

Lab Manual

CAM Lab

List of G-Code (Preparatory Functions) and M-code (Machine Functions) used for Milling Operations

G00	Rapid Positioning	M00	Program Stop
G01	Linear Interpolation	M01	Optional Stop
G02	Clockwise Circular Interpolation	M02	Program End
G03	Anti-Clockwise Circular Interpolation	M03	Spindle Rotation Clockwise
G04	Exact Stop (Dwell)	M04	Spindle Rotation CCW
G17	XY Plane	M05	Spindle Stop
G18	ZX Plane	M06	Tool Change
G19	YZ Plane	M08	Coolant On
G20	Input in Inch	M09	Coolant Off
G21	Input in mm	M10	Vice Open
G28	Return to reference Point	M11	Vice Close
G50	Scaling OFF	M13	Spindle Rotation Coolant on
G51	Scaling ON	M14	Spindle Rotation Coolant off
G73	High Speed Drilling Cycle	M20	ATC Arm in
G74	Left Hand Tapping Cycle	M21	ATC Arm out
G76	Fine Boring	M22	ATC Arm out
G80	Canned Cycle Cancel	M23	ATC Arm down
G81	Spot Drilling	M24	ATC Tool Clamping
G84	Right Hand Tapping Cycle	M25	ATC Draw Bar Releasing
G85	Boring Cycle with Feed retraction	M27	ATC Reset
G86	Boring Cycle with rapid retraction	M30	Program Stop and Reset
G88	Boring Cycle	M70	X-Mirror ON
G90	Absolute Coordinate System	M71	Y-Mirror ON
G91	Incremental Coordinate System	M80	X-Mirror OFF
G94	Feed per Minute	M81	Y-Mirror OFF
G95	Feed per revolution	M98	Sub-Program Call
G98	Return to Initial point in a canned Cycle	M99	Sub Program Exit

G99

Return to R Point in a canned
Cycle

List of Codes used in Lathe Operations

M00	Program Stop	G00	Positioning (Rapid traverse)
M01	Optional Stop	G01	Linear interpolation (Cutting feed)
M02	Program End	G02	Circular interpolation (Clockwise)
M03	Spindle Rotation Clockwise	G03	Circular interpolation (Counter Clockwise)
M04	Spindle Rotation Counter Clockwise	G04	Dwell
M05	Spindle Stop	G17	XY plane selection
M06	Tool Change	G18	ZX plane selection
M08	Coolant On	G19	YZ plane selection
M09	Coolant Off	G20	Input in inch
M10	Chuck Open	G21	Input in mm
M11	Chuck Close	G28	Return to reference point
M30	Program Stop and Rewind	G40	Tool Nose Radius compensation cancel
M62	Output 1 On	G41	Tool Nose Radius compensation left
M63	Output 2 On	G42	Tool Nose Radius compensation right
M64	Output 1 Off	G70	Finishing Cycle
M65	Output 2 Off	G71	Multiple Turning Cycle
M66	Wait input 1 On	G72	Multiple Facing Cycle
M67	Wait input 2 On	G73	Pattern Repeating Cycle
M76	Wait input 1 Off	G74	Drilling Cycle
M77	Wait input 2 Off	G75	Grooving Cycle
M98	Sub-program Call	G76	Multiple Threading Cycle
M99	Sub-program Exit	G90	Turning Cycle
		G92	Threading Cycle
		G94	Facing Cycle
		G96	Constant Surface Speed Control
		G97	Constant Surface Speed Control Cancel
		G98	Feed Per Minute

	G99	Feed Per Revolution
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Address Characters As per DIN 66025	
Character	Meaning
A	Rotation about, X-axis
B	Rotation about, Y-axis
C	Rotation about, Z-axis
D & E	Rotational about additional axis
F	Feed
G	Preparatory Function
H	Unassigned
I	Thread pitches parallel to X-axis
J	Thread pitches parallel to Y-axis
K	Thread pitches parallel to Z-axis
L	Unassigned
M	Machine Function
N	Block Number
O	Program Number
P, Q, R	Parameter are used in cycles
S	Spindle speed
T	Tool function
U, V, W	Second movement parallel to X, Y, Z axes respectively



Structure of Program

- Start Up program

O1000

G21 G94

G91 G28 Z0

G28 X0 Y0

M06 T01

M03 S1500

G00 X0 Y0 Z5

- Profile Program: Based on the given part drawing.
- End of the program

G91 G28 Z0

G28 X0 Y0

M05

M30

Experiment: 01

Aim: To perform the linear and circular interpolation using CNC Milling.

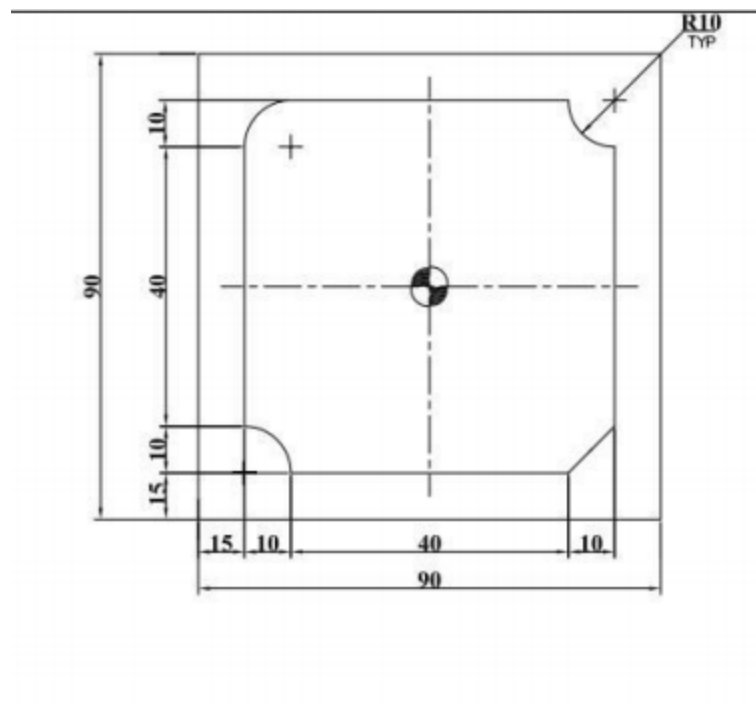
Material: Aluminum 90×90×10 mm

Tool Used: End Drill bit 6mm

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Check the Air pressure to 6 bar and clamp the job on machine bed.
- Write the program on CNC Editor using G-codes and M-codes.
- Run and check the program in SINGLE mode.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing



Part Program

```
G21 G94
G91 G28 Z0
G28 X0 Y0
M06 T1
M03 S1500
G90 G00 X-30 Y-20 Z5
G01 Z-1 F100
G01 X-30 Y20
G02 X-20 Y30 R10
G01 X20 Y30
G03 X30 Y20 R10
G01 X30 Y-20
G01 X20 Y-30
G01 X-20 Y-30
G03 X-30 Y-20 R10
G00 Z5 G91
G28 Z0
G28 X0 Y0
M05
M30
```

Result: When all the steps are executed, the desired machine surface is achieved with better surface finish and more accuracy. The final product is achieved as per the part program using END MILL CUTTER and G-code and M-codes.

Experiment: 02

Aim: To perform the mirroring operation using sub-program on CNC Milling.

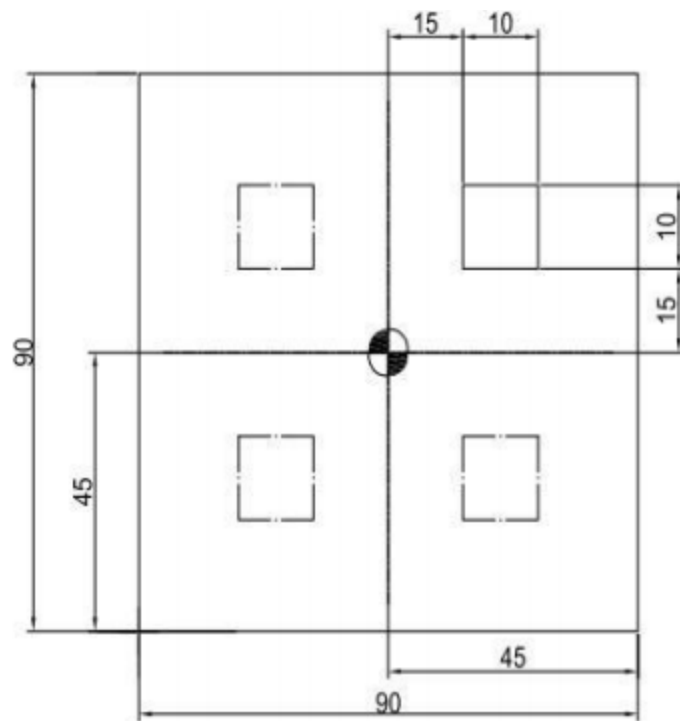
Material: Aluminum 90×90×10 mm

Tool Used: End Drill bit 6mm

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.
- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing:



Part Program

G21 G94

G91 G28 Z0

G28 X0 Y0

M06 T1

M03 S1500

M98 P2244

M70

M98 P2244

M80

M71

M98 P2244

M81

M70

M71

M98 P2244

M80

M81

G00 Z5

```
G91 G28 Z0
G28 X0 Y0
M05
M30
O2244
G90 G00 X15 Y15 Z5
G01 Z-1 F100
G01 X15 Y25
G01 X25 Y25
G01 X25 Y15
G01 X15 Y15
G00 Z5
G00 X0 Y0
M99
```

Result: When all the steps are executed, the desired machine surface is achieved with better surface finish and more accuracy. The final product is achieved as per the part program using END MILL CUTTER and G-code and M-codes.

Experiment: 03

Aim: To perform the circular and rectangular pocket milling operation using CNC Milling.

Material: Aluminum 90×90×10 mm

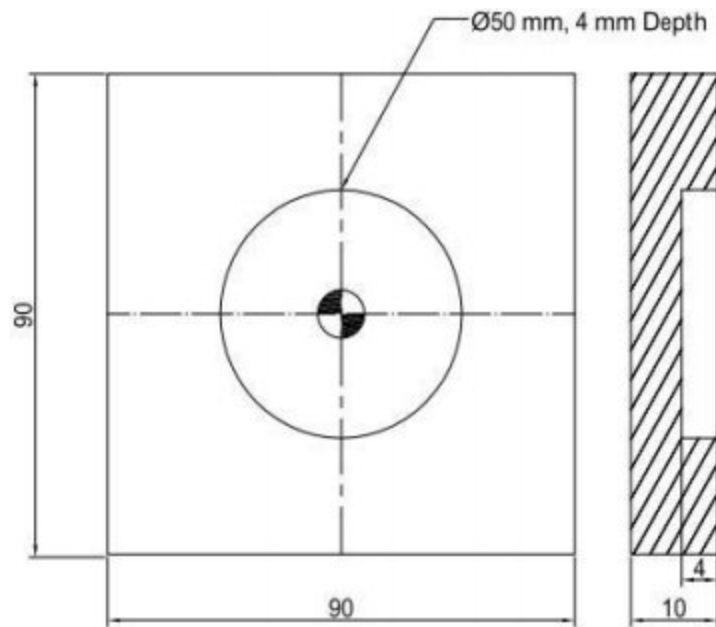
Tool Used: End Drill bit 6mm

Procedure:

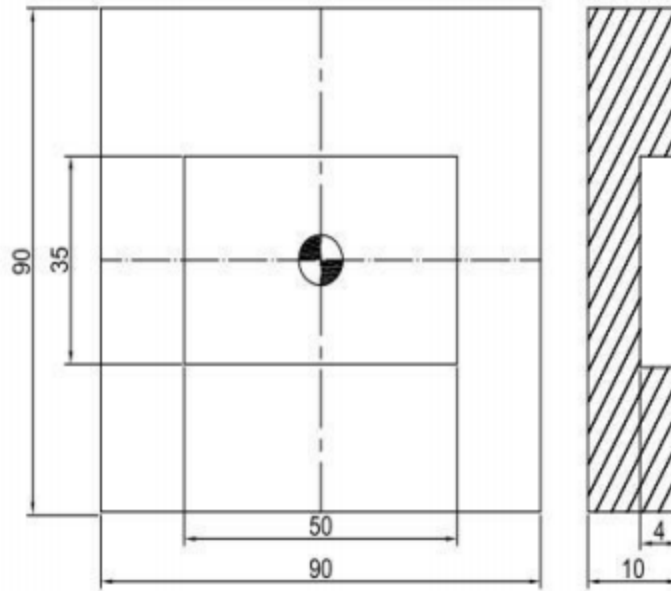
- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.
- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.

- Click the CYCLE RUN to start the machining.

Part Drawing:



Circular Pocket



Rectangular Pocket Milling

Part Program

Circular Pocket

```
G21 G94
G91 G28 Z0
G28 X0 Y0
M06 T1
M03 S1500
G90 G00 X0 Y0 Z5
G170 P0 Q1 R0.5 X0 Y0 Z-4 I0.1 J0.1 K25
G171 P50 S1200 R60 F100 B1500 J60
G170 P1 Q1 R0.5 X0 Y0 Z-4 I0 J0 K25
G171 P50 S1200 R60 F100 B1500 J60
G00 Z5
G91 G28 Z0
G28 X0 Y0
M05
M30
```

Rectangular Pocket Milling

G21 G94

G91 G28 Z0

G28 X0 Y0

M06 T1

M03 S1500

G90 G00 X0 Y0 Z5

G172 P0 Q1 R0.5 X-25 Y-17.5 Z-4 I50 J35 K0

G173 P50 S1200 T1 R60 F100 B1500 J60 Z5 I0.1 K0.1

G172 P1 Q1 R0.5 X-25 Y-17.5 Z-4 I50 J35 K0

G173 P50 S1200 T1 R60 F100 B1500 J60 Z5 I0 K0

G00 Z5

G91 G28 Z0

G28 X0 Y0

M05

M30

Result: When all the steps are executed, the desired machine surface is achieved with better surface finish and more accuracy. The final product is achieved as per the part program using END MILL CUTTER and G-code and M-codes.

Experiment: 04

Aim: To perform the drilling operation using CNC Milling.

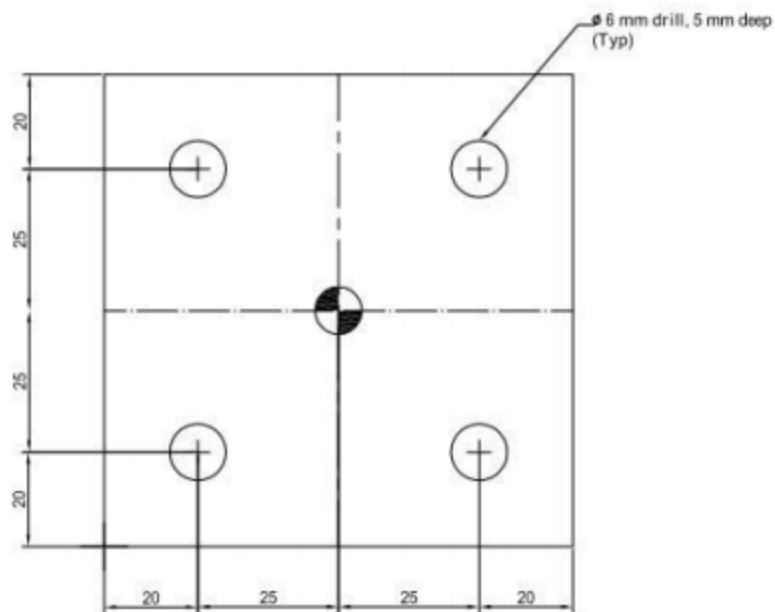
Material: Aluminum 90×90×10 mm

Tool Used: End Drill bit 6mm

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.
- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing:



Part Program

```
G21 G94
G91 G28 Z0
G28 X0 Y0
M06 T1
M03 S1500
G90 G00 X25 Y25 Z5
G01 Z2 F100
G73 G99 X25 Y25 Z-5 Q1 R0.5 F80 K1
X-25 Y25
X-25 Y-25
X25 Y-25
G00 Z5
G80
G91 G28 Z0
G28 X0 Y0
M05
M30
```

Result: When all the steps are executed, the desired machine surface is achieved with better surface finish and more accuracy. The final product is achieved as per the part program using END MILL CUTTER and G-code and M-codes.

Experiment: 05

Aim: To perform the Drilling Operation on PCD Operation using CNC Milling.

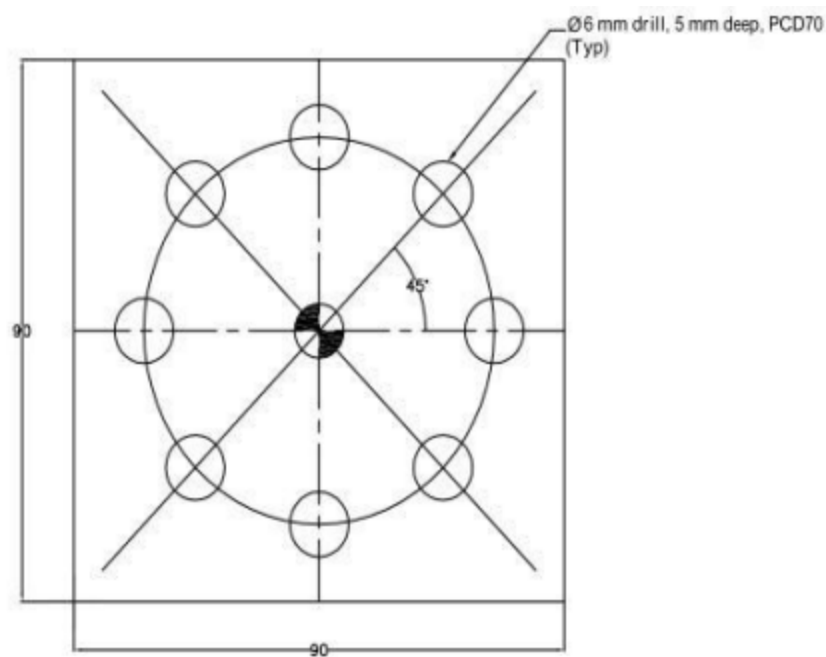
Material: Aluminum 90×90×10 mm

Tool Used: End Drill bit 6mm

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.
- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing:



Calculations

$$X = \text{PCD} / 2 \sin 45^\circ$$

$$= 70 / 2 \sin 45^\circ$$

$$= 24.748$$

$$Y = \text{PCD} / 2 \cos 45^\circ$$

$$= 70 / 2 \cos 45^\circ$$

$$= 24.748$$

Part Program

G21 G94

G91 G28 Z0

G28 X0 Y0

M06 T1

M03 S1500

G90 G00 X35 Y0 Z5

G73 G99 X35 Y0 Z-5 Q1 R0.5 F80 K1

X24.748 Y24.748

X0 Y35

X-24.748 Y24.748

X-35 Y0

X-24.748 Y-24.748

X0 Y-35

X24.748 Y-24.748

G00 Z5

G80

G91 G28 Z0

G28 X0 Y0

M05

M30

Result: When all the steps are executed, the desired machine surface is achieved with better surface finish and more accuracy. The final product is achieved as per the part program using END MILL CUTTER and G-code and M-codes.

Experiment: 06

Aim: To perform the operation using scaling command using CNC Milling.

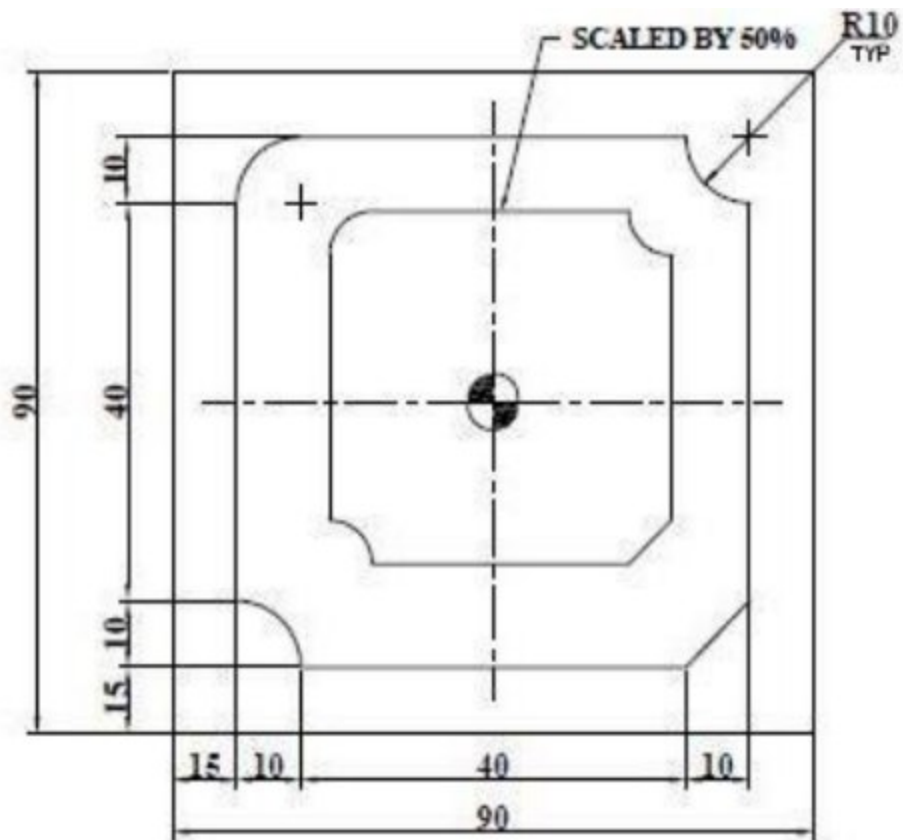
Material: Aluminum 90×90×10 mm

Tool Used: End Drill bit 6mm

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.
- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing:



Part Program

G21 G94

G91 G28 Z0

G28 X0 Y0

M06 T1

M03 S1500

M98 P7777

G90 G00 Z5

M98 P8888

G90 G00 Z5

G91 G28 Z0

G28 X0 Y0

M05

M30

O7777

G90 G00 X-30 Y-20 Z5

```
G01 Z-1 F100
G01 X-30 Y20
G02 X-20 Y30 R10
G01 X20 Y30
G03 X30 Y20 R10
G01 X30 Y-20
G01 X20 Y-30
G01 X-20 Y-30
G03 X-30 Y-20 R10
M99
O8888
G51 P0.5
M98 P7777
G00 Z5
G50
M99
```

Result: When all the steps are executed, the desired machine surface is achieved with better surface finish and more accuracy. The final product is achieved as per the part program using END MILL CUTTER and G-code and M-codes.

Experiment: 07

Aim: To perform the Programming for Facing Operation using CNC Lathe.

Material: Aluminum ϕ 25.4mm

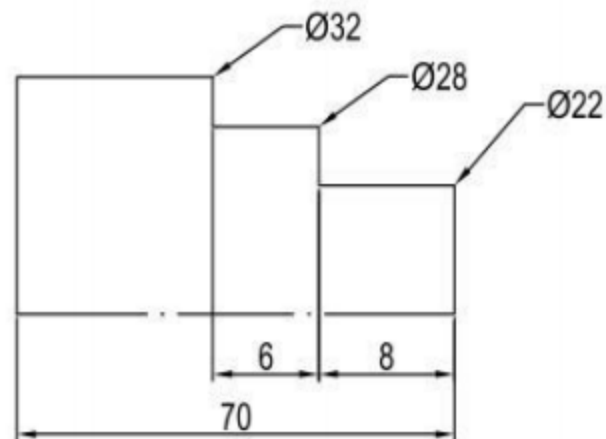
Tool Used: Carbide tool

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.

- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing:



Part Program

```
G21 G98
G28 U0 W0
M06 T1
M03 S1500
G00 X33 Z5
G94 X22 Z-0.5 F80
Z-1
Z-1.5
Z-2
Z-2.5
Z-3
Z-3.5
Z-4
Z-4.5
```

Z-5
Z-5.5
Z-6
Z-6.5
Z-7
Z-7.5
Z-8
G00 X33 Z-8
G94 X28 Z-8.5 F80
Z-9
Z-9.5
Z-10
Z-10.5
Z-11
Z-11.5
Z-12
Z-12.5
Z-13
Z-13.5
Z-14
G28 U0 W0
M05
M30

Result: When all the steps are executed, the desired machine surface is achieved with better surface finish and more accuracy. The final product is achieved as per the part program using END MILL CUTTER and G-code and M-codes.

Experiment: 08

Aim: To perform the Programming for Turning Operation using CNC Lathe.

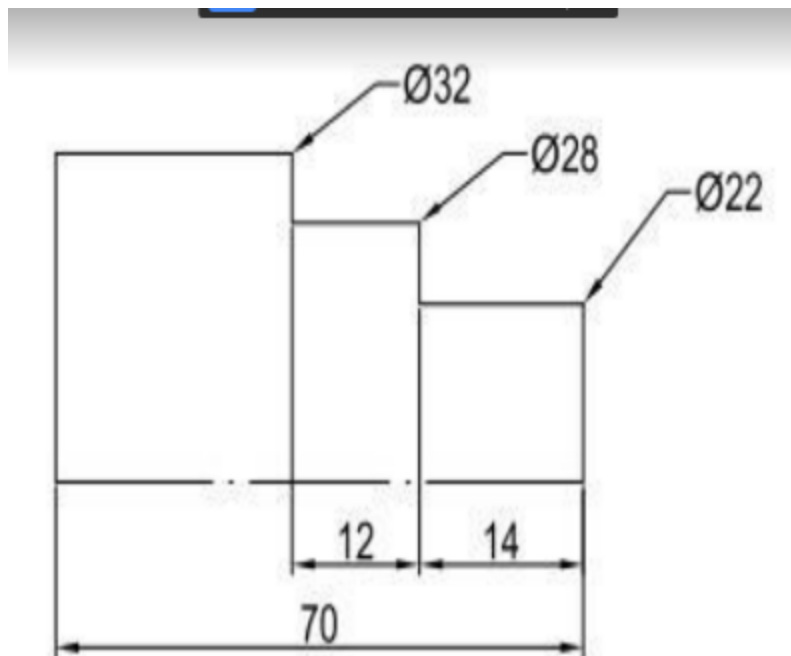
Material: Aluminum ϕ 25.4mm

Tool Used: Carbide tool

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.
- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing:



Part Program

G21 G98
G28 U0 W0
M06 T1
M03 S1500
G00 X33 Z5
G90 X31 Z-26 F100
X30
X29
X28
X27 Z-14
X26
X25
X24
X23
X22
G28 U0 W0
M05
M30

Result: After execution of all steps, the required surface is produced with better surface finish and high accuracy.

Experiment: 09

Aim: To perform the Programming for Grooving Cycle using CNC Lathe.

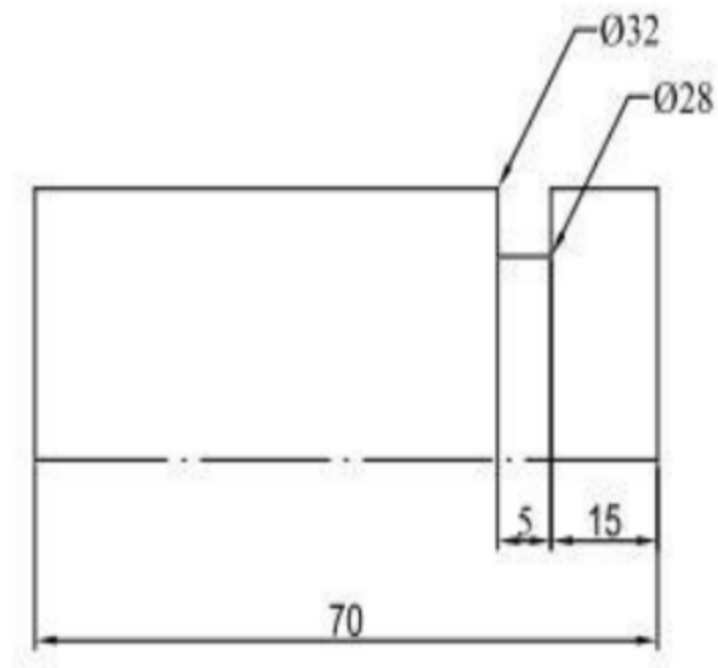
Material: Aluminum ϕ 25.4mm

Tool Used: Carbide tool

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.
- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing:



Part Program

G21 G98

G28 U0 W0

M06 T1

M03 S400

G00 X33 Z-18

G75 R1

G75 X28 Z-20 P50

Q1000 F40

G28 U0 W0

M05

M30

Result: After execution of all steps, the required surface is produced with better surface finish and high accuracy.

Experiment: 10

Aim: To perform the Programming for Threading Cycle using CNC Lathe.

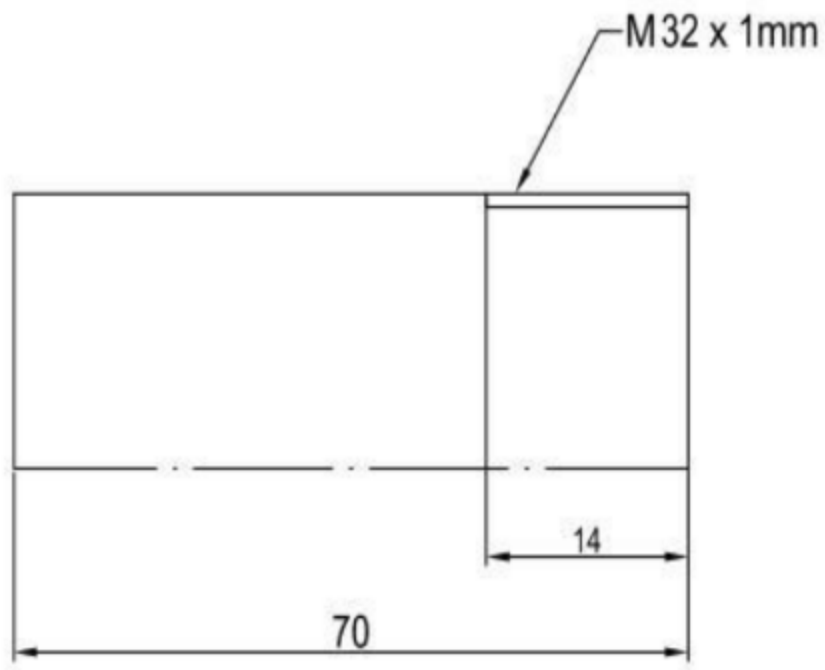
Material: Aluminum ϕ 25.4mm

Tool Used: Carbide tool

Procedure:

- Switch On the machine and Controller.
- Insert the Security key and open the software.
- Write the program on CNC Editor.
- Run and check the program.
- Click on the Machine Link.
- Set the TOOL OFFSET.
- Click the CYCLE RUN to start the machining.

Part Drawing:



Part Program

Minor Diameter Calculation

d= Minor Diameter

D= Minor Diameter

P= Thread Height

$d = D - 2 (P)$

$d = 32 - 2 (0.613)$

$d = 32 - 1.226$

$d = 30.774$

Thread Height, $P = 0.613 \times \text{Pitch of the Thread}$

$= 0.613 \times 1$

$P = 0.613$

G21 G98

G28 U0 W0

M06 T1

M03 S1500

G00 X32.5 Z5

G76 P040060 Q50 R0.01

G76 X30.774 Z-14 P613 Q100 F1

G28 U0 W0

M05

M30

Result: After execution of all steps, the required surface is produced with better surface finish and high accuracy.

Experiment: 11

Aim: To perform the measurement of various profiles e.g. cylinder, cone, etc

Machine: Phoenix Coordinate Measuring Machine.

Tool Used: 5mm Probe, Stylus, Profiles.

Procedure:

- Open the software after switching ON the machine.
- Click on MOTOR ON.
- Click on HOME ALL.
- Touch the Stylus number of times as per the instructions appearing on the screen.
- Select the profile to be measured from the MEASUREMENT Option.
- Select the CYLINDER Option from Measurement Option.
- Touch the specimen using TOUCH PROBE as displayed on the screen and as per the instruction appearing on the screen.
- The final measurement will be displayed on the screen.

Result: The dimension of the cylinder will be measured using the touch probe and final reading will appear on the screen.

Experiment: 12

Aim: To perform pick and place operation using SCARA Robot.

Machine: SCARA Robot

Jobs: Cylindrical Jobs.

Procedure:

- Switch on the controller and open the software.
- Select HOME ALL to move all the axis on home position.
- Set the Speed of robotic arm during whole operation by adding SPEED command from the dropdown Menu.
- Click on the joint to move to pick the cylindrical jobs from their position
- Select the joint to move the

Part Program

SPEED 100

JOINT A1 0.00 A2 -0.00 A3 0.00 A4 0.00

GRIPPER OPEN

JOINT A1 0.00 A2 0.00 A3-140.75 A4 0.00

GRIPPER CLOSE

JOINT A1 0.00 A2 0.00 A3-55.75 A4 0.00

JOINT A1-0.77 A2-72.45 A3-55.94 A4 0.00

JOINT A1-0.77 A2-72.45 A3-148.74 A4 0.00

GRIPPER OPEN

JOINT A1-0.77 A2-72.05 A3 38.45 A4 0.00

HOME ALL

Result: The robot will perform the required pick and place operation.