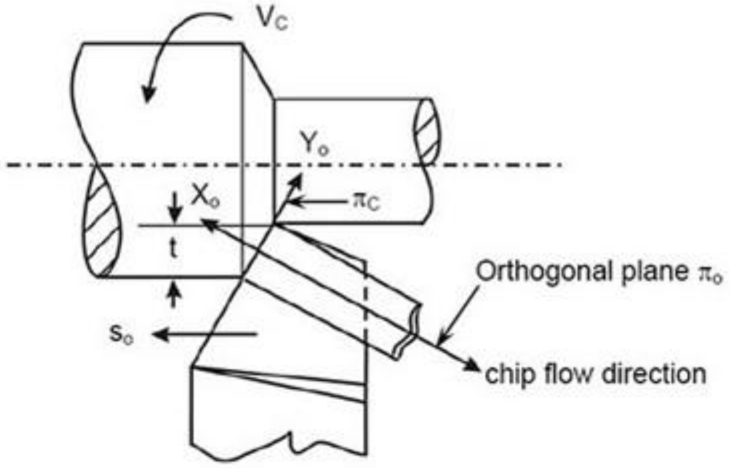
EXPERIMENT NO. 1

Aim: To study of Orthogonal & Oblique Cutting on a Lathe.

Experimental set up.: Lathe Machine

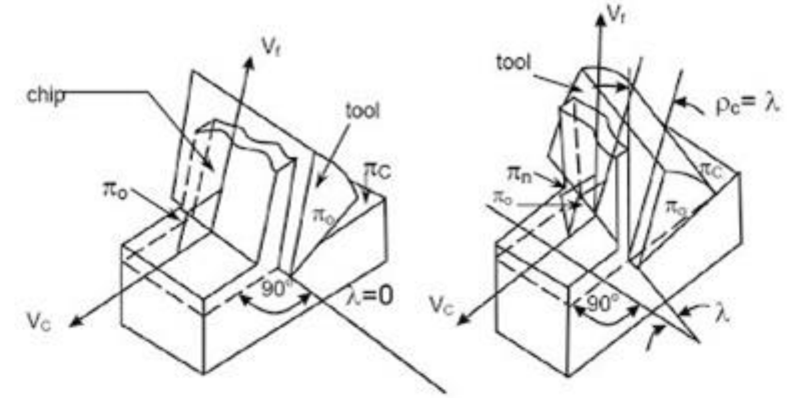
Theoretical concept:

It is appears from the diagram in the following figure that while turning ductile material by a sharp tool, the continuous chip would flow over the tool's rake surface and in the direction apparently perpendicular to the principal cutting edge, i.e., along orthogonal plane which is normal to the cutting plane containing the principal cutting edge. But practically, the chip may not flow along the orthogonal plane for several factors like presence of inclination angle, λ, etc.



The role of inclination angle, λ on the direction of chip flow is schematically shown in figure which visualizes that,

- when $\lambda=0$, the chip flows along orthogonal plane, i.e, $\rho_c = 0$
- when $\lambda\neq0$, the chip flow is deviated from π_o and $\rho_c = \lambda$ where ρ_c is chip flow deviation (from π_o) angle



(a) $\lambda = 0$

(b) $\lambda \neq 0$

Orthogonal cutting: when chip flows along orthogonal plane, π_o, i.e., $\rho_c = 0$

Oblique cutting : when chip flow deviates from orthogonal plane, i.e. $\rho_c \neq 0$

But practically ρ_c may be zero even if $\lambda = 0$ and ρ_c may not be exactly equal to λ even if $\lambda \neq 0$. Because there are some other (than λ) factors also which may cause chip flow deviation.

Result: Hence the study of Orthogonal & Oblique Cutting on a Lathe is completed.

EXPERIMENT NO. 2

Aim: To calculate the machining time for cylindrical turning on a Lathe and compare with the actual machining time.

Experimental set up: Lathe Machine

Theoretical concept:

The major aim and objectives in machining industries generally are;

- reduction of total manufacturing time, T
- increase in MRR, i.e., productivity
- reduction in machining cost without sacrificing product quality
- increase in profit or profit rate, i.e., profitability.

Hence, it becomes extremely necessary to determine the actual machining time, TC required to produce a job mainly for,

- assessment of productivity
- evaluation of machining cost
- measurement of labour cost component
- assessment of relative performance or capability of any machine tool, cutting tool, cutting fluid or any special or new techniques in terms of saving in machining time.

The machining time, TC required for a particular operation can be determined

- roughly by calculation i.e., estimation
- precisely, if required, by measurement.

Measurement definitely gives more accurate result and in detail but is tedious and expensive. Whereas, estimation by simple calculations, though may not be that accurate, is simple, quick and inexpensive.

Hence, determination of machining time, specially by simple calculations using suitable equations is essentially done regularly for various purposes.

Procedure:

The factors that govern machining time will be understood from a simple case of machining. A steel rod has to be reduced in diameter from D1 to D2 over a length L by straight turning in a centre lathe as indicated in Figure.

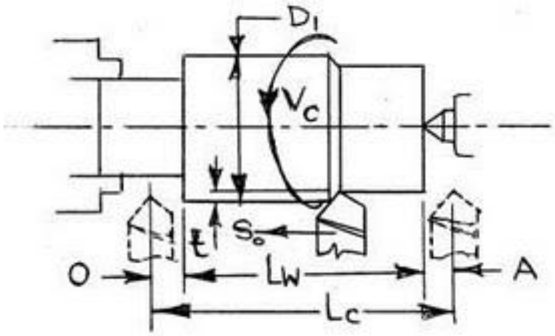


Fig. *Estimation of machining time in turning.*

Here, $T_C = \frac{L_C}{N s_o} x n_p$

where, L_C = actual length of cut
$= L + A + O$
A, O = approach and over run as shown
N = spindle speed, rpm
s_o = feed (tool), mm/rev
n_p = number of passes required

Speed, N, is determined from cutting velocity, V_C

$$V_C = \frac{\pi D N}{1000} \, m/\text{min}$$

where, D = diameter of the job before cut

Therefore, $N = \frac{1000 V_C}{\pi D}$

The number of passes, n_p is mathematically determined from,

$$n_p = \frac{D_1 - D_2}{2t}$$

where, t = depth of cut in one pass, mm.

Calculations:

Sr. No	L	A	O	L_C	V_C	D	N	S_O	D1	D2	T	n_p	T_c

Where,

L= length of the work piece in mm;

A= approach run in mm;

O= over run in mm;

L_c=actual length of cut in mm;

V_c= cutting velocity in mm/min;

D= diameter of the job before cut in mm;

N=spindle speed in rpm;

S_o= tool feed in mm/rev;

D1= initial diameter before passes in mm;

D2=final diameter after passes in mm;

t=depth of cut in one pass in mm;

n_p=no of passes;

Tc=machining time in min;

Result: The machining time of the turning operation is done and compared.

EXPERIMENT NO. 3

Aim: To study the Tool Life while Milling a component on the Milling Machine.

Experimental set up: Milling Machine

Theoretical concept:

Tool life: Time of cutting during two successive milling or indexing of the tool. Tool life is the length of cutting time that a tool can be used or a certain flank wear value has occurred (0.02”).

Taylor’s tool life equation:

$$V T^n = C$$

V = cutting speed

n = cutting exponent

C = cutting constant

T = tool life

n and C depend on speed, work material, tool material, etc.

Cutting Speed can be obtained by the formula as shown:

N= (v*1000) / (π*d)

Where :

N=spindle speed in rpm;

v=cutting speed in m/min;

d=diameter of cutter in mm;

Procedure:

1. Determine the cutting speed by using given d and N values.
2. Apply Taylor’s equation and the n and C values, we can solve for tool life.

Calculations:

Sr. No.	n	C	d	N	V	T

Result: Thus the tool life of milling cutter is found out.

EXPERIMENT NO. 4

Aim: To study Tool wear of a cutting tool while Drilling on a Drilling Machine.

Experimental set up: Drilling Machine

Theoretical concept:

Wear:

Wear can be defined as a process where interaction between two surfaces or bounding faces of solids within the working environment results in dimensional loss of one solid, with or without any actual decoupling and loss of material. Aspects of the working environment which affect wear include loads and features such as unidirectional sliding, reciprocating, rolling, and impact loads, speed, temperature, but also different types of counter-bodies such as solid, liquid or gas and type of contact ranging between single phase or multiphase, in which the last multiphase may combine liquid with solid particles and gas bubbles.

Classification of wear:

- Adhesive wear
- Abrasive wear
- Surface fatigue
- Fretting wear
- Erosive wear
- Corrosion and oxidation wear

Adhesive wear:

Adhesive wear can be found between surfaces during frictional contact and generally refers to unwanted displacement and attachment of wear debris and material compounds from one surface to another.

Generally, adhesive wear occurs when two bodies slide over or are pressed into each other, which promote material transfer. This can be described as plastic deformation of very small fragments within the surface layers. The asperities or microscopic high points or surface roughness found on each surface, define the severity on how fragments of oxides are pulled off and adds to the other surface, partly due to strong adhesive forces between atoms but also due to accumulation of energy in the plastic zone between the asperities during relative motion.

Abrasive wear:

Abrasive wear occurs when a hard rough surface slides across a softer surface. Abrasive wear is commonly classified according to the type of contact and the contact environment. The type of contact determines the mode of abrasive wear. The two modes of abrasive wear are known as two-body and three-body abrasive wear. Two-body wear occurs when the grits or hard particles remove material from the opposite surface. The common analogy is that of material being removed or displaced by a cutting or plowing operation. Three-body wear occurs when the particles are not constrained, and are free to roll and slide down a surface. The contact environment determines whether the wear is classified as open or closed. An open contact environment occurs when the surfaces are sufficiently displaced to be independent of one another

Surface fatigue

Surface fatigue is a process by which the surface of a material is weakened by cyclic loading, which is one type of general material fatigue. Fatigue wear is produced when the wear particles are detached by cyclic crack growth of micro cracks on the surface. These micro cracks are either superficial cracks or subsurface cracks.

Fretting wear

Fretting wear is the repeated cyclical rubbing between two surfaces, which is known as fretting, over a period of time which will remove material from one or both surfaces in contact. It occurs typically in bearings, although most bearings have their surfaces hardened to resist the problem. Another problem occurs when cracks in either surface are created, known as fretting fatigue. It is the more serious of the two phenomena because it can lead to catastrophic failure of the bearing. An associated problem occurs when the small particles removed by wear are oxidized in air. The oxides are usually harder than the underlying metal, so wear accelerates as the harder particles abrade the metal surfaces further. Fretting corrosion acts in the same way, especially when water is present. Unprotected bearings on large structures like bridges can suffer serious degradation in behavior, especially when salt is used during winter to deice the highways carried by the bridges.

Erosive wear

Erosive wear can be defined as an extremely short sliding motion and is executed within a short time interval. Erosive wear is caused by the impact of particles of solid or liquid against the surface of an object. The impacting particles gradually remove material from the surface through repeated deformations and cutting actions. It is a widely encountered mechanism in industry. Due to the nature of the conveying process, piping systems are prone to wear when abrasive particles have to be transported.

The rate of erosive wear is dependent upon a number of factors. The material characteristics of the particles, such as their shape, hardness, impact velocity and impingement angle are primary factors along with the properties of the surface being eroded. The impingement angle is one of the most important factors and is widely recognized in literature.

For ductile materials the maximum wear rate is found when the impingement angle is approximately 30°, whilst for non ductile materials the maximum wear rate occurs when the impingement angle is normal to the surface.

Corrosion and oxidation wear

This kind of wear occurs in a variety of situations both in lubricated and unlubricated contacts. The fundamental cause of these forms of wear is chemical reaction between the worn material and the corroding medium. This kind of wear is a mixture of corrosion, wear and the synergistic term of corrosion-wear which is also called tribocorrosion

Result: Study of the tool wear of cutting tool on drilling machine is complete

EXPERIMENT NO. 5

Aim: To study the Speed, Feed, Tool, Preparatory (Geometric) and miscellaneous functions for NC part programming

Experimental set up: NC Machine

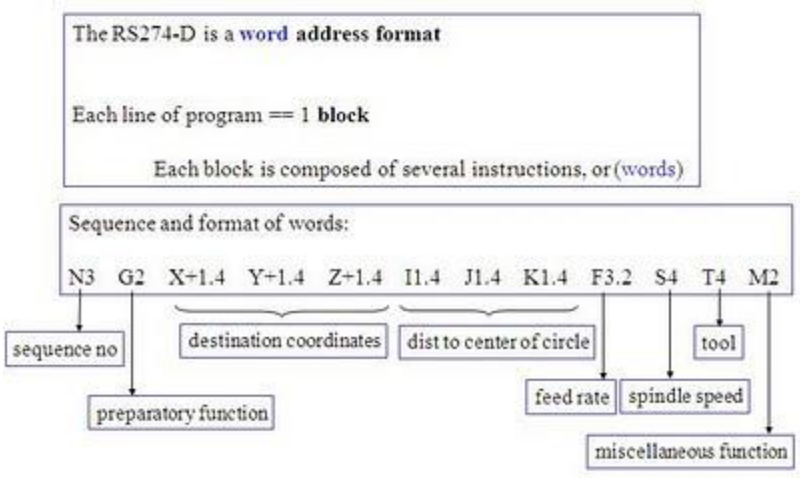
Theoretical concept:

Part program: A computer program to specify

- Which tool should be loaded on the machine spindle;
- What are the cutting conditions (speed, feed, coolant ON/OFF etc)
- The start point and end point of a motion segment
- how to move the tool with respect to the machine.

Standard Part programming language: RS 274-D (Gerber, GN-code)

Controlling a CNC machine: RS 274



The RS274-D is a **word address format**

Each line of program == 1 **block**

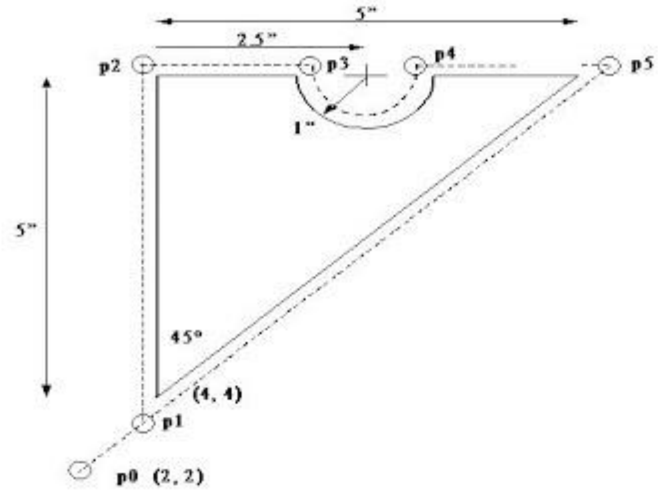
Each block is composed of several instructions, or (words)

Sequence and format of words:

N3 G2 X+1.4 Y+1.4 Z+1.4 I1.4 J1.4 K1.4 F3.2 S4 T4 M2

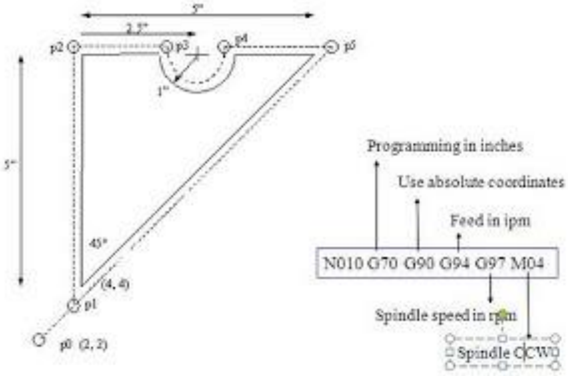
Procedure:

Part Programming Example



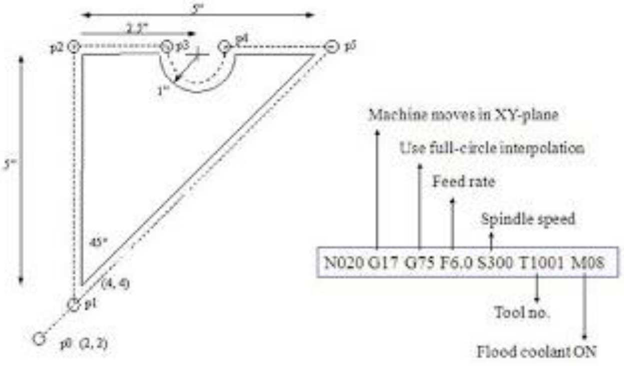
Tool size = 0.25 inch,
Feed rate = 6 inch per minute,
Cutting speed = 300 rpm,
Tool start position: 2.0, 2.0
Programming in inches
Motion of tool:
p0 □ p1 □ p2 □ p3 □ p4 □ p5 □ p1 □ p0

1. Set up the programming parameters



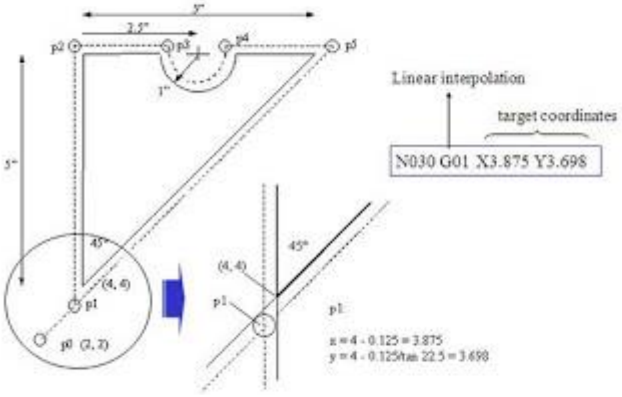
```
N010 G70 G90 G94 G97 M04
```

2. Set up the machining conditions



```
N020 G17 G75 F6.0 S300 T1001 M08
```

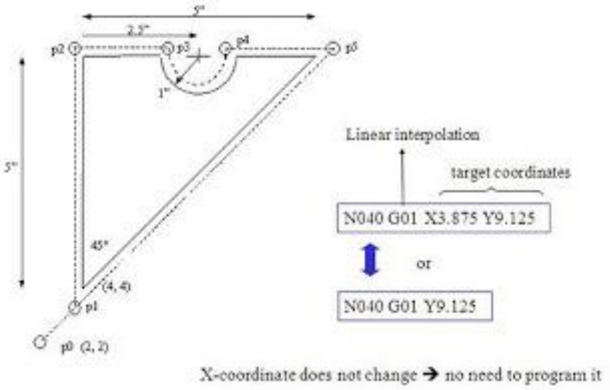
3. Move tool from p0 to p1 in straight line



```
N030 G01 X3.875 Y3.698
```

x = 4 - 0.125 = 3.875
y = 4 - 0.125/tan 22.5 = 3.698

4. Cut profile from p1 to p2

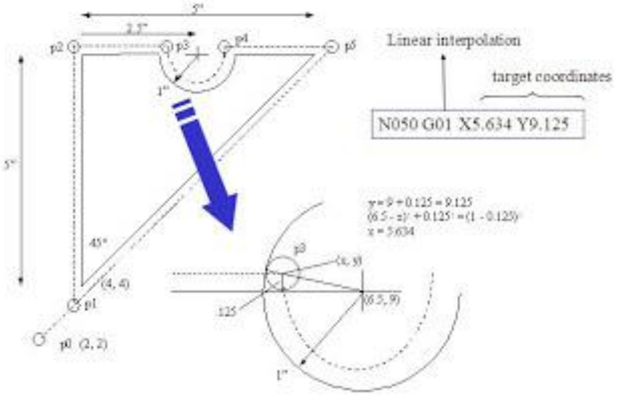


```
N040 G01 X3.875 Y9.125
```

```
N040 G01 Y9.125
```

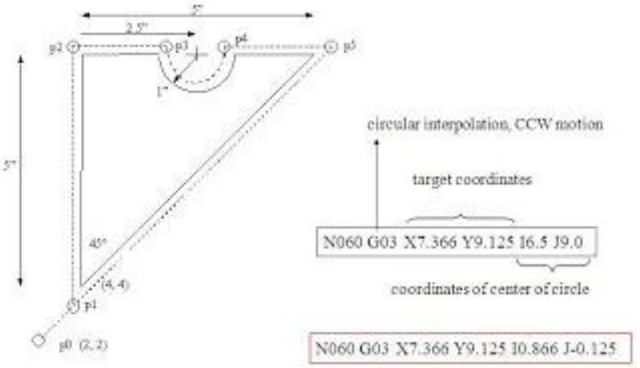
X-coordinate does not change → no need to program it

5. Cut profile from p2 to p3



```
N050 G01 X5.634 Y9.125
```

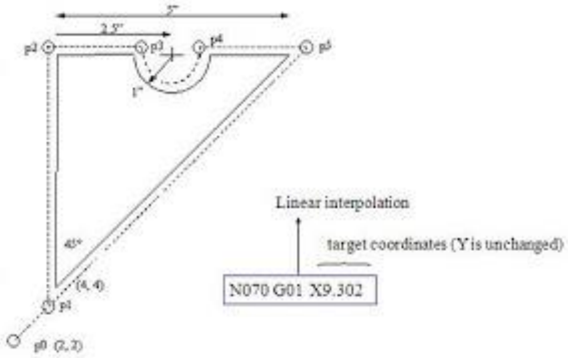
6. Cut along circle from p3 to p4



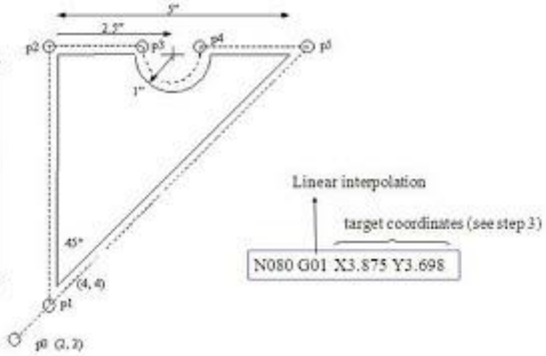
```
N060 G03 X7.366 Y9.125 I6.5 J9.0
```

```
N060 G03 X7.366 Y9.125 I0.866 J-0.125
```

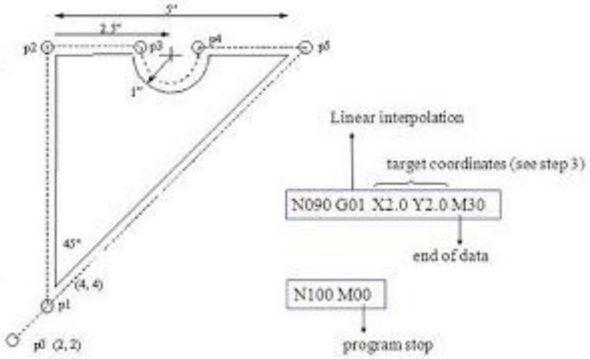
7. Cut from p4 to p5



8. Cut from p5 to p1



9. Return to home position, stop program



10. Complete RS-274 program

```
N010 G70 G90 G94 G97 M04
N020 G17 G75 F6.0 S300 T1001 M08
N030 G01 X3.875 Y3.698
N040 G01 X3.875 Y9.125
N050 G01 X5.634 Y9.125
N060 G03 X7.366 Y9.125 I0.866 J-0.125
N070 G01 X9.302
N080 G01 X3.875 Y3.698
N090 G01 X2.0 Y2.0 M30
```

Result: Hence the study of NC part programming is completed

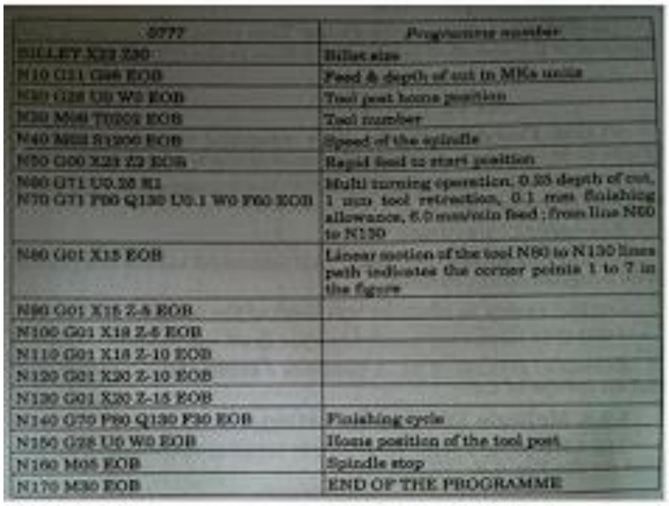
EXPERIMENT NO. 6

Aim: To study the part programming on a NC Lathe: Step Turning, Taper Turning, Drilling

Experimental set up: NC Lathe Machine

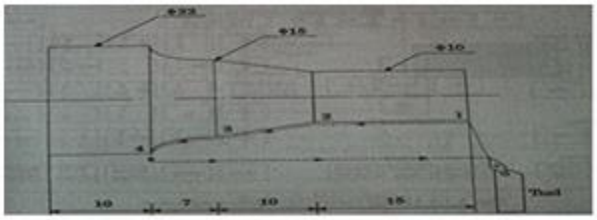
Procedure:

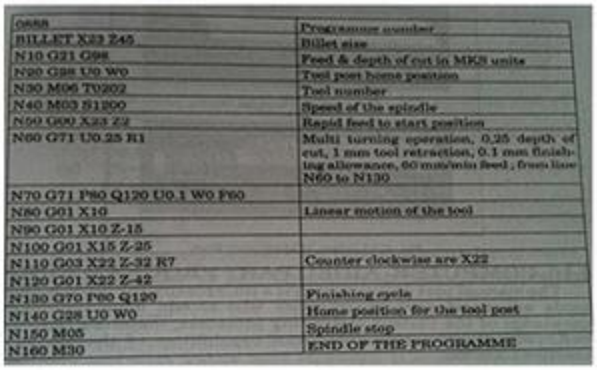
Example for step turning.



O777	Programme number
BILLET X22 Z30	Billet size
N10 G21 G98 EOB	Feed & depth of cut in MKs units
N20 G28 U0 W0 EOB	Tool post home position
N30 M06 T0202 EOB	Tool number
N40 M03 S1200 EOB	Speed of the spindle
N50 G00 X23 Z2 EOB	Rapid feed to start position
N60 G71 U0.25 R1 N70 G71 P80 Q130 U0.1 W0 F60 EOB	Multi turning operation, 0.25 depth of cut, 1 mm tool retraction, 0.1 mm finishing allowance, 6.0 mm/min feed ; from line N80 to N130
N80 G01 X15 EOB	Linear motion of the tool N80 to N130 lines path indicates the corner points 1 to 7 in the figure
N90 G01 X15 Z-5 EOB	
N100 G01 X18 Z-5 EOB	
N110 G01 X18 Z-10 EOB	
N120 G01 X20 Z-10 EOB	
N130 G01 X20 Z-15 EOB	
N140 G70 P80 Q130 F30 EOB	Finishing cycle
N150 G28 U0 W0 EOB	Home position of the tool post
N160 M05 EOB	Spindle stop
N170 M30 EOB	END OF THE PROGRAMME

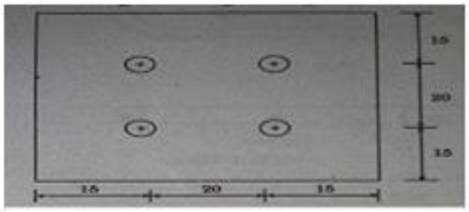
Example for taper turning.

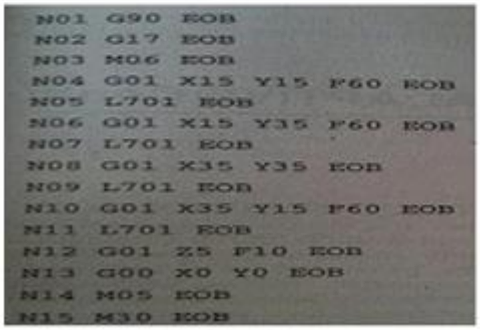




O888	Programme number
BILLET X23 Z45	Billet size
N10 G21 G98	Feed & depth of cut in MKS units
N20 G28 U0 W0	Tool post home position
N30 M06 T0202	Tool number
N40 M03 S1200	Speed of the spindle
N50 G00 X23 Z2	Rapid feed to start position
N60 G71 U0.25 R1	Multi turning operation, 0.25 depth of cut, 1 mm tool retraction, 0.1 mm finishing allowance, 60 mm/min feed ; from line N60 to N130
N70 G71 P80 Q120 U0.1 W0 F60	
N80 G01 X10	Linear motion of the tool
N90 G01 X10 Z-15	
N100 G01 X15 Z-25	
N110 G03 X22 Z-32 R7	Counter clockwise arc X22
N120 G01 X22 Z-42	
N130 G70 P80 Q120	Finishing cycle
N140 G28 U0 W0	Home position for the tool post
N150 M05	Spindle stop
N160 M30	END OF THE PROGRAMME

Example for Drilling:





```
N01 G90 EOB
N02 G17 EOB
N03 M06 EOB
N04 G01 X15 Y15 F60 EOB
N05 L701 EOB
N06 G01 X15 Y35 F60 EOB
N07 L701 EOB
N08 G01 X35 Y35 EOB
N09 L701 EOB
N10 G01 X35 Y15 F60 EOB
N11 L701 EOB
N12 G01 Z5 F10 EOB
N13 G00 X0 Y0 EOB
N14 M05 EOB
N15 M30 EOB
```

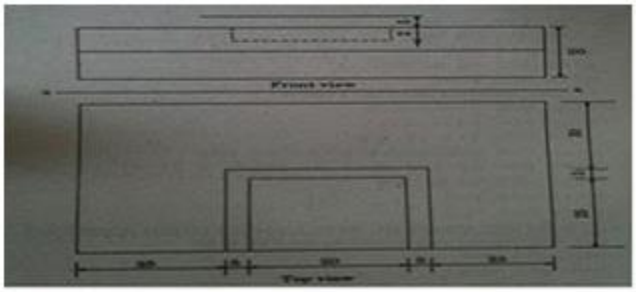
Result: Hence the study of NC Programming is completed.

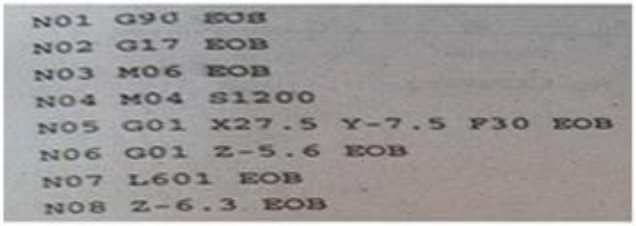
EXPERIMENT NO. 7

Aim: To study the part programming on a NC Milling Machine for a Rectangular Slot.

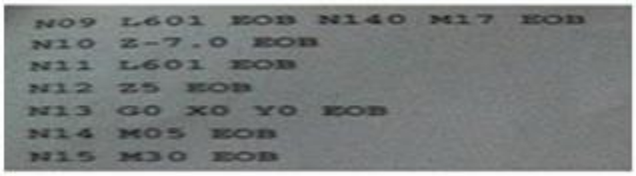
Experimental set up: NC Milling Machine

Procedure:





```
N01 G90 EOB
N02 G17 EOB
N03 M06 EOB
N04 M04 S1200
N05 G01 X27.5 Y-7.5 F30 EOB
N06 G01 Z-5.6 EOB
N07 L601 EOB
N08 Z-6.3 EOB
```



```
N09 L601 EOB N140 M17 EOB
N10 Z-7.0 EOB
N11 L601 EOB
N12 Z5 EOB
N13 G0 X0 Y0 EOB
N14 M05 EOB
N15 M30 EOB
```

Result: Hence the study of NC Programming is completed.