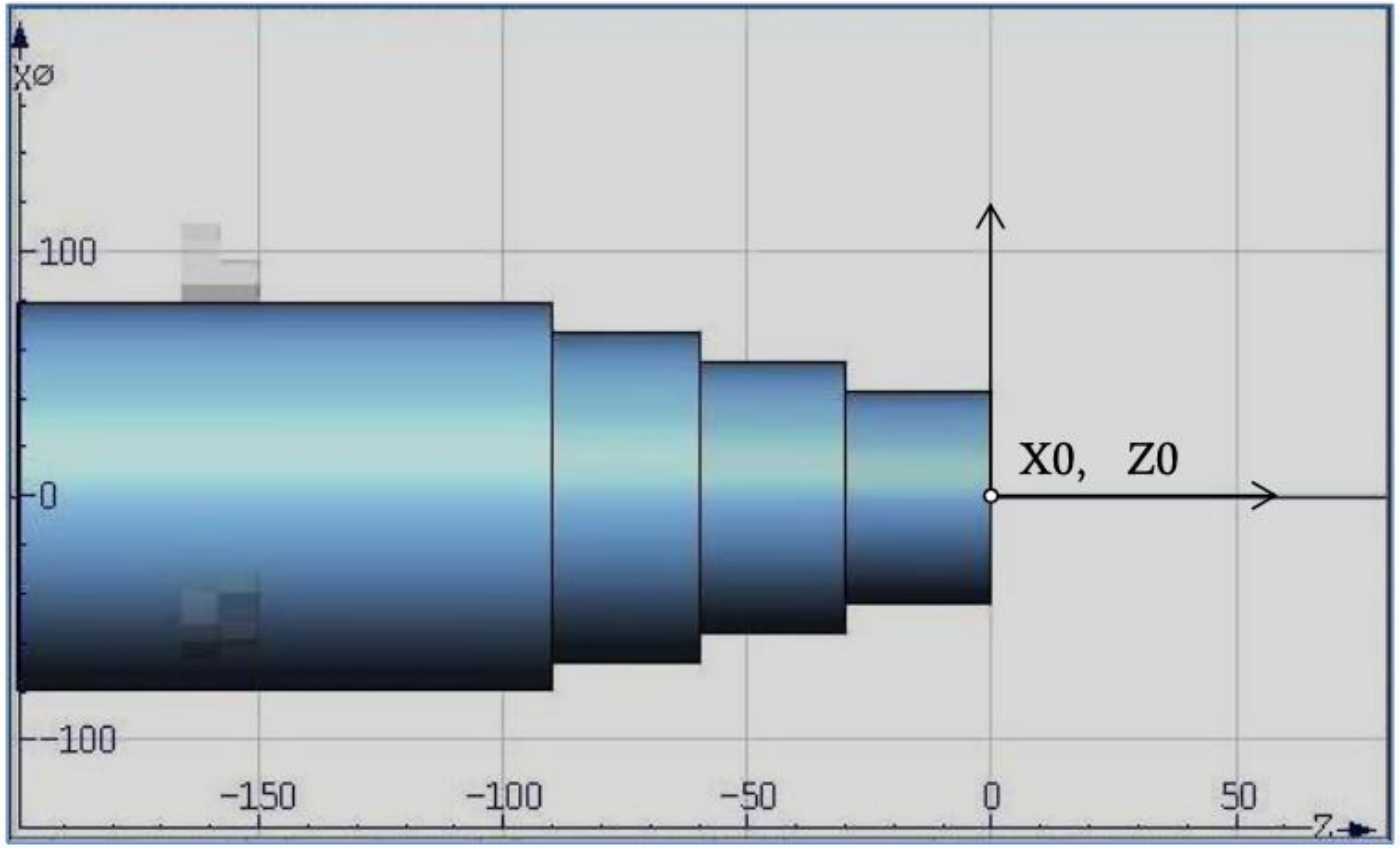


Fig. 82. Origin of the axes in the absolute coordinate system referring to the part zero

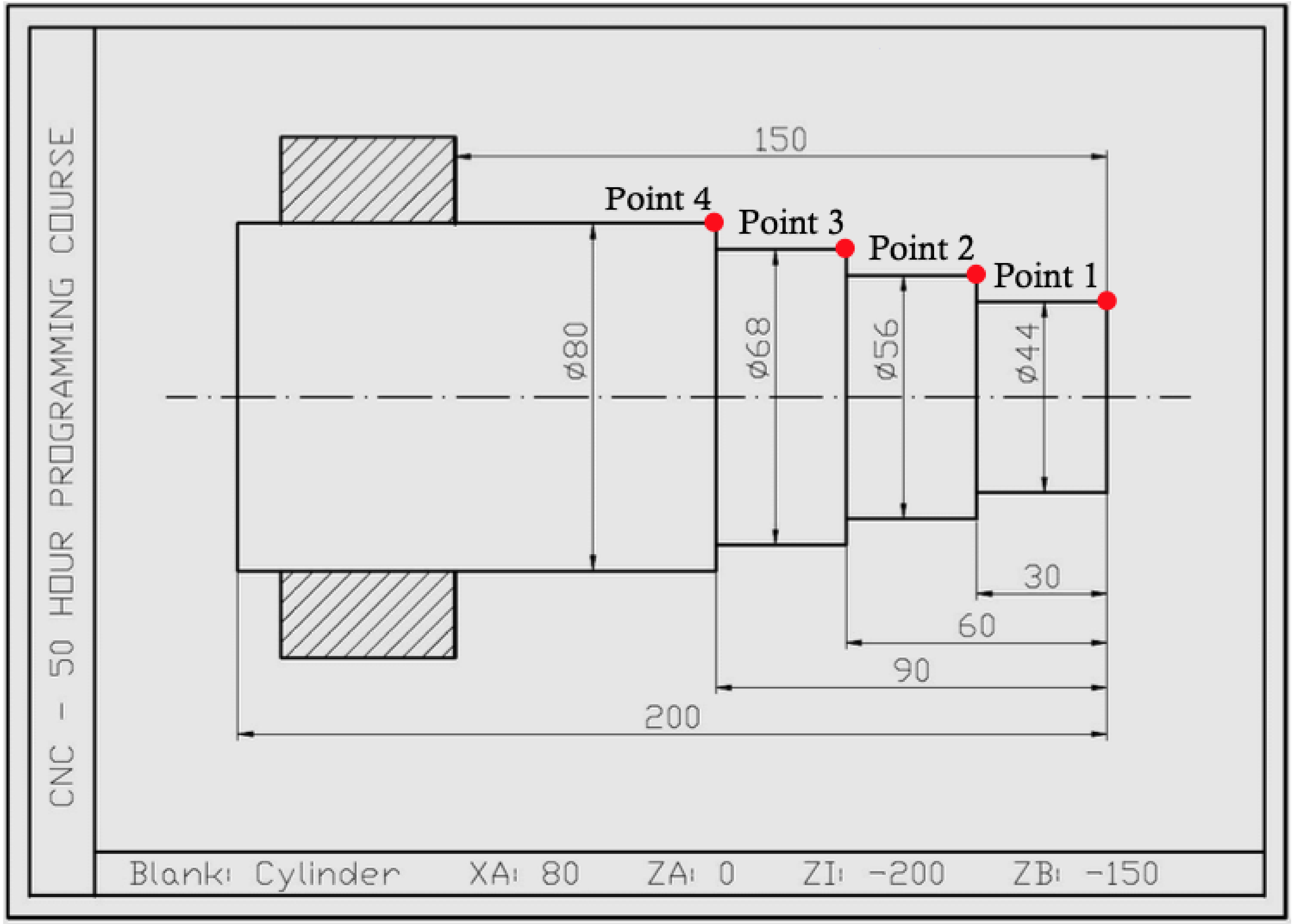


Fig. 83. Design values referring to the part zero point.

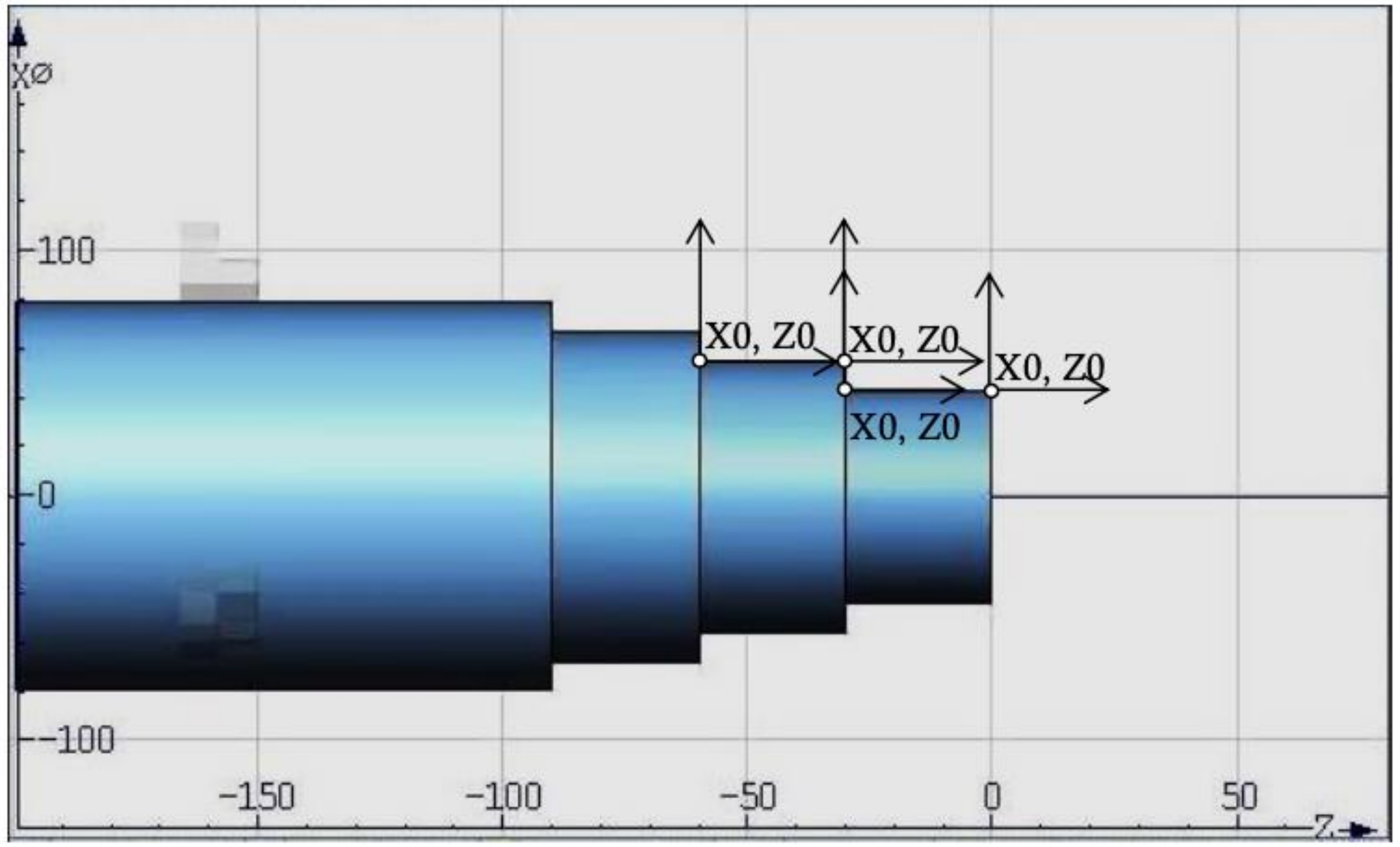


Fig. 84. Origin of the axes in the incremental coordinate system

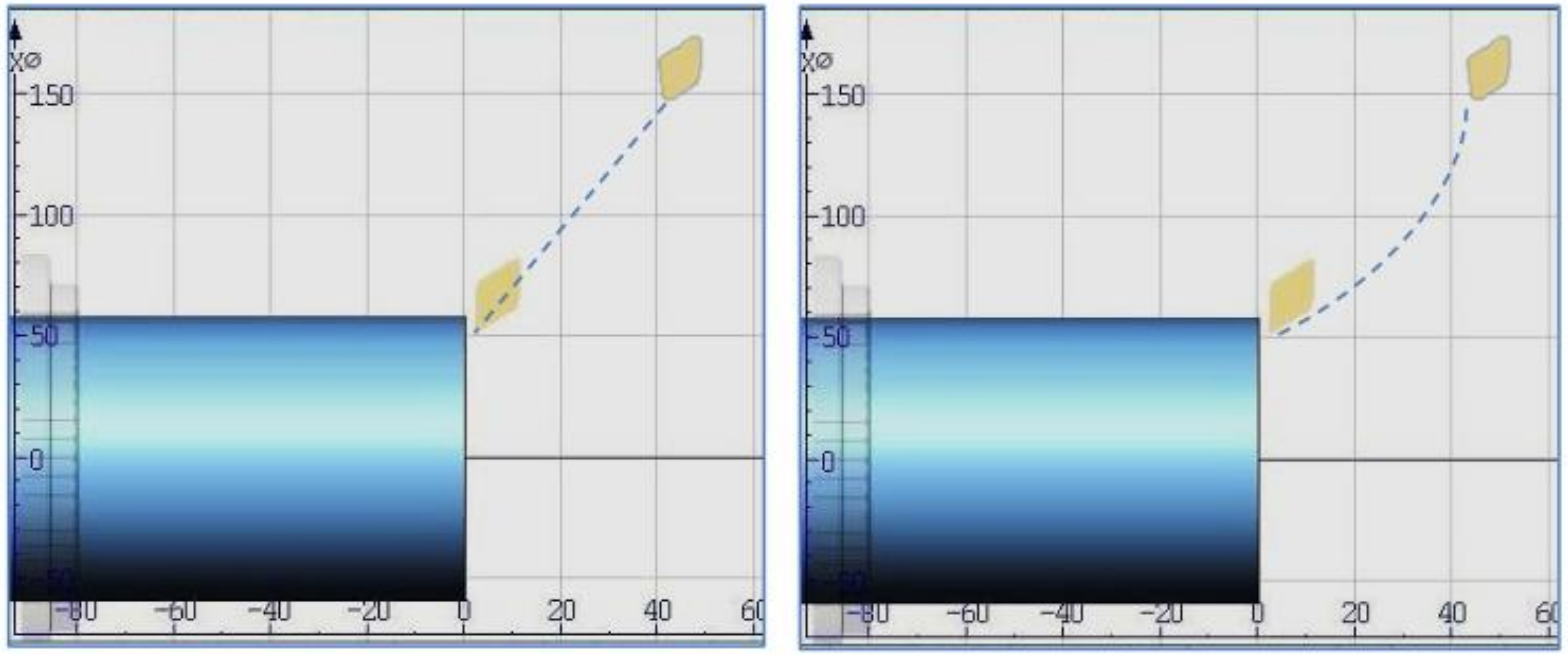


Fig. 85. Trajectory of rapid approach with the functions RTLION and RTLIOF

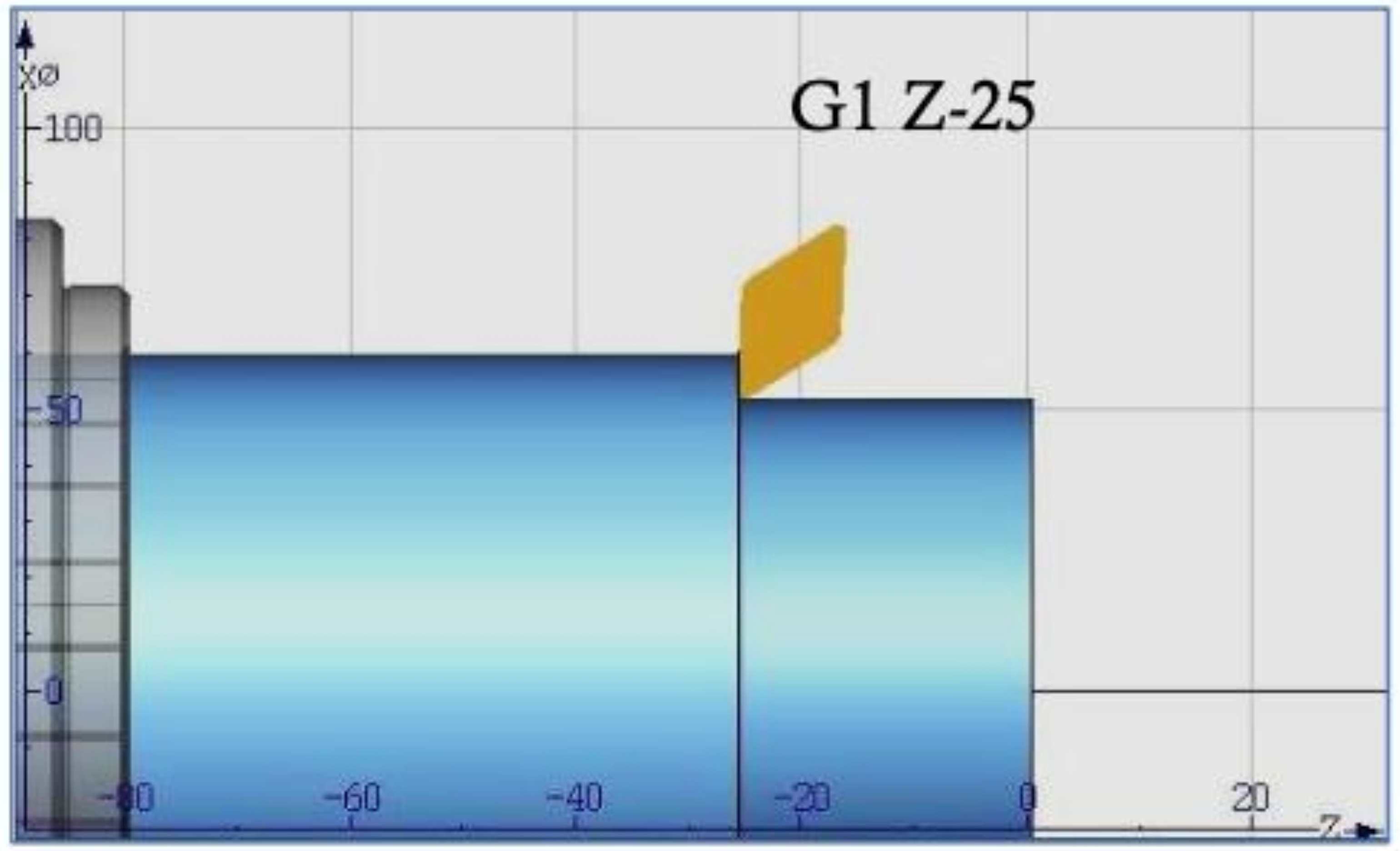


Fig. 86. Movement of the tool along the Z-axis

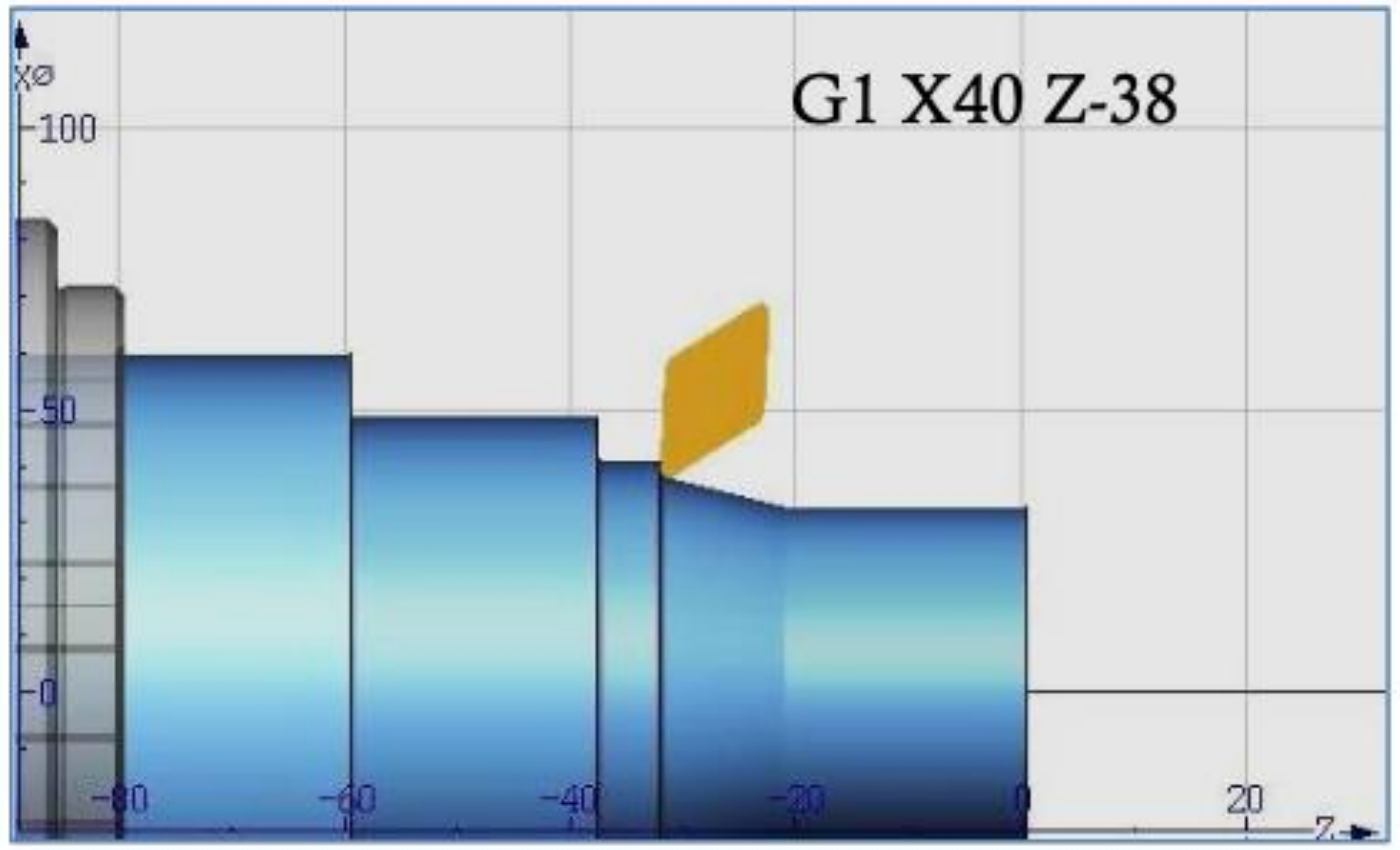


Fig. 87. Linear interpolation with tool moving along the axes X and Z

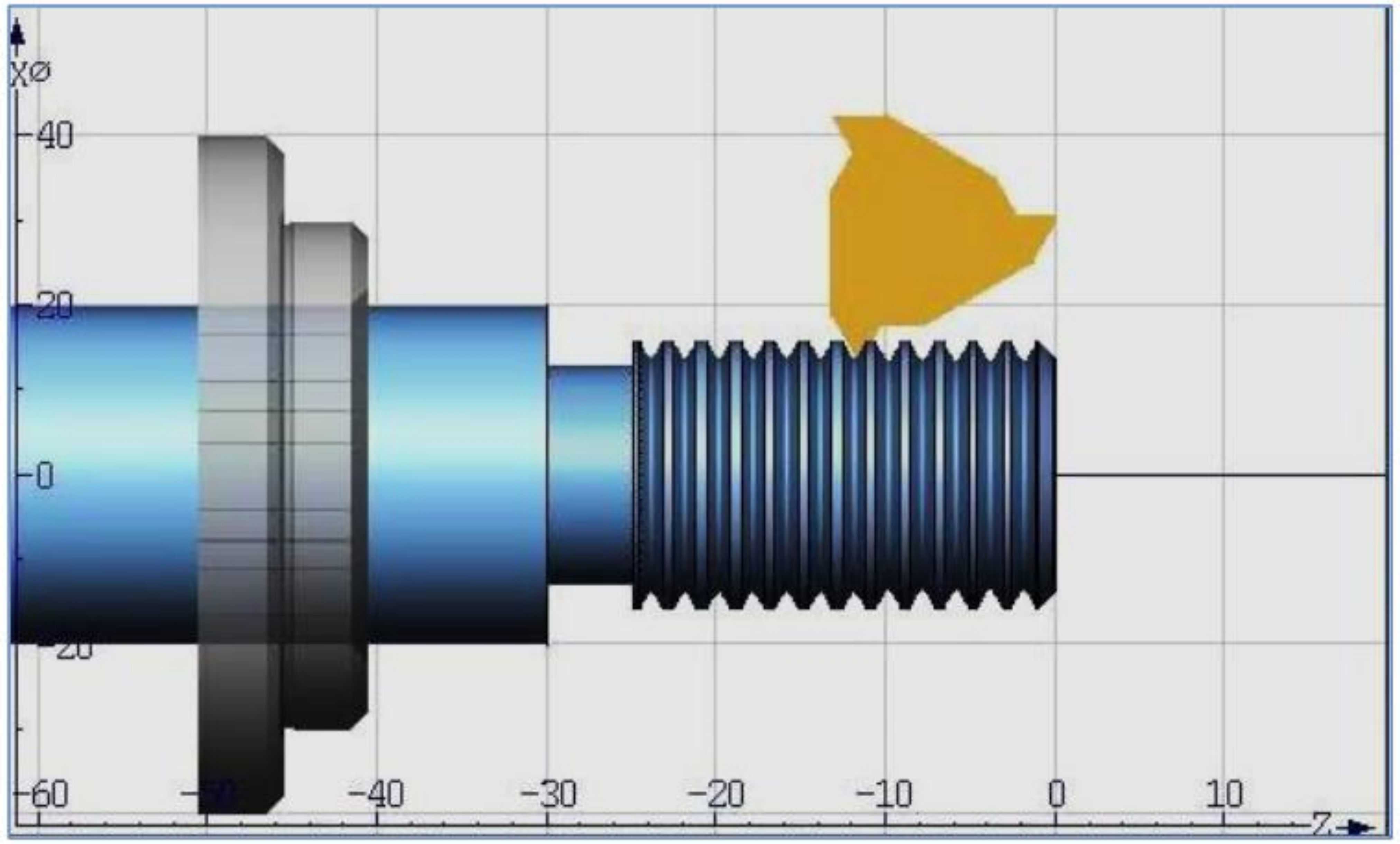


Fig. 88. Execution of a threading in multiple passes with G33

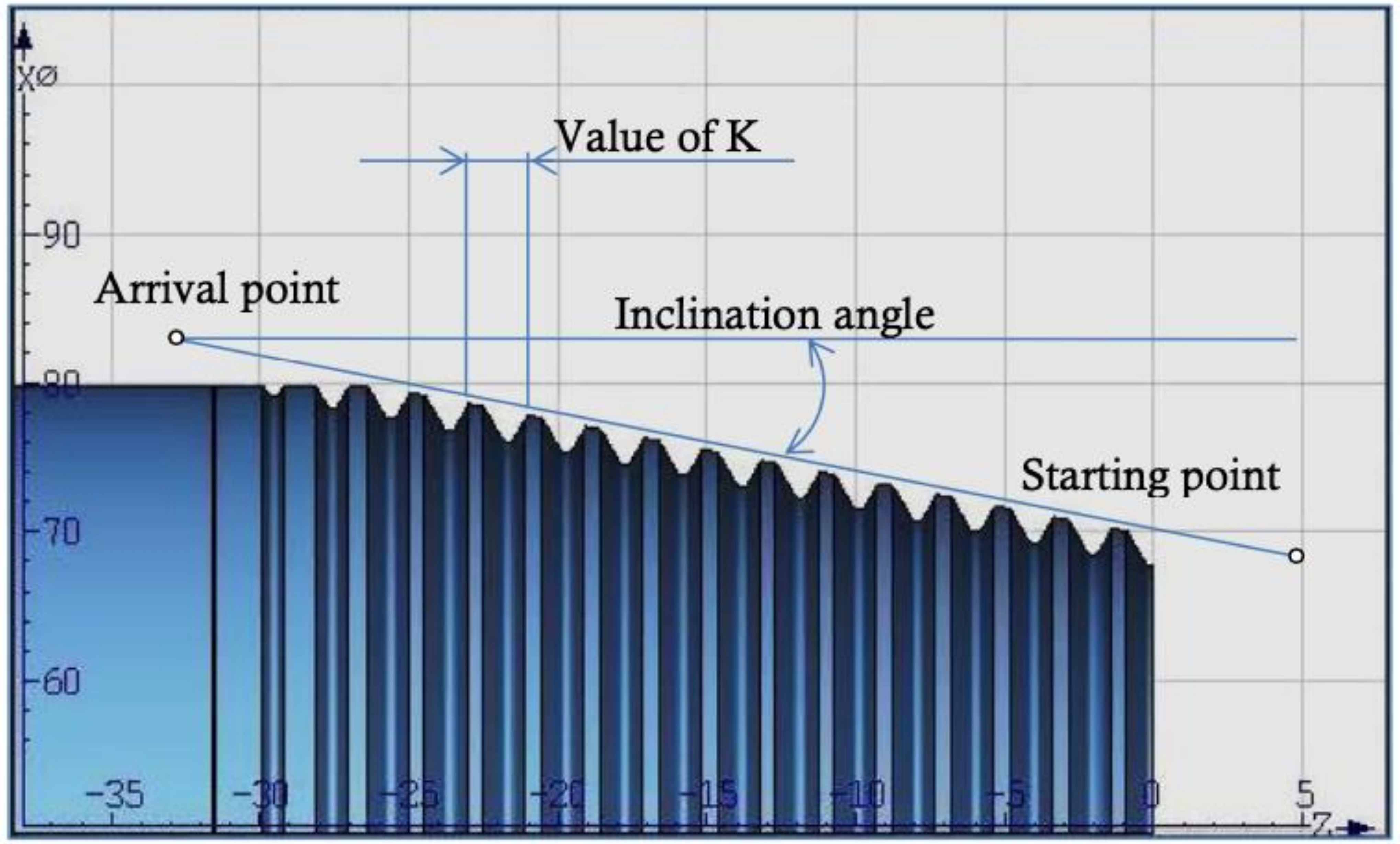
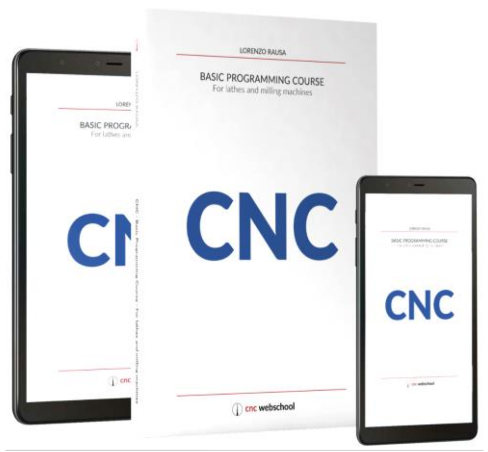


Fig. 89. Lead value to be programmed in a conical thread executed with G33



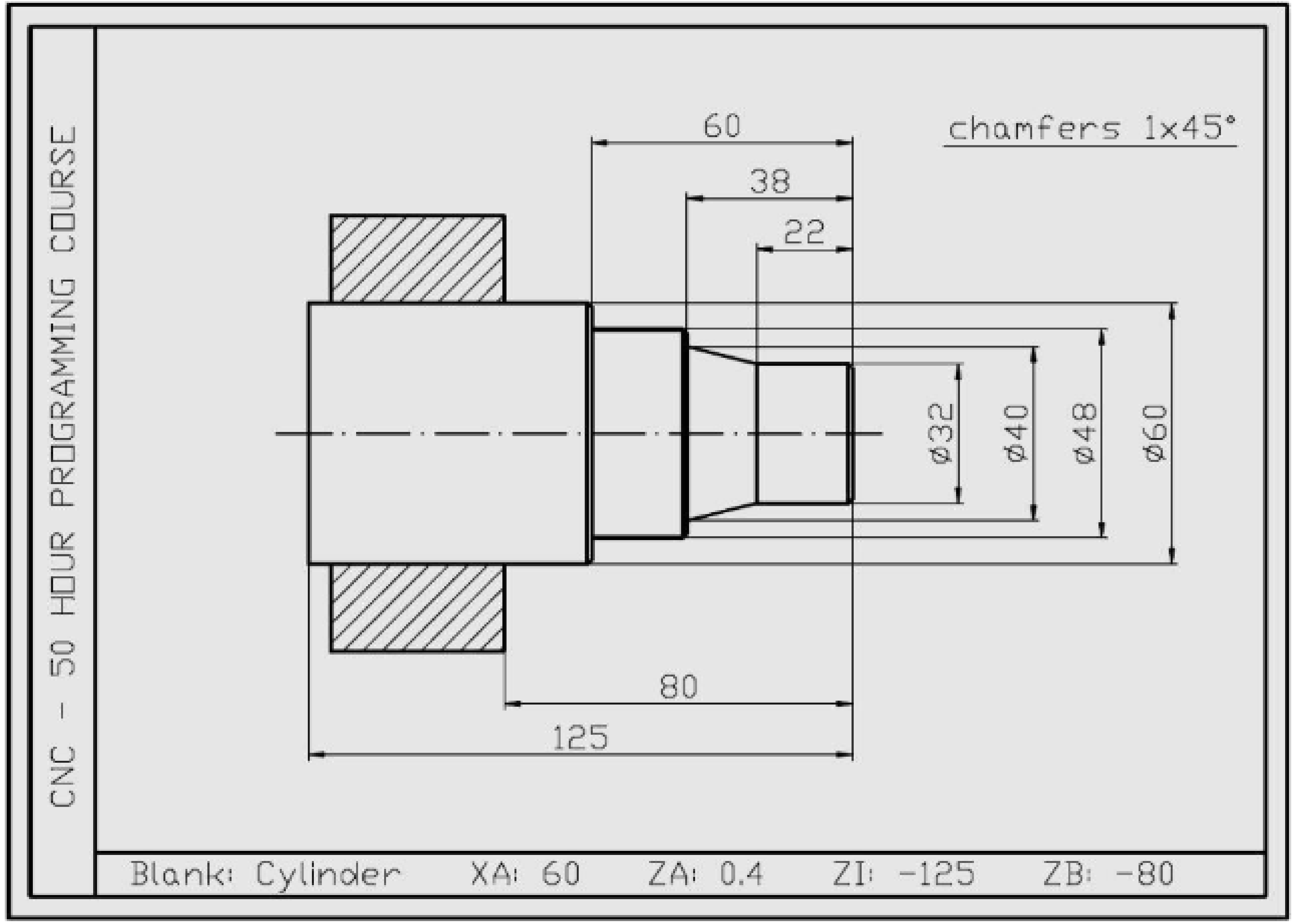


Fig. 90. Example of the programming of an external turning

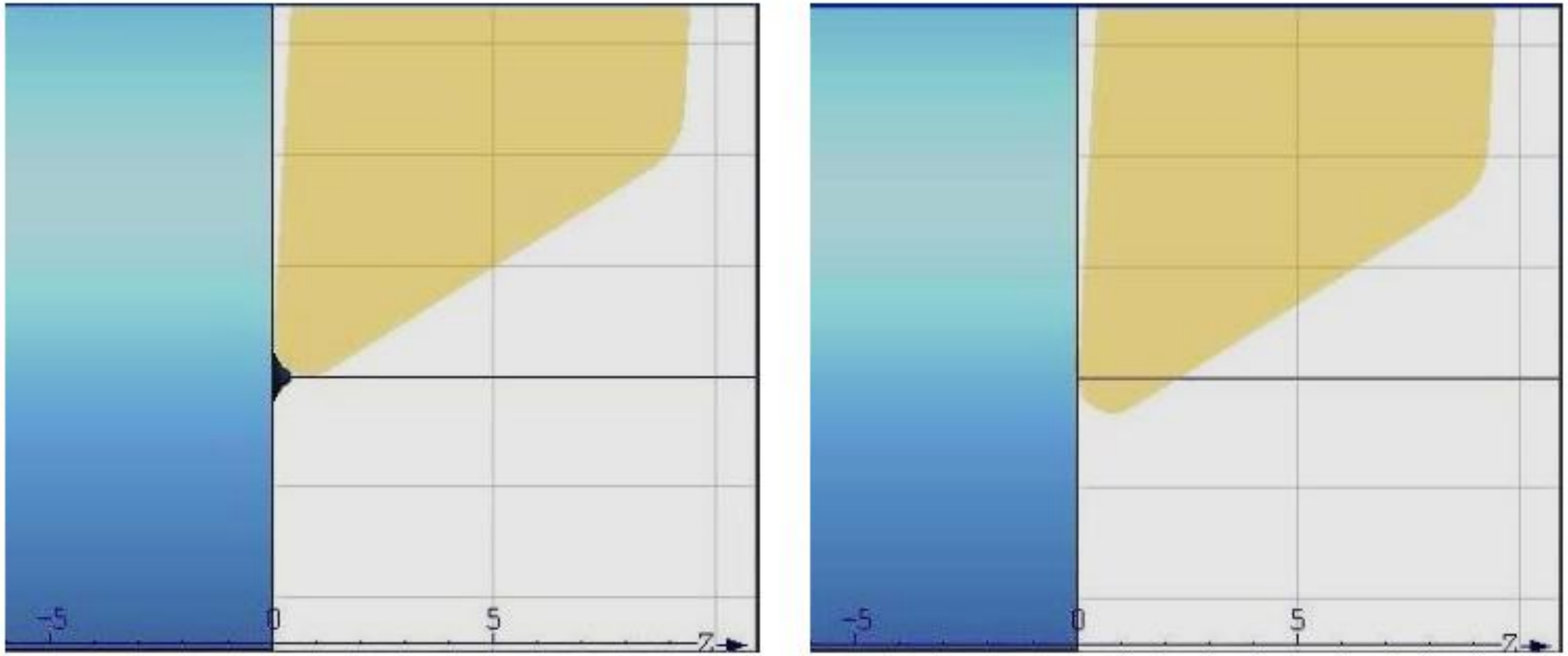


Fig. 91. Elimination of the facing witness mark

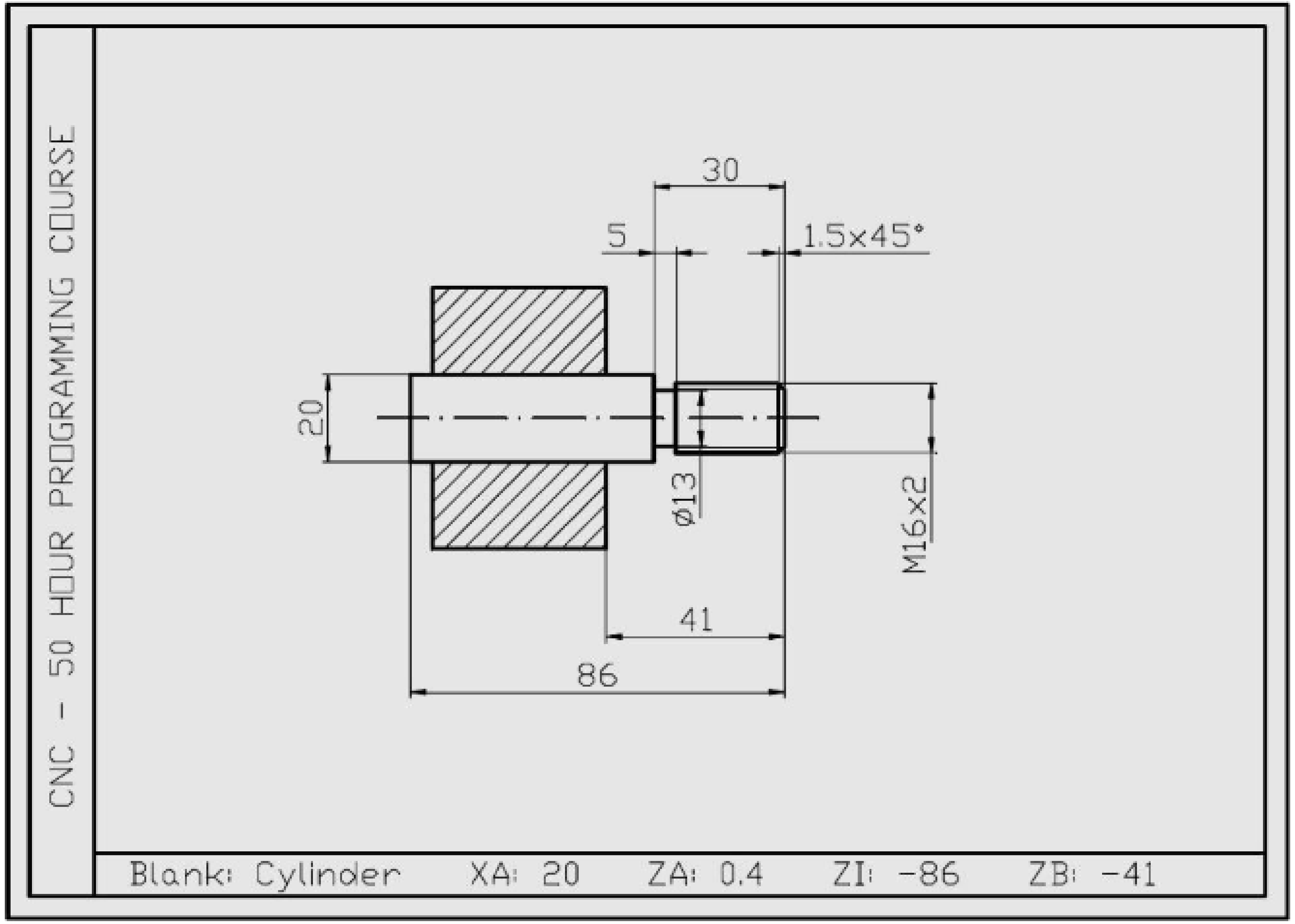


Fig. 92. Example of the programming of a threaded workpiece

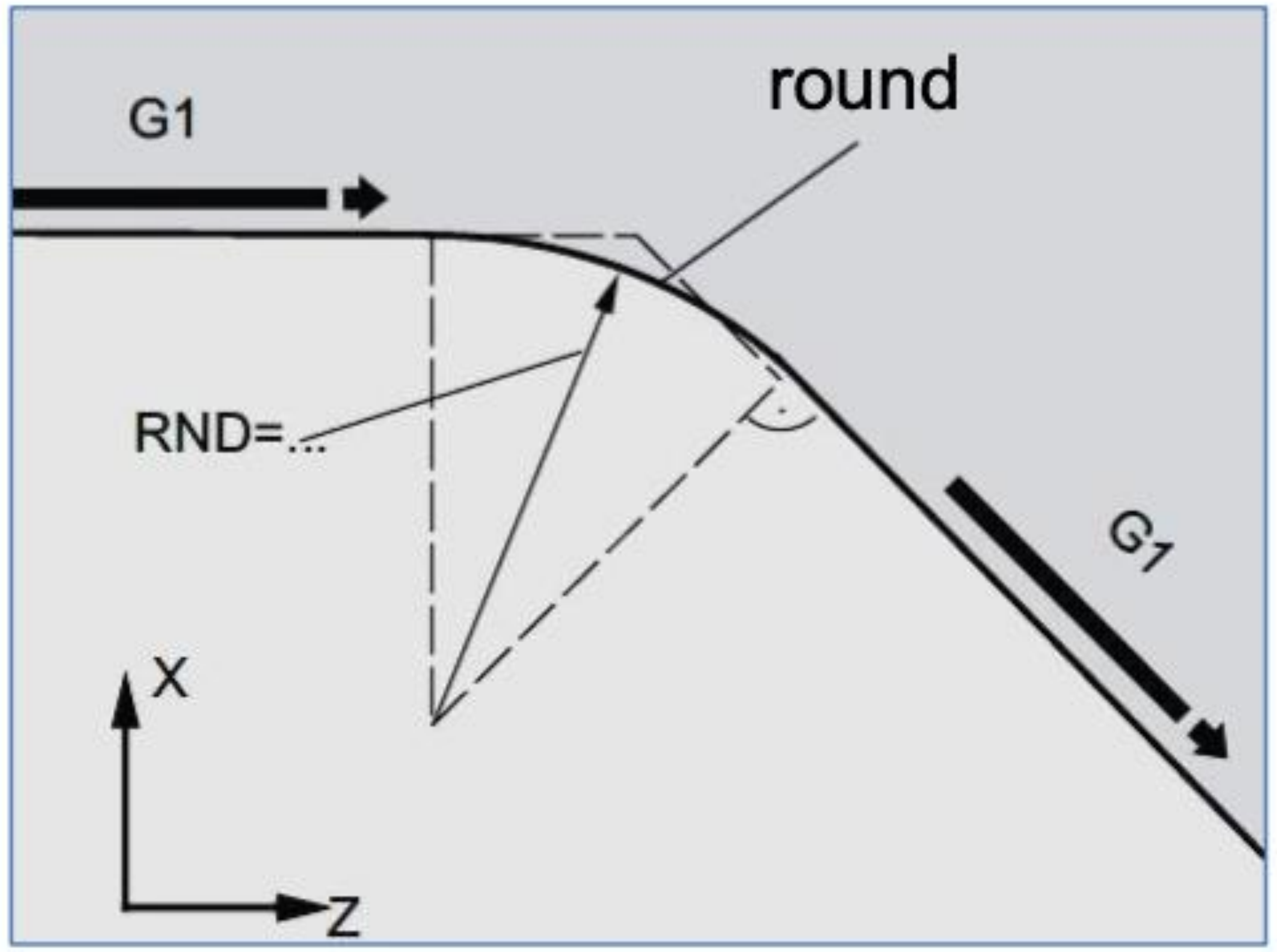


Fig. 93. Round between two line by means of the RND function

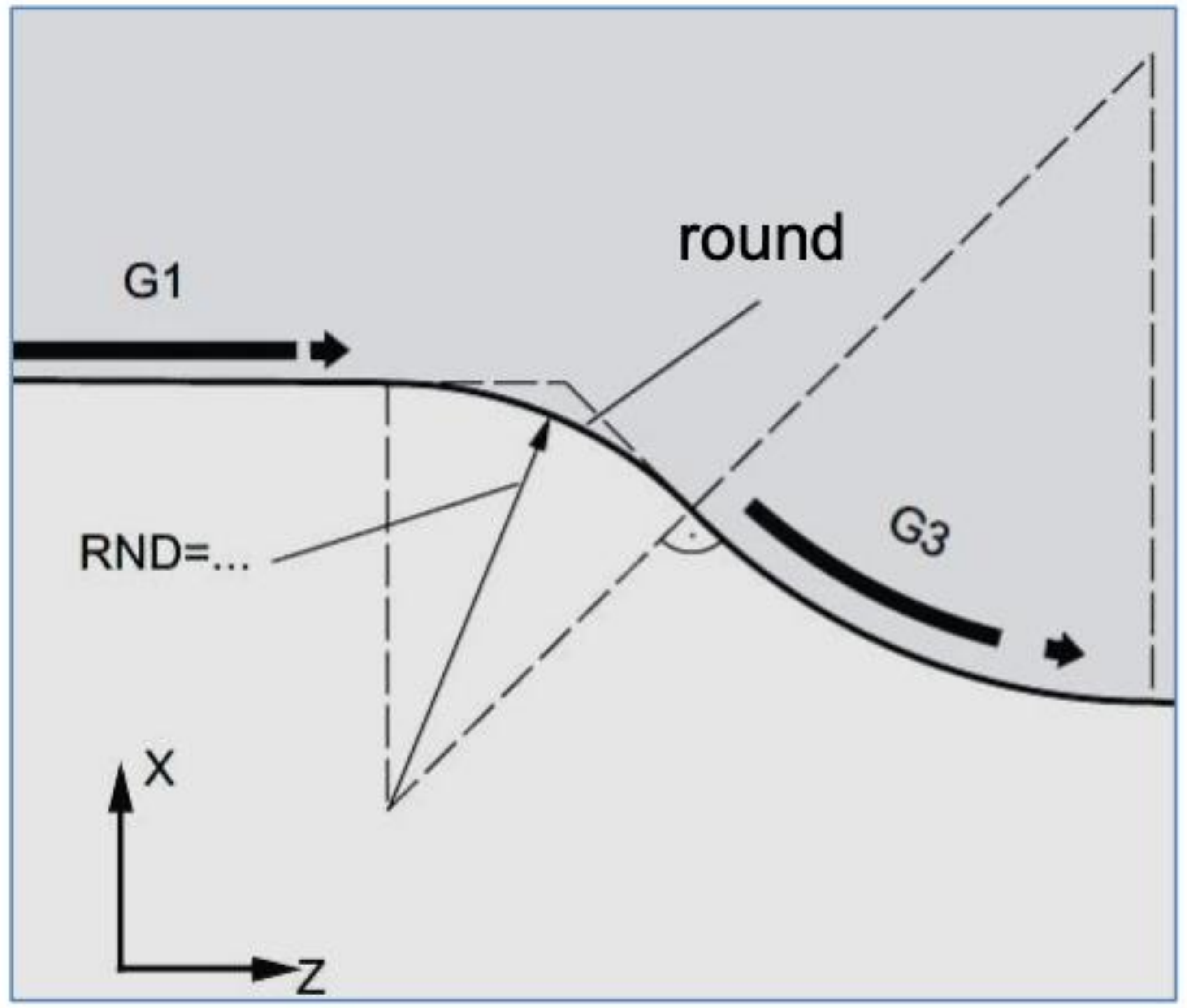


Fig. 94. Round between a line and a circle arc by means of the RND function

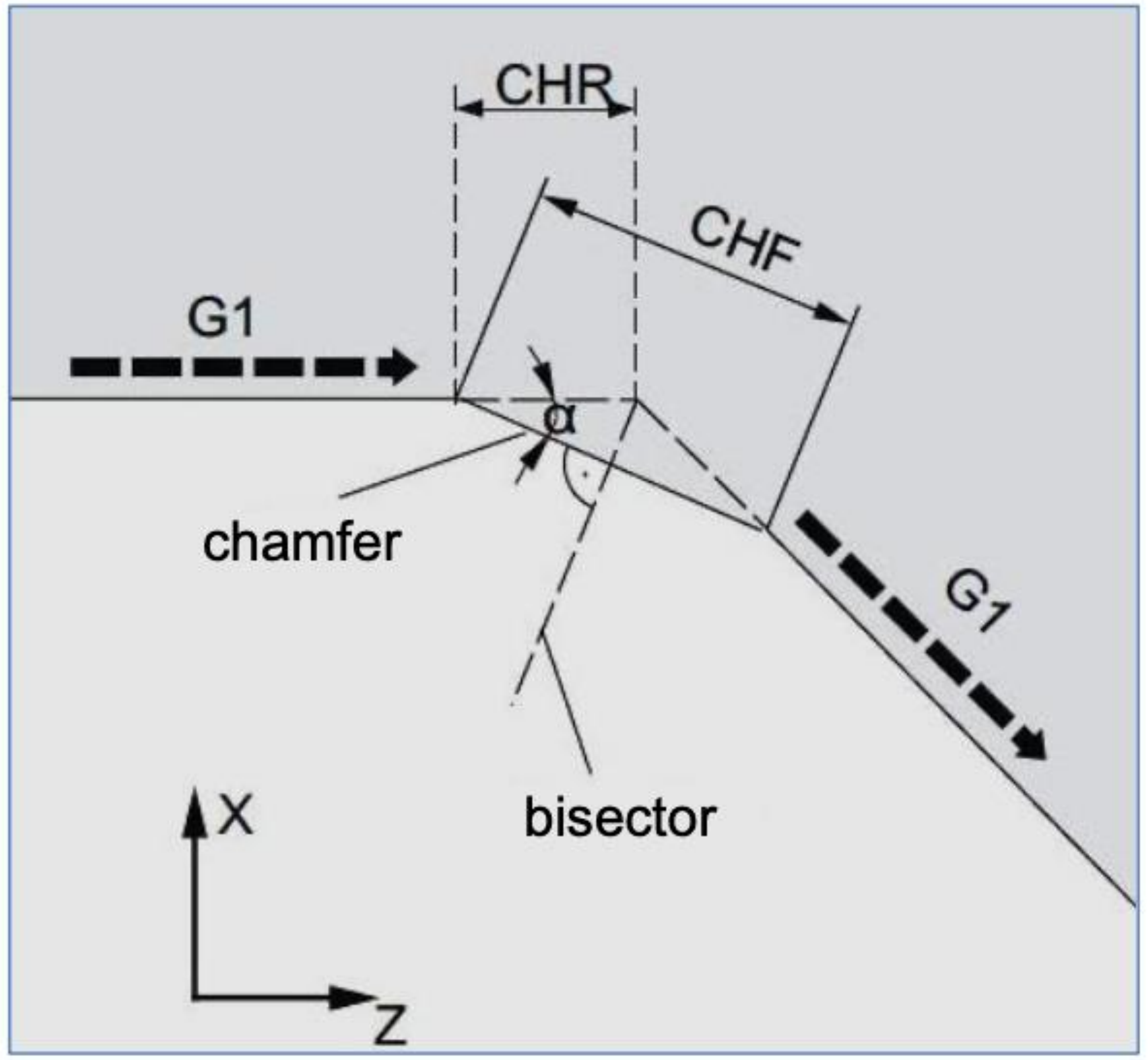


Fig. 95. Chamfer executed between two lines by means of the function CHR or CHF

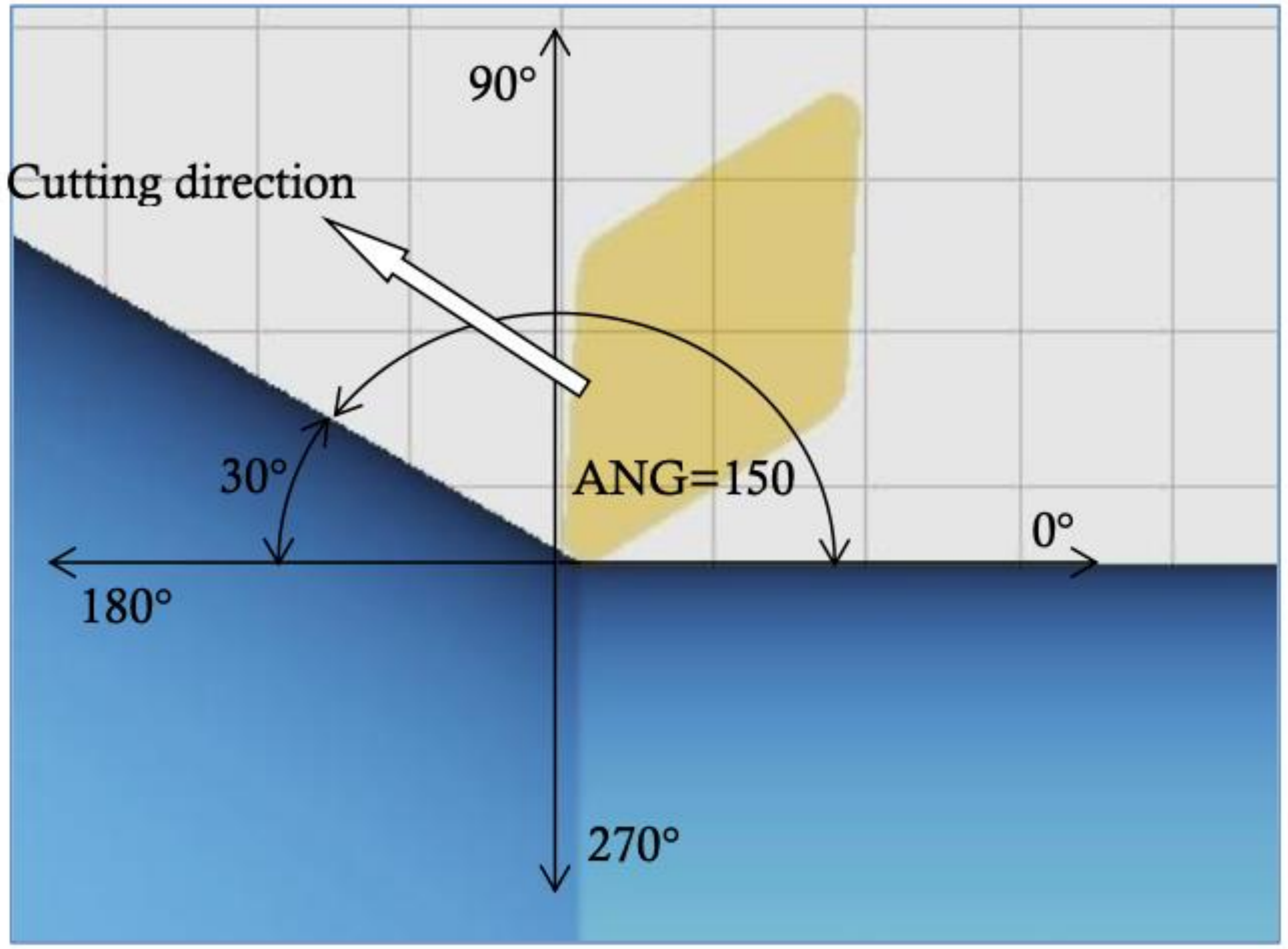


Fig. 96. Scheme for the definition of the angle by means of the function ANG

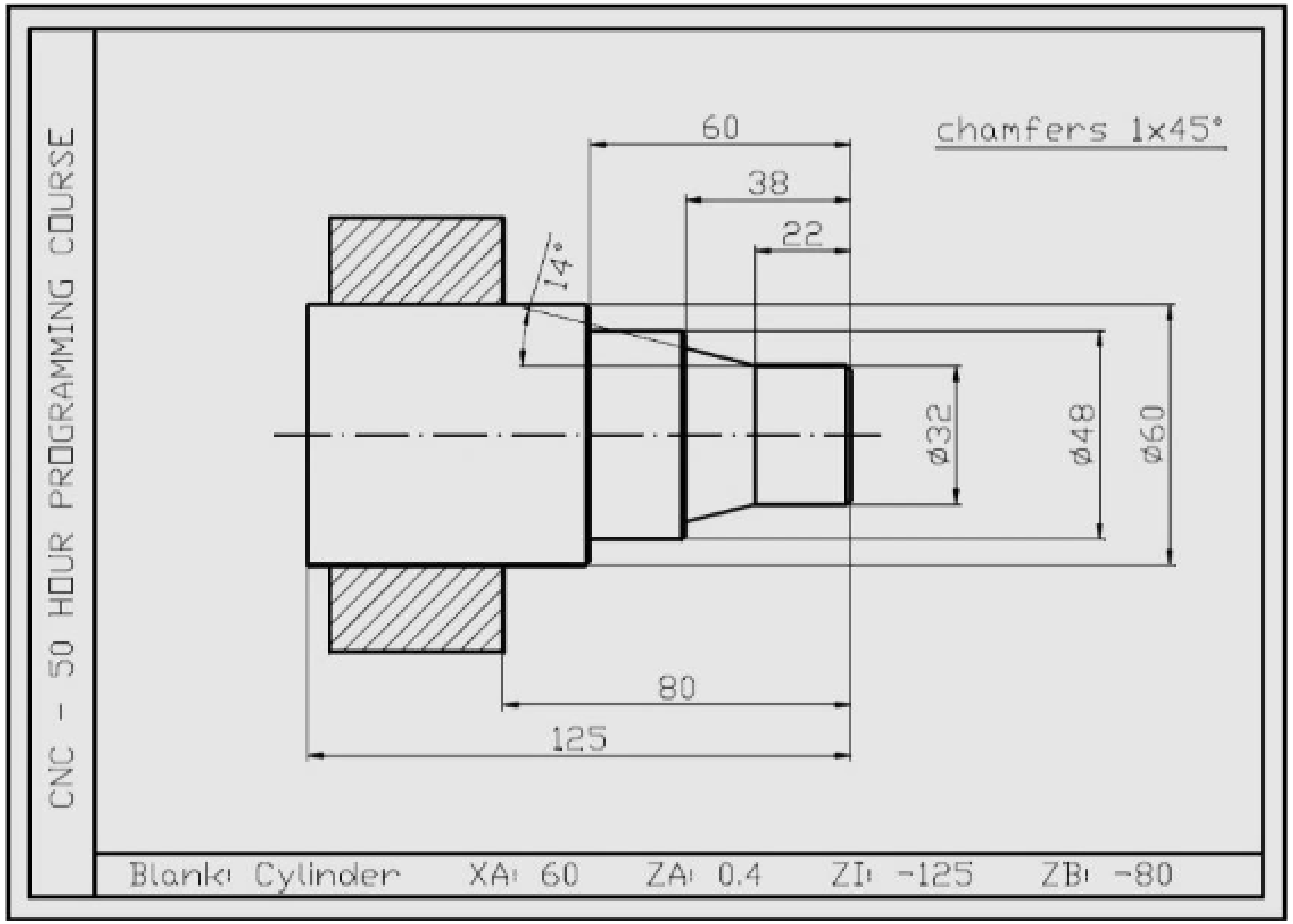


Fig. 97. Programming of a profile by means of the functions CHR, FRCM and ANG

Previous program created by programming the arrival point coordinates.	New program created by direct programming of chamfers and angles.
;FINISHING OF THE PROFILE T2 D1 G95 S1800 M4 **G0 X30 Z2** G1 Z0 F0.1 G1 X32 Z-1 G1 Z-22 G1 X40 Z-38 G1 X46 G1 X48 Z-39 G1 Z-60 G1 X58 G1 X60 Z-61 G1 Z-62 G1 X61 G0 X200 G0 Z200 M30	;FINISHING OF THE PROFILE T2 D1 G95 S1800 M4 **G0 X26 Z2** G1 Z0 F0.1 **G1 X32 CHR=1 FRCM=0.04** **G1 Z-22** **G1 Z-38 ANG=166** **G1 X48 CHR=1** **G1 Z-60** **G1 X60 CHR=1** G1 Z-62 G1 X61 G0 X200 G0 Z200 M30

Fig. 98. Comparison between the two programs which create the same profile: in the left column by means of the point to point programming, in the right column by using the direct programming functions CHR, FRCM and ANG

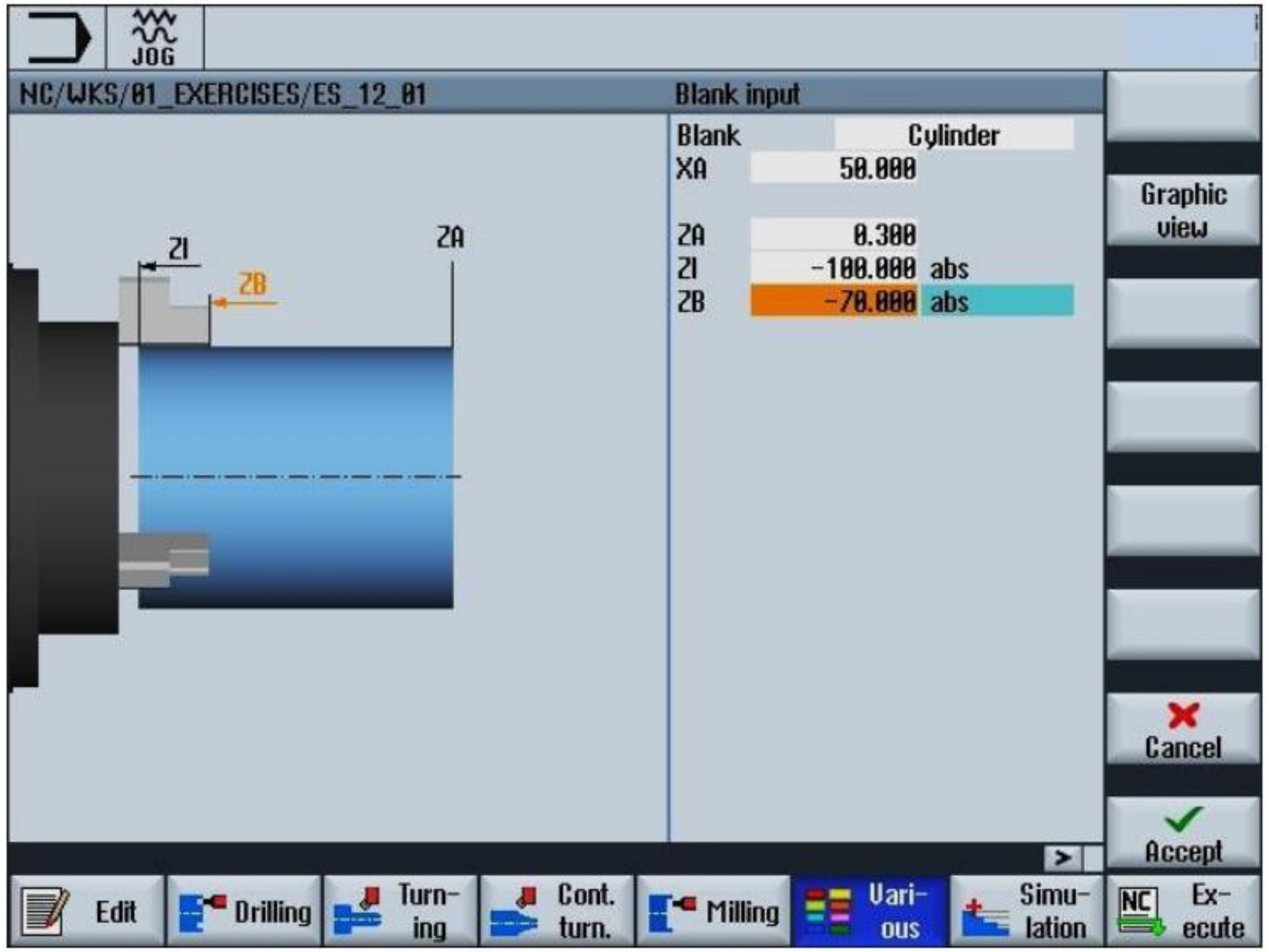
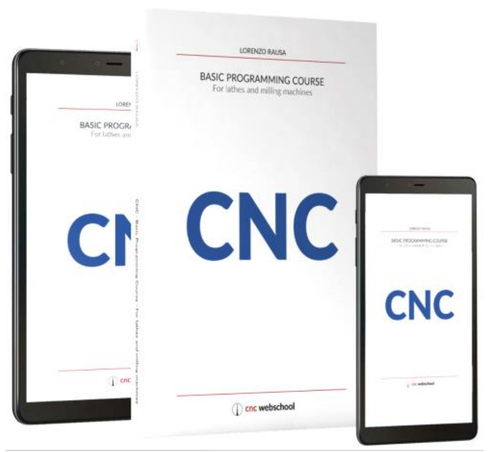


Fig. 99. Page for entering the blank part data



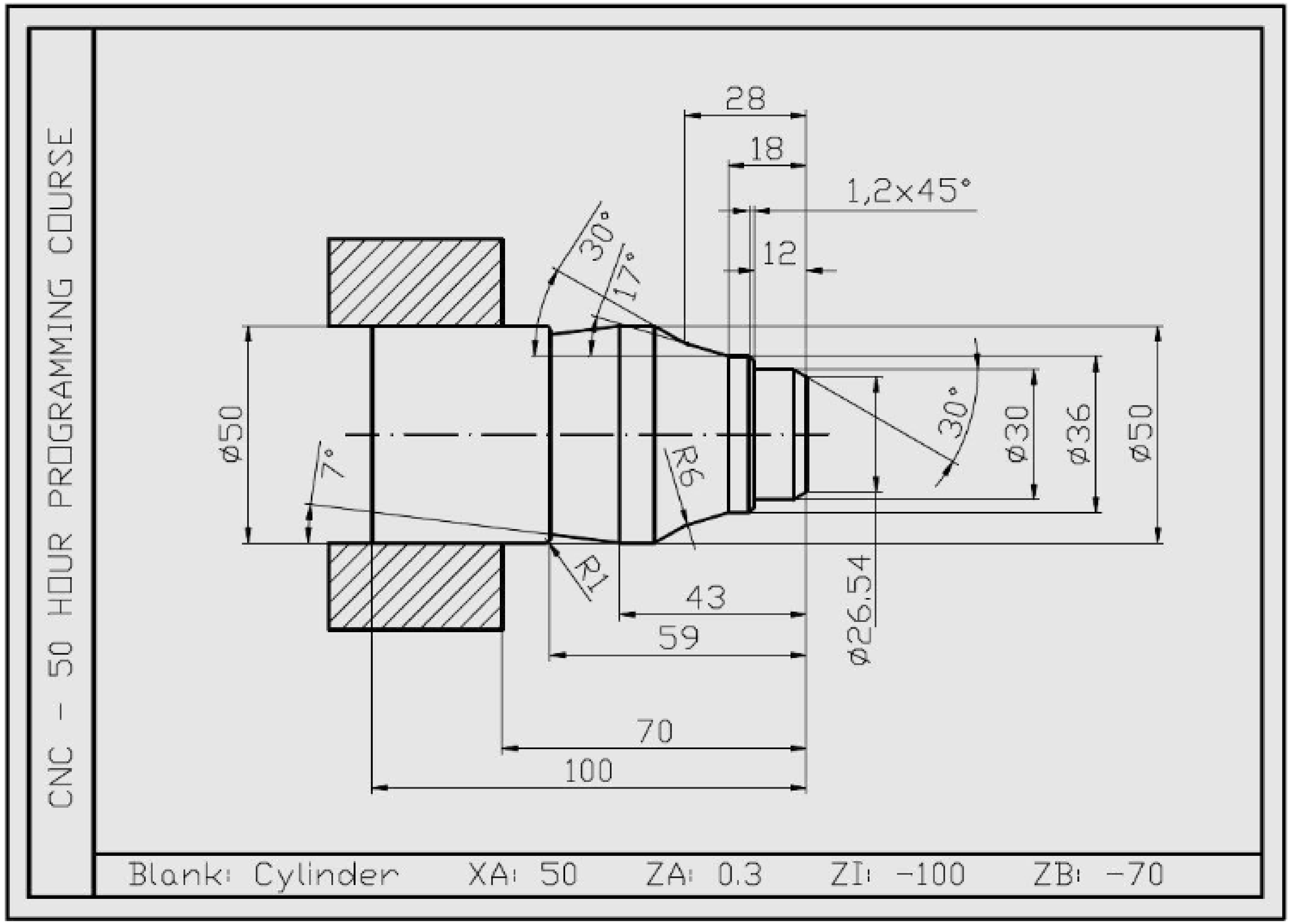
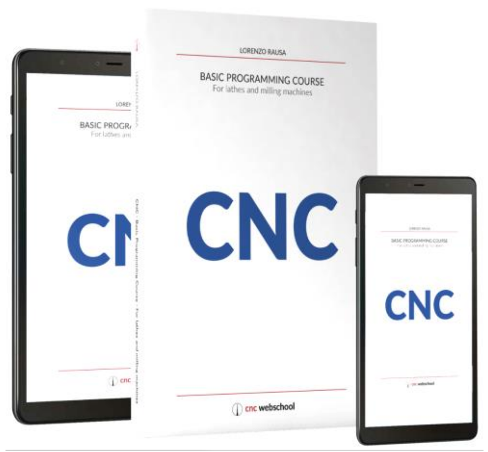


Fig. 100. Enter the missing data for the execution of this profile



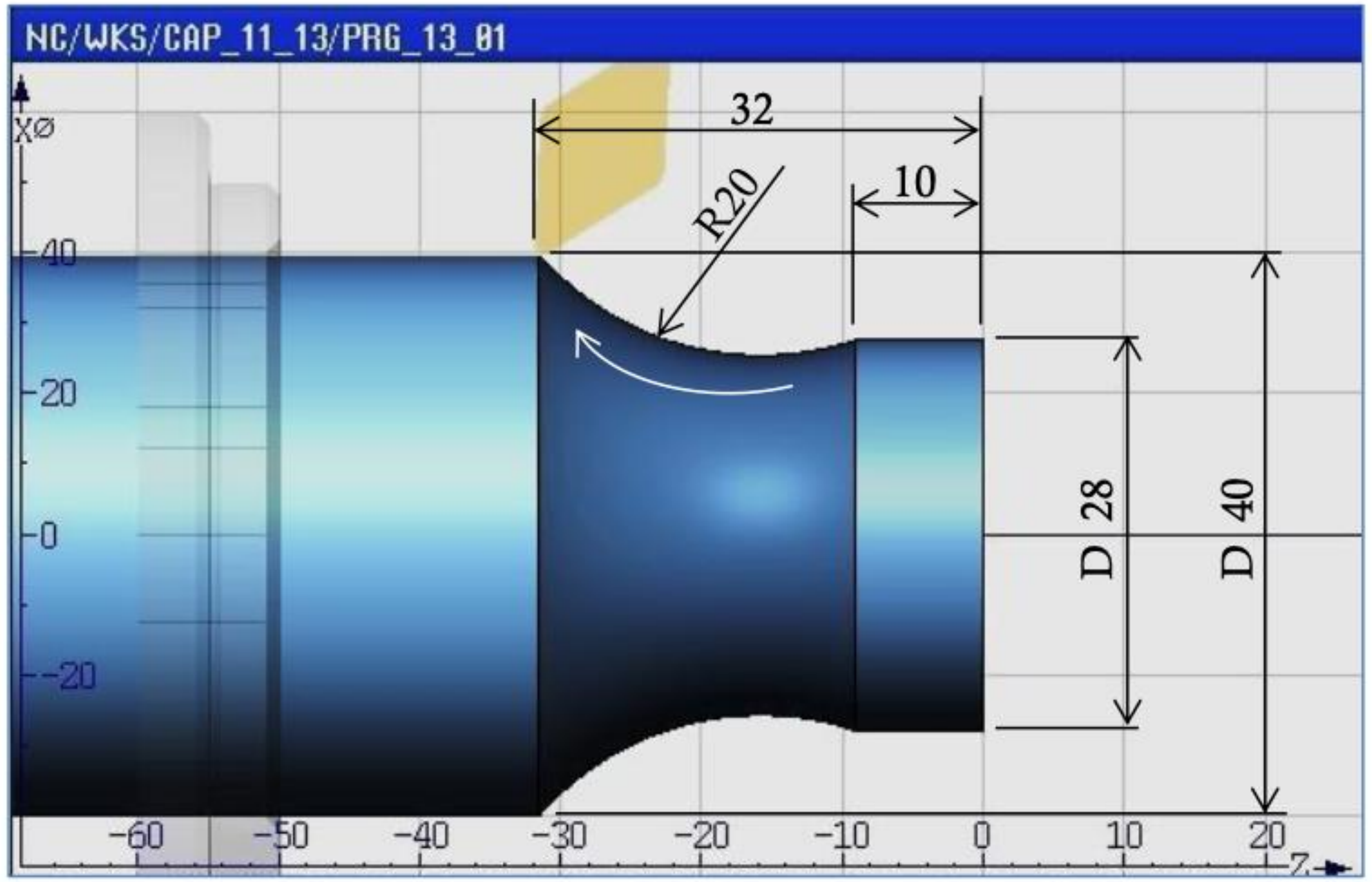


Fig. 101. G2 : circular interpolation in clockwise direction

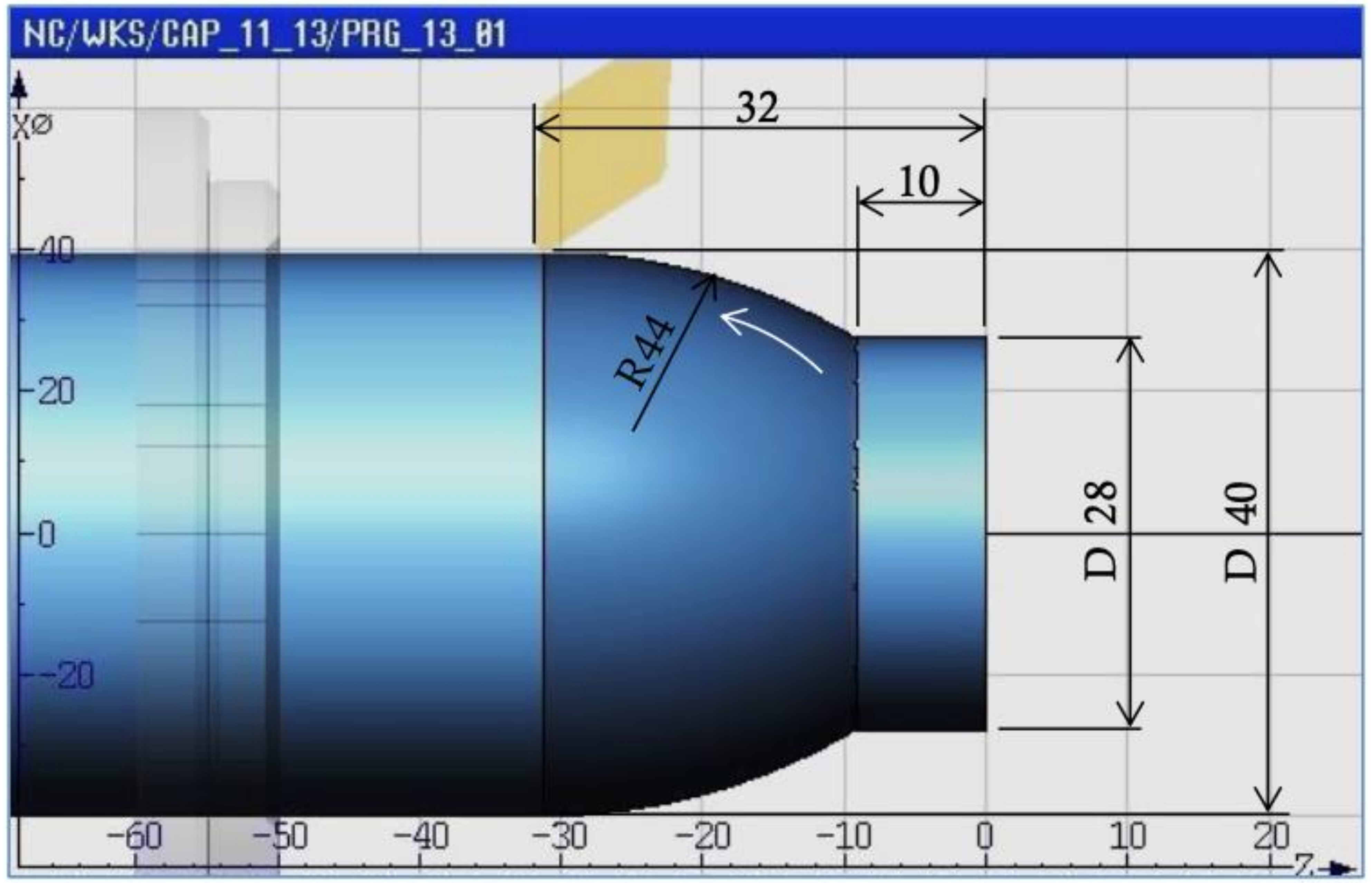


Fig. 102. G3 : circular interpolation in counterclockwise direction

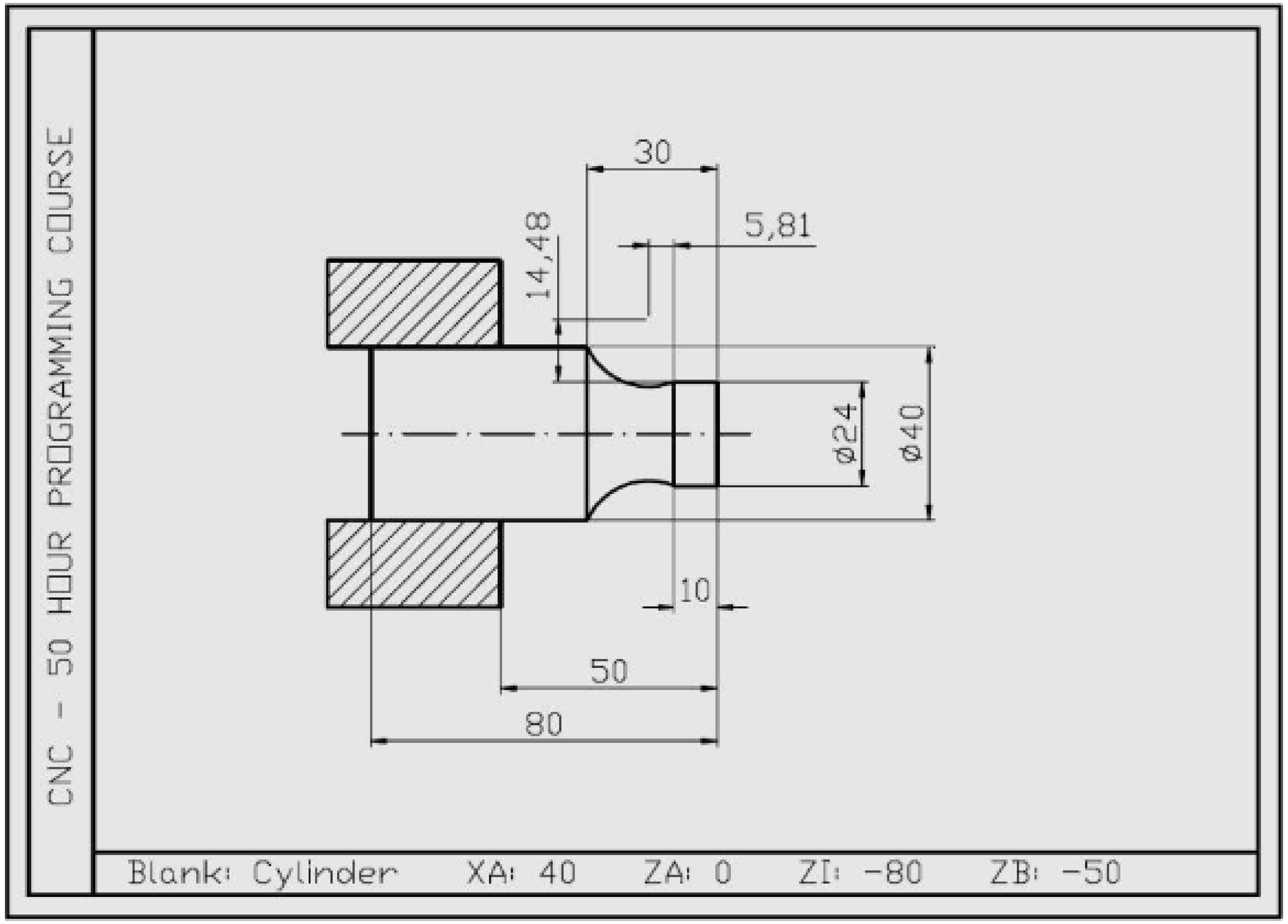


Fig. 103. Programming of an arc by means of the radius center coordinates

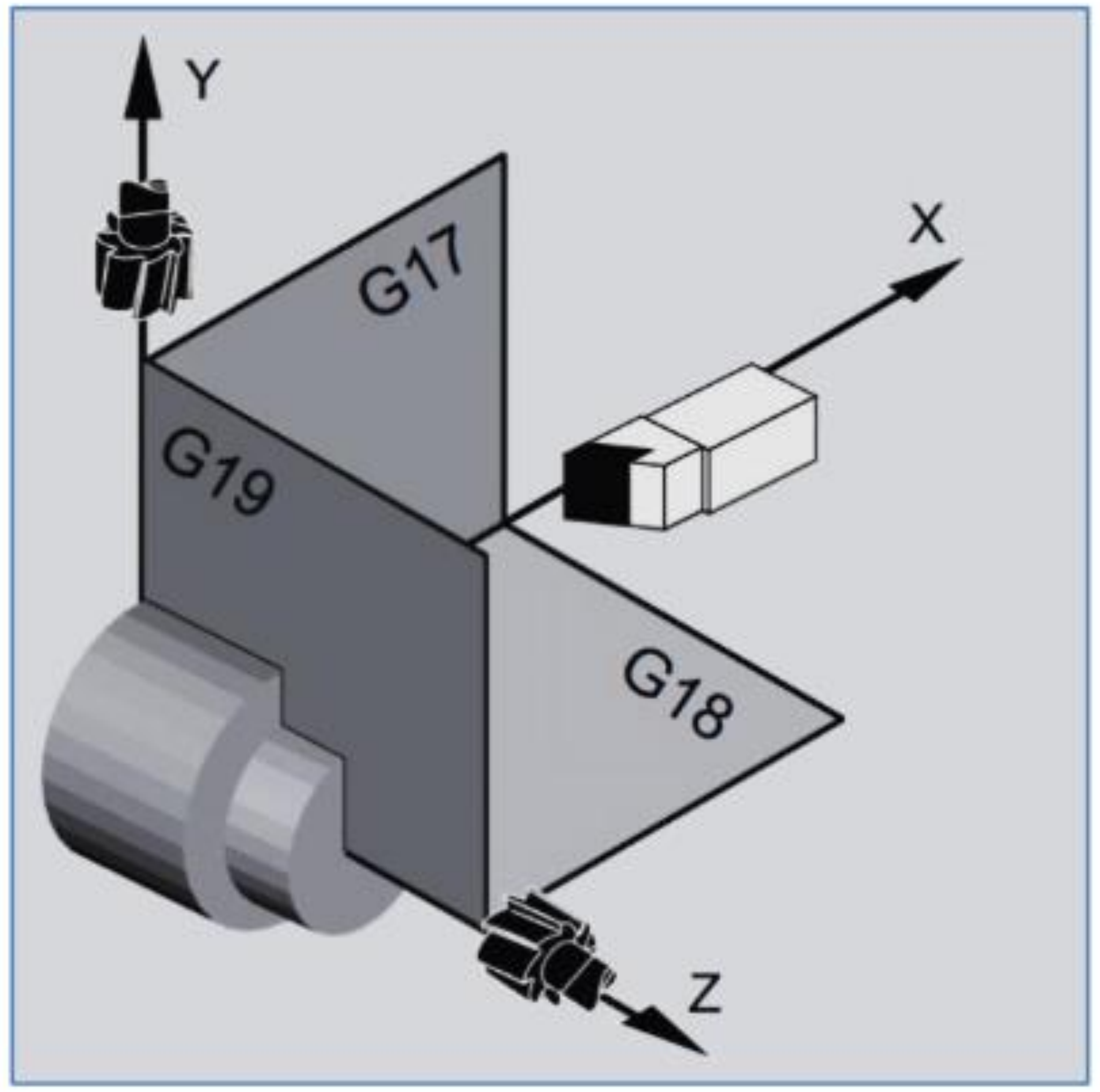


Fig. 104. Functions for the definition of the working plane

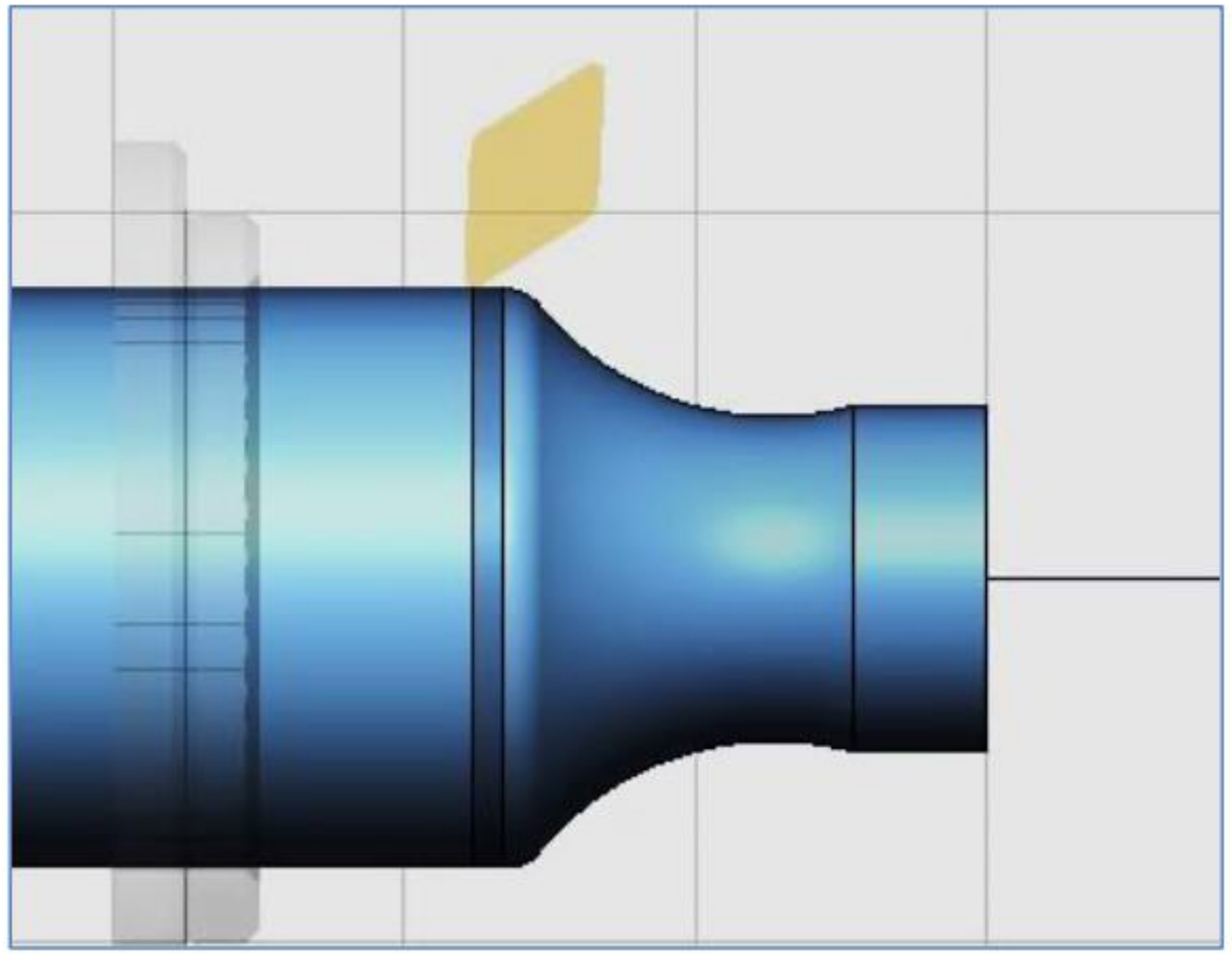


Fig. 105. Round between a radius and the following line by means of G2 and RND

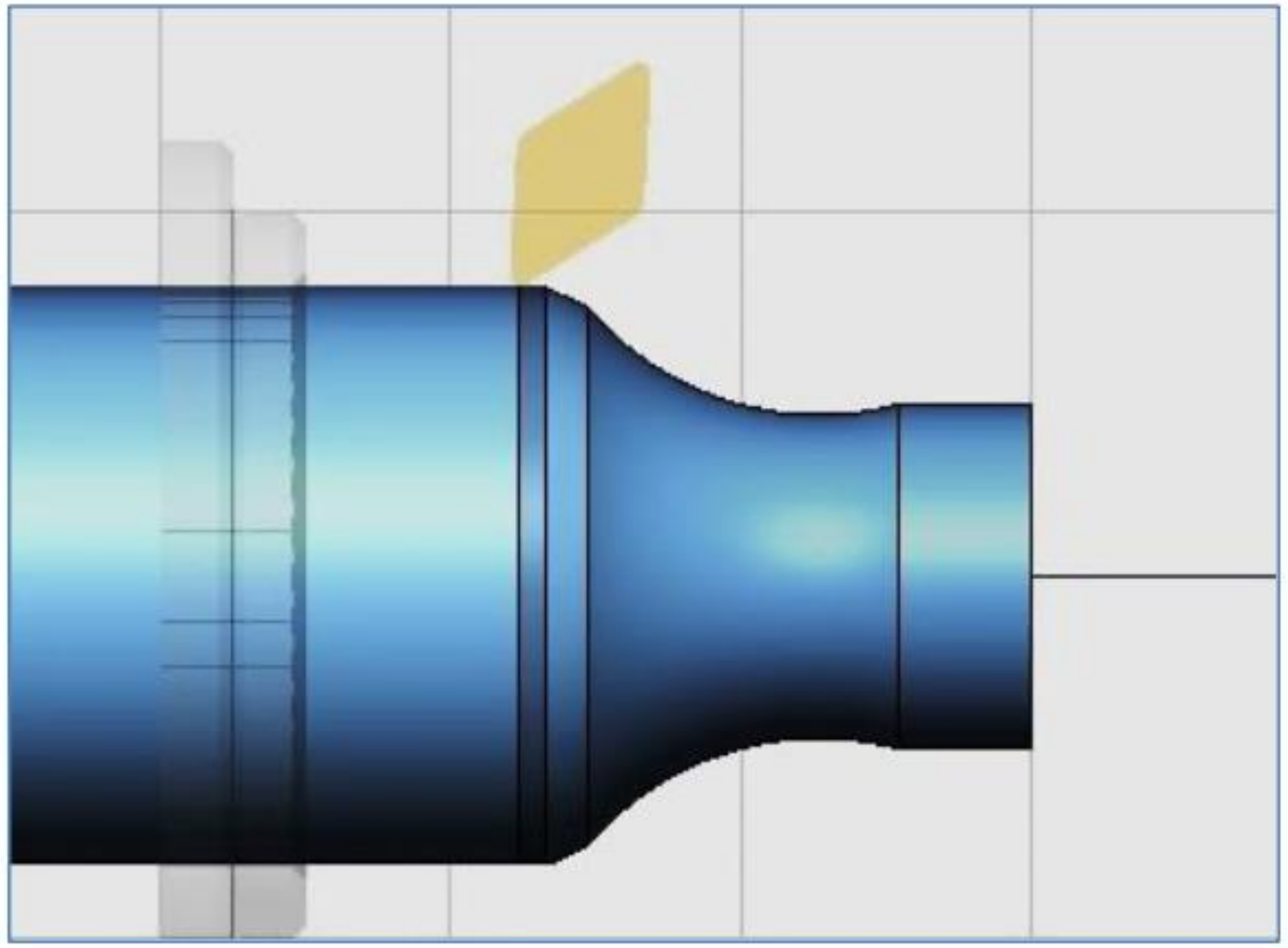


Fig. 106. Chamfer between a radius and the following line by means of G2 and CHR

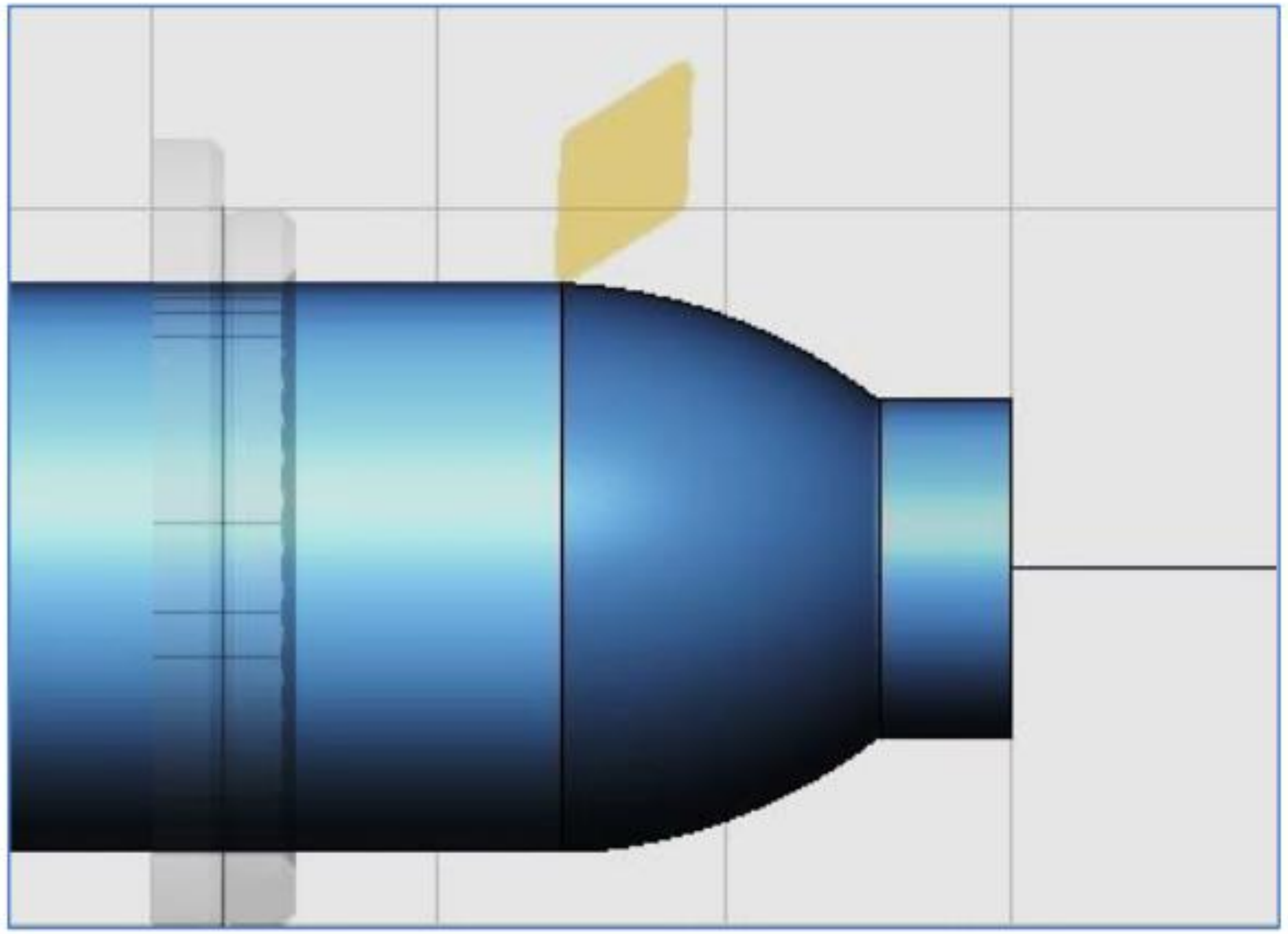


Fig. 107. Use of the function G3

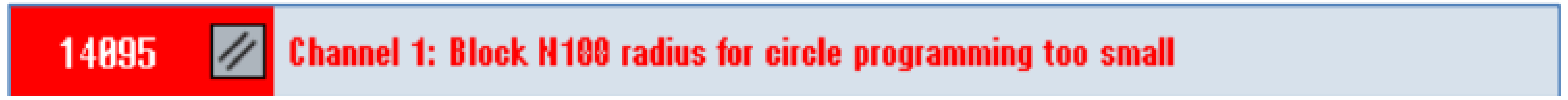


Fig. 108. Type of alarm displayed in the event of a programming error in a radius

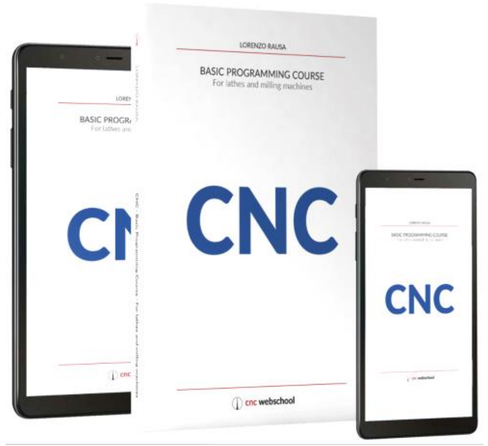
Tool list MAGAZIN

Loc.	Type	Tool name	ST	D	Length X	Length Z	Ø		Tip angle		
1		ROUGHING TOOL	1	1	88.000	40.000	0.800	←	93.0	55	11.0
2		FINISHING TOOL	1	1	94.000	40.000	0.200	←	93.0	55	11.0
3		OD GROOVING W.3MM	1	1	98.000	40.000	0.100		3.000		10.0
4		OD THREADING	1	1	88.000	46.000	0.200				
5		CENTER DRILL D.6	1	1	100.000	24.000	6.000		118.0		
6		AX. DRILL D.8.5	1	1	100.000	56.000	8.500		118.0		

Fig. 109. List of tools to be created and used in the test program

Tooling sequence	Tool	Operation	Cutting speed (m/min)	Feed rate (mm/rev)
1 st	T1 D1	Roughing	100	0.18
2 nd	T2 D1	Finishing	120	0.12
3 rd	T3 D1	Groove	78	0.1
4 th	T4 D1	Threading	60	-
5 th	T5 D1	Center drilling	80	0.08
6 th	T6 D1	Hole D8.5	80	0.1

Fig. 110. Sequence of tooling operations and cutting parameters to use in the test



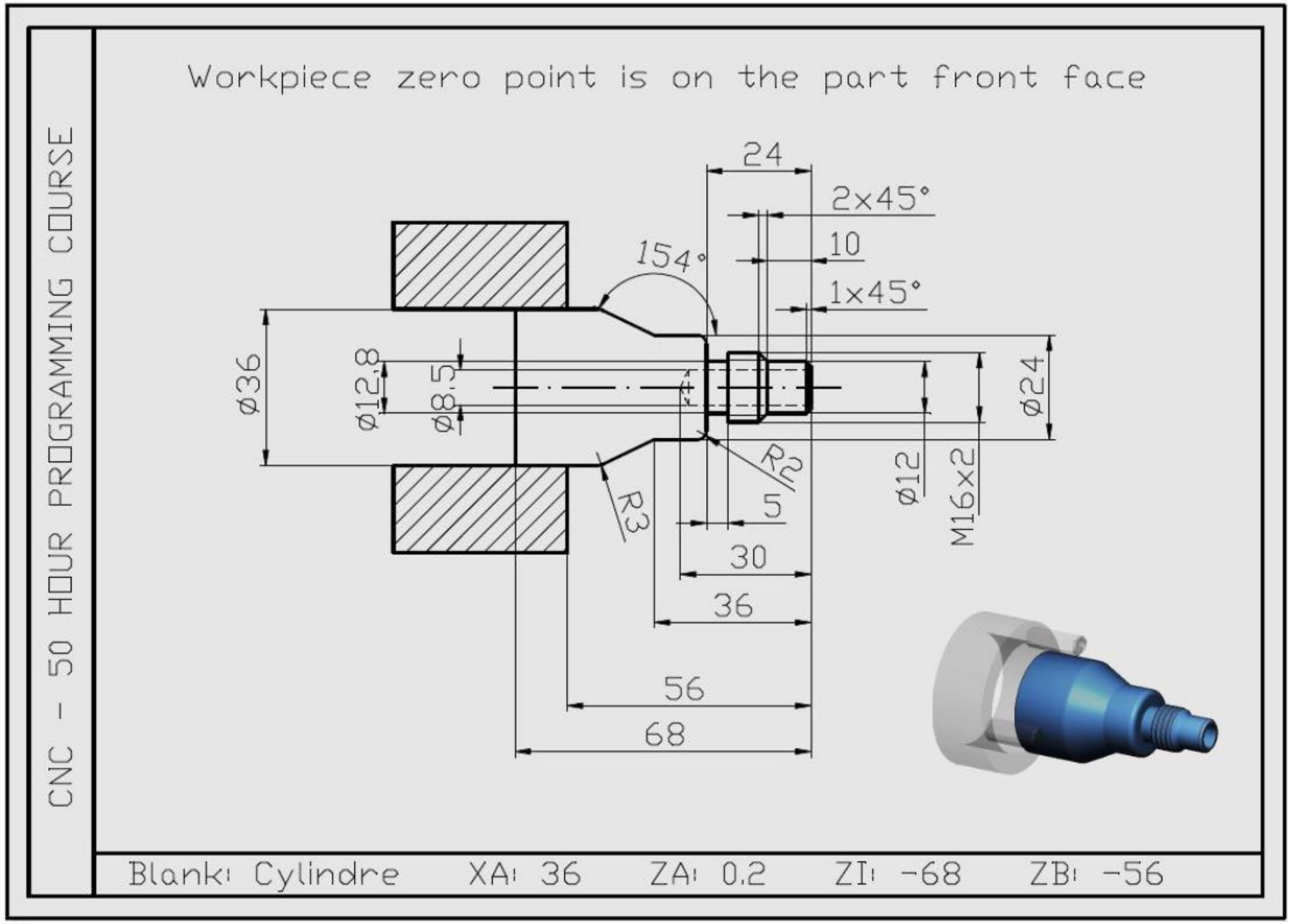


Fig. 111. Drawing of the part to create

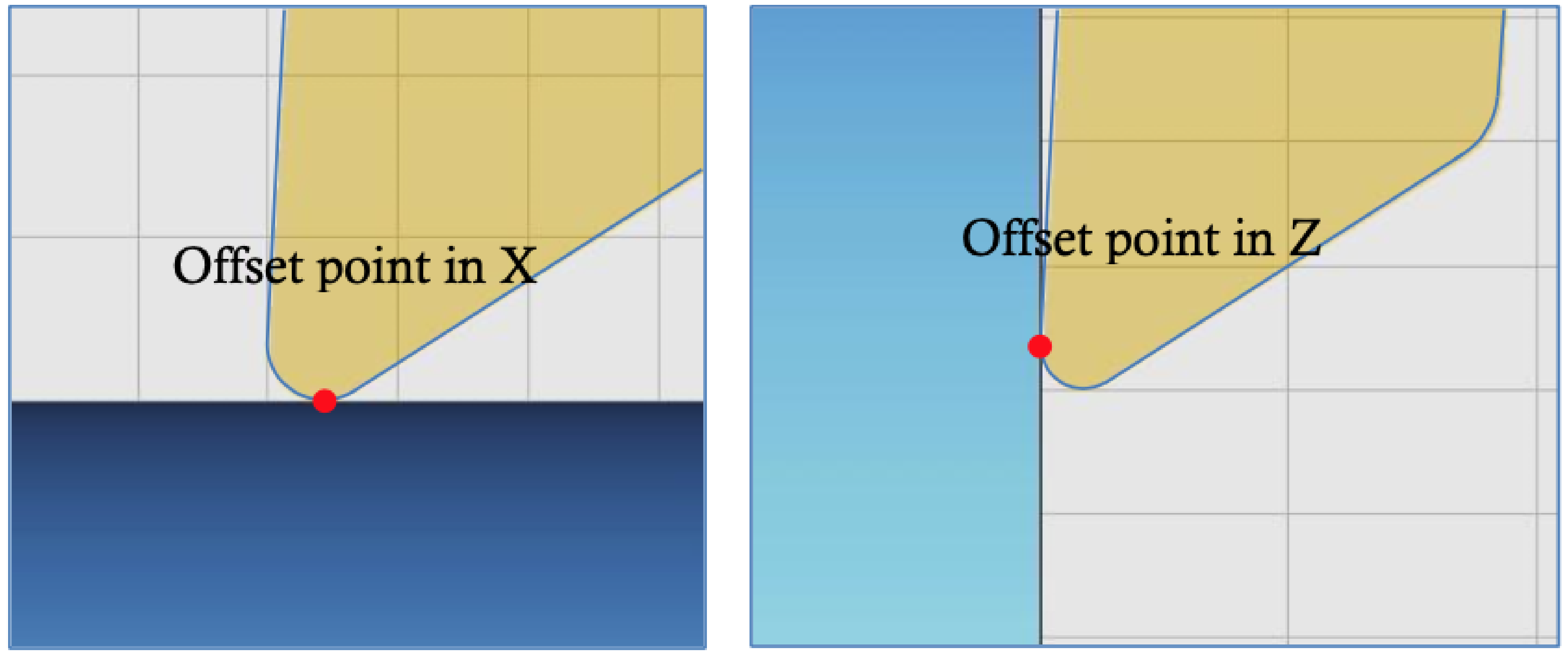


Fig. 112. Offset points on the X-axis and Z-axis with tool radius

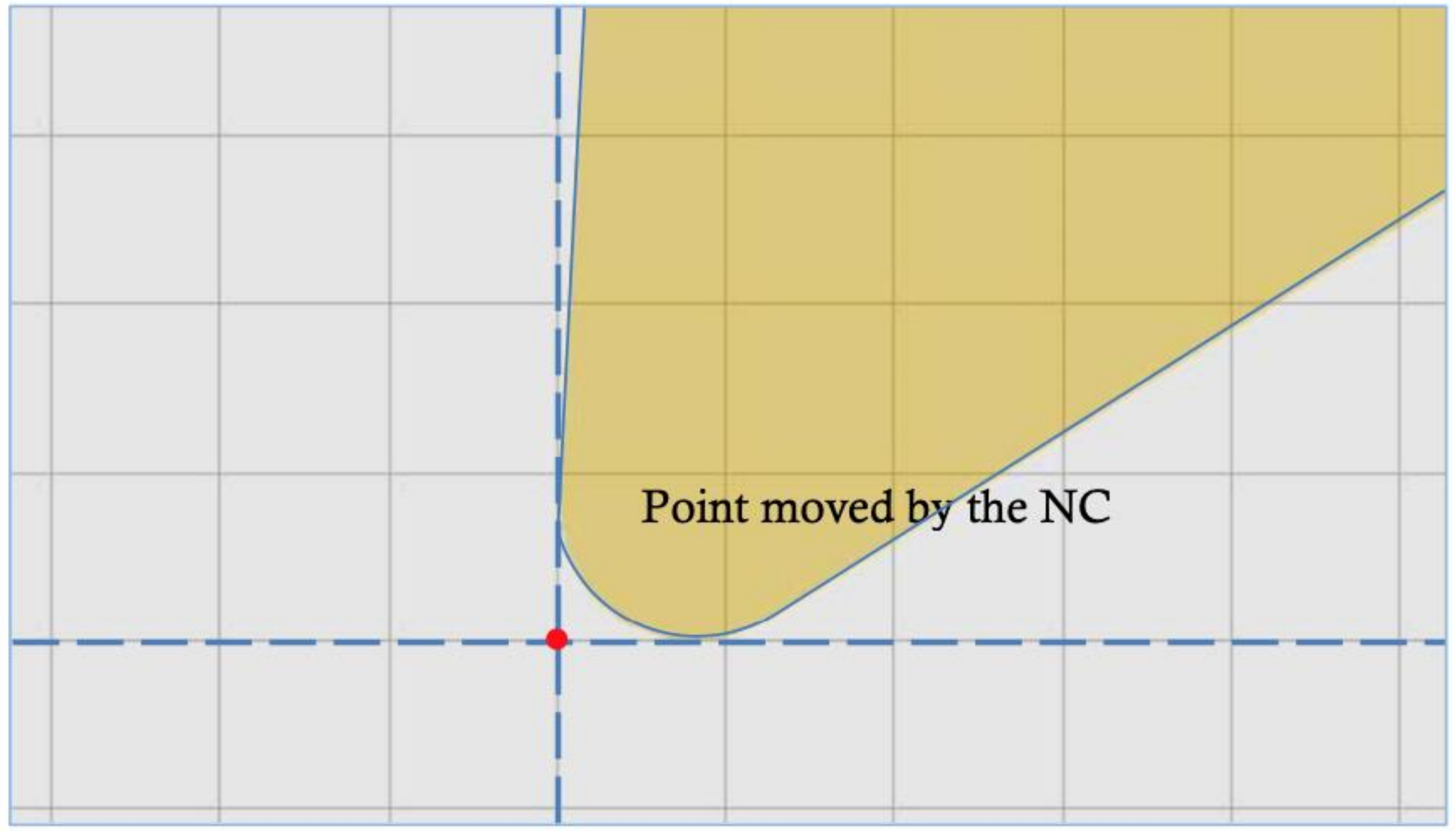
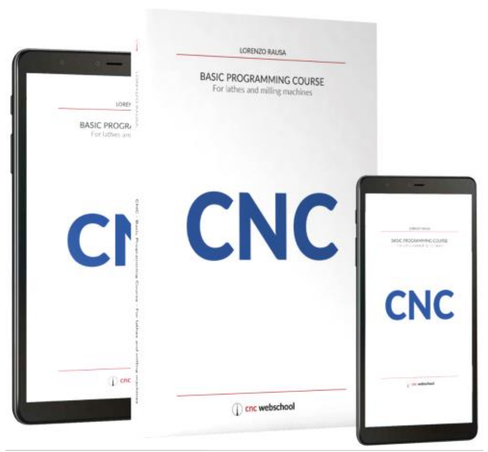


Fig. 113. Point moved by the NC after the tool offset



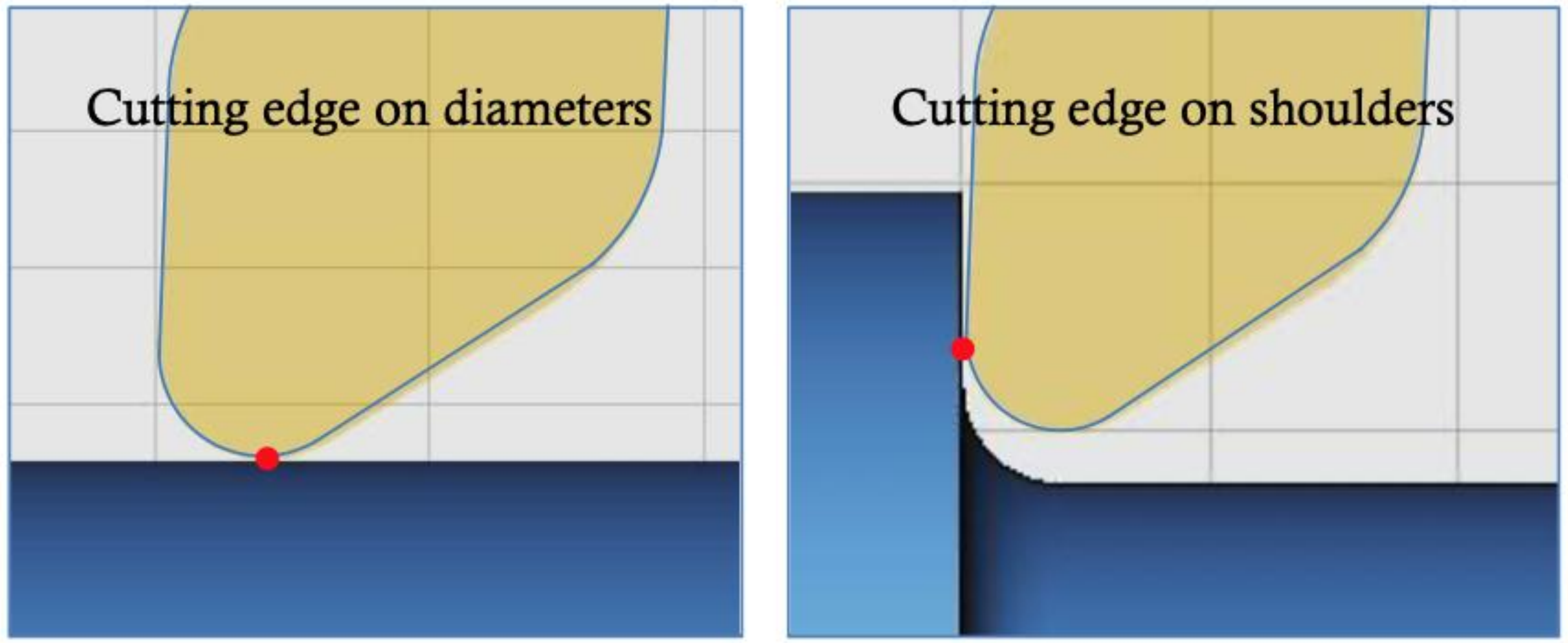


Fig. 114. Absence of changes due to the tool radius on diameters and shoulders

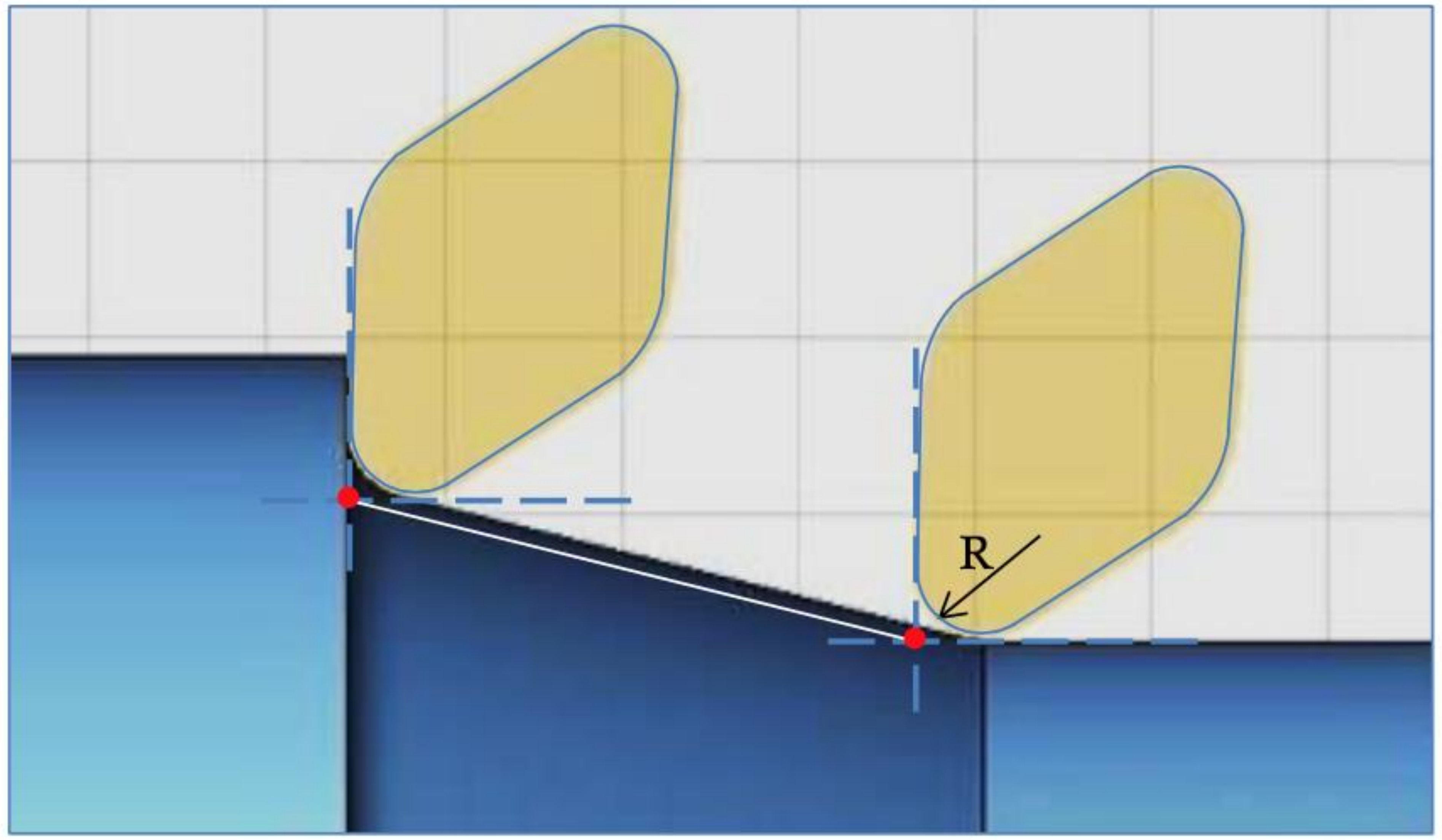
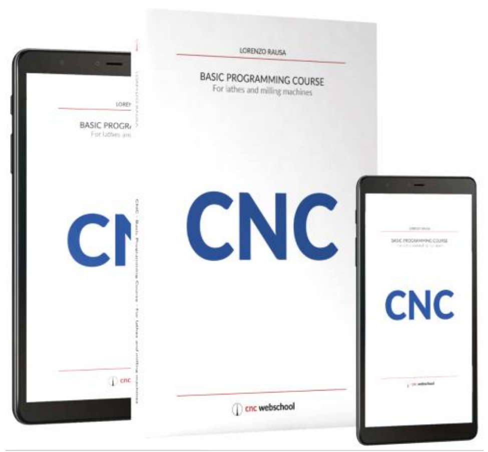


Fig. 115. Dimensional error caused by the insert radius during the execution of conical turnings



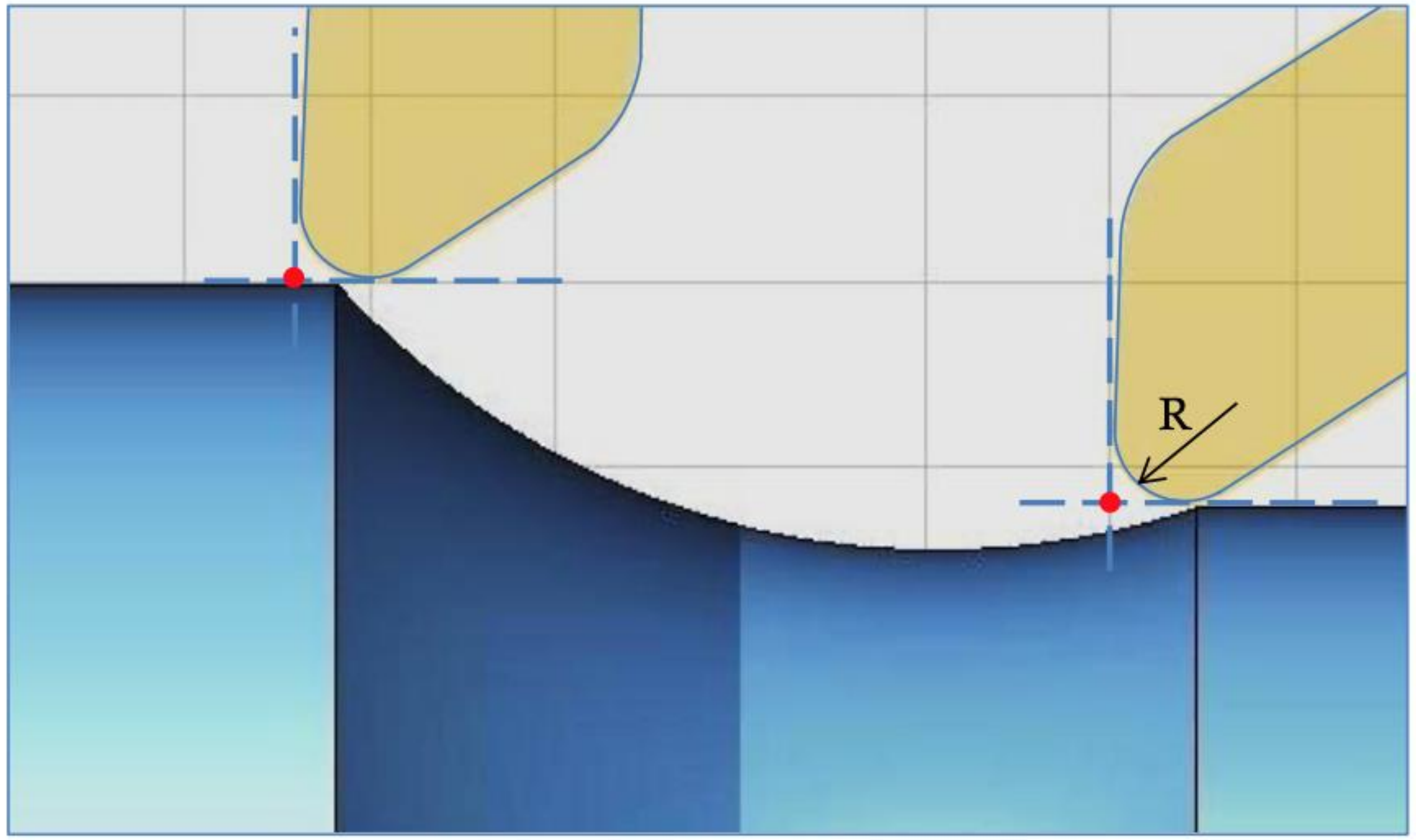


Fig. 116. Error caused by the insert radius during the execution of a circular interpolation

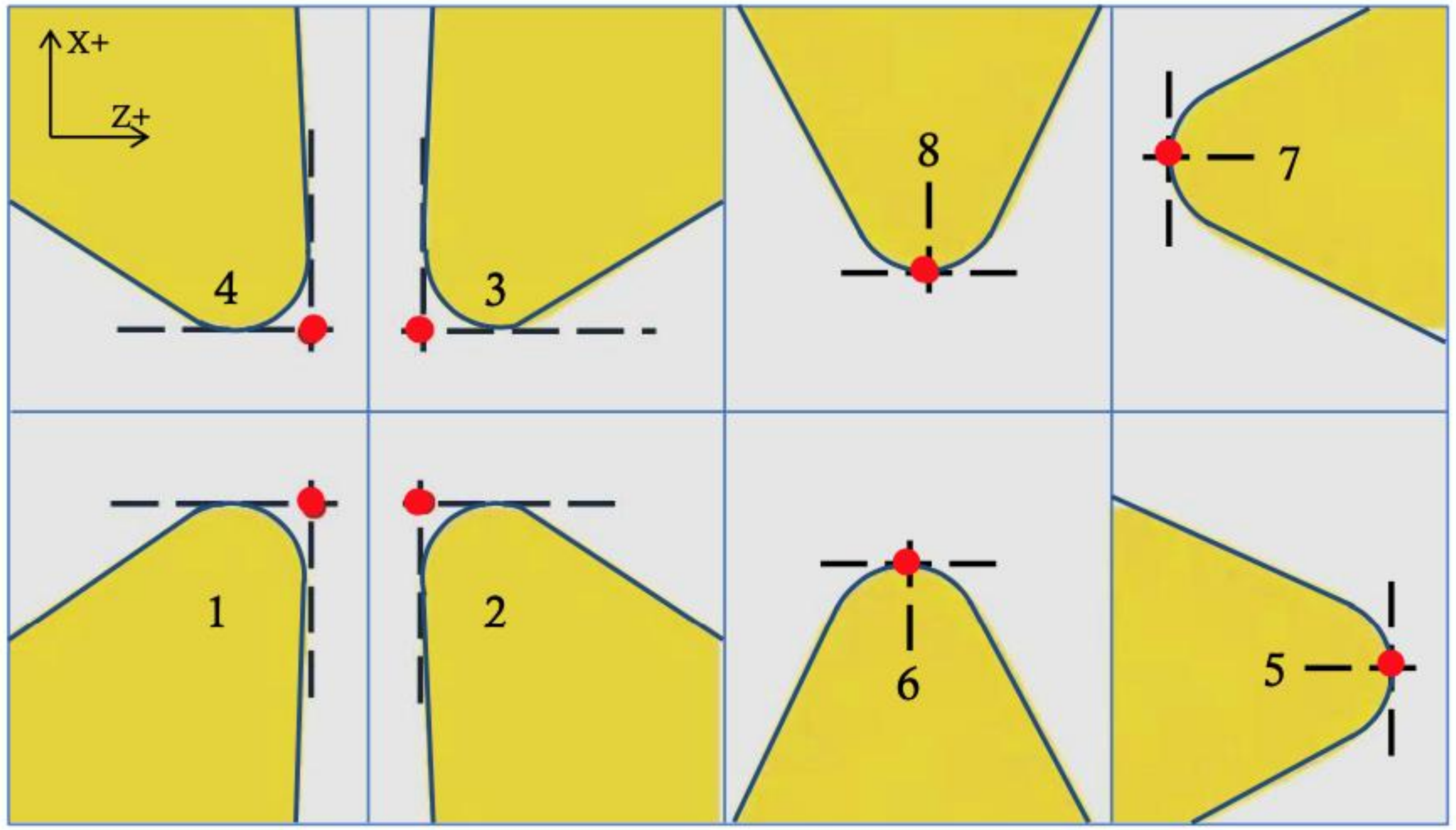


Fig. 117. Quadrant code defining the radius position with respect to the zero point

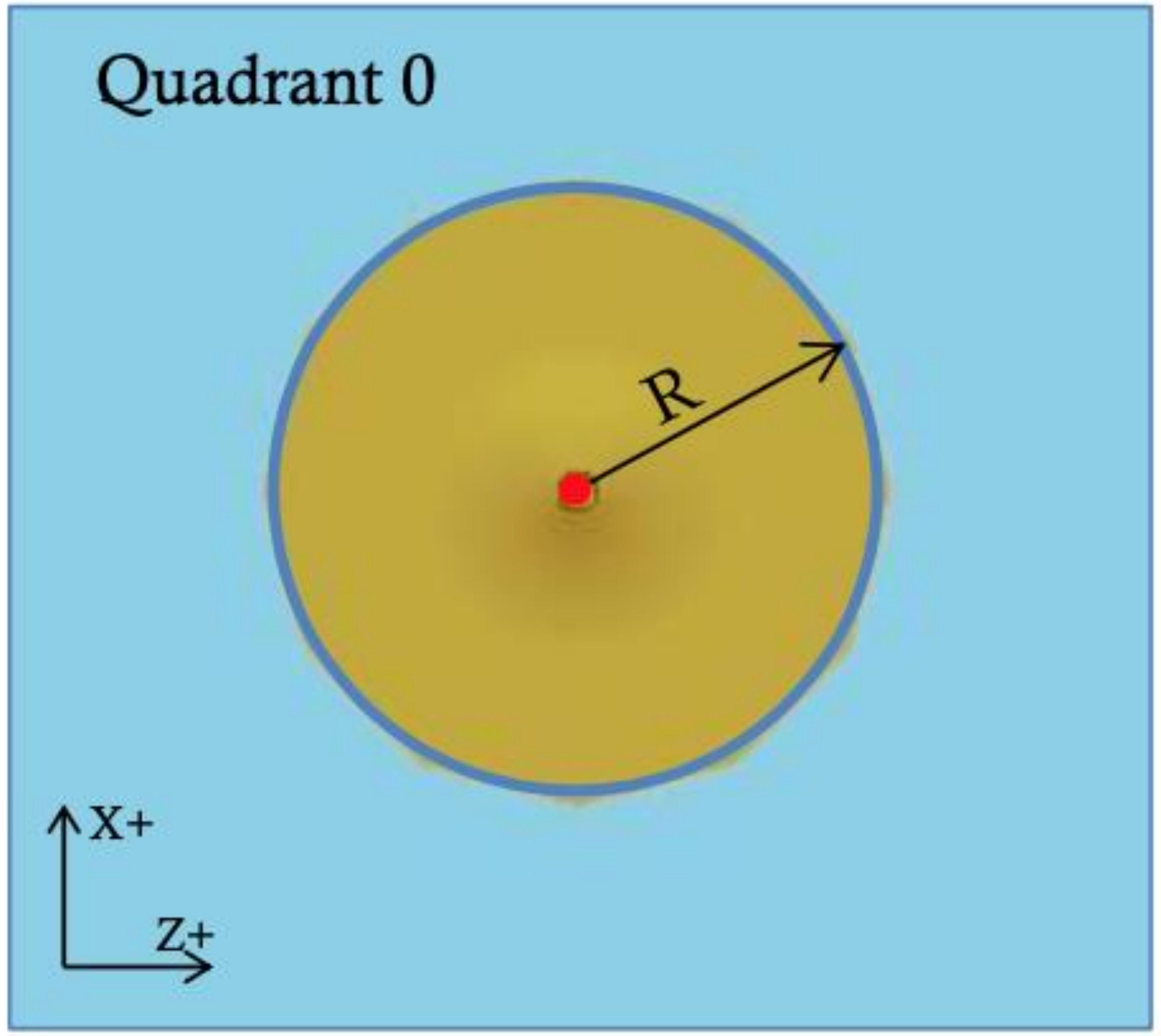


Fig. 118. Quadrant code 0 or 9 for tools offset at the radius center

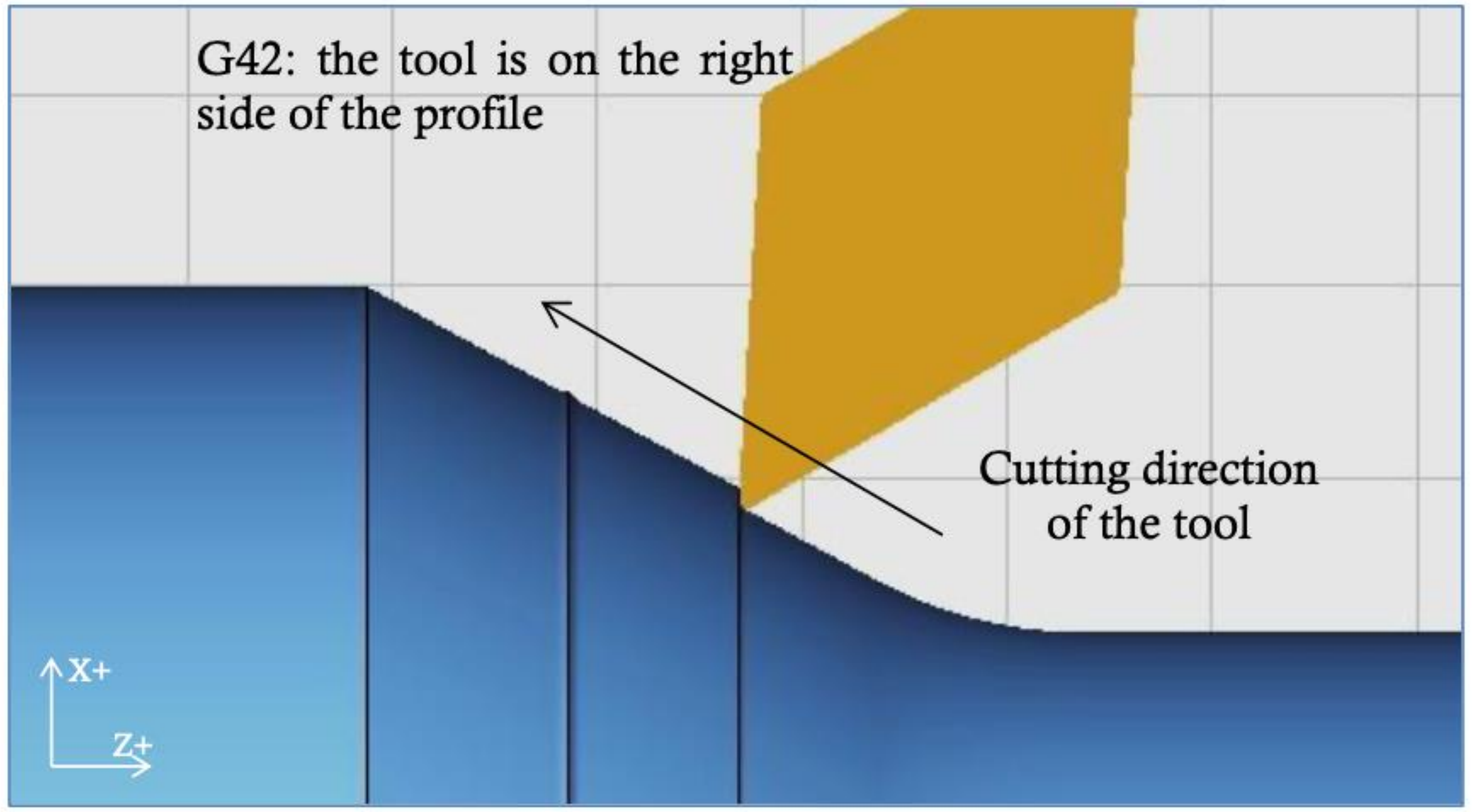


Fig. 119. G42: radius tool 0.2, quadrant 3, to the right of the profile

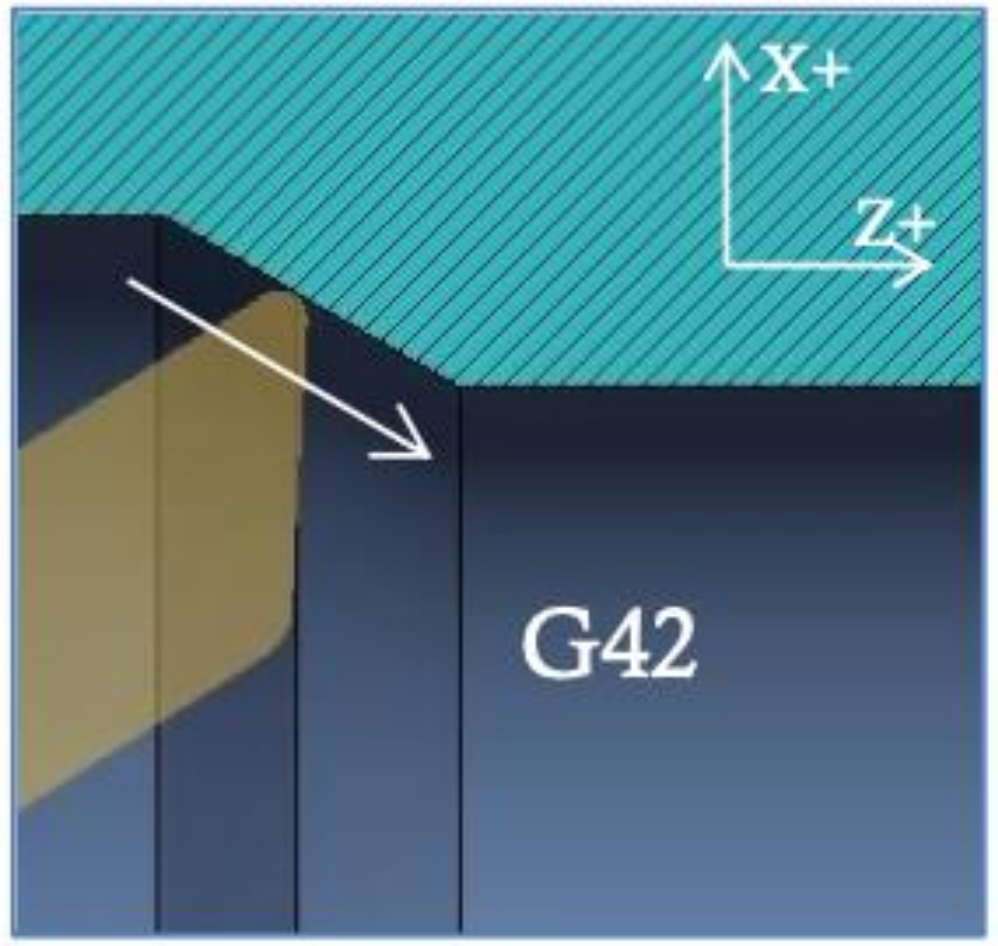


Fig. 120. G42: radius tool 0.8, quadrant 1, to the right of the profile

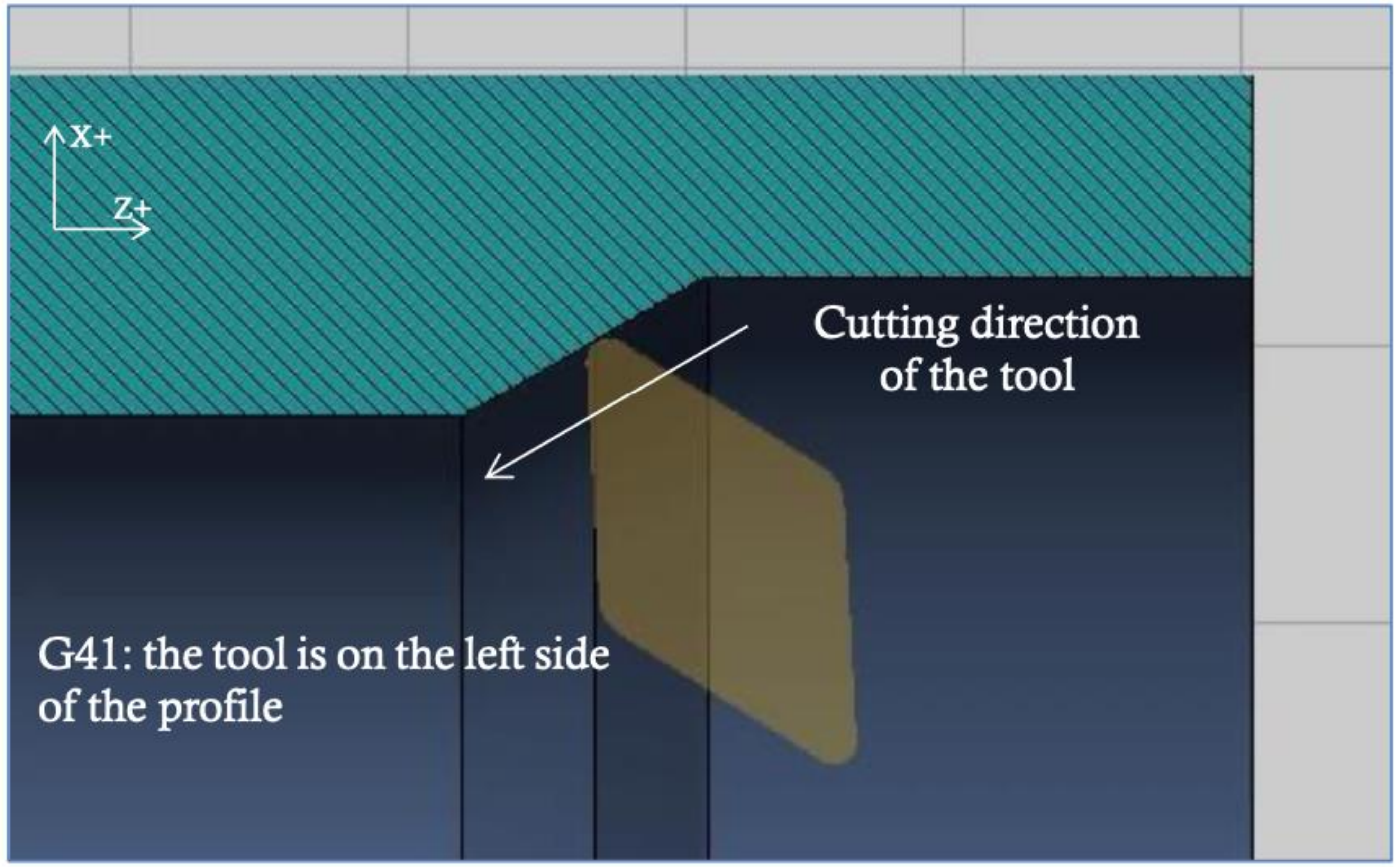
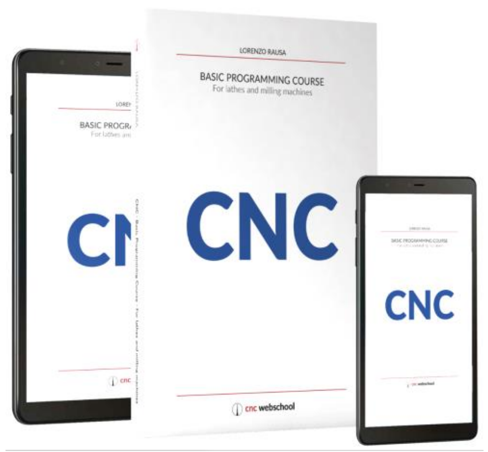


Fig. 121. G41: radius tool 0.8, quadrant 2, to the left of the profile



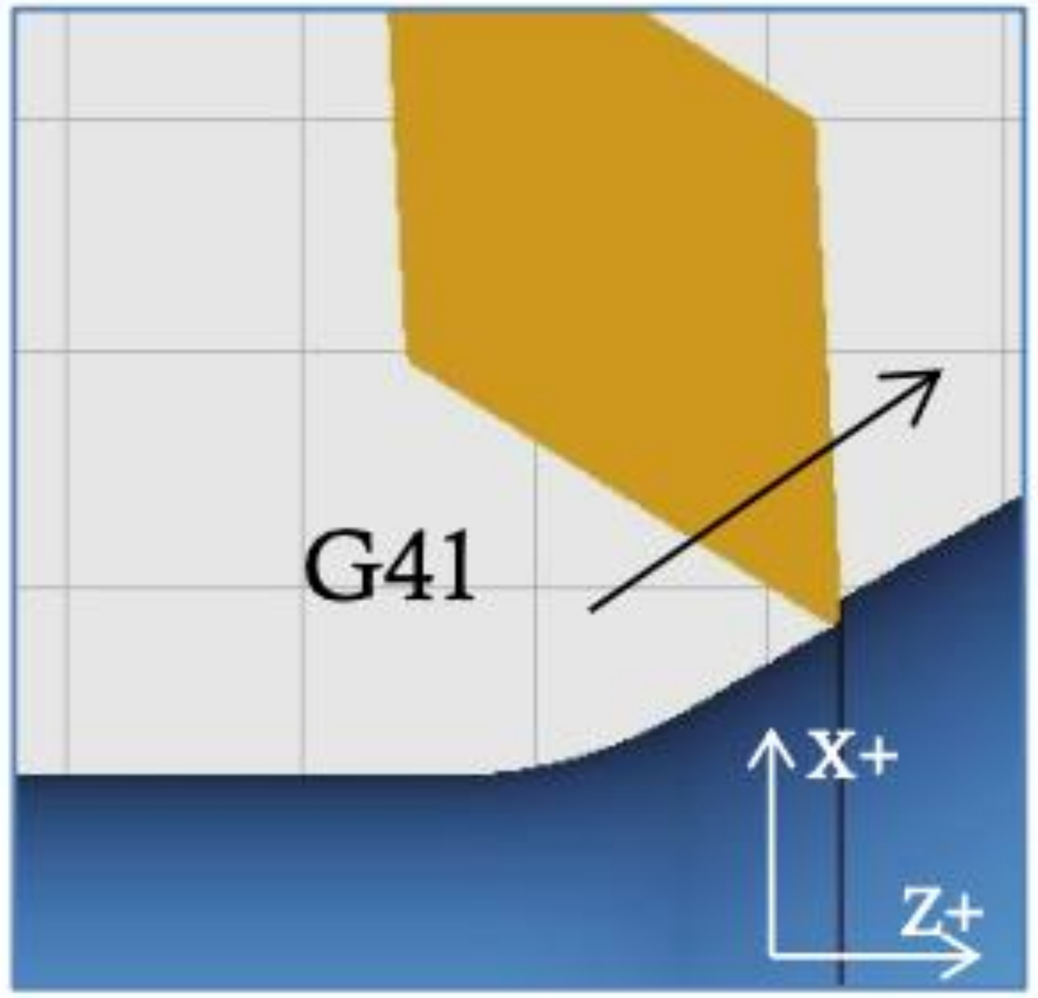


Fig. 122. G41: radius tool 0.2, quadrant 4, to the left of the profile

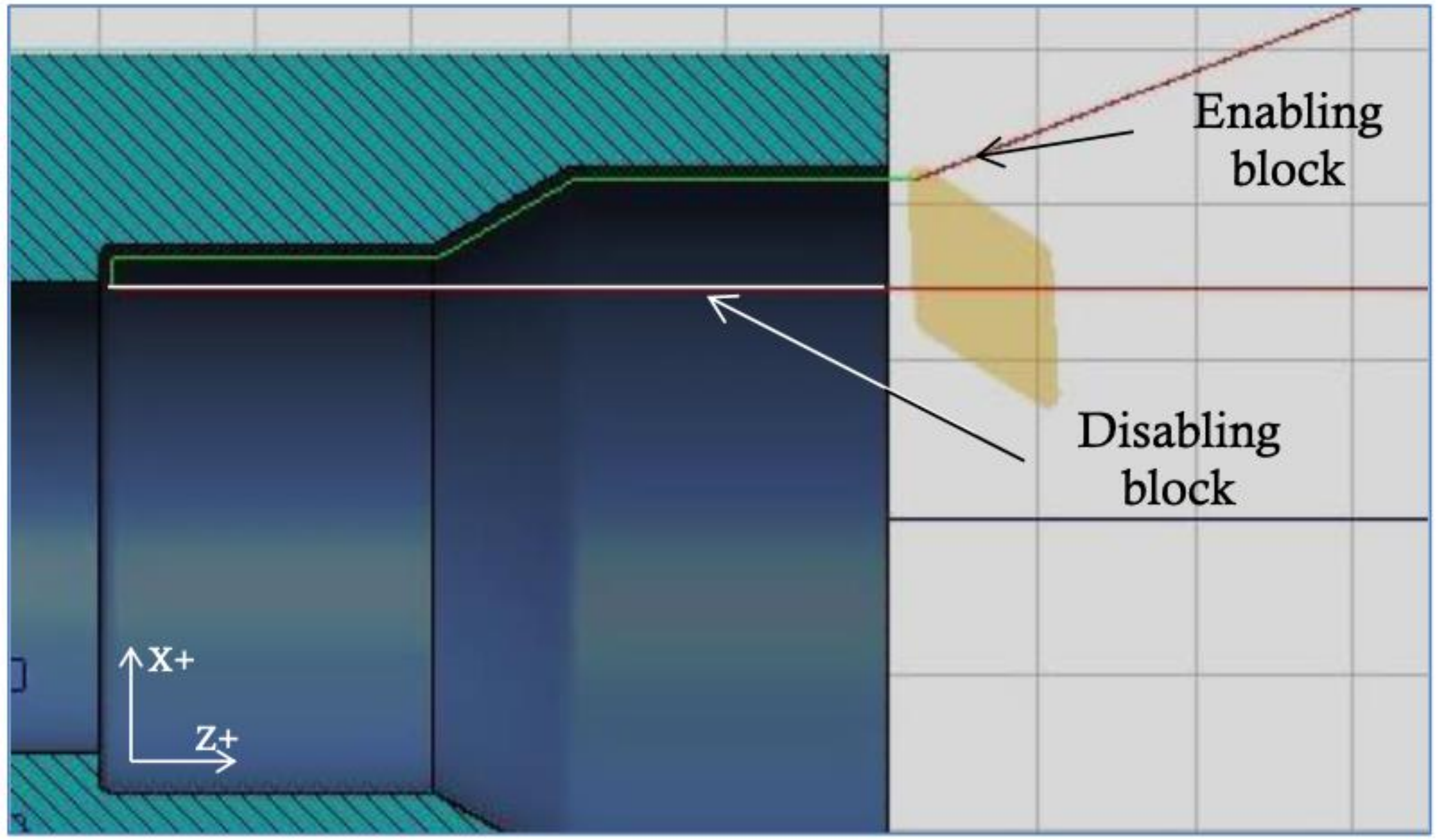


Fig. 123. Enabling and disabling block outside of the profile

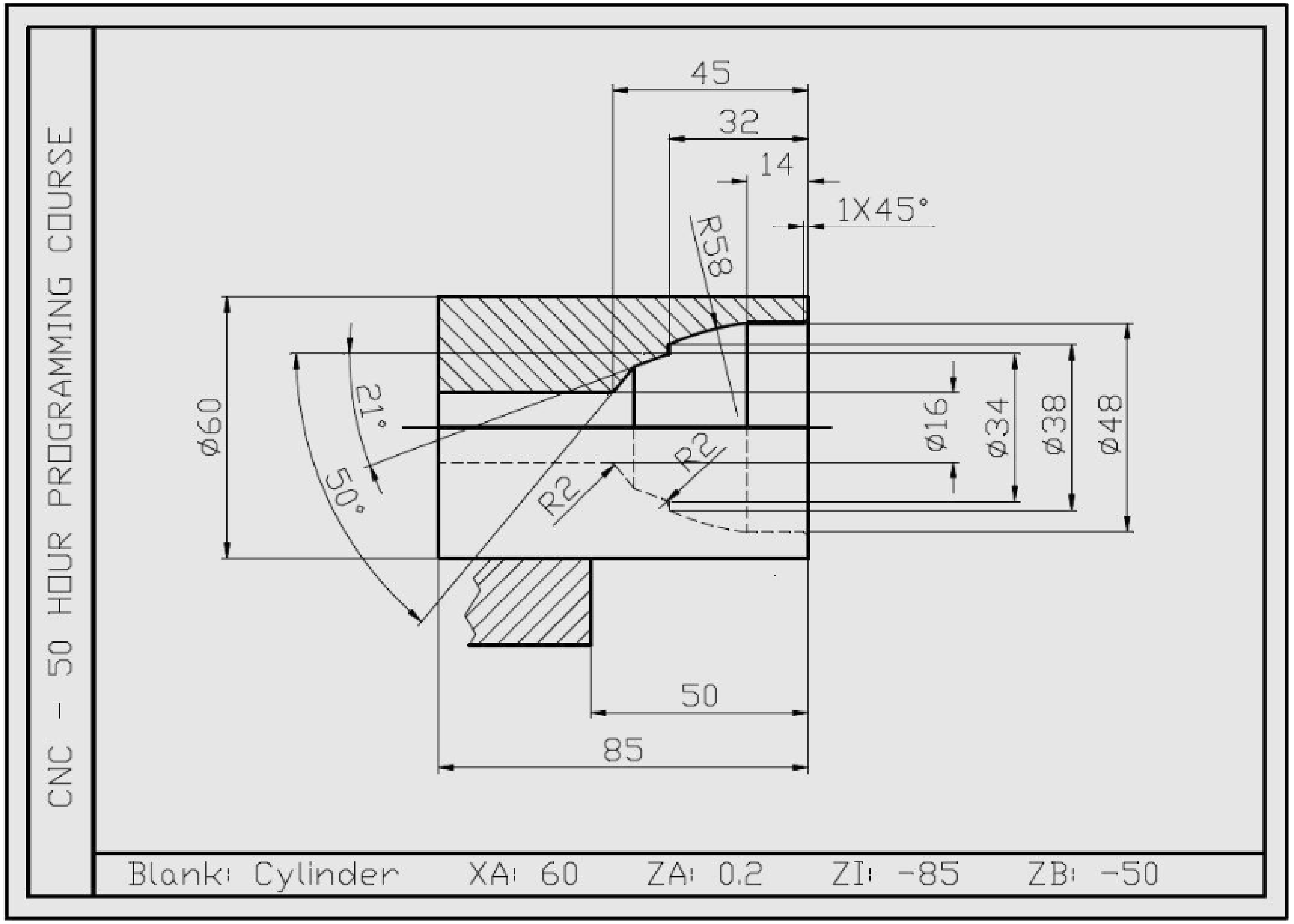
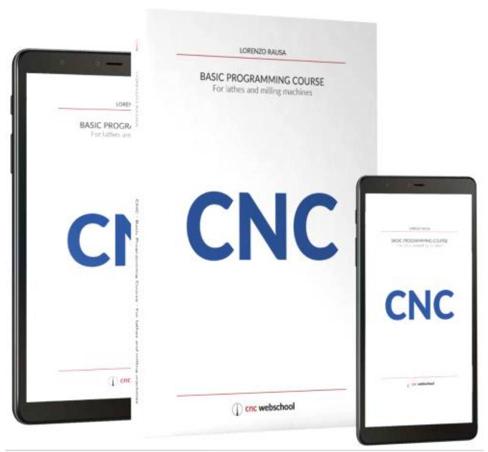


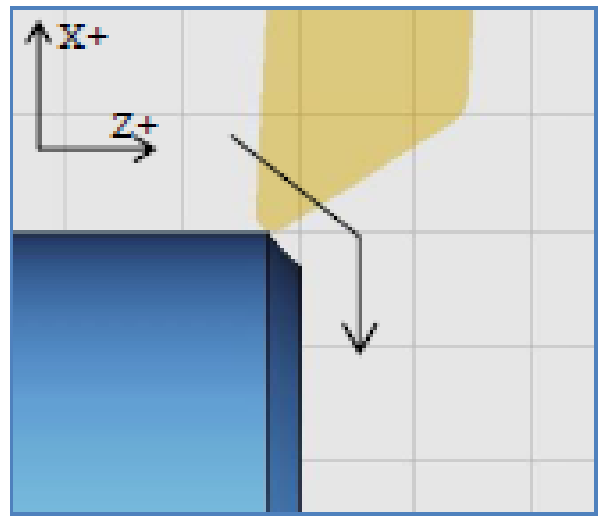
Fig. 124. Drawing of the part to create



11		AX. DRILL D.16	1	1	100.000	120.000	16.000		118.0		
12		ROUGH. BORING-BAR	1	1	86.000	92.000	0.400	←	93.0	55	8.0

Fig. 125. Data of the new tools to create for the execution of the cycle

1)

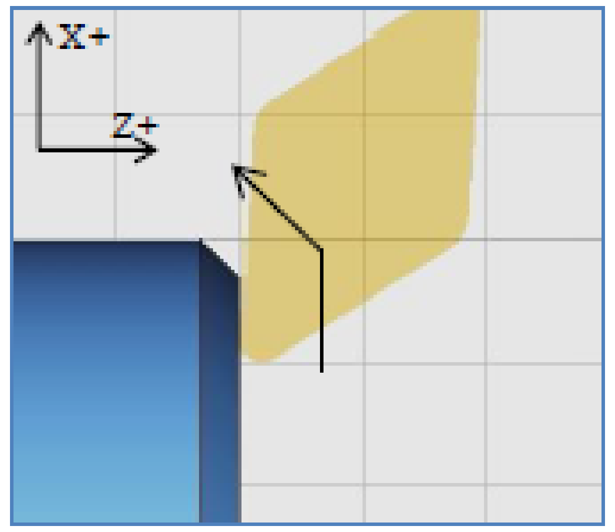


a) G42, quadrant 3

b) G41, quadrant 3

c) G41, quadrant 4

2)

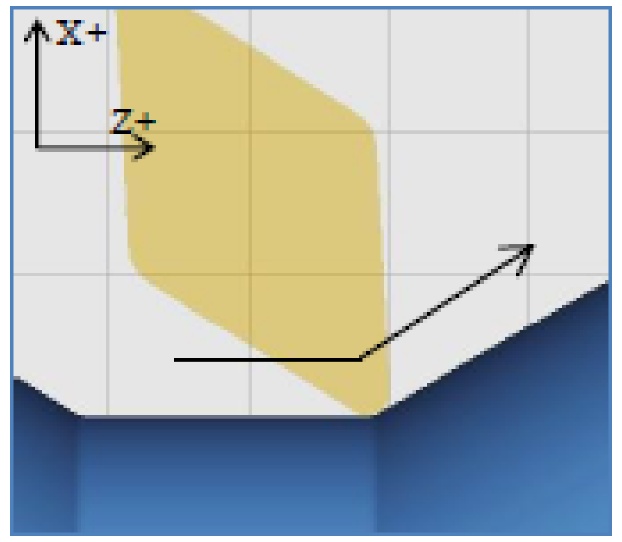


a) G41, quadrant 1

b) G42, quadrant 3

c) G42, quadrant 2

3)

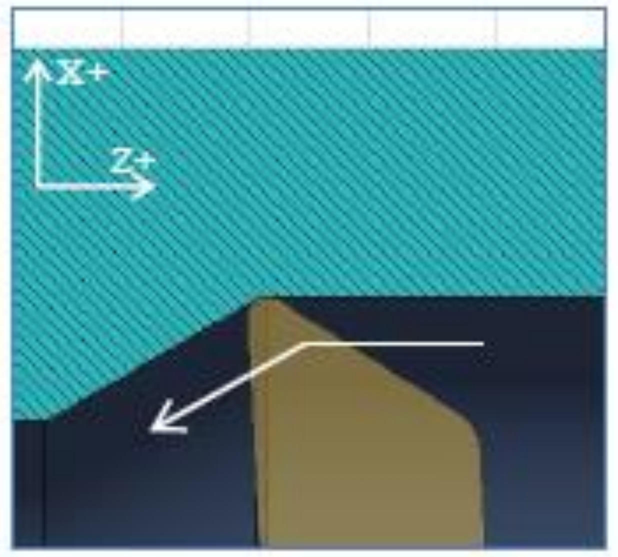


a) G42, quadrant 4

b) G42, quadrant 2

c) G41, quadrant 4

4)

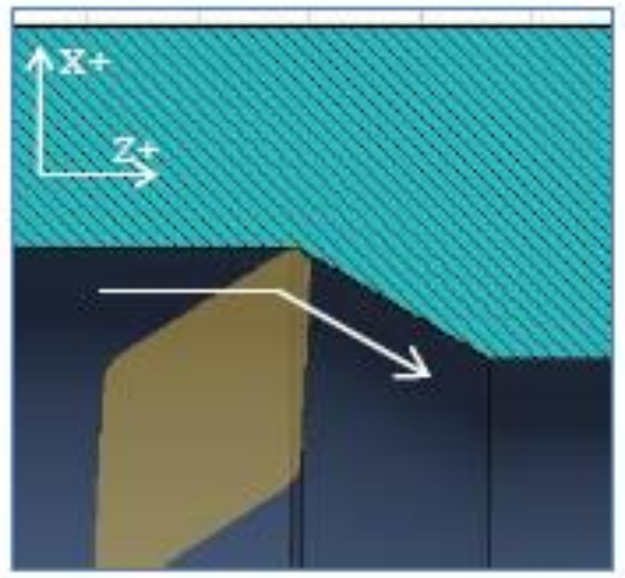


a) G41, quadrant 2

b) G42, quadrant 2

c) G41, quadrant 3

5)

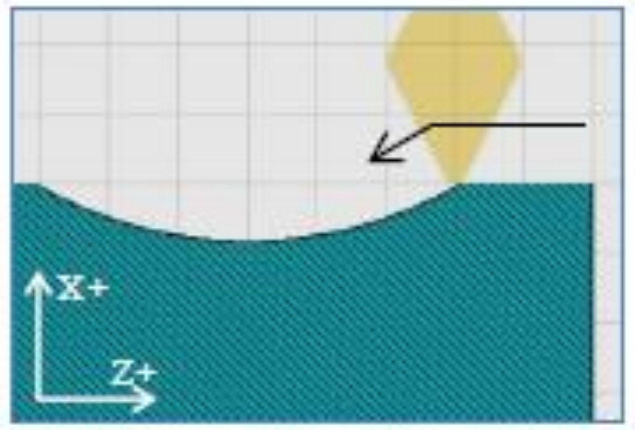


a) G42, quadrant 2

b) G41, quadrant 2

c) G42, quadrant 1

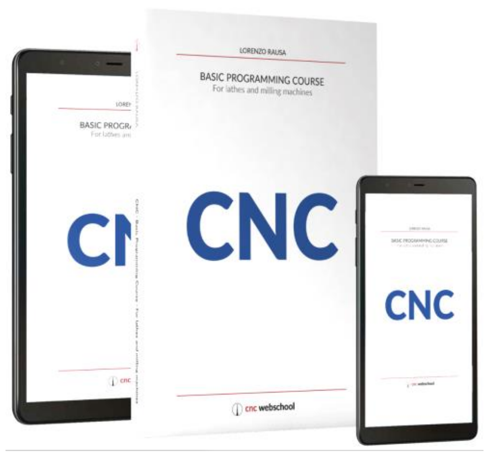
6)



a) G41, quadrant 6

b) G42, quadrant 3

c) G42, quadrant 8



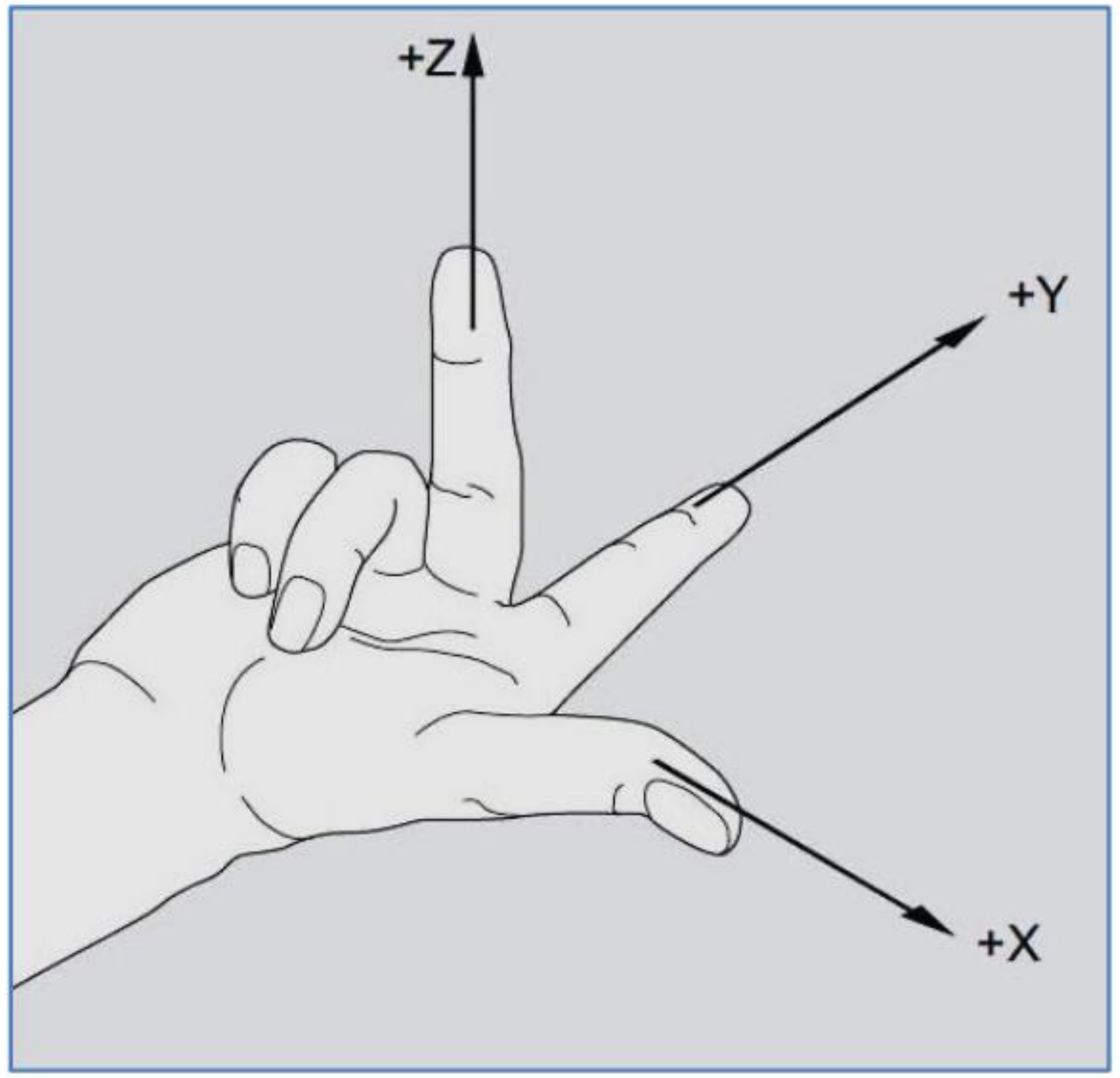


Fig. 126. The same right hand rule applies both to the lathe and to the mill.

Fig. 127. Positive direction of the axes: the arrows show the movements of the tool compared to the workpiece

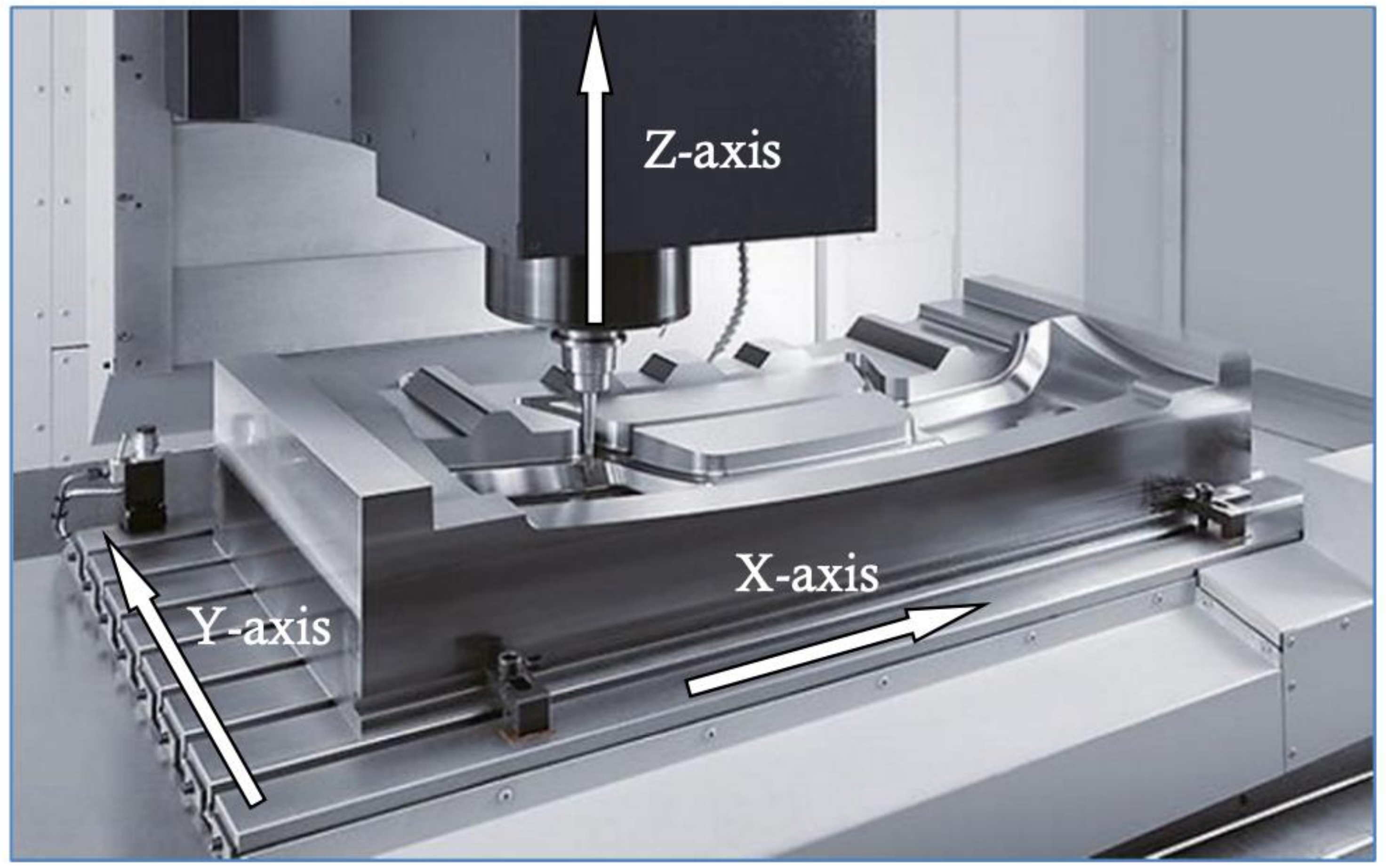


Fig. 128. Vertical mill

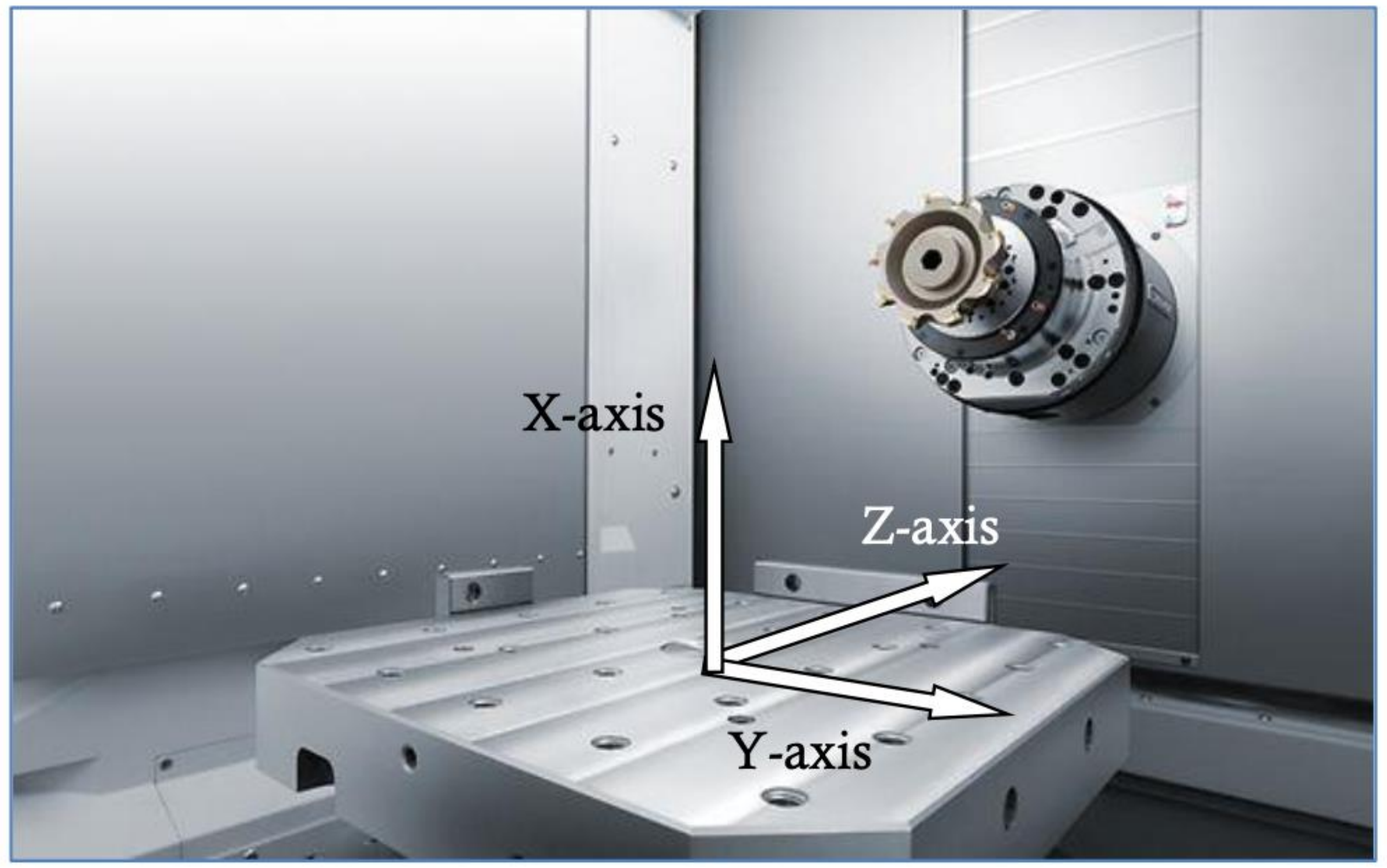
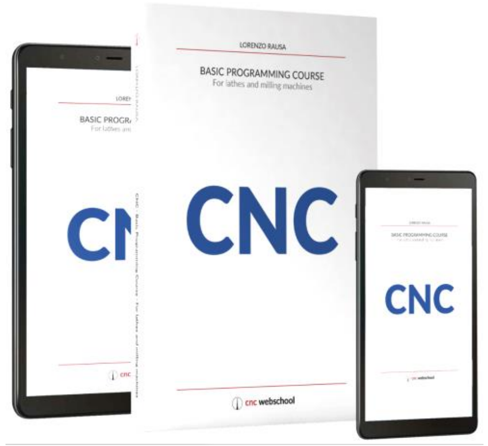


Fig. 129. Horizontal mill



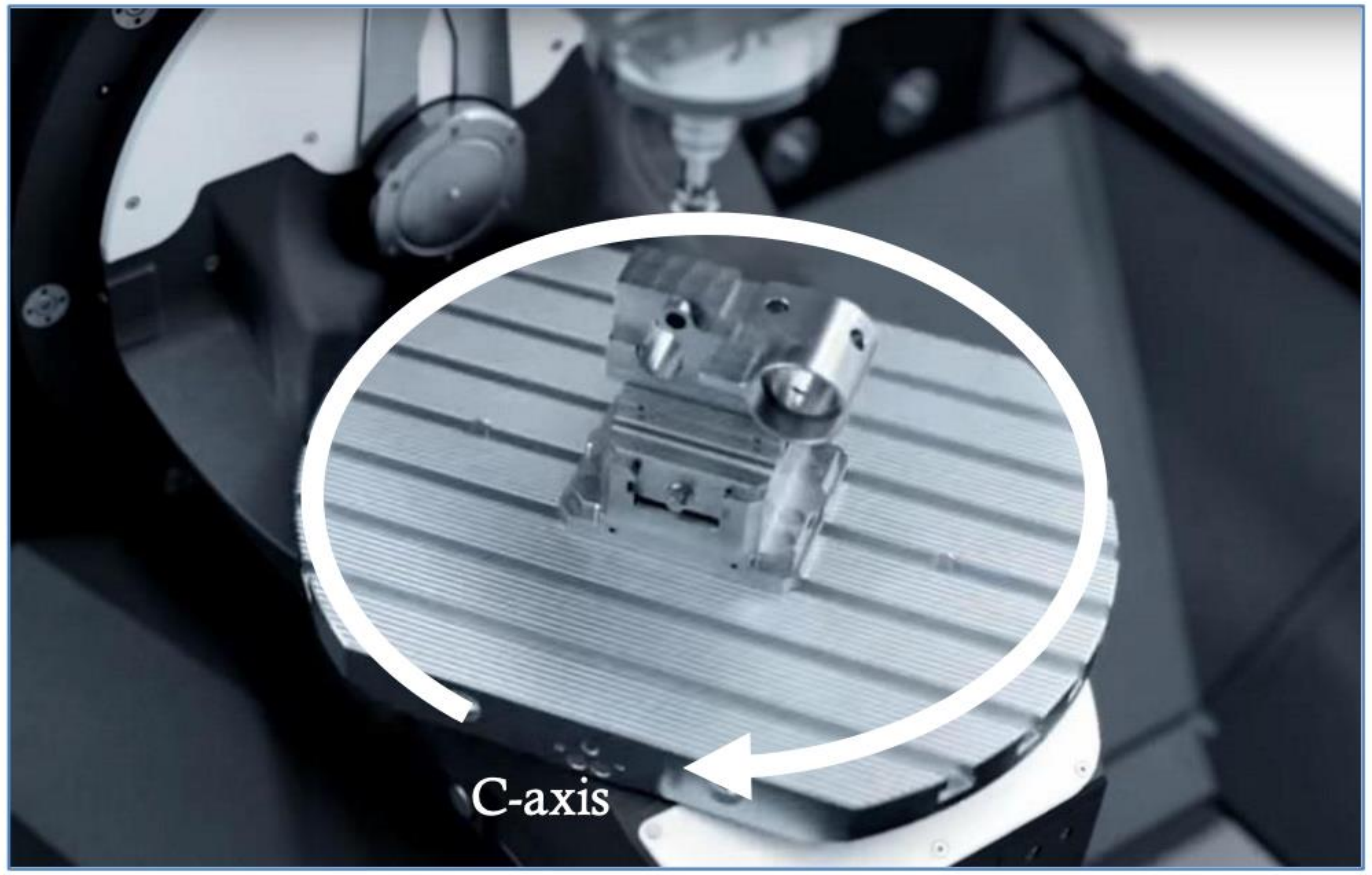


Fig. 130. C-axis in a machining center

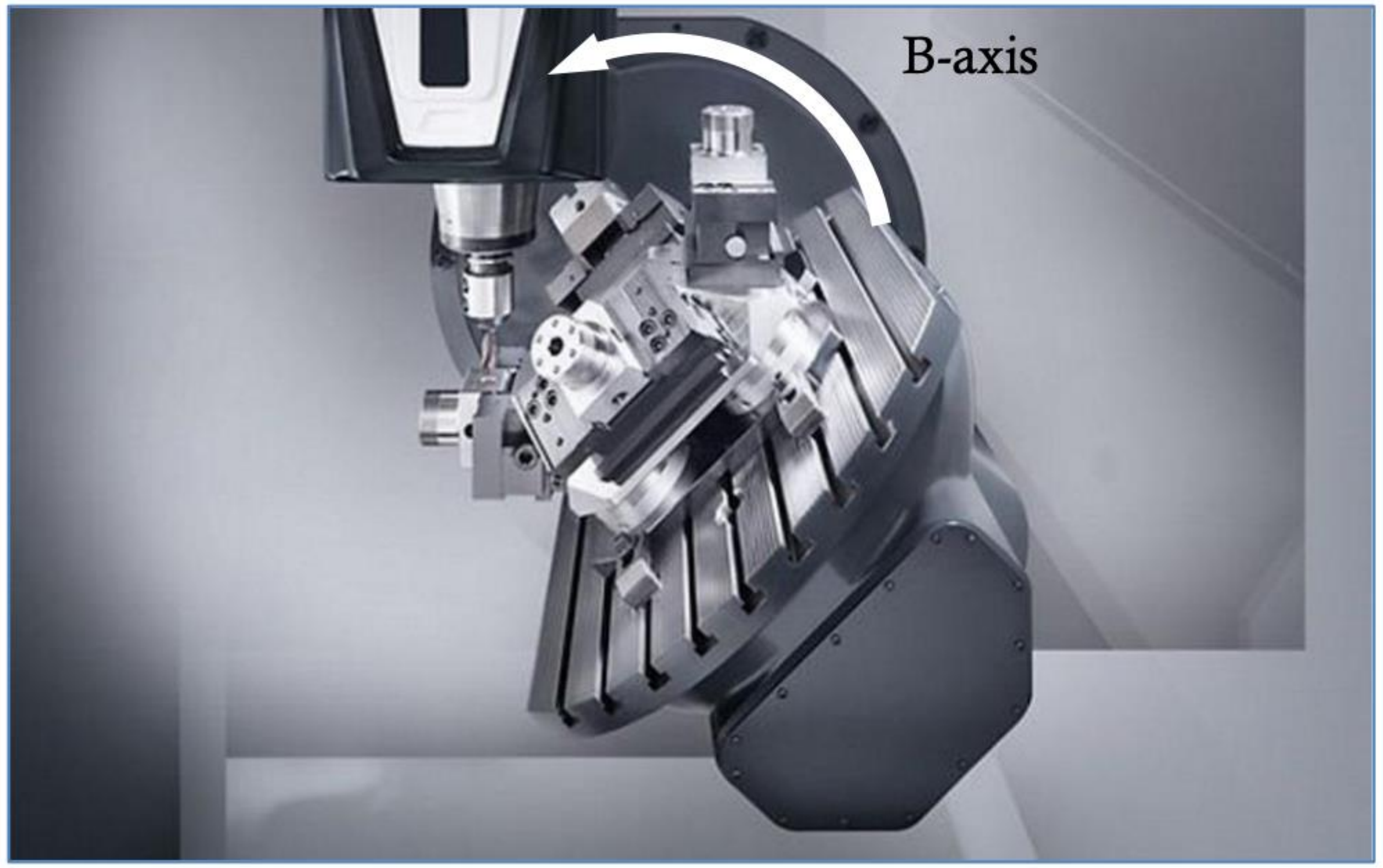


Fig. 131. B-axis in a machining center

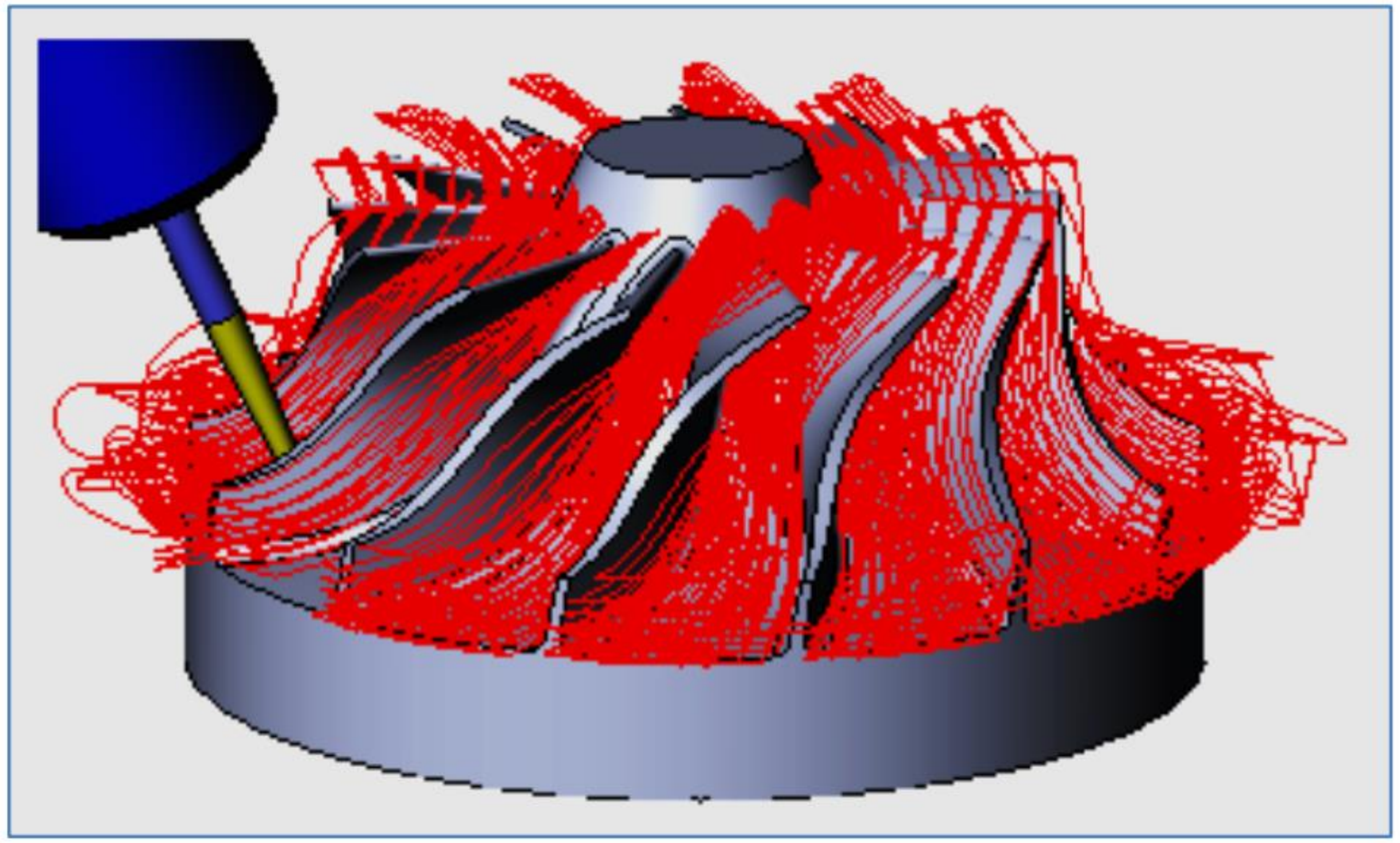


Fig. 132. CAM-generated profile for five-axis machining center

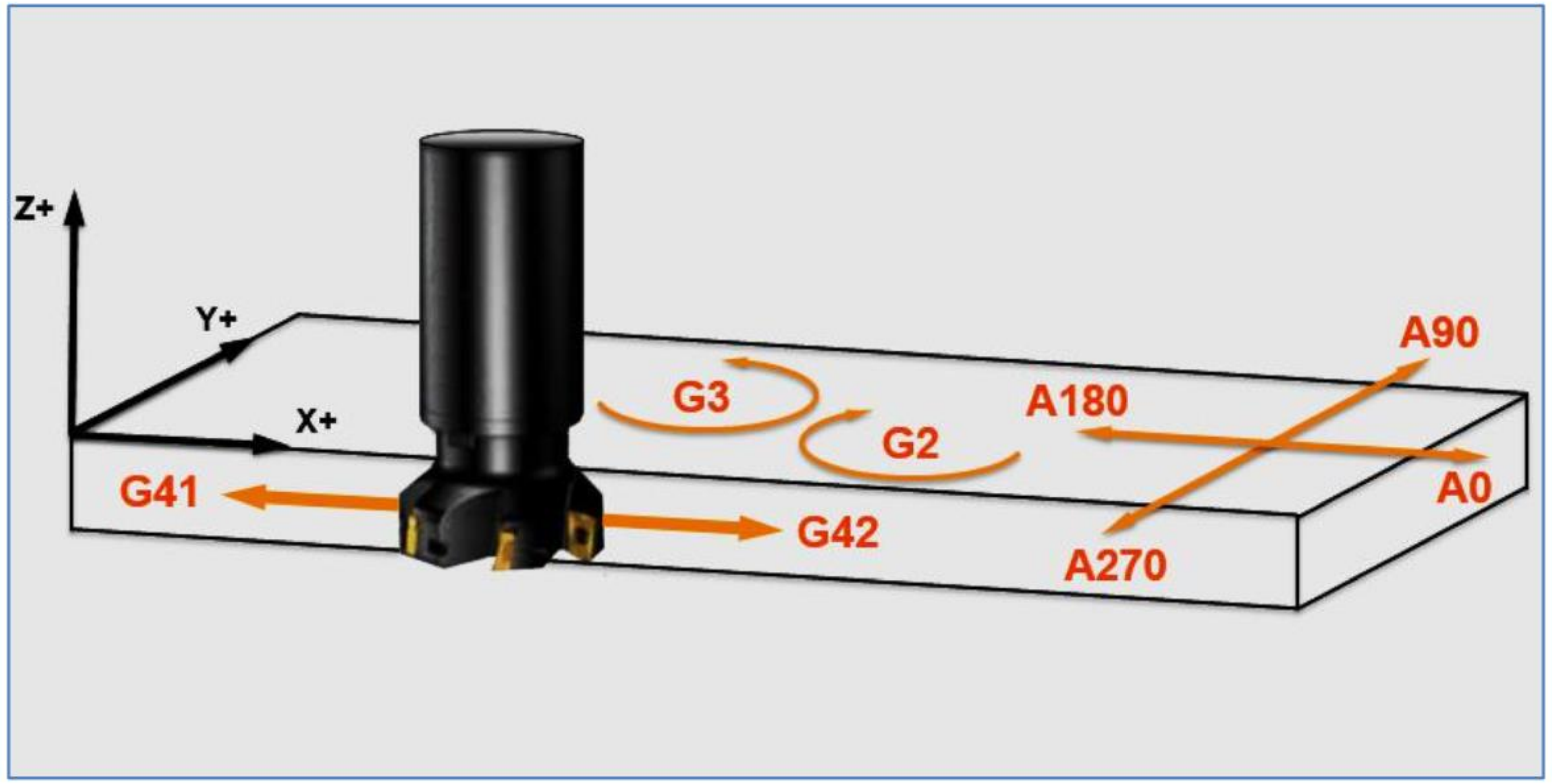


Fig. 133. Programming scheme on plane G17

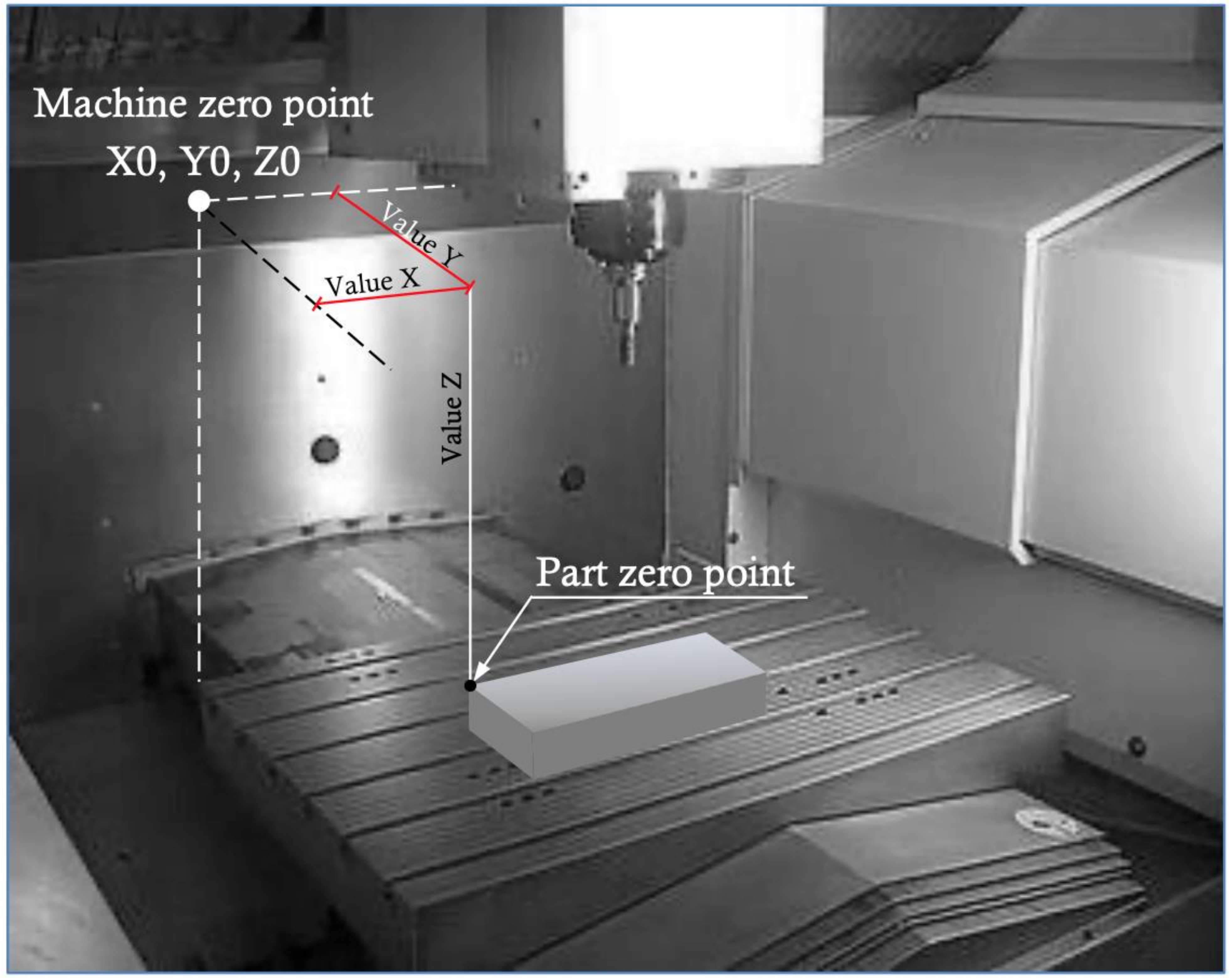


Fig. 134. Position of the machine zero point and values to enter into the zero offset function for the definition of the part zero point

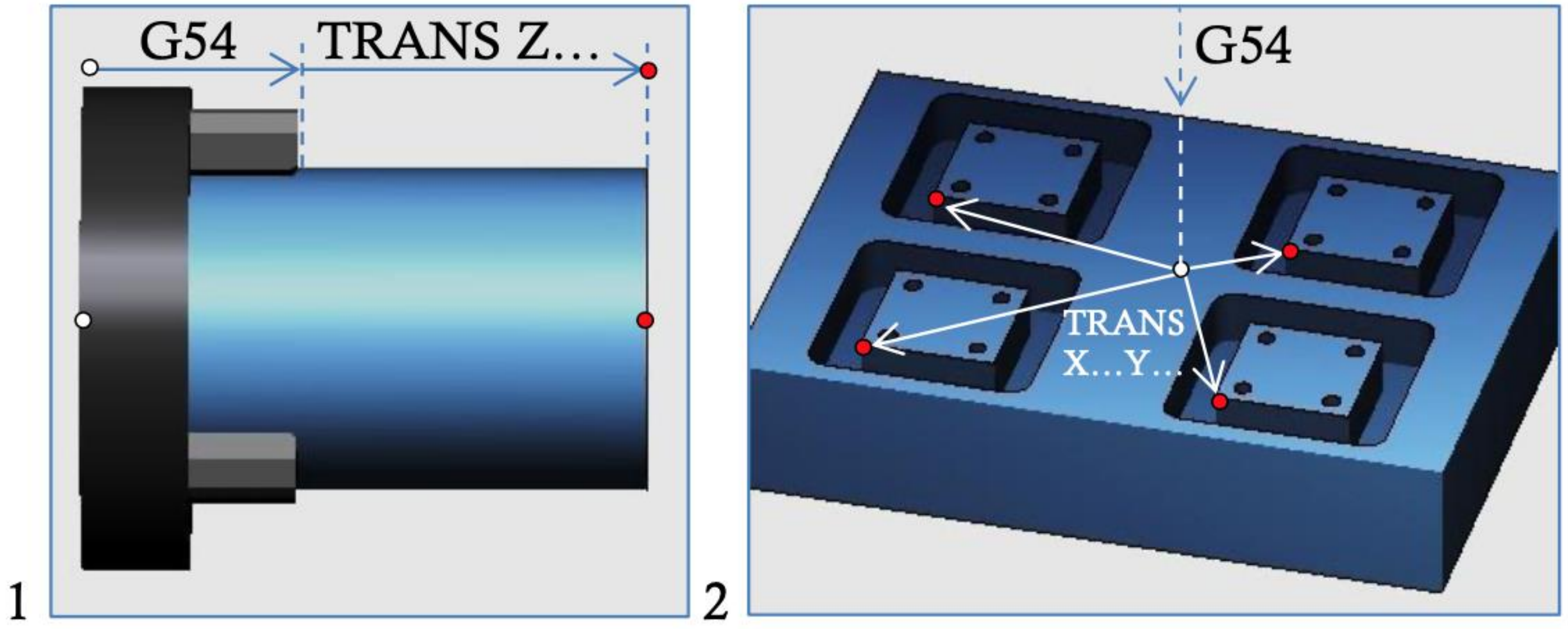
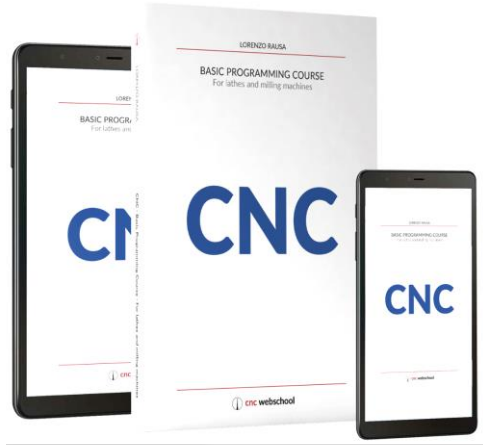
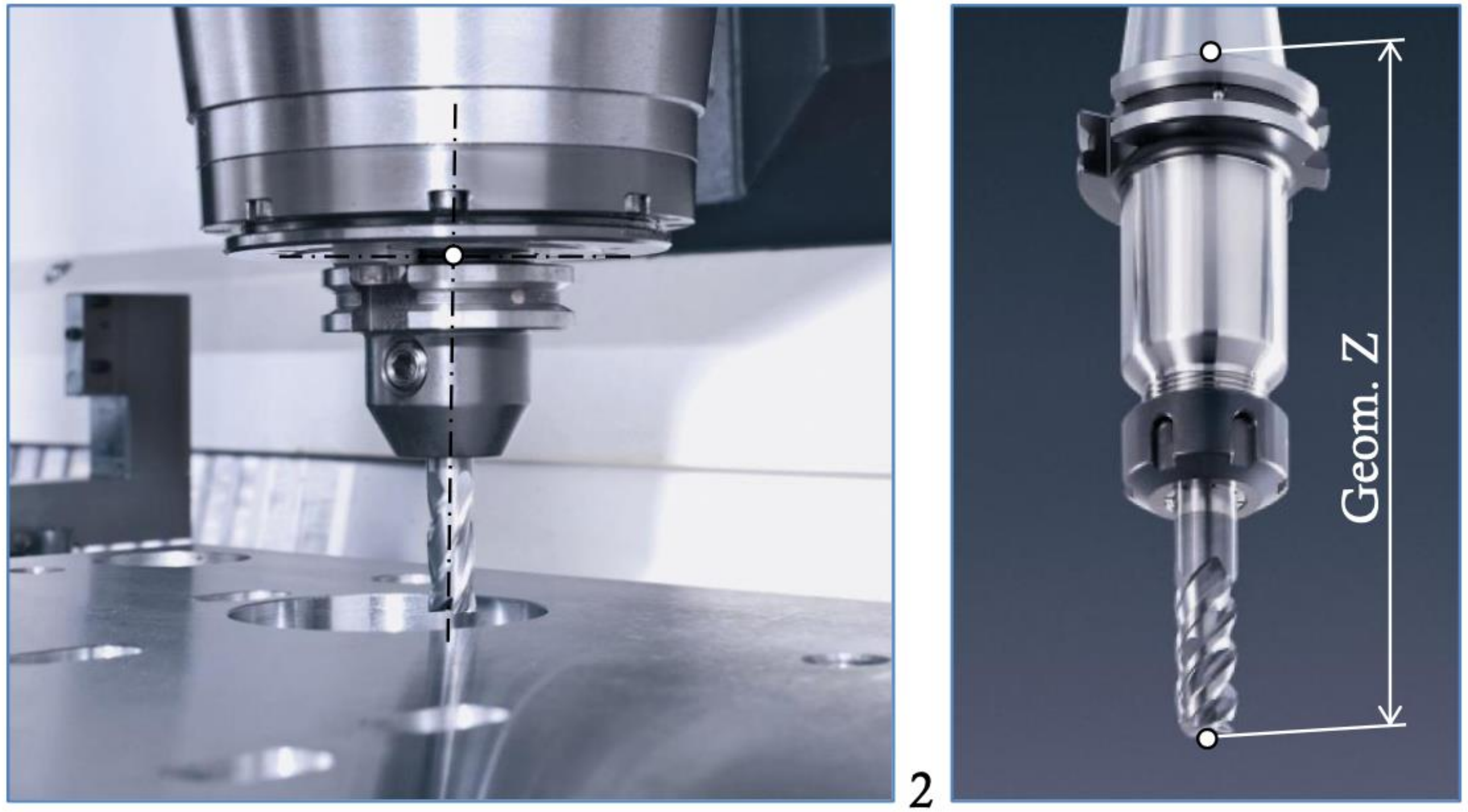


Fig. 135. Use of TRANS: 1: in a lathe; 2: in a machining center





1 2

Fig. 136. 1:Point moved by the NC; 2:Offset value of a mill on the Z-axis

Fig. 137. Measuring system outside the machine

Fig. 138. Start-up of the mill in the training software

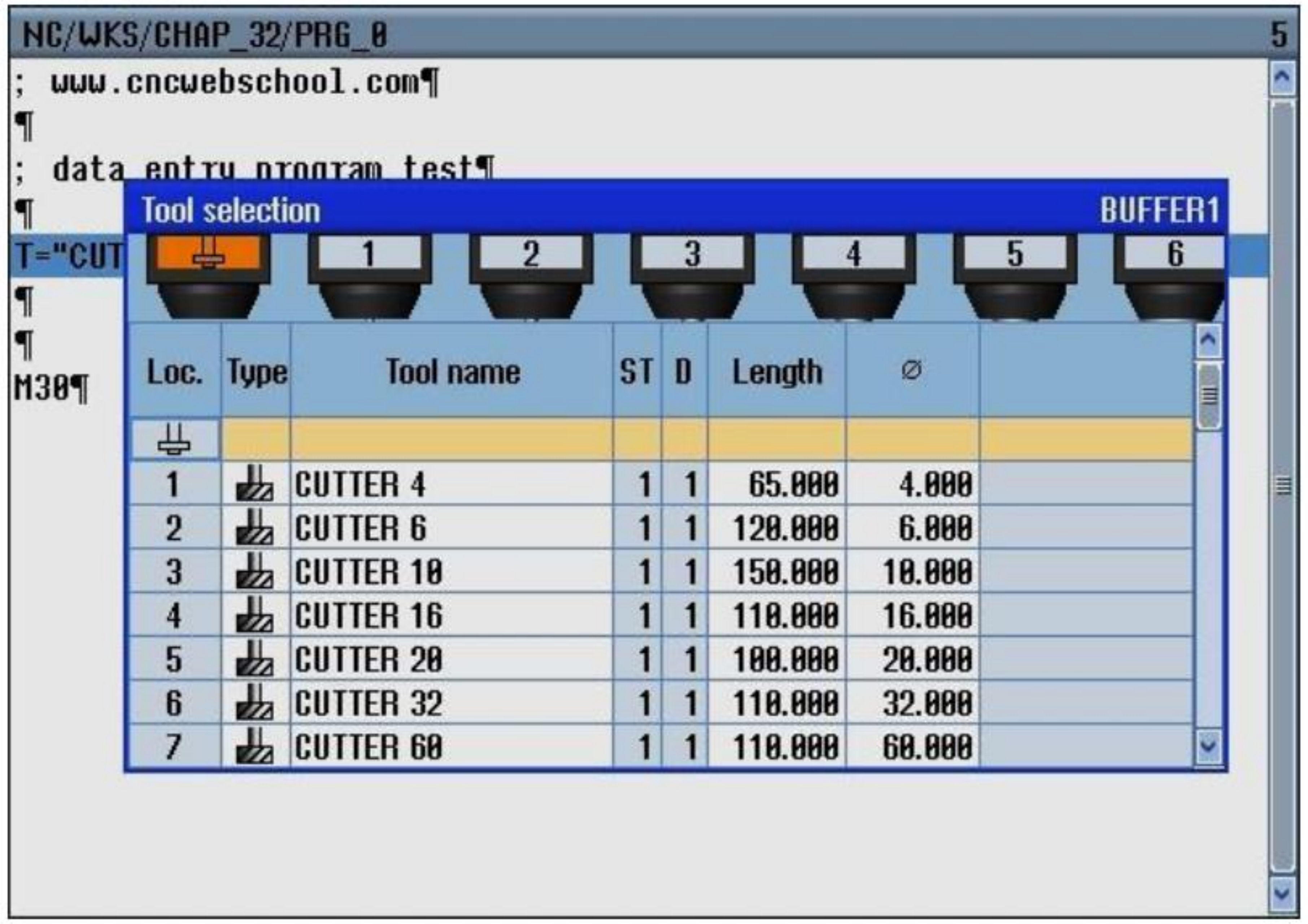


Fig. 139. Page for the selection of the tools directly from the magazine

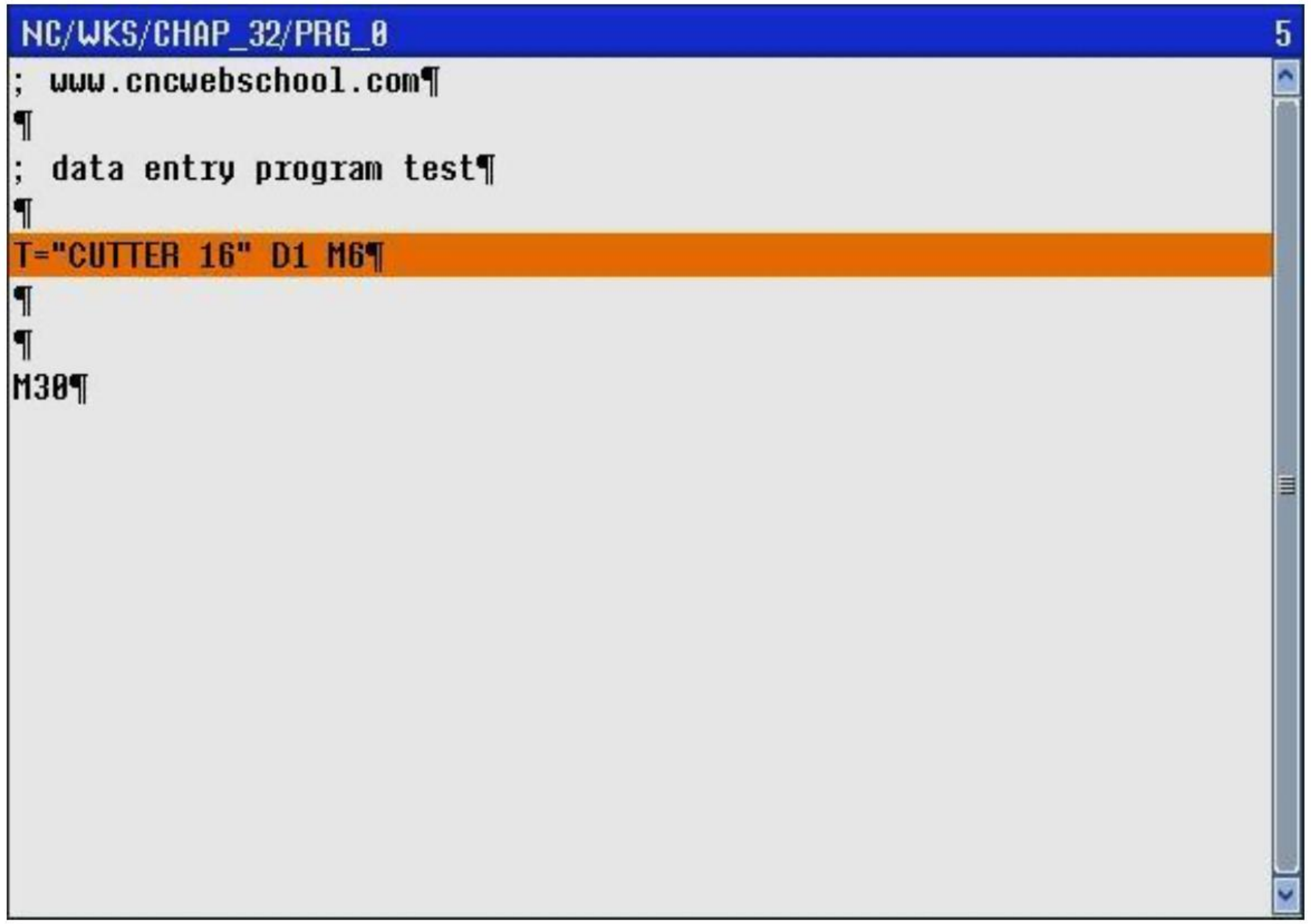
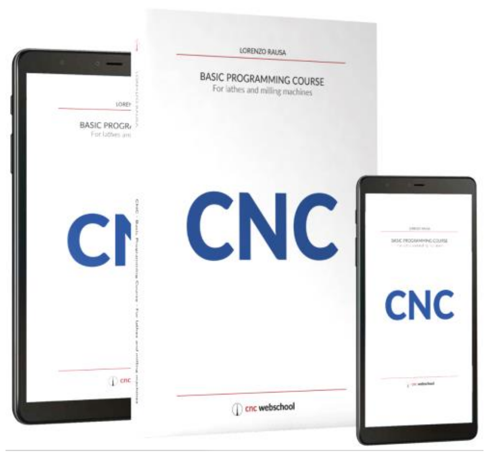


Fig. 140. Completion of the direct tool call instruction in the program



Blank part:	Cylinder
XA:	Cylinder diameter.
ZA:	Position of the upper face of the workpiece referring to the part zero point.
ZI - **absolute**: - **incremental**:	Distance from the lower face of the workpiece: **referring to the part zero point.** **referring to the upper face.**

Fig. 141. Description of the blank part dimensions: CYLINDER

Blank part:	Pipe
XA:	External diameter of the pipe.
XI:	Internal diameter of the pipe.

Fig. 142. Description of the blank part dimensions: PIPE

Blank part:	Block Centered
W:	Side of the rectangle positioned along the Y-axis.
L:	Side of the rectangle positioned along the X-axis.

Fig. 143. Description of the blank part dimensions: BLOCK CENTERED

Blank part:	Block
X0:	Coordinate X of the edge referring to the part zero point.
Y0:	Coordinate Y of the edge referring to the part zero point.
X1:	Coordinate X of the opposite edge referring to the part zero point (abs.) or to the first edge (incr.).
Y1:	Coordinate Y of the opposite edge referring to the part zero point (abs.) or to the first edge (incr.).

Fig. 144. Description of the workpiece dimensions: BLOCK

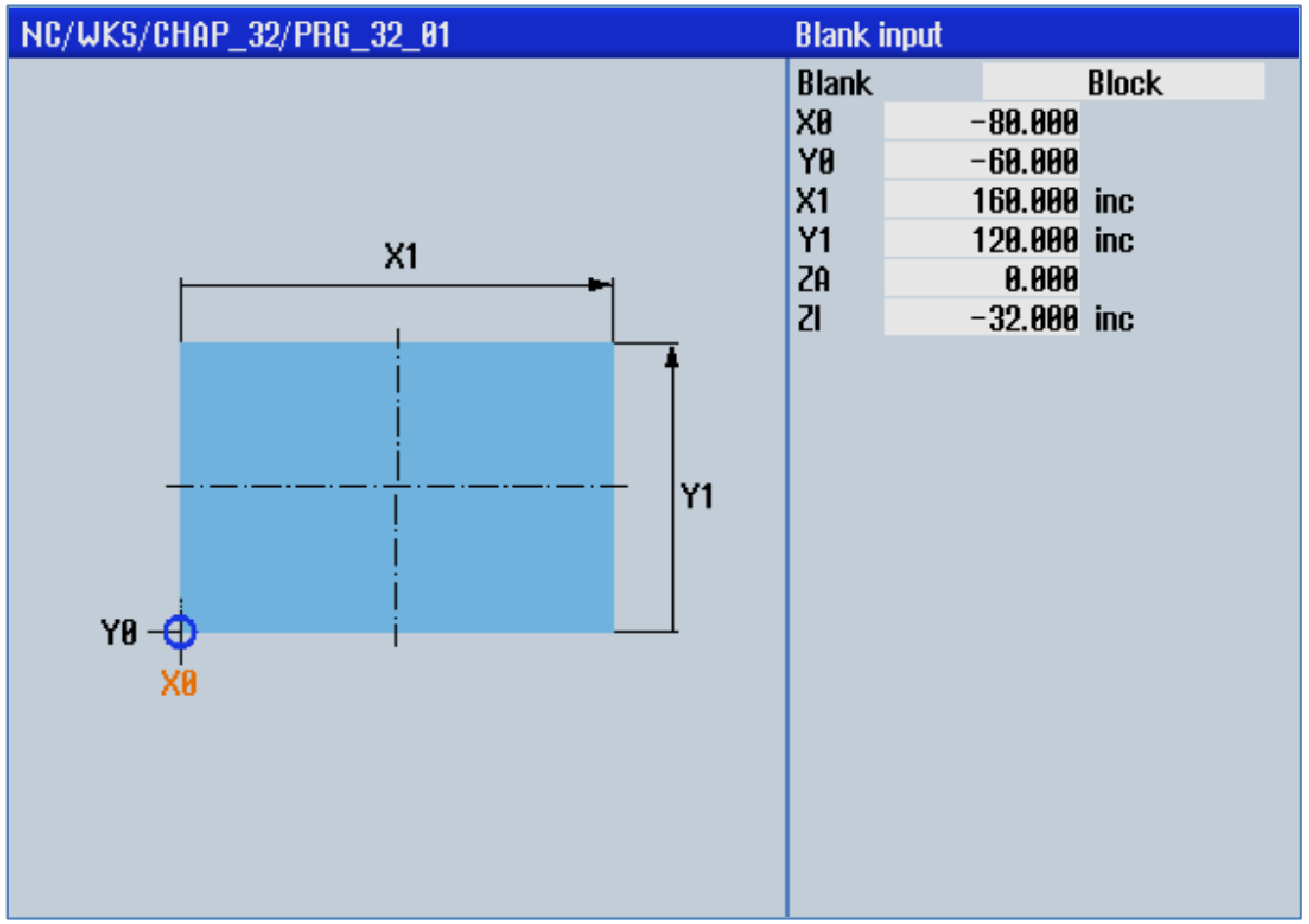
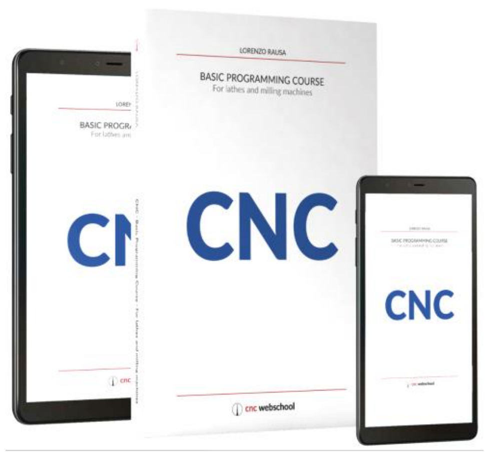


Fig. 145. Description of the blank part dimensions: BLOCK

Blank part:	N Corner
N:	Number of edges of the polygon.
SW:	Dimension of the polygon's key (available only for polygons with even number of edges).

Fig. 146. Description of the workpiece dimensions: N CORNER



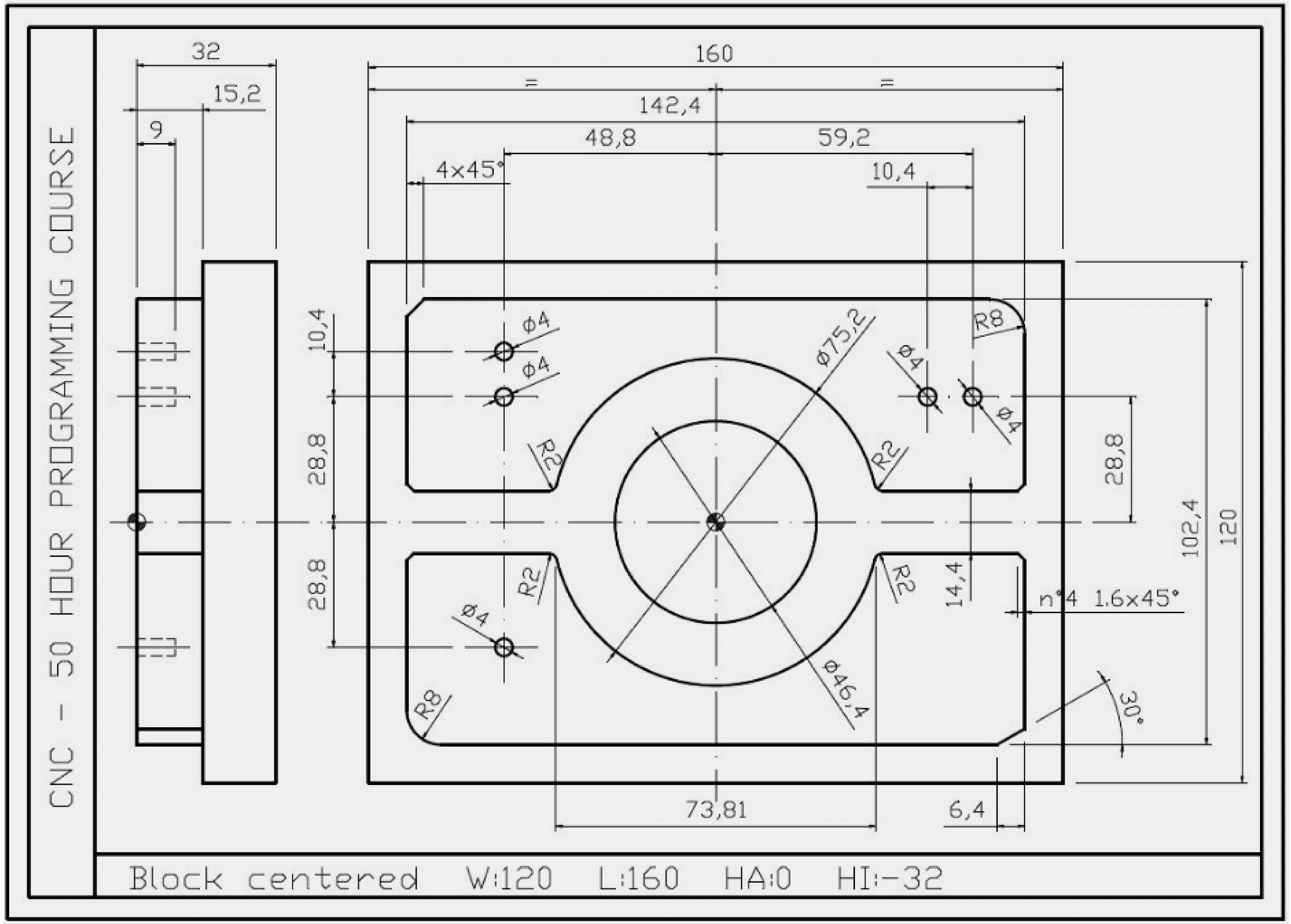
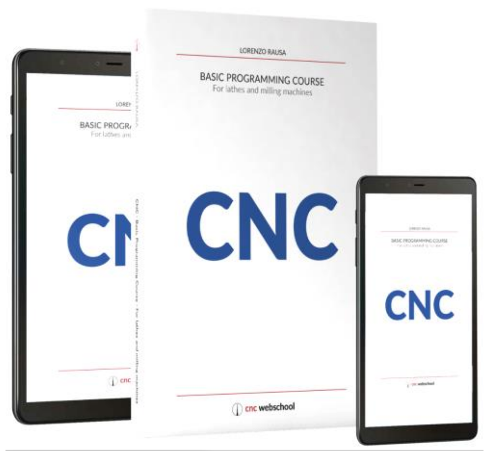


Fig. 147. Drawing of the part to be created



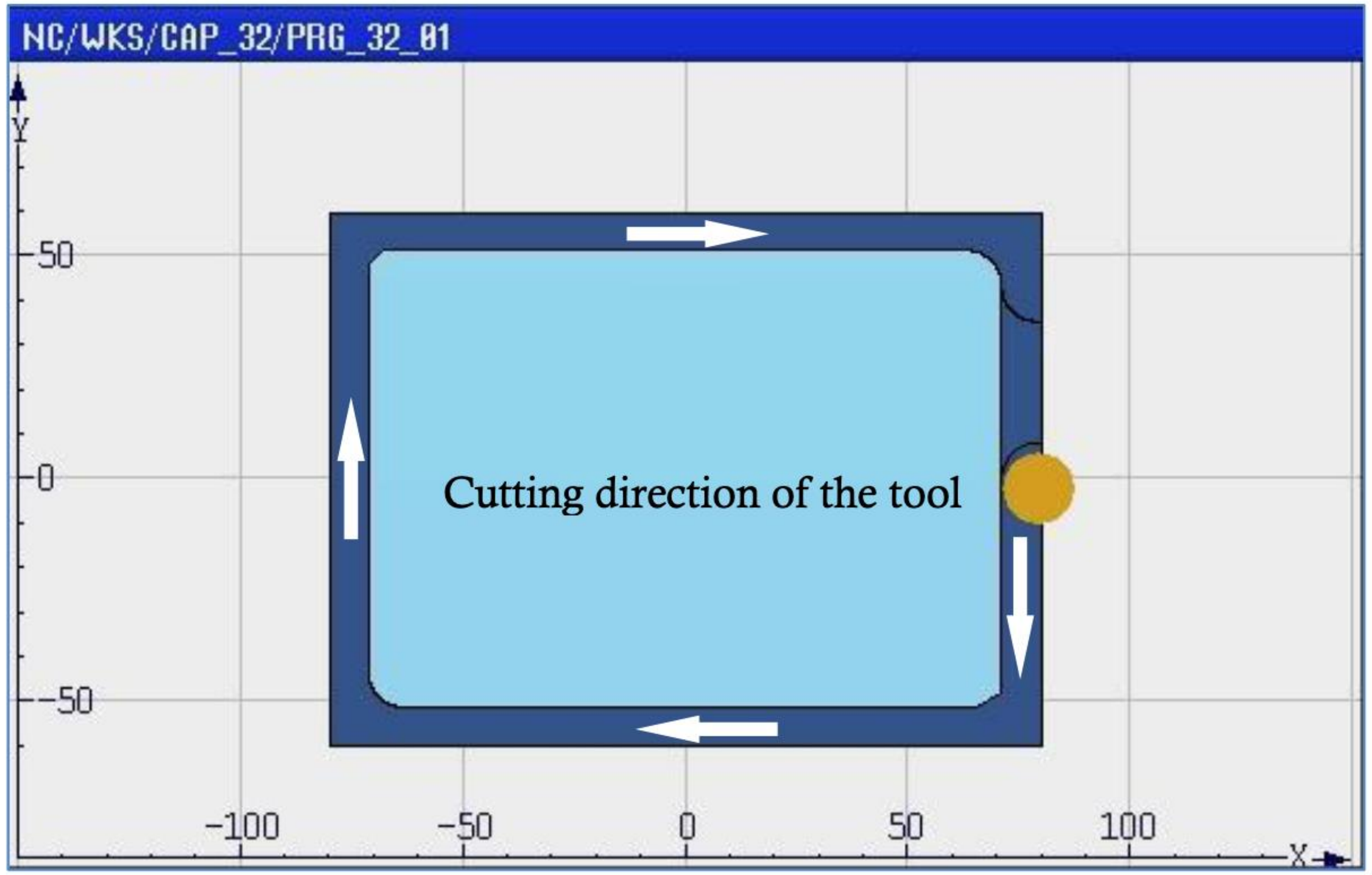


Fig. 148. Creation of the external profile

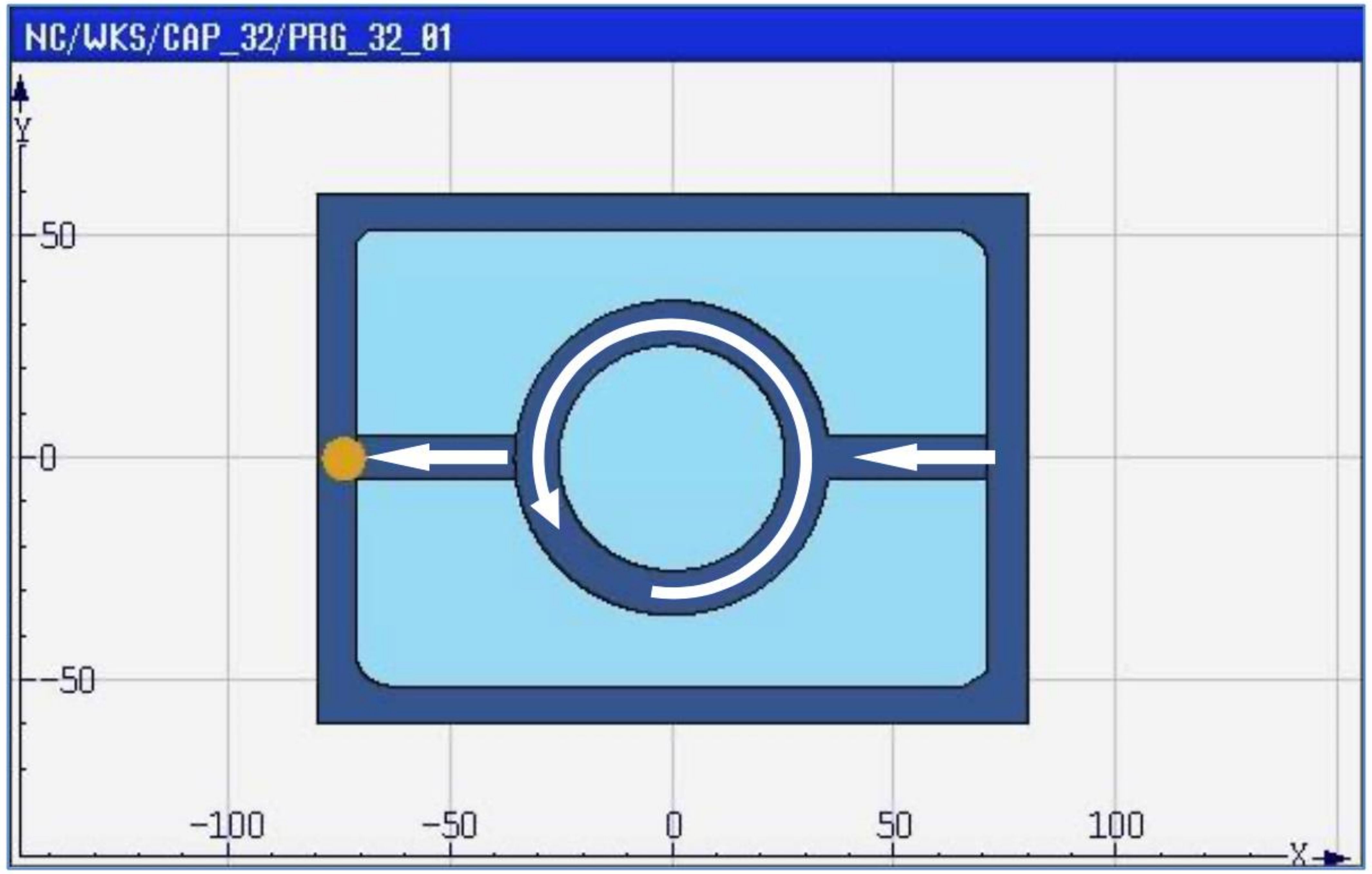


Fig. 149. Roughing of the internal profile

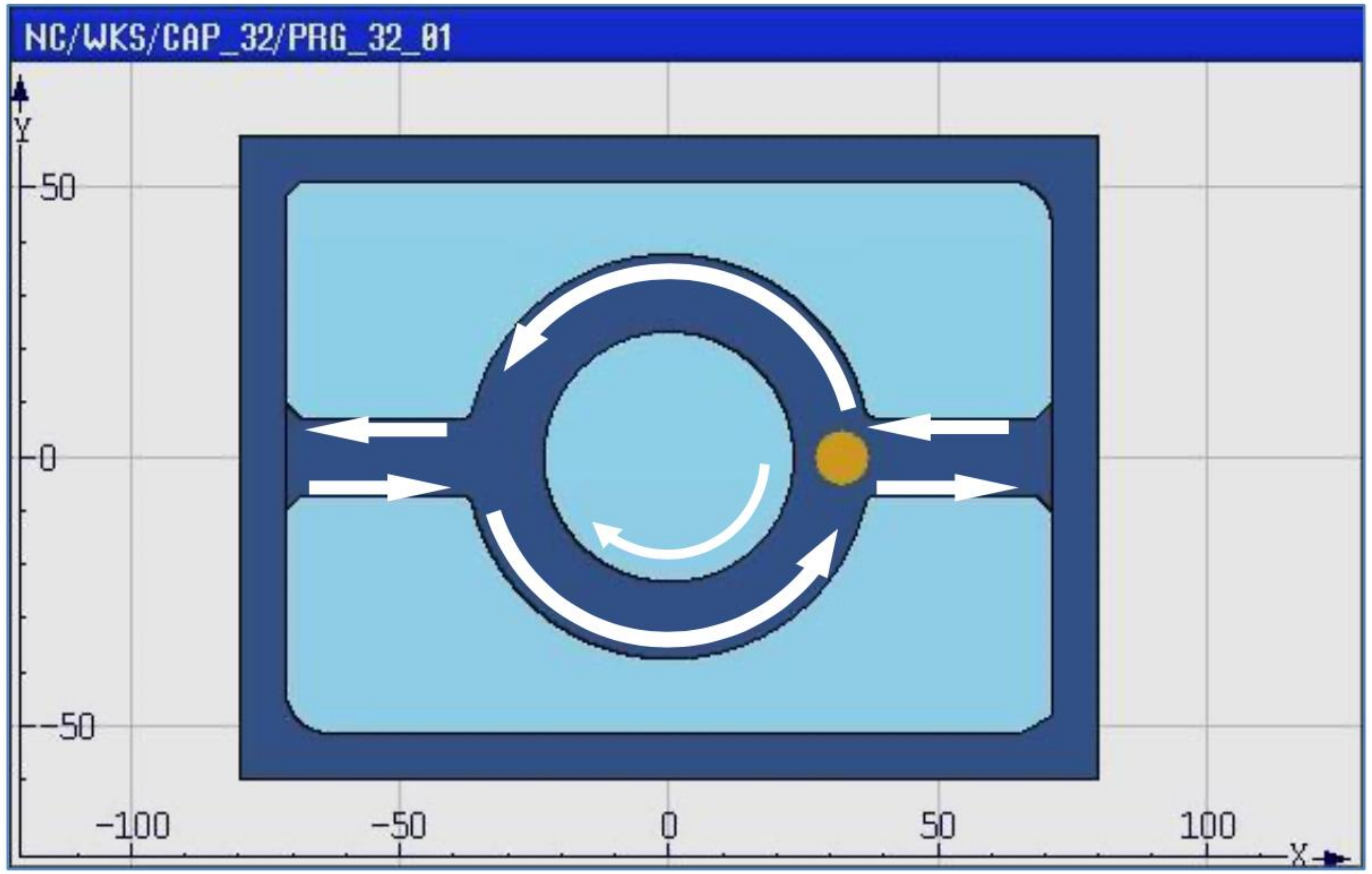


Fig. 150. Finishing of the internal profile

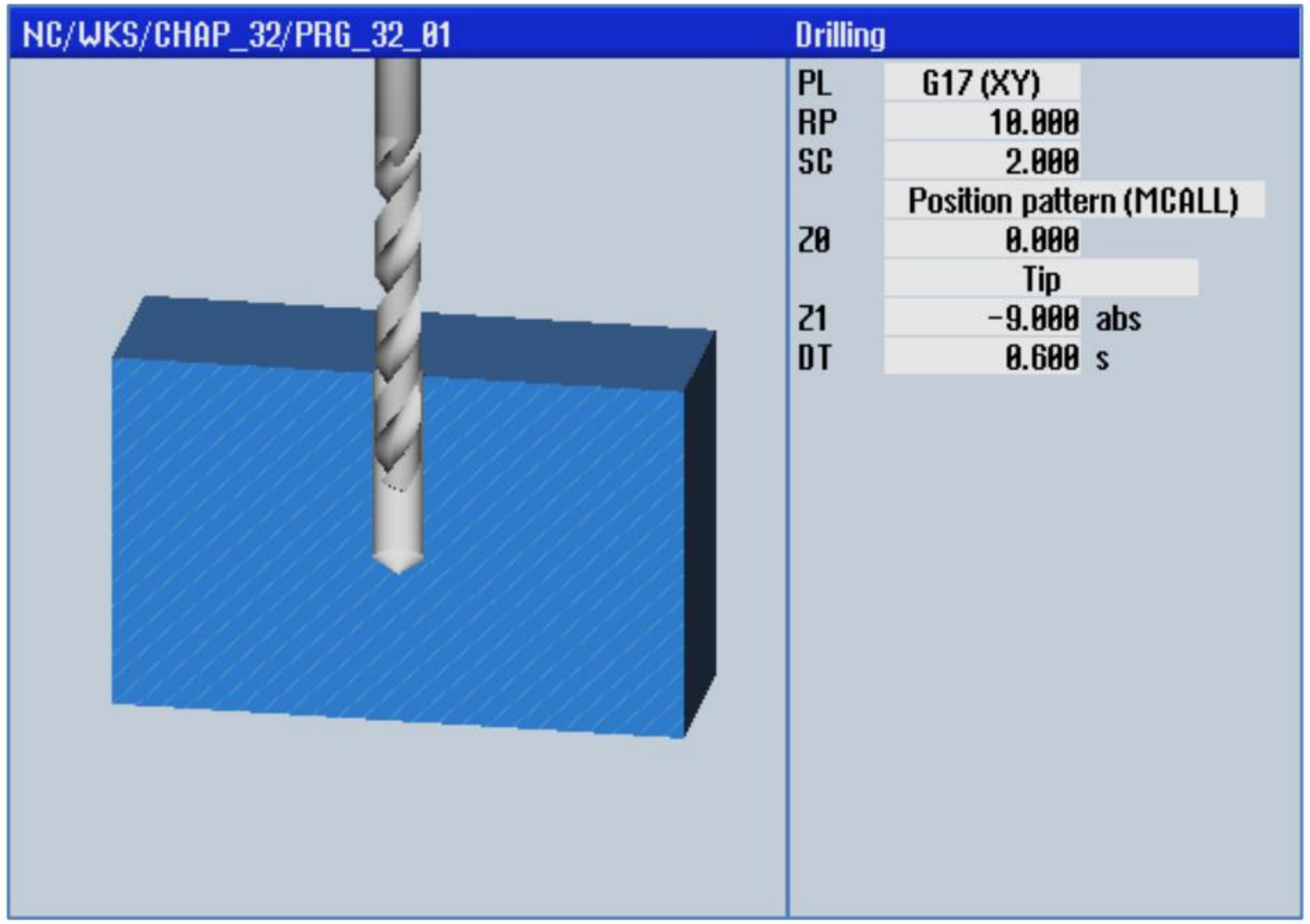
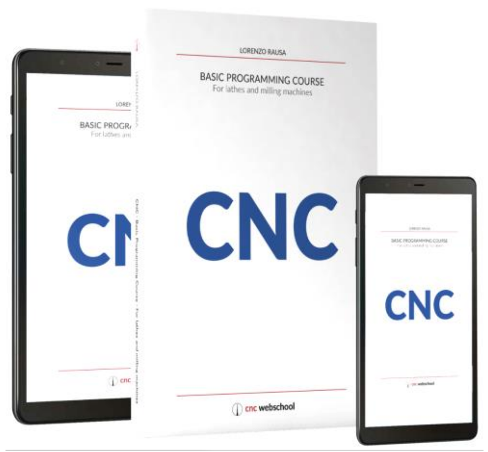


Fig. 151. Data entered in drilling cycle



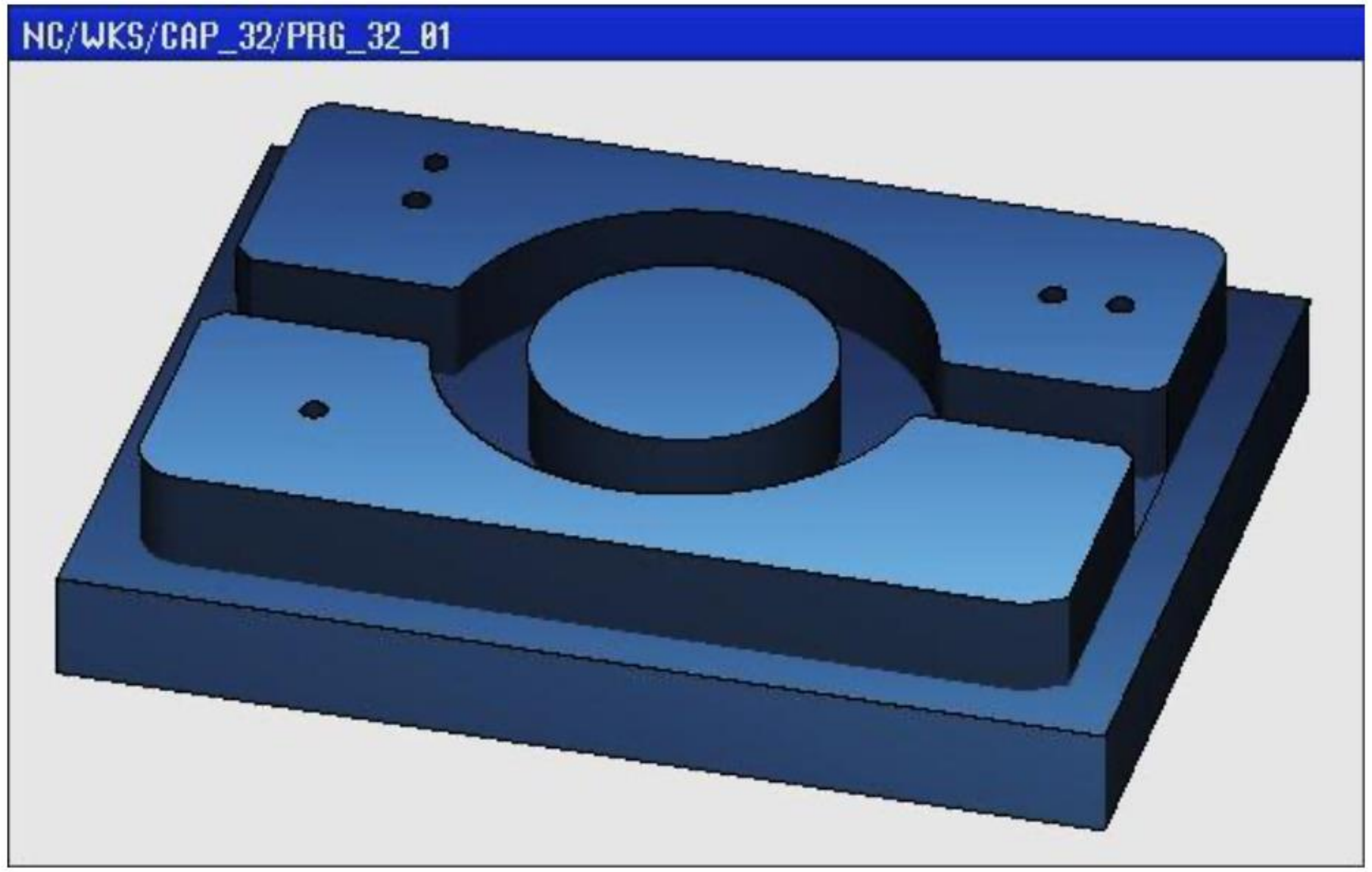


Fig. 152. Graphic 3D image of the finished part

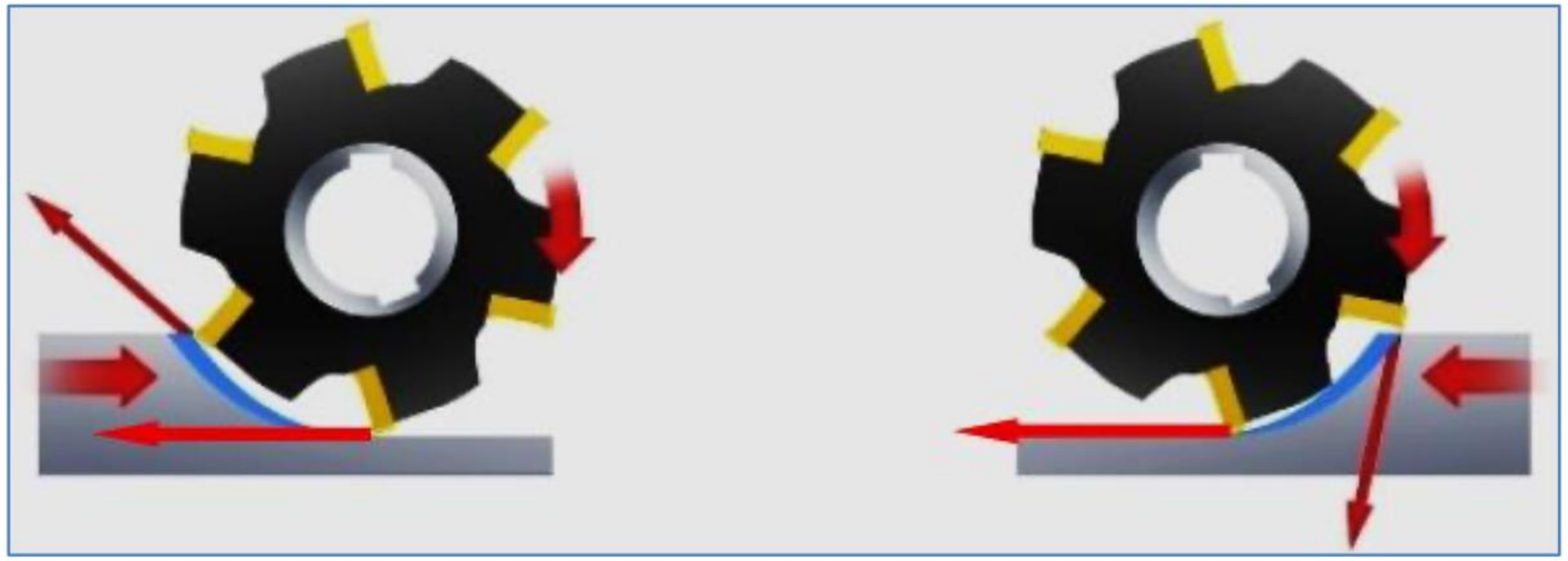


Fig. 153. Discordant cutting direction (left) and concordant cutting direction (right)

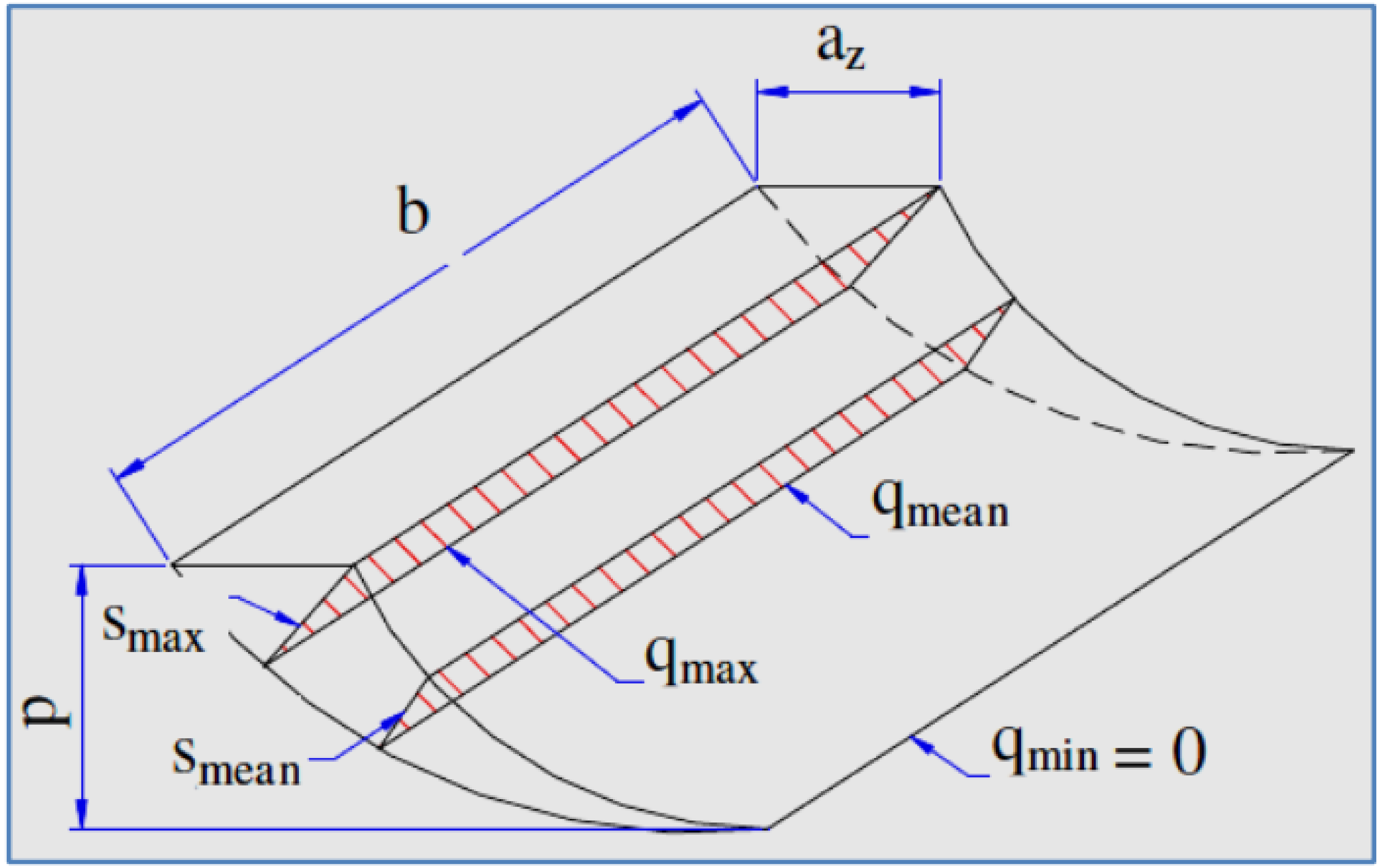


Fig. 154. Chip section area

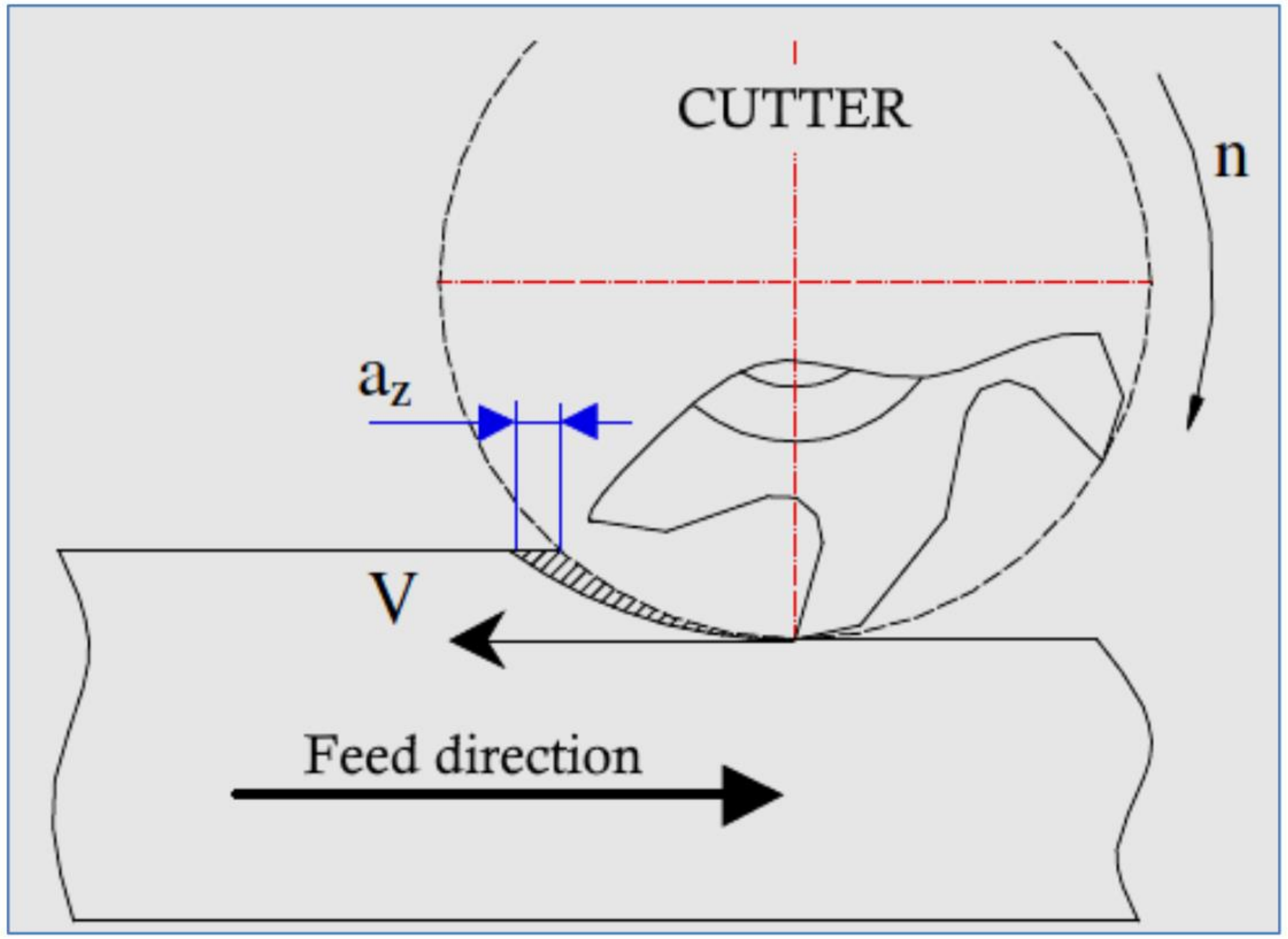


Fig. 155. Relative movement between cutter and workpiece with discordant feed direction

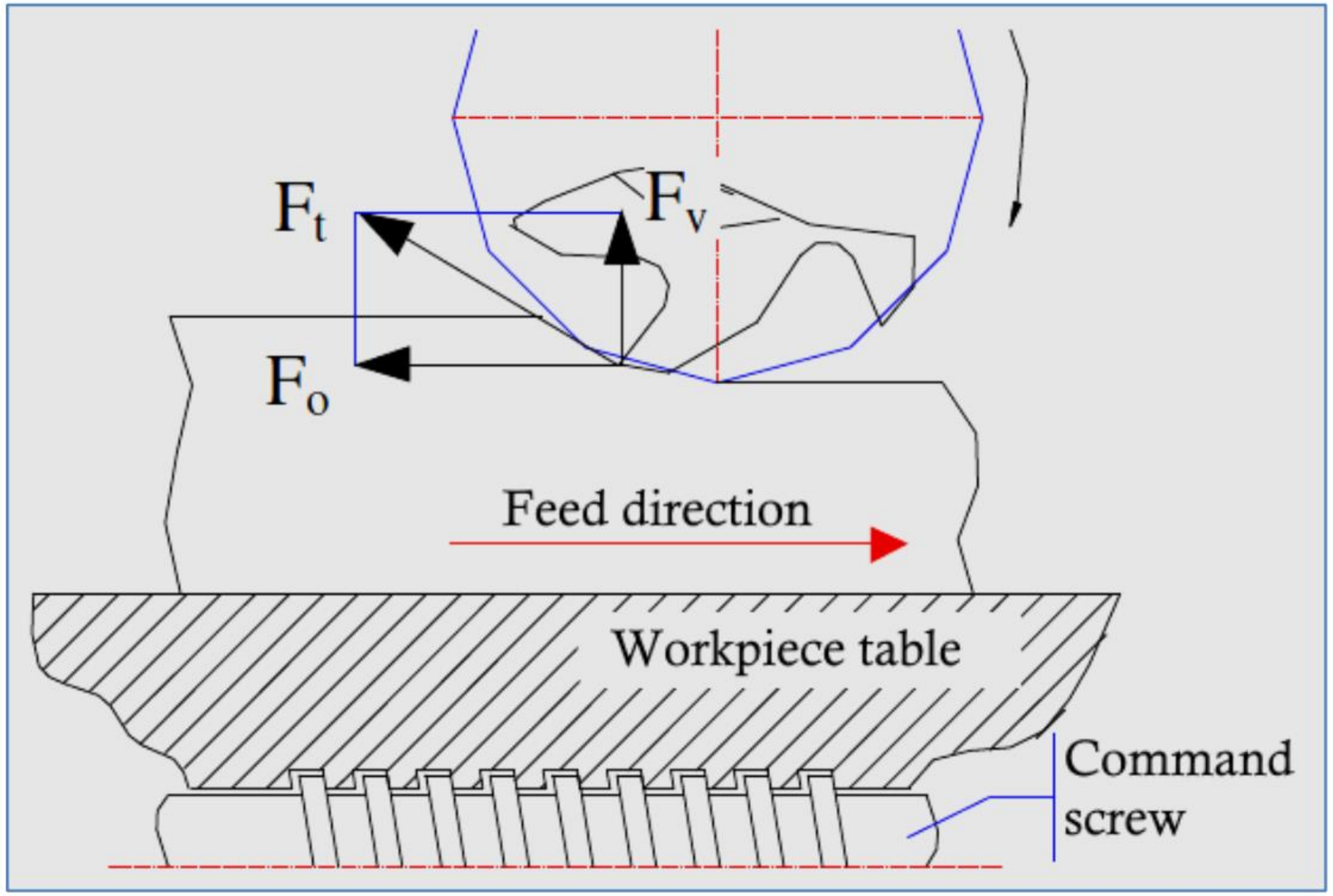


Fig. 156. Cutting forces with discordant feed direction

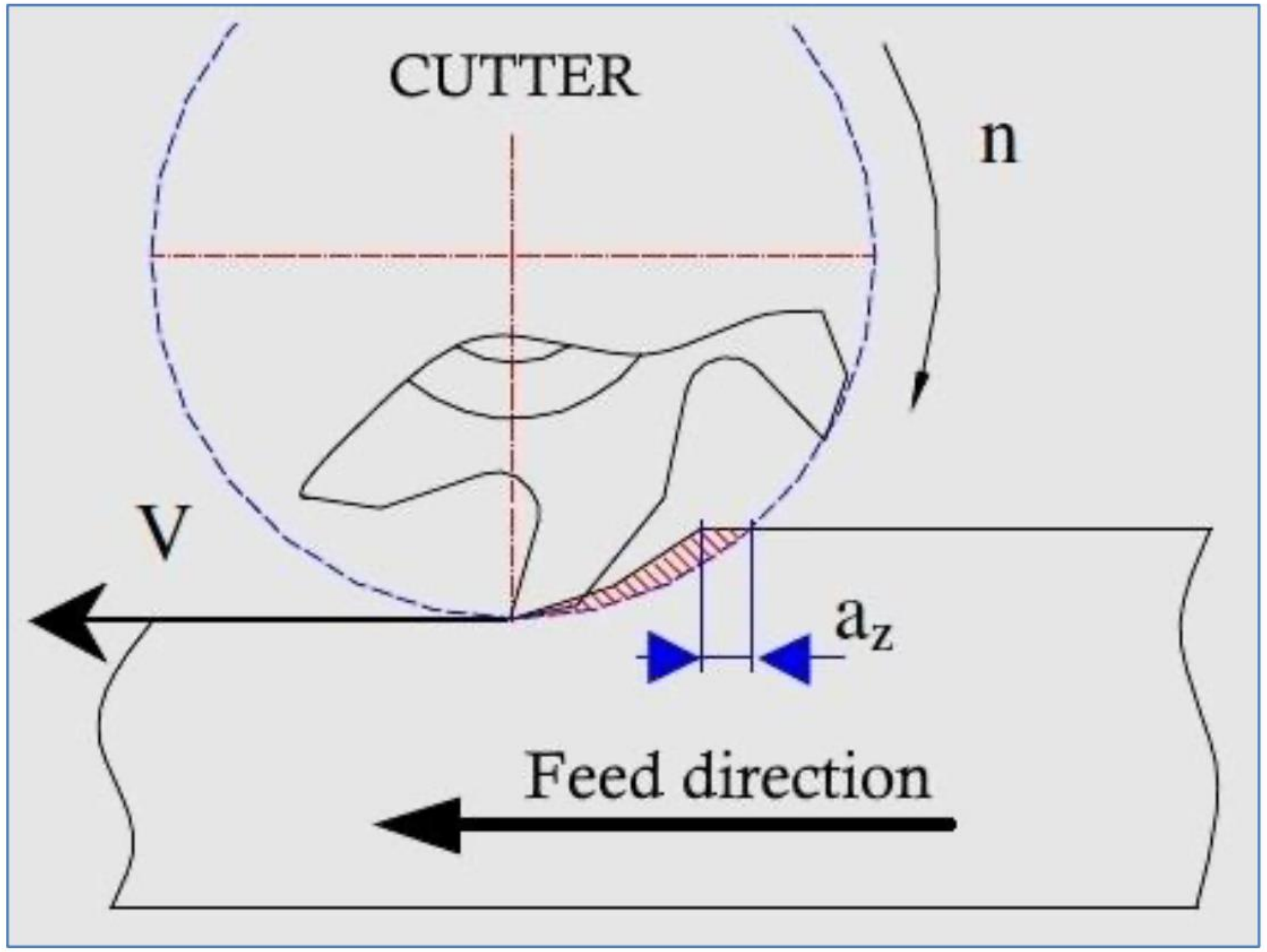


Fig. 157. Relative movement between cutter and workpiece with concordant feed direction

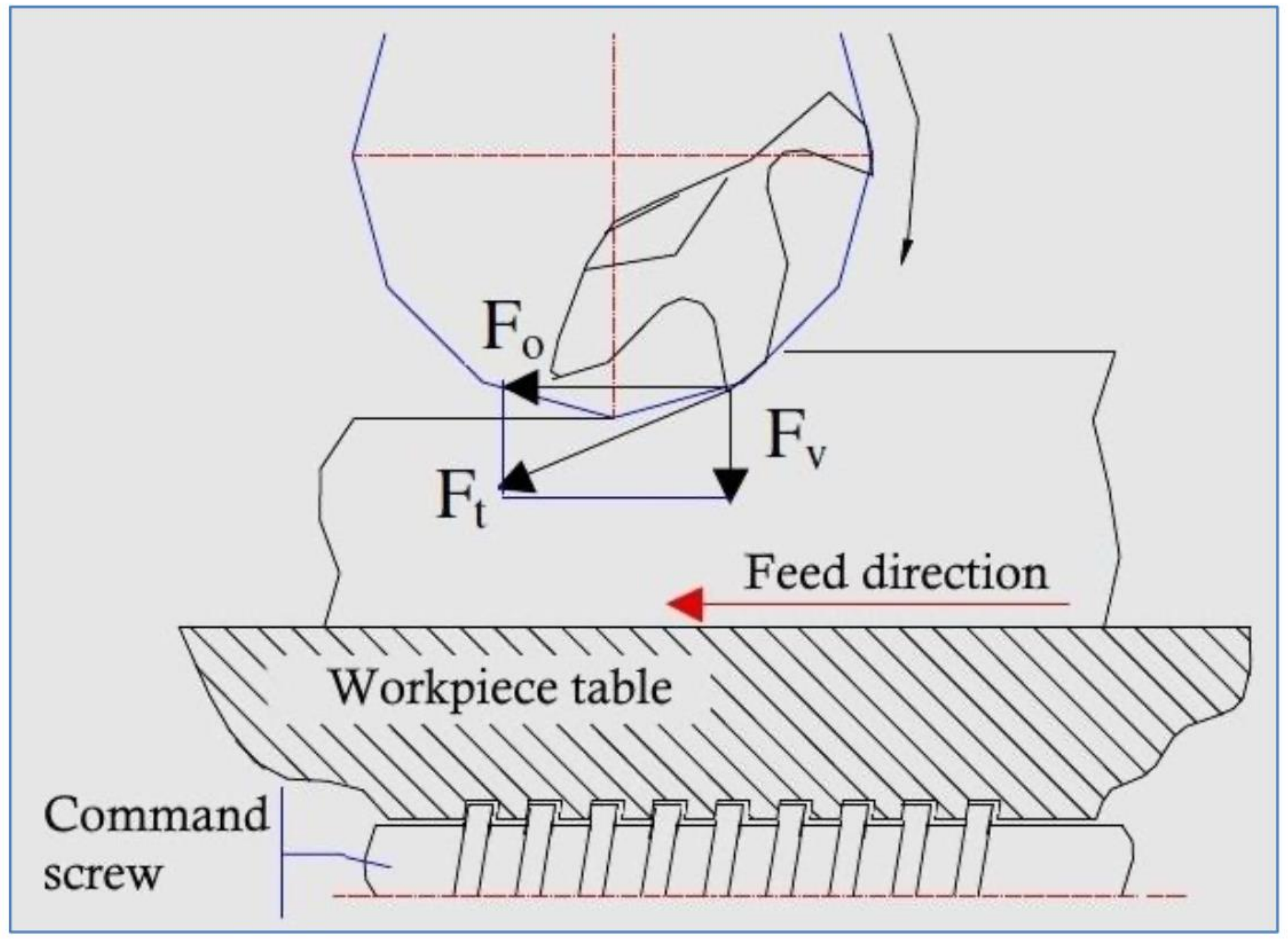


Fig. 158. Cutting forces with concordant feed direction

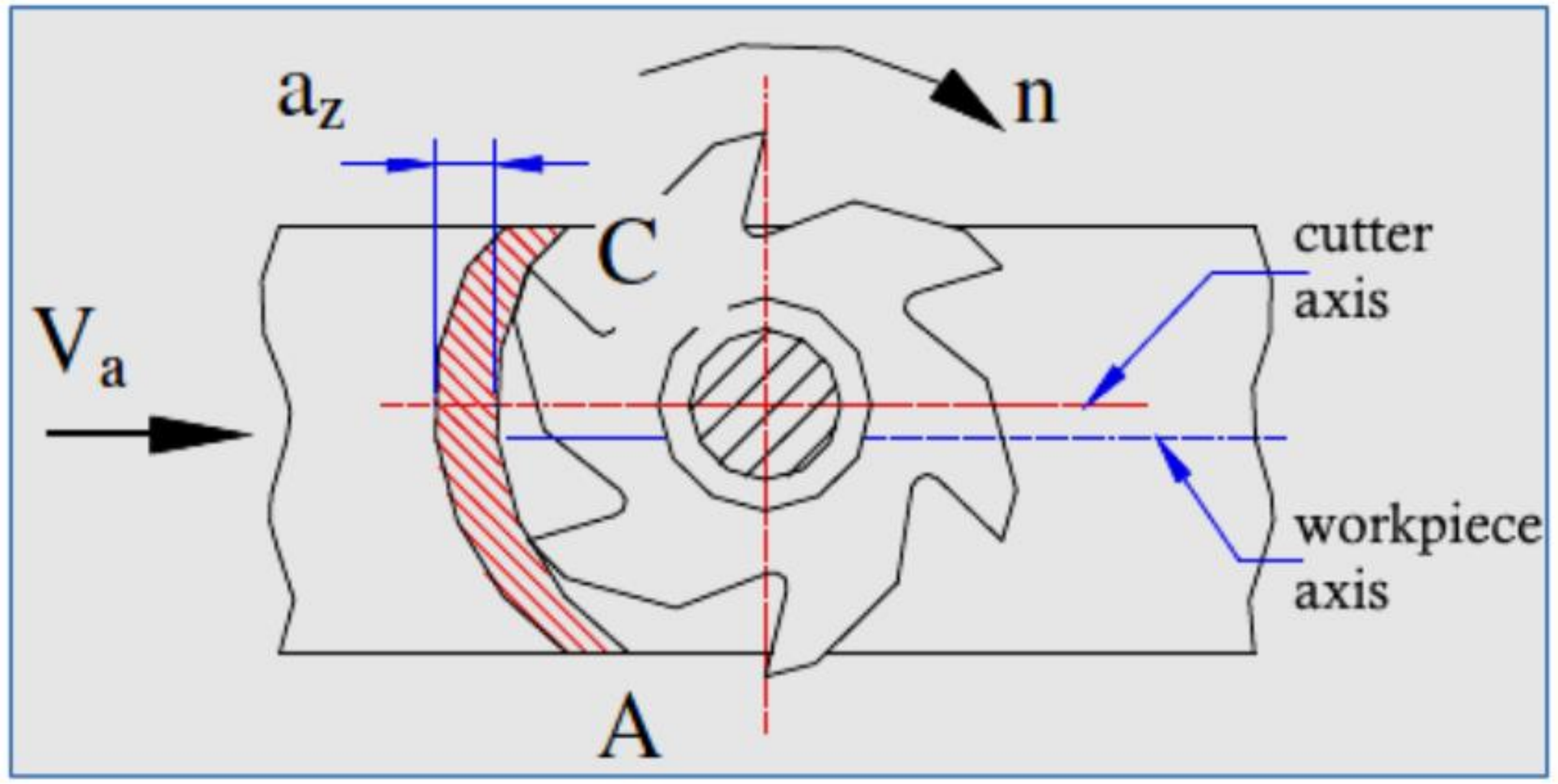


Fig. 159. Cutting forces with concordant feed direction

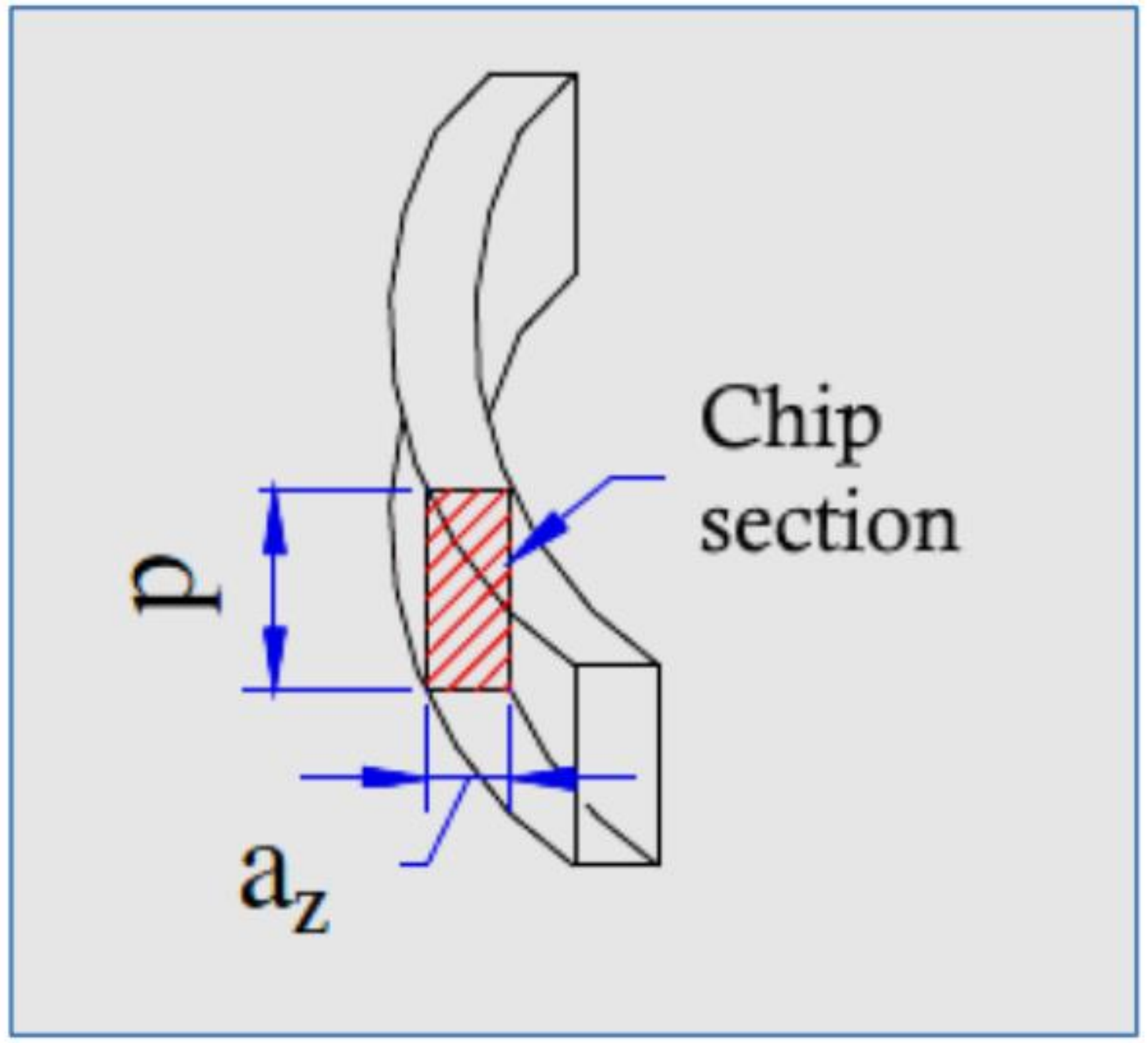


Fig. 160. Cutting forces with concordant feed direction

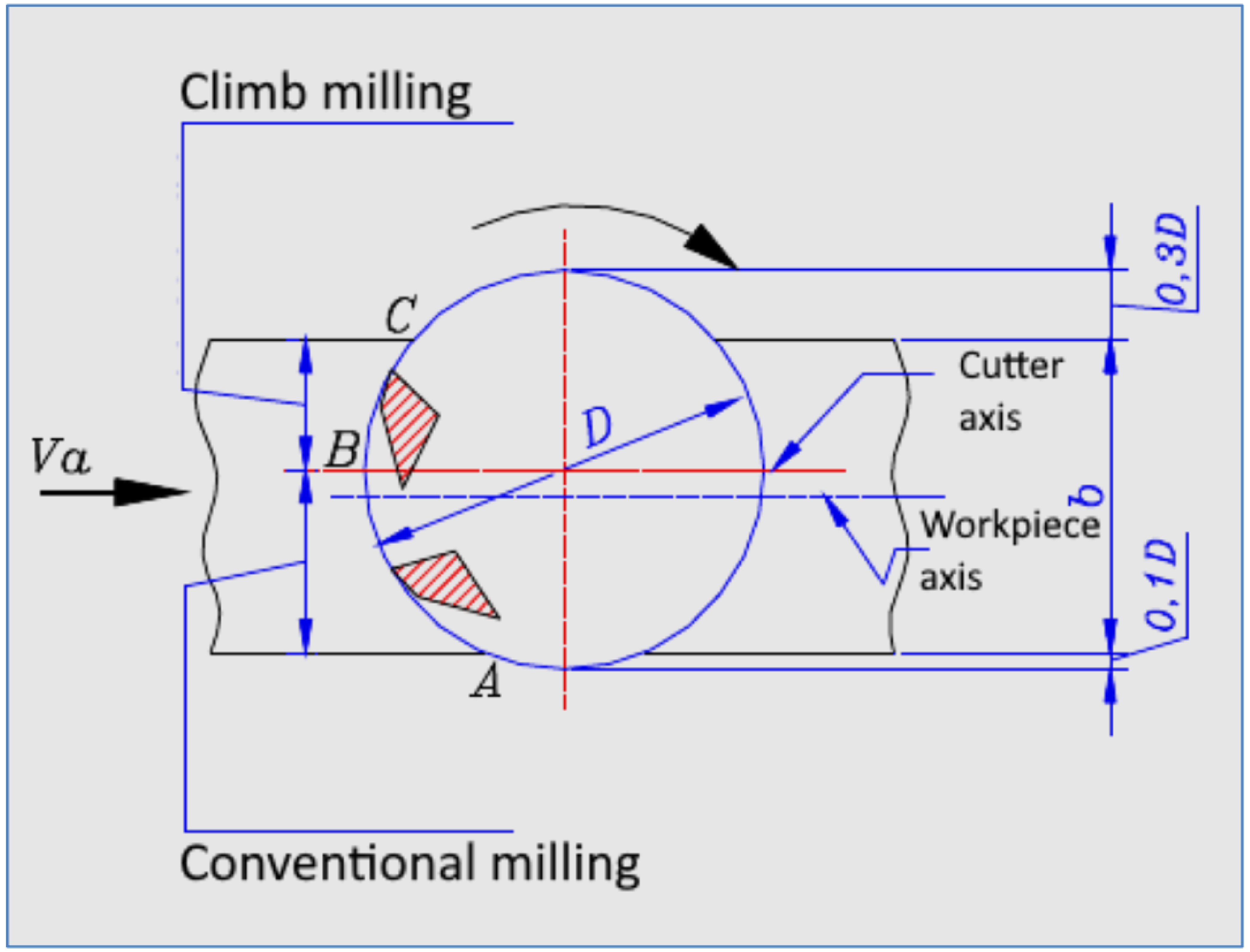


Fig. 161. Conventional and climb face milling

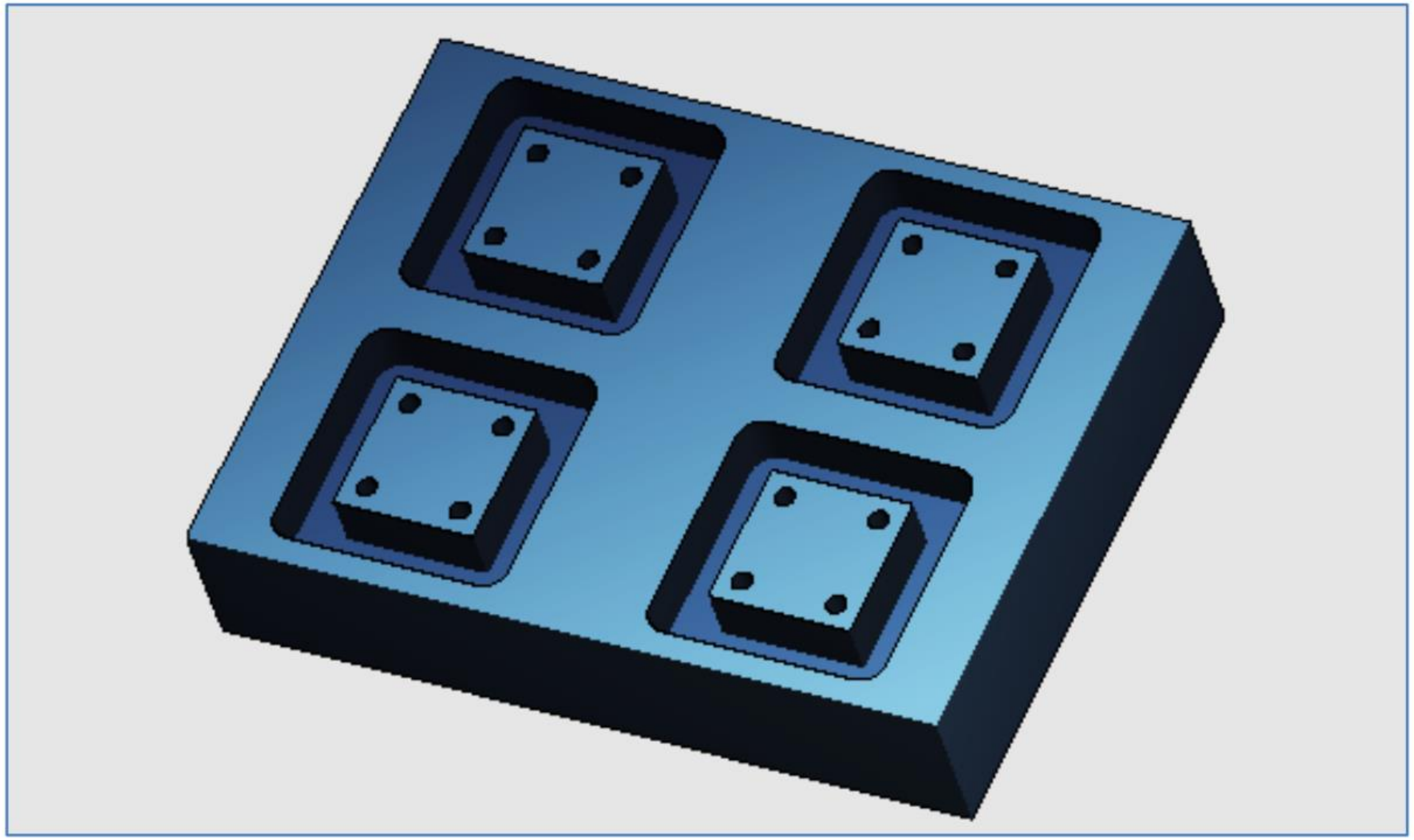


Fig. 162. Three-dimensional representation of the workpiece

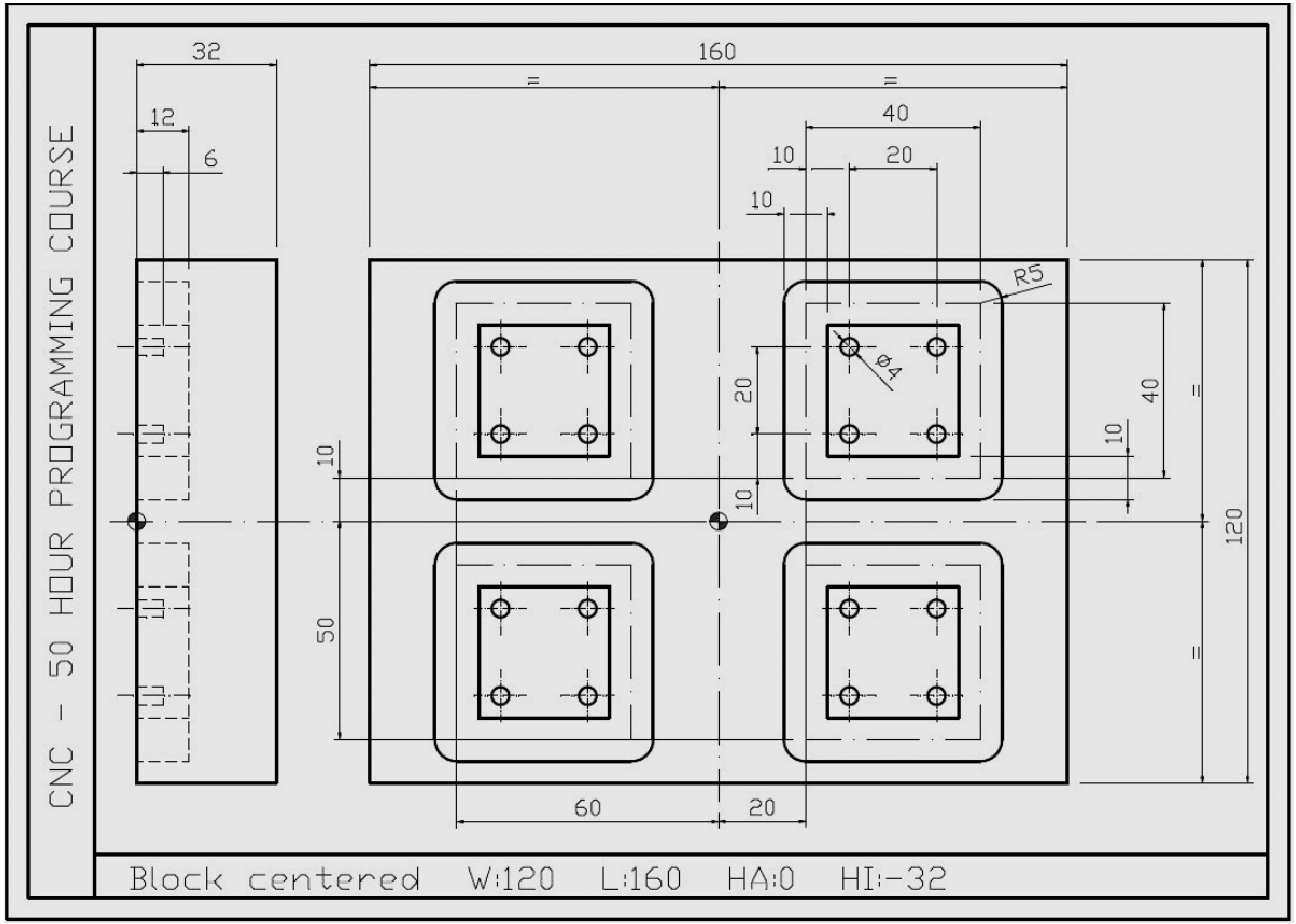


Fig. 163. Drawing of the part to create

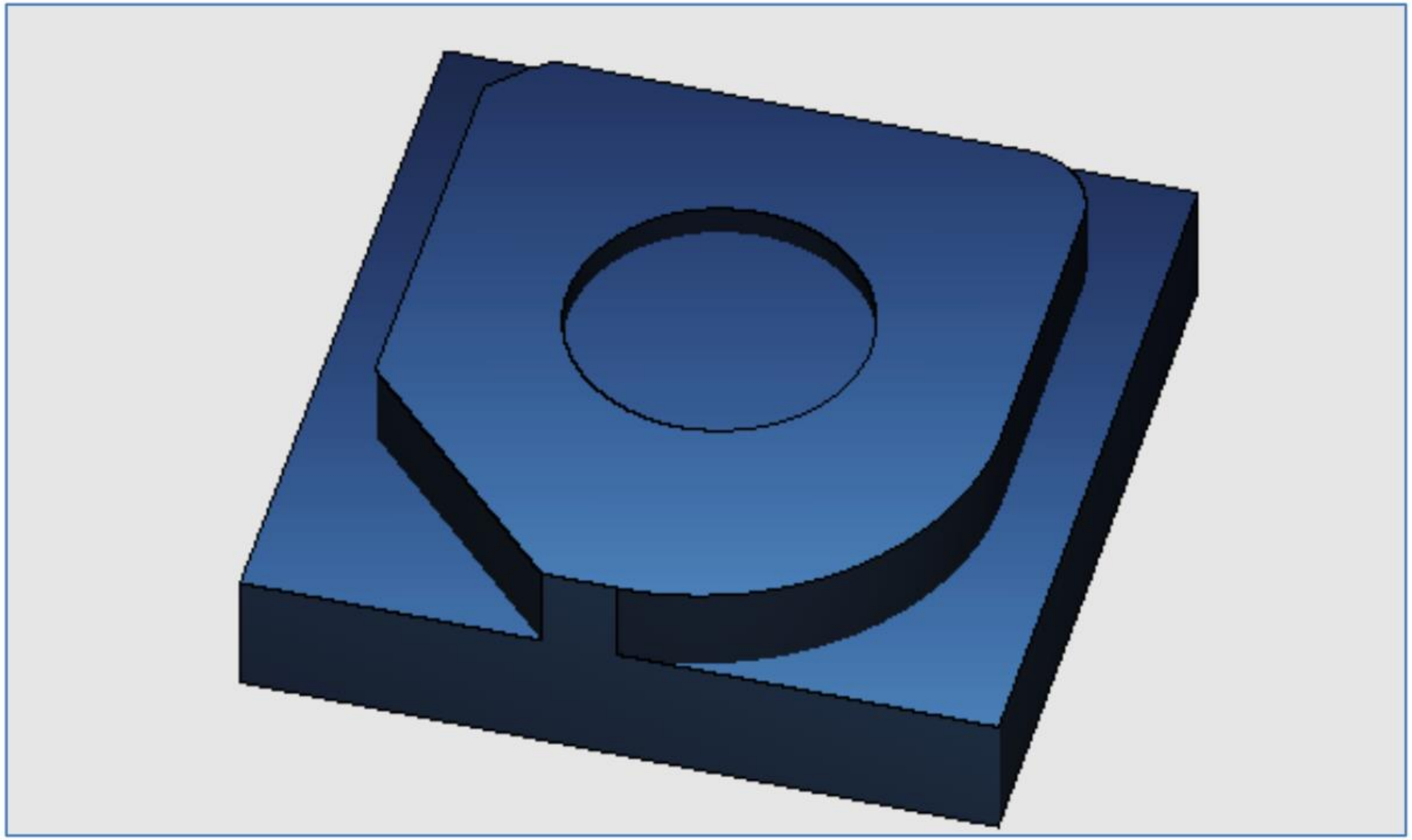


Fig. 164. Three-dimensional representation of the workpiece

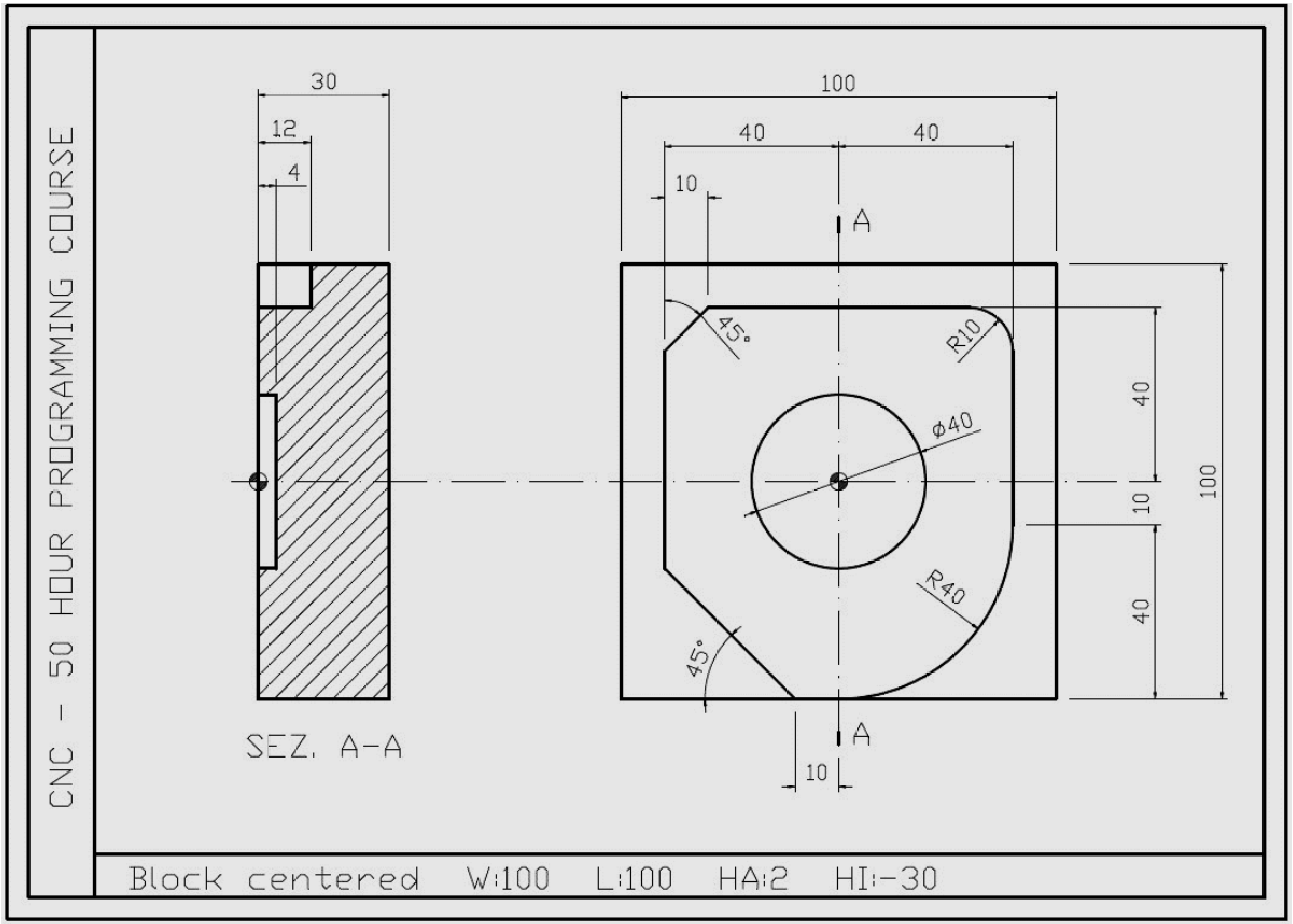
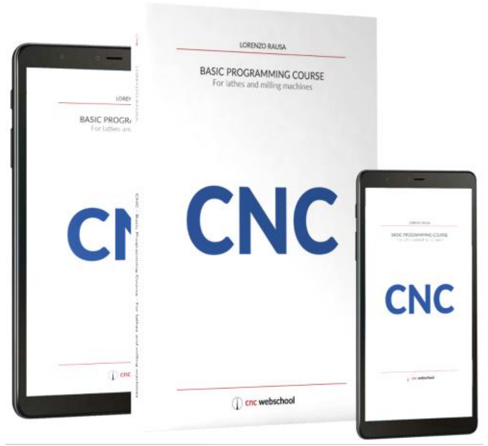


Fig. 165. Drawing of the part to create



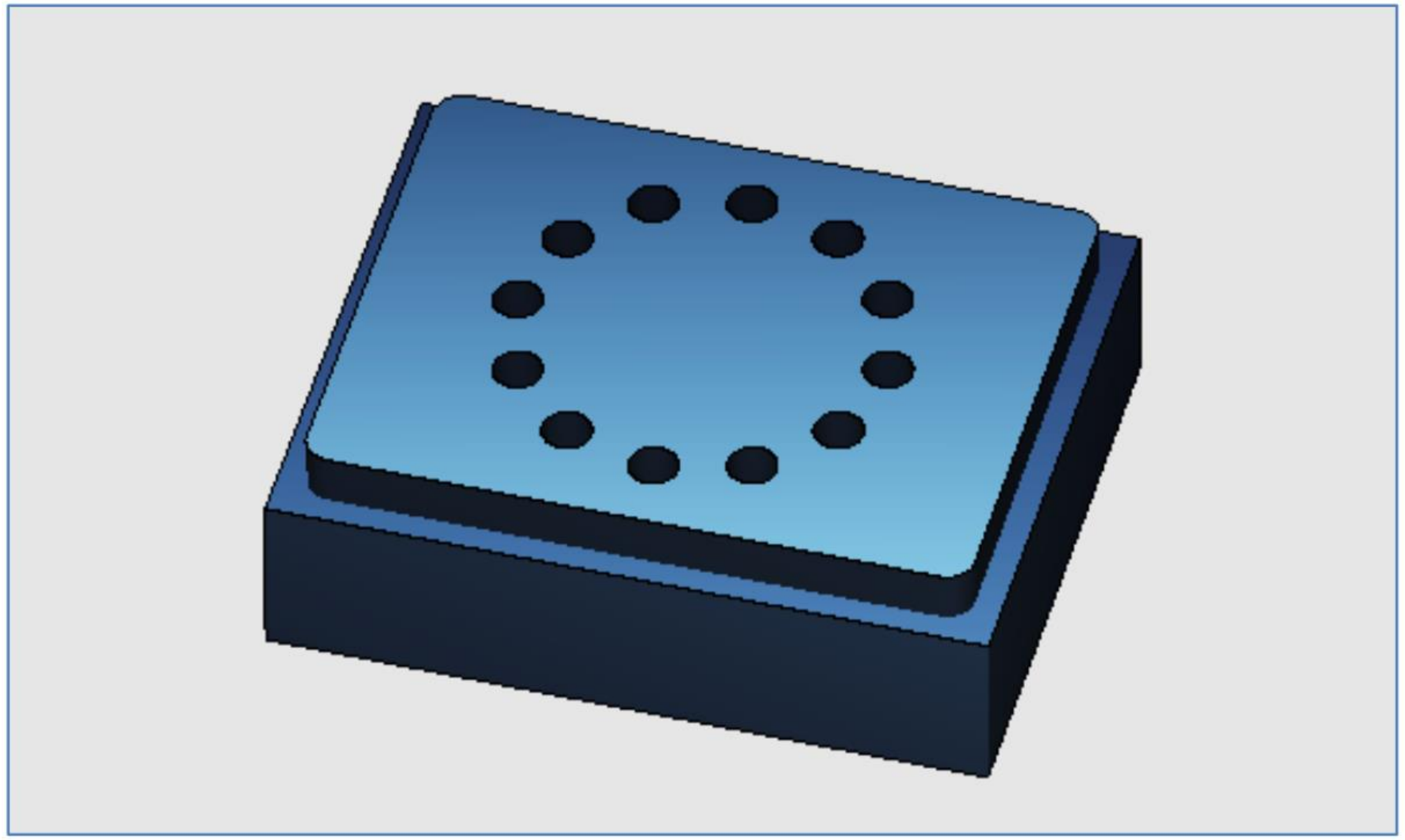


Fig. 166. Three-dimensional representation of the workpiece

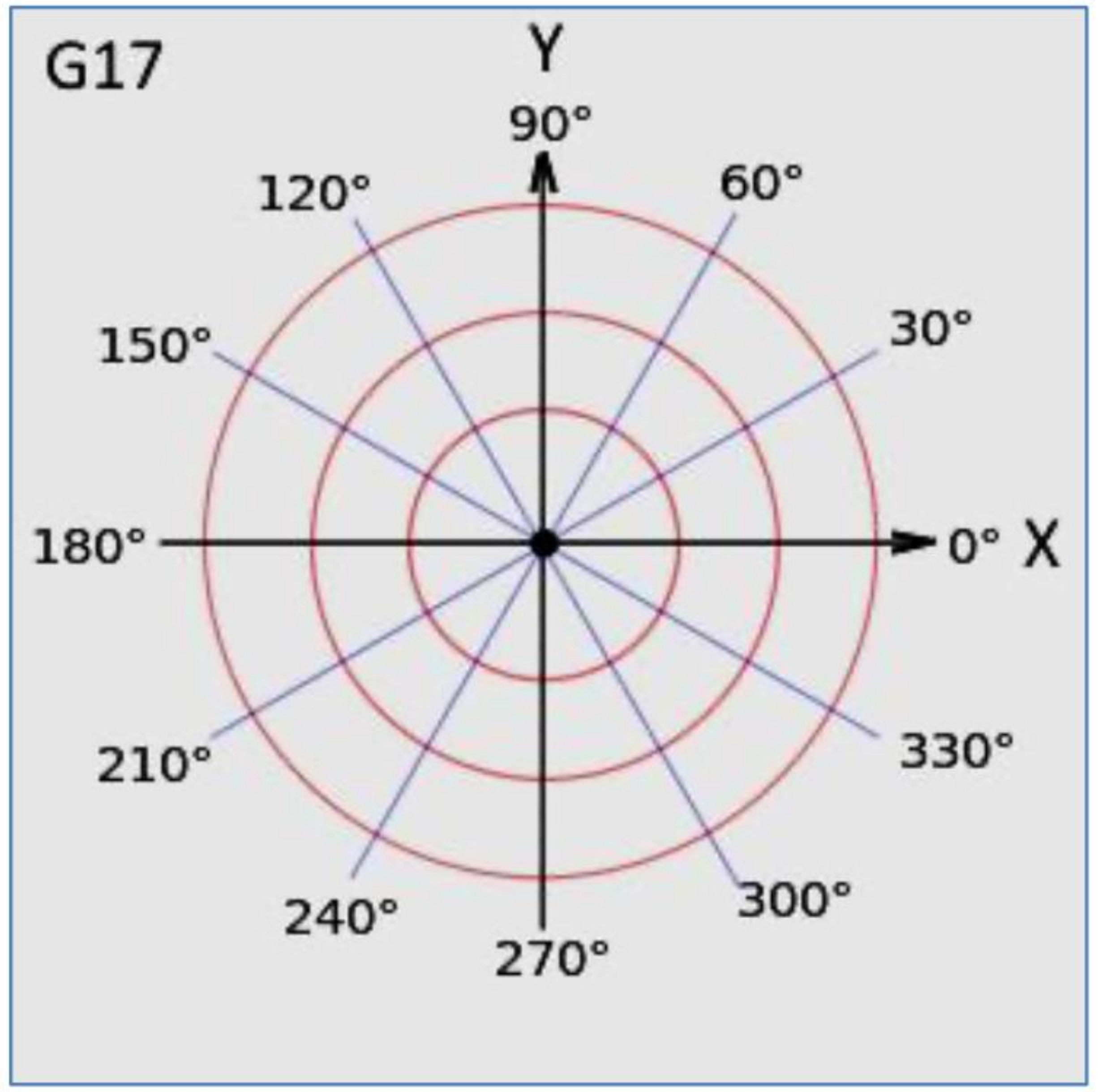


Fig. 167. Definition of a point in plane G17 using polar coordinates

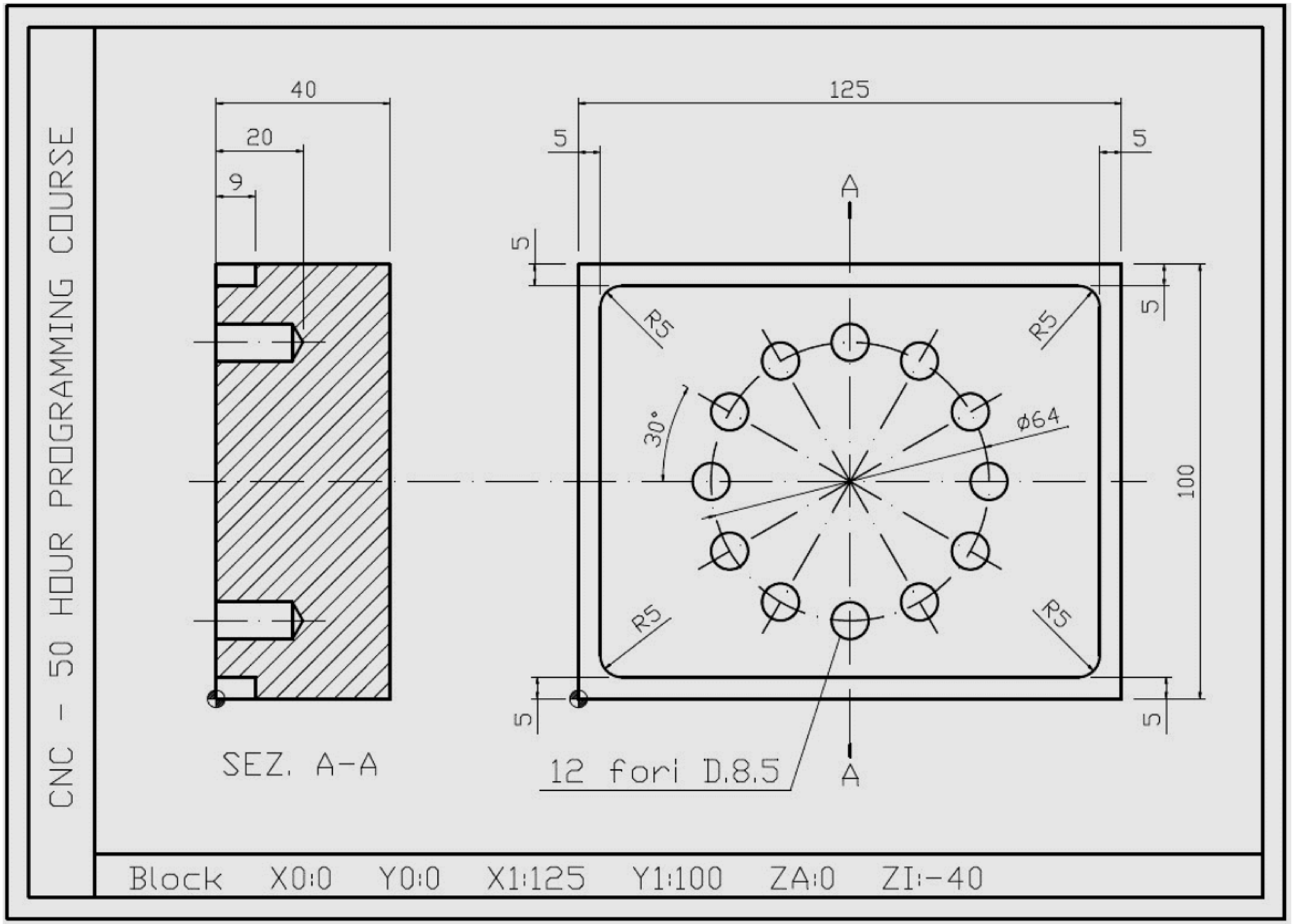


Fig. 168. Drawing of the part to create

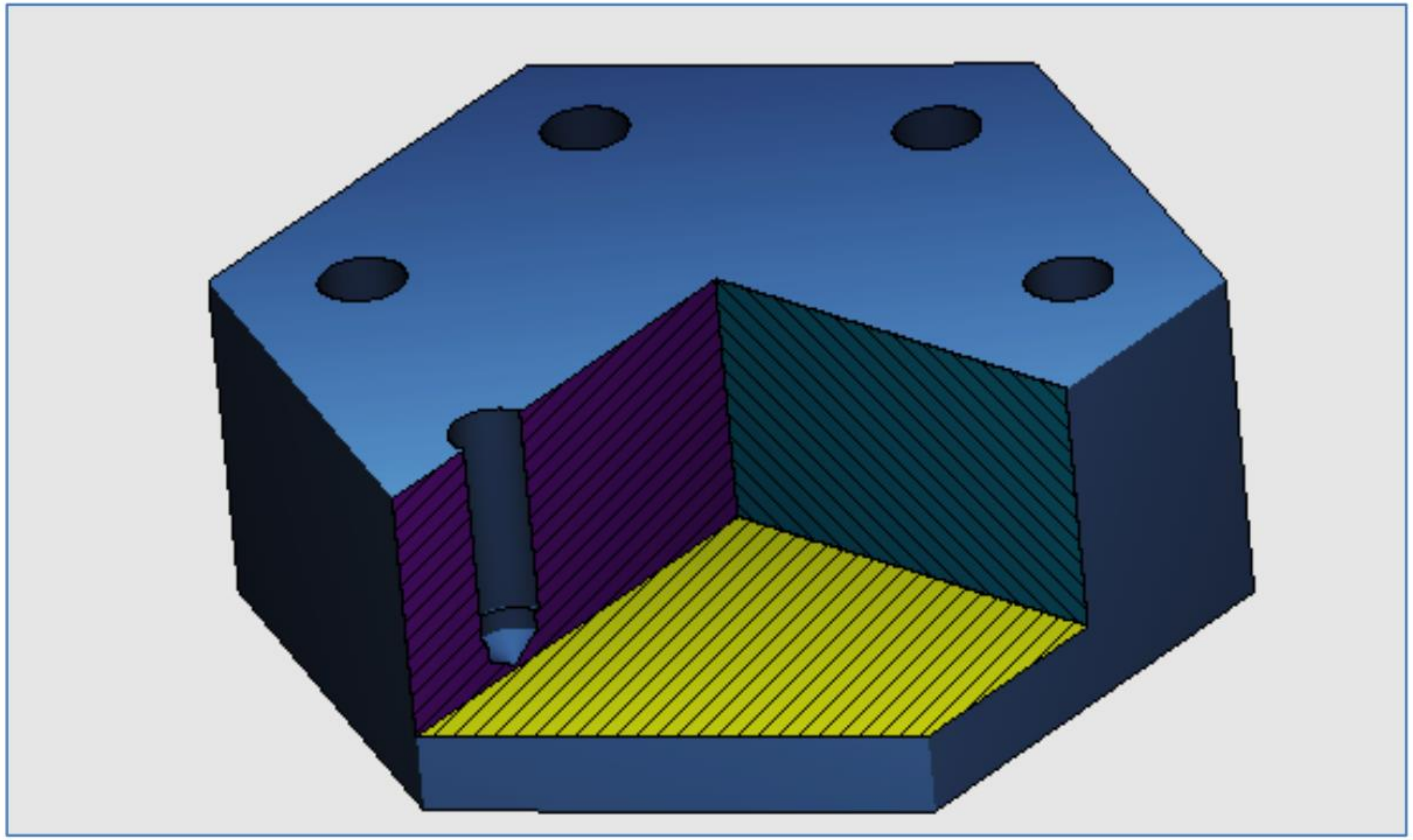


Fig. 169. Three-dimensional representation of the workpiece

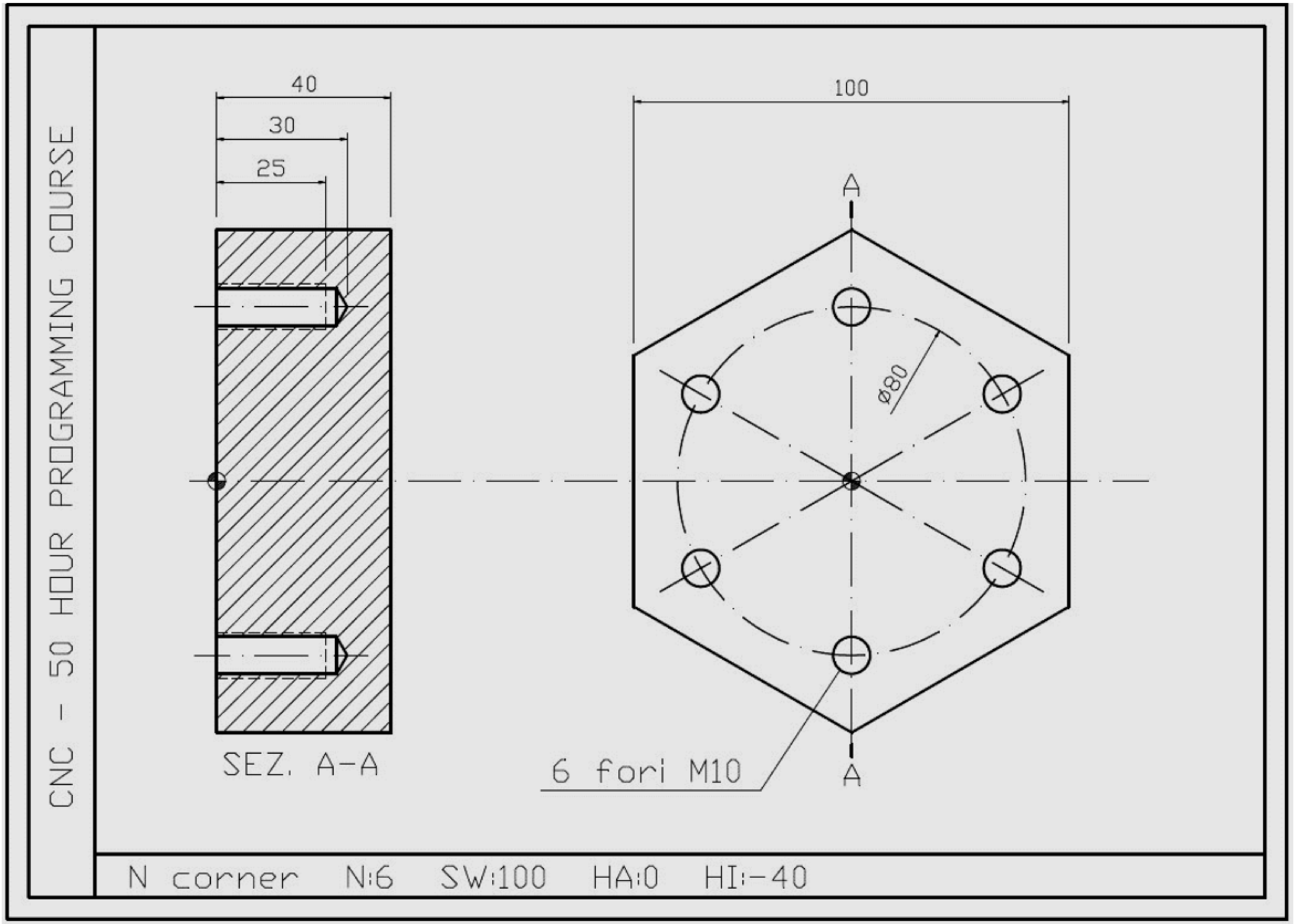
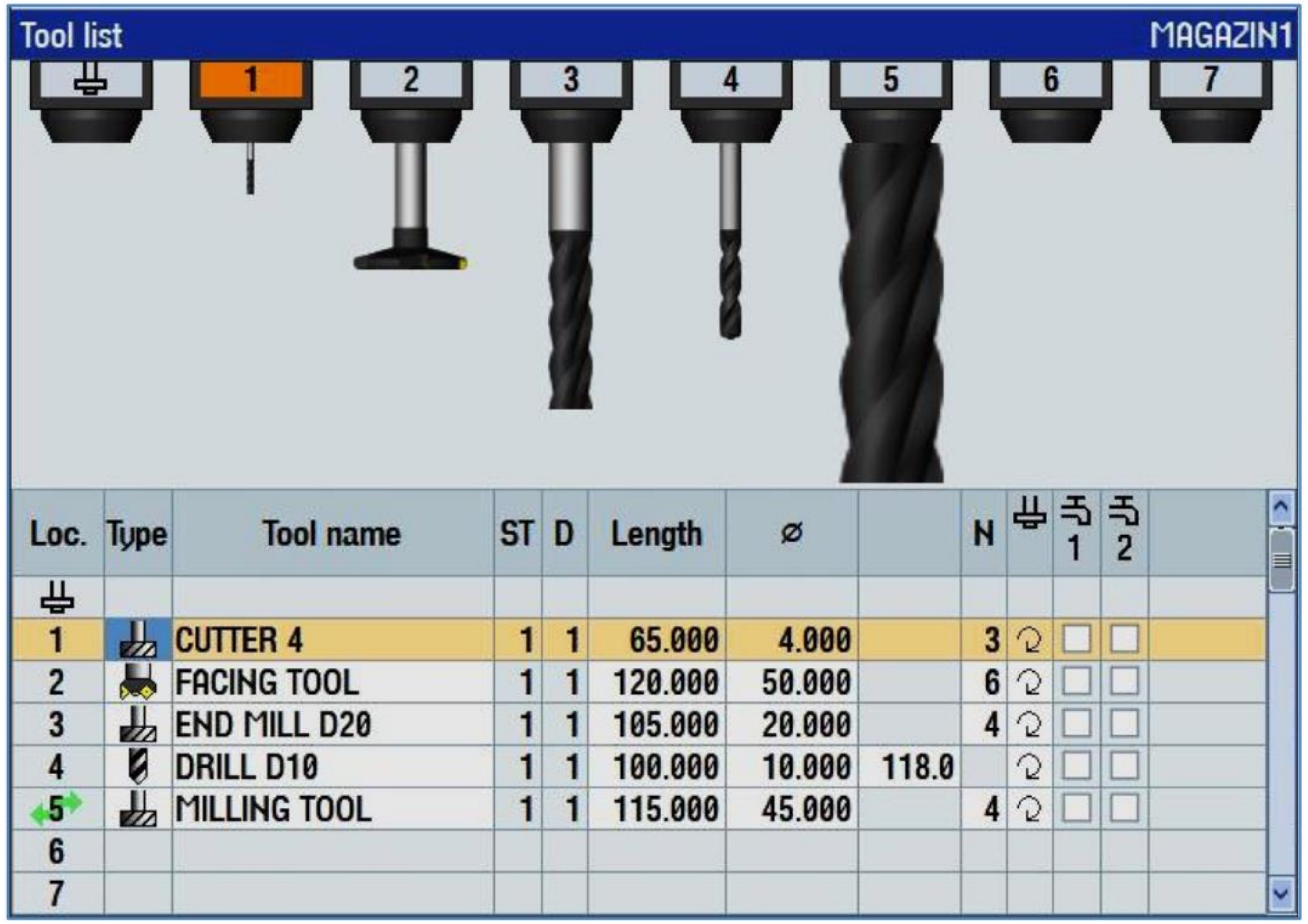


Fig. 170. Drawing of the part to create

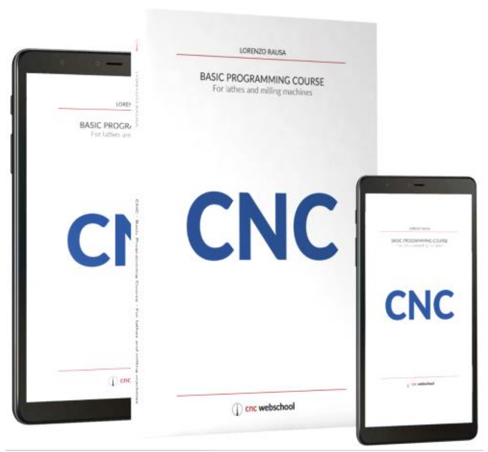


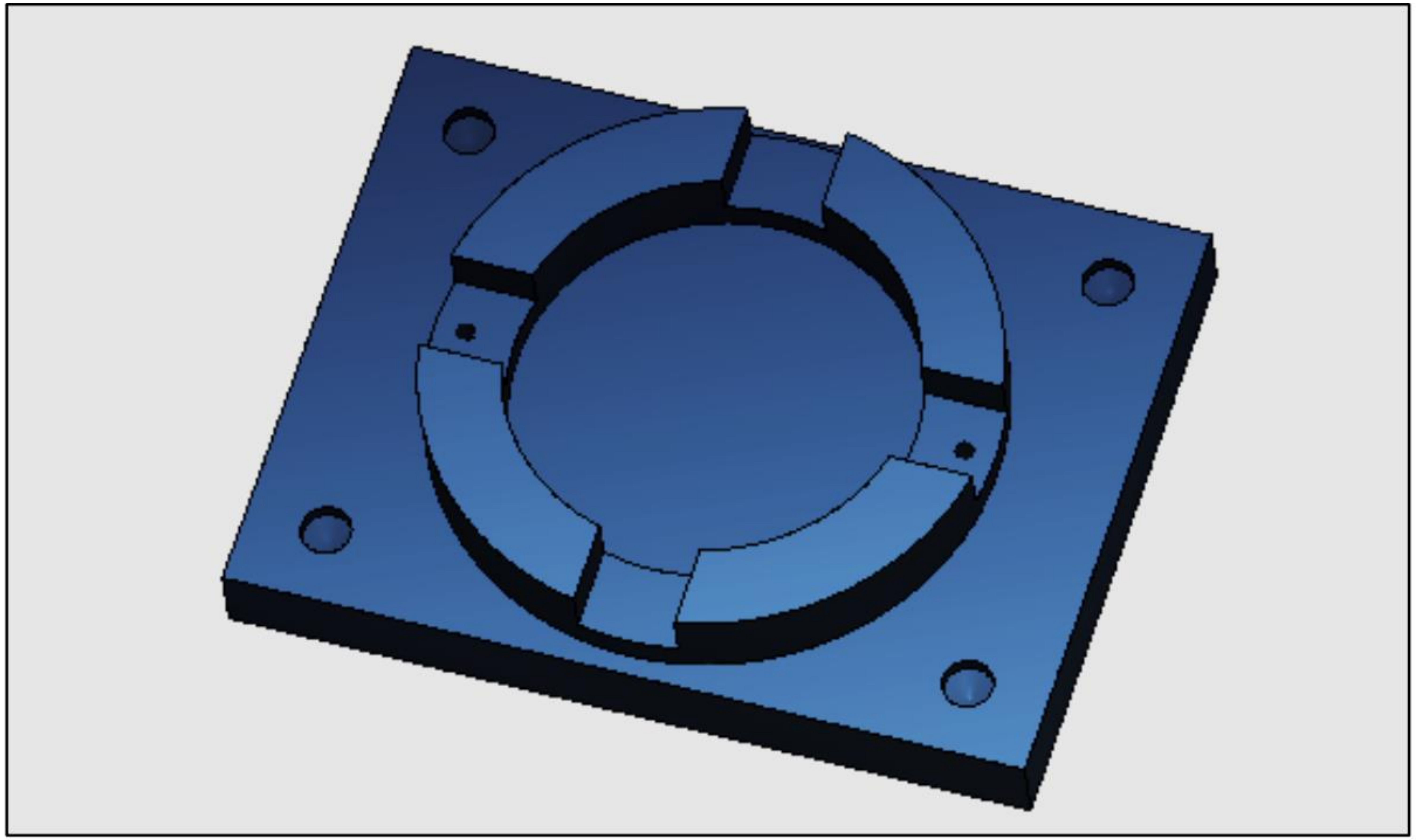
Loc.	Type	Tool name	ST	D	Length	Ø		N
1		CUTTER 4	1	1	65.000	4.000		3
2		FACING TOOL	1	1	120.000	50.000		6
3		END MILL D20	1	1	105.000	20.000		4
4		DRILL D10	1	1	100.000	10.000	118.0	
5		MILLING TOOL	1	1	115.000	45.000		4
6								
7								

Fig. 171. List of tools to be created and used in the test program

Tooling sequence	Tool name	Operation	Cutting speed (m/min)	Feed rate (mm/rev)
1 st	T2 D1	Flattening	100	0.6
2 nd	T5 D1	Cylinder D112	120	0.3 climb milling
3 rd	T3 D1	Pocket D80	90	0.2 climb milling
4 th	T3 D1	Four milling operations	110	0.32
5 th	T1 D1	N2 holes D4	80	0.06
6 th	T4 D1	N4 holes D10	80	0.12

Fig. 172. Sequence of tooling operations and cutting parameters to use for the test





Three-dimensional representation of the workpiece

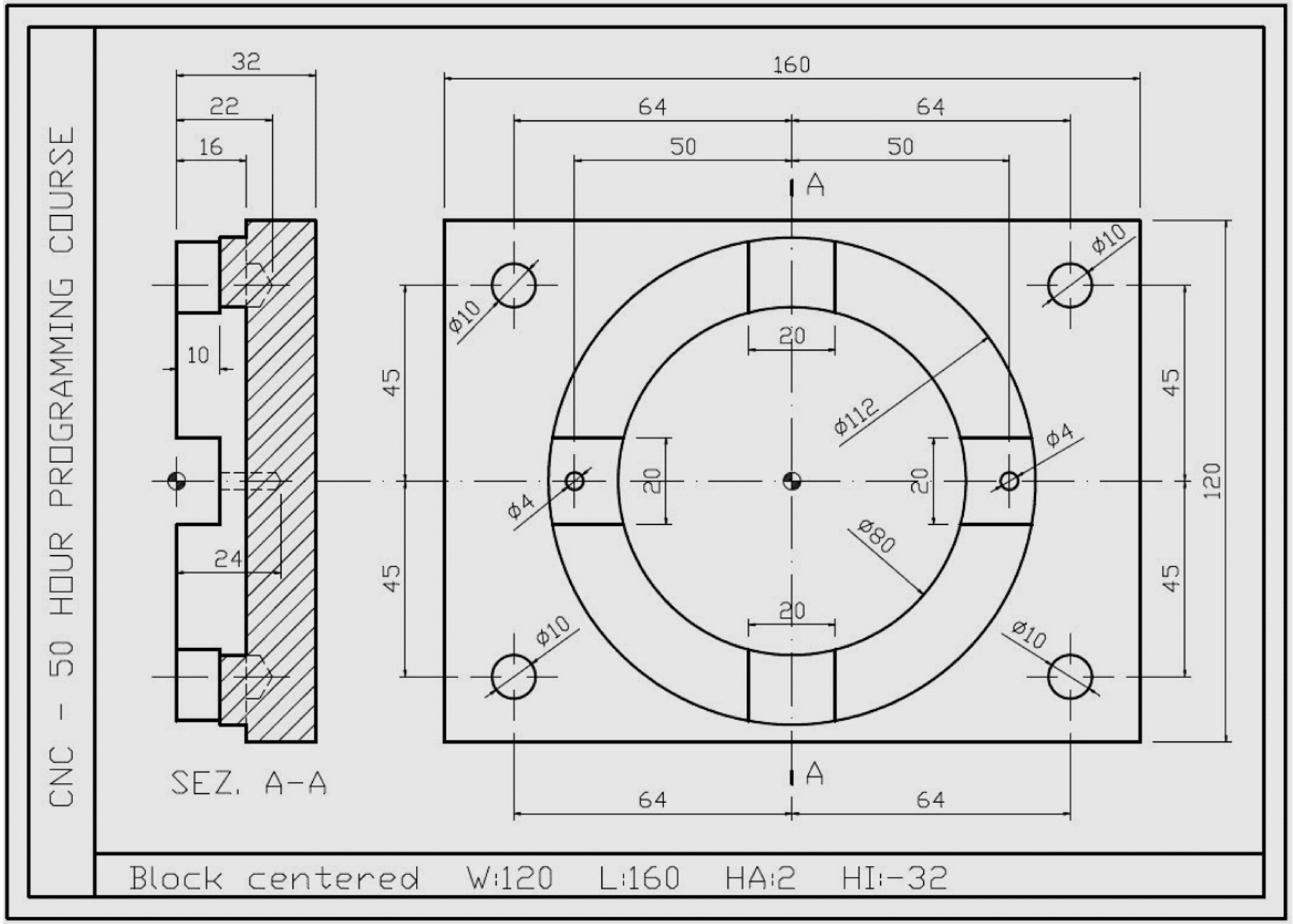


Fig. 173. Drawing of the part to create