

# CNC - 50 HOUR PROGRAMMING COURSE

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Fig. 1. Optional control panel for SinuTrain

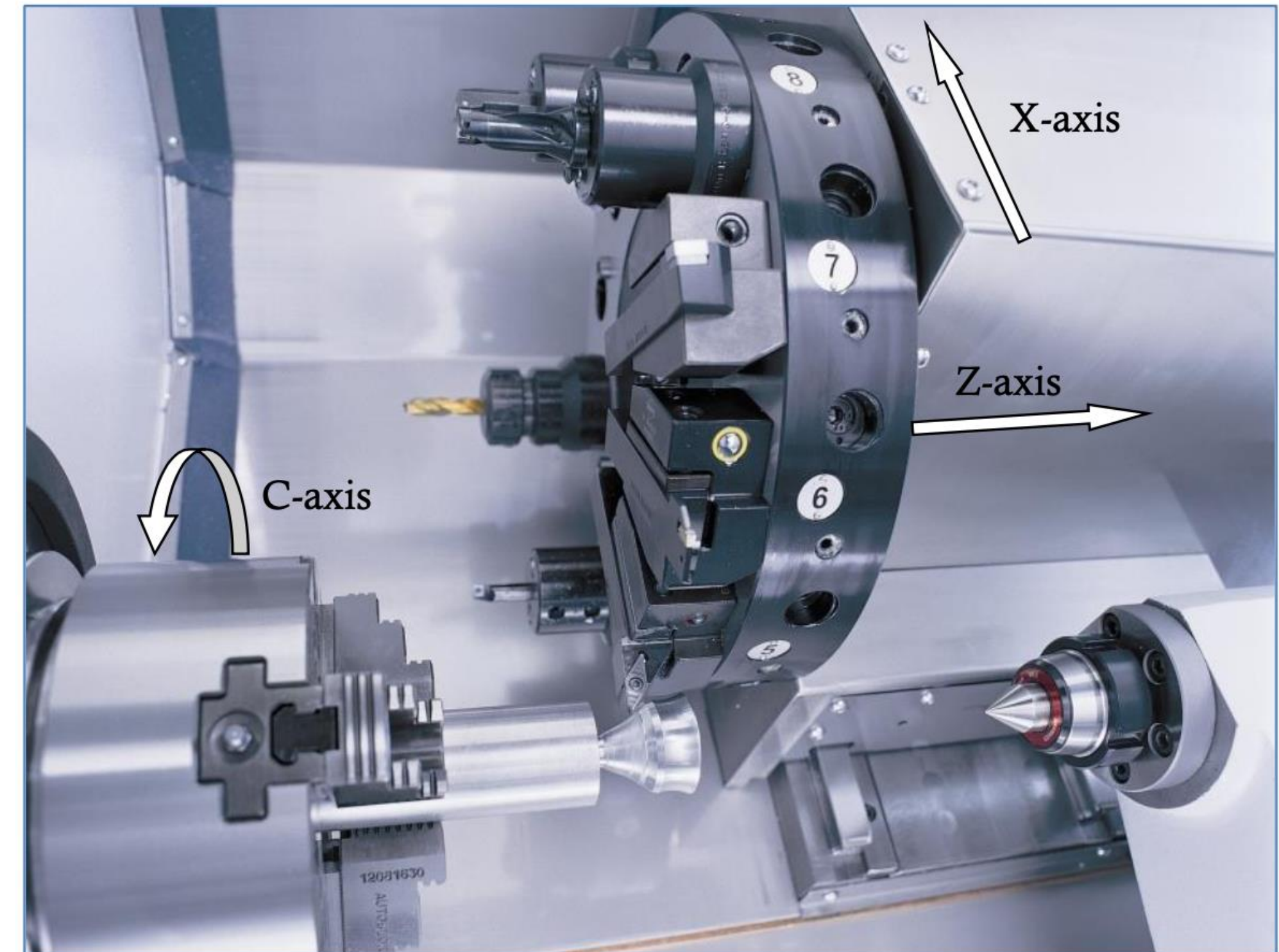


Fig. 2. Lathe with 3 axes and driven tools





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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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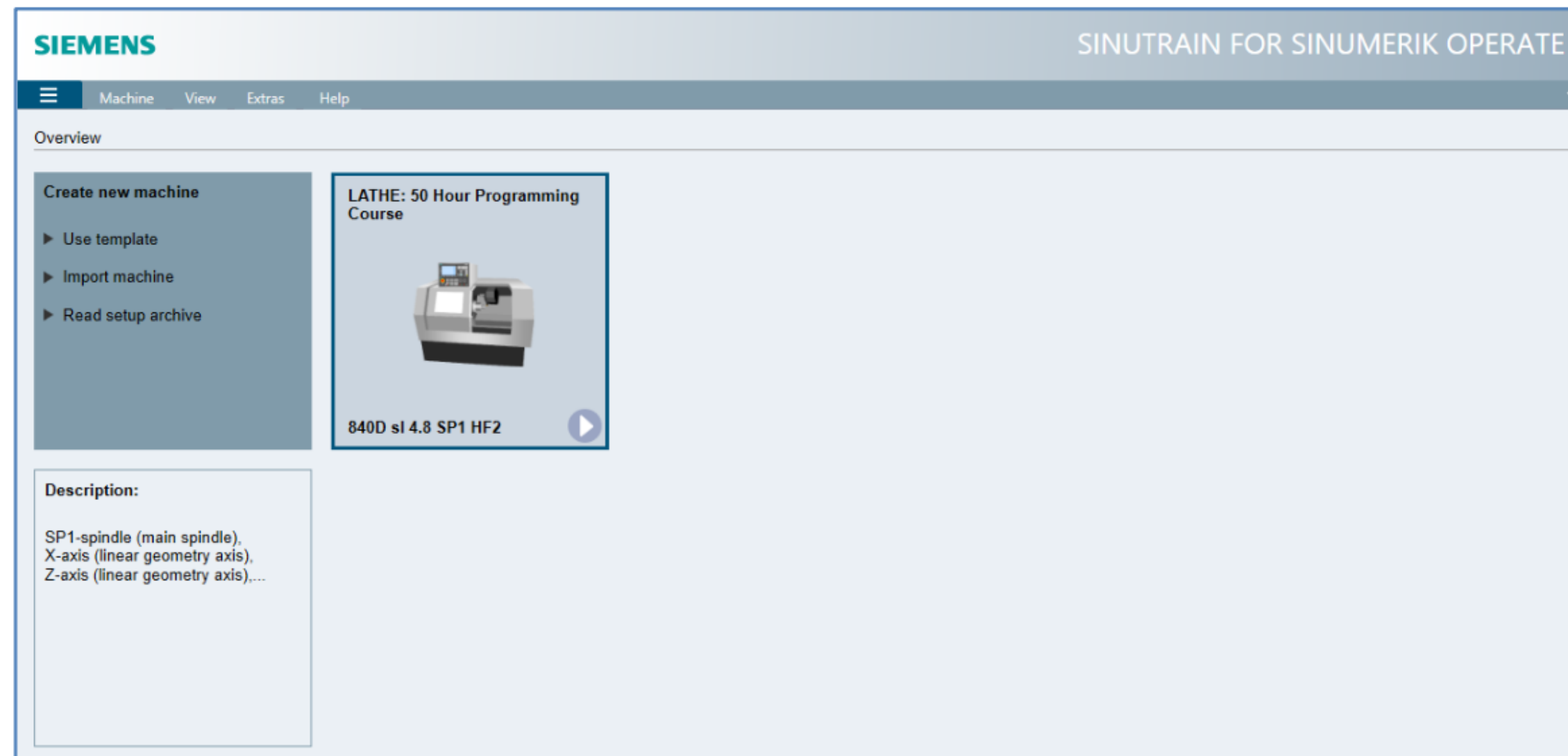


Fig. 5. Starting window of the simulation program

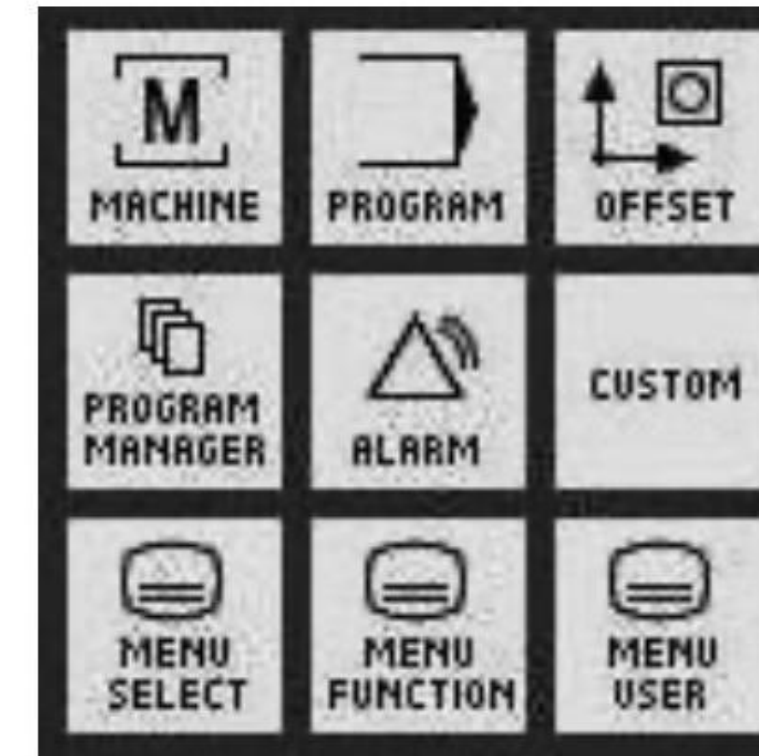


Fig. 6. Buttons for the selection of the operating environments

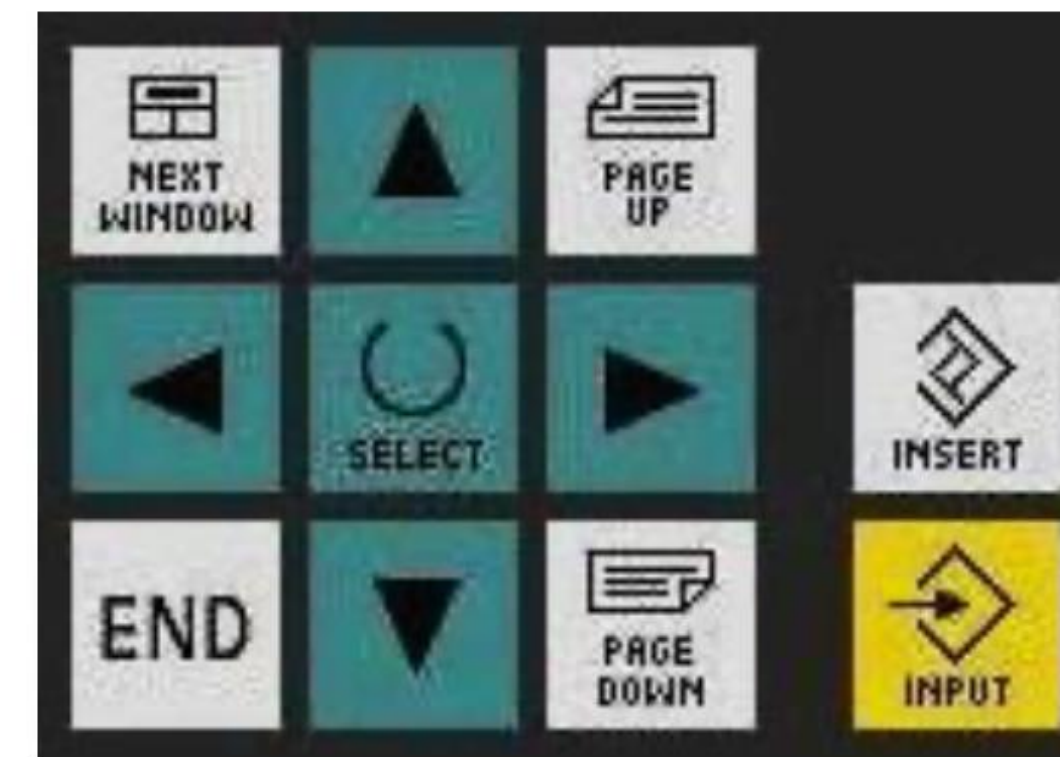
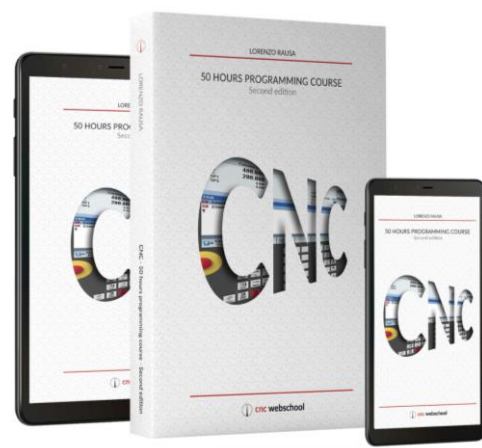


Fig. 7. Buttons for cursor movement and data entry





## A collection of 50 HOURS PRO books and tablets. The central focus is a large white book titled "50 HOURS PRO CNC" by "50 HOURS PRO". The cover features a large, stylized "CNC" logo composed of various national flags. To the left, a tablet displays the same "CNC" logo. To the right, another tablet displays the "CNC" logo. In the background, a stack of books is visible, with the top one being "50 HOURS PRO CNC". The books are arranged in a way that suggests a comprehensive set of materials for learning CNC.



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



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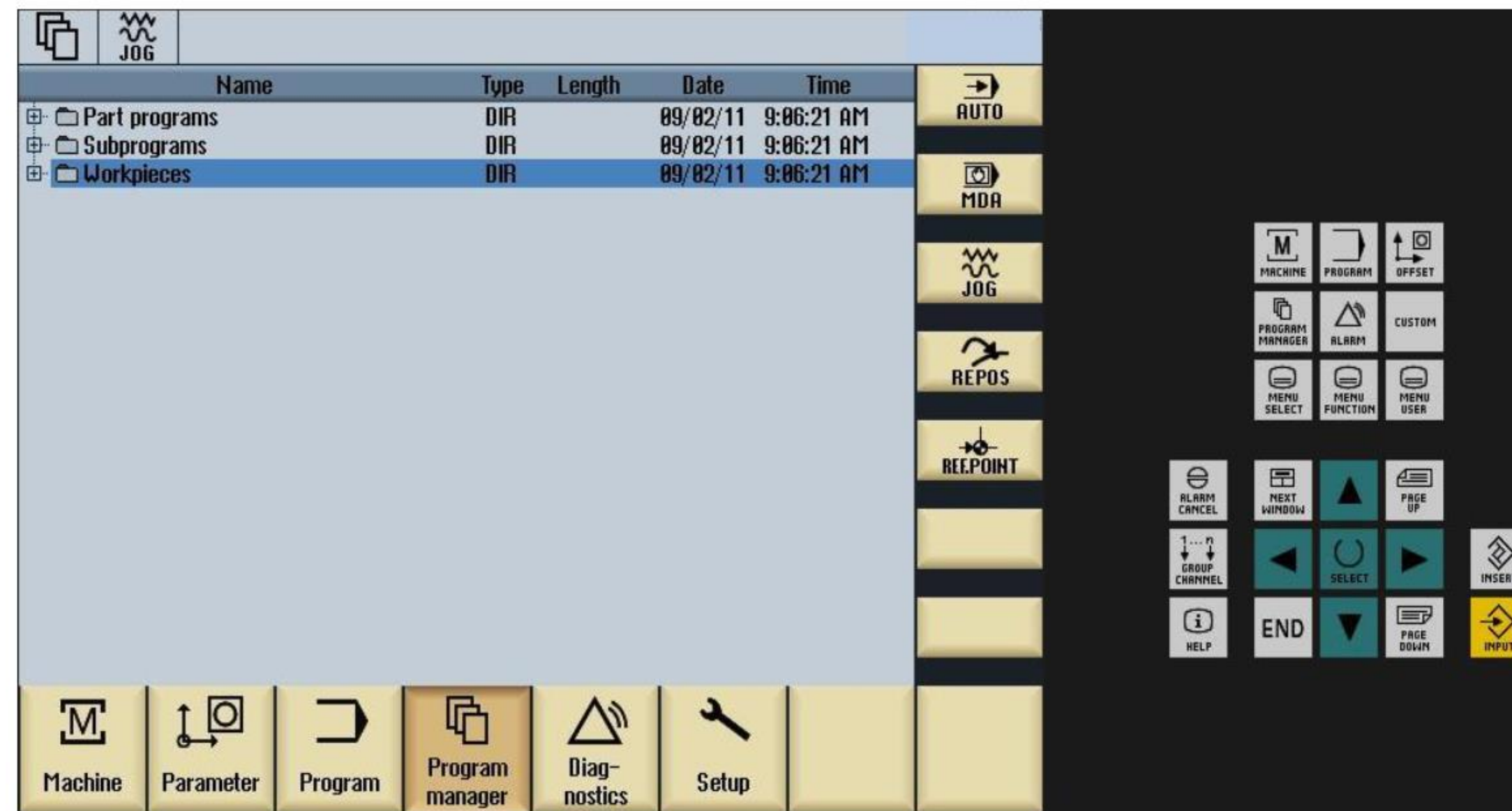


Fig. 9. Organization of the programs on the PROGRAM MANAGER page

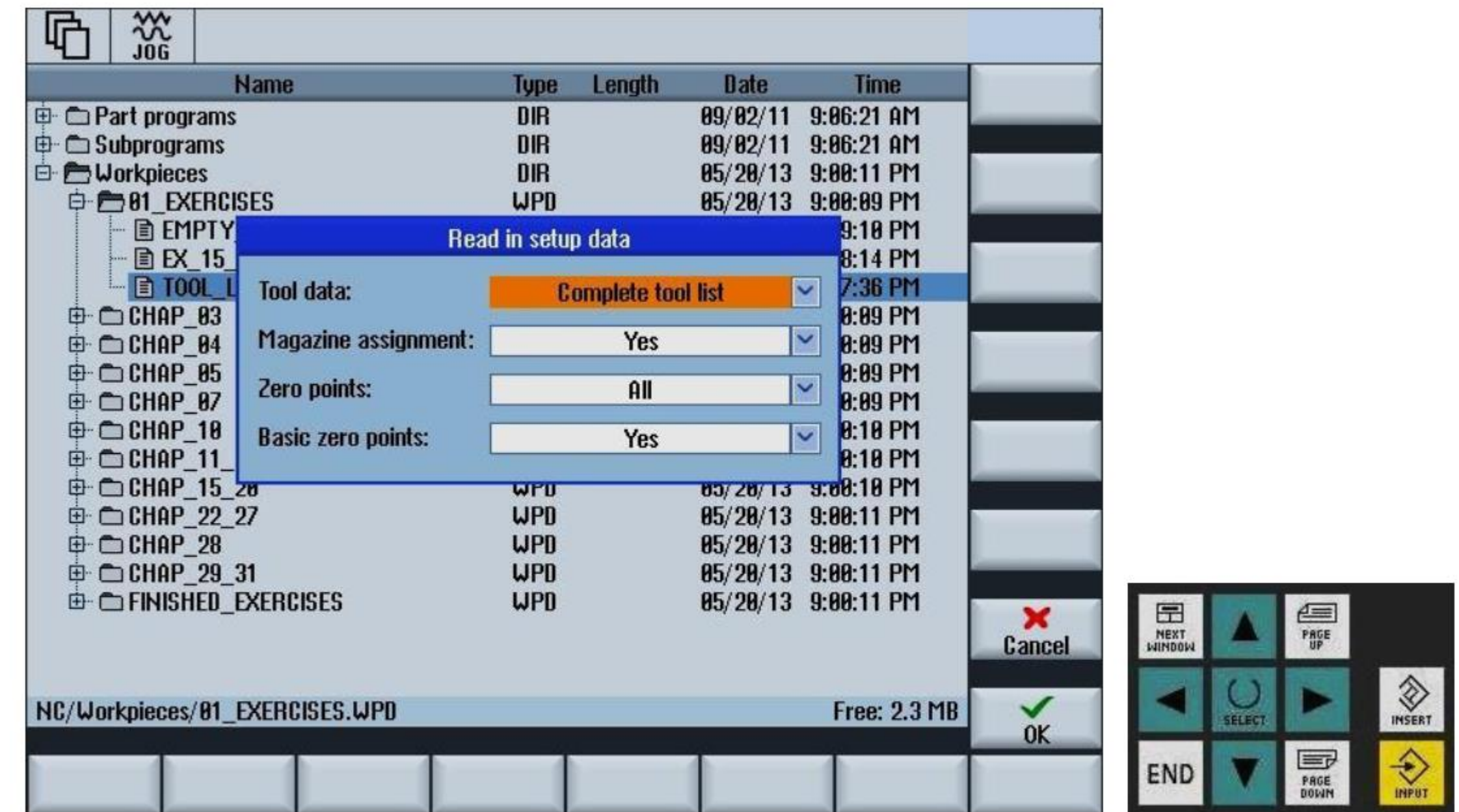


Fig. 10. Dialog box for the import of tooling data





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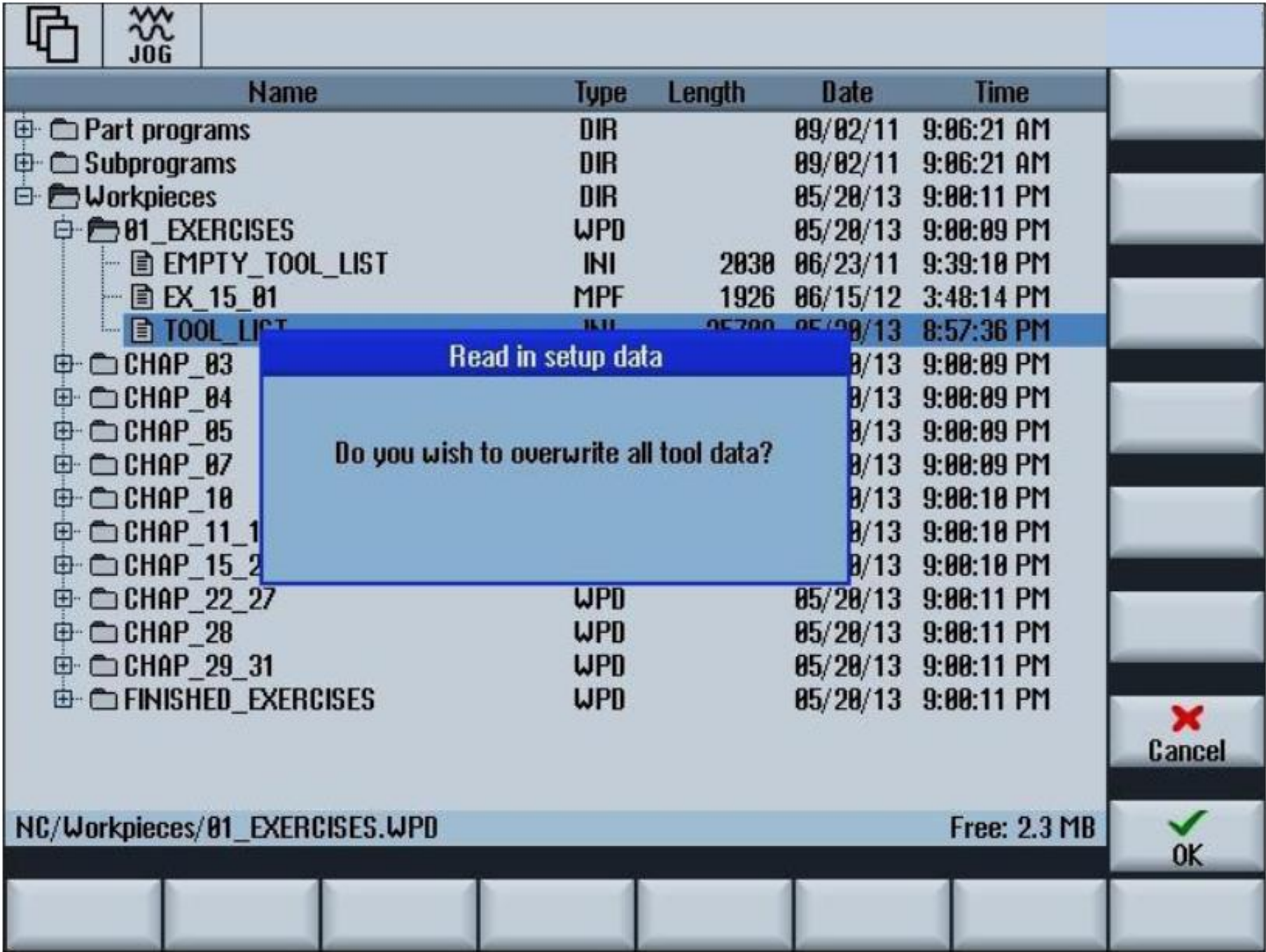


Fig. 11. Window for the confirmation and overwriting of the tool data

<b>Blank part:</b>	Shape of the blank part (e.g. cylinder)
<b>XA:</b>	External diameter of the blank part (e.g. 80 mm).
<b>ZA:</b>	Value of the machining allowance on the front face of the blank part (e.g. 0.5 mm).
<b>ZI:</b>	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.
<b>ZB:</b>	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





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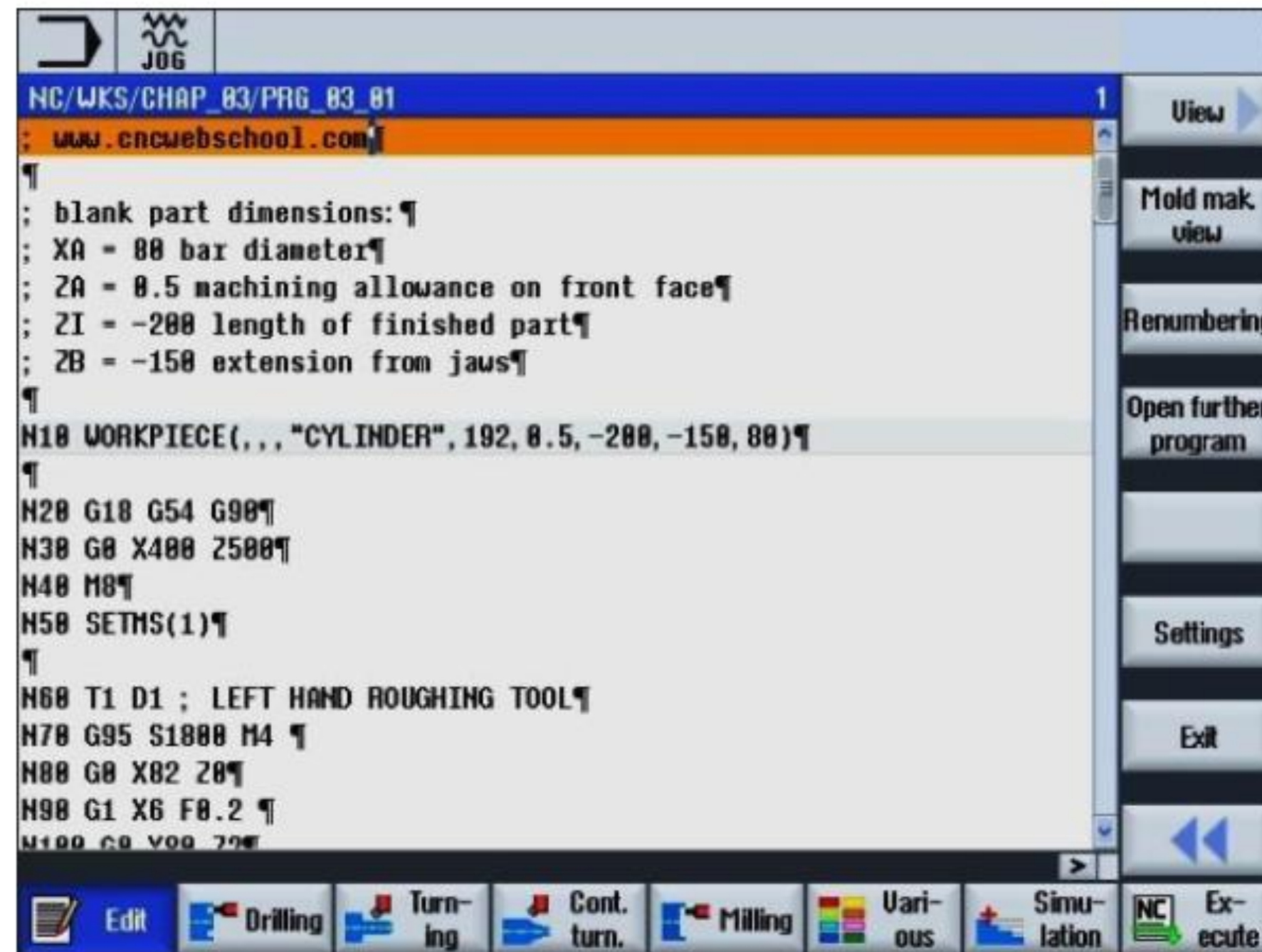


Fig. 13. Program opened and ready for simulation

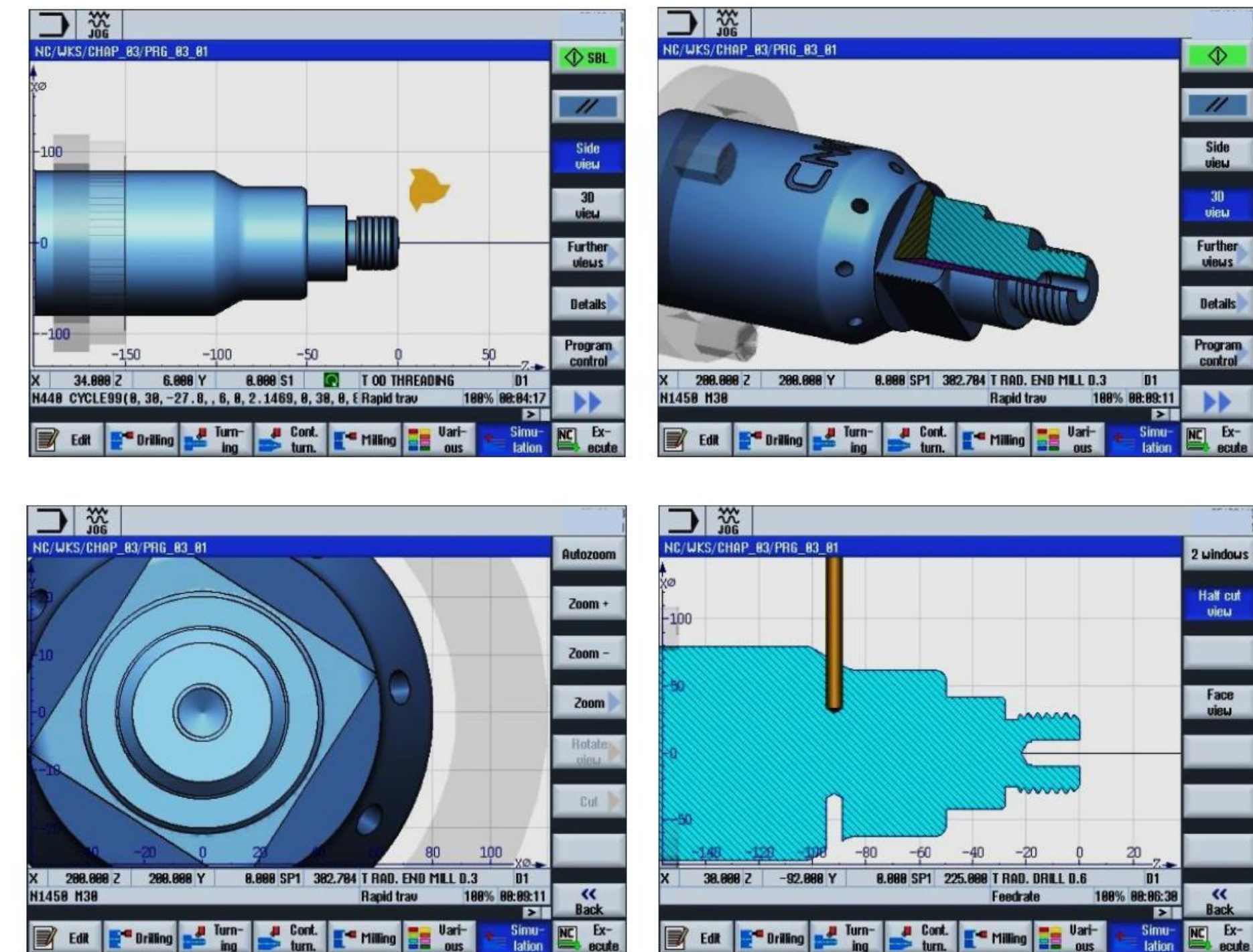


Fig. 14. Display options for the workpiece







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

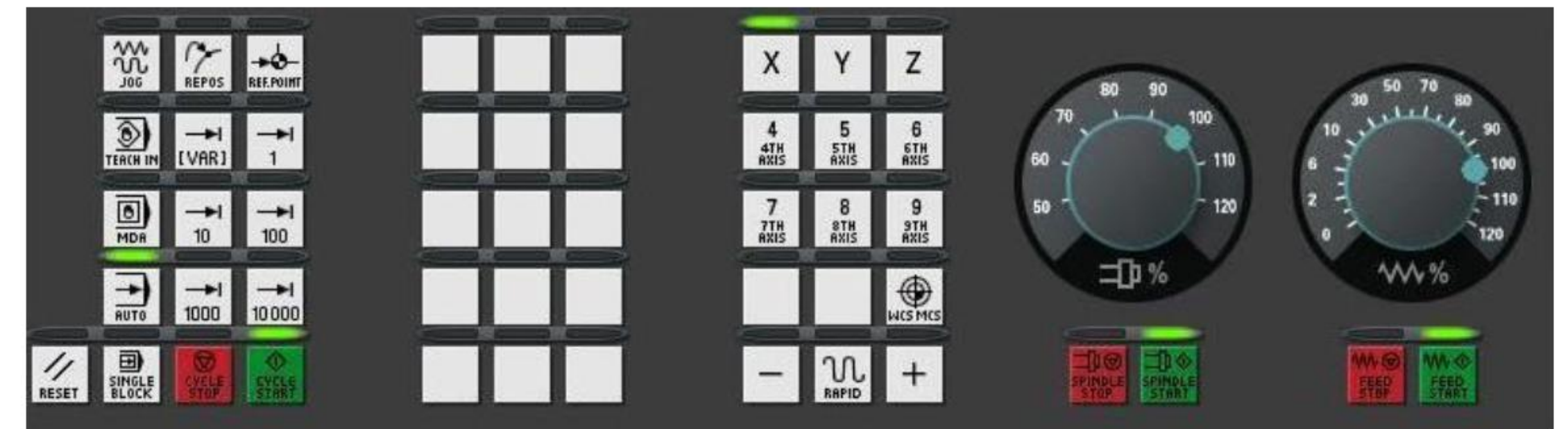


Fig. 16. Activation and setting of the potentiometers for the execution of the program in automatic cycle



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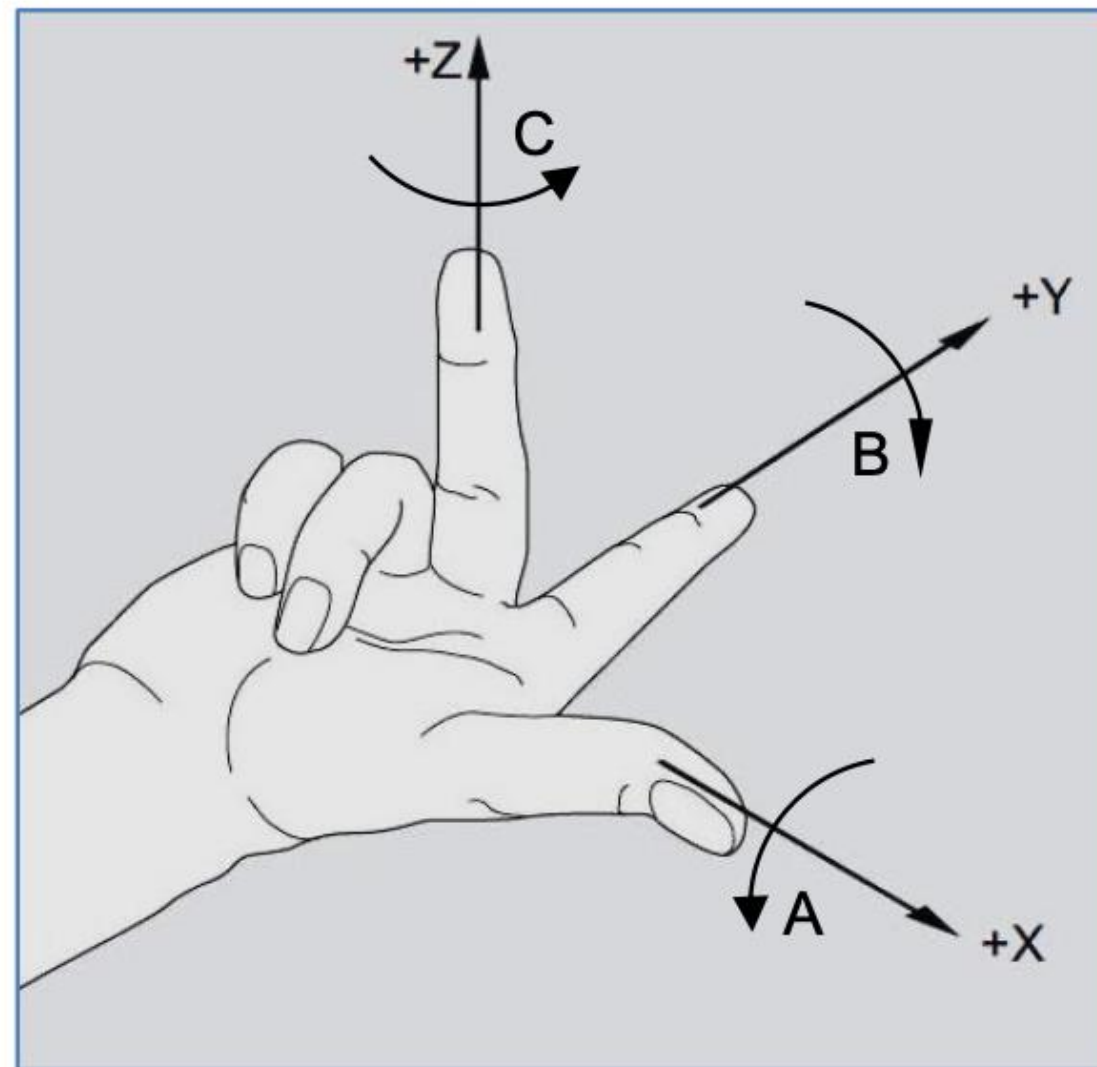


Fig. 17. Right-hand rule: definition of the axes and their positive motion according to ISO Standards. The positive motion is always determined in relation to the moving path of the tool on the workpiece.

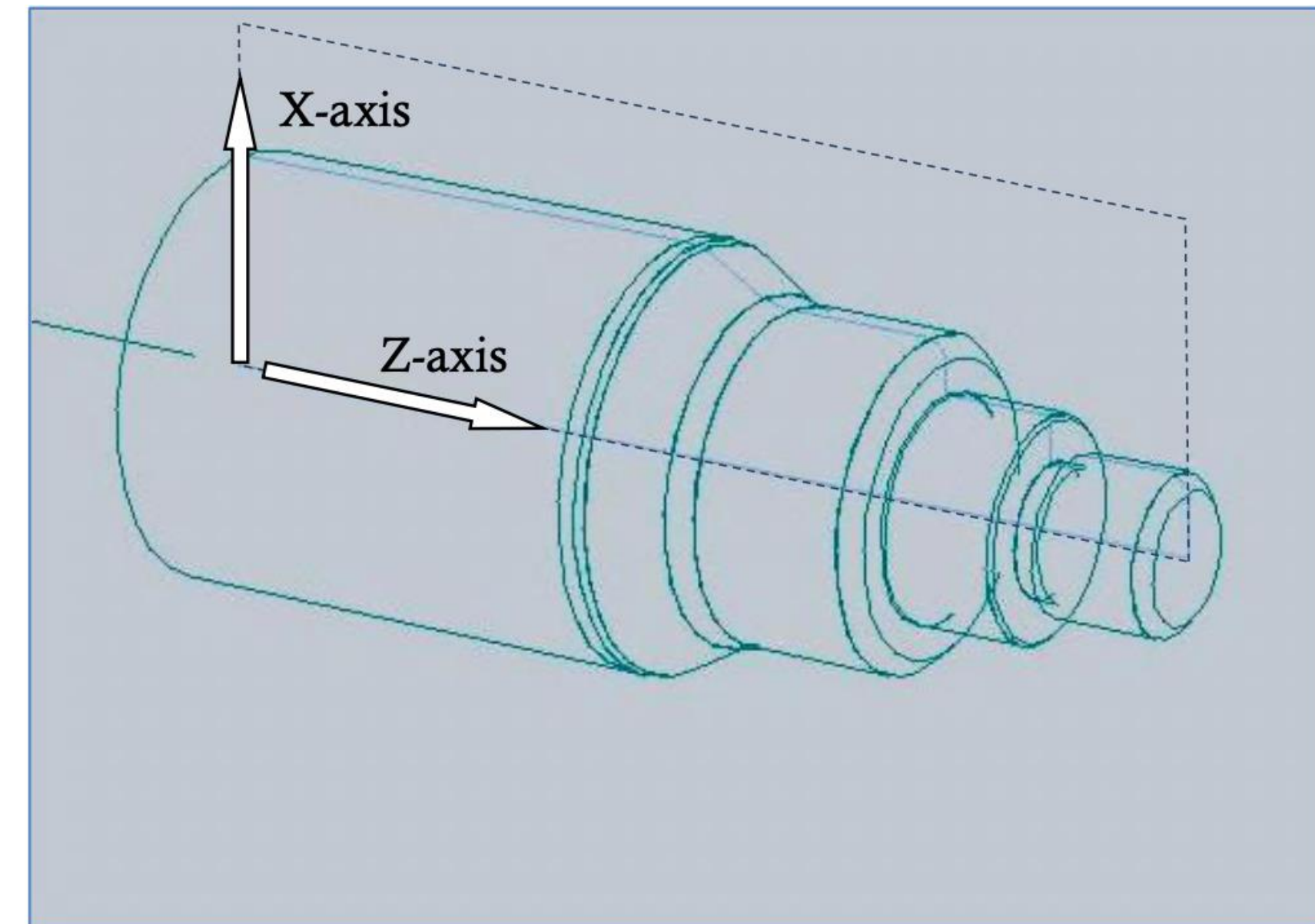


Fig. 18. Solid of revolution around the Z-axis of the profile described on the plane X-Z





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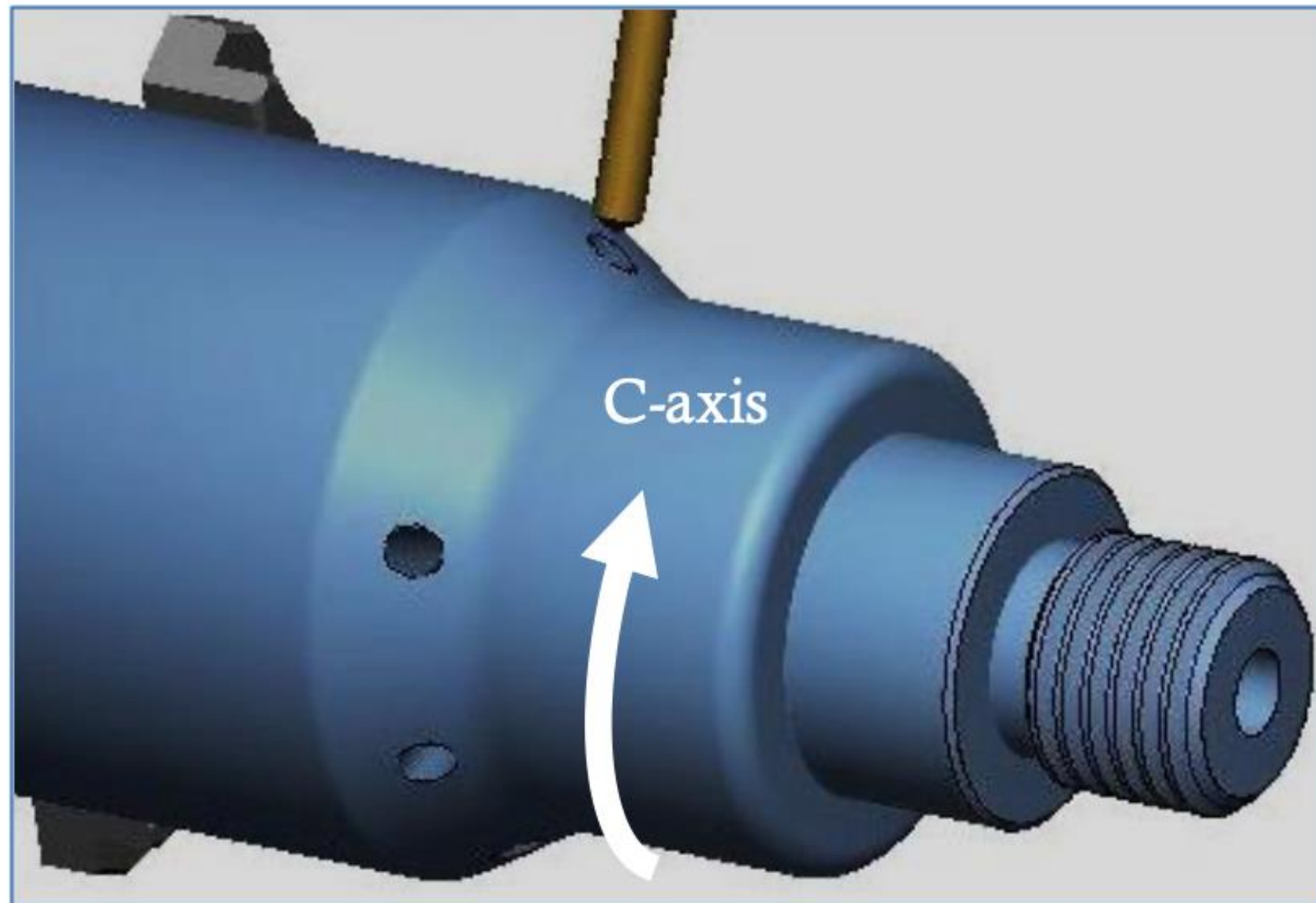


Fig. 19. Angular orientation of the spindle for the creation of radial holes

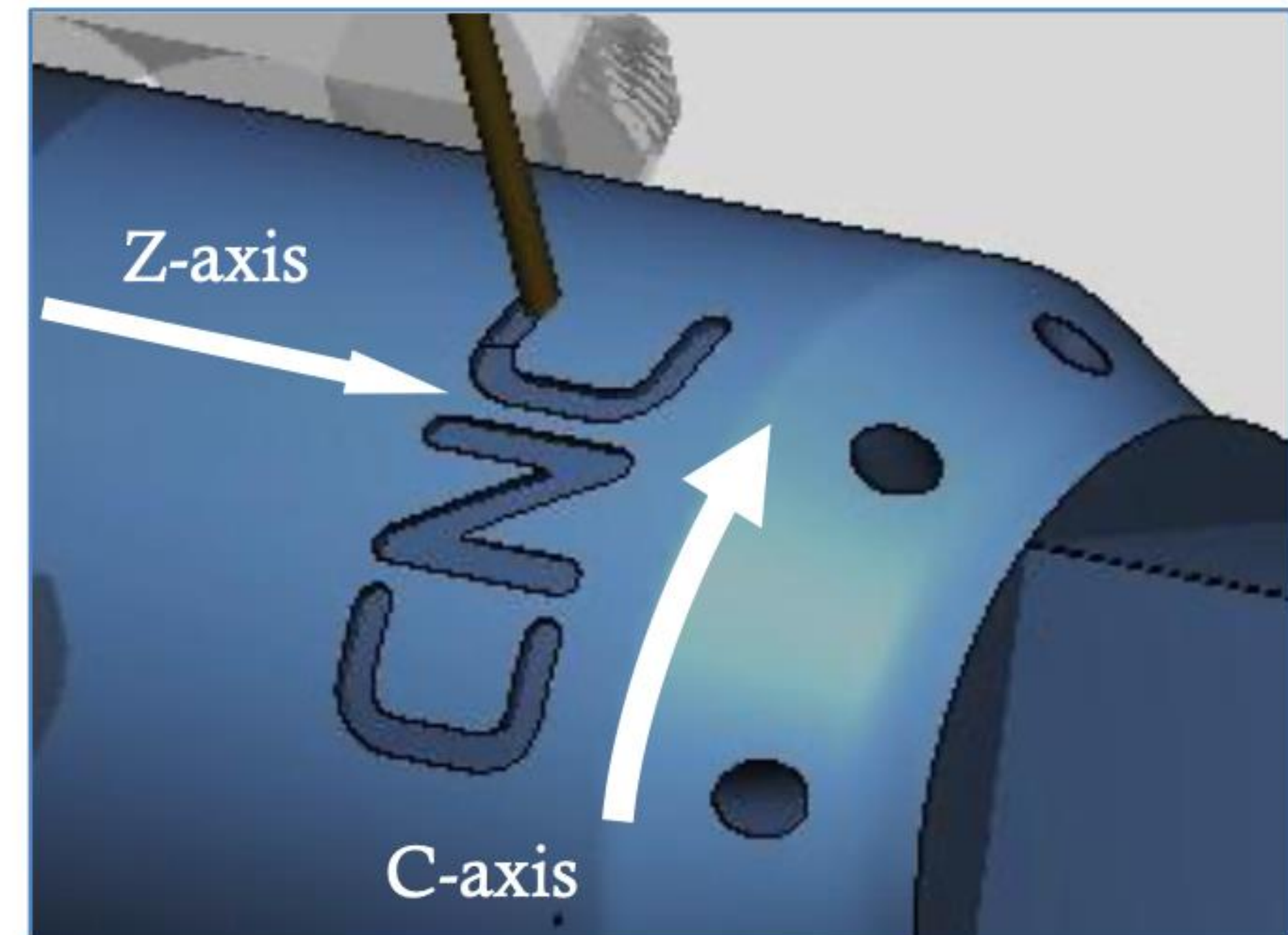


Fig. 20. Example of a cylindrical interpolation C-Z





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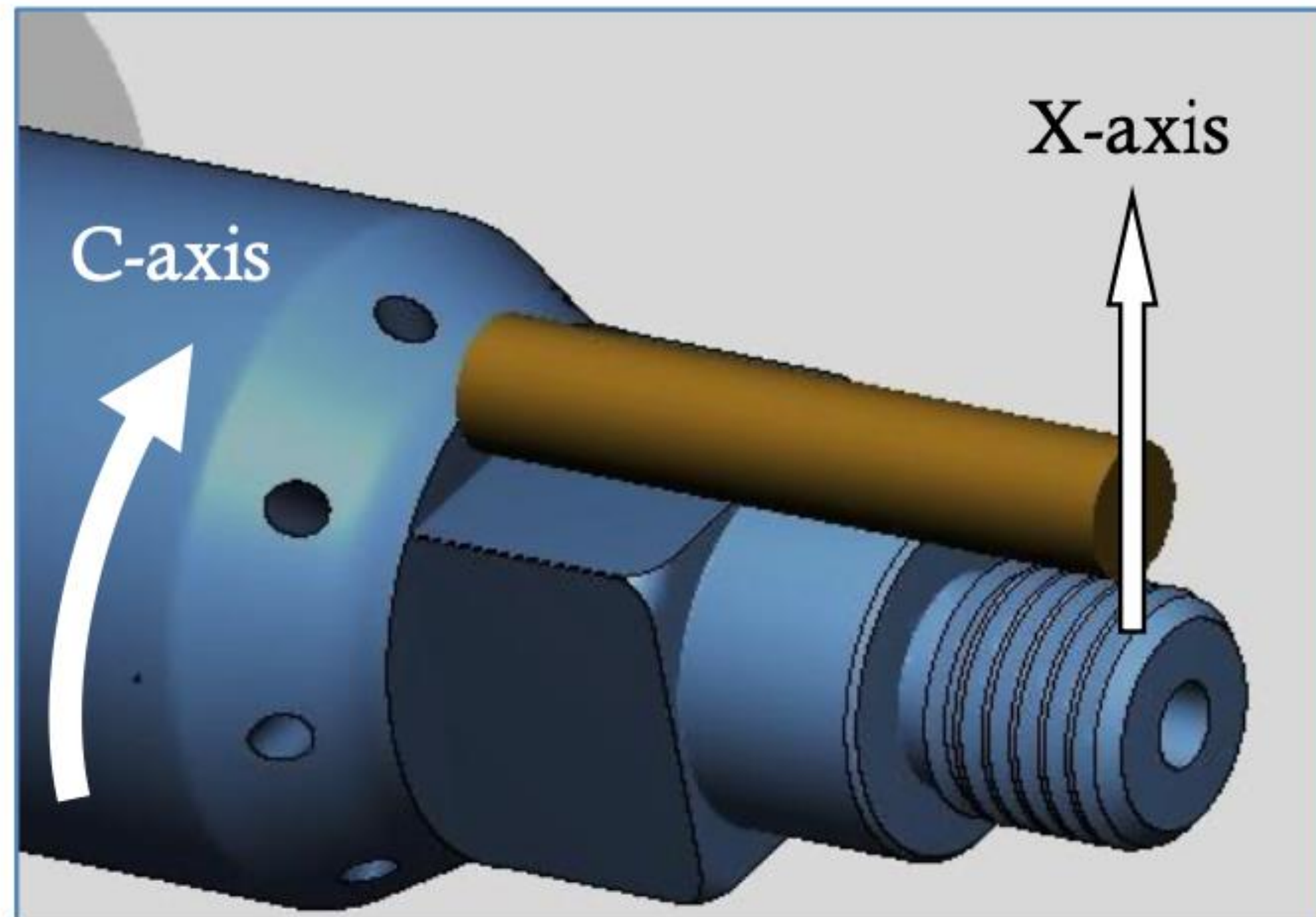


Fig. 21. Example of a frontal interpolation C-X

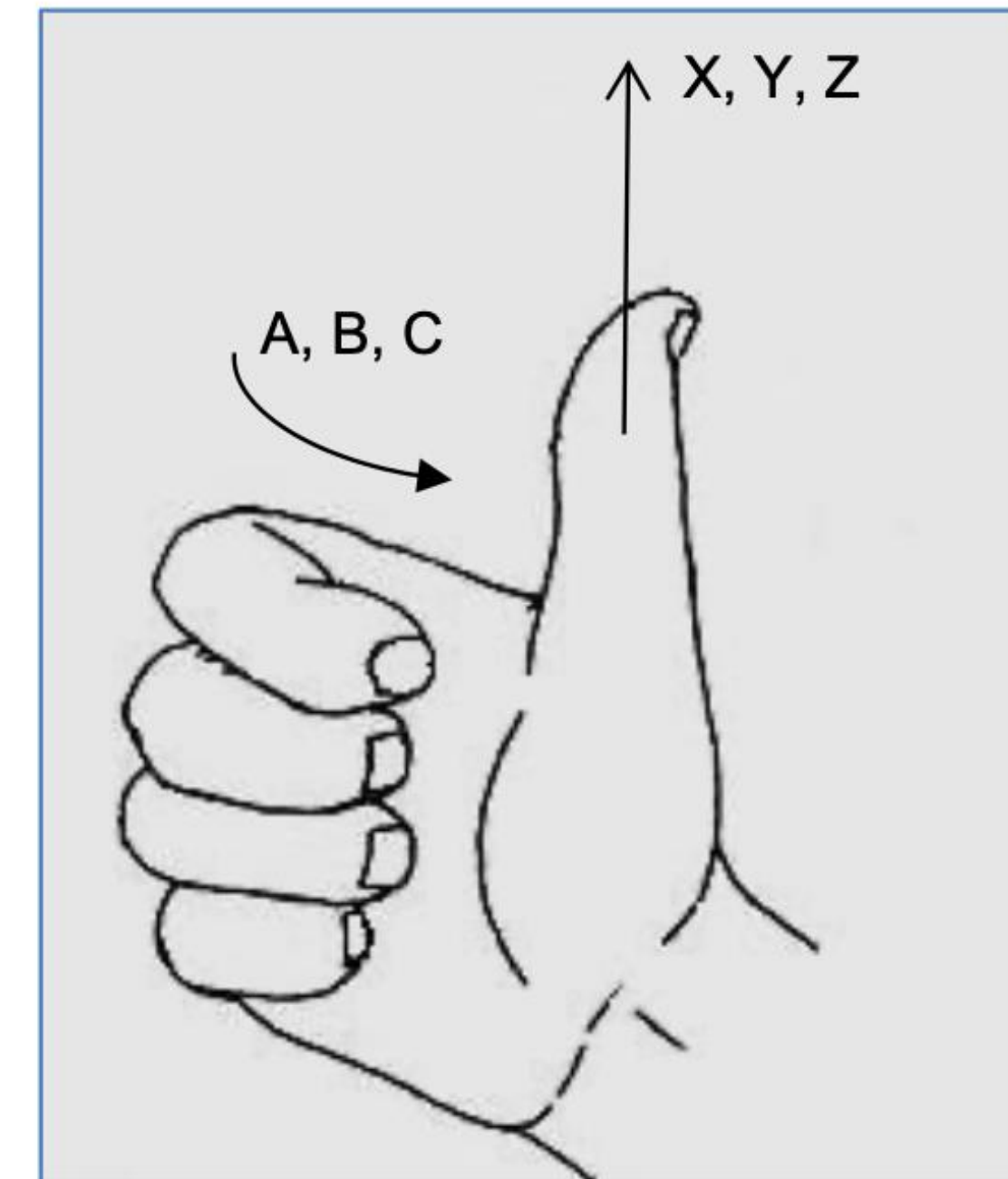


Fig. 22. Right-hand rule to determine the positive motion of the rotating axes





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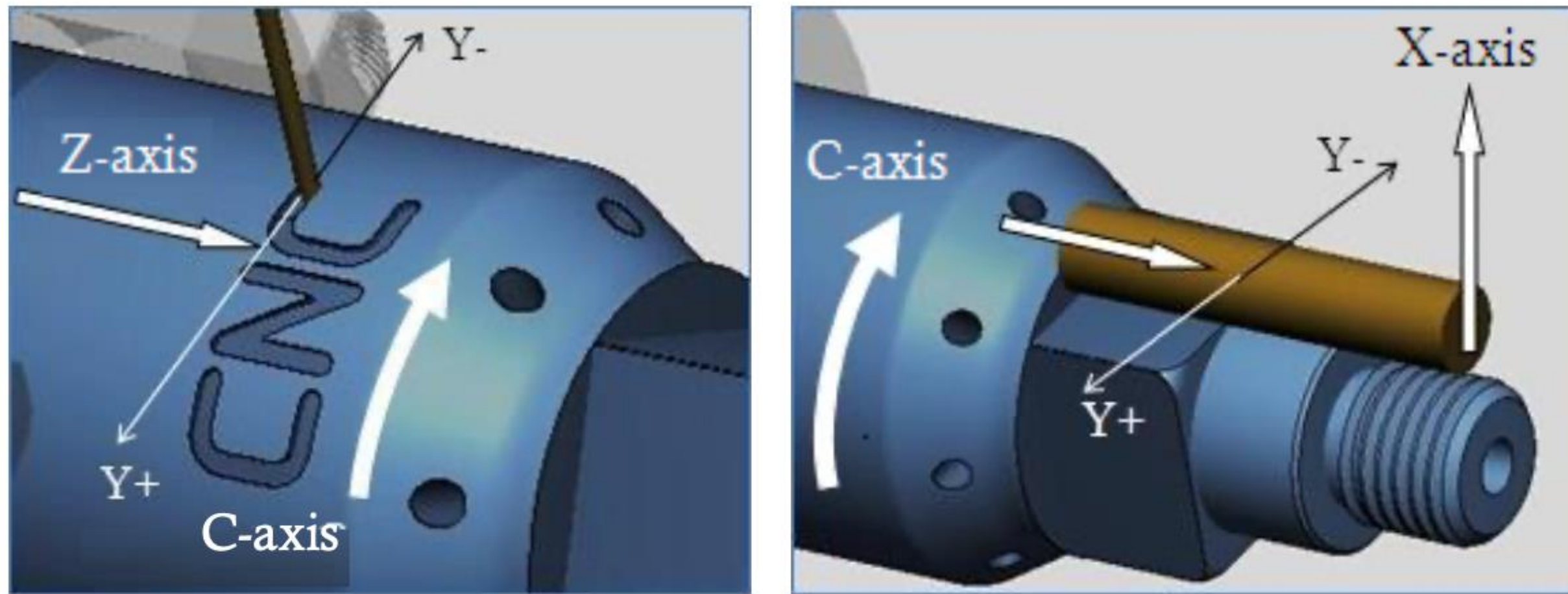


Fig. 23. C-axis positive programming direction and real movement of the workpiece

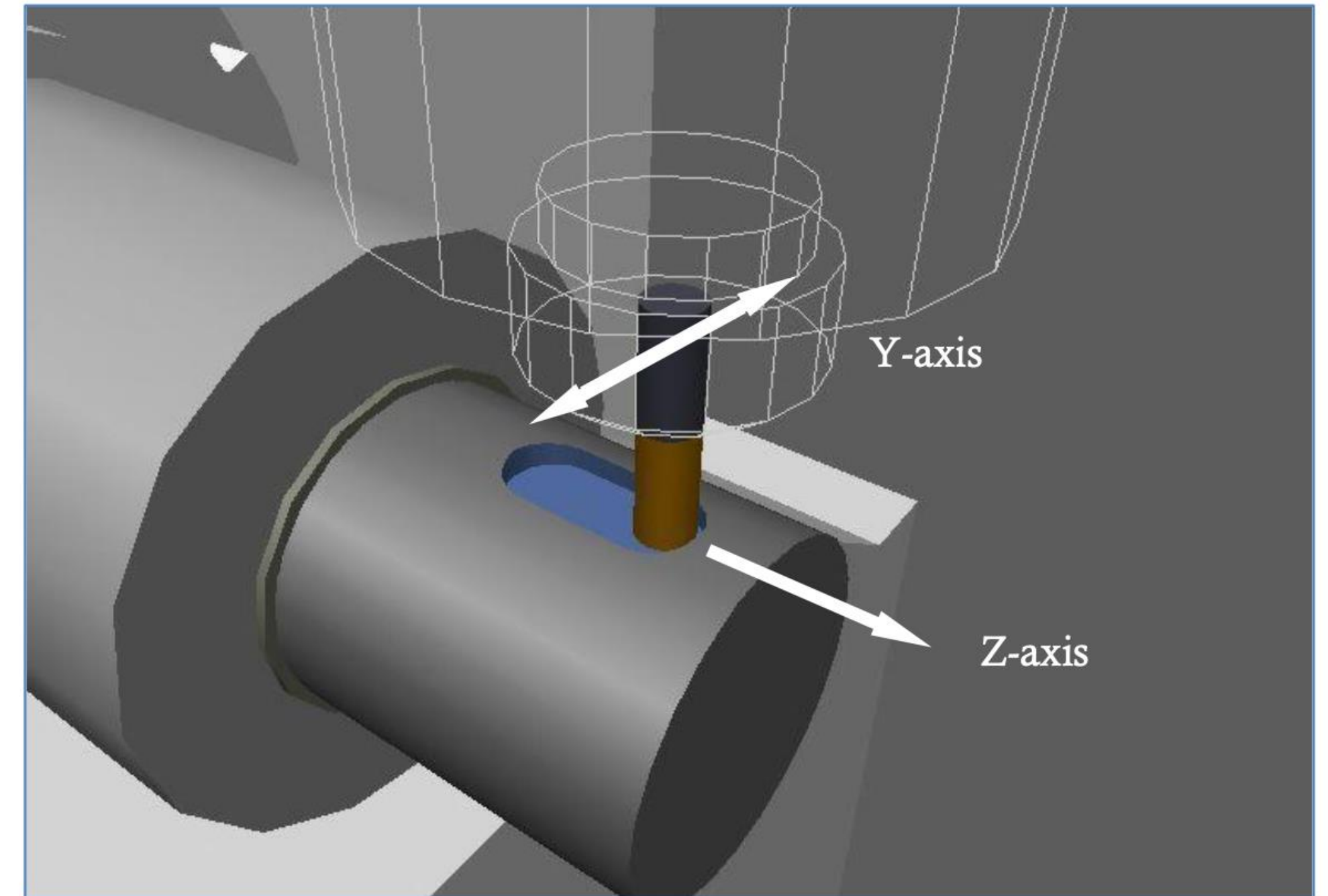


Fig. 24. Milling of a key using the real Y-axis





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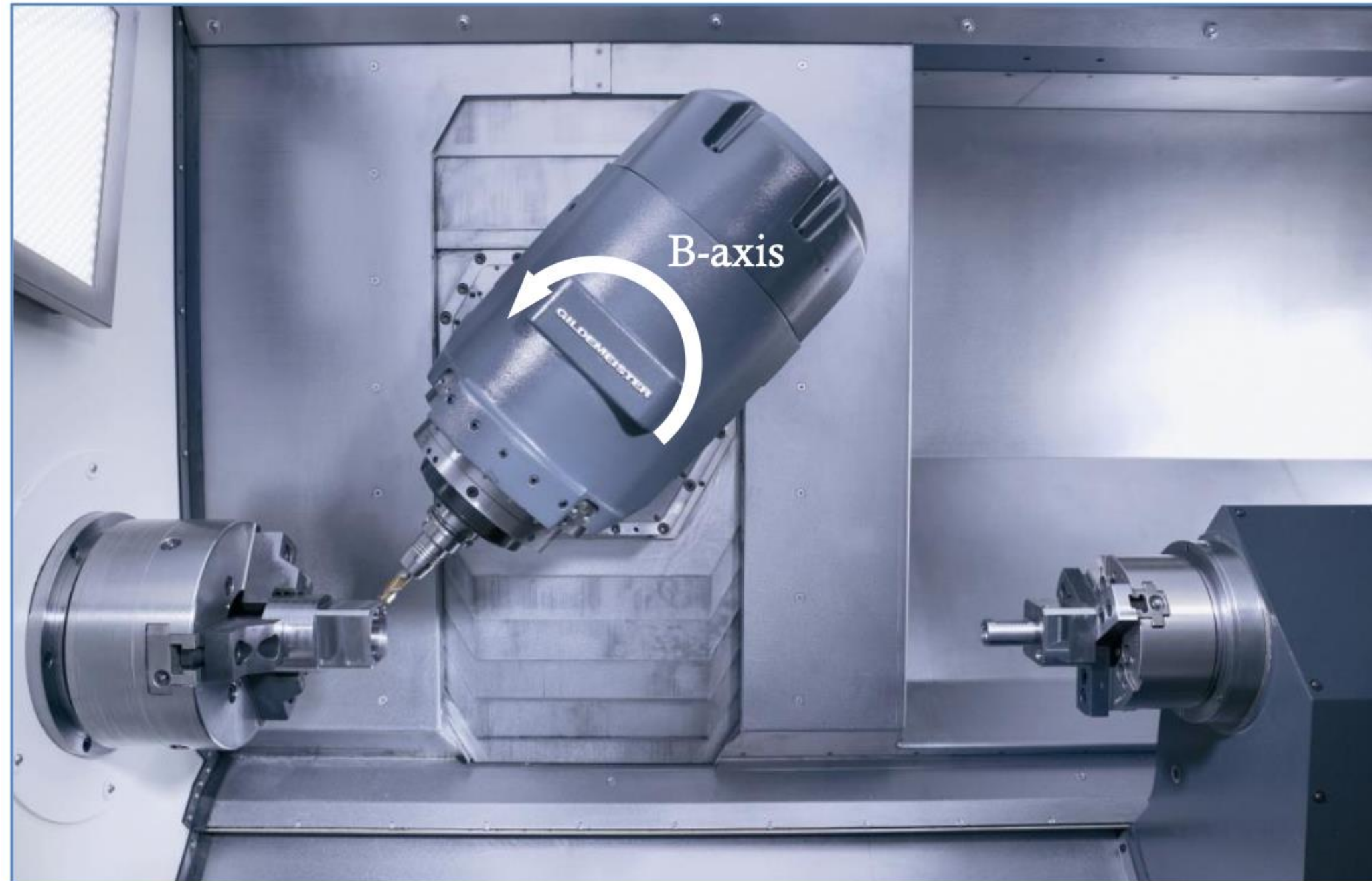


Fig. 25. Universal lathe with B-axis

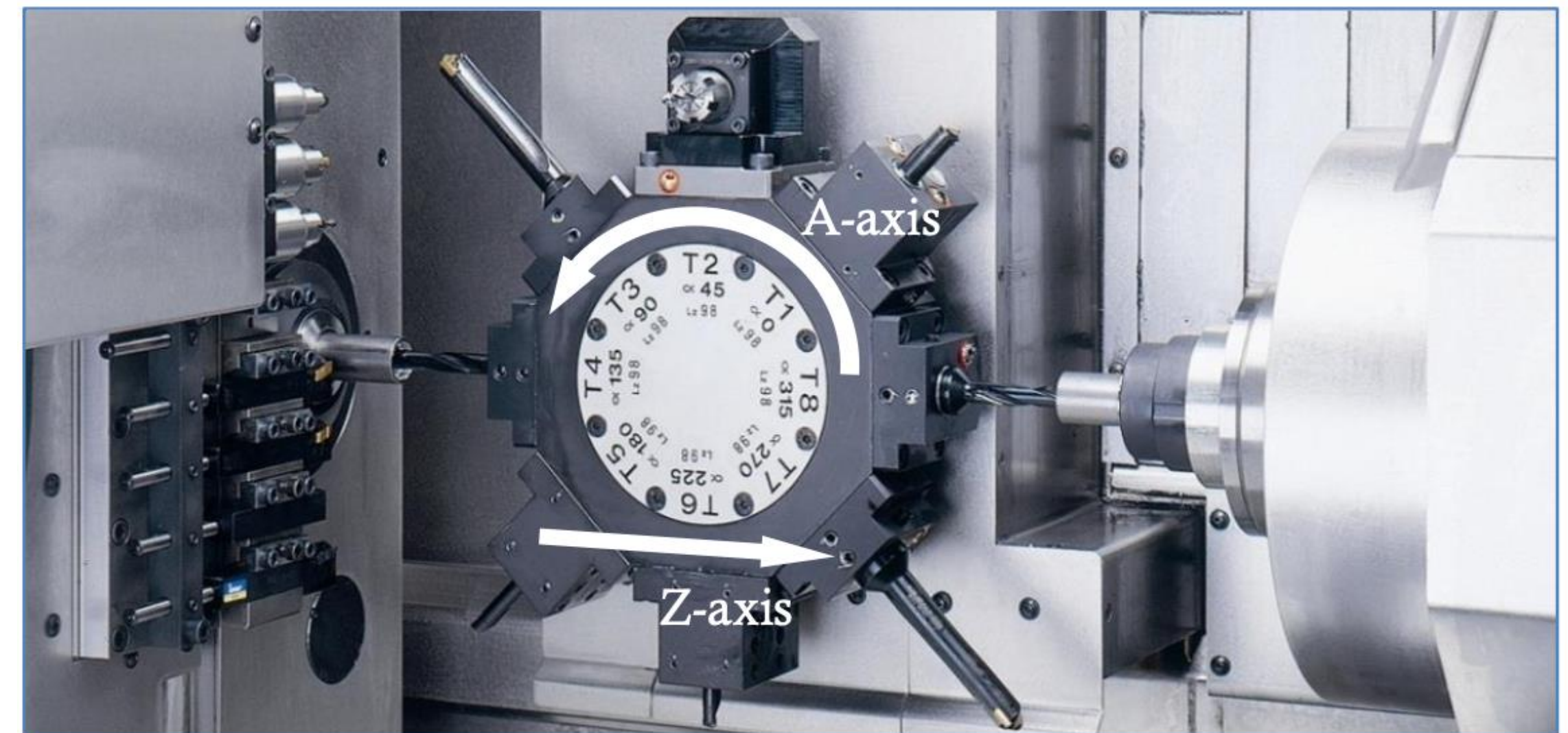
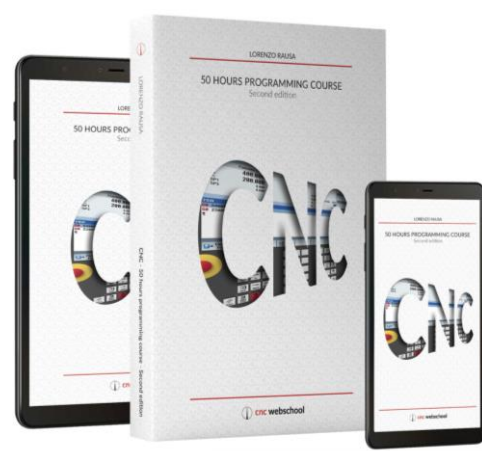


Fig. 26. Lathe with A-axis





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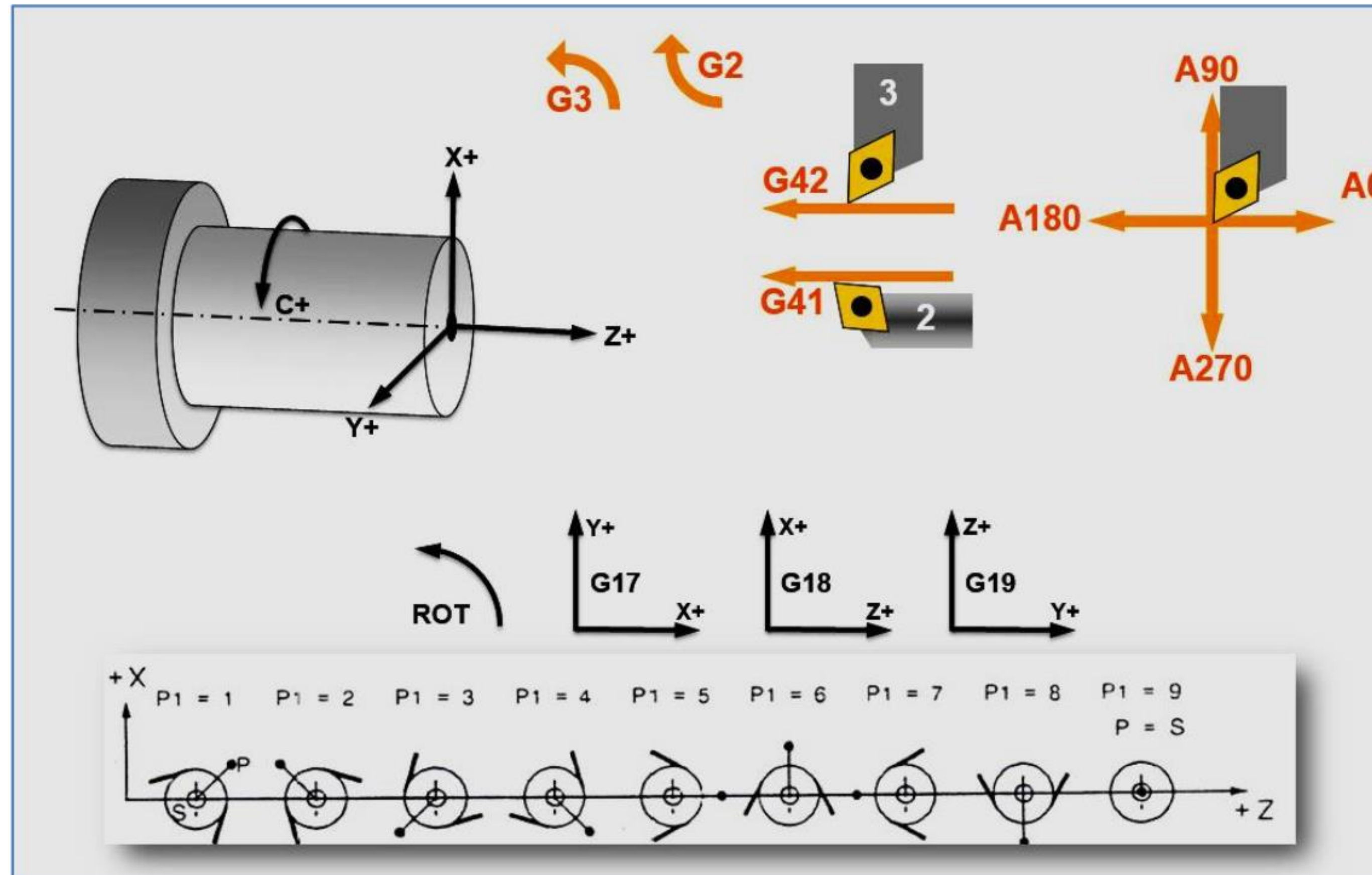
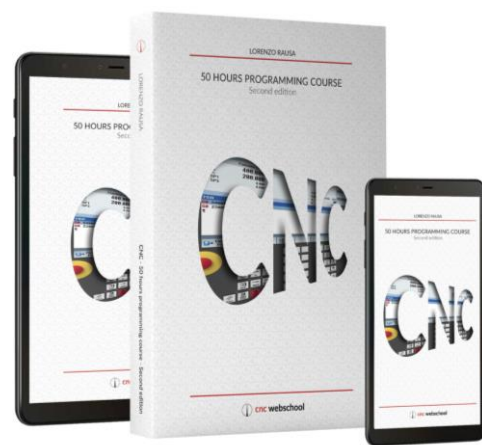


Fig. 27. Programming scheme





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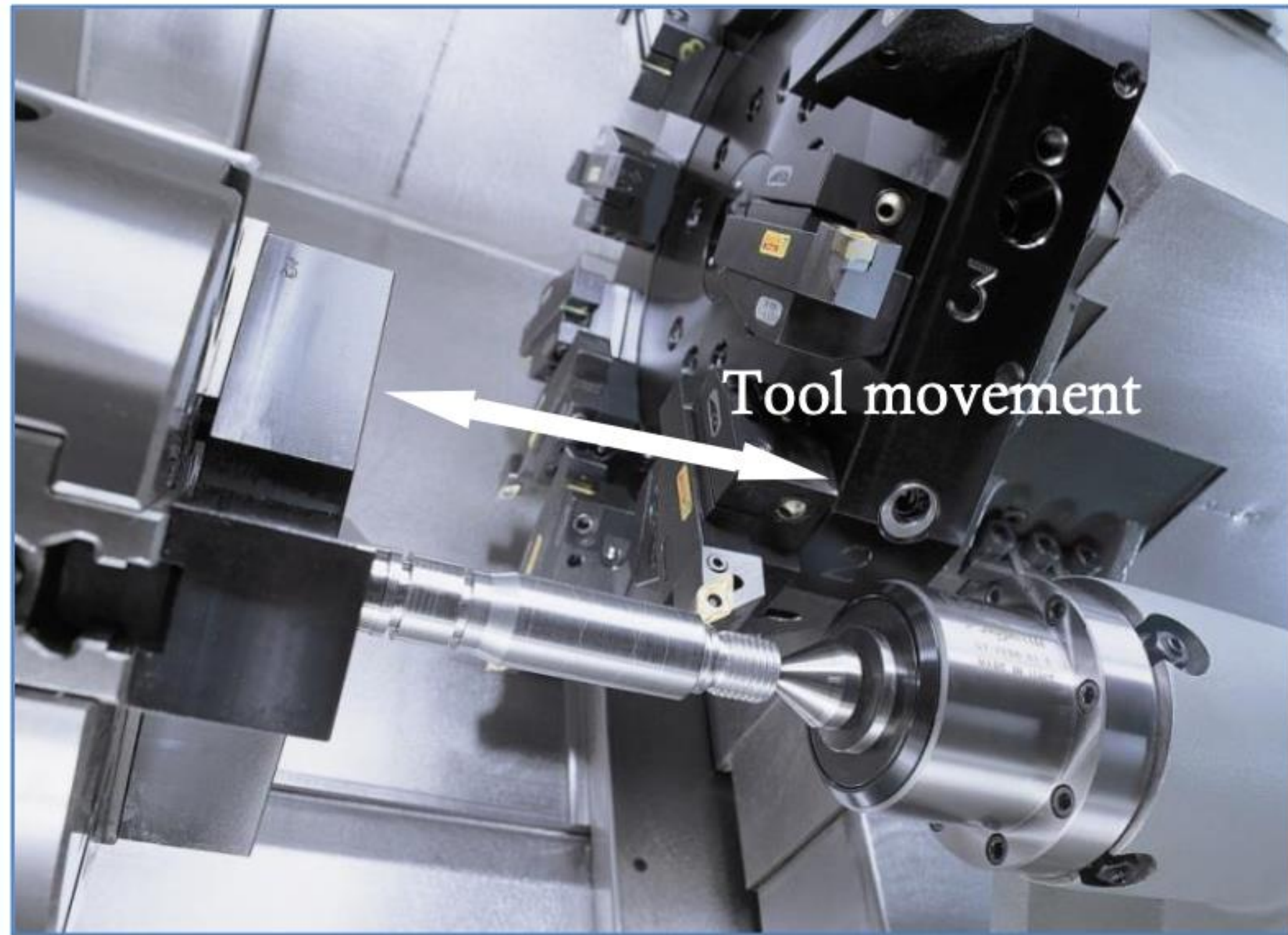


Fig. 28. Traditional lathe where the tool moves on the workpiece

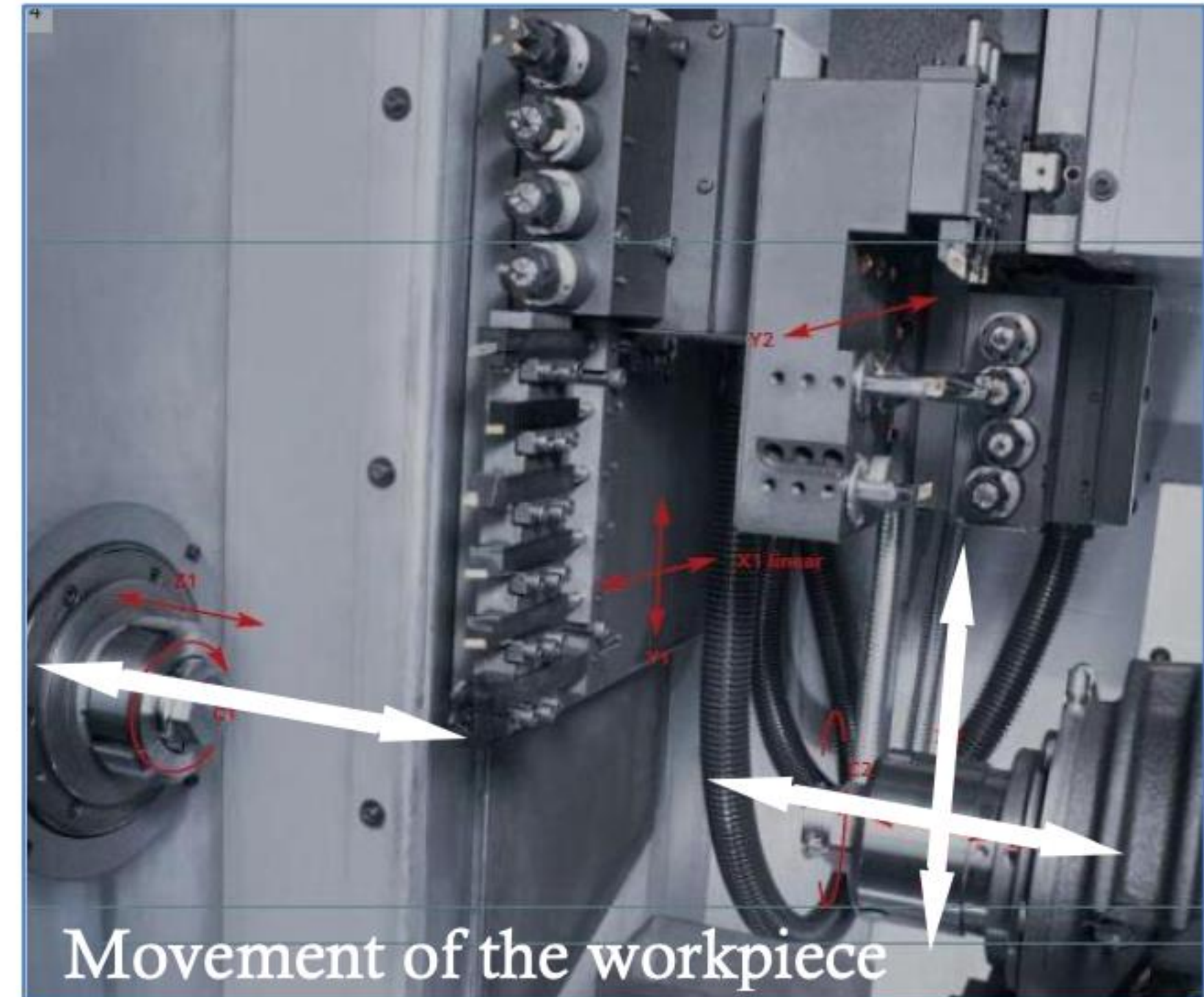


Fig. 29. Lathe with real movement of the Z-axis and of the X-axis on the workpiece





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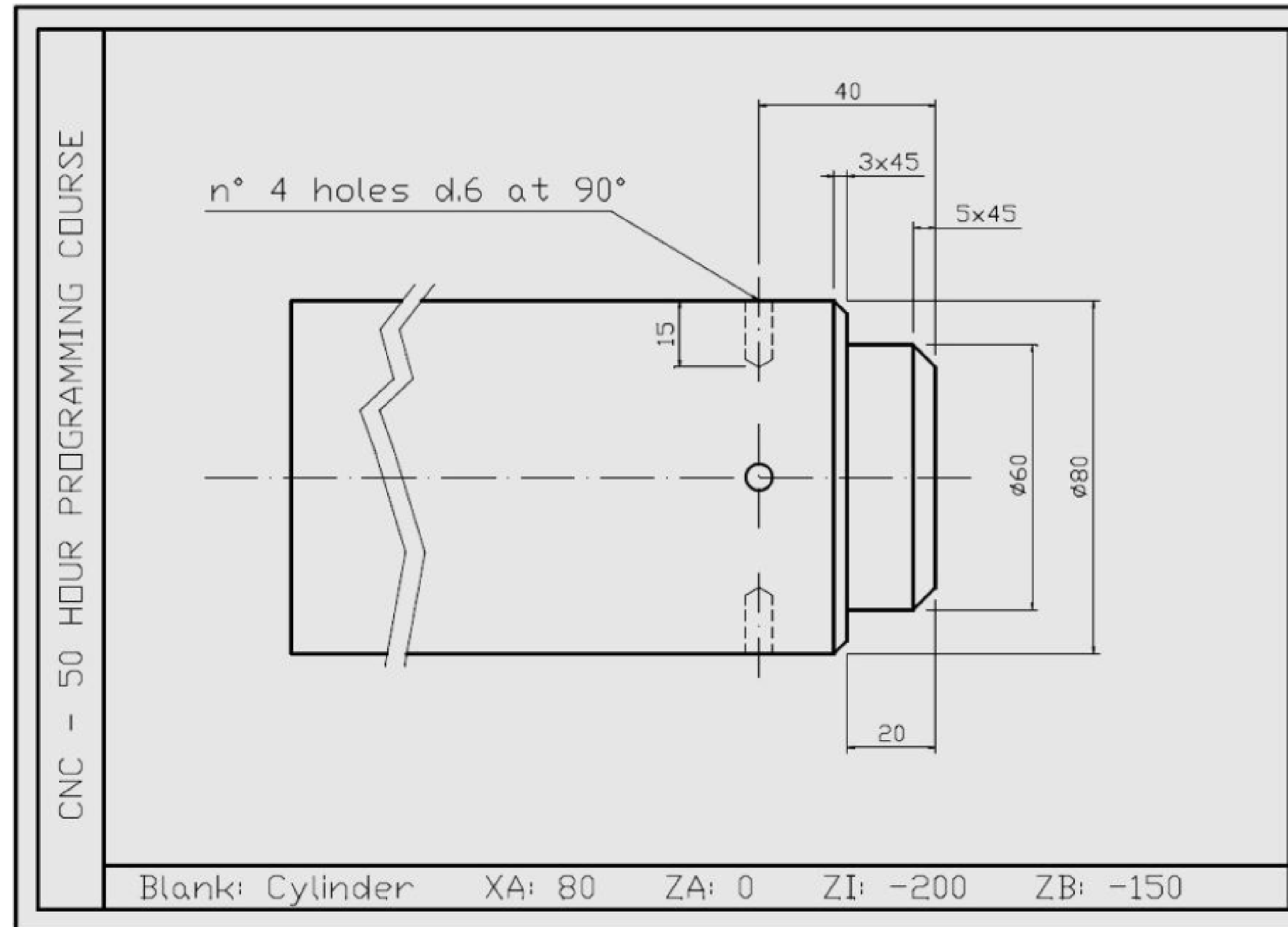
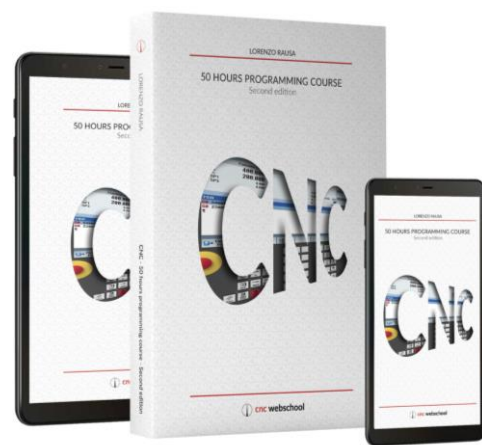


Fig. 30. Technical drawing created by the program PRG\_04\_01





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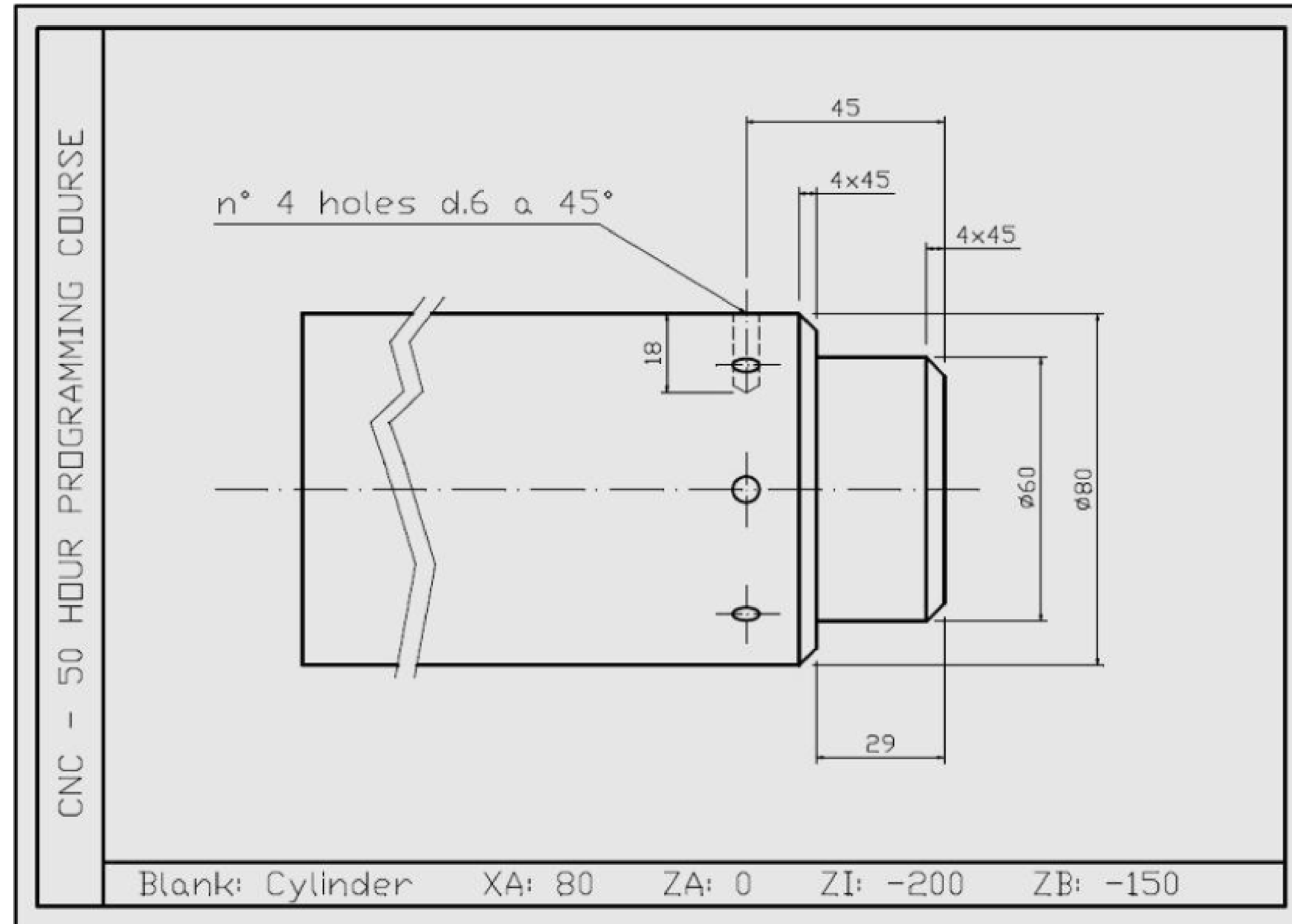
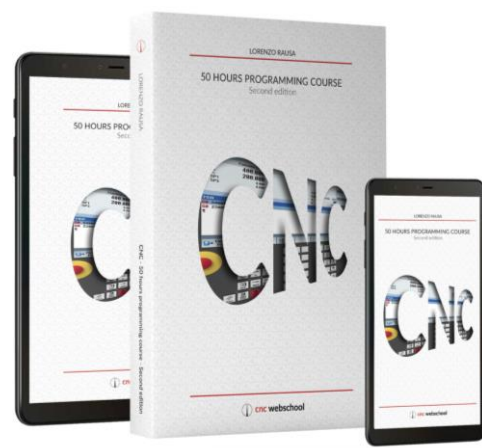


Fig. 31. Technical drawing of the part to create in program EX\_04\_01





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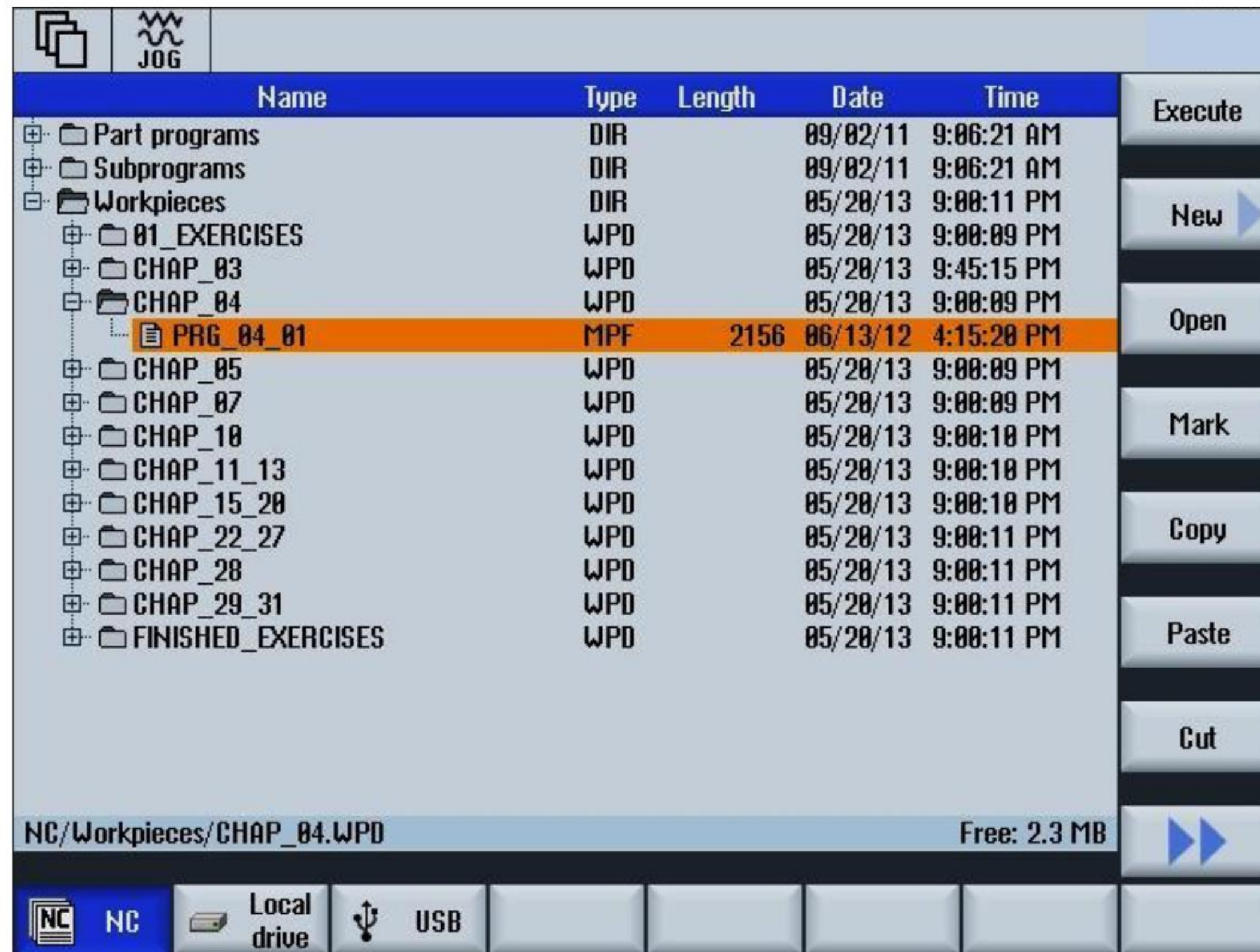


Fig. 32. Display of the PROGRAM MANAGER

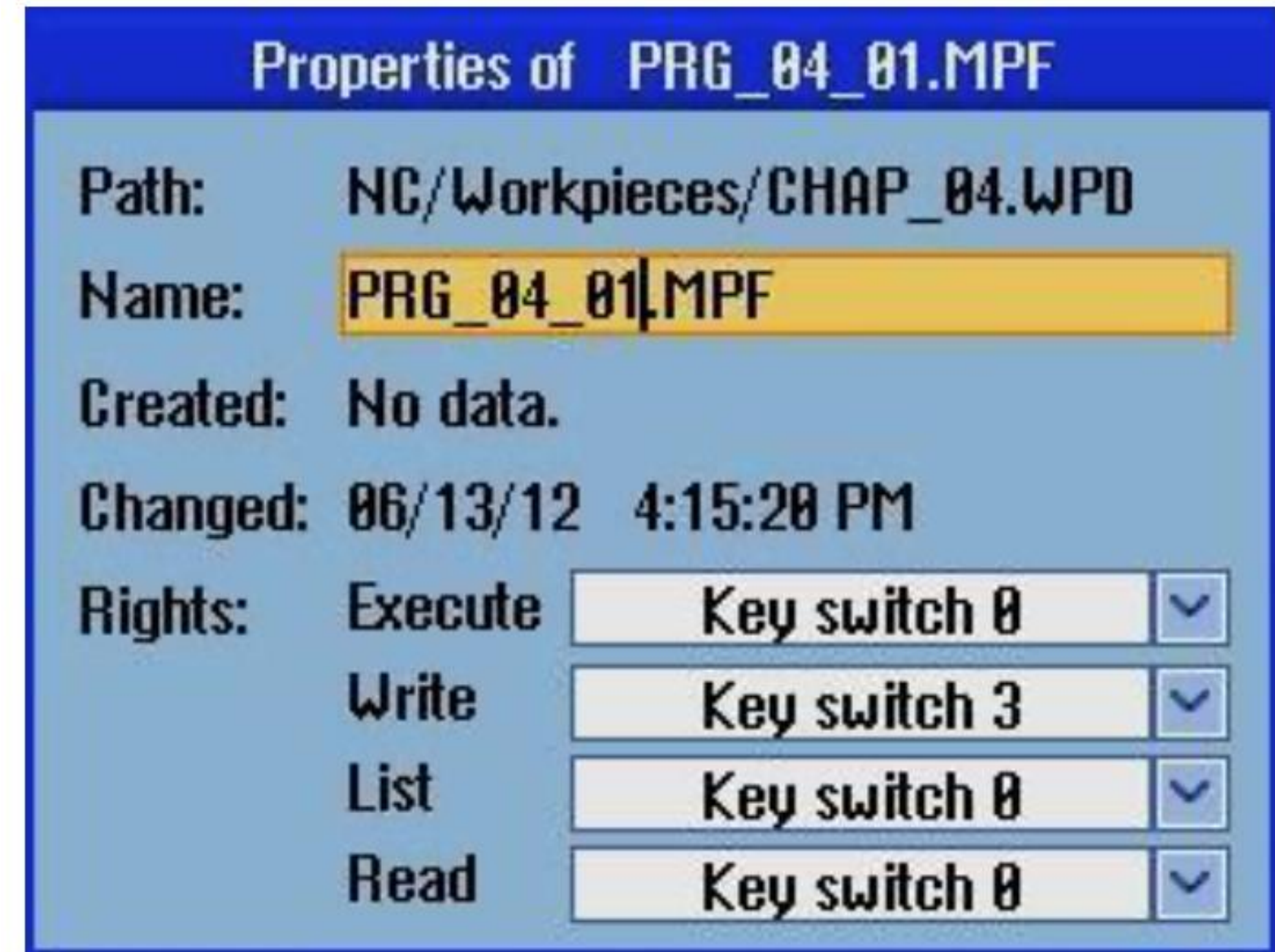
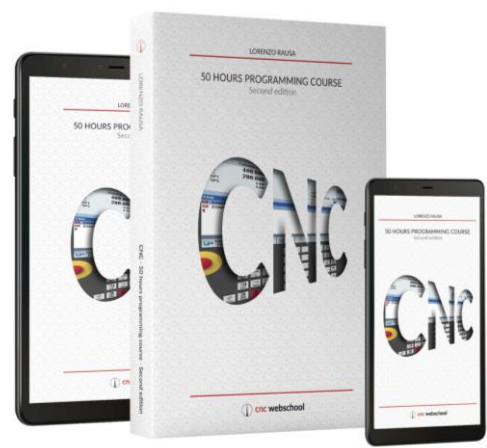


Fig. 33. File properties window





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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





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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





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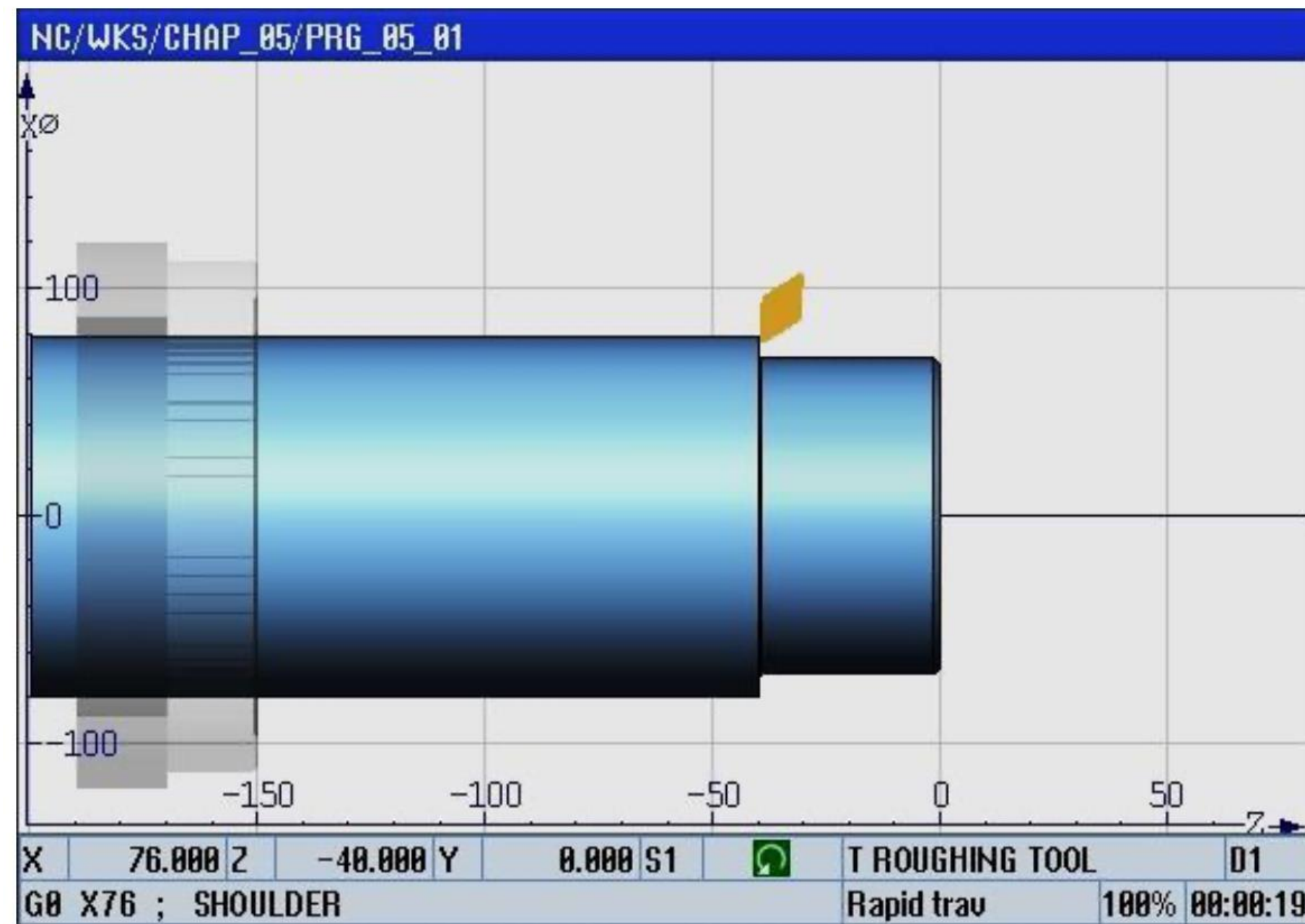


Fig. 46. Start of the simulation in order to analyze the program

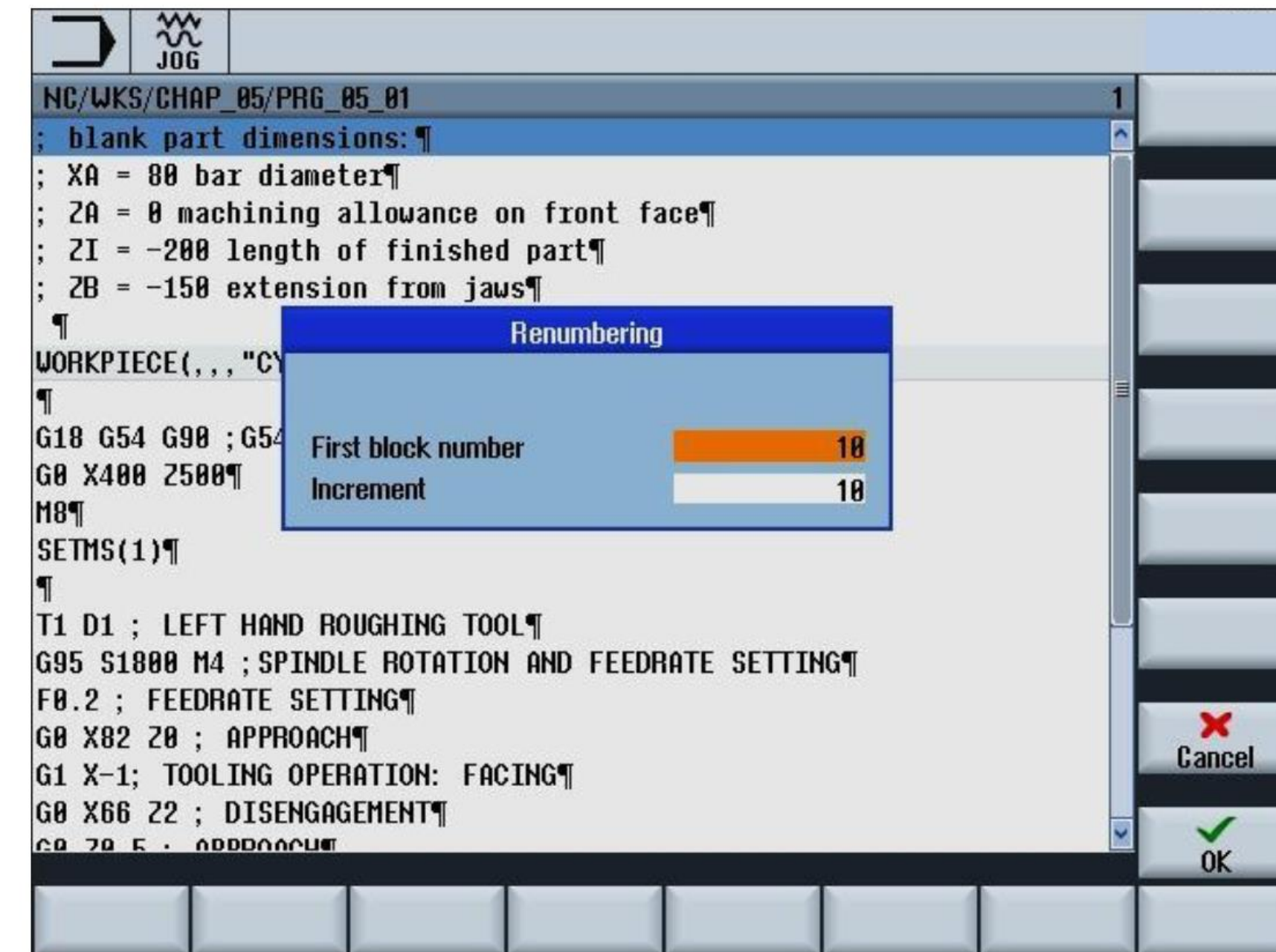


Fig. 47. Automatic block numbering screen





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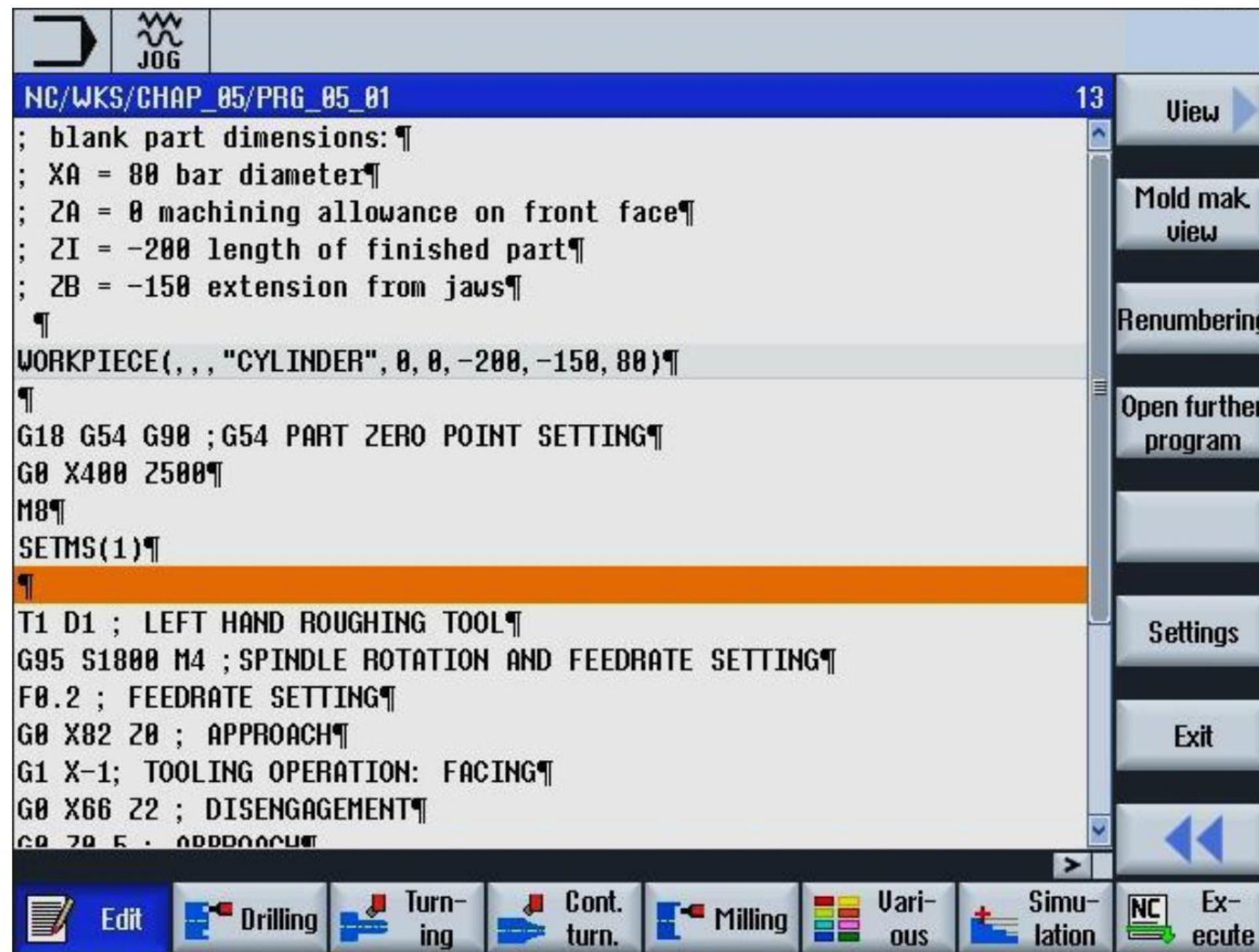


Fig. 48. Program without block numbers

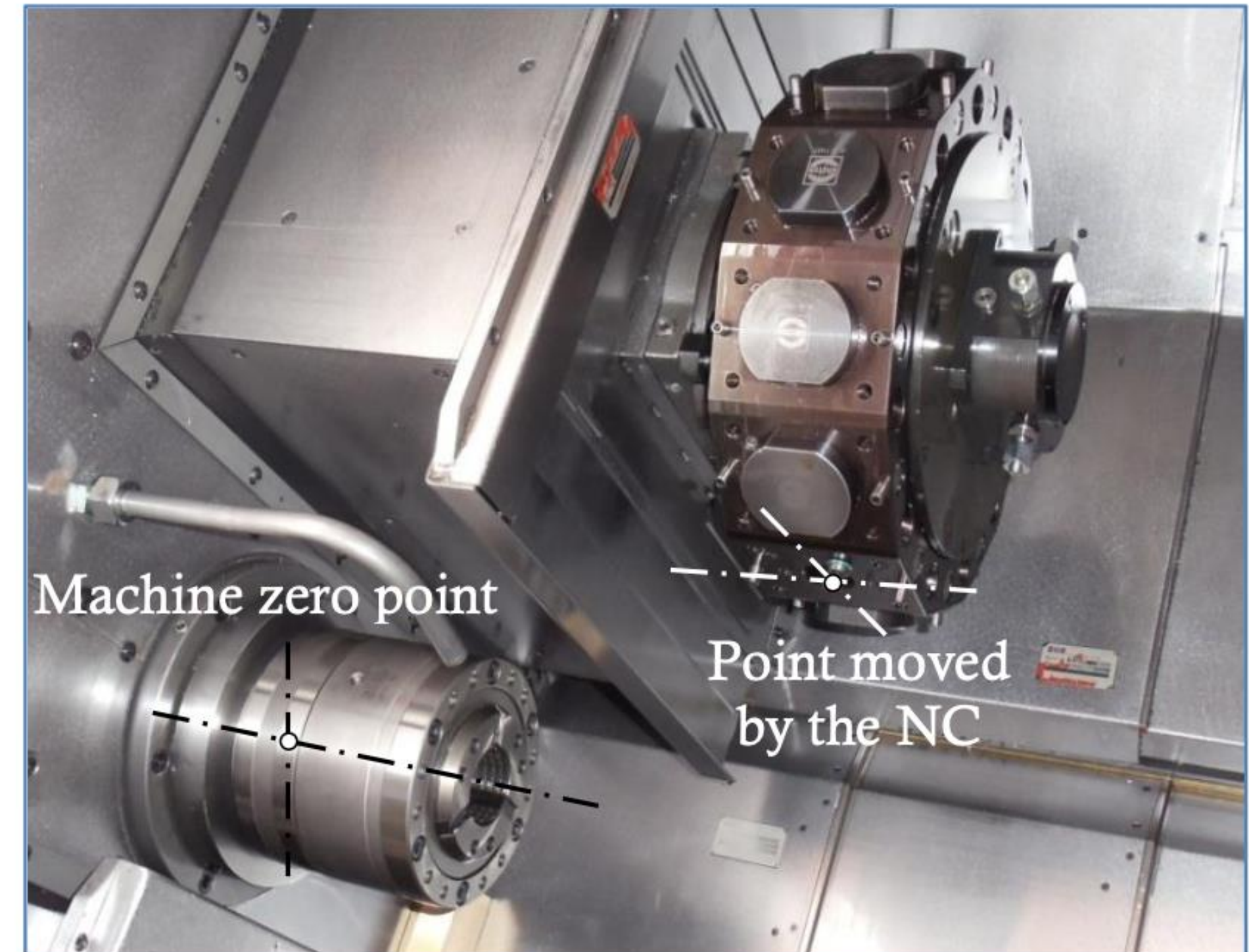


Fig. 49. Machine coordinate system: point moved by the NC referring to the machine zero point





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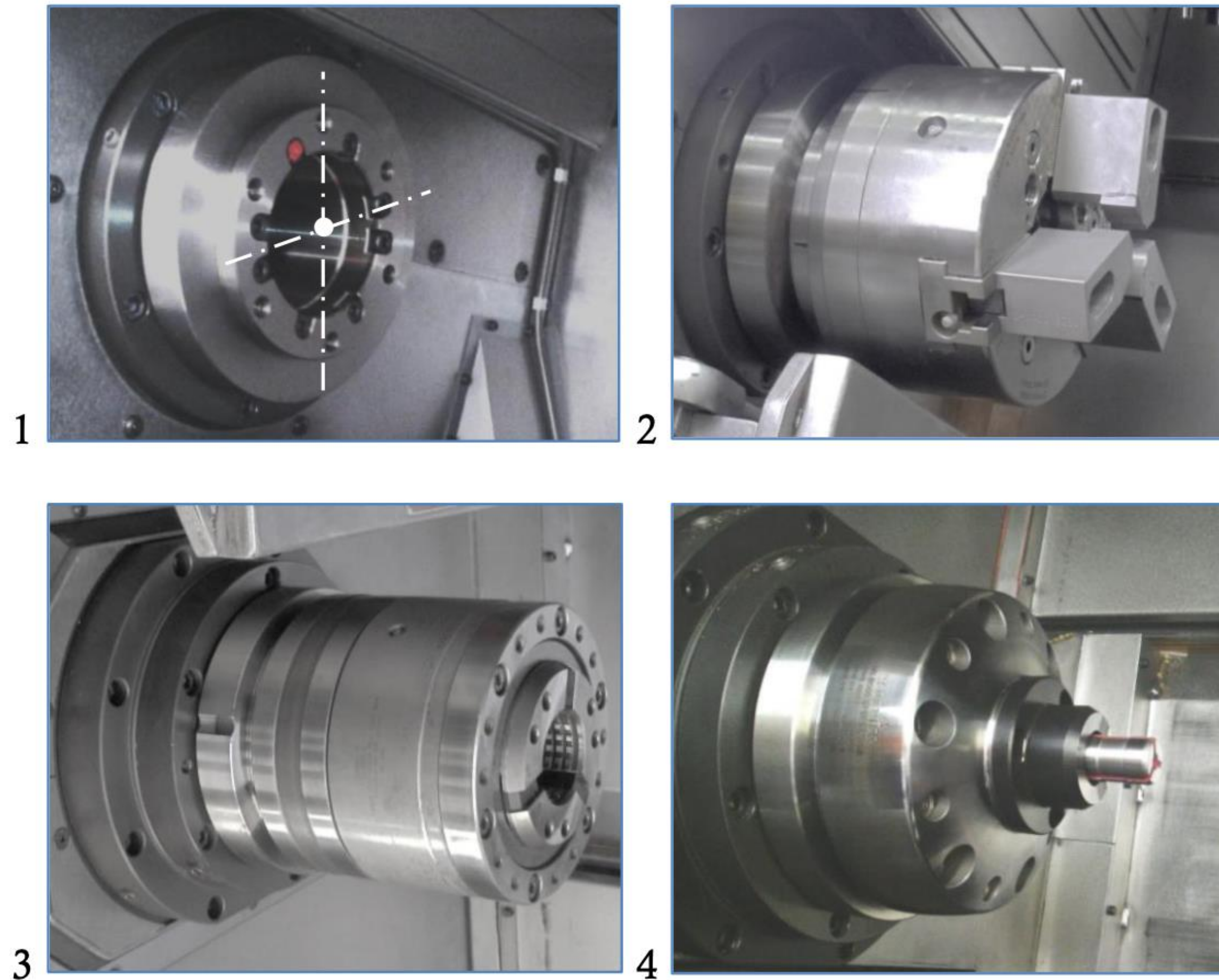
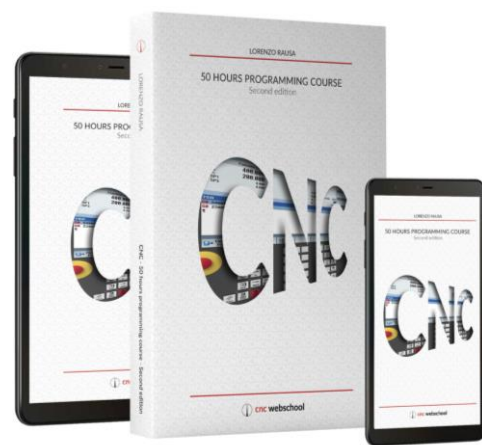


Fig. 50. 1: Spindle nose ; 2: chuck with three jaws ; 3: Elastic collet for external hold;  
4: Elastic expansion collet for internal hold of the workpiece





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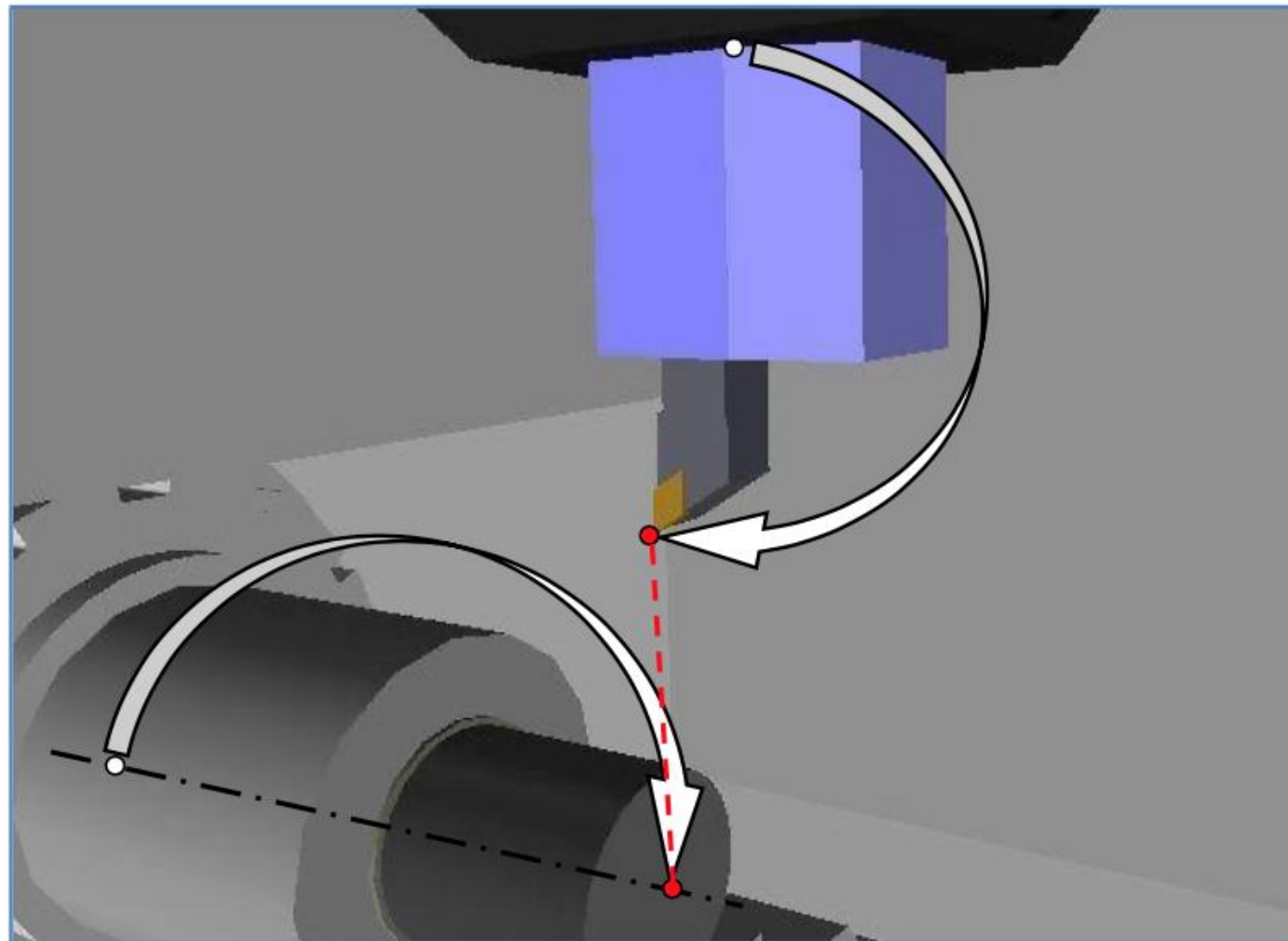


Fig. 51. Workpiece coordinate system: tool tip referring to the part zero point

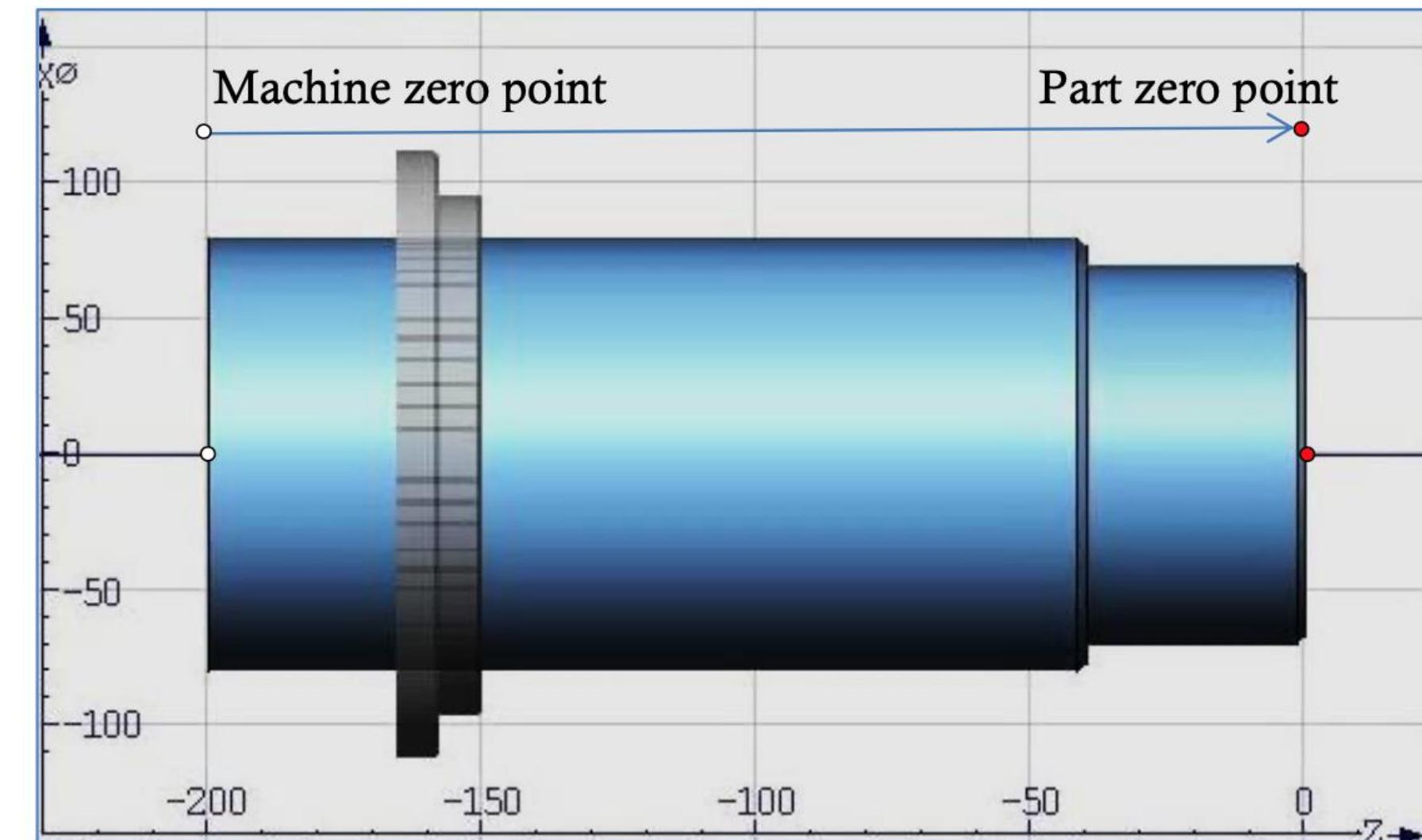


Fig. 52. Definition of the part zero point





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Work offset - G54 ... G57 [mm]

		X	Z	SP1	SP3	Workpiece zero p't
G54		0.000	200.000	0.000	0.000	
	Fine	0.000	0.000	0.000	0.000	Active
G55		0.000	0.000	0.000	0.000	
	Fine	0.000	0.000	0.000	0.000	Overview
G56		0.000	0.000	0.000	0.000	
	Fine	0.000	0.000	0.000	0.000	
G57		0.000	0.000	0.000	0.000	Base
	Fine	0.000	0.000	0.000	0.000	

Details

Tool list Tool wear Magazine Work offset User variable SD Setting data

Fig. 53. Table of work offsets

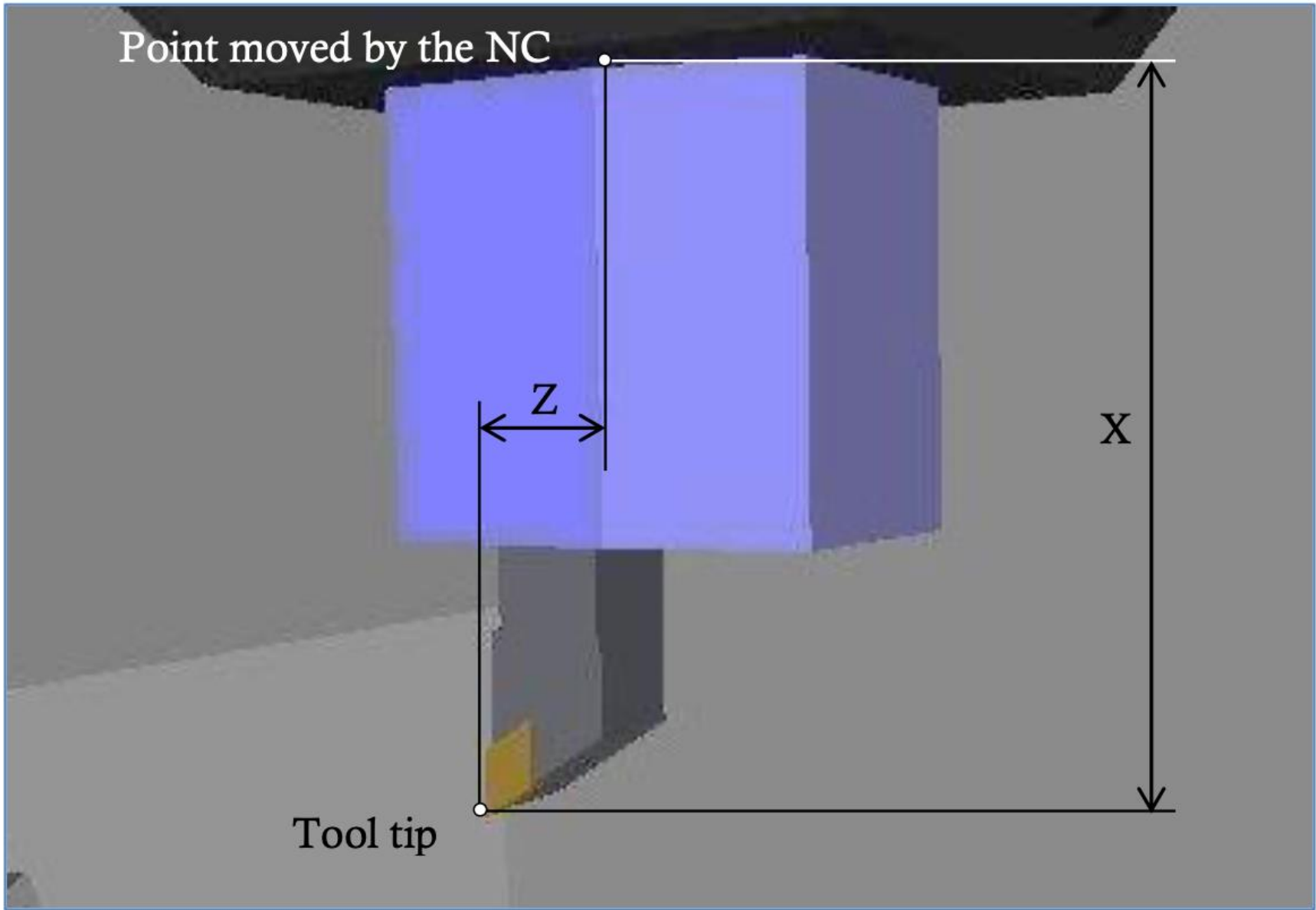


Fig. 54. Tool offset values





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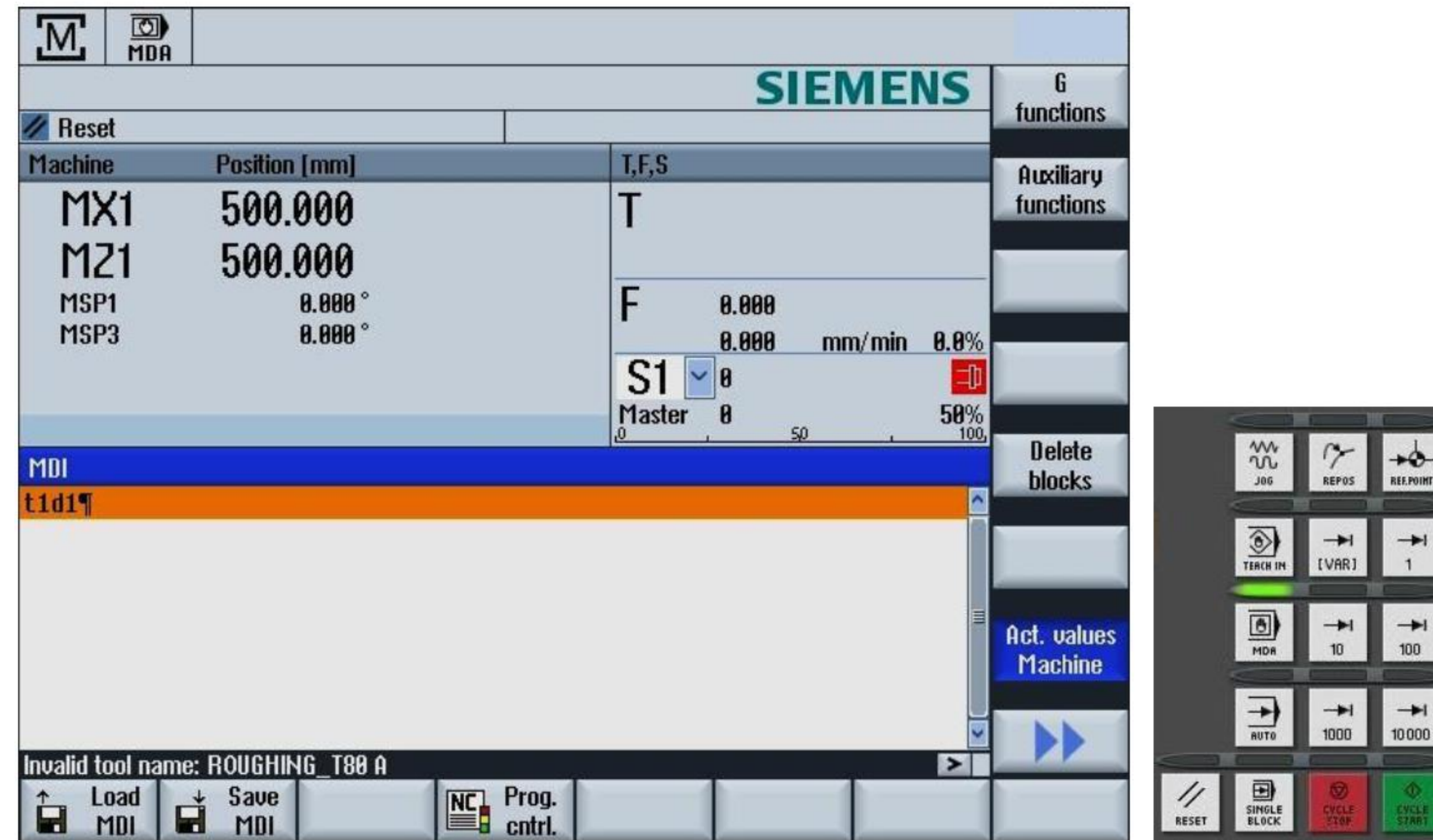
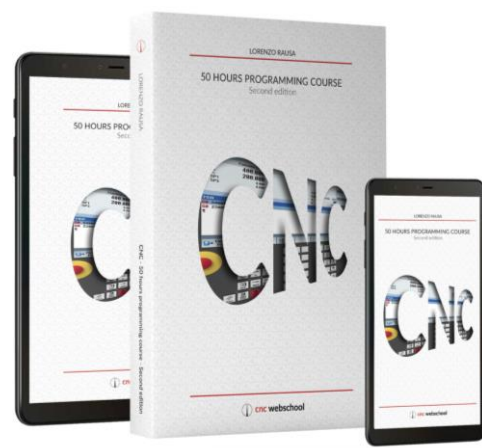


Fig. 55. Page for manual data entry



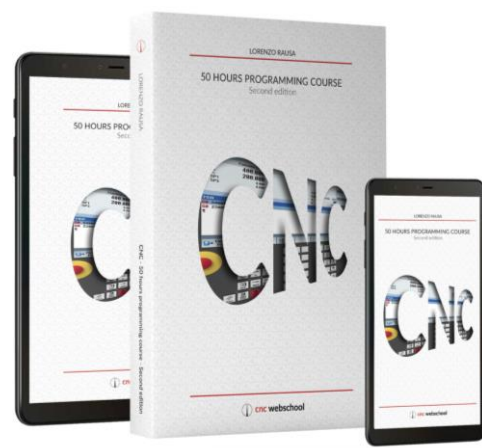


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Fig. 56. Buttons for the selection of the continuous manual feed





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

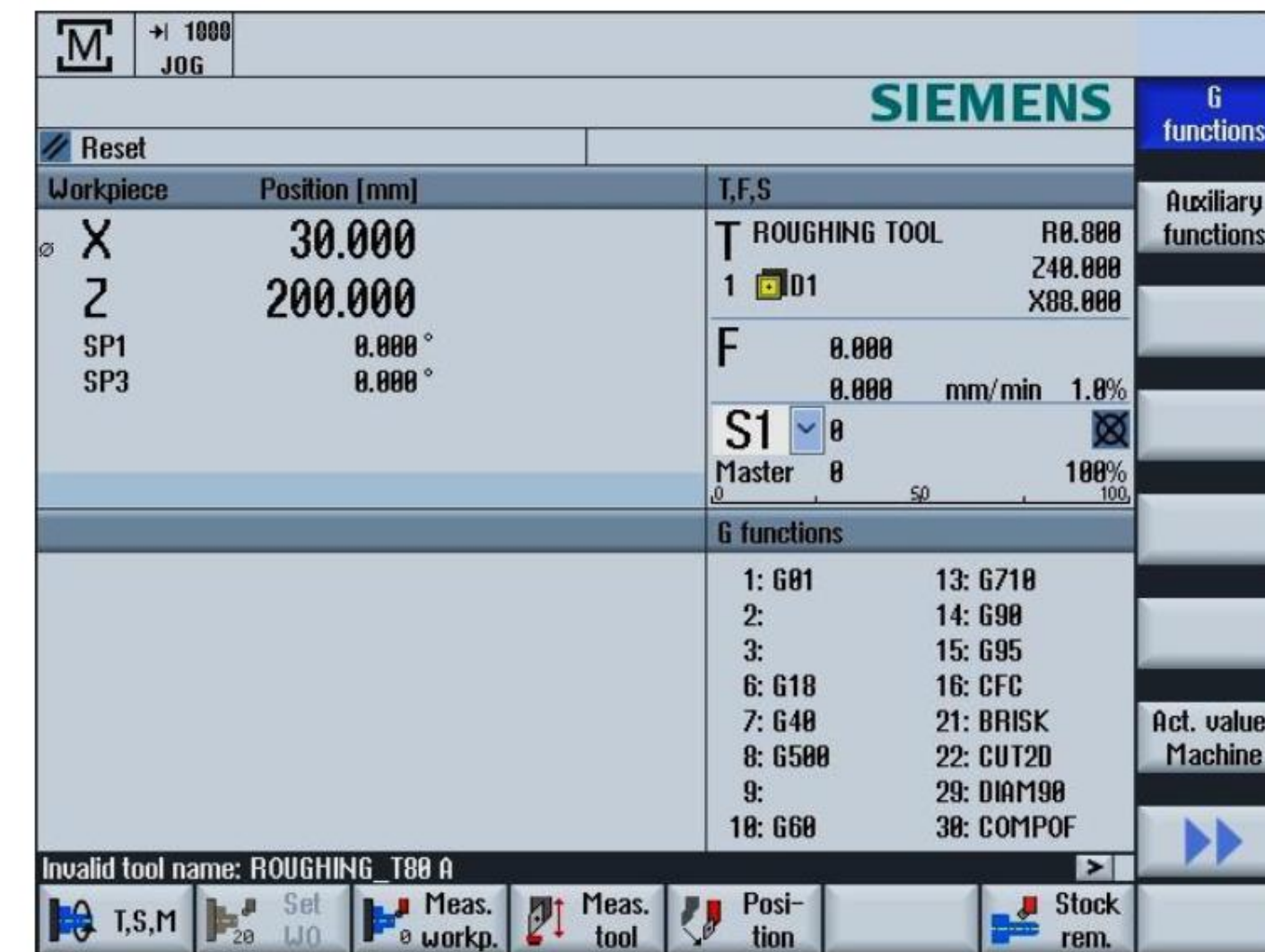


Fig. 58. Touch-off position of the part face in the workpiece coordinate system





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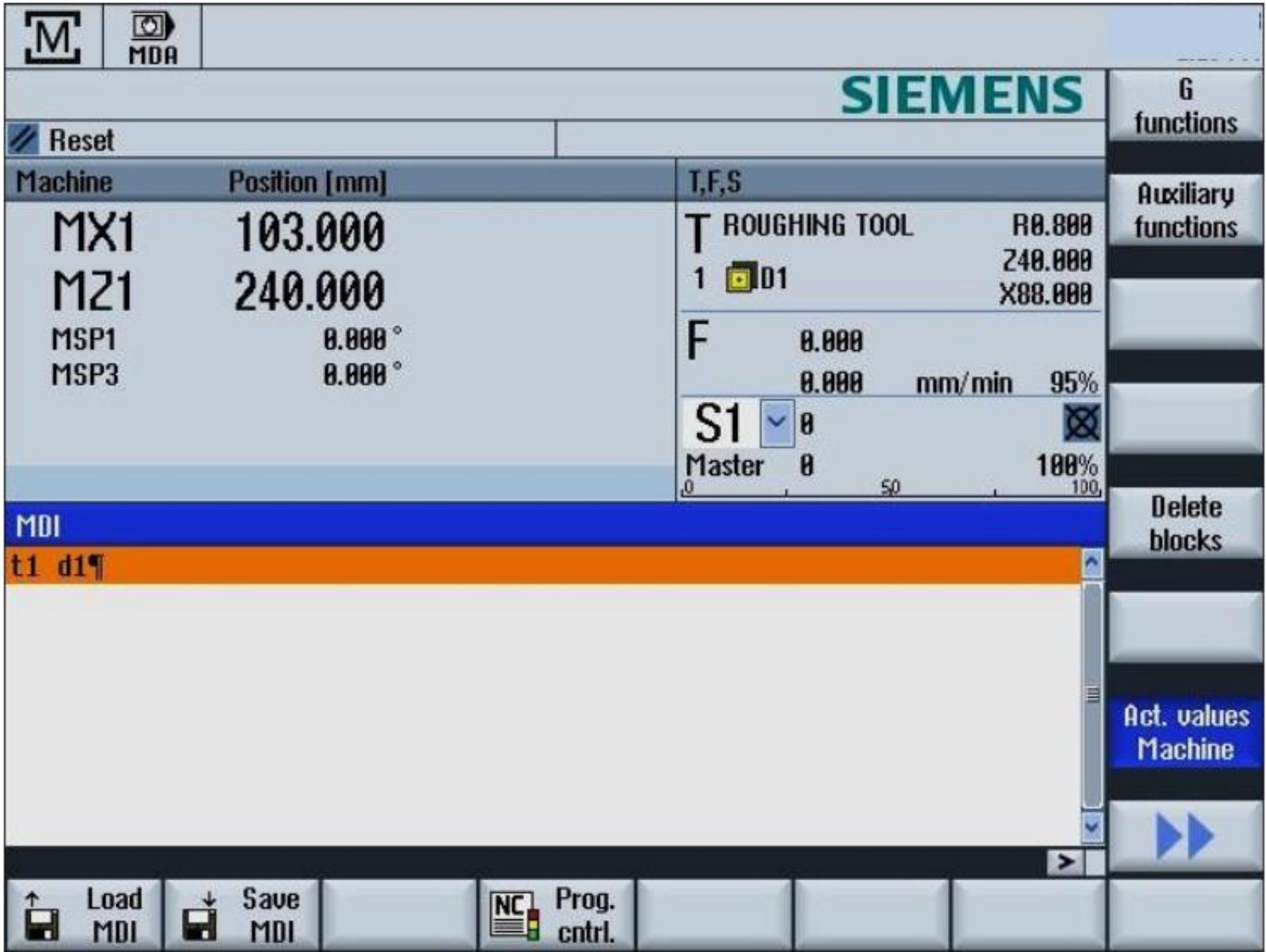


Fig. 59. Touch-off position of the part face in the machine coordinate system

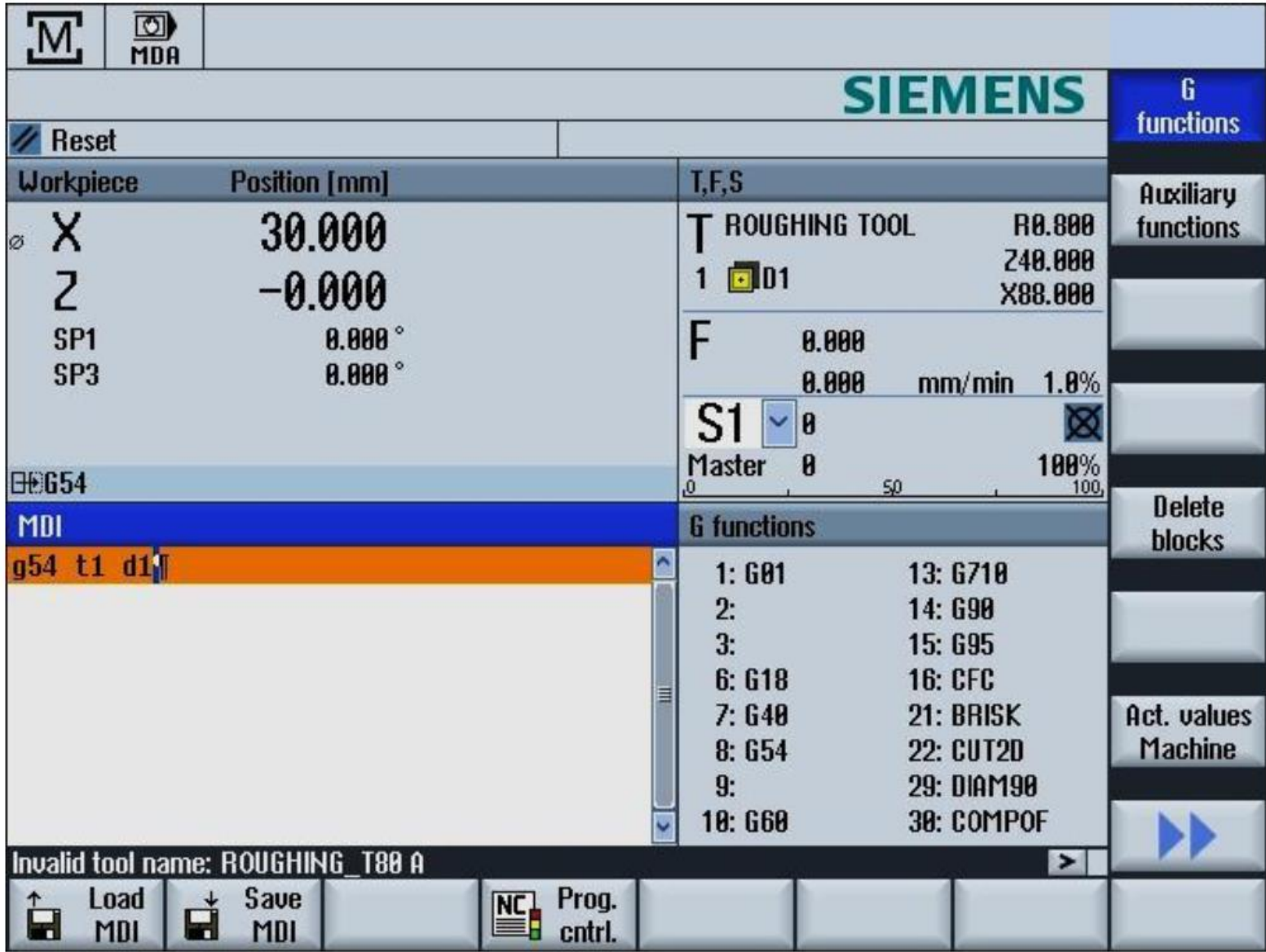


Fig. 60. Current position of the tool after activation of the workpiece coordinate system programmed in MDA





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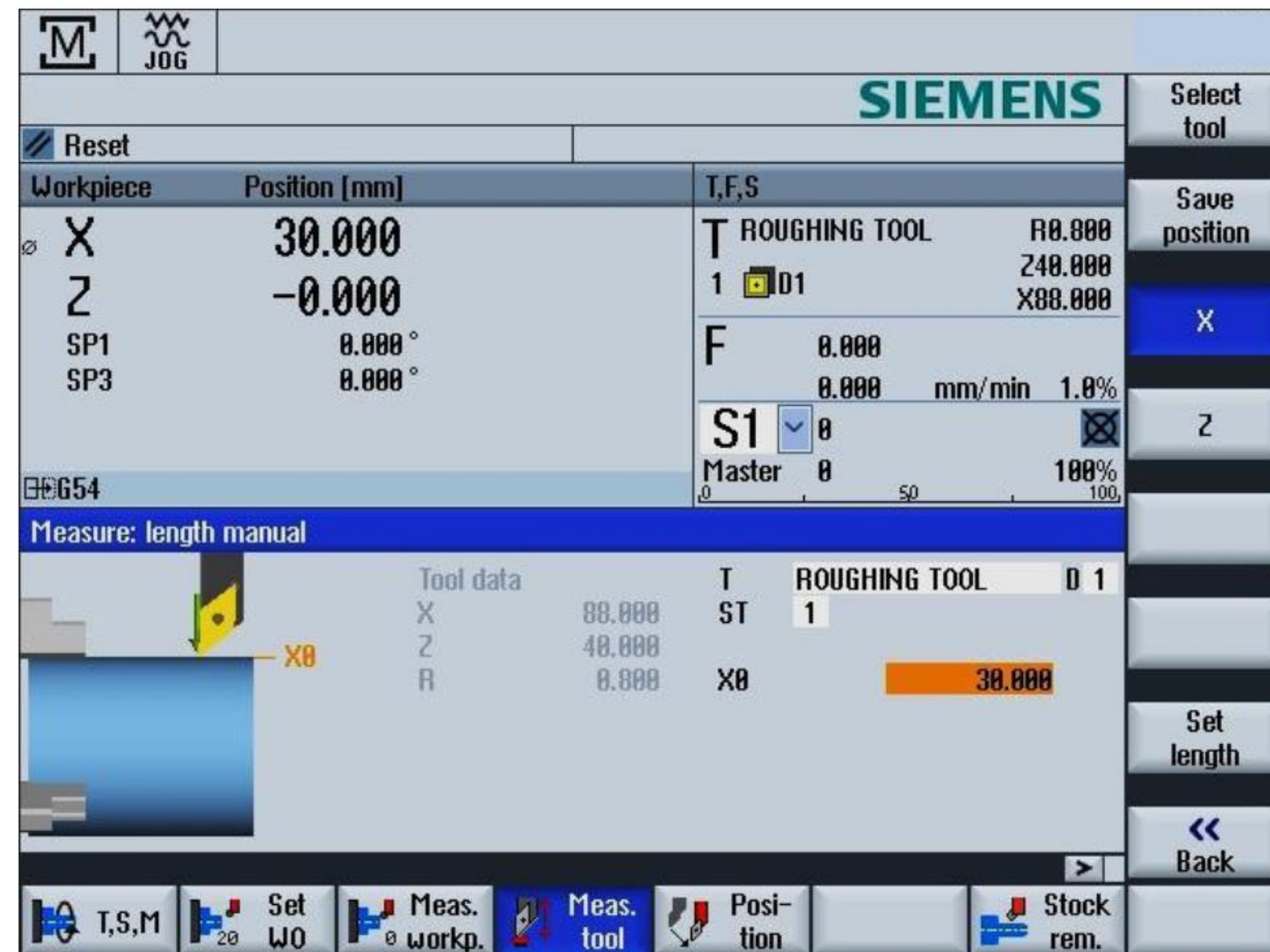


Fig. 61. Page for the automatic offset by touching the workpiece

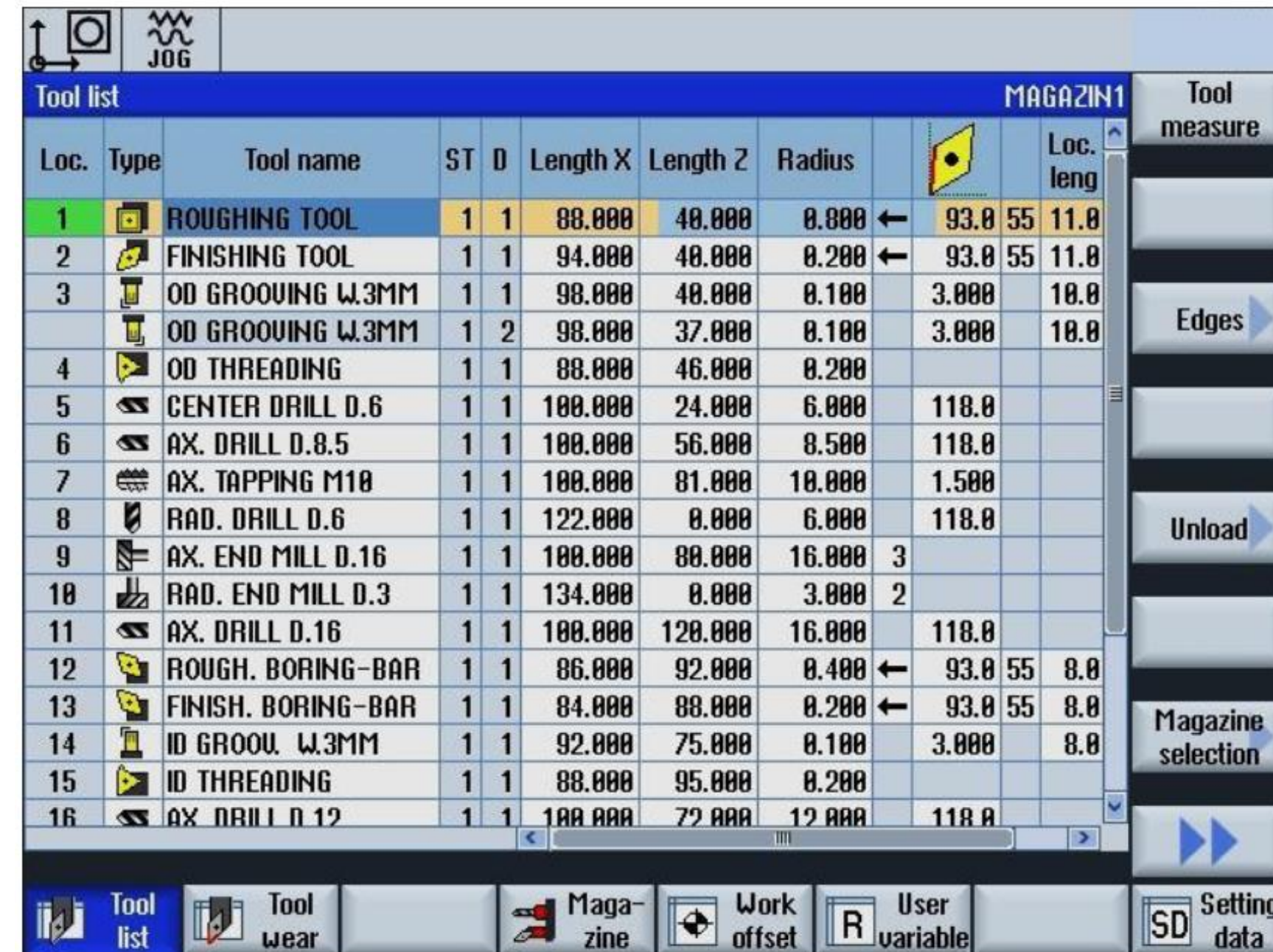
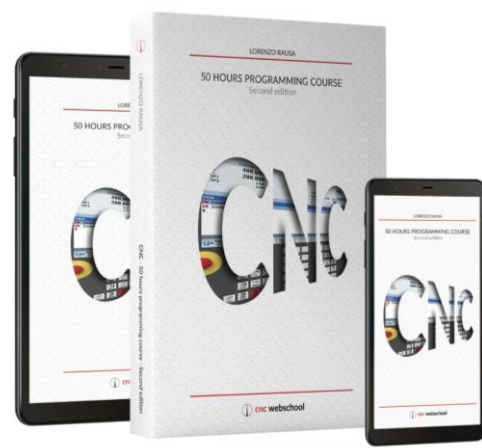




Fig. 62. Tool list page





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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

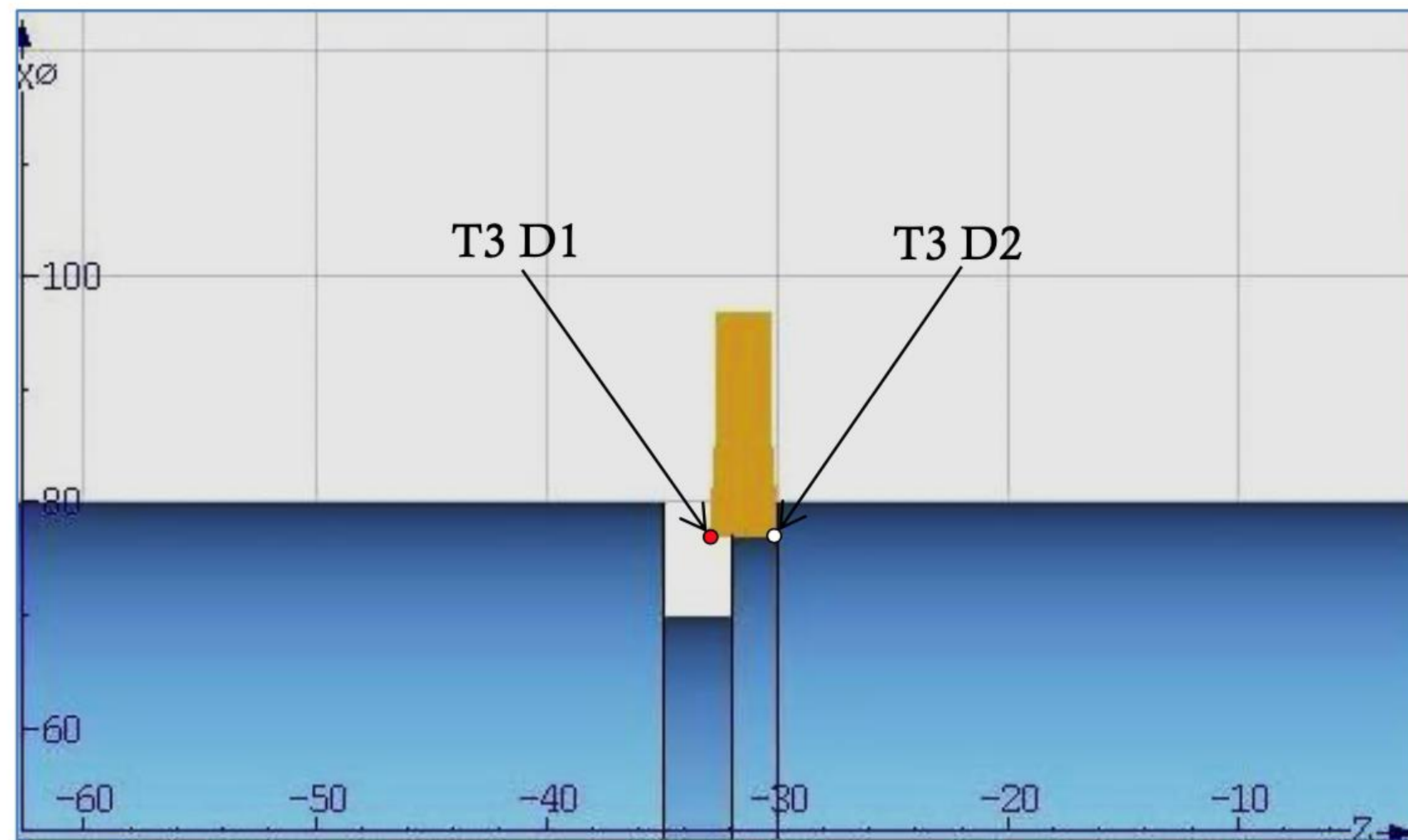


Fig. 63. Double corrector used for a 3 mm grooving tool


















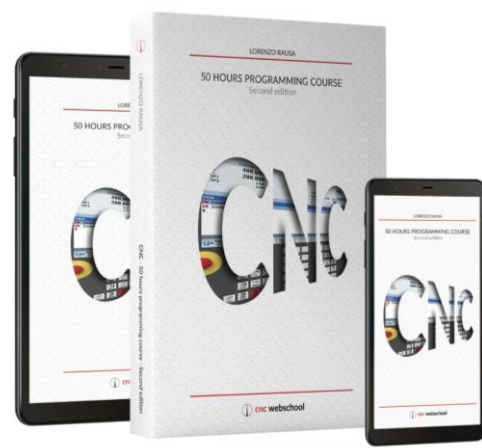
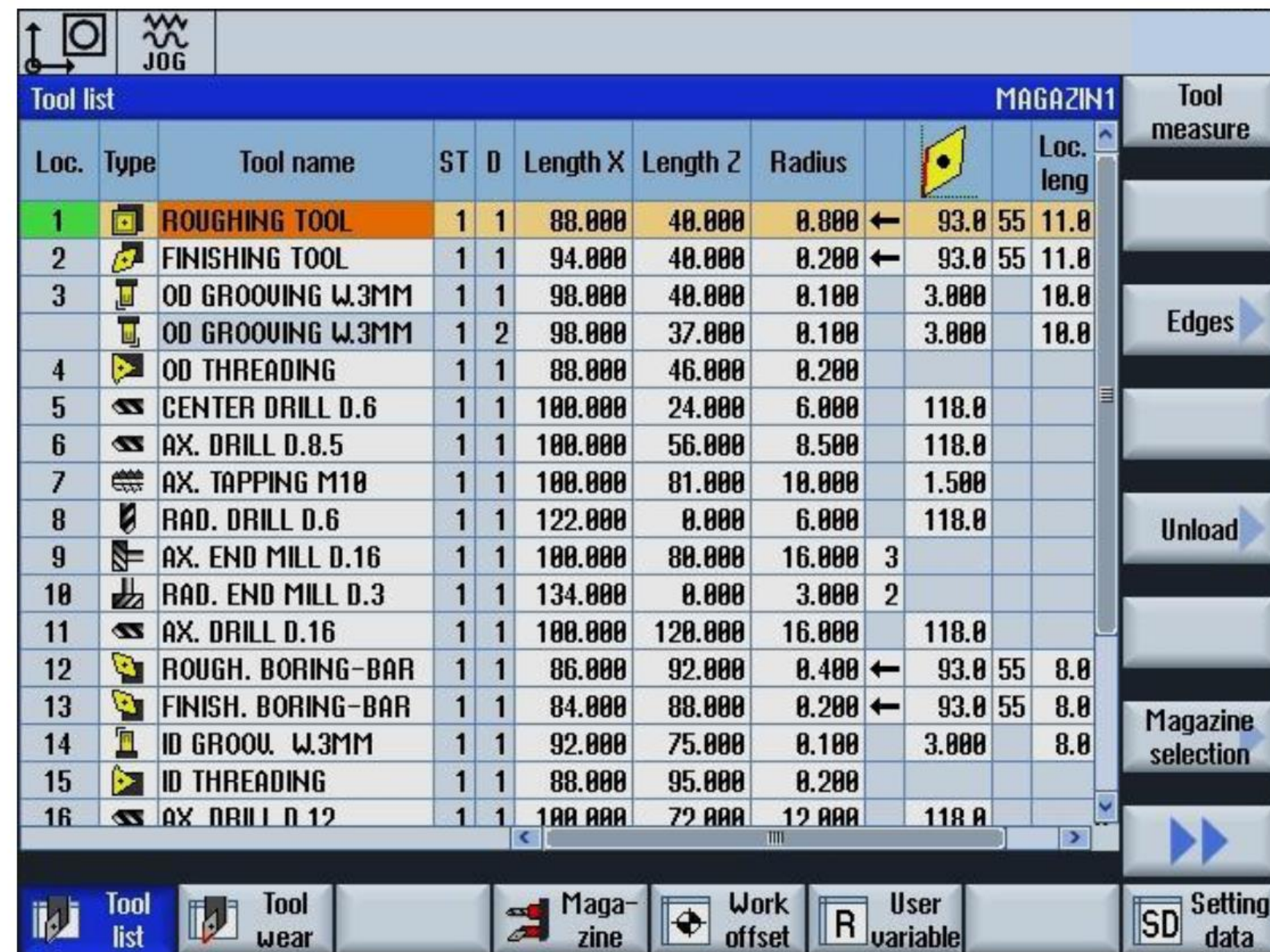
MAGAZIN1									
Tool wear									
Loc.	Type	Tool name	ST	D	ΔLength X	ΔLength Z	ΔRadius	T C	
1		ROUGHING TOOL	1	1	0.000	0.000	0.000		
2		FINISHING TOOL	1	1	0.000	0.000	0.000		
3		OD GROOVING W.3MM	1	1	0.000	0.000	0.000		
		OD GROOVING W.3MM	1	2	0.000	0.000	0.000		
4		OD THREADING	1	1	0.000	0.000	0.000		
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





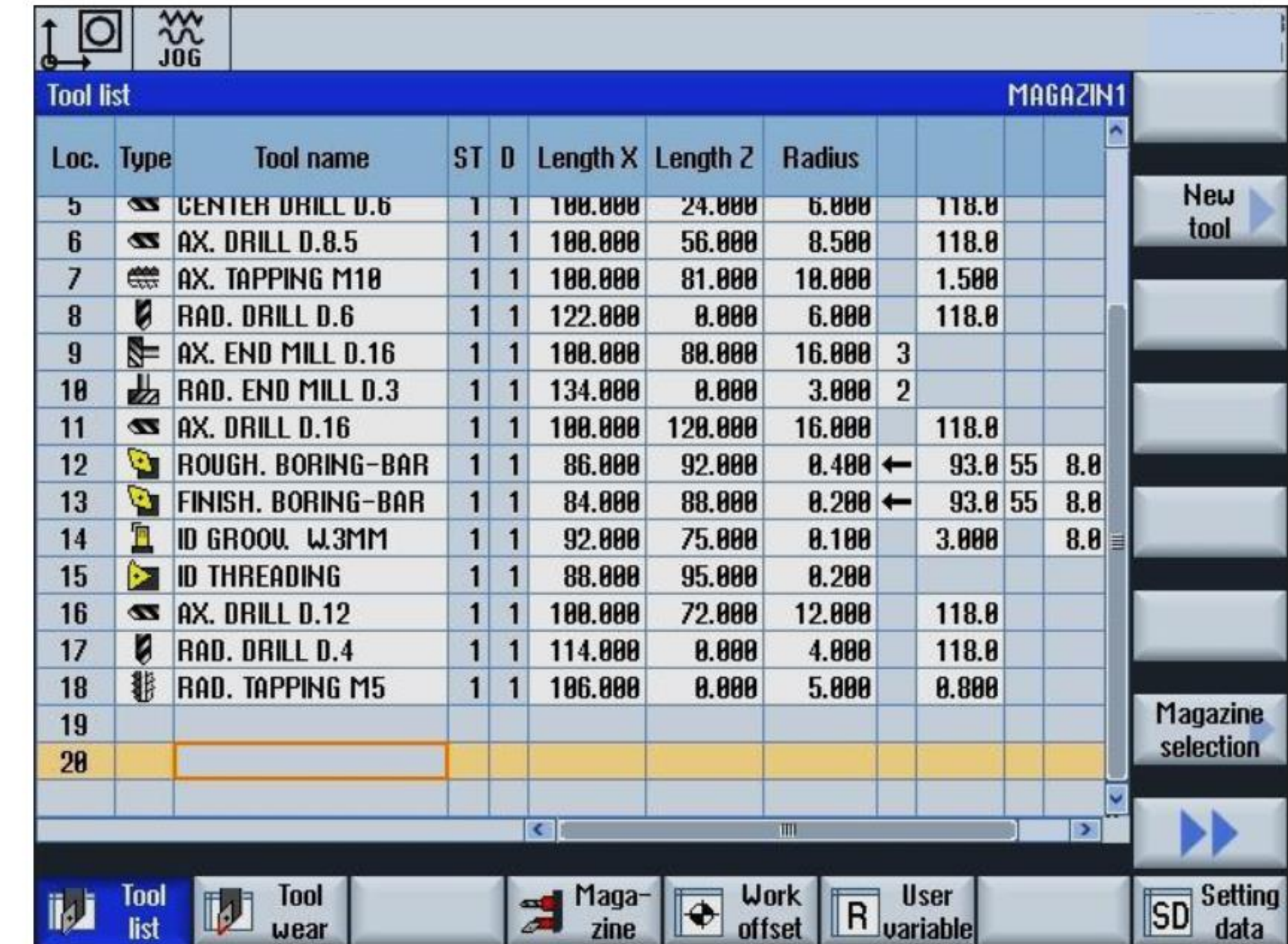
# CNC - 50 HOUR PROGRAMMING COURSE



The screenshot shows a CNC control interface with a 'Tool list' table. The first row, 'ROUGHING TOOL' at location 1, is highlighted in orange. The 'Edges' button on the right is active. The bottom menu includes 'Tool list', 'Tool wear', 'Magazine', 'Work offset', 'User variable', and 'Setting data'.

Loc.	Type	Tool name	ST	D	Length X	Length Z	Radius		Loc. leng
1		ROUGHING TOOL	1	1	88.000	40.000	0.000	← 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
		OD GROOVING W.3MM	1	2	98.000	37.000	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	
7		AX. TAPPING M10	1	1	100.000	81.000	10.000	1.500	
8		RAD. DRILL D.6	1	1	122.000	0.000	6.000	118.0	
9		AX. END MILL D.16	1	1	100.000	80.000	16.000	3	
10		RAD. END MILL D.3	1	1	134.000	0.000	3.000	2	
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
13		FINISH. BORING-BAR	1	1	84.000	88.000	0.200	← 93.0 55	8.0
14		ID GROOV. W.3MM	1	1	92.000	75.000	0.100	3.000	8.0
15		ID THREADING	1	1	88.000	95.000	0.200		
16		AX. DRILL D.12	1	1	100.000	72.000	12.000	118.0	

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



The screenshot shows the same CNC control interface, but now location 20 is highlighted in orange. The 'New tool' button on the right is active. The bottom menu is identical to the previous figure.

Loc.	Type	Tool name	ST	D	Length X	Length Z	Radius		Loc. leng
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	
7		AX. TAPPING M10	1	1	100.000	81.000	10.000	1.500	
8		RAD. DRILL D.6	1	1	122.000	0.000	6.000	118.0	
9		AX. END MILL D.16	1	1	100.000	80.000	16.000	3	
10		RAD. END MILL D.3	1	1	134.000	0.000	3.000	2	
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
13		FINISH. BORING-BAR	1	1	84.000	88.000	0.200	← 93.0 55	8.0
14		ID GROOV. W.3MM	1	1	92.000	75.000	0.100	3.000	8.0
15		ID THREADING	1	1	88.000	95.000	0.200		
16		AX. DRILL D.12	1	1	100.000	72.000	12.000	118.0	
17		RAD. DRILL D.4	1	1	114.000	0.000	4.000	118.0	
18		RAD. TAPPING M5	1	1	106.000	0.000	5.000	0.000	
19									
20									

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





# CNC - 50 HOUR PROGRAMMING COURSE



0	EXAMPLE	1	1	80.000	40.000	0.100	3.000	10.0
---	---------	---	---	--------	--------	-------	-------	------

Fig. 68. Creation of a new tool

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





# CNC - 50 HOUR PROGRAMMING COURSE

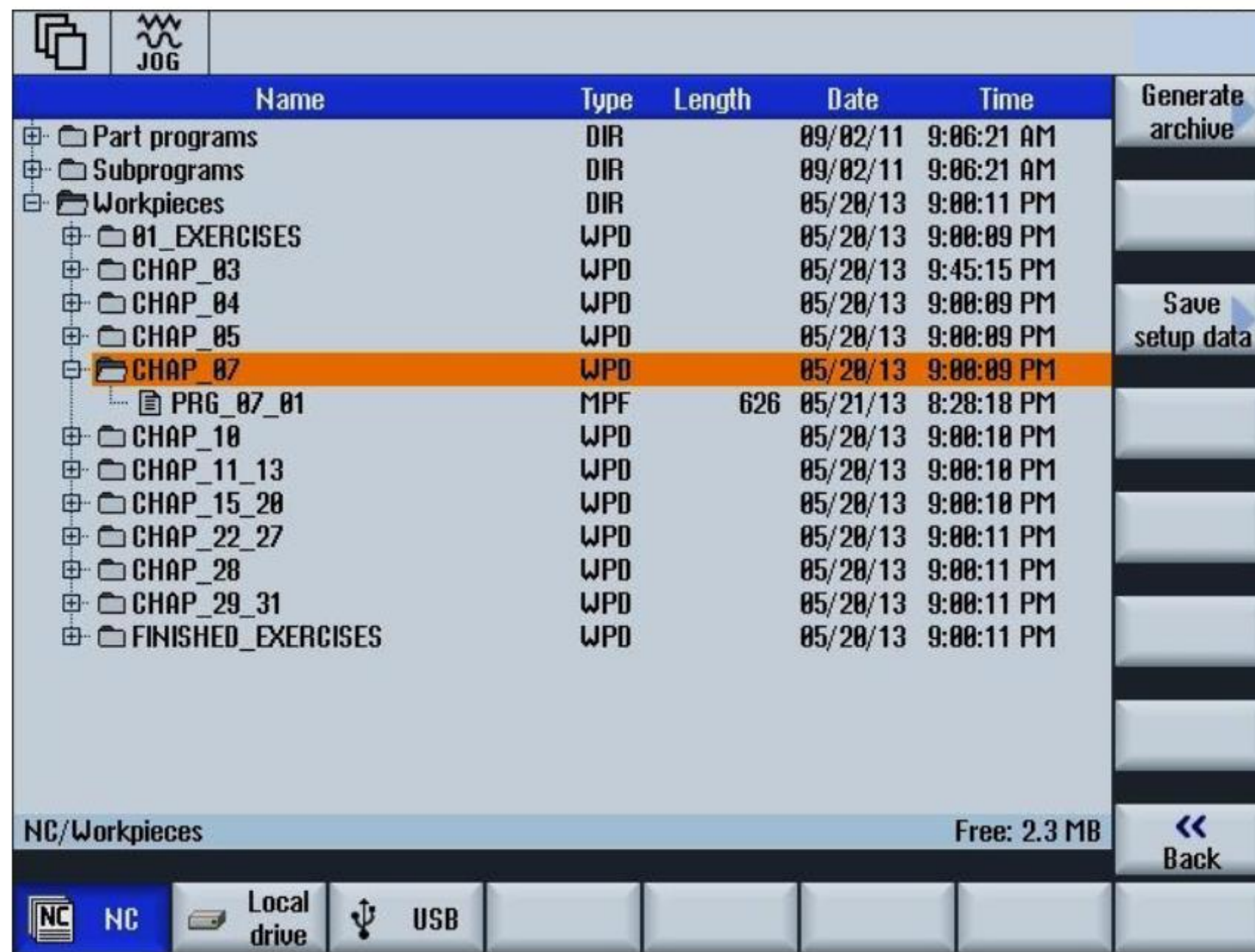


Fig. 69. Saving of tooling data

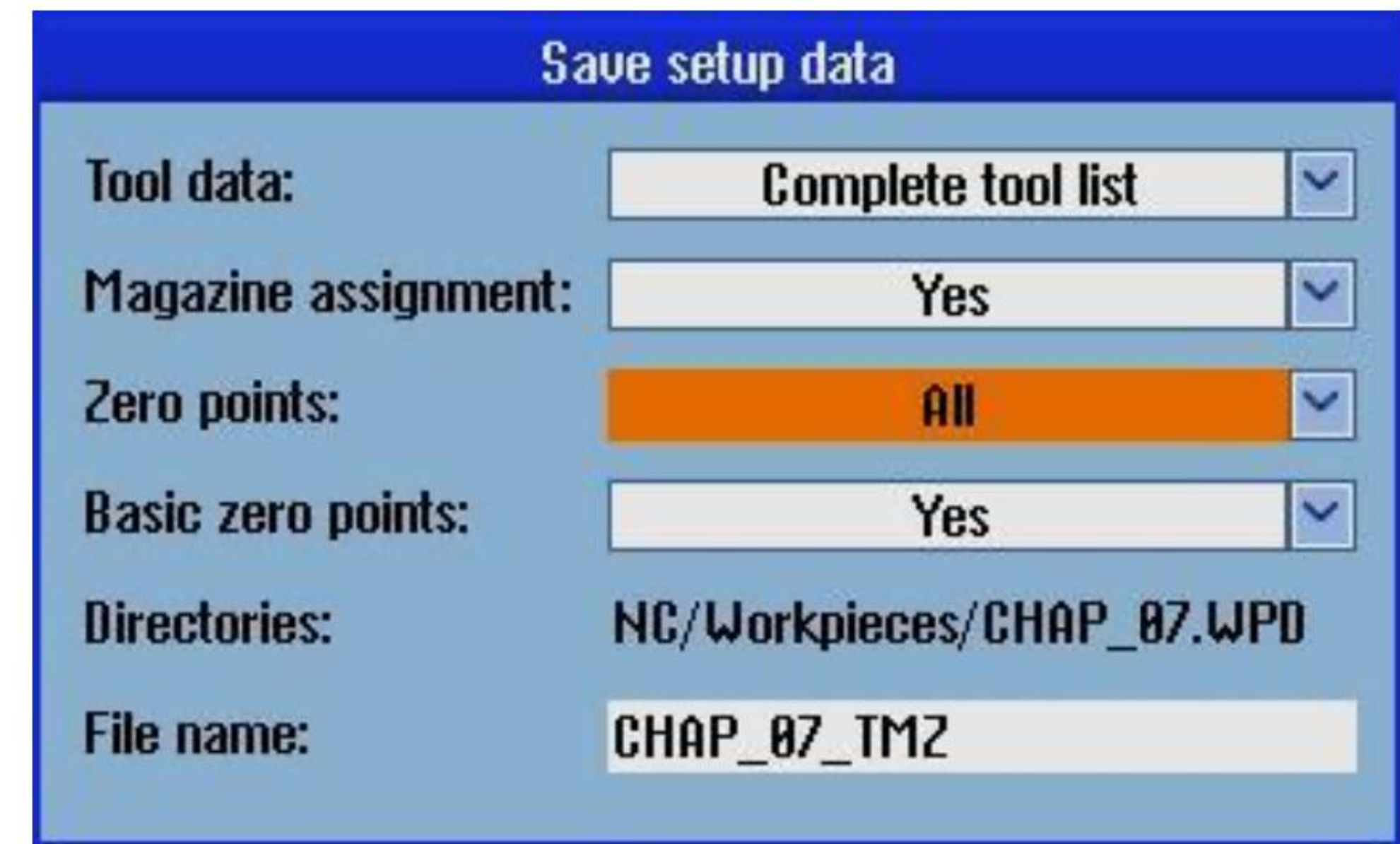
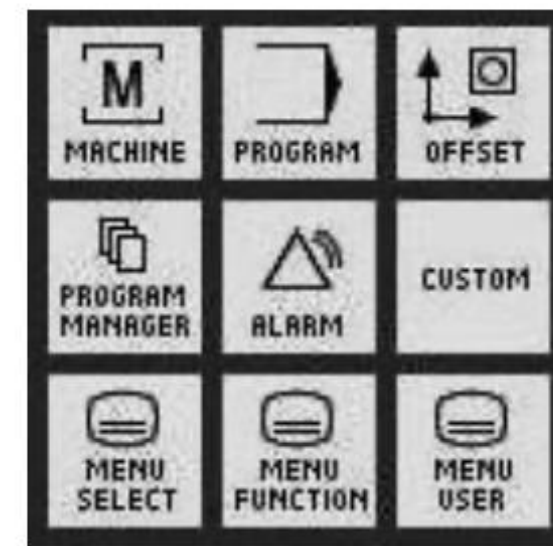
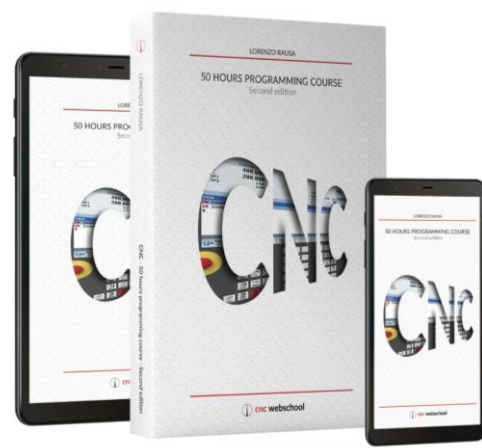


Fig. 70. Window for the saving of tooling data





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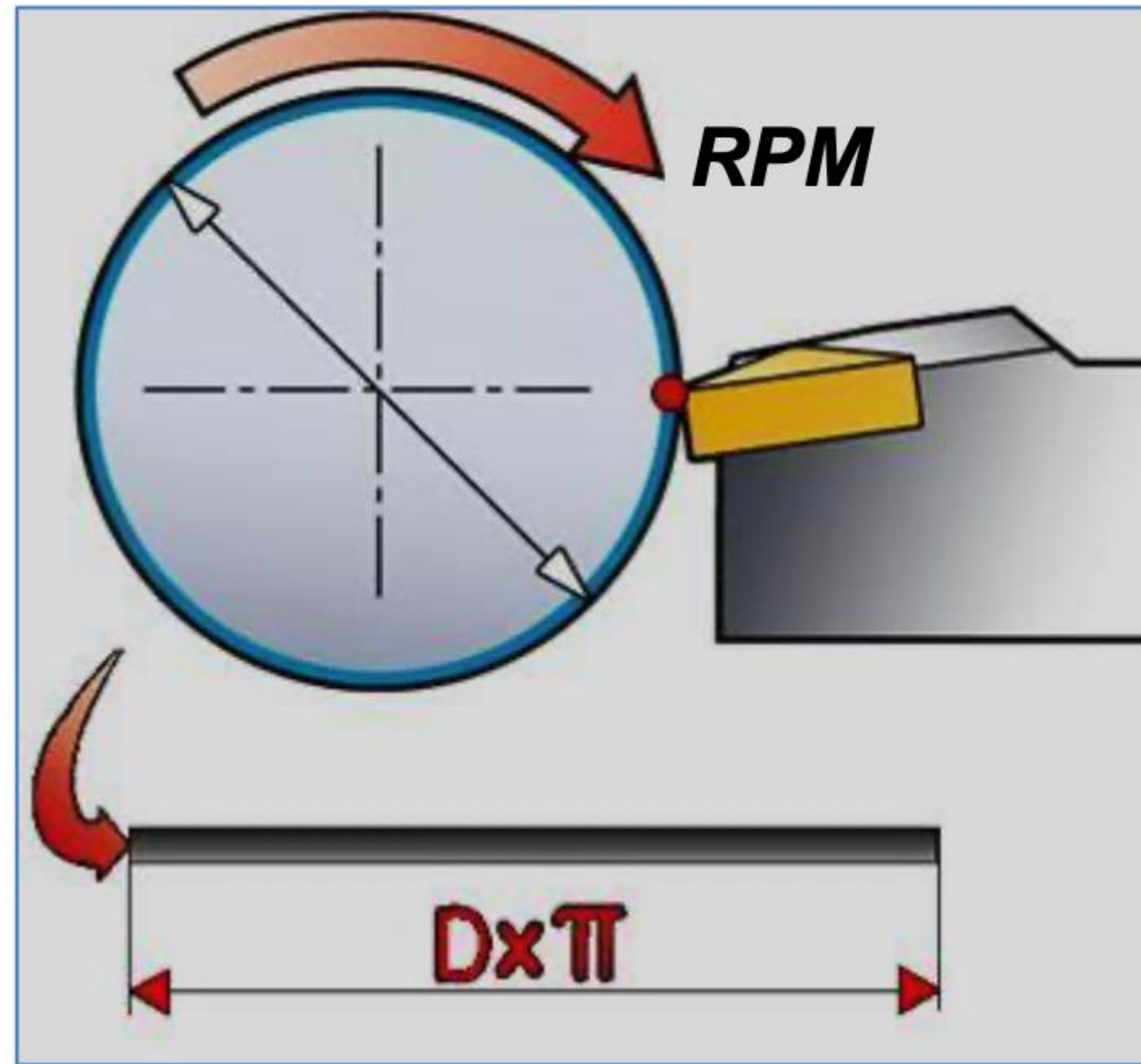


Fig. 71. Distance traveled by the tool in one revolution

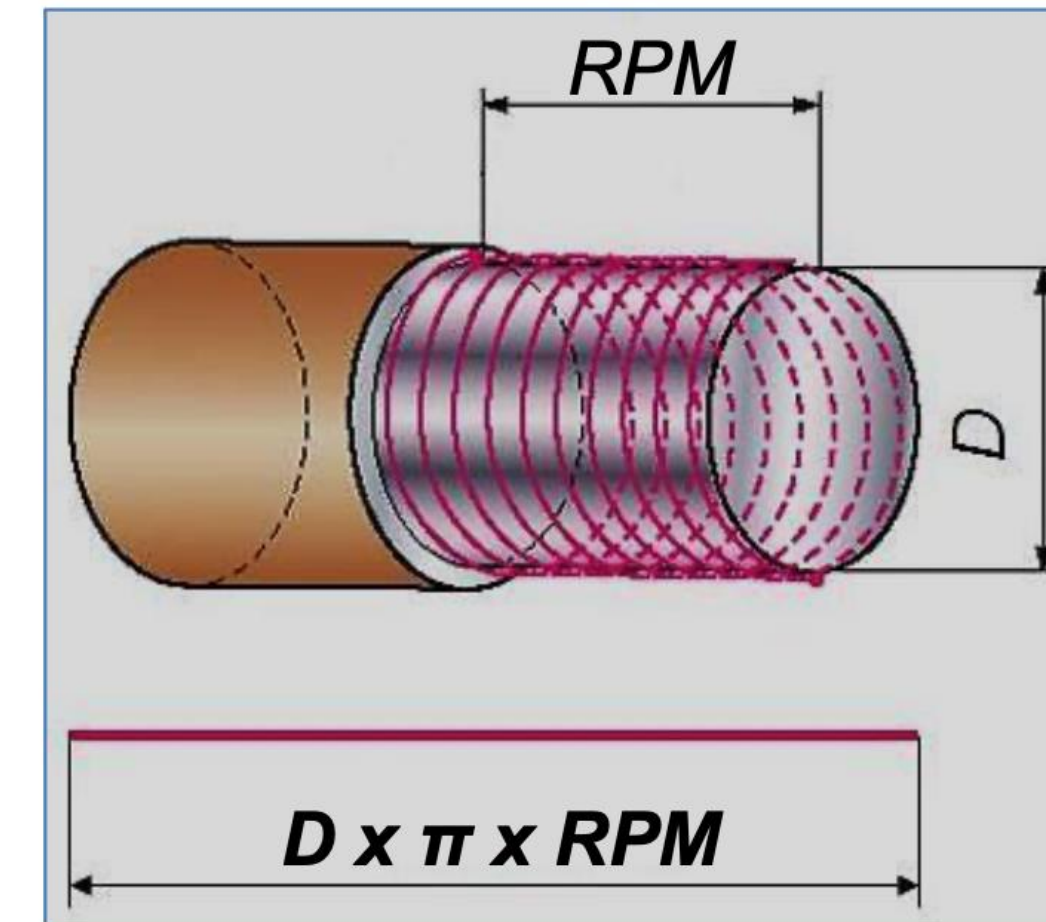
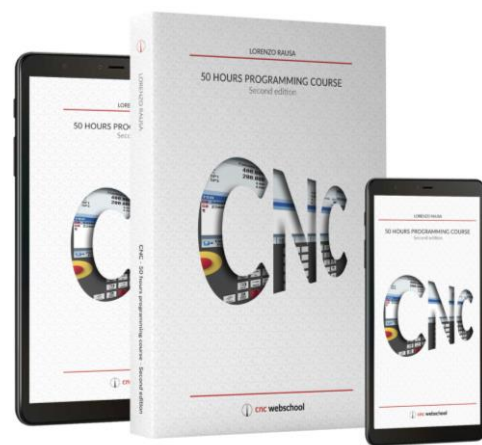


Fig. 72. Distance traveled by the tool in one minute with rotating workpiece

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

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

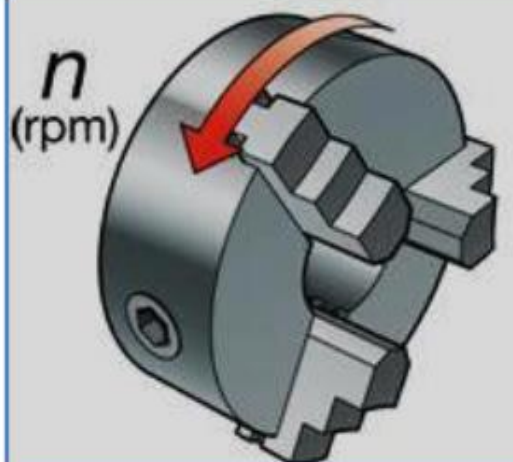




# CNC - 50 HOUR PROGRAMMING COURSE

Reset		
Workpiece	Position [mm]	
X	30.000	
Z	0.001	
SP1	0.000°	
SP3	0.000°	
G54		

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


$$RPM = \frac{1.000 \times C_s}{D \times \pi}$$

Rev  
min

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





# CNC - 50 HOUR PROGRAMMING COURSE

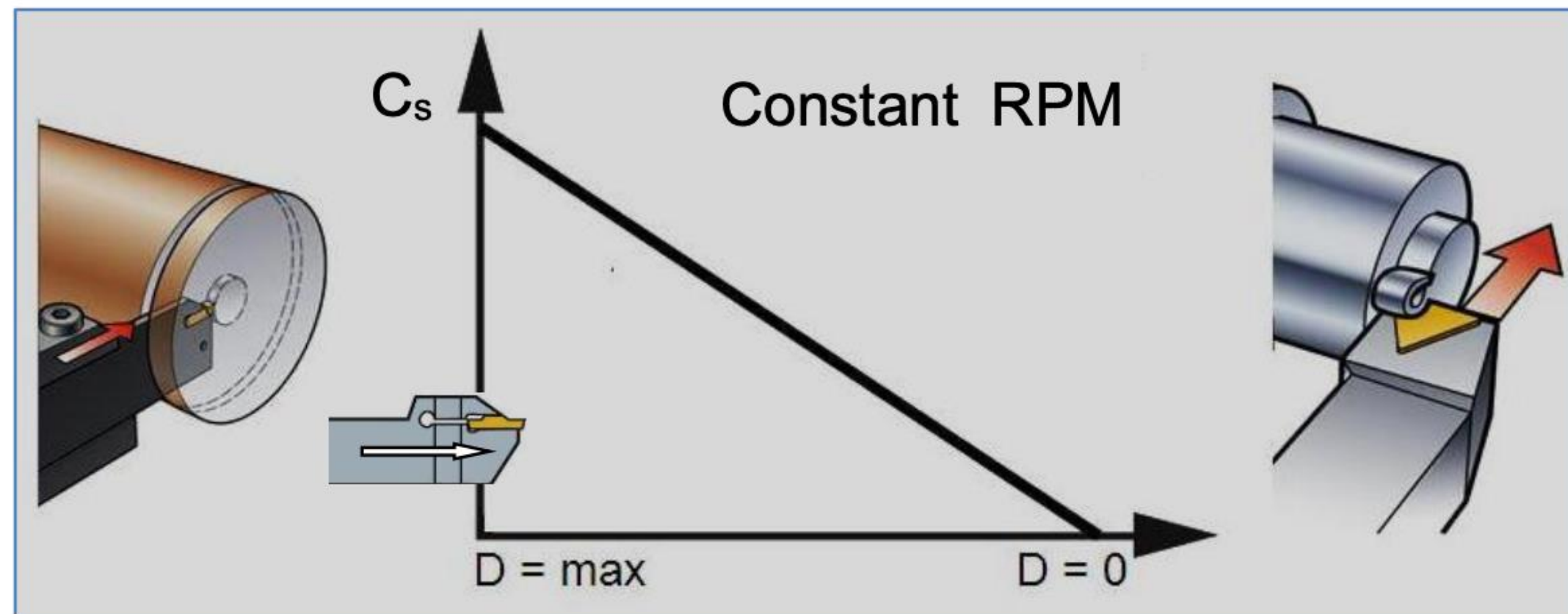


Fig. 76. Graph for the evolution of cutting speed at variation of working diameter, at constant number of revolutions

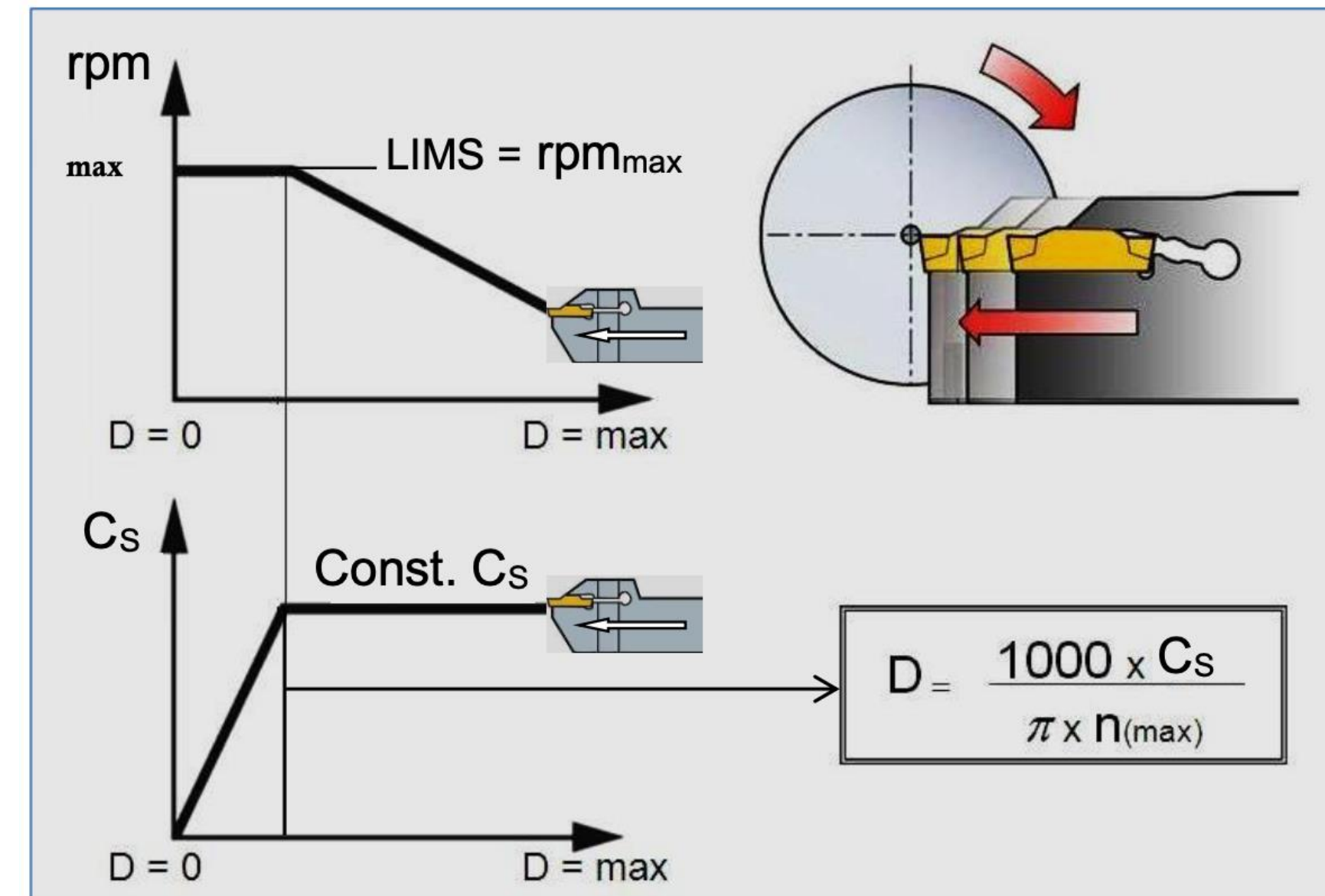


Fig. 77. Graph for the cutting speed trend beyond the number of revolutions threshold





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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

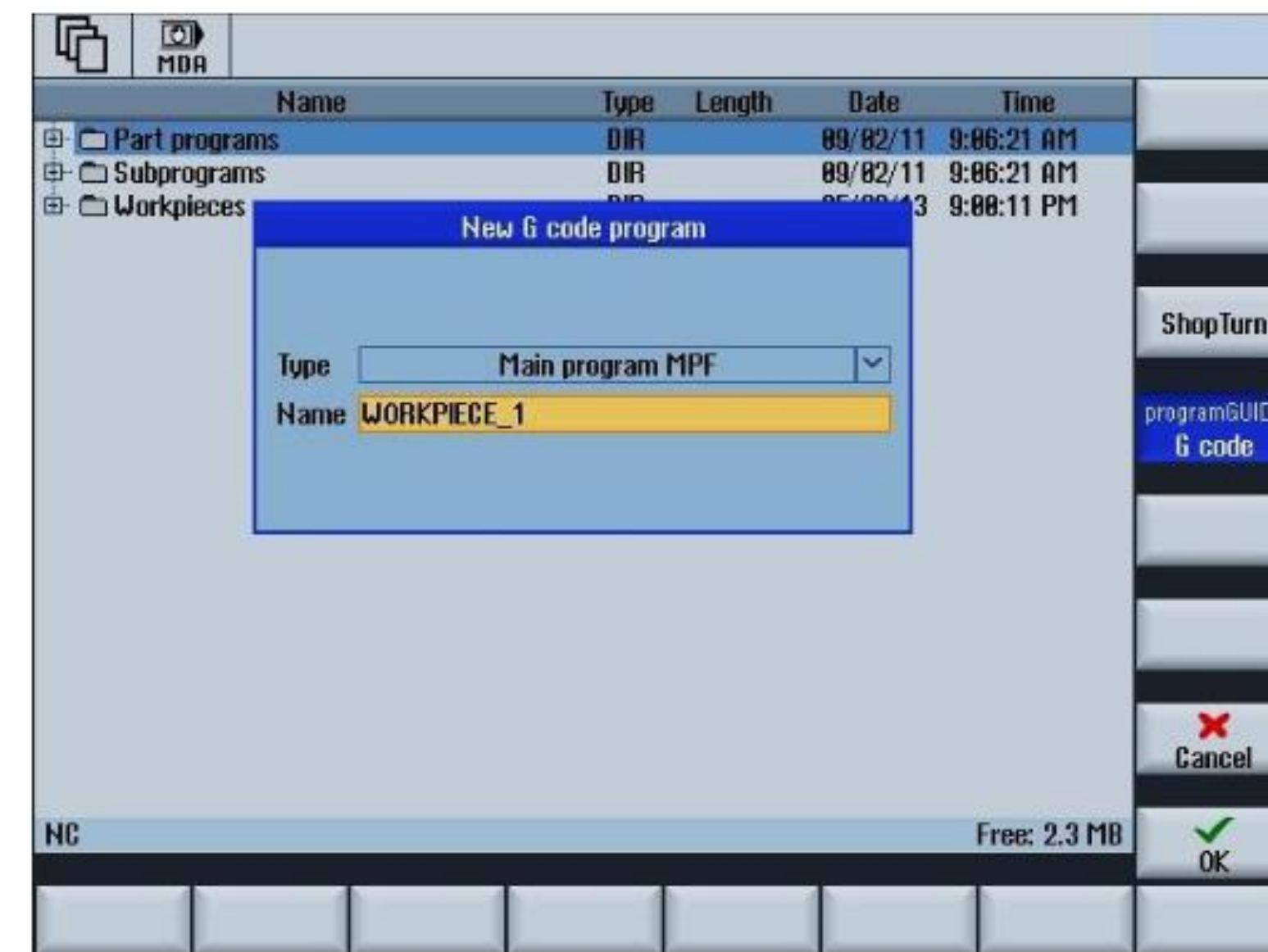
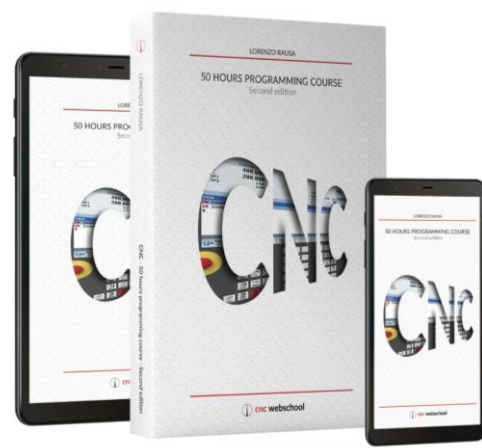


Fig. 79. Creation of a new program





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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

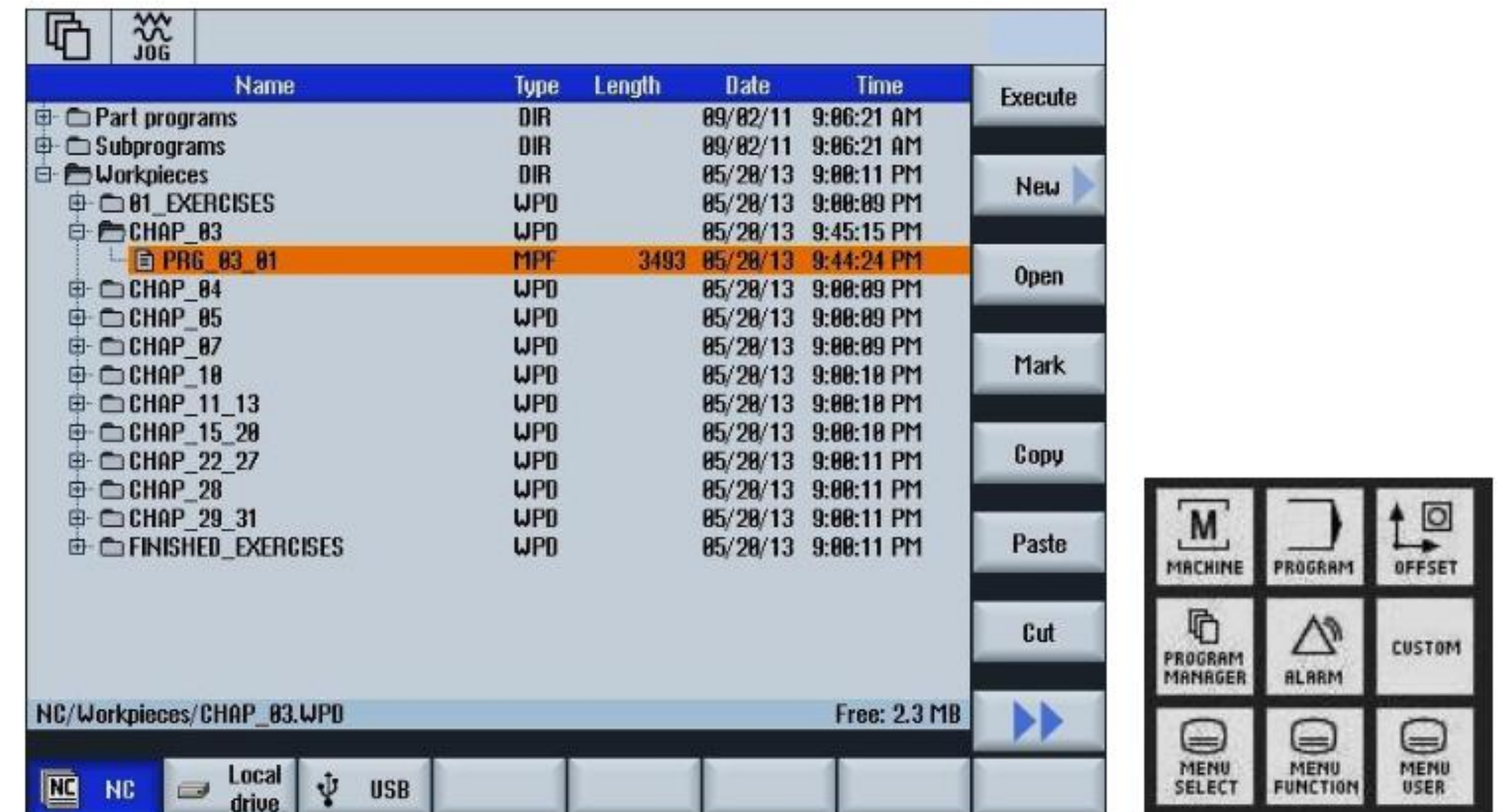


Fig. 81. Saving of folders and programs in an external memory





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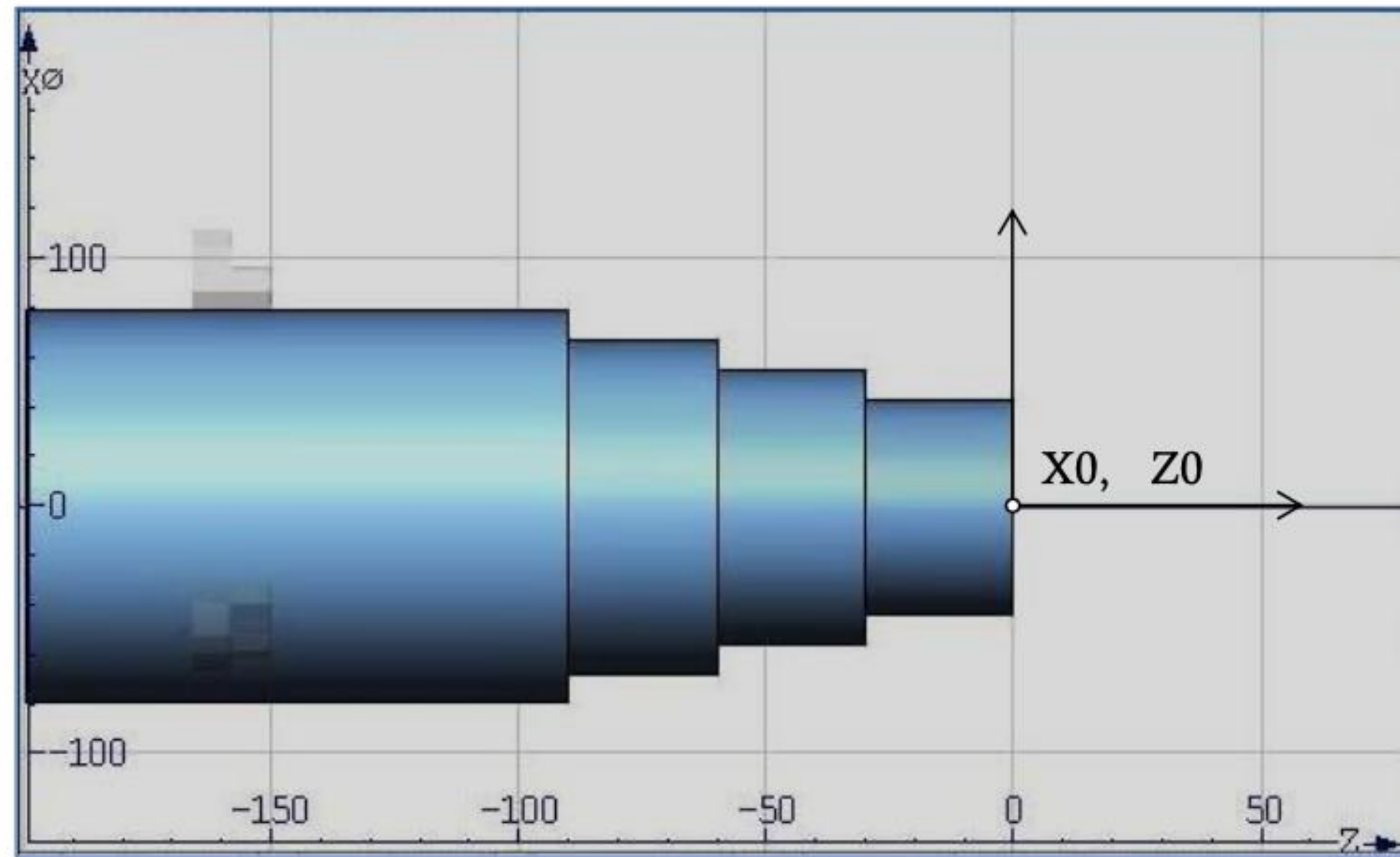
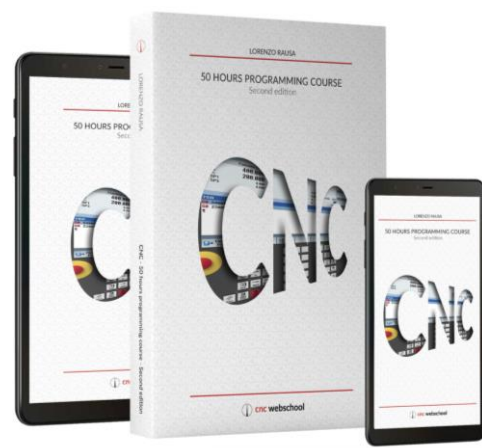


Fig. 82. Origin of the axes in the absolute coordinate system referring to the part zero





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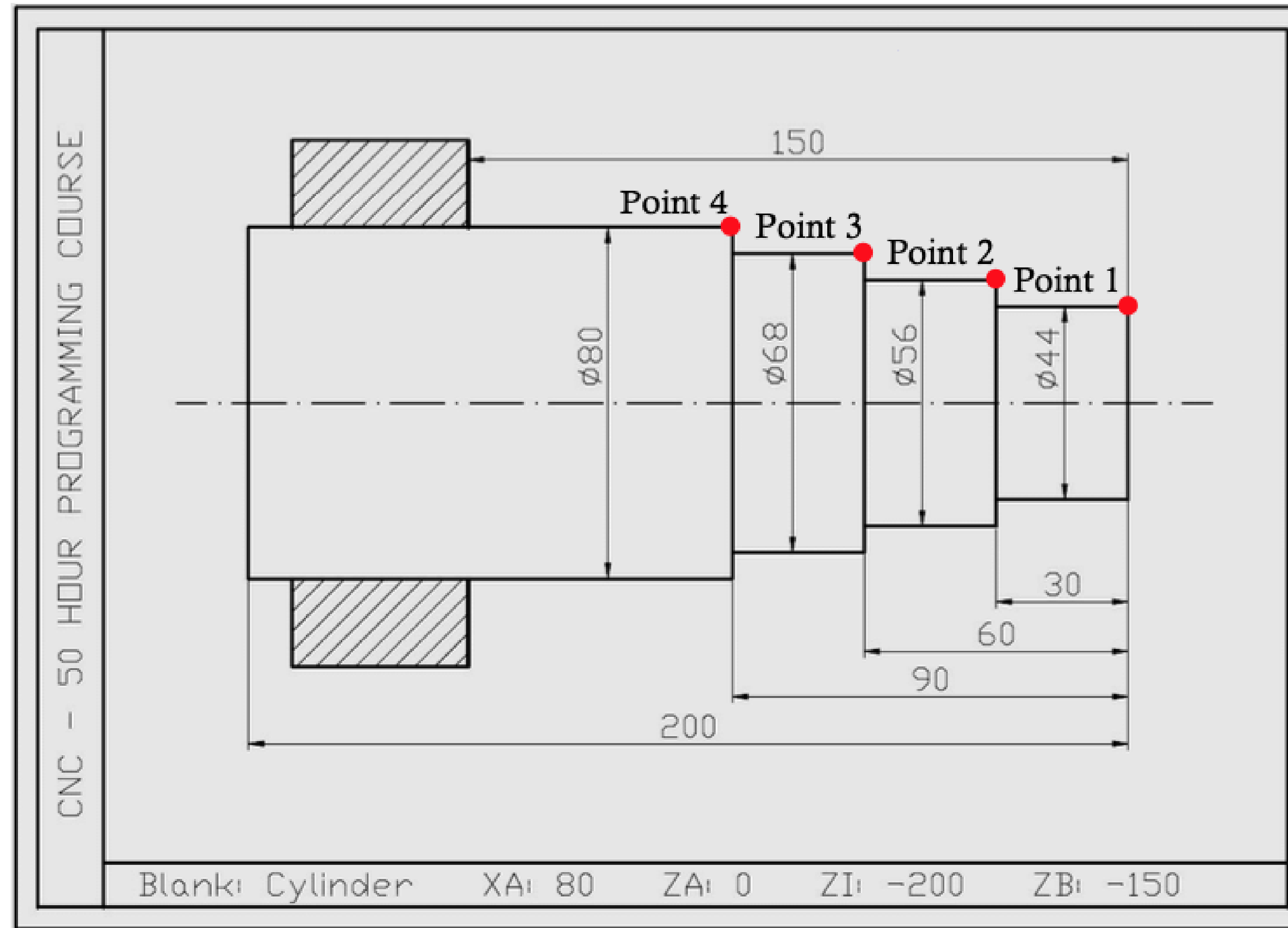
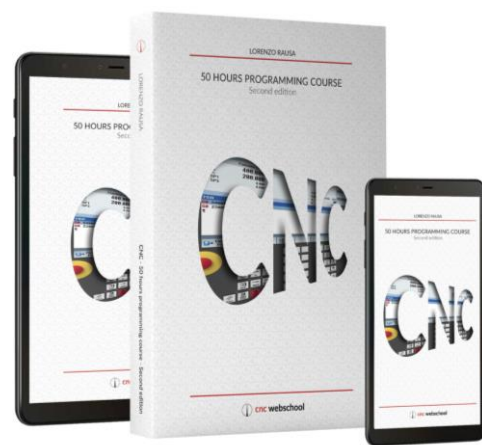


Fig. 83. Design values referring to the part zero point.





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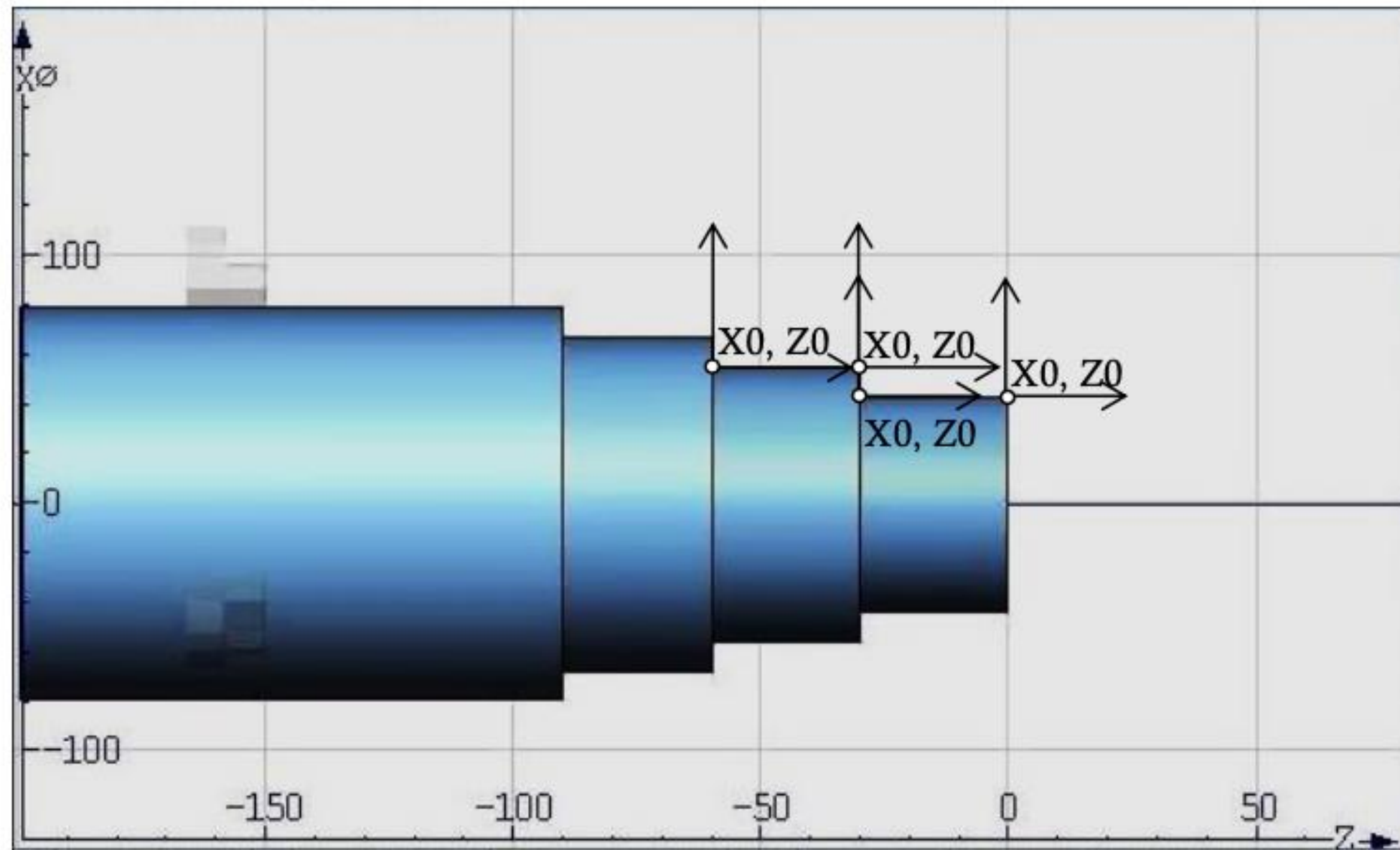


Fig. 84. Origin of the axes in the incremental coordinate system

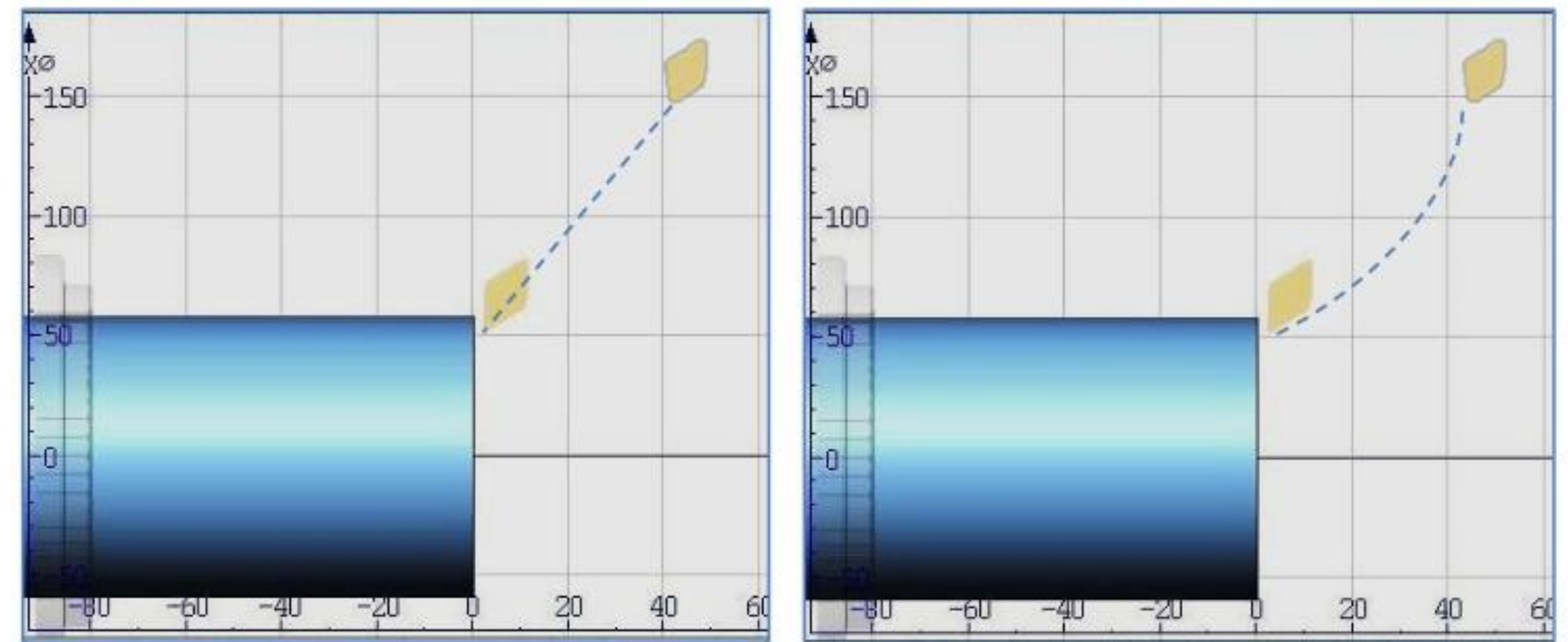


Fig. 85. Trajectory of rapid approach with the functions RTLION and RTLIOF





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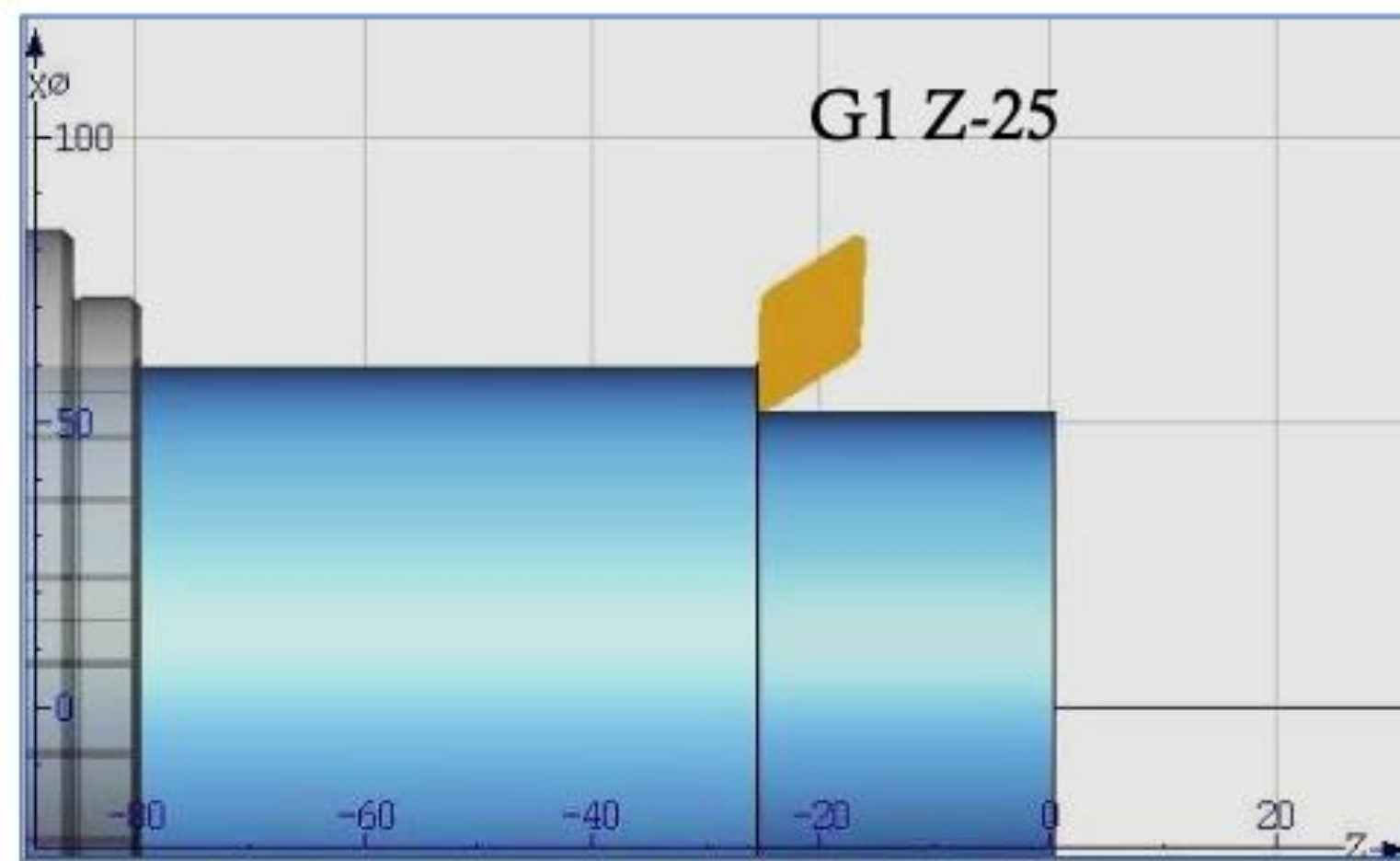


Fig. 86. Movement of the tool along the Z-axis

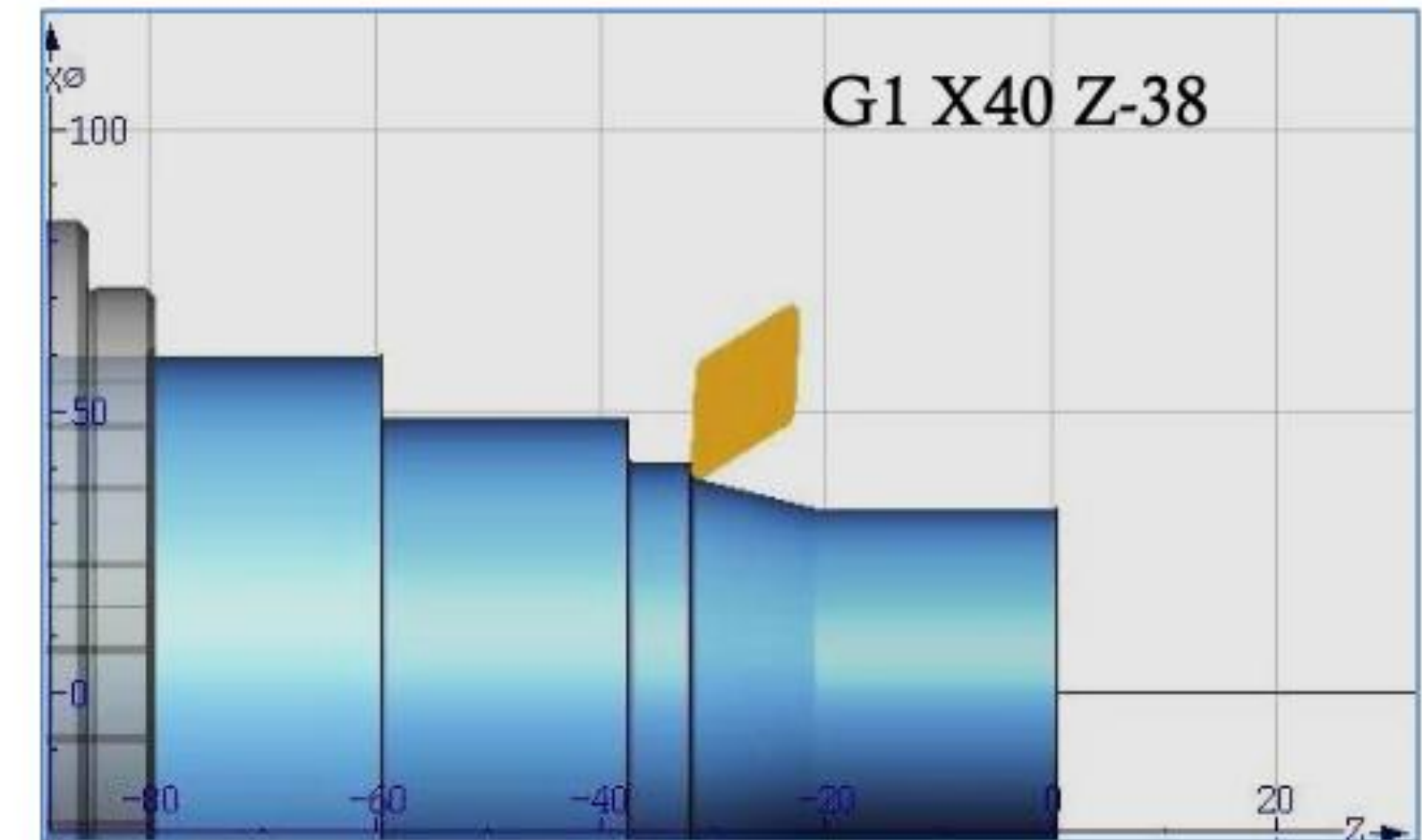
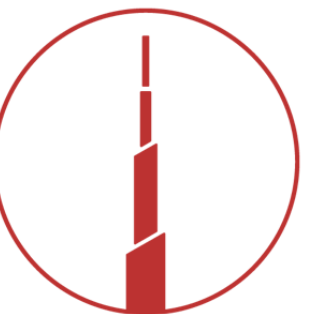
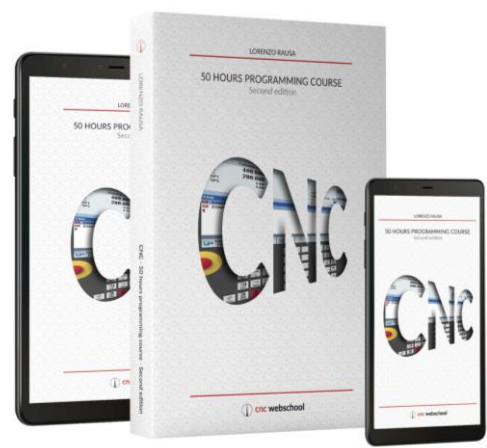


Fig. 87. Linear interpolation with tool moving along the axes X and Z





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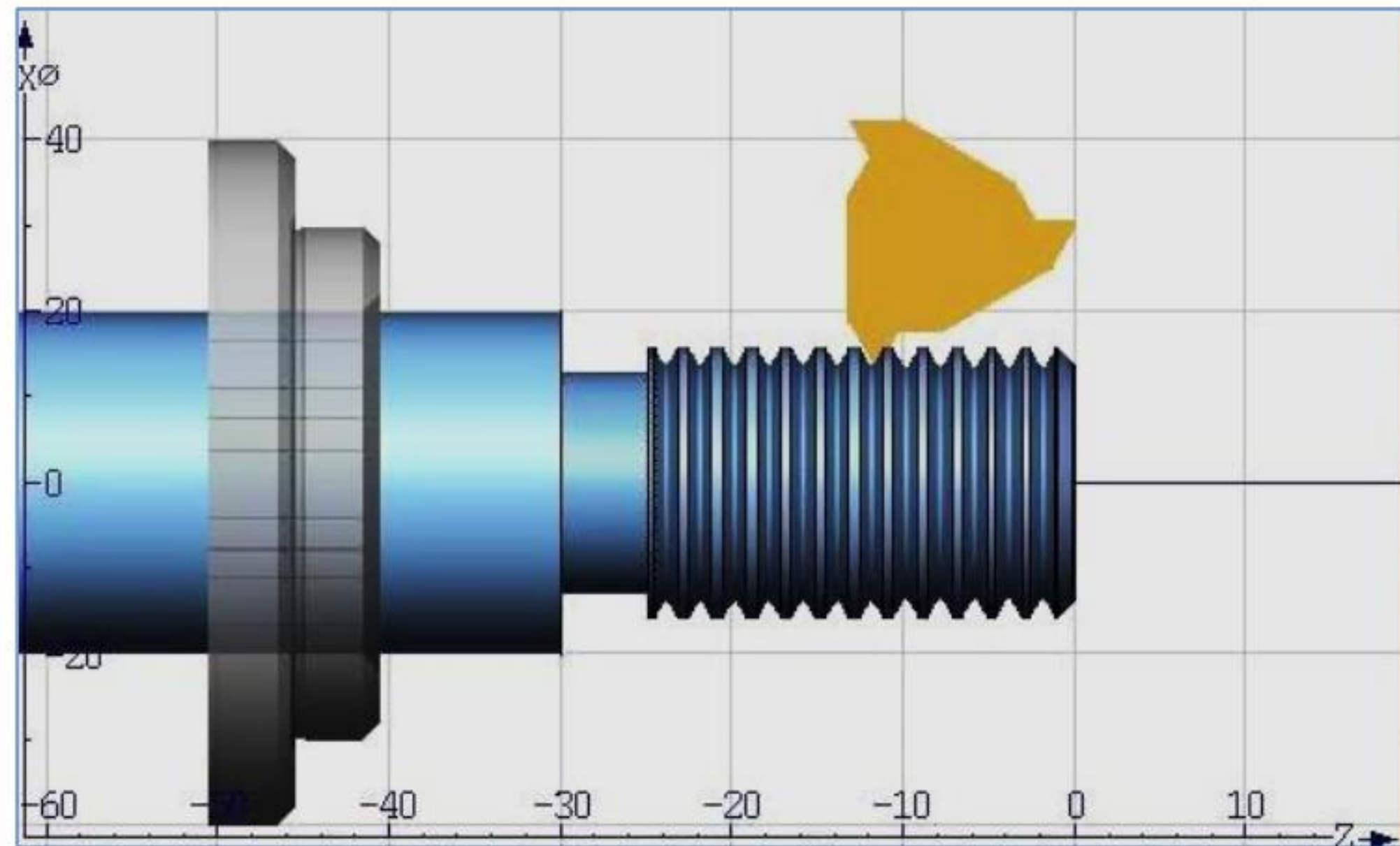


Fig. 88. Execution of a threading in multiple passes with G33

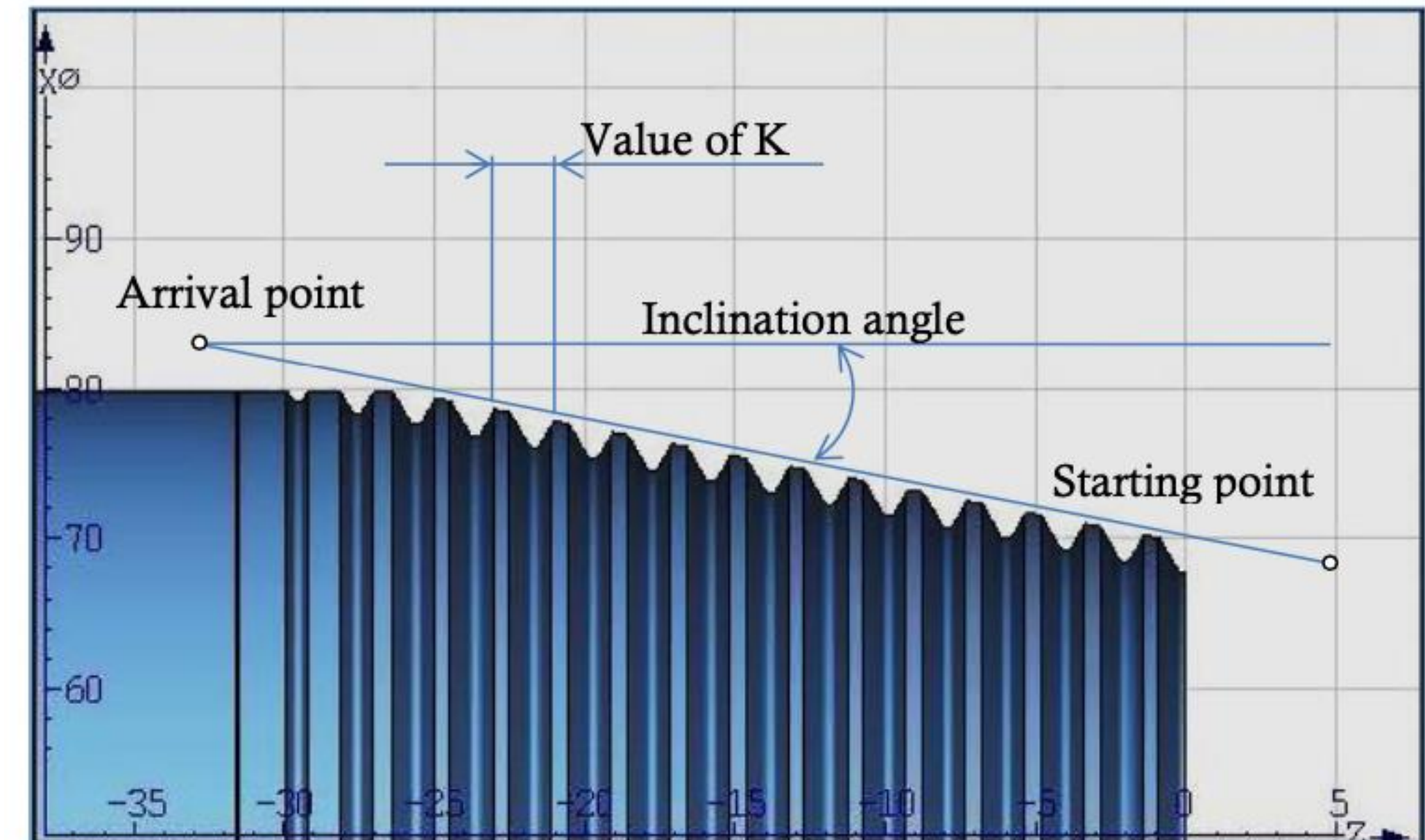


Fig. 89. Lead value to be programmed in a conical thread executed with G33





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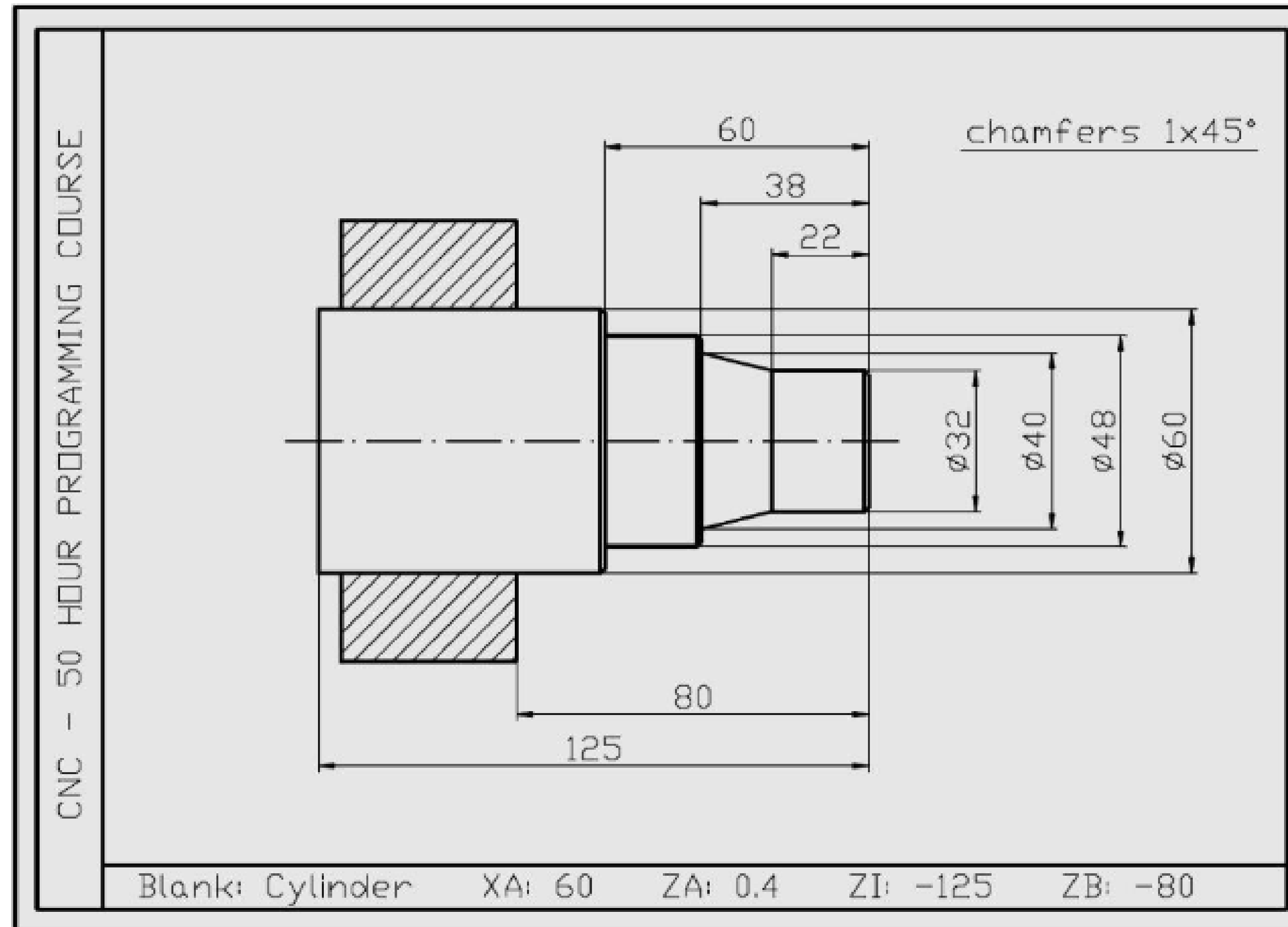
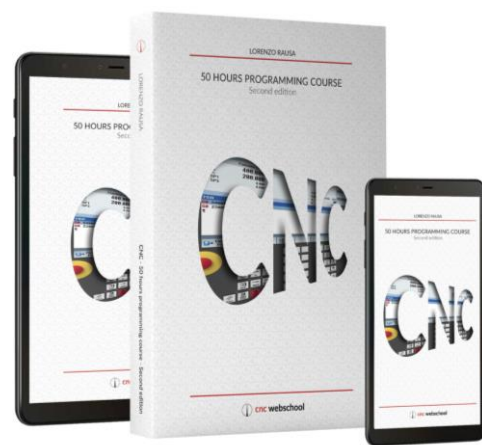


Fig. 90. Example of the programming of an external turning





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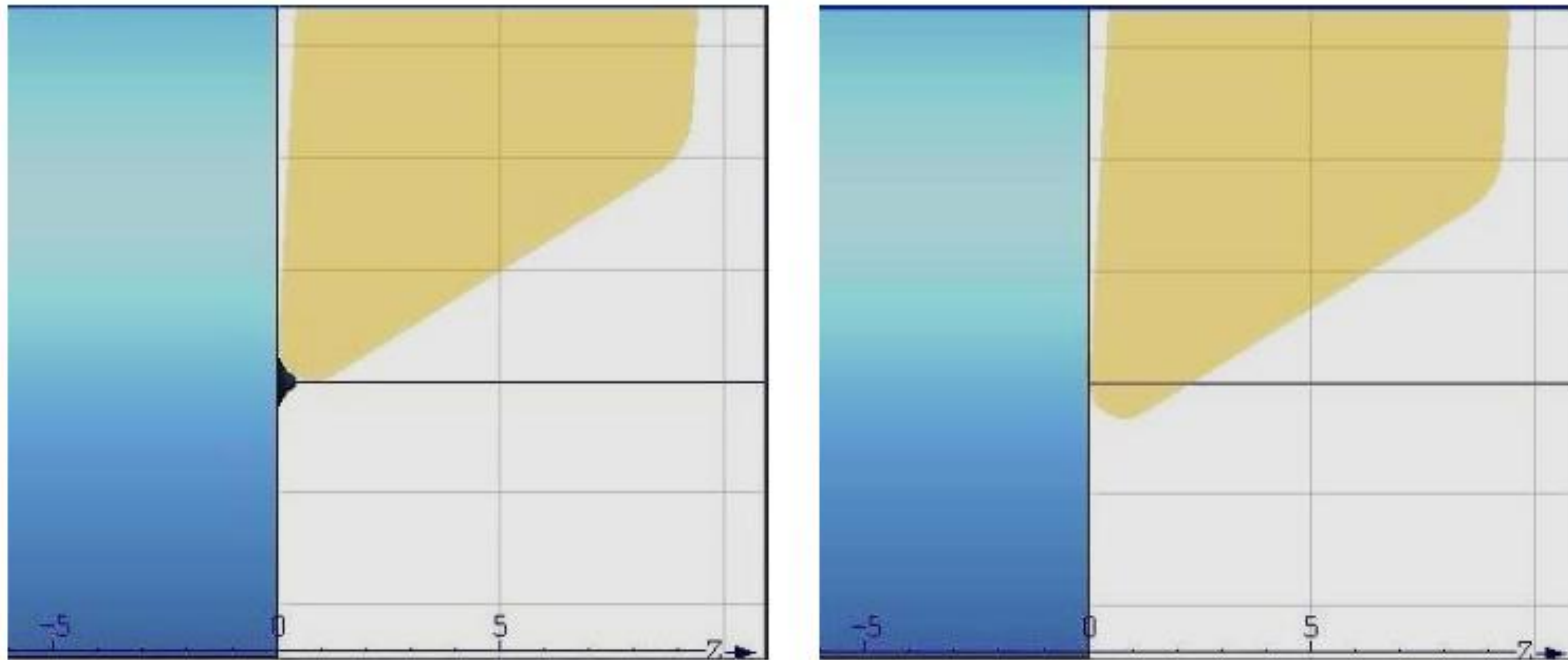
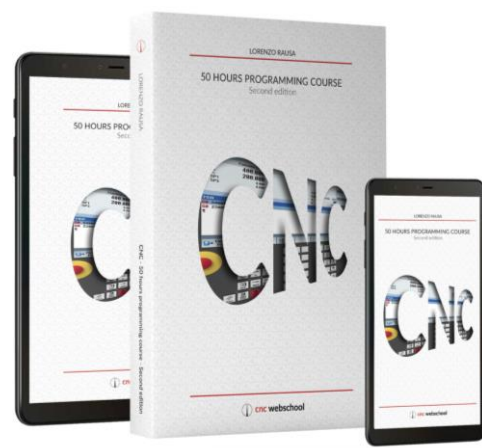


Fig. 91. Elimination of the facing witness mark





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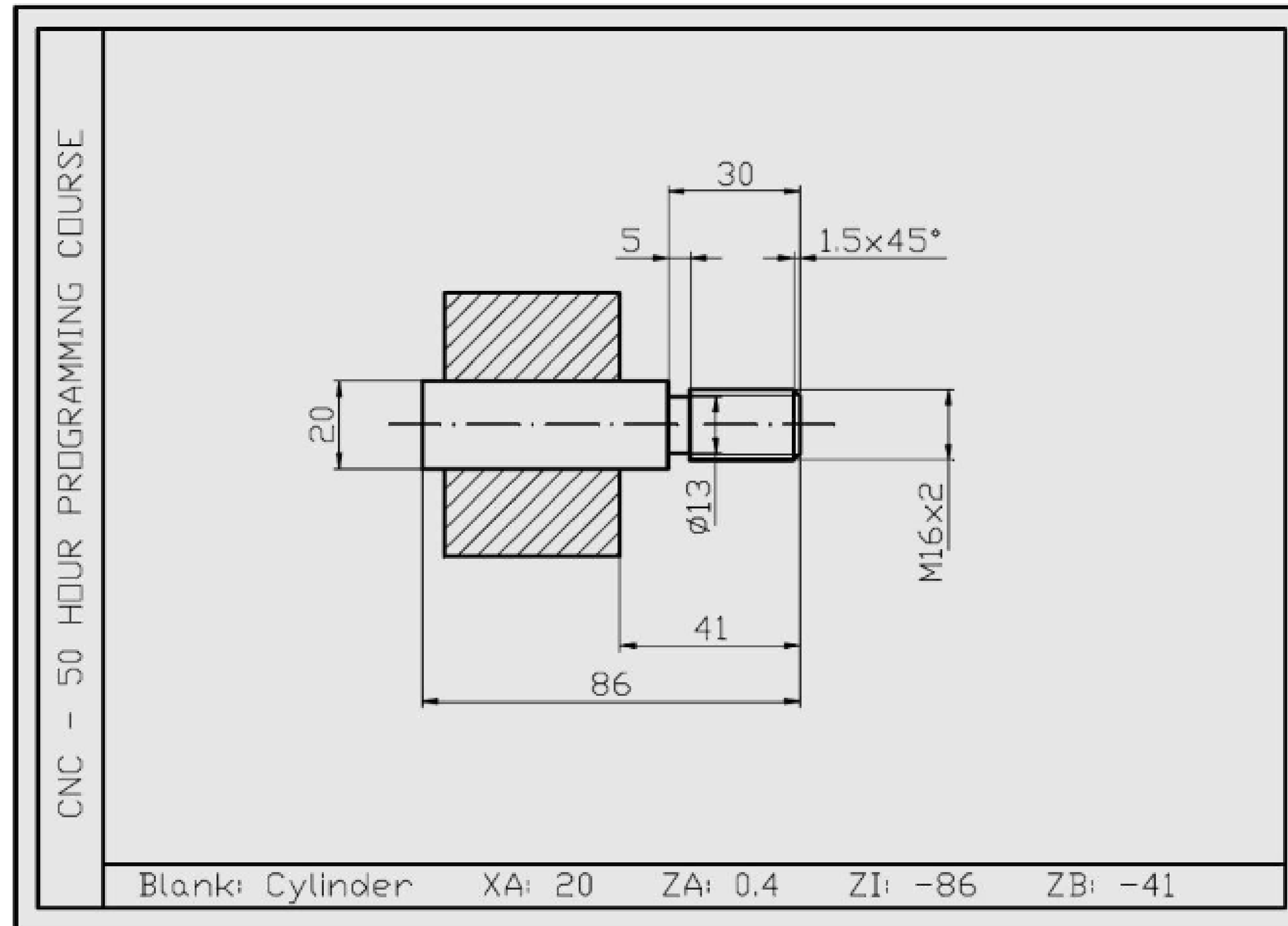


Fig. 92. Example of the programming of a threaded workpiece





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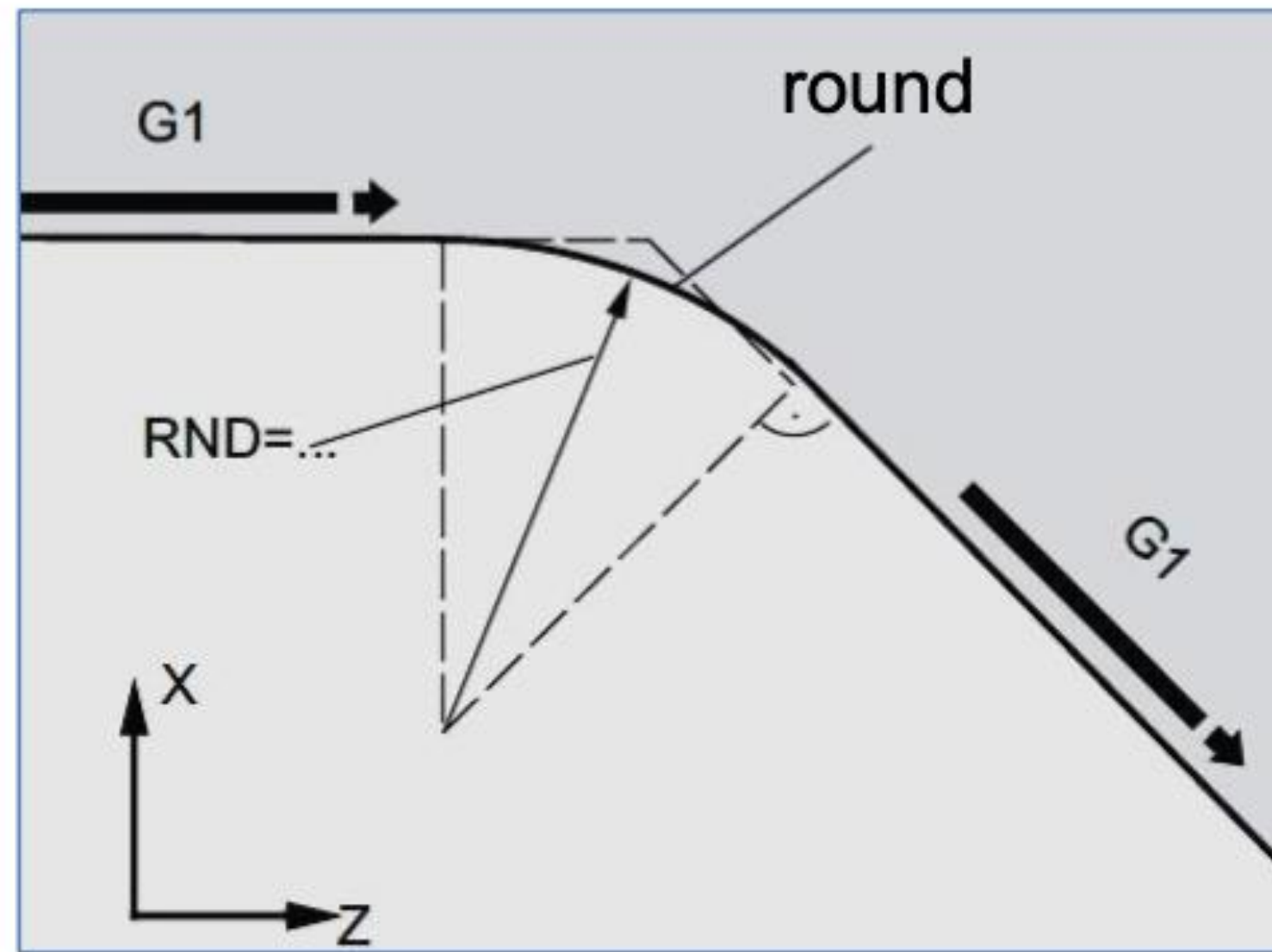


Fig. 93. Round between two line by means of the RND function

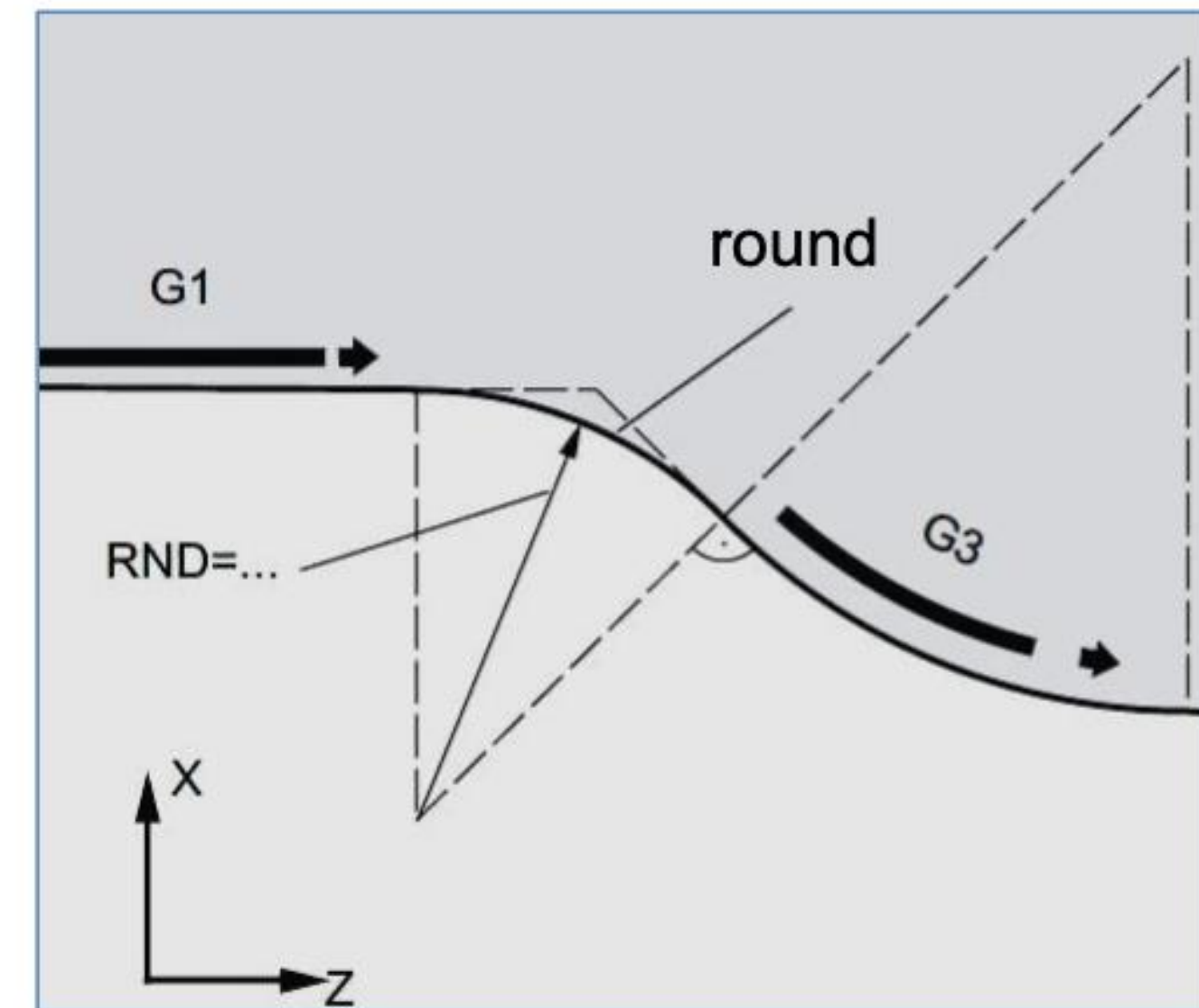


Fig. 94. Round between a line and a circle arc by means of the RND function





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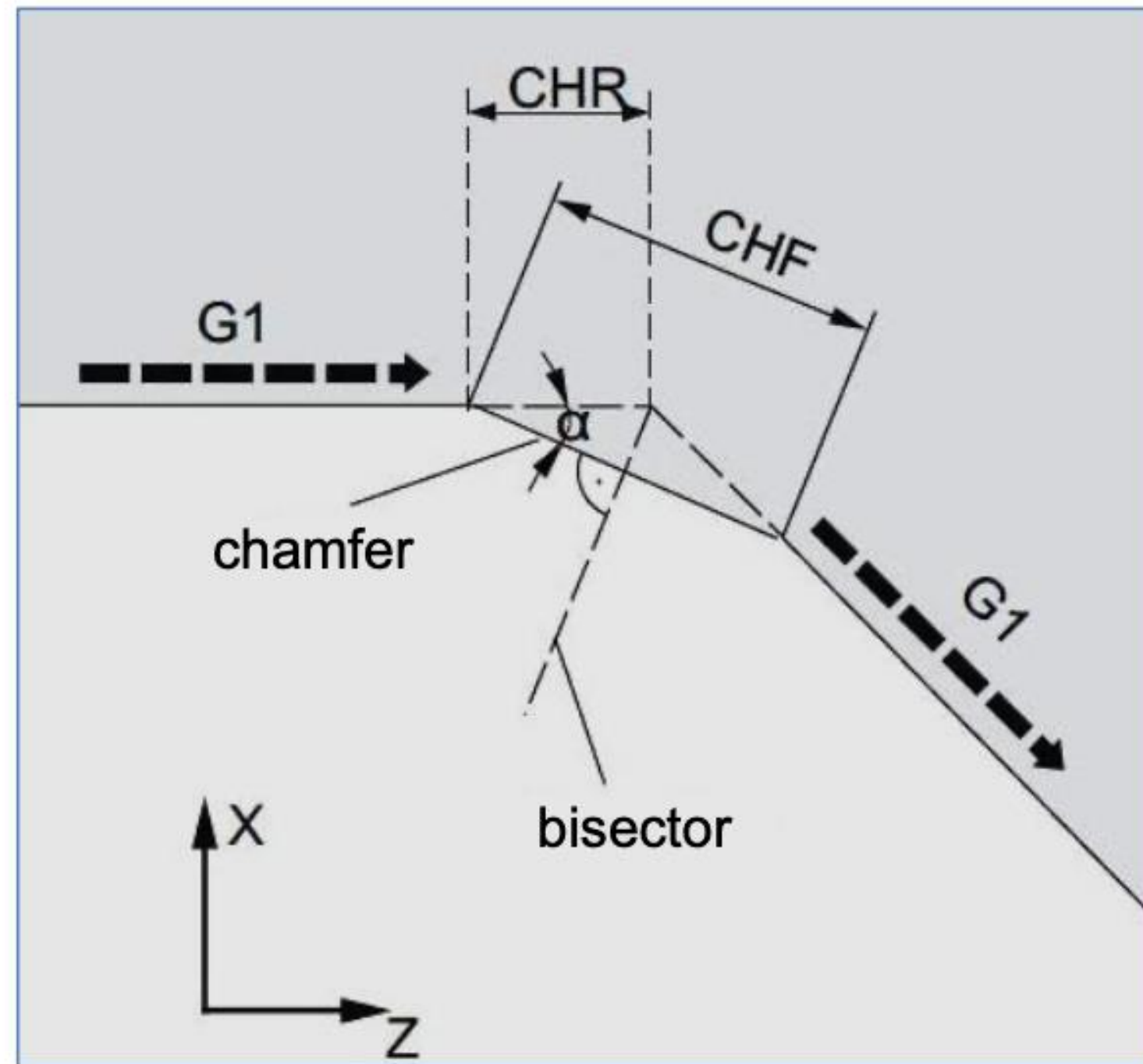


Fig. 95. Chamfer executed between two lines by means of the function CHR or CHF

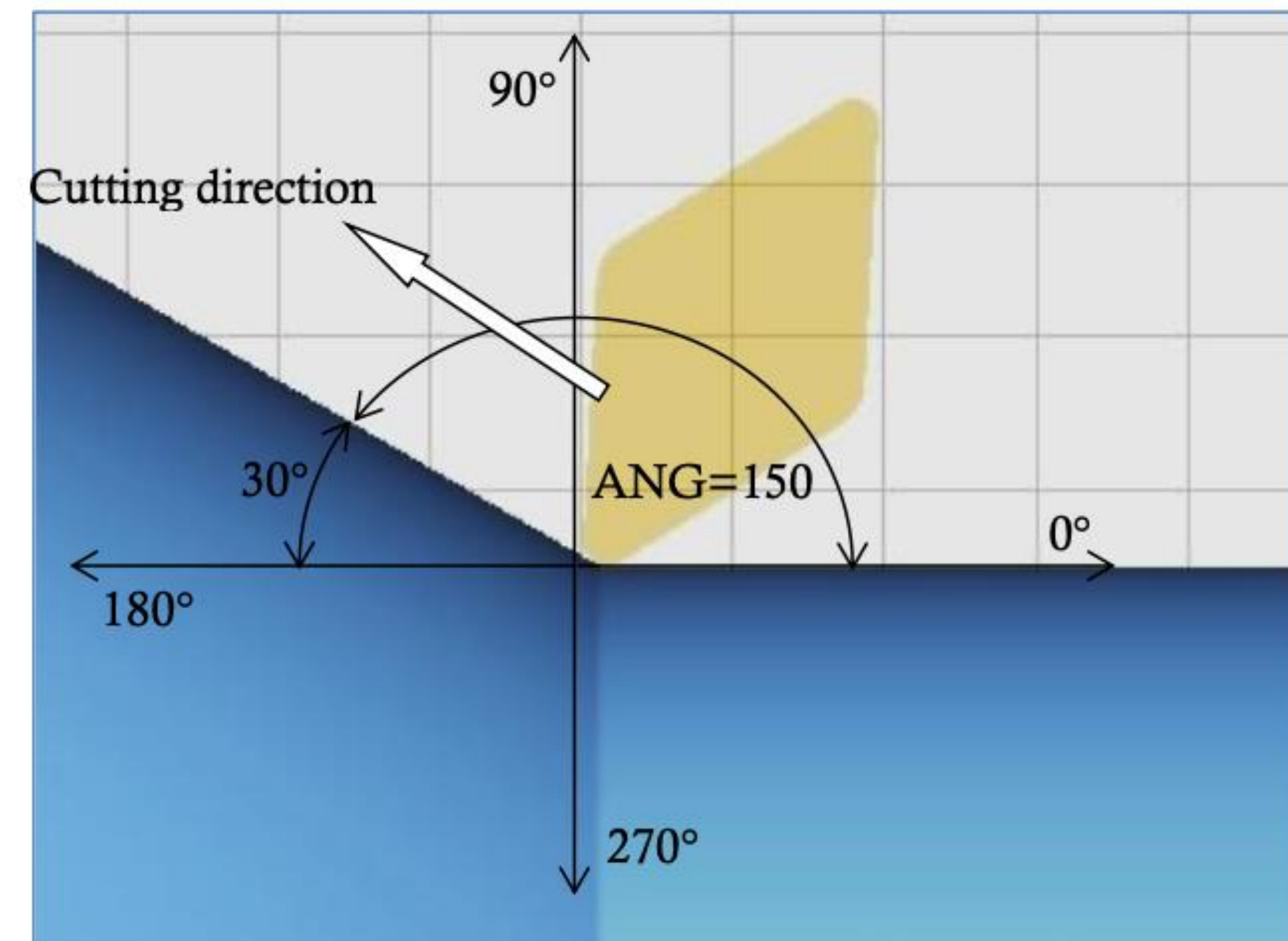


Fig. 96. Scheme for the definition of the angle by means of the function ANG





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The technical drawing shows a mechanical part with a central horizontal axis. The part has a total length of 125. The left end has a diameter of 60. The right end has a diameter of 48. The part features a 14° chamfer on the left end. The right end has a 14° chamfer. The part has a central section with a diameter of 32. The dimensions are: 125 (total length), 80 (length of the left section), 60 (length of the right section), 38 (length of the central section), 22 (length of the central section), 60 (diameter of the left end), 48 (diameter of the right end), 32 (diameter of the central section), 14° (chamfer angle), and 1x45° (chamfer specification).

Blank: Cylinder    XA: 60    ZA: 0.4    ZI: -125    ZB: -80

A collection of CNC programming materials. On the left is a tablet displaying '50 HOURS PRO' and a large 'CNC' logo. In the center is a book titled '50 HOURS PROGRAMMING COURSE' by 'UNIVERSITY DESIGN', featuring a large 'CNC' logo and the text 'CNC DESIGN'. On the right is another tablet displaying '50 HOURS PROGRAMMING COURSE' and a large 'CNC' logo. The book and the right tablet also feature the 'cnc webtech' logo at the bottom.



# CNC - 50 HOUR PROGRAMMING COURSE

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

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

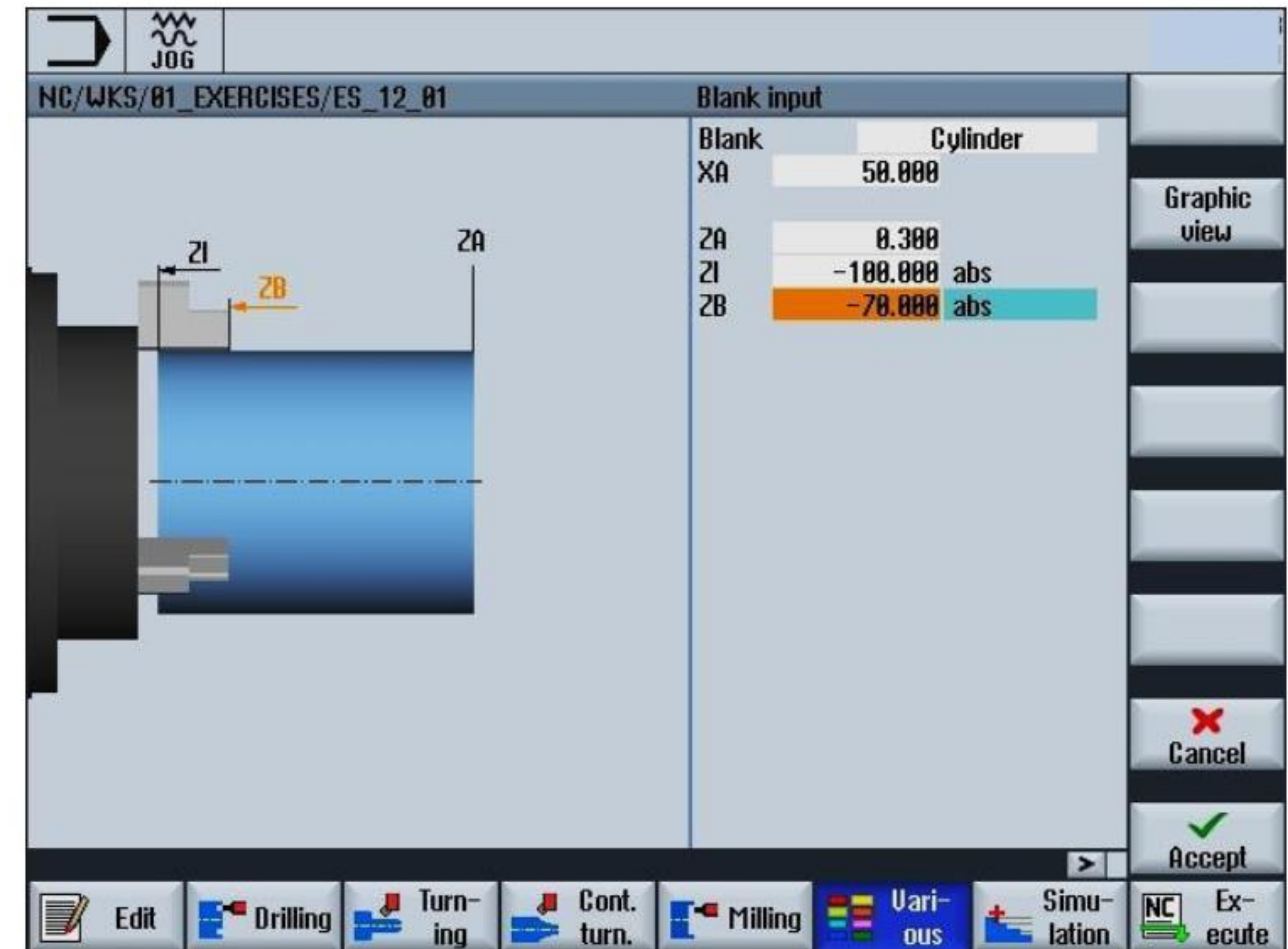
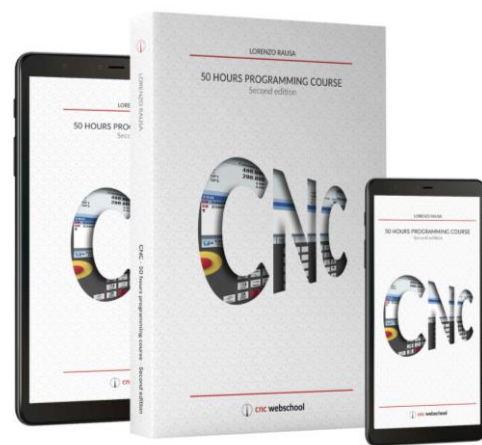


Fig. 99. Page for entering the blank part data





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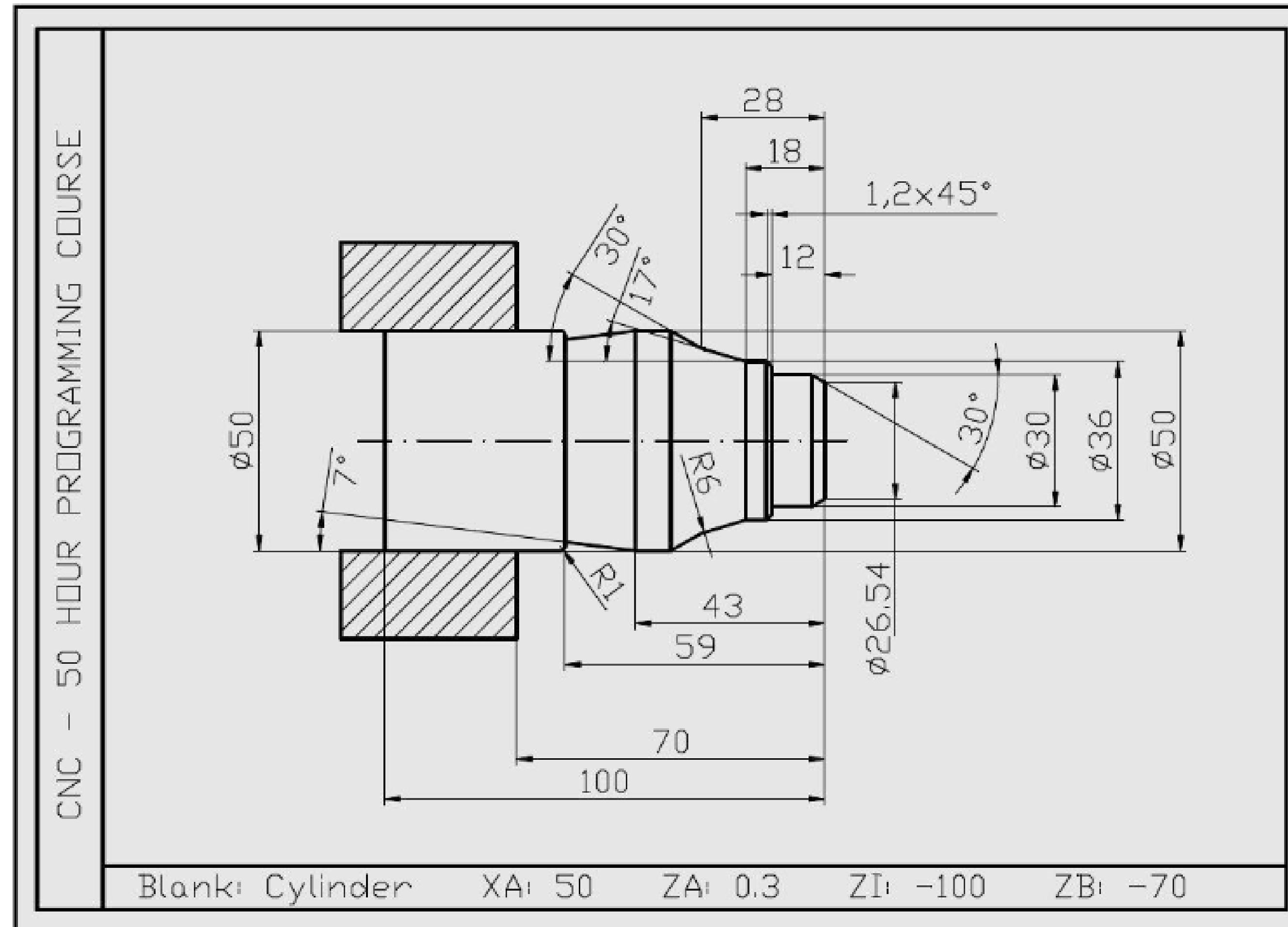
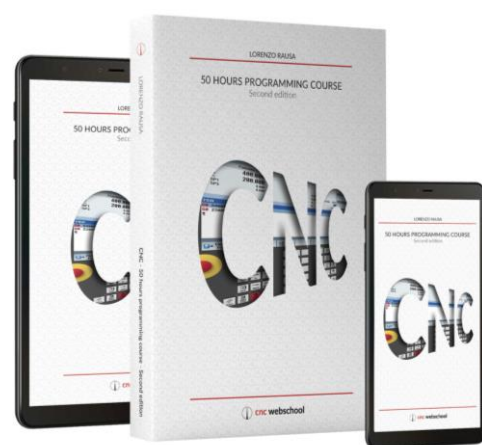


Fig. 100. Enter the missing data for the execution of this profile



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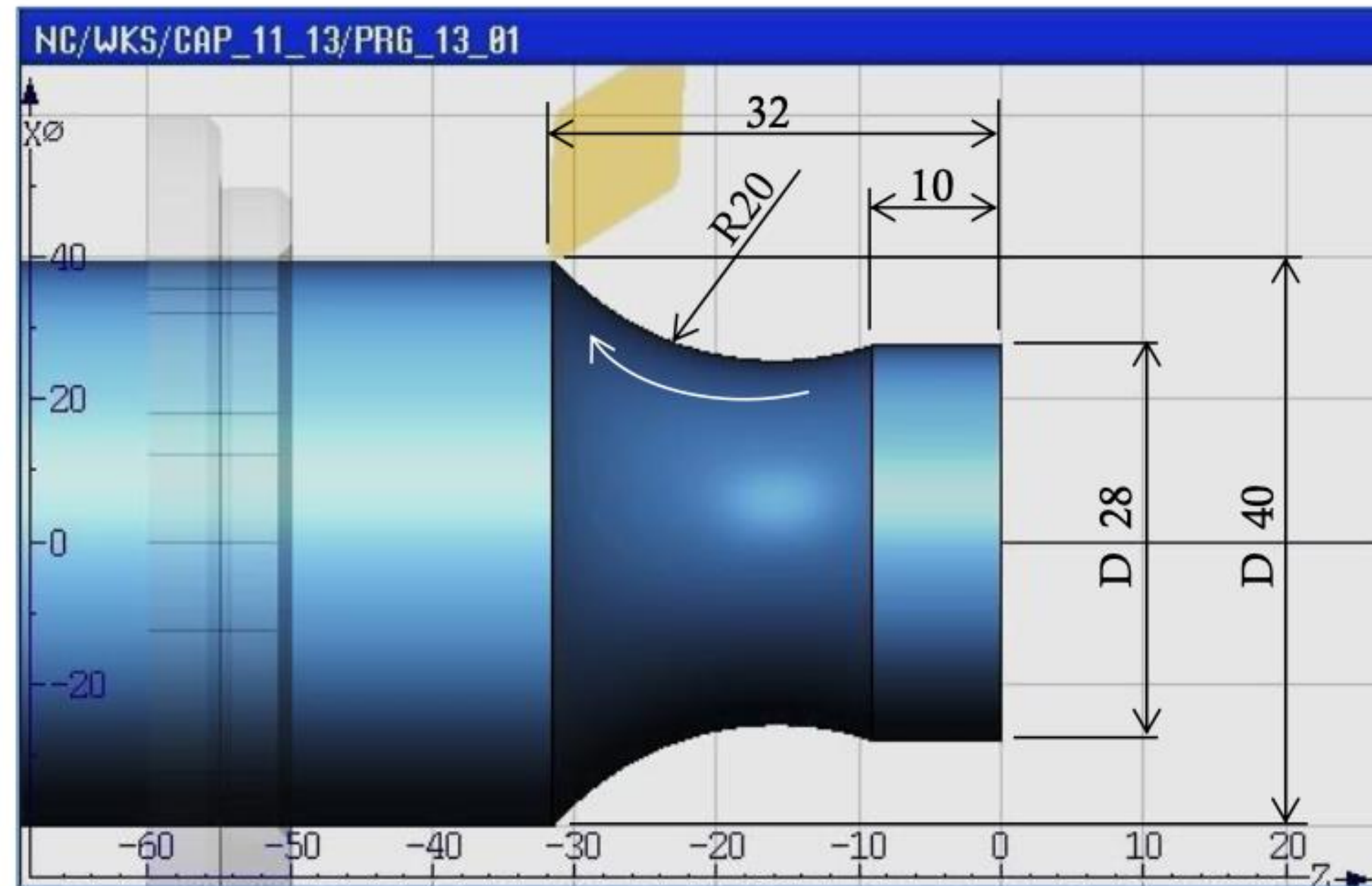


Fig. 101. G2 : circular interpolation in clockwise direction

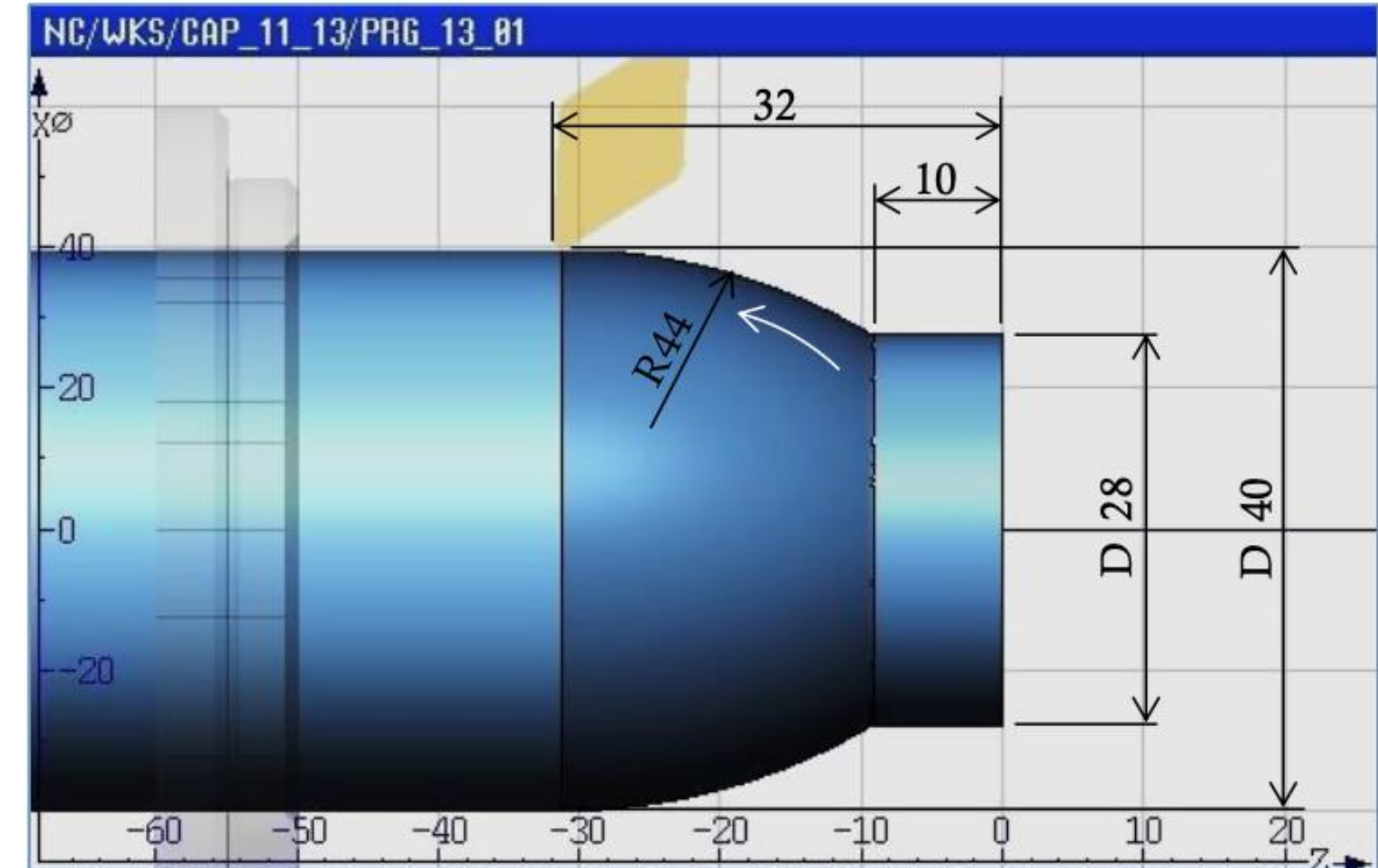
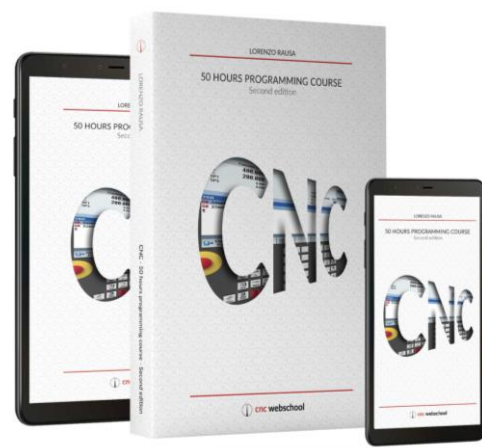


Fig. 102. G3 : circular interpolation in counterclockwise direction





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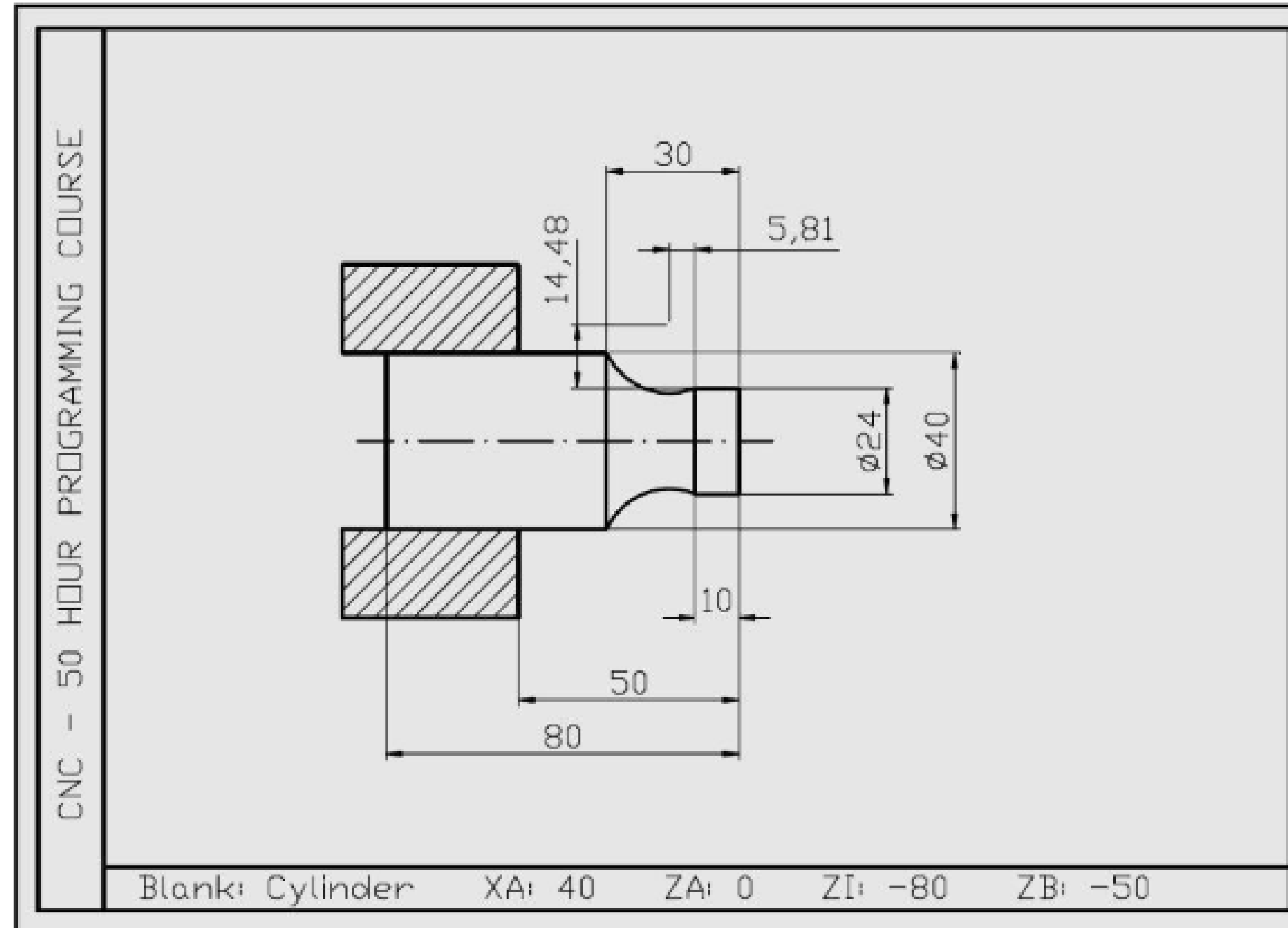
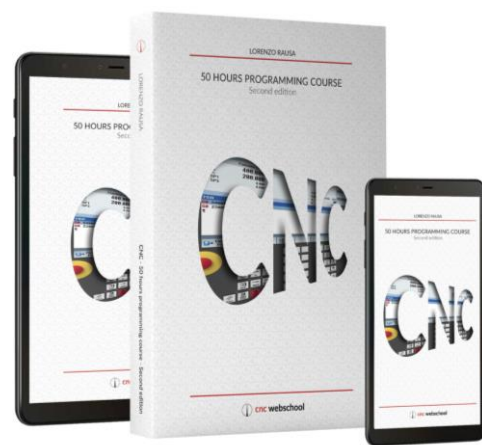


Fig. 103. Programming of an arc by means of the radius center coordinates



# CNC - 50 HOUR PROGRAMMING COURSE

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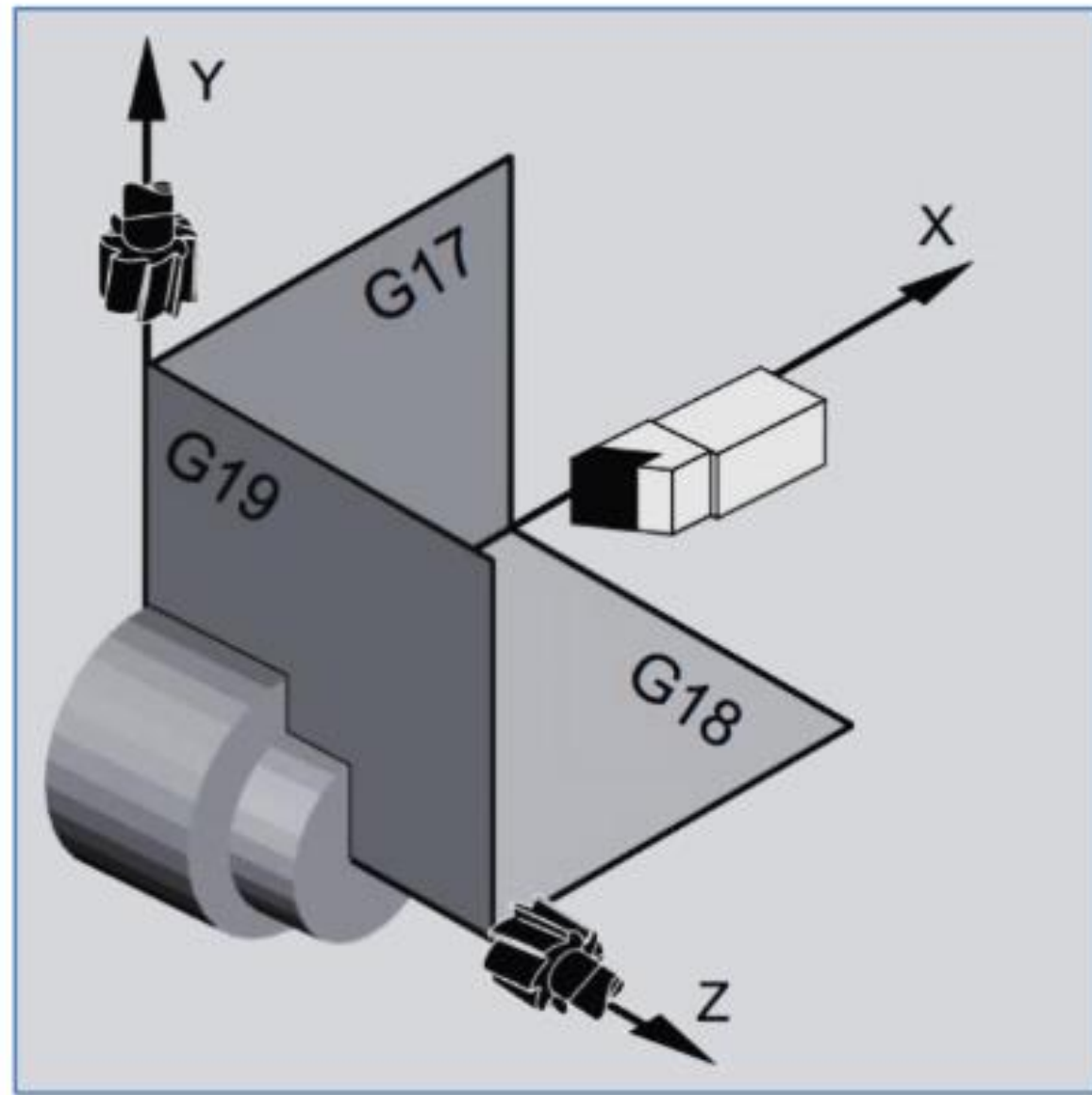


Fig. 104. Functions for the definition of the working plane

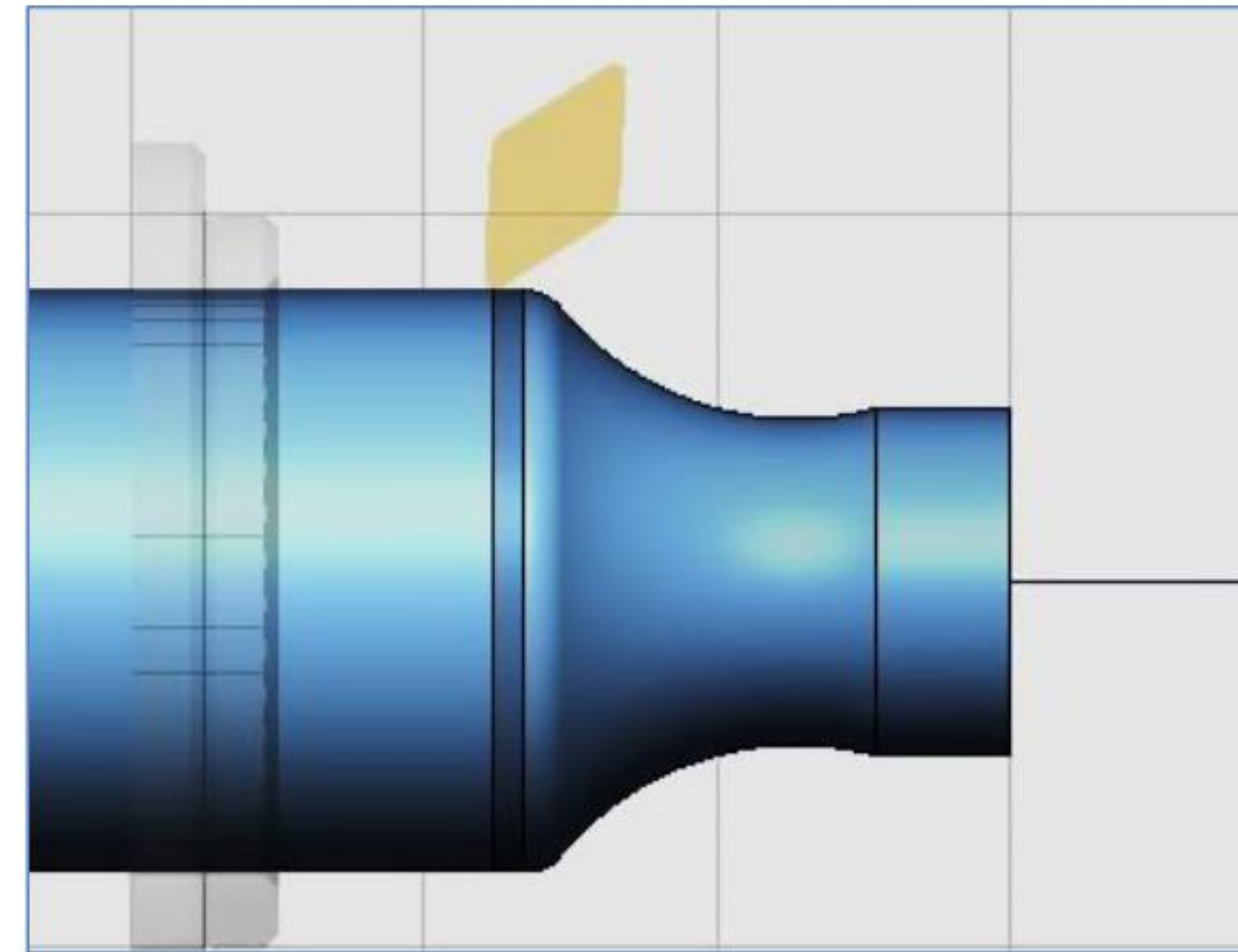
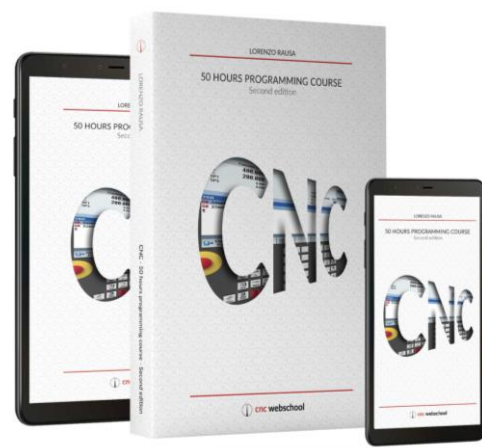


Fig. 105. Round between a radius and the following line by means of G2 and RND





# CNC - 50 HOUR PROGRAMMING COURSE

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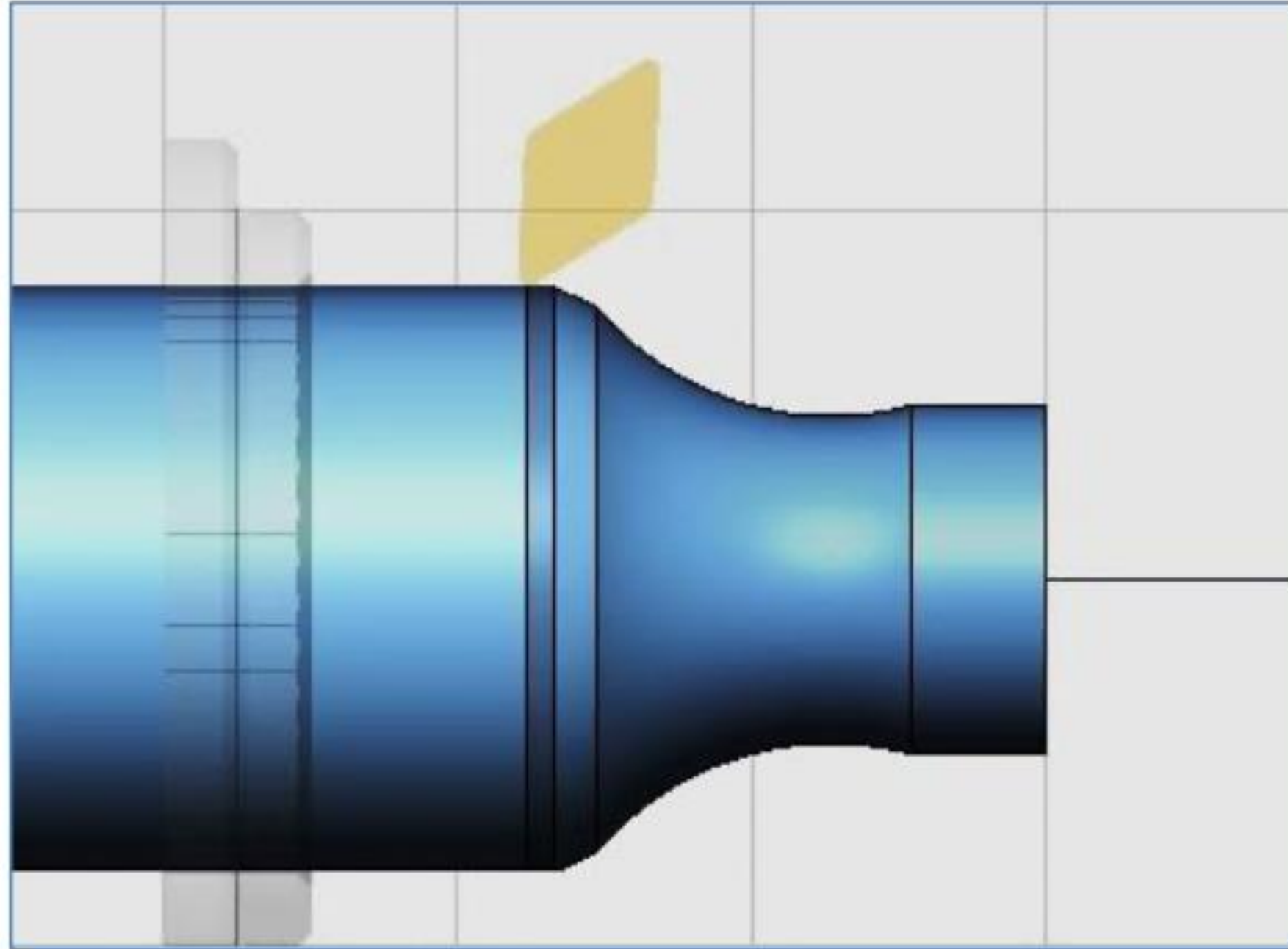


Fig. 106. Chamfer between a radius and the following line by means of G2 and CHR

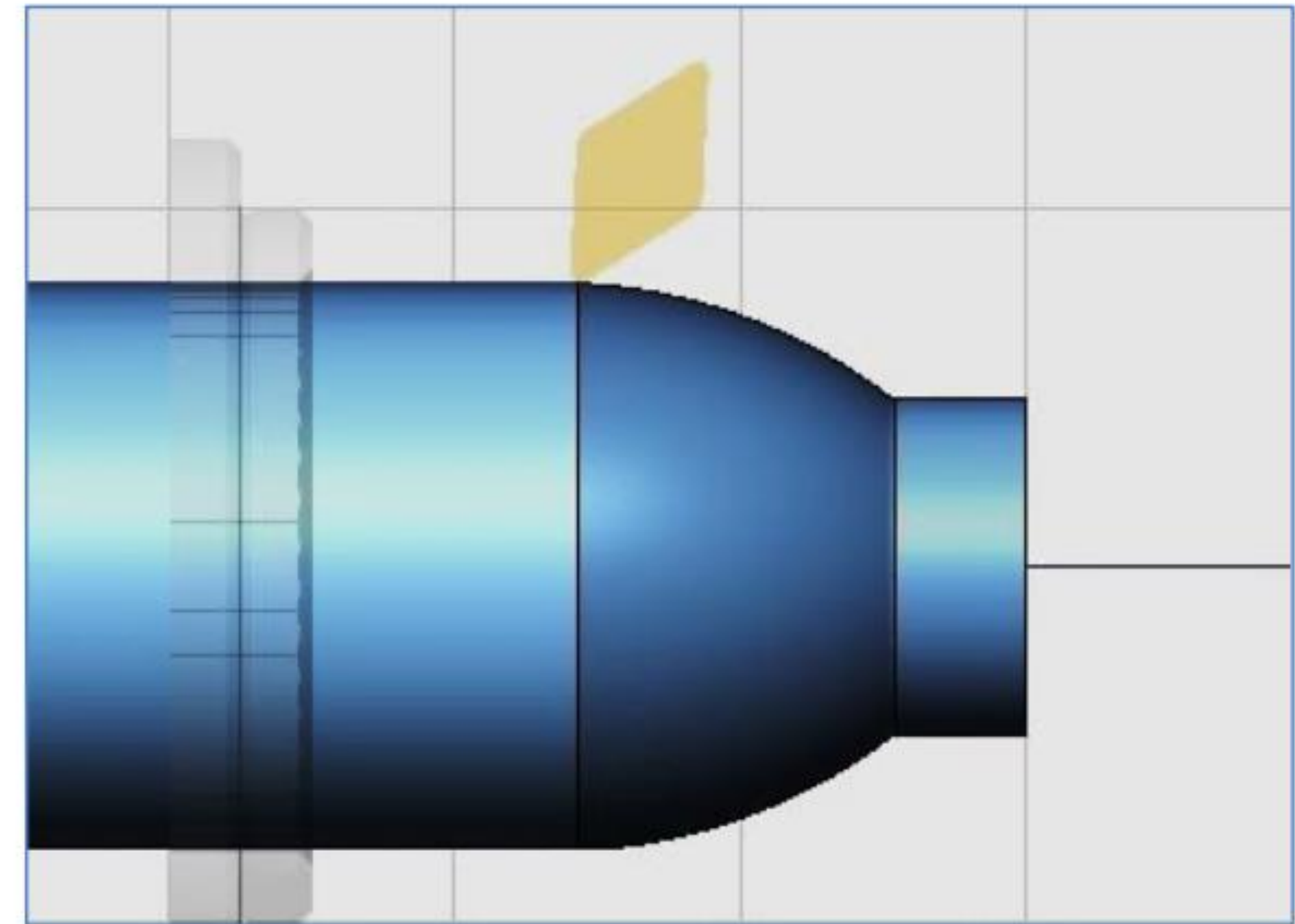
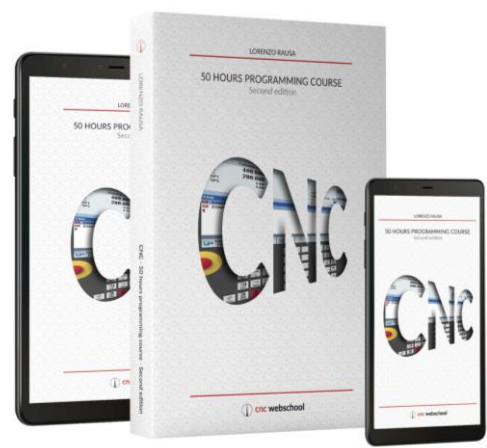


Fig. 107. Use of the function G3



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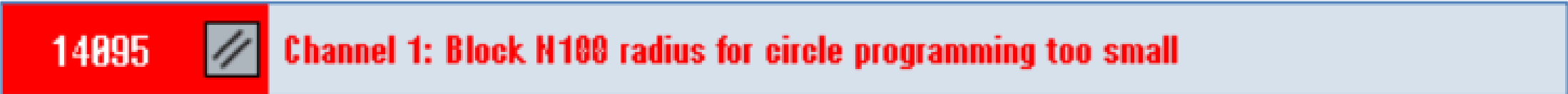


Fig. 108. Type of alarm displayed in the event of a programming error in a radius

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 <sup>st</sup>	T1 D1	Roughing	100	0.18
2 <sup>nd</sup>	T2 D1	Finishing	120	0.12
3 <sup>rd</sup>	T3 D1	Groove	78	0.1
4 <sup>th</sup>	T4 D1	Threading	60	-
5 <sup>th</sup>	T5 D1	Center drilling	80	0.08
6 <sup>th</sup>	T6 D1	Hole D8.5	80	0.1

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





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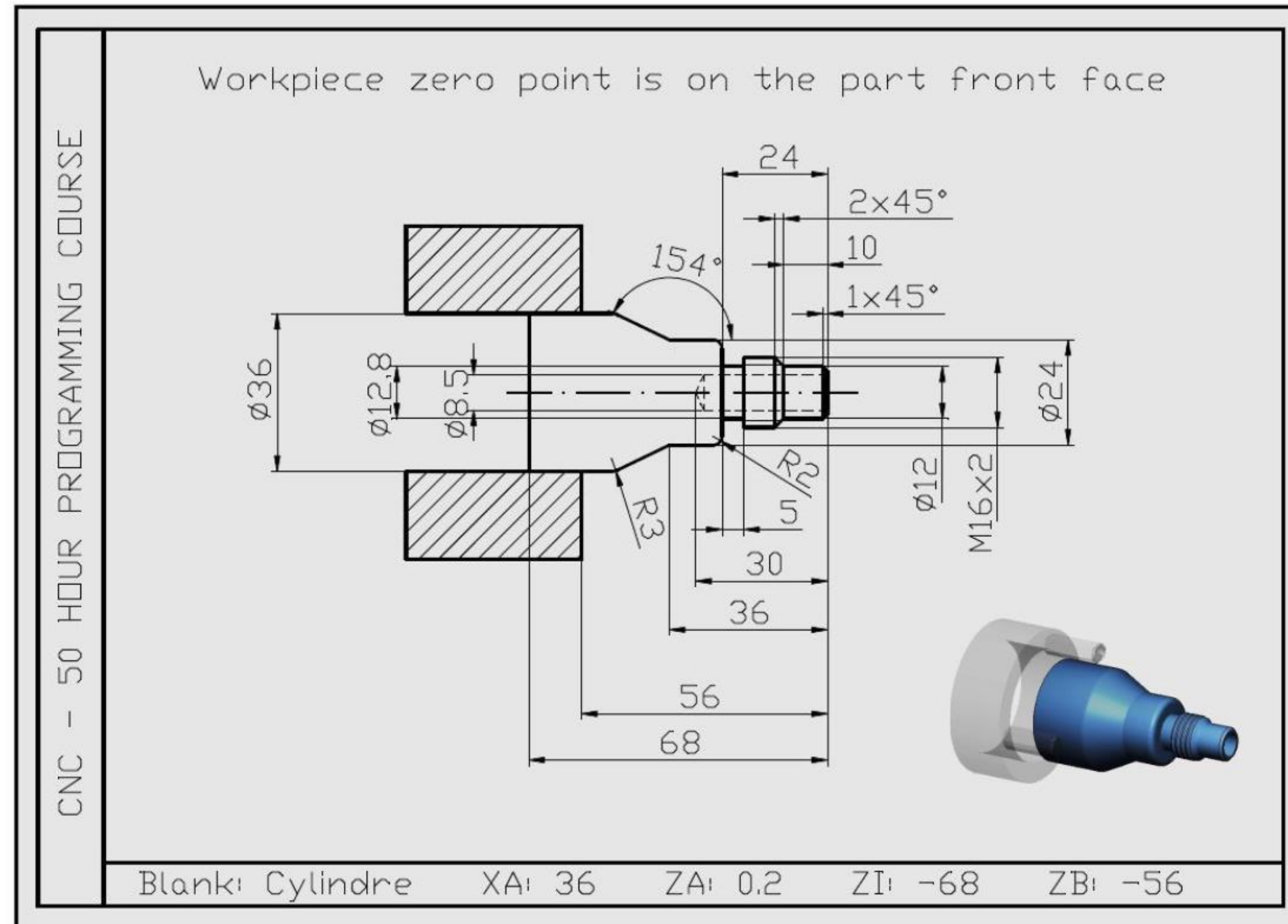
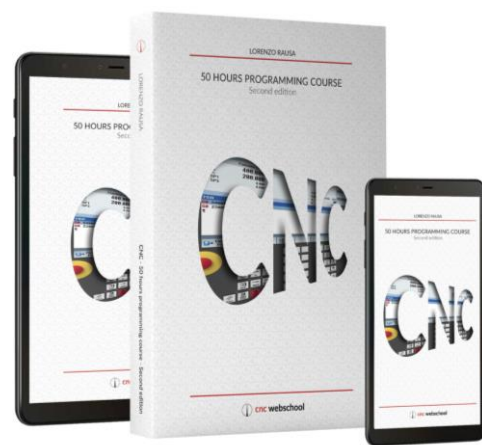


Fig. 111. Drawing of the part to create



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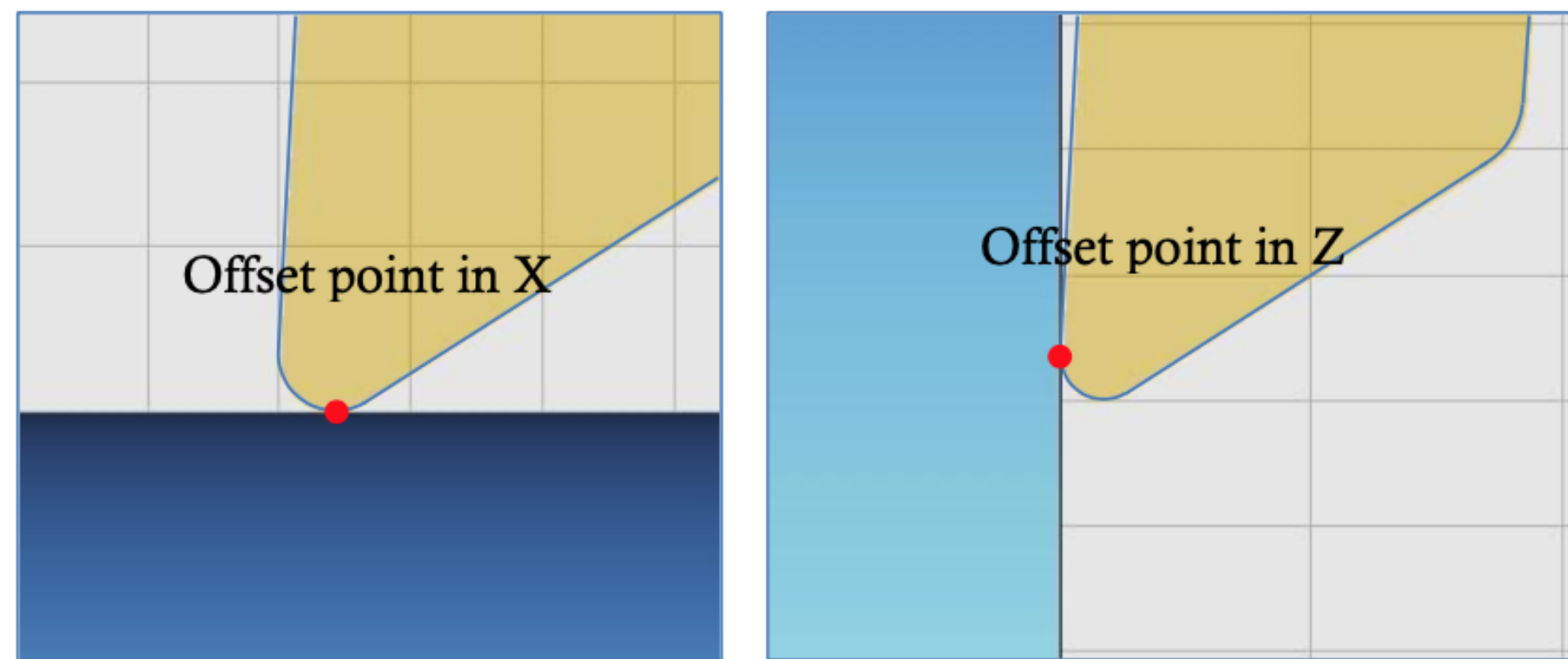


Fig. 112. Offset points on the X-axis and Z-axis with tool radius

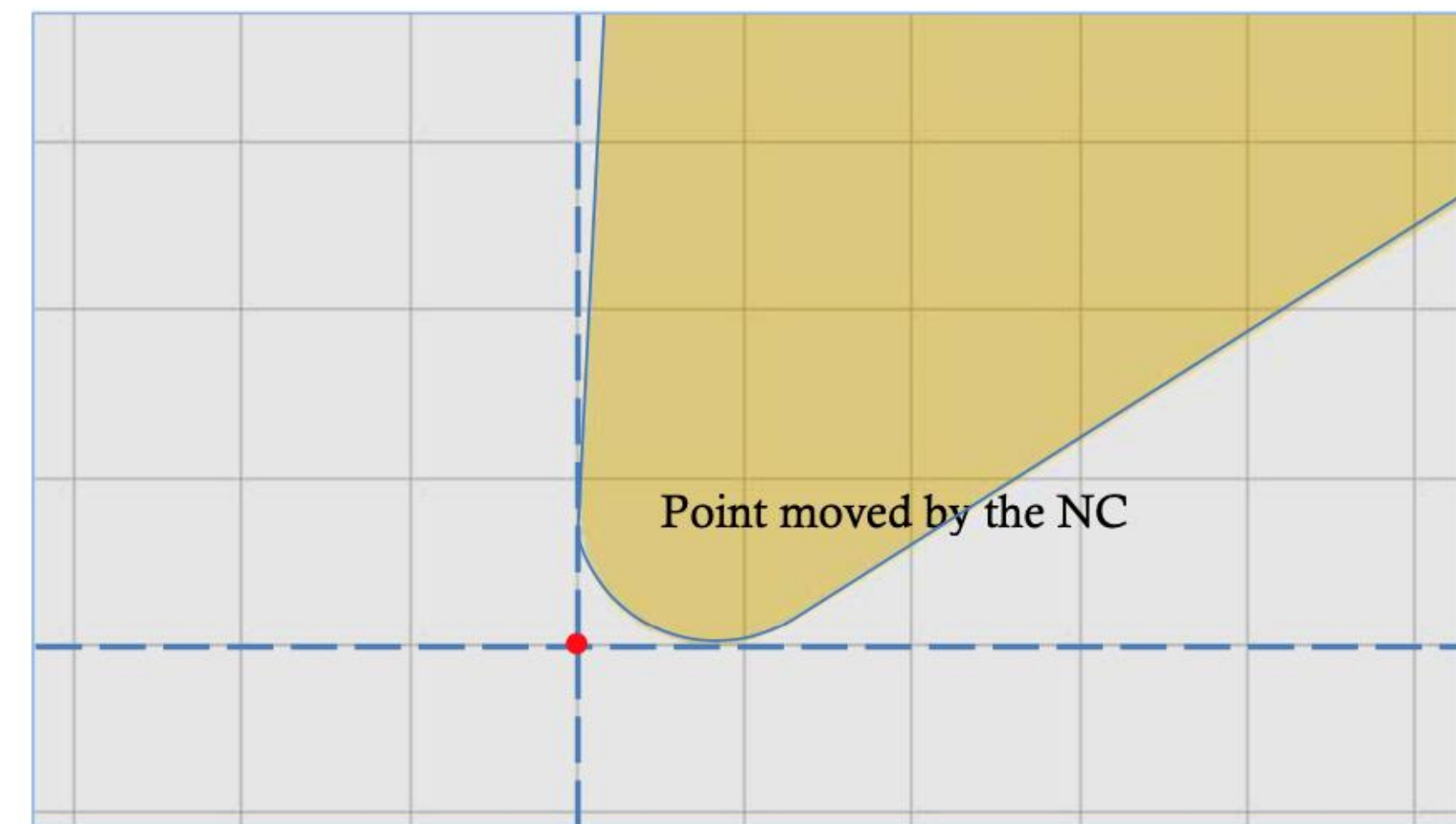
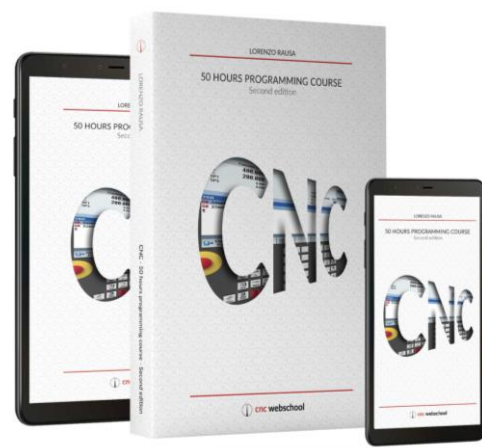


Fig. 113. Point moved by the NC after the tool offset





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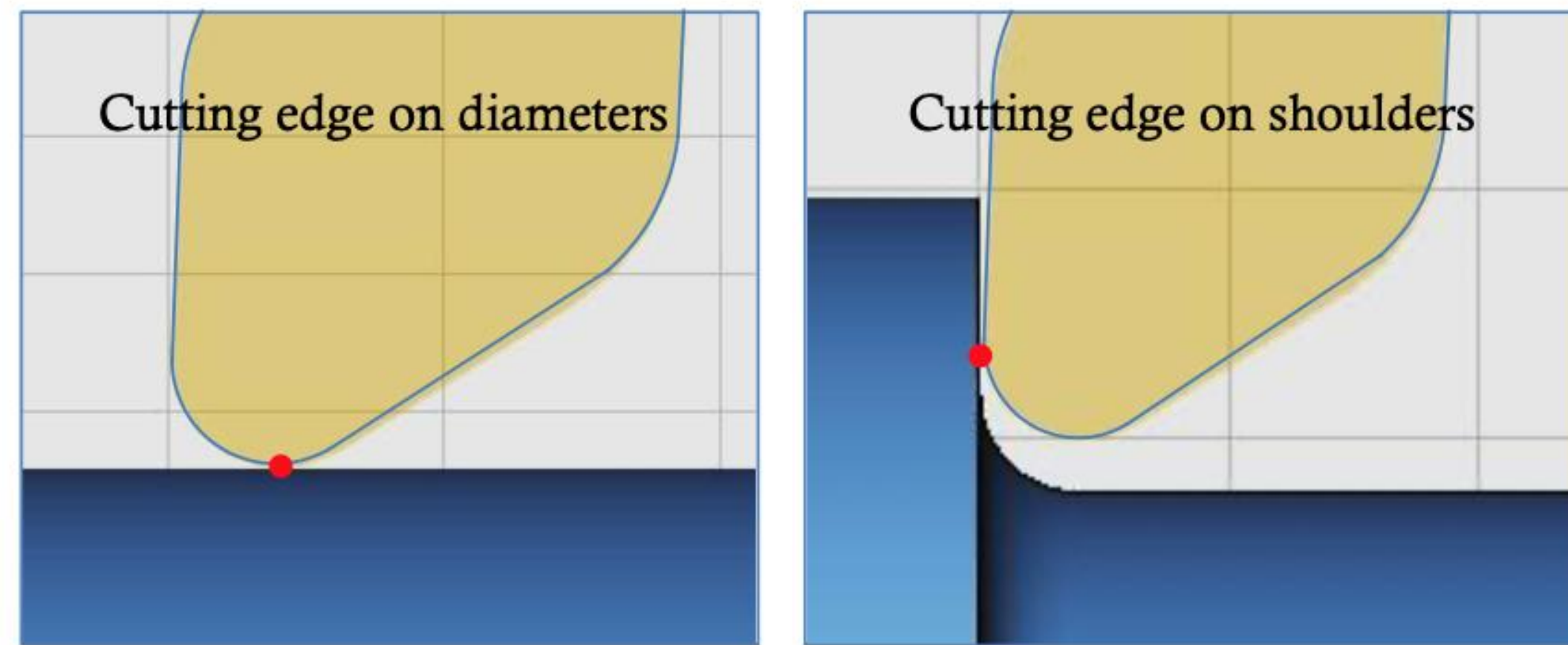


Fig. 114. Absence of changes due to the tool radius on diameters and shoulders

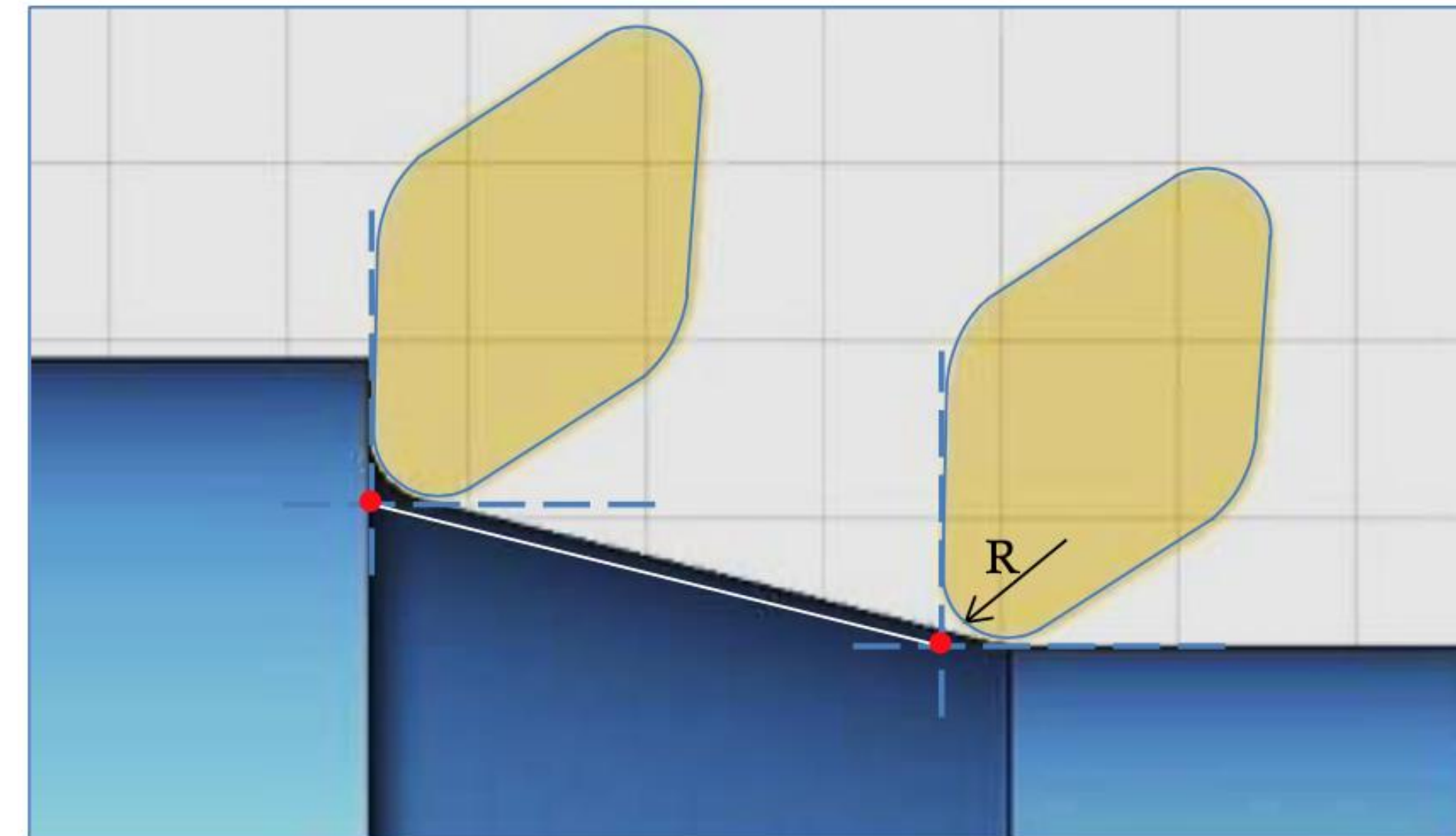


Fig. 115. Dimensional error caused by the insert radius during the execution of conical turnings



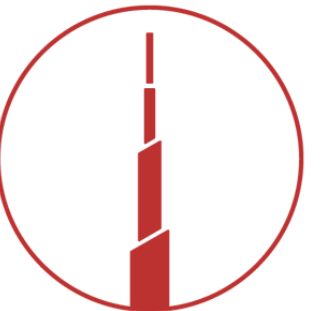


Fig. 117. Quadrant code defining the radius position with respect to the zero point



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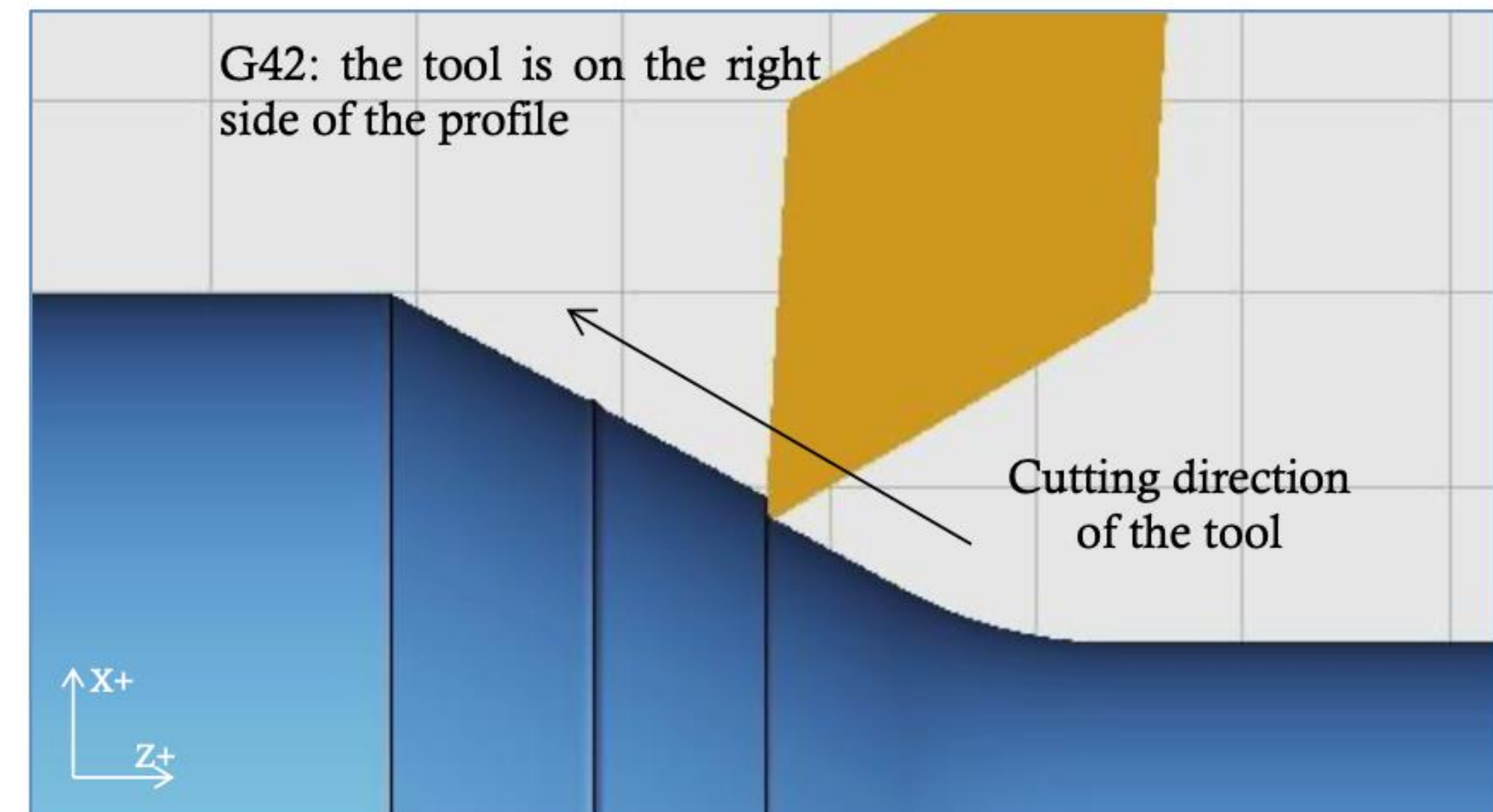
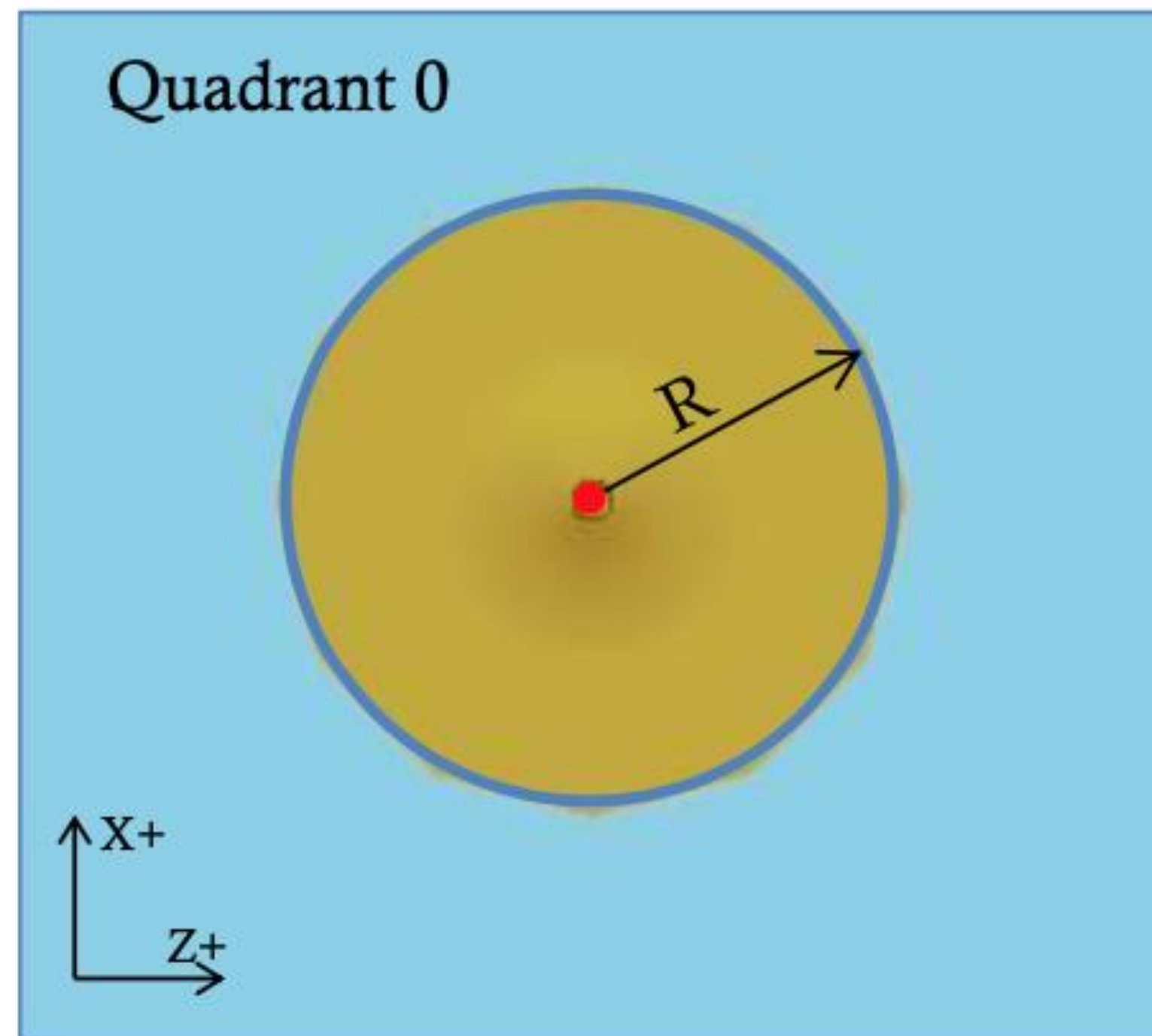


Fig. 119. G42: radius tool 0.2, quadrant 3, to the right of the profile

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



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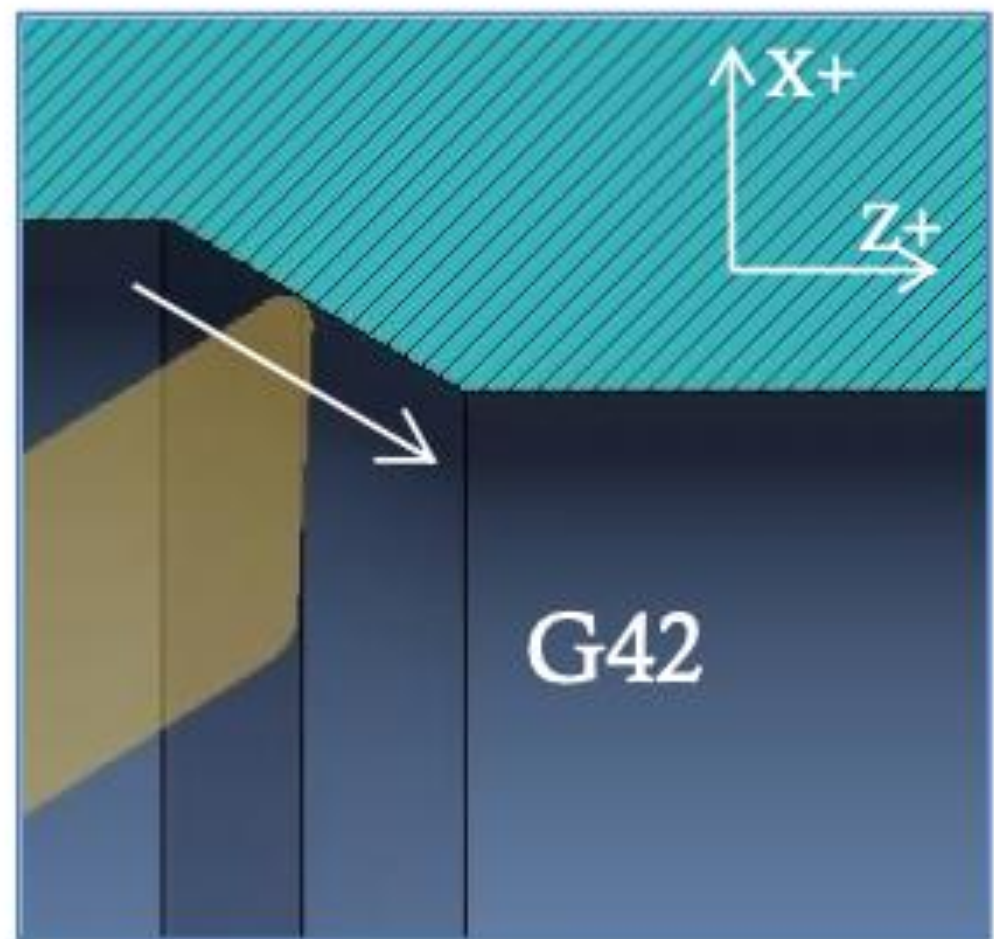


Fig. 120. G42: radius tool 0.8, quadrant 1, to the right of the profile

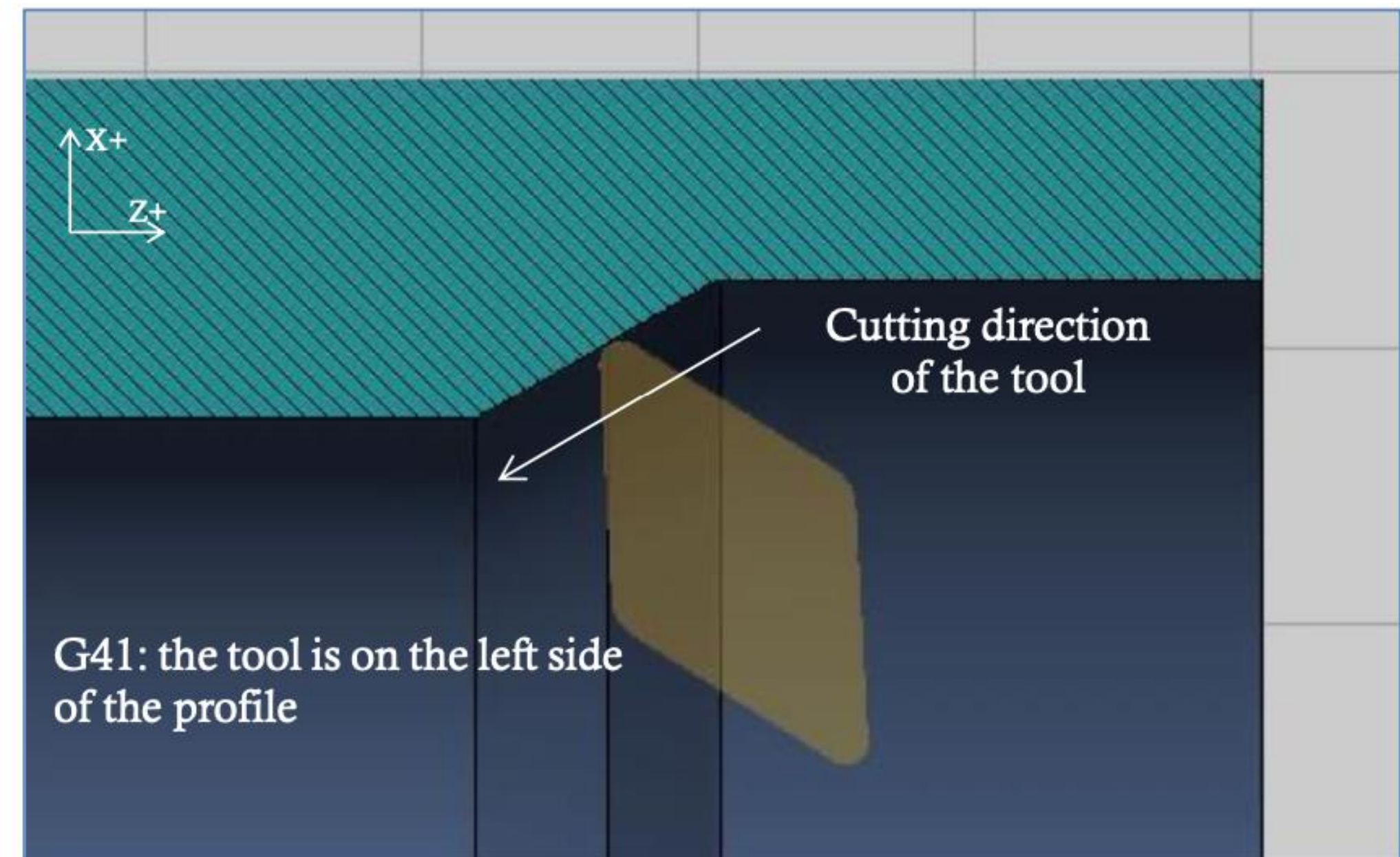
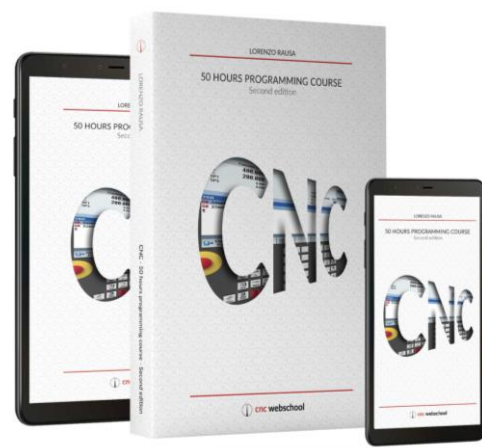


Fig. 121. G41: radius tool 0.8, quadrant 2, to the left of the profile





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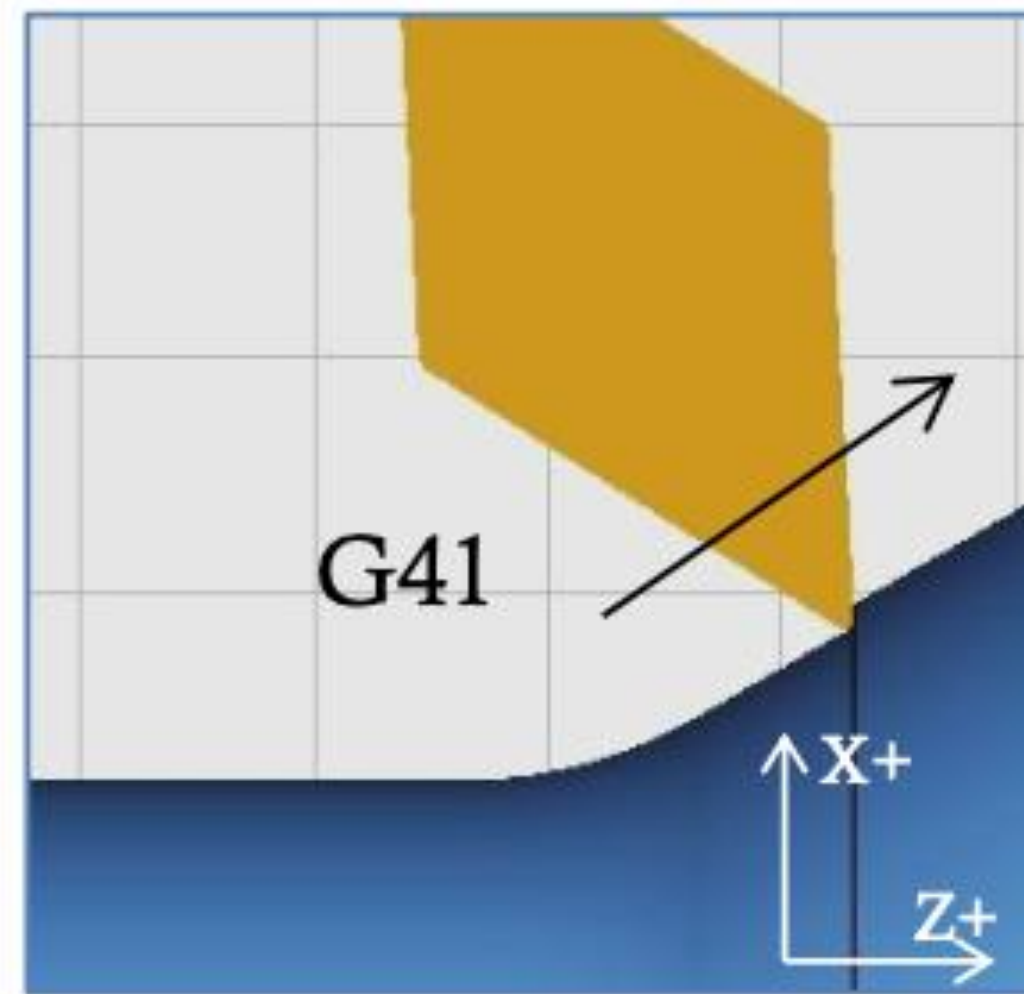


Fig. 122. G41: radius tool 0.2, quadrant 4, to the left of the profile

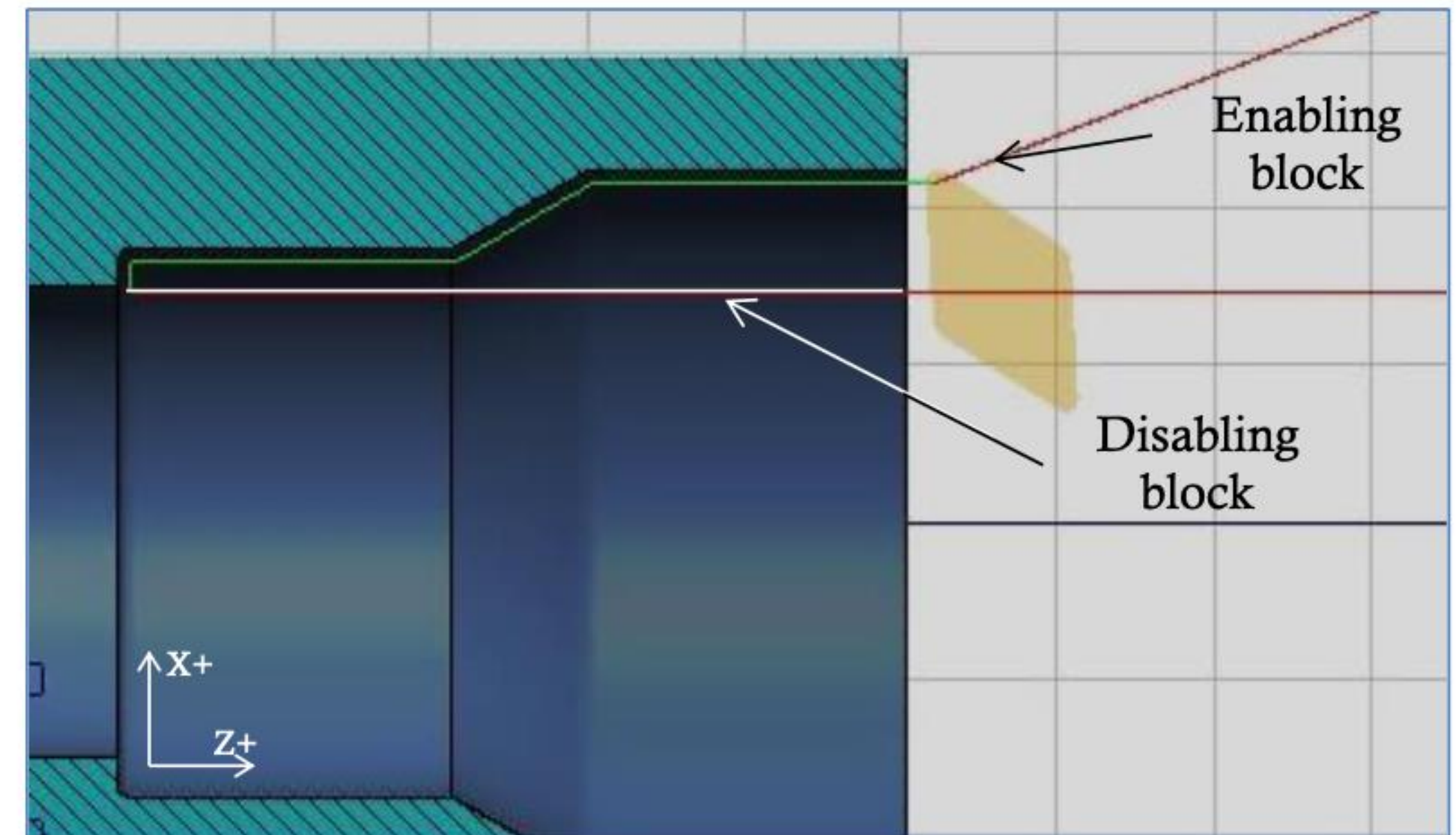


Fig. 123. Enabling and disabling block outside of the profile





Fig. 124. Drawing of the part to create



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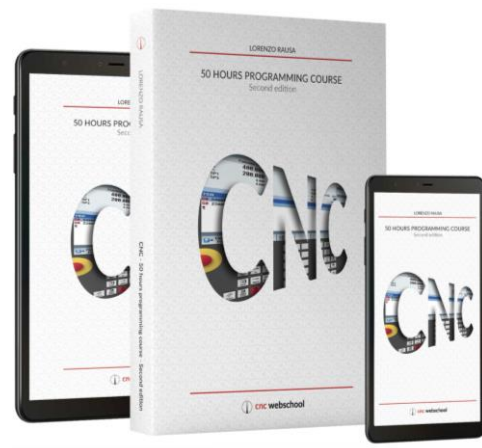
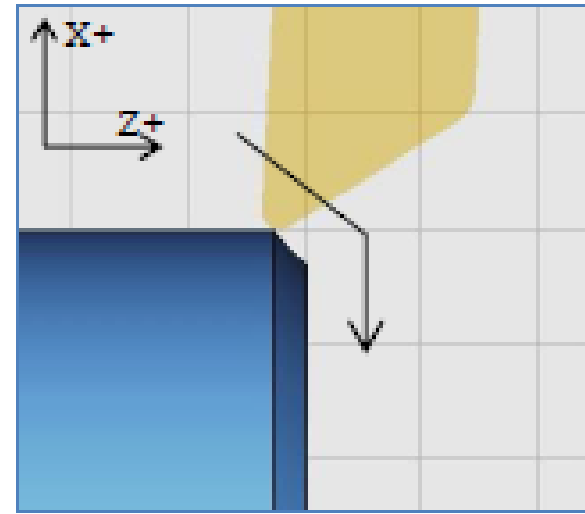
11		AX. DRILL D.16	1	1	100.000	120.000	16.000		118.0		
12		ROUGH. BORING-BAR	1	1	86.000	92.000	0.400	←	93.0	55	8.0

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



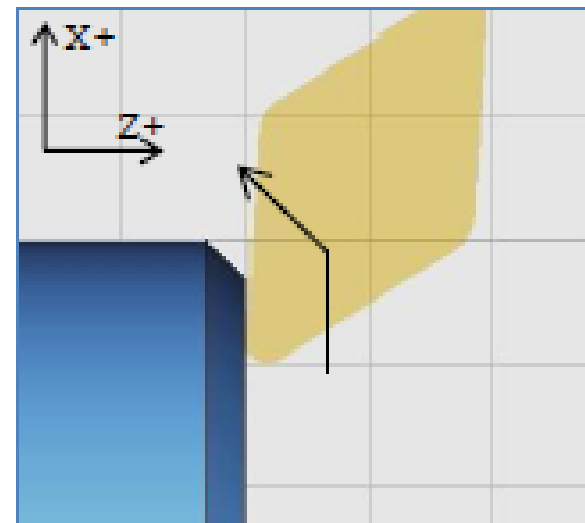
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1)



- a) G42, quadrant 3
- b) G41, quadrant 3
- c) G41, quadrant 4

2)



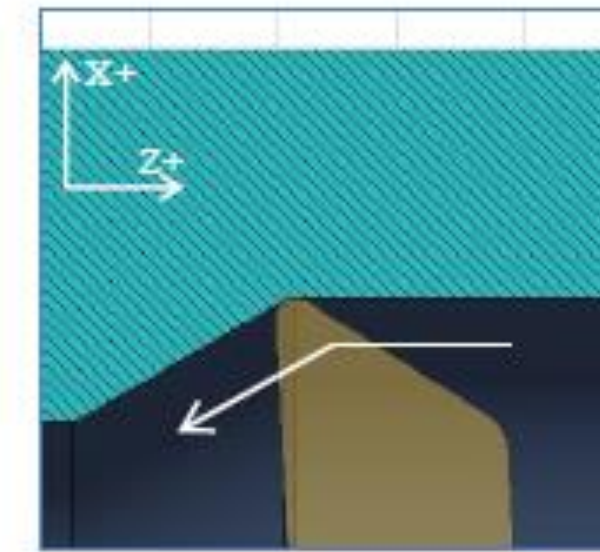
- a) G41, quadrant 1
- b) G42, quadrant 3
- c) G42, quadrant 2

3)



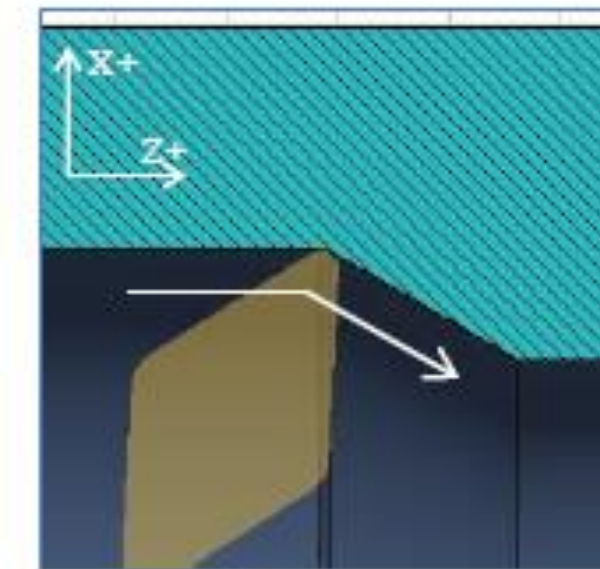
- a) G42, quadrant 4
- b) G42, quadrant 2
- c) G41, quadrant 4

4)



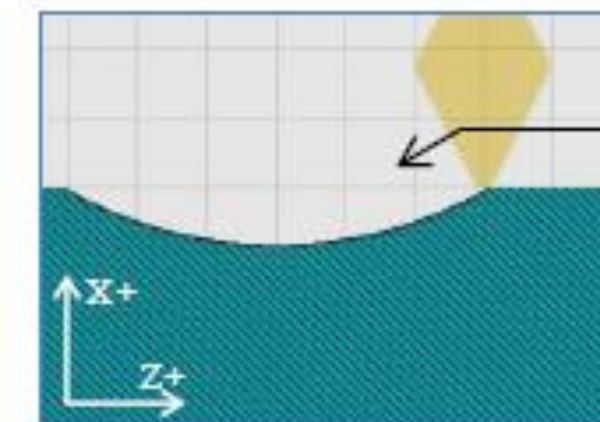
- a) G41, quadrant 2
- b) G42, quadrant 2
- c) G41, quadrant 3

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

