LABORATORY MANUAL

18MEL38A /18MEL48A MACHINE SHOP AND WORKSHOP PRACTICE LAB

2019-2020

ATRIA
INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING
ATRIA INSTITUTE OF TECHNOLOGY
Adjacent to Bangalore Baptist Hospital
Hebbal, Bengaluru-560024

Department of Mechanical Engineering

Vision

To be a center of excellence in Mechanical Engineering education and interdisciplinary research to confrontreal world societal problems with professional ethics.

Mission

1. To push the frontiers of pedagogy amongst the students and develop new paradigms in research.

2. To develop products, processes, and technologies for the benefit of society in collaboration withindustry and commerce.

3. To mould the young minds and build a comprehensive personality by nurturing strong professionalswith human ethics through interaction with faculty, alumni, and experts from academia/industry.

LATHE

- The lathe is an ancient tool. The earliest evidence of a lathe dates back to Ancient Egypt around 1300 BC.
- The lathe was very important to the Industrial Revolution. It is known as the *mother of machine tools*, as it was the first machine tool that led to the invention of other machine tools. In 1718 Russian engineer Andrey Nartov invented one of the first lathes with a mechanical cutting tool-supporting carriage and a set of gears (also known as a compound rest or slide rest) with the first to invent such a lathe.
- The first fully documented, all-metal slide rest lathe was invented by Jacques de Vaucanson around 1751.

MILLING MACHINE

Milling evolved from rotary filing, so there is a continuum of development between the earliest milling cutters known, such as that of Jacques de Vaucanson from about the 1760s or 1770s, through the cutters of the milling pioneers of the 1810s through 1850s (Whitney, North, Johnson, Nasmyth, and others), to the cutters developed by Joseph R. Brown of Brown & Sharpe in the 1860s, which were regarded as a break from the past

LABORATORY CERTIFICATE

This is to certify that Mr. / Ms. ____

has satisfactorily completed the course of experiments in **MACHINE SHOP** bearing subject code **18MEL48** prescribed by the Visvesvaraya Technological University, Belagavi of this Institute for the academic year 2020 – 2021.

USN : ____________________________________

Branch : ____________________________________

Semester :________________Sec: ________________

MARKS	
Maximum Marks	Marks Obtained
40	

Signature of Faculty-In-Charge   Head of the Department

PREFACE

The engineers can create a new kind of civilization, based on technology, where art, beauty and finer things of life are accepted as everyone's due. Engineers, whatever is their line of activity, must be proficient with all aspects of manufacturing. However, it should not be forgotten that practice without theory is blind and the theory without practice is lame. A person involved in acquiring manufacturing skills must have balanced knowledge of theory as well as practice. This manual is written to meet the objectives of the training modules in Machine Shop Practice for the III Semester of Mechanical Engineering course in Atria Institute of technology, Bangalore. It imparts basic knowledge of Machine tools such as Lathe, Shaping Machine, Milling machine etc and their use in performing different operations in the manufacturing such as Turning, Step Turning, Knurling, taper Turning, Threading, Gear Cutting etc. The study of Machine shop practice acts as the basis for further technical studies. This manual gives the perception to build technical knowledge by acting as a guide for imparting fundamental awareness. Numerous neatly drawn illustrations provided in the manual will help the students in understanding the subject, and the concepts related it, better. Sincere attempts have been made to present the contents in a simple language, supplemented with line diagrams, three dimensional views which are self explanatory and easy to reproduce. We would like to express our sincere thanks to Dr. Rajashekar Patil, HOD, Department of Mechanical Engineering, Atria Institute of Technology, Bangalore and colleagues for their consistent support. Suggestions for improvement in this manual will be thankfully acknowledged and incorporated in the next edition.

CHETAN C S

18MEL38A/48A

MACHINE SHOP

B.E, IV Semester, Mechanical Engineering

[As per Choice Based Credit System (CBCS) scheme]

Course Code	**18MEL38B / 48B**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**03 (1 Hour Instruction + 2 Hours Laboratory)**	**SEE Marks**	**60**
RBT Levels	**L1, L2, L3**	**Exam Hours**	**03**
Credits – 02			

Course Learning Objectives:

- To guide students to use fitting tools to perform fitting operations.
- To provide an insight to different machine tools, accessories and attachments.
- To train students into fitting and machining operations to enrich their practical skills.
- To inculcate team qualities and expose students to shop floor activities.
- To educate students about ethical, environmental and safety standards.

PART-A

Preparation of at least two fitting joint models by proficient handling and application of hand tools V-block, marking gauge, files, hack saw drills etc.

PART-B

Preparation of three models on lathe involving - Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning. Exercises should include selection of cutting parameters and cutting time estimation.

PART C

Cutting of V Groove/ dovetail / Rectangular groove using a shaper. Cutting of Gear Teeth using Milling Machine. Exercises should include selection of cutting parameters and cutting time estimation.

PART D (DEMONSTRATION ONLY)

Study & Demonstration of power tools like power drill, power hacksaw, portable hand grinding, cordless screw drivers, production air tools, wood cutter, etc., used in Mechanical Engineering.

Course outcomes:

- To read working drawings, understand operational symbols and execute machining operations.
- Prepare fitting models according to drawings using hand tools- V-block, marking gauge, files, hack saw, drills etc.
- Understand integral parts of lathe, shaping and milling machines and various accessories and attachments used.
- Select cutting parameters like cutting speed, feed, depth of cut, and tooling for various machining operations.
- Perform cylindrical turning operations such as plain turning, taper turning, step turning, thread cutting, facing, knurling, internal thread cutting, eccentric turning and estimate cutting time.

- Perform machining operations such as plain shaping, inclined shaping, keyway cutting, Indexing and Gear cutting and estimate cutting time.

Scheme of Examination:

One Model from Part – A 30 Mark
One Model from Part – B 50 Marks
Viva Voce 20 Marks
Total 100 Marks

REFERENCE BOOKS:

1. **"All about Machine Tools", -** Heinrich Gerling.
2. **"Elements of Workshop Technology" –** Vol – 2, - S K Hajra Choudhury**.**

***Instructions to the students*:**

1. Always be in time to the machine shop session.
2. Be regular to the classes.
3. Attend the laboratory session in the blue prescribed uniform.
4. Protect your feet by wearing shoes regularly.
5. Respect your instructor; do not switch on/operate any machine without the permission of the instructor.
6. Avoid dangling any part of your person or dress near rotating parts of the machines.
7. Clean and lubricate the machine surface before starting.
8. Always leave the machine clean and covered with rust preventive oil after completing your work.
9. Do never hesitate to clarify your doubts however trivial they are from your faculty/instructor.
10. We facilitate your learning; but it is your concerted, conscious and continued effort that makes your learning complete.

INDEX

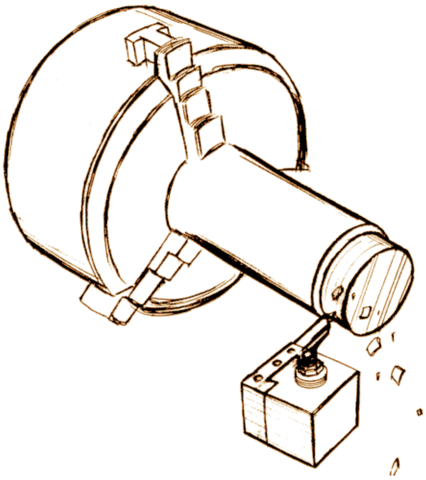
As Per Syllabus:

Write about the following topics with neat sketches and descriptions in machine shop journal.

1. Sketch and name the major parts of a center lathe.
2. Sketch and name a universal milling machine.(A block diagram would do)
3. Principle of Turning.
4. Principle of Threading.
5. Principle of Taper turning.
6. Methods of Taper turning.
7. Saddle apron mechanism.
8. Kinematic diagram of a center lathe.
9. Specification of a center lathe, a shaper, a milling machine.
10. Working principle of an Indexing head.
11. Shaper mechanism.
12. How to select cutting parameters for turning, milling and shaping.
13. Single point cutting tool angles.
14. Specification of a gear.

1. MACHINING and MACHINE TOOL

Machining is a process of removal of excess material from the work-piece in the form of chips by a wedge shaped tool having a single/multipoint cutting edge in order to produce desired size and shape. Figure shows the machining operation.



A **Machine Tool** is a power-driven machine, capable of holding and supporting the work and tool and at the same time directing and guiding the cutting tool or job or both to perform various metal cutting operations for providing different sizes and shapes

OR

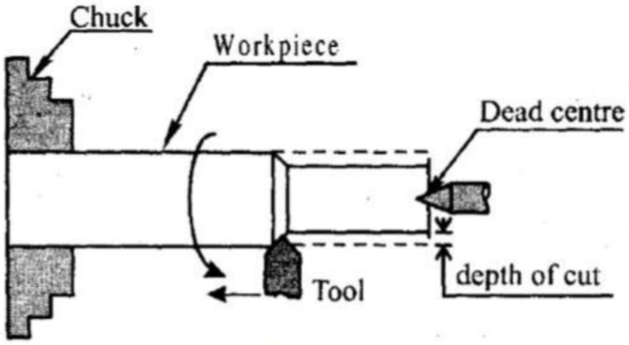
A **Machine Tool** can also be defined as a power driven machine used to perform the machining operations. Figure shows the sketch of a machine tool.

1.1 LATHE

Lathe is an oldest machine tool and it is called the "Mother of all the Machines" because almost all machining operations can be performed on this machine.

Lathe is a machine tool, which holds the work in a work holding device and rotating it against a suitable cutting tool to remove the excess metal from the work.

Working Principle of Lathe:


Chuck
Workpiece
Dead centre
Tool
depth of cut

The lathe is a machine tool which holds the work piece between two rigid and strong supports called chucks or centers or faceplates which revolves. Cutting tool is held and fed against the revolving work. Cutting tool is fed either parallel or at right angles to the axis of the work piece or may also at an angle

1.2 CLASSIFICATION OF LATHES

Lathes may be classified as:

1. Bench Lathe
2. Speed Lathe
3. Center Lathe
4. Tool Room Lathe
5. Turret Lathe
6. Capstan Lathe
7. Automatic Lathe
8. CNC Lathe

- **Bench Lathe**

It is a small machine mounted on a bench. It is generally employed for small and precision work.

- **Speed Lathe**

A speed lathe is so called because of its high spindle speed. It is the simplest form of the lathe used for wood turning, metal spinning etc.

- **Center Lathe**

It is the most widely used machine in the general purpose metal working. A number of different speeds on the spindle can be made available with the help of a pair of stepped cone pulley and a back gear arrangement.

- **Tool Room Lathe**

It is basically a small lathe specially designed for precision work in the tool room. Generally it is used for making tools, dies and gauges.

- **Turret Lathe**

A turret lathe is used for repetitive production work. It is a medium production semi- automatic machine. The tailstock is replaced with an index able tool holder called a turret. The turret is directly mounted on the lathe bed and can be fixed and at any desired position. It allows multiple cutting operations to be performed, each with a different cutting tool. Turret lathes are used in heavy duty operations.

- **Capstan Lathe**

It is also a semi-automatic production lathe. Though similar to the turret lathe, here the tailstock is replaced by a hexagonal tool holder which can carry six different tools at a time. Capstan lathe is used for small-sized light duty operation.

- **Automatic Lathe**

In automatic lathe all the elements of the machining process such as feeding of a job, movements of all cutting tools in a proper sequence, parting off and unloading the finished job are performed automatically.

- **CNC Lathe**

Lathes that are controlled by a computer are called CNC Lathes.

1.3 Construction and Main Parts

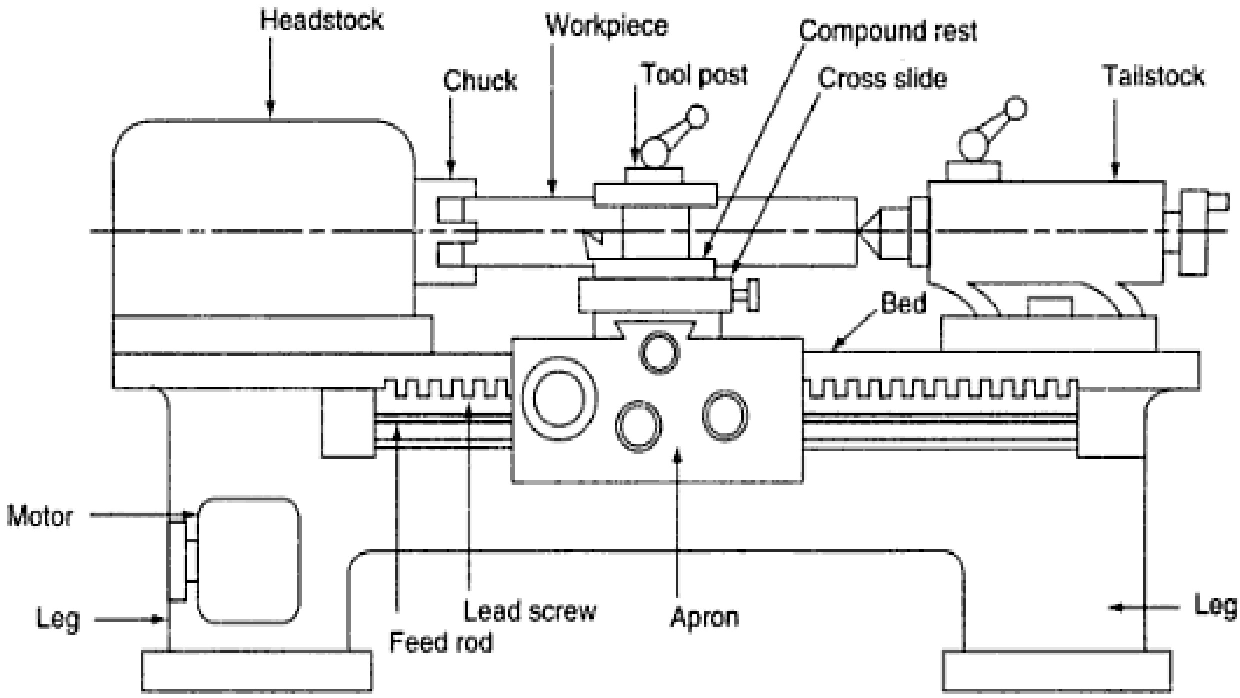


Figure Lathe machine.

Following are the main parts of the lathe:

1) **Bed:** The lathe bed provides a heavy rigid frame on which all the main components like headstock, tailstock and carriage are mounted. It comprises inner and outer guide rails that are precision machined to assure accuracy of movement of carriage, tailstock or other mountings.

2) **Headstock:** It is mounted in a fixed position at the left end of the bed. It is also called as live Centre. It is equipped with motors, pulleys and V-belts that supply power to a spindle at various rotational speeds. The work piece is held rigidly in headstock using a chuck.

3) **Tailstock:** It is called as dead center. It is used to support one end of the workpiece. It is also used to hold tools for drilling, reaming, tapping etc. It can be adjusted in different positions along the guide ways of the bed for accommodating different lengths of workpiece.

4) **Feed Rod:** The feed rod is a stationary rod mounted in front of the lathe bed and facilitates longitudinally movement of the carriage during turning, boring and facing operations.

5) **Lead Screw:** It is a screw rod which runs longitudinally in front of the lathe bed. The rotation of the lead screw moves the carriage to and fro longitudinally during thread cutting operations.

6) **Carriage:** The carriage is located between the headstock and tailstock and serves the purpose of supporting, guiding and feeding the tool against the job during operation. The main parts of carriage are:

a) **The saddle** is an H-shaped casting mounted on the top of lathe ways. It provides support to cross-slide, compound rest and tool post.

b) **The cross slide** is mounted on the top of saddle, and it provides a mounted or automatic cross movement for the cutting tool.

c) **The compound rest** is fitted on the top of cross slide and is used to support the tool post and the cutting tool.

d) **The tool post** is mounted on the compound rest, and it rigidly clamps the cutting tool or tool holder at the proper height relative to the work center line.

e) **The apron** is fastened to the saddle and it houses the gears, clutches and levers required to move the carriage or cross slide.

1.4 KINEMATIC DIAGRAM OF A LATHE:

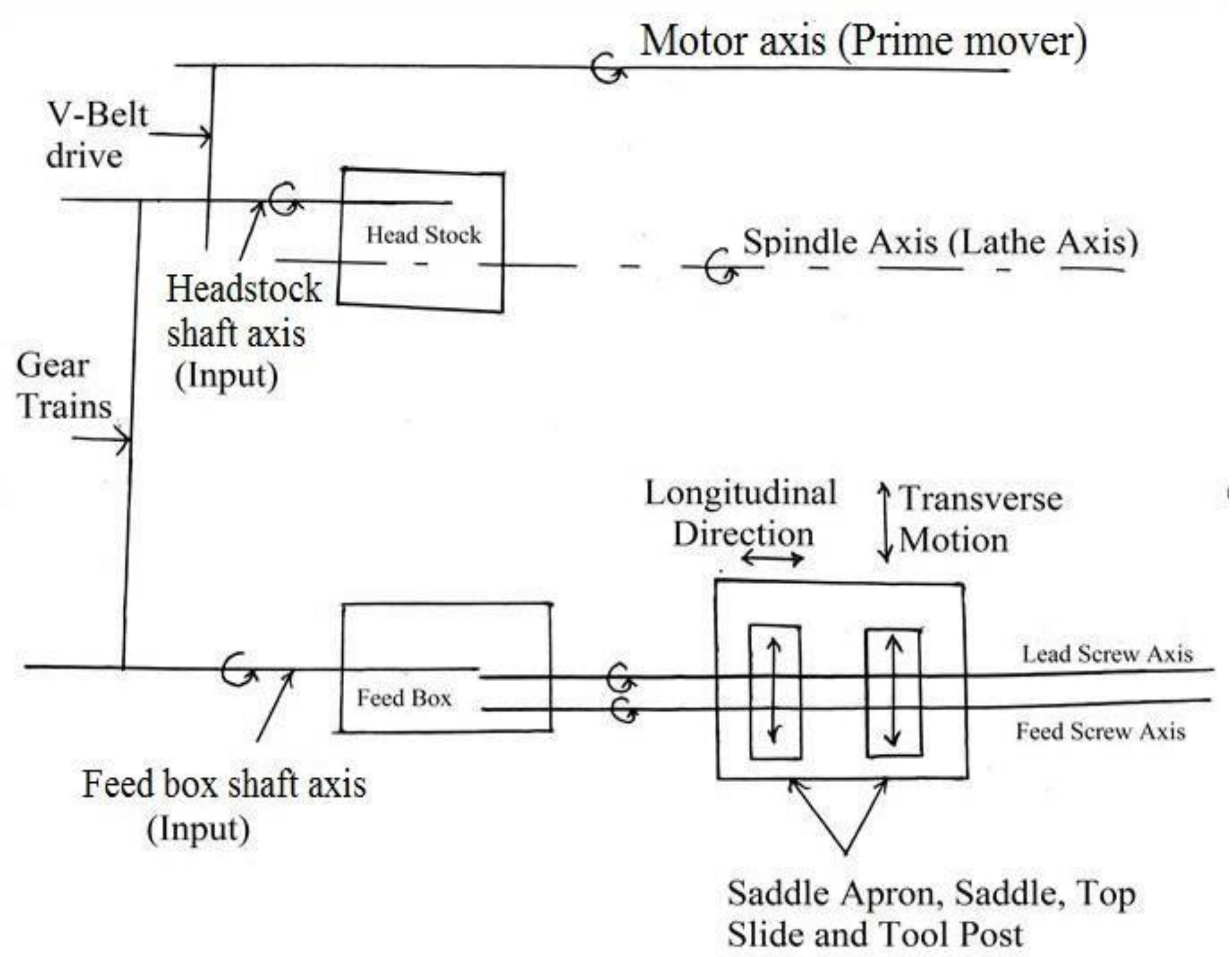


Fig: Kinematic Diagram of Lathe

Among the various types of the lathe, Centre lathe are the most versatile and commonly used. For machining in machine tools, the job and cutting tool need to be moved relatively to each other. The tool work motions are

- Formative motions - Cutting motion and Feed motion.
- Auxiliary motions – Indexing motion and Relieving motion.

In Lathe,

- Cutting motion is attained by rotating the Job (Primary motion).
- Feed motion by linear travel of the tool; either axially for longitudinal feed or radially for cross feed (Secondary motion).

The job gets rotation from the motor through the belt driven pulley and then the speed box which splits the workpiece speed into a number of speeds by operating the cluster gears inside the head stock.

The cutting tool device takes automatic feed motion from the rotation of spindle via the gear quadrant feed gear box and the apron mechanism.

As and when the tailstock is shifted along the lathe bed by operating the clamping bolt and tailstock quickly moved towards the job or away from it and is kept locked at desired position. The versatility or working range of the Centre lathe is arranged by using several attachments like

a) Taper turning attachment

b) Thread milling attachment

c) Copying attachment

d) Spherical turning attachment.

1.5 SPECIFICATION OF A LATHE:

TURNER: - LX -175 All Geared Head Lathe Machine

Standard Accessories:

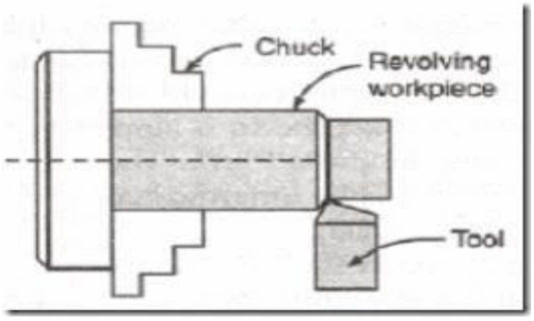
- Notron Gear Box (Double Screw)
- Chuck Plate
- Tool Post Key
- Centre Adapter
- Dead Centre (2 Nos.)
- Motor Pulley
- Four position Tool Post
- Electric Motor (2 HP, 3 Ph 1440 rpm
- V- belt set for motor
- R-F Switch with electricals.

TECHNICAL SPECIFICATION			
SPECIFICATION	**175/LX-1**	**175/LX-2**	**175/LX-3**
BED:			
Bed type	2V&2Flat	2V&2Flat	2V&2Flat
Bed length	1375(4´66´´)	1600(5´3´´)	1825(6´)
Bed width	280(11´´)	280(11´´)	280(11´´)
Gap length	110 mm	110 mm	110 mm
Gap length in front of face plate	105 mm	105 mm	105 mm
CAPACITY:			
Height of Centre	175(7´´)	175(7´´)	175(7´´)
Swing over bed	370 mm	370 mm	370 mm
Swing over gap	550 mm	550 mm	550 mm
Swing over cross slide	200 mm	200 mm	200 mm
Admit between Centre	530 mm	750 mm	980 mm
Movement of cross slide	200 mm	200 mm	200 mm
Movement of compound slide	110 mm	110 mm	110 mm
MAIN SPINDLE:			
Spindle nose	Φ 61.85 mm	Φ 61.85 mm	Φ 61.85 mm
Taper bore in spindle sleeve	MT – 3	MT - 3	MT - 3
Spindle bore	Φ 40 (1.5´´)	Φ 40 (1.5´´)	Φ 40 (1.5´´)
TAILSTOCK:			
Quill Dia.	Φ 58.8 mm	Φ 50.8 mm	Φ 50.8 mm
Taper in Quill	MT - 3	MT - 3	MT - 3
Quill Travel	130 mm	130 mm	130 mm
SPEED:			
No. of Spindle Speed	8	8	8
RPM (Low/High)	45-900	45-900	45-900
FEED:			
Nos. of Feeds range	32	32	32
Longitudinal / Rev.	0.05 to 0.7 mm	0.05 to 0.7 mm	0.05 to 0.7 mm
Transverse / Rev	0.025 to 0.35 mm	0.025 to 0.35 mm	0.025 to 0.35 mm
THREAD/NO. OF RANGE			
Metric Thread	20 (0.5 to 7.5 mm)	20 (0.5 to 7.5 mm)	20 (0.5 to 7.5 mm)
English Thread	32 (4 to 60 TPI)	32 (4 to 60 TPI)	32 (4 to 60 TPI)
Lead Screw	Φ $1_{1/4}$´´ × 4 TPI	Φ $1_{1/4}$´´ × 4 TPI	Φ $1_{1/4}$´´ × 4 TPI
Feed Shaft	Φ 1´´	Φ 1´´	Φ 1´´
ELECTRICALS:			
Motor Power	2 HP / 1.5 Kw	2 HP / 1.5 Kw	2 HP / 1.5 Kw
GENERAL:			
Weight (Approx.)	700 kg	850 kg	1000 kg
Floor Space Occupied in mm (approx.) L×W×H	1675×780×1150	1900×780×1150	2125×780×1150

1.6 LATHE OPERATIONS:

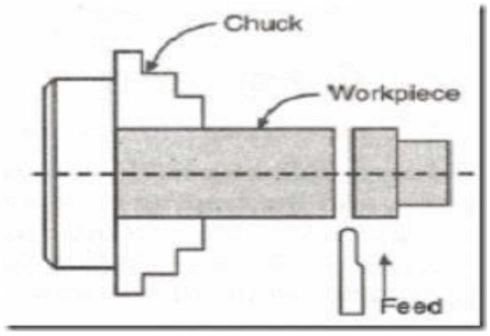
1) Plain Turning

Plain turning is the operation of removing excess amount of material from the surface of a cylindrical job. The tool is moved parallel to the axis of rotation of the workpiece.



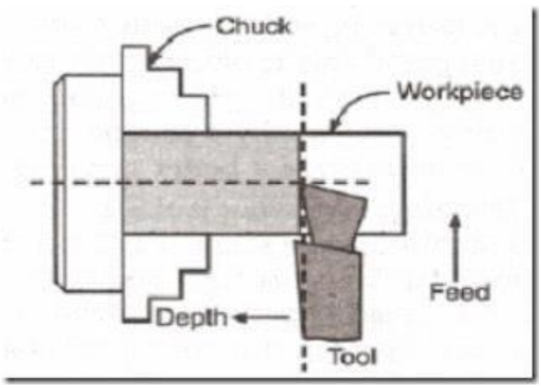
2) Facing

The facing is a machining operation by which the end surface of the work piece is made flat by removing metal from it. It is also used to cut the workpiece to the required length. The one end of the workpiece is held rigidly in the headstock using chuck. The tool is moved perpendicular to the axis of rotation of the workpiece.



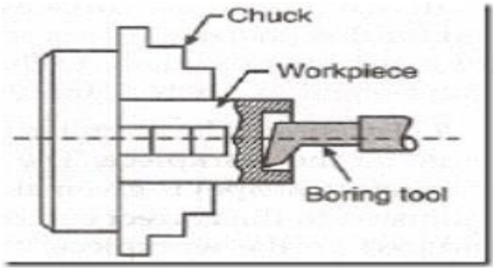
3) Parting

The parting or cutting off is the operation of cutting away a desired length of the workpiece, *i.e.*, dividing the workpiece in two or more parts.



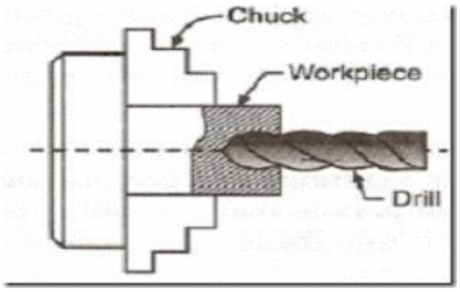
4) Boring

The boring operation is the process of enlarging a hole already produced by drilling. It uses single point cutting tool called a boring bar. In boring, the boring bar can be rotated, or the work part can be rotated.



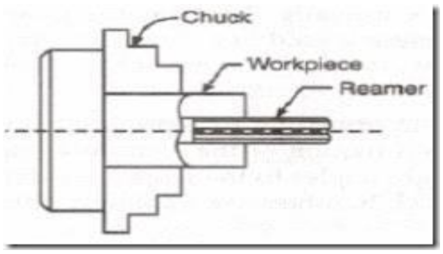
5) Drilling

Drilling is the operation of originating a cylindrical hole in the workpiece.



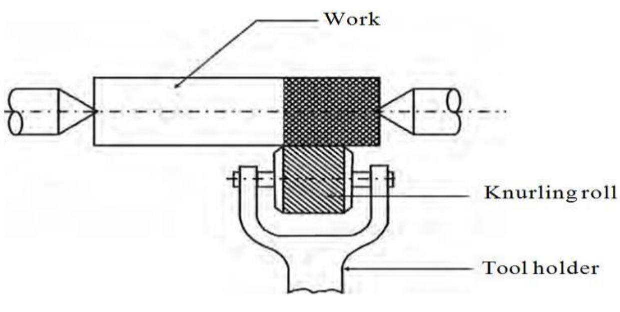
6) Reaming

The holes that are produced by drilling are rarely straight and cylindrical in form. The reaming operation finishes and sizes the hole already drilled into the workpiece.



7) Knurling

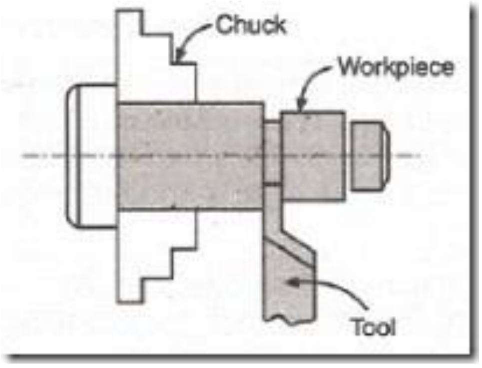
The knurling is a process of embossing (impressing) a diamond-shaped or straight-line pattern into the surface of workpiece. Knurling is essentially a roughening of the surface and is done to provide a better gripping surface.



Knurling

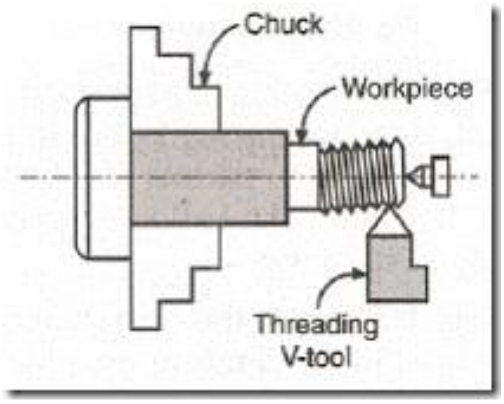
8) Grooving

Grooving is the act of making grooves of reduced diameter in the workpiece.



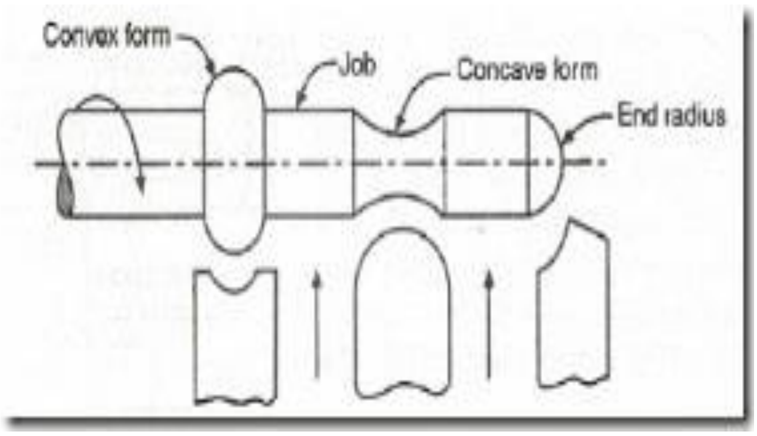
9) Threading

Threading is the act of cutting of the required form of threads on the internal or external cylindrical surfaces.



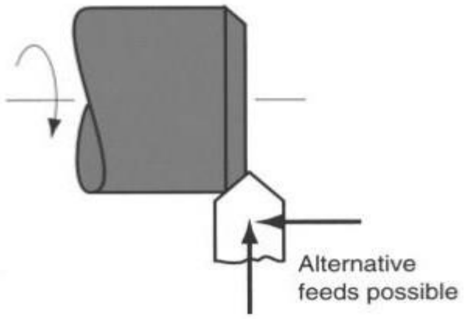
10) Forming

The forming is an operation that produces a convex, concave or any irregular profile on the workpiece.



11) Chamfering

Chamfering removes the burrs and sharp edges, and thus makes the handling safe. Chamfering can be done by a form tool having angle equal to chamfer which is generally kept at 45°.



12) Taper Turning

The taper turning is an operation of producing a conical surface externally or internally by gradual reduction in the diameter of a cylindrical workpiece.

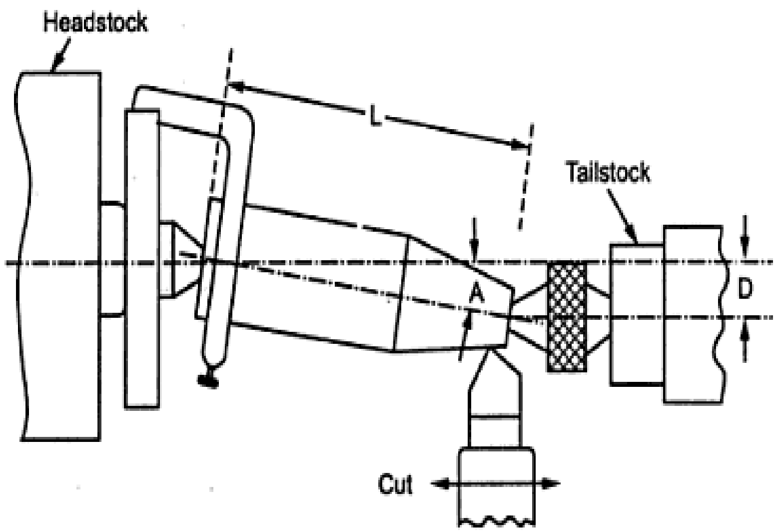
A taper may be produced on the workpiece by any one of the methods:

a) Taper turning by set over the tail stock.

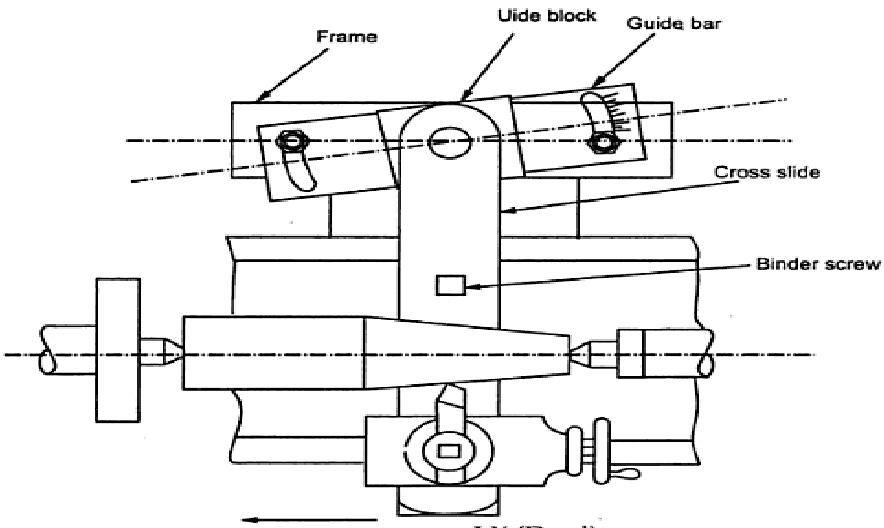
b) Taper turning by swiveling the compound rest.

c) Taper turning by a taper turning attachment.

a. Taper turning by set over the tail stock.



The principle of taper turning by this method is shifting the axis of rotation of the workpiece at an angle to the lathe axis and feeding the tool parallel to the lathe axis. The angle through which the axis of rotation is shifted is half the angle of the taper. For this the body of the tailstock is made to slide on its base towards or away from the operator by asset over screw. This method is suitable for turning small taper on long jobs.



$$\text{Set over} = \frac{LX(D-d)}{2X1}$$

Where

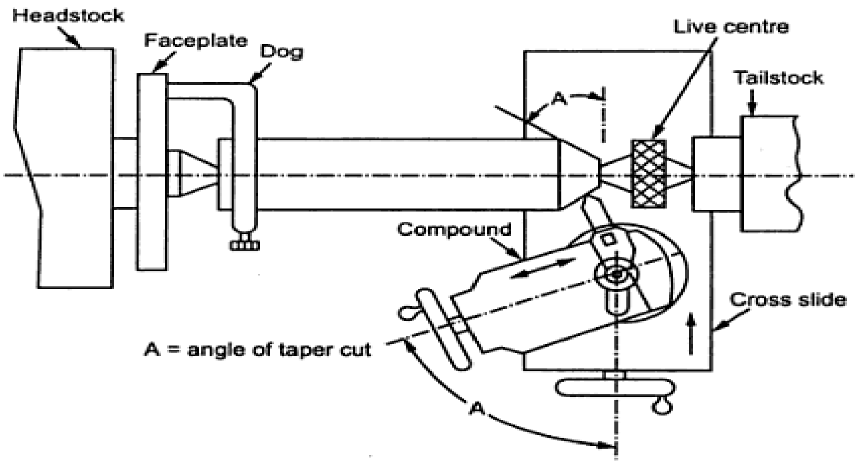
L = Length of Work.

D = Larger Diameter.

d = Smaller Diameter.

l = Length of taper.

b. Taper turning by swiveling the compound rest.



This method employs the principle that the work piece is rotated along the lathe axis and the tool is fed at an angle to the axis of rotation of the workpiece. The tool is held in a tool post which is mounted on the compound rest.

The compound rest is mounted on the cross slide, which is graduated in degrees and can be swiveled or clamped at any desired position. The compound rest is set at an angle equal to half the taper angle. After this compound slide screw is rotated it makes the tool to be fed at desired angle generating corresponding taper.

c. Taper turning by a taper turning attachment.

The principle of taper turning by this method is that a taper attachment is used to guide a tool in a straight path which is set at an angle to the axis of rotation of the workpiece. The workpiece is rotated between the centers or in a chuck.

It consists of a frame which is attached to the rear end of the lathe bed. It supports the guide bar pivoted at the center. The bar may be held at the desired angle with the lathe axis.

When the taper turning attachment is used, the cross slide is made free from the lead screw. The rear end of the cross slide is tightened.

During engagement of longitudinal feed the tool on the cross slide follows angular path. The required depth of cut is obtained by a compound slide which is placed perpendicular to the lathe axis. The angle of the guide bar should be half the taper to be worked on the workpiece.

1.7 Calculation of the machining time for turning operations

The amount of time which is assigned for the completion of a work order (e.g , manufacture of a bolt) is called Total Time. It is the sum of setting time, machining time, auxiliary time, and delay time.

Setting time: it is the time needed for preparing for a certain operation, and after operation, bringing it to its original state; this includes also the study of drawings, the time required for adjusting tools, getting tools out of store and regurning them.

Auxiliary time: it is the time required regularly for progress of the operation such as positioning and removing of the workpiece, setting the depth of cut, measuring and tool sharpening.

Machining time: it is the time during which operations are performed which contribute directly to the completion of the work order (e.g., time in which the workpiece is machined, operating time of the machine, cutting time).

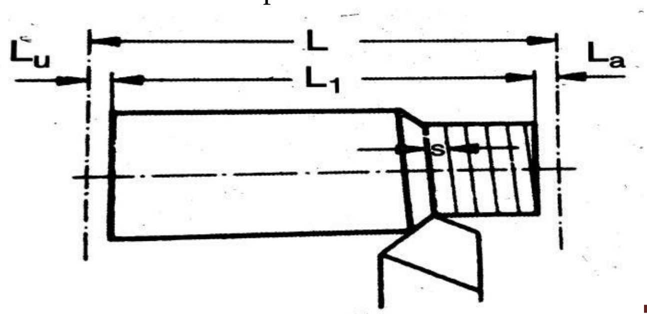
Delay time: it is the time allowed for personal needs, overcoming fatigue, and unavoidable delays. Delay time occurs irregularly. It comprises of such conditions as walking to the lavatory, rest periods, waiting for material, etc. Machining time can be determined by calculation.

$$\text{Machining time} = \frac{\text{Turning length}}{\text{Feed/min.}} \qquad t_m = \frac{L}{s \times n}$$

Terms: L = turning length [L = length of workpiece (L_1) + starting allowance (la) + allowance after turning (lu)]:

$L = L_1 + la + lu$; s = feed in mm/rev; n = revolutions per min;

Feed per min: s' = s x n.



Longitudinal turning:
Example: d = 80 mm; L_1=490 mm; la= lu = 5 mm; v = 20 m/min.; s= 0.5 mm/rev.
Result: L = 490 mm + 5 mm + 5 mm; n = 74 rpm.

$$t_m = \frac{L}{s \times n} = \frac{500\text{ mm}}{0.5\text{ mm} \times 74\text{ / min.}} = 13.5\text{ min.}$$

Facing: the turning length L corresponds with the radius plus starting allowance.
L = r+la.
Example: d=190mm; la = 5mm; v= 20m/min; s=0.5 mm/rev.
Result:

$$L = \frac{190\text{ mm}}{2} + 5 = 100\text{ mm};$$

n=37 rpm

$$t_m = \frac{L}{s \times n} = \frac{100\text{ mm}}{0.5\text{ mm} \times 37\text{ / min.}} = 5.4\text{ min.}$$

1.8 Cutting speed

The cutting speed is the rate of cutting on the main motion. When the workpiece rotates once, a certain length (cutting length) passes by edge of the tool, which corresponds to the circumference of the workpiece (C = π×d).

If the diameter *d* of the workpiece is then 85 mm, the circumference will be 85 mm x 3.14 i.e., 267 mm = 0.267 m

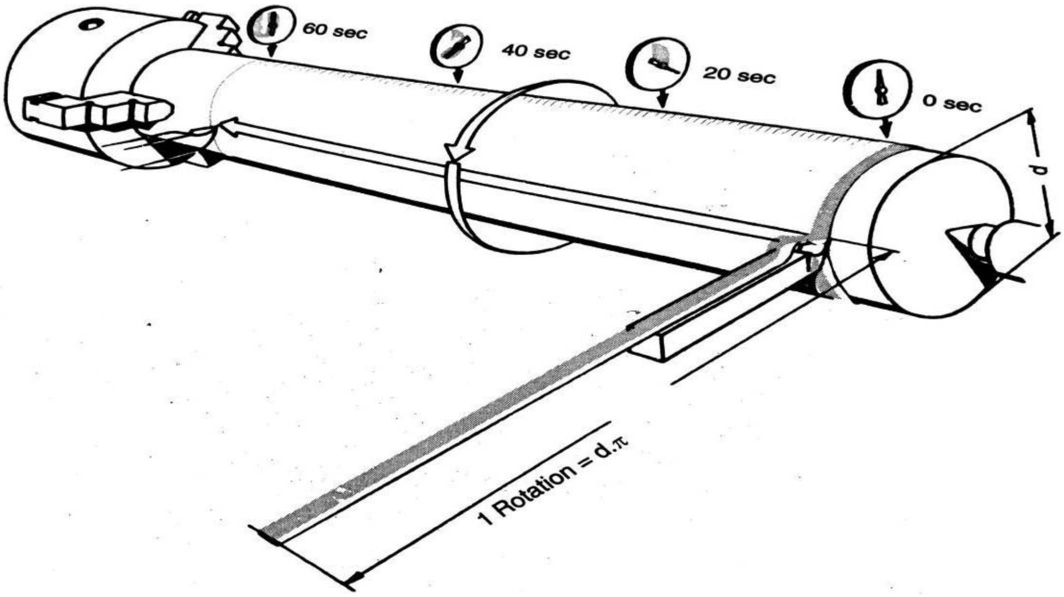


Fig: Cutting speed for turning operations.

When the workpiece rotates 100 times per min. the cutting length will be 0.267 m x 100, i.e., 26.7 m per minute.
The distance which is travelled in a unit of time is called speed. The speed of a circular motion is called circumferential speed.

The cutting length in m/per min. corresponds to the circumferential speed and, therefore to the speed by which the chip is removed.

Cutting speed is the cutting length in m per min. (m/min.).

It is denoted by the letter v, the diameter of the workpiece in mm by *d*, the number revolutions of the workpiece per min. by n.

$$v = \frac{\pi \times d \times n}{1000} \quad \text{m/min.}$$

Example: Calculate the cutting speed by which a workpiece is to be machined

Given: Diameter of workpiece = 50 mm, rpm. n = 160.

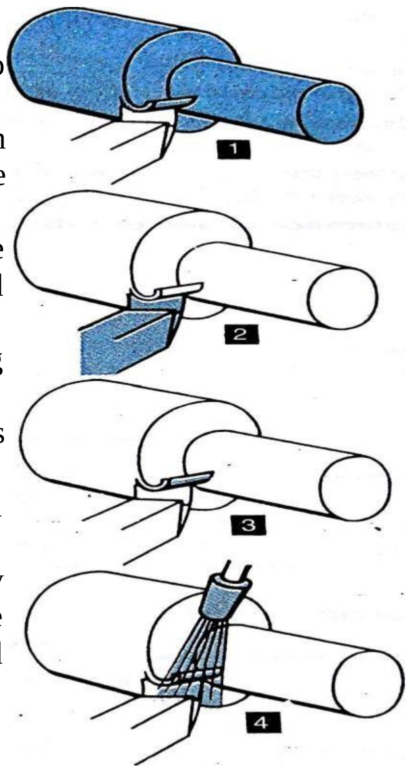
Result:

$$v = \frac{\pi \times d \times n}{1000} \; ; \; v = \frac{3.14 \times 50 \text{ mm} \times 160 \text{ min.}}{1000} = 25.12 \text{ m/min.}$$

The most favorable cutting speed should be selected every time.

For the determination of the cutting speed, the following points have to be observed.

1. Material of the workpiece. Hard materials generate more heat than soft ones, while cutting off chips. Therefore, hard materials have to be machined at a lower speed.
2. Material of the turning tool. Cemented carbide withstands more heat than high-speed steel and for that reason a higher cutting speed can be selected.
3. Cross section of chips. While cutting thin chips (finishing operation), the cutting speed can be higher than while cutting thick chips (roughing operation), as large chips develop more heat than small ones.
4. Cooling. A higher cutting speed can be selected when using coolants during the turning process.
5. Design of the machine. A heavy machine has the capacity to maintain a higher cutting speed than a light one. The machine must be equipped in such a way that the selected cutting speed can be actually set.



Influencing the cutting speed

Calculation of the rpm

The permissible cutting speed can be derived table given below.

Example: According to table, a cutting speed of 22m/min is suitable for roughing a shaft of St 50. Before turning, the rpm of the workpiece must be known in order to obtain the desired cutting speed.

Example: to calculate rpm given: d= 125mm, v= 20m/min

$$n = \frac{1000 \times v}{\pi \times d} = \frac{1000 \times 20\ \mathrm{m/min.}}{3.14 \times 125\ \mathrm{mm}} \approx 51\ \mathrm{rpm.}$$

Material	Tool	Cutting angles			Roughing ▼ Depth of cut a =4…10 s			Finishing ▼ ▼ Depth of cut a=2…5.s			Coolant and lubricant for	
		α	β	Γ	Cutting speed v m/min	Feed s	Depth of cut a	Cutting speed v m/min	Feed s mm/U	Depth of cut a	Roughing ▼	Finishing ▼ ▼
Steel strength 50kgf/mm²	TS HSS H	8^0 5^0	62^0 67^0	20^0 18^0	14 22 150	0.5 1 2.5	4 101 5	20 30 250	0.2 0.5 0.25	1 1 1.5	E	E o.P
50-70 kgf/mm²	TS HSS H	8^0 5^0	68^0 75^0	14^0 10^0	10 20 120	0.5 1 2.5	4 101 5	15 24 200	0.2 0.5 0.25	1 1 1.5	E	E o.P
70-85 kgf/mm²	TS HSS H	8^0 5^0	68^0 75^0	14^0 10^0	8 15 80	0.5 1 2	4 101 5	12 20 140	0.2 0.5 0.2	1 1 1.5	E	E o.P
Tool steel	TS HSS H	8^0 5^0	76^0 79^0	6^0 6^0	6 12 30	6.5 1 0.6	3 8 5	8 16 50	0.2 0.5 0.15	1 1 1	E	E o.P
TS= Tool steel HSS = High speed steel		H = Cemented carbide E = Water soluble oil					R = Rape oil P = Kerosene				dr= dry	
For thread cutting , v will be about ½ of the cutting speed for longitudinal turning												

Table: Reference values for cutting angles – cutting speed, feed, depth of cut, coolant.

1.9 GENERAL PROCEDURE TO PREPARE ANY JOBS:

1. Read and interpret the drawing given.
2. Identify the operations to be performed and sequence them.
3. Select the machine, equipment's (job holding and job supporting), tools and measuring instruments to complete the job.
4. Compute and select cutting parameters like cutting speed, speed, feed, depth of cut, number of passes for each operation.
5. Write and list chronological sequence of operations, job holding details, job support details, tools required and parameters of each operation.
6. Complete the each operation as per above (5.).
7. Compute the job by completing all operations.
8. Inspect and apply antirust oil to the job.
9. Punch your USN and store.

PART-A

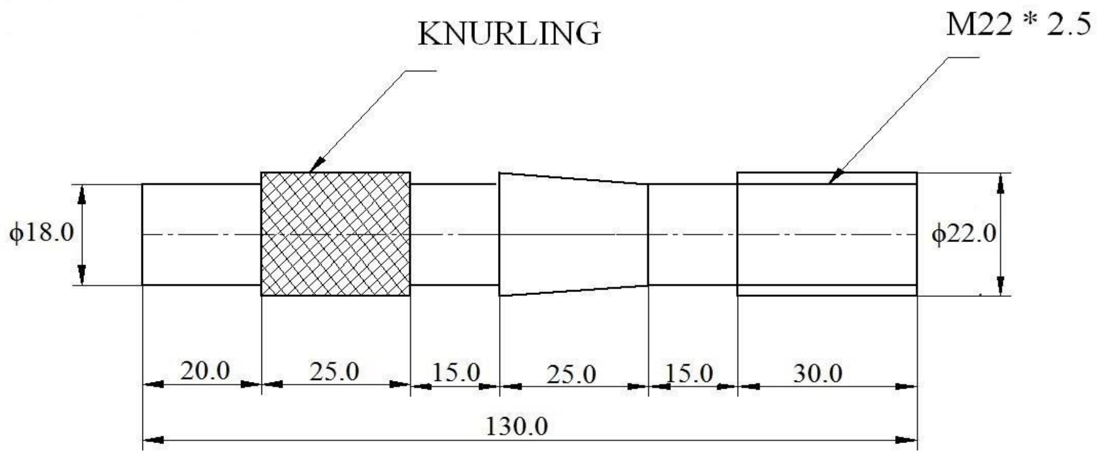
MODEL - 1

AIM:
To perform facing, plain turning, step turning, grooving, taper turning, chamfering and drilling operation on the given work piece.

MATERIAL REQUIRED:
Mild steel rod of 25 mm diameter and 135 mm long.

TOOLS REQUIRED:
Vernier calipers, steel rule, spanner, chuck spanner, and H.S.S. single point cutting tool.

PROCEDURE:



All dimensions are in mm

- Hold the job in self-centering 3 jaw chuck firmly with enough overhang to work on the job on the other side; face and counter sink one end.
- Reverse and face to size 130mm and countersink the other end.
- Hold the job in chuck, support the other end with revolving center fixed in tailstock; turn ϕ23×65mm long (approximately). Turn steps ϕ18×20 mm, ϕ22×25 mm, ϕ18×15 mm and knurl as per the drawing.
- Reverse and hold the chuck and support with revolving center (tailstock) and turn ϕ22 for complete length.
- Step turn ϕ 17.5×15 mm and cut M22×2.5pitch×30mm thread and taper turn as per the drawing.
- Inspect the job.

Operation Plan:

Sl. No.	Sequence of operations	Tools
1	Turning to length and facing the ends	Facing tools
2	Centering	Centre drill Bit
3	Chucking the workpiece and turning to 20ϕ	Single point cutting tool
4	Turning to length and deburring of steps	Side tool, hand tool
5	Knurling of gripping position	Step turning tool
6	Taper turning	Single point cutting tool
7	Cutting of external thread M 22*2.5	V- tool
Measurements and checking instruments; Vernier caliper, depth gauge, micrometer		

Table showing parameters of cutting and time taken to complete operations/ job:

Sl. No	Operations	Speed (rpm)	Feed (mm/rev)	No. of passes	Time taken (mts)
1					
2					
.					
.					
.					
.					
.					

RESULT:

DISCUSSION:

CONCLUSION:

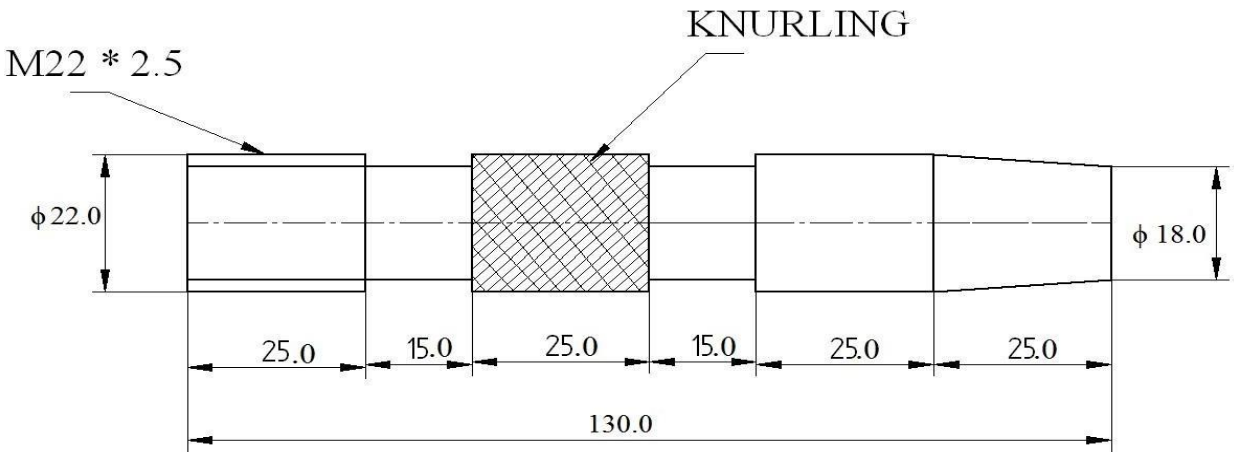
Model - 2

AIM:
To perform facing, plain turning, step turning, grooving, taper turning, chamfering and drilling operation on the given work piece.

MATERIAL REQUIRED:
Mild steel rod of 25 mm diameter and 135 mm long.

TOOLS REQUIRED:
Vernier calipers, steel rule, spanner, chuck spanner, and H.S.S. single point cutting tool.

PROCEDURE:



All dimensions are in mm

- Hold the job in self-centering 3 jaw chuck firmly with enough overhang to work on the job on the other side; face and counter sink one end.
- Reverse and face to size 130mm and countersink the other end.
- Hold the job in chuck, support the other end with revolving center fixed in tailstock; turn ϕ23×65mm long (approximately). Turn steps ϕ18×20 mm, ϕ22×25 mm, ϕ18×15 mm and taper turn as per the drawing.
- Reverse and hold the chuck and support with revolving center (tailstock) and turn ϕ22 for complete length.
- Step turn ϕ 17.5×15 mm and cut M22×2.5pitch×30mm thread and knurl as per the drawing.
- Inspect the job

Operation Plan:

Sl. No.	Sequence of operations	Tools
1	Turning to length and facing the ends	Facing tools
2	Centering	Centre drill Bit
3	Chucking the workpiece and turning to 20ϕ	Single point cutting tool
4	Turning to length and deburring of steps	Side tool, hand tool
5	Knurling of gripping position	Step turning tool
6	Taper turning	Single point cutting tool
7	Cutting of external thread M 22*2.5	V- tool
Measurements and checking instruments; Vernier caliper, depth gauge, micrometer		

Table showing parameters of cutting and time taken to complete operations/ job:

Sl. No	Operations	Speed (rpm)	Feed (mm/rev)	No. of passes	Time taken (mts)
1					
2					
.					
.					
.					
.					
.					

RESULT:

DISCUSSION:

CONCLUSION:

Model - 3

AIM:

To perform facing, plain turning, step turning, eccentric turning and drilling operation on the given work piece.

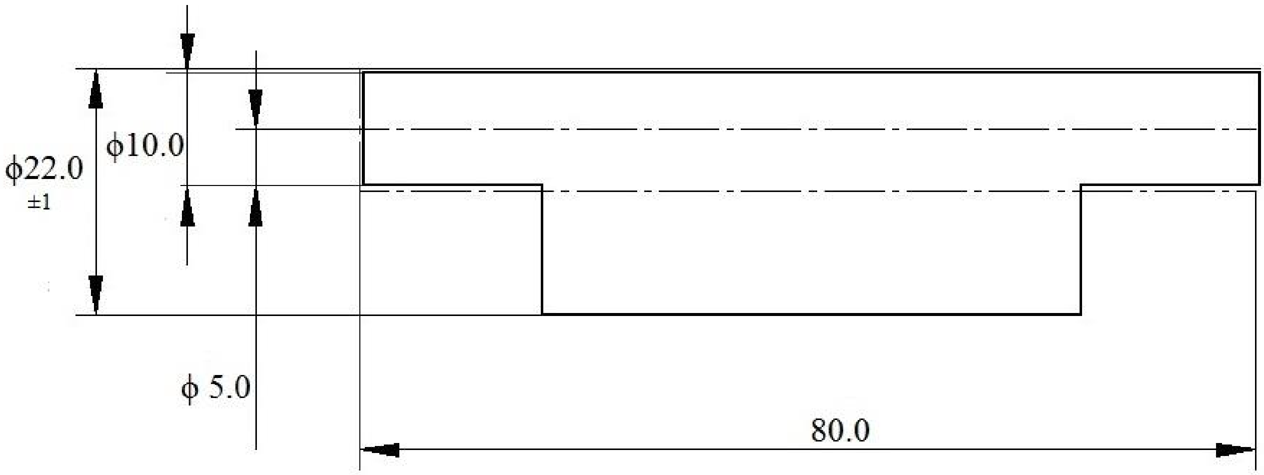
MATERIAL REQUIRED:

Mild steel rod of 25 mm diameter and 80 mm long.

TOOLS REQUIRED:

Vernier calipers, steel rule, spanner, chuck spanner, and H.S.S. single point cutting tool.

PROCEDURE:



All dimensions are in mm

- Hold the job in self-centering 3 jaw chuck firmly, face and counter sink at one end.
- Reverse and face to size 80mm and countersink the other end.
- Hold the job between centers and turn ϕ 22 to maximum length of the job possible; reverse and turn ϕ22 for the remaining portion of the job.
- Mark for eccentric turning at both ends of the job as per the drawing.
  Marking procedure:
  Mount the job on ϕ 22 on a v-block.
  Using a Vernier height gauge mark the center line horizontally parallel to the surface plate on the faces at both the ends of the job.
  Rotate the job through 90 degrees to make the line drawn in the above step perpendicular to the surface plate; check at both ends.(use a try square)
  Mark for eccentric centers at both the ends simultaneously.
- Countersink for eccentric turning on a drilling machine using self-centering chuck.
- Mount between centers for eccentric tuning; turn the eccentric diameter at one end.
- Reverse and hold between centers and turn the eccentric diameter at the other end.
- Inspect the job

Operation Plan:

Sl. No.	Sequence of operations	Tools
1	Turning to length and facing the ends	Facing tools
2	Drilling of Centers	Centre drill Bit
3	Rough turning to 22 ϕ between centers	Roughing tool
4	Marking and drilling of off-center bores	Marking block, divider, Centre drill
5	Finish turning between centers	finishing tool
6	Rough and finish turning the jobs	Roughing, finishing and side tool
Measurements and checking instruments; Vernier caliper, depth gauge, micrometer		

Table showing parameters of cutting and time taken to complete operations/ job:

Sl. No	Operations	Speed (rpm)	Feed (mm/rev)	No. of passes	Time taken (mts)
1					
2					
.					
.					
.					
.					

RESULT:

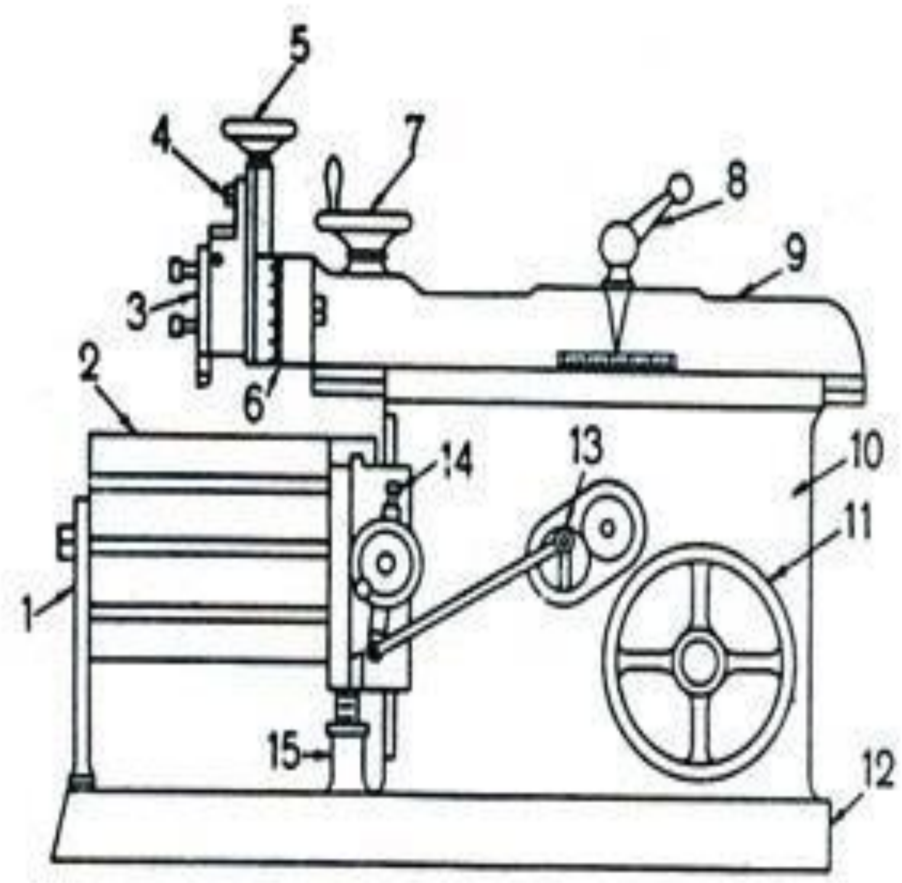
DISCUSSION:

CONCLUSION:

2. SHAPING MACHINE

A shaper is a reciprocating type of machine tool intended primarily to produce flat surfaces. These surfaces may be horizontal, vertical or inclined.

In general, the shaper can produce any surface composed of straight line element. Modern shaper can generate contoured surfaces also.



1. Table support, 2. Table, 3. Clapper box, 4. Apron clamping bolts, 5. Downfeed hand wheel, 6. Swivel base degree graduations, 7. Position of stroke adjustment handwheel, 8. Ram block locking handle, 9. Ram, 10. Column, 11. Driving pulley, 12. Base, 13. Feed disc, 14. Pawl mechanism, 15. Elevating screw

PRINCIPAL PARTS:

BASE: the base is the necessary bed or support required for all machine tools. The base may be rigidly bolted to the floor of the shop.

COLUMMN: The column is a box like casting mounted upon the base. It encloses the ram driving mechanism. Two accurately machined guide ways are provided on the column, which server as the guide ways for the cross rail is also accurately machined.

CROSSRAIL: it is mounted on the front vertical guide ways of the column.

SADDLE: a saddle is mounted on the cross rail which hold the table firmly on its top. Cross vice movement of the saddle by rotating the cross feed screw by hand or power causes the table to move sideways.

TABLE: the table which is bolted to the saddle receives cross vice and vertical movements ram the saddle and the cross rail. It is a box like casting having T-slots both on this top and sides for clamping the work.

RAM: the Ram is the reciprocating member of the shaper. This is semi cylindrical inform and heavily rubbed inside to make it more rigid. It slides on the accurately machined dovetail guide ways on the top of the column and is connected to the reciprocating mechanism.

TOOL HEAD: the tool head of the shaper holds tool rigidity, provides vertical and angular feed moment of the tool and allows the tool to have an automatic relief during its return stroke. The vertical slide of the tool head has a swivel head base which is held on a circular seat on the ram.

SHAPER SIZE: the maximum length of the stroke or cut it can make and determines the size of a shaper. The usual size ranges from 175 to 900mm the length of stroke indicates.

2.1 SPECIFICATION OF THE UNIVERSAL SHAPING MACHINE:

A deep cut high metal removal & sustained accuracy

The machine is naturally casting. All castings are ribbed to withstand shock loads. Gears are made on high Precision Gear Shaper and tooth rounded for easy sliding. C I casting confirming to IS : 210 ensure long life of the machine. All alignments confirm to IS: 2310 – 1989. All the components manufactured are inspected and approved by qualified and experienced engineers at every stage. The machine is especially for increased production, precision performance and deep cut.

Gears & casting are of high tensile strength. High tensile strength Allen bolts used. High quality paints used. Approved by N S I C All important shafts held on both sides on antifriction bearings. All gears in gear box run in oil bath. Stroke Adjustment indicator arranged for machining all metal with optimum output. Arranged clutch with easy reach to operator.

Cap	Unit	UMT 300	UMT 450	UMT 600	UMT 750	UMT 900	UMT 1025
Length of Ram Stroke	mm	350	500	650	800	950	1050
Max. Distance table to ram	mm	340	390	450	480	530	550
Working Surface of Table universal	mm	310 x 215	450 x 310	620 x 380	770 x 380	920 x 475	1020 x 510
Max. Horizontal Travel of Table	mm	410	520	780	810	1060	1205
Max travel of tool slide	mm	120	135	185	200	210	240
Max. Swivel of tool head	degree	60L 60R	60L 60R	60L 60R	60L 60R	60L 60R	60L 60R
Max. Size of Tool Shank	mm	16x16	25x25	25x25	25x25	28x28	30x30
Ram speed	Nos	3	3	4	4	4	4
Ram speed in case of all geared	Nos	4	4	4	4	4	6
Table feed in Horizontal direction	Nos	3	3	3	3	3	3
Main Drive Motor	HP	1	2	3	3	5	5
Floor space required	Mm	1250 x1000	1450 x1200	1720 x1300	1900 x1350	2100 x1550	2250 x1700
Approx. Weight of the machine	Kgs	800	1200	1900	2200	2700	3500

2.2 SHAPER MECHANISM

In a shaper, rotatory moment of the drive is converted into reciprocating moment by the mechanism contained within the column of the machine. The shaper mechanism should be so designed that it can allow the ram to move at a faster rate idle return time. This mechanism is known as Quick return mechanism. The reciprocating moment of ram and the quick return mechanism of the machine are usually obtained by anyone of the following methods:

Crack and Slotted link mechanism

Whitworth quick return mechanism

Hydraulic shaper mechanism

2.2.1 Crank and Slotted Lever Mechanism

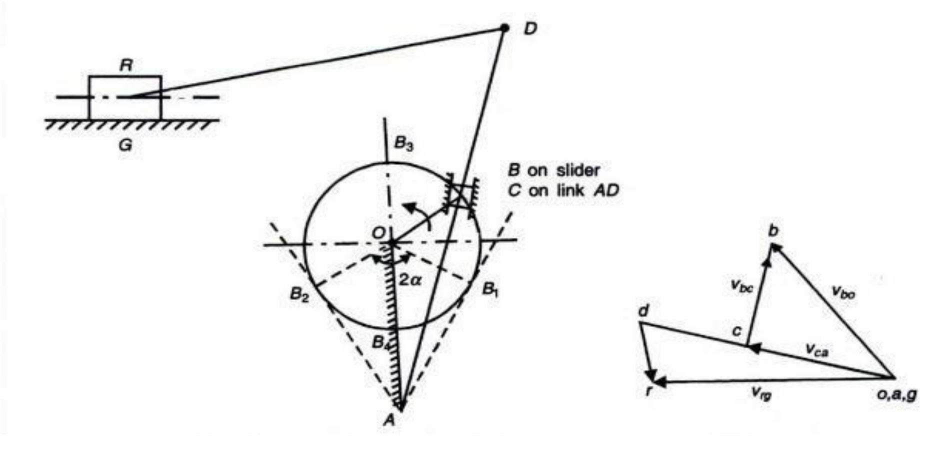
A crank and slotted lever mechanism, which is one type of quick return motion mechanism, is widely used in shaper machines. It executes the return stroke in the shortest possible time. In this mechanism, the crank OB rotates with uniform angular velocity w rad/ s about the fixed point 0. At the end B of the crank, a slider is pivoted such that C be a point on the link AD immediately below the slider B. As the crank OB rotates about the point 0, the slider reciprocates along the lever AD and there is a relative motion between the points B and C. The lever AD oscillates about the fulcrum point A. The other end of the lever is connected to ram R through a link DR. A cutting tool is attached to the ram which performs cutting and idle stroke.

The velocities of various links of a crank slotted lever mechanism can be determined by drawing a velocity polygon as discussed below:

1. Compute tangential velocity of crank OB, v_{bo} = w x OB
2. Choose a convenient point *o* and draw a vector ob perpendicular to crank *08* in counterclockwise direction to some suitable scale as shown in Figure (b).
3. The vector ob has two components, one parallel to the lever *AD* and another perpendicular to it, such that the following vector equation is satisfied:

$$v_{bo},, = v_{ca} + v_{bc} \text{ or } ob = ac + cb$$

Where velocity of point *C* relative to point A, V_{ca} is perpendicular to lever *AD* and V_{bc}, is parallel to the lever *AD.*



(a) Crank and slotted lever mechanism (b) velocity polygon

Figure: Velocity analysis of crank and slotted lever mechanism.

3. Therefore, draw a line *ac* perpendicular to the lever *AD.* Also draw another line *bc* from point *b* which is parallel to the lever *AD.* These lines intersect at point *c.*
4. The velocity of point *C* on the lever *AD* is represented by vector *ac.* Extend this line up to

$$\frac{\overline{ac}}{\overline{ad}} = \frac{AC}{AD}$$

point *d* in proportion such that it satisfies the following relation:

5. Draw a vector dr of unknown magnitude perpendicular to the link DR.
6. The velocity of the ram R relative to the fixed guide G. v_{rg} is along the line of stroke. Thus from point g, draw a line parallel to the line of stroke to intersect vector dr at point r. The vector gr represents the velocity of the ram relative to the fixed point G.

In a crank and slotted lever mechanism, when the crank takes the position OB_1 and OB_2, the component of velocity of crank pin perpendicular to the lever is zero. Thus during forward stroke, the crank moves through (360° — 2α) and during return stroke, it executes when the crank moves through 2α [See Figure (a)]. Therefore,

$$\frac{\text{Time of cutting}}{\text{Time of return}} = \frac{360° - 2\alpha}{2\alpha}$$

2.2.2 Whitworth Quick Return Mechanism.

A whitworth quick return mechanism, used in slotting machine, is shown in Figure. The link 2 is fixed and link 3 acts as input crank. The link 1, which rotates about center 0, is extended up to point C. An additional link 5 is pivoted at point C. The other end of link 5 is pivoted to tool head. The axis of tool movement passes through center 0 and is perpendicular to link 2. In this mechanism, when slider 4 is at position B_1, the tool head will be at extreme left position. When crank 3 rotates at constant angular speed, the link 1 along with slider rotates at the circumference of outer circle. The movement of slider along the path B_1-B-B_2 completes the forward movement of tool head. Further rotation of crank 3 causes slider to move along the path B_2-B_3-B_1 during which the tool head takes return stroke. It is evident from Figure that angle for forward stroke is an obtuse angle a, which is greater than angle for return stroke β, thus tool traverses rapidly during the return stroke. The ratio of forward to return stroke timing is given as:

$$r = \frac{\text{Time of cutting}}{\text{Time of return}} = \frac{\alpha}{\beta}$$

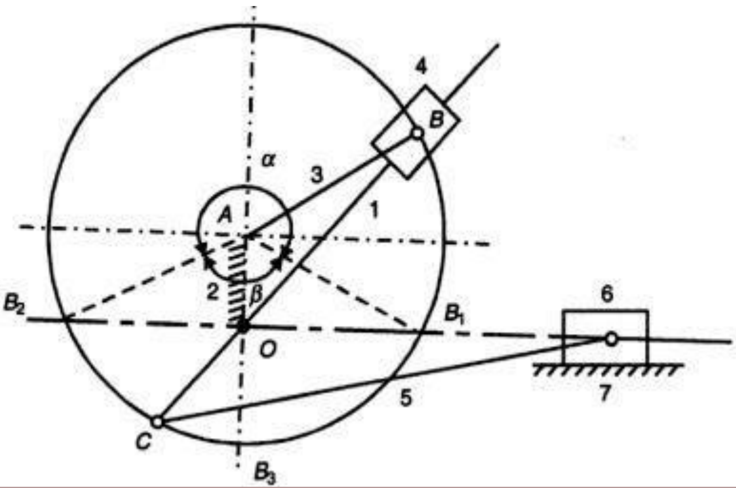


Fig: Whitworth quick return mechanism.

PART-B

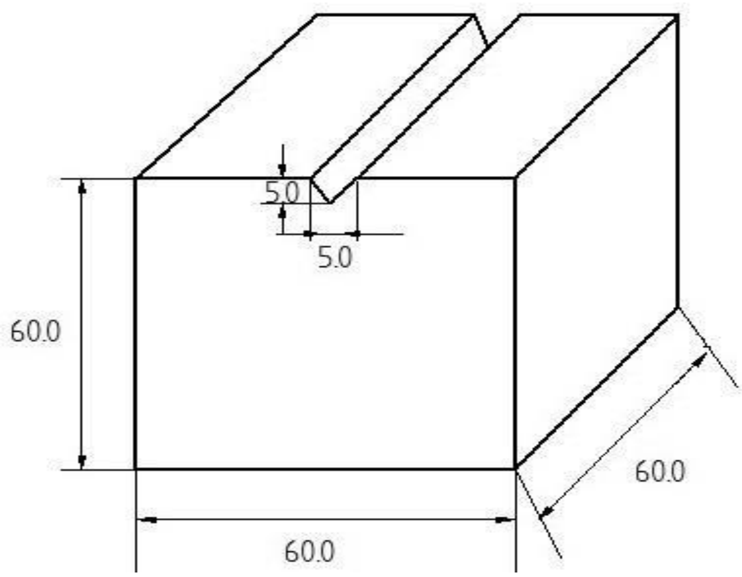
MODEL – 4

AIM:
To cut a v-groove in the given square block using shaping machine

MATERIAL REQUIRED:
Cast Iron block of dimension 60×60×60 mm.

TOOLS REQUIRED:
Vernier calipers, steel rule and H.S.S. single point cutting tool.

PROCEDURE:



All dimensions are in mm

- Make the given dimensions on the surface face of the workpiece.
- Fix the v-cutting tool in the tool post of the shaping machine.
- Fix the work piece firmly on the work table.
- Adjust the stroke length and RPM in the Shaper machine.
- Adjust the tool position to take small depth of cut the workpiece.
- Switch on the shaper machine and start giving feed gradually.
- Continuously increase the feed by rotating tool head lever until the required depth in workpiece is obtained.

Ram speed:

Depth of cut in each increment:

Stroke Length:

Operation plan:

Sl. No.	Sequence of operations	Tools
1	Mounting and aligning of workpiece	Machine vice, steel parallels
2	Clamping of shaping tool	Straight left hand roughing tool
3	Setting the number of cycles, stroke length, stroke position and feed	
4	Successive shaping of longitudinal sides	Straight left hand roughing tool, pointed finishing tool, slip gauges
5	Marking of v-block, recesses and grooves	Try square, bevel protractor, Vernier caliper, scriber, center punch
6	Rough shaping of v-block	Pointed finishing tool
7	Clamping of grooving tool and shaping of groove	Straight grooving tool
8	Setting tool side at angle clamping of finishing tool, shaping of oblique surfaces	Pointed finishing tool
9	Setting tool side into normal position, reclaiming of workpiece, shaping of recess	Pointed finishing tool, straight grooving tool
10	Reclaiming, shaping of grooves on the small sides	Straight grooving tool
11	Deburring	Smooth file
Measurements and checking instruments; Vernier caliper, depth gauge, try square, universal bevel protractor		

RESULT:

DISCUSSION:

CONCLUSION:

MODEL – 5

AIM:

To cut a Square-groove in the given square block using shaping machine

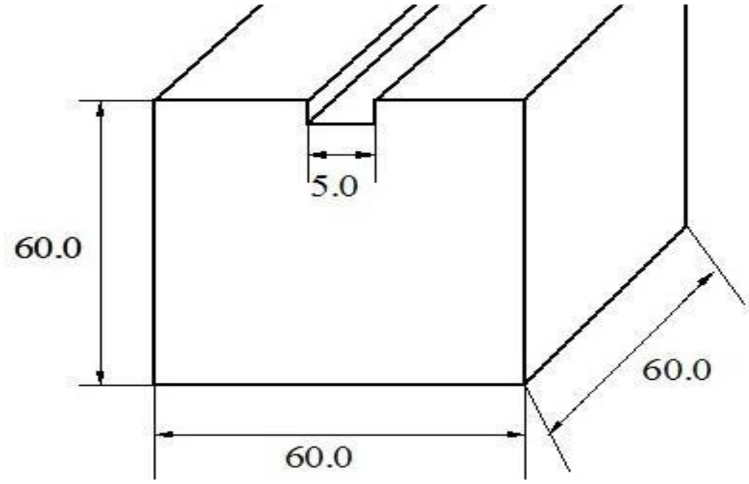
MATERIAL REQUIRED:

Cast Iron block of dimension 60×60×60 mm.

TOOLS REQUIRED:

Vernier calipers, steel rule and H.S.S. single point cutting tool.

PROCEDURE:



All dimensions are in mm

- Make the given dimensions on the surface face of the workpiece.
- Fix the Square-cutting tool in the tool post of the shaping machine.
- Fix the work piece firmly on the work table.
- Adjust the stroke length and RPM in the Shaper machine.
- Adjust the tool position to take small depth of cut the workpiece.
- Switch on the shaper machine and start giving feed gradually.
- Continuously increase the feed by rotating tool head lever until the required depth in workpiece is obtained.

Ram speed:

Depth of cut in each increment:

Stroke Length:

Operation plan:

Sl. No.	Sequence of operations	Tools
1	Mounting and aligning of workpiece	Machine vice, steel parallels
2	Clamping of shaping tool	Straight left hand roughing tool
3	Setting the number of cycles, stroke length, stroke position and feed	-----
4	Successive shaping of longitudinal sides	Straight left hand roughing tool, pointed finishing tool, slip gauges
5	Marking of Square-block, recesses and grooves	Try square, bevel protractor, Vernier caliper, scriber, center punch
6	Rough shaping of Square –block	Pointed finishing tool
7	Clamping of grooving tool and shaping of groove	Straight grooving tool
8	Setting tool side at angle clamping of finishing tool, shaping of oblique surfaces	Pointed finishing tool
9	Setting tool side into normal position, reclaiming of workpiece, shaping of recess	Pointed finishing tool, straight grooving tool
10	Reclaiming, shaping of grooves on the small sides	Straight grooving tool
11	Deburring	Smooth file
Measurements and checking instruments; Vernier caliper, depth gauge, try square, universal bevel protractor		

RESULT:

DISCUSSION:

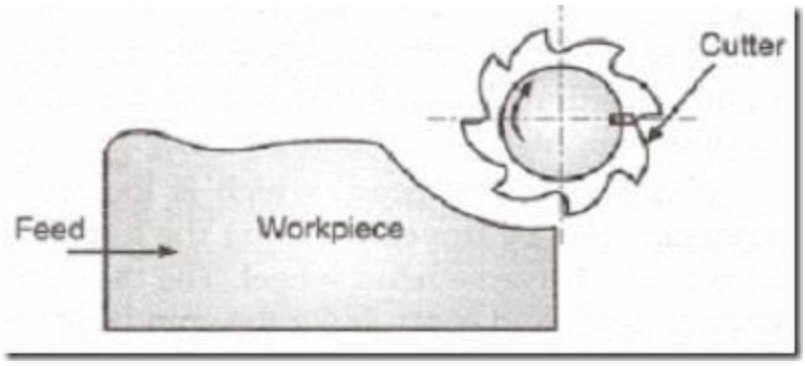
CONCLUSION:

3. MILLING MACHINES

Milling is a process of producing flat and complex shapes with the use of multi-tooth cutting tool, which is called a milling cutter and the cutting edges are called teeth. The axis of rotation of the cutting tool is perpendicular to the direction of feed, either parallel or perpendicular to the machined surface. The machine tool that traditionally performs this operation is a milling machine.

Working Principle:

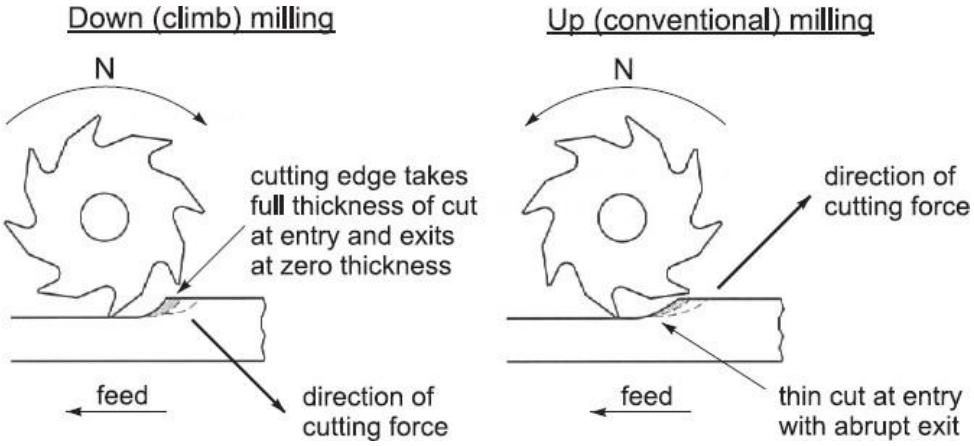
The workpiece is holding on the worktable of the machine. The table movement controls the feed of workpiece against the rotating cutter. The cutter is mounted on a spindle or arbor and revolves at high speed. Except for rotation the cutter has no other motion. As the workpiece advances, the cutter teeth remove the metal from the surface of workpiece and the desired shape is produced.



Types of Milling

There are two basic types of milling, as shown in the figure:

- **Down (climb) milling** - when the cutter rotation is in the same direction as the motion of the workpiece being fed, and
- **Up (conventional) milling** - in which the workpiece is moving towards the cutter, opposing the cutter direction of rotation:



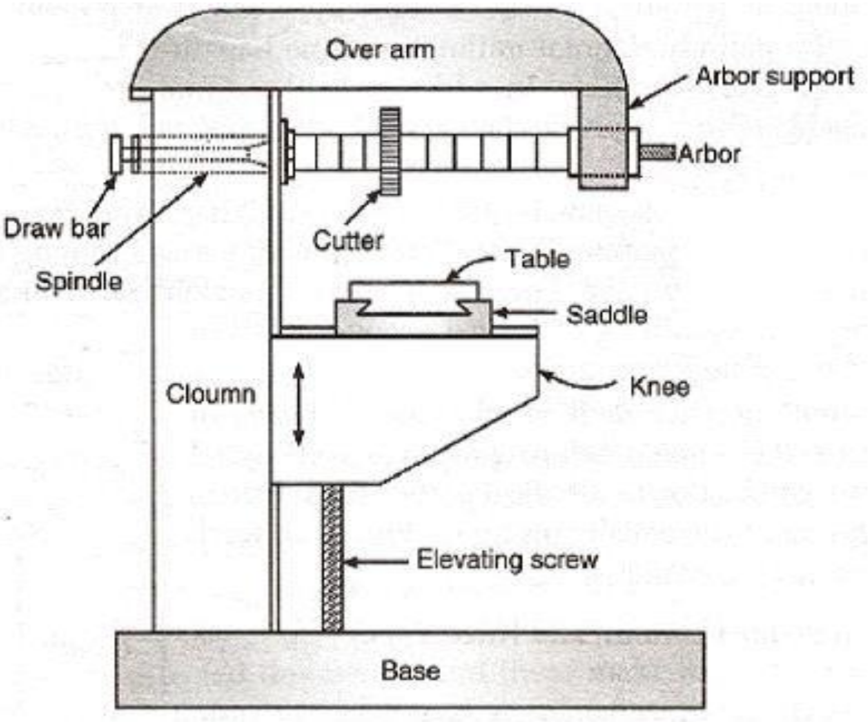
In **down milling**, the cutting force is directed into the work table, which allows thinner work parts to be machined. Better surface finish is obtained but the stress load on the teeth is abrupt, which may damage the cutter.

In **up milling**, the cutting force tends to lift the workpiece. The work conditions for the cutter are more favorable. Because the cutter does not start to cut when it makes contact (cutting at zero cut is impossible), the surface has a natural waviness.

3.1 Classification of Milling Machines

- Horizontal milling machines
- Vertical milling machines
- Universal milling machines
- Planar type milling machines
- Fixed bed type milling machines

3.2 MAIN PARTS OF A MILLING MACHINE



1. Base

The base gives support and rigidity to the machine and also acts as a reservoir for the cutting fluids.

2. Column

The column face is a precision machined and scraped section used to support and guide the knee when it is moved vertically.

3. Knee

The knee is attached to the column face and may be moved vertically on the column face either manually or automatically. It houses the feed mechanism.

4. Table

The table rests on guide ways in the saddle and travels longitudinally in a horizontal plane. It supports the vise and the work.

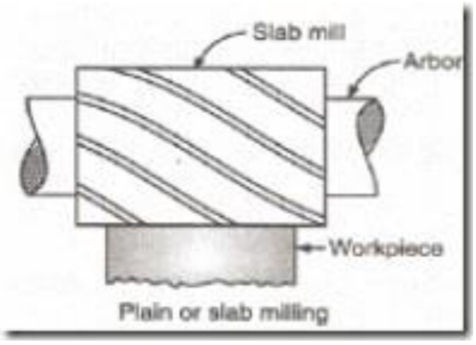
5. Overarm/Head

The overarm provides for correct alignment and support of the arbor and various attachments. It can be adjusted and locked in various positions, depending on the length of the arbor and the position of the cutter.

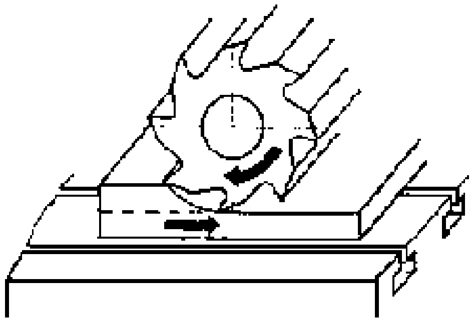
3.3 MILLING OPERATIONS

1) Plain Milling

Plain milling is the process of production of the plain, flat, horizontal surface parallel to the axis of rotation of a plain milling cutter. This operation is also called slab milling or peripheral milling.

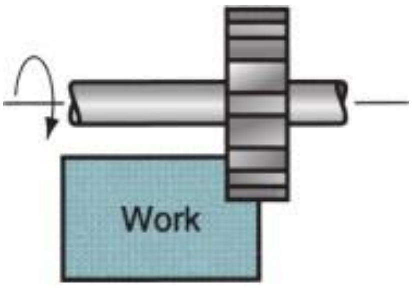


Plain or slab milling



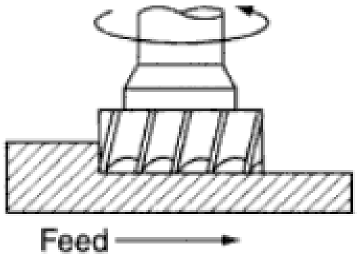
2) Side Milling

Side milling is the operation of production of a flat vertical surface on the side of a workpiece by using a side milling cutter.



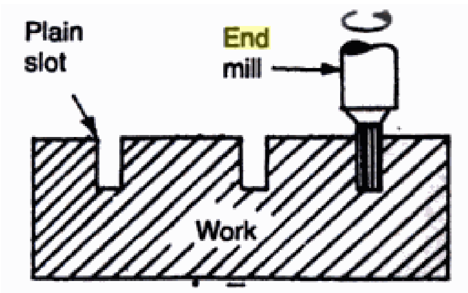
3) Face Milling

The face milling operation is performed by a face milling cutter rotated about an axis perpendicular to the work surface.



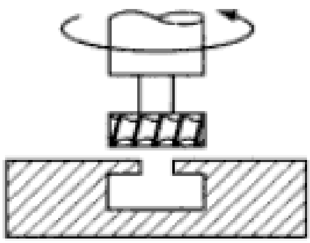
4) End Milling

The end milling is the operation of production of narrow slots, grooves and key slots using an end milling cutter. The mill tool may be attached to the vertical spindle for milling the slot. Depth of cut is given by raising the machine table.



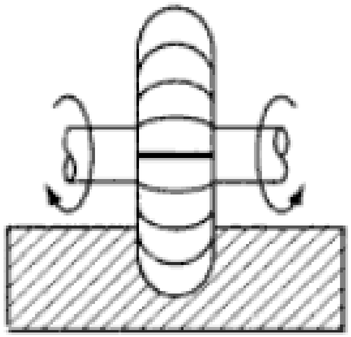
5) Slot Milling

Slot milling is the operation of producing slot on workpiece using a cutter called slot mill or slot drill. Different types of cutters are used to produce different types of slots. To produce T-slots, two different cutters are used. Initially an open slot is formed along the length of the workpiece by using a side cutter or end cutter, which provides the passage to move T-slot cutter. The T-slot cutter is used to cut the headspace of slot.



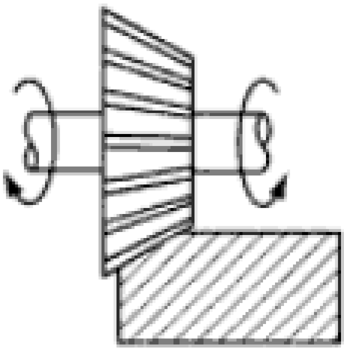
6) Form Milling

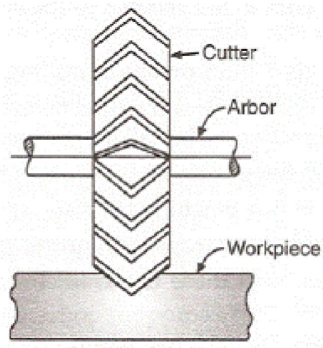
It is the operation of producing curved profiles using cutter called form mill. Form mill has teeth on its outer periphery. The form mill cutter is selected based on the type of surface being machined. Irregular contours like concave and convex type profiles can also be produced.



7) Angular Milling

Angular milling is an operation of producing angular surface on the workpiece other than at right angles to the axis of the milling machine spindle and also used for milling all types of grooves, chamfers and serrations. The faces of the angular cutters may be the same or different angle.

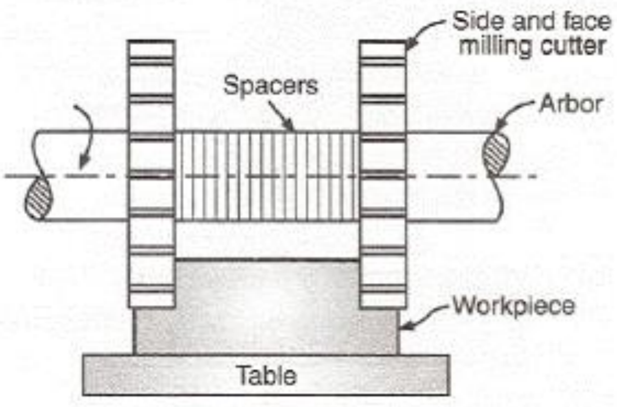




Angular milling

8) Straddle Milling

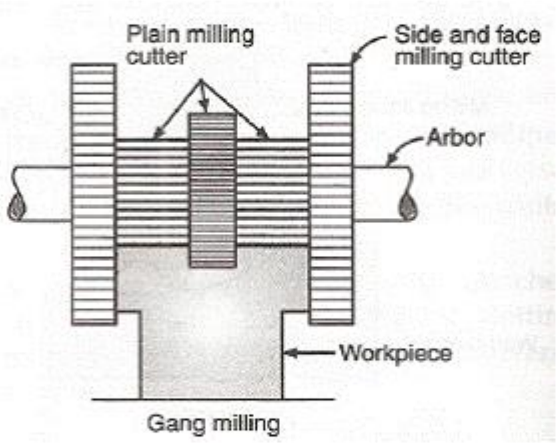
Straddle milling is an operation of producing flat vertical surfaces on both sides of a workpiece simultaneously by using two side milling cutters mounted on the same arbor. The milling cutter has a cutting edge on one side or both sides as well as on the periphery. The distance between the two cutters is adjusted correctly by using suitable spacing collars.



Straddle milling

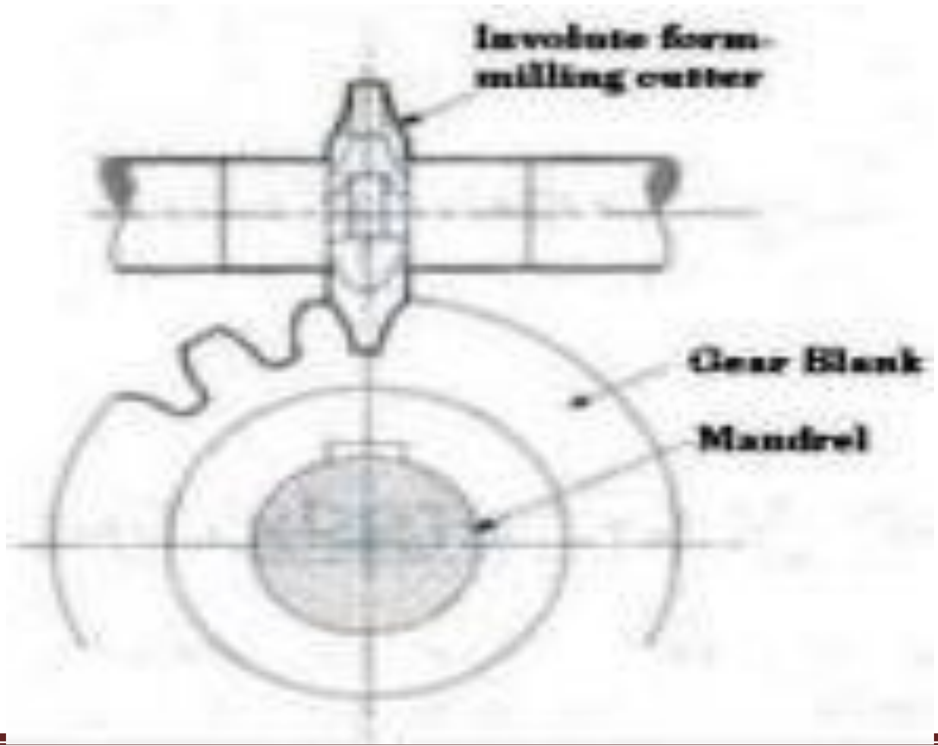
9) Gang Milling

Gang milling is the operation of machining several surface of the workpiece simultaneously by feeding the table against the number of cutters having same or different diameter mounted on the arbor of the machine. This method saves much of machining time and is widely used in respective work.



10) Gear Cutting

Gear cutting operation is the best known and metal removal process for making gears. This method requires the usage of a milling machine. It is also to be noted that this method can produce nearly all types of gears. The method involves the use of a form cutter, which is passed through the gear blank to create the tooth gap. This method is right now used only for the manufacture of gears requiring very less dimensional accuracy.



3.4 MILLING OF SPUR GEAR BY INDEXING METHOD

Gear milling cutters which must have the shape of the tooth space are required as tools. With increasing number of teeth, the form of the tooth space changes at equal pitch. To be able to manufacture all numbers of teeth, a complete set of milling cutters is required for individual module. Depending on the accuracy which the completed gear shall have, the cutter will be taken from the set of 8 or 15 milling cutters. The following particulars stated on the gear milling cutter: Module, No. of cutter, suitable for which number of teeth, pitch in mm. and height of tooth = milling depth in mm.

Classification of the set of 8 cutters								
Cutter –Nr.	1	2	3	4	5	6	7	8
For number of teeth	12 -13	14 -16	17 -20	21 -25	26 -34	35 -34	55 -135	135 up to Tooth rack

Classification of the set of 15 cutters															
Cutter –Nr.	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8
For number of teeth	12	13	14	15 -16	17 -18	19 -20	21 -22	23 -25	26 -29	30 -34	35 -41	42 -54	55 -80	81 -134	135 up to tooth rack

Example of manufacturing of teeth:

Selection of cutter: the cutter will be selected from the eight piece cutter set and must have the following inscription: Module 2.5, Nr. 4.21 – 25 Z, pitch 7.85, and milling depth 5.42.

Setting of dividing head: the revolutions of the handle have to be calculated:

$$n = \frac{Z}{T} = \frac{40}{25} = 1\frac{15}{25} = 1\frac{3}{5} = 1\frac{12}{20} \quad \begin{matrix} \text{—No. of holes} \\ \text{—hole circle} \end{matrix}$$

After the milling of a tooth space, the handle of a dividing head is turned around once and is then shifted 12 holes further on the hole circle of 20. During milling, plenty of coolant should be applied.

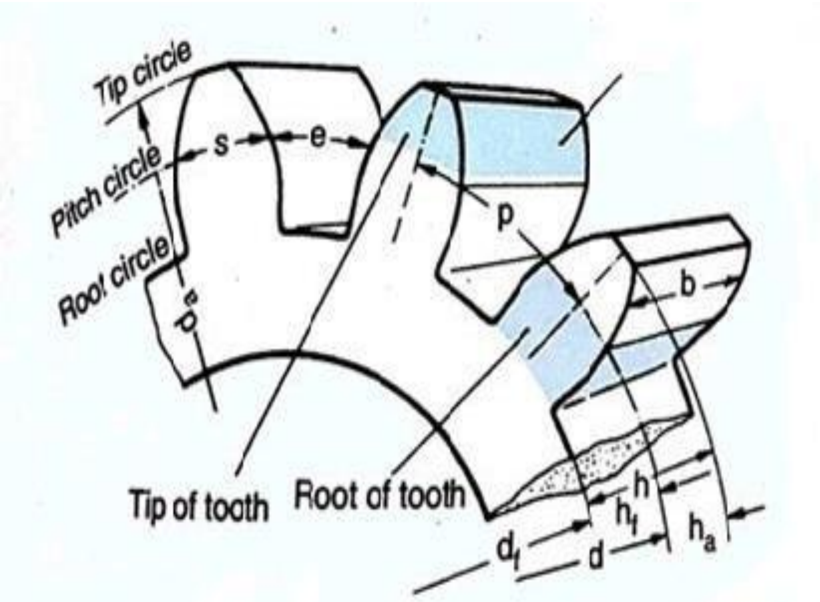
MODEL – 6

AIM:
To cut a Spur gear teeth on the circular blank using Milling machine.

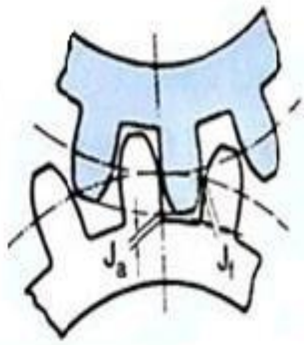
MATERIAL REQUIRED:
Cast Iron circular blank of ϕ 102 mm.

TOOLS REQUIRED:
Vernier calipers, steel rule and Multi point cutting tool.

PROCEDURE:



Fig(a): Designations on a Spur gear with straight teeth.



Fig(b): Meshing Gears

d – Pitch circle diameter ha – addendum e –Space Width
da - Tip Diameter h_f – dedendum b- face width
d_f - Root Diameter p - Pitch
h- Tooth Depth S- tooth thickness

- Fix the work piece firmly in the universal dividing head.
- Calculate the index movement required for a given number of teeth on workpiece.
- The speed of the spindle may be adjusted by changing positions of the lever on speed box.
- Fix involute cutter in the spindle and rotate the cutter at a required speed.
- The depth of cut is given by raising working table in each pass.
- The required involute profile teeth are cut the given blank by giving feed with the help of cross slide.

OPERATION PLAN:

SL. NO.	OPERATIONS	TOOLS
1	Mounting and aligning of the dividing head and the tailstock on the Horizontal Milling machine	Dividing head, tailstock, dial indicator.
2	Mounting of gear milling cutter arbor and checking for concentric running	Gear cutter module 2.5, 21 …25 teeth, cutter arbor
3	Clamping of workpieces between centers and setting to center of cutter	Square, Slip gauges
4	Adjusting the sector arms of the indexing head (dividing head).	----
5	Setting of revolutions and feed for milling	----
6	Cutter should shave slightly on the workpiece	----
7	Withdrawing of -workpiece out of range of the cutter and lifting the milling table by the height of the tooth (5.42mm)	----
8	Milling of 1st tooth space.	----
9	Withdrawing workpiece from the cut and turning the indexing handle by the tooth pitch, milling of the next tooth space.	----
10	Milling of remaining teeth.	----
	Measuring and checking instruments: Vernier caliper, micrometer, and dial indicator, slip gauges, Vernier gear tooth caliper.	

Calculations:

1. Determination of gear blank and other particulars
   i. Blank diameter, D = m (Z+2)=
   ii. Tooth depth = 2.25×m
   iii. Cutter pitch = 3×m.

2. Indexing:
   Index crack movement = 40/Z

3. Selection of cutter is chosen using the table of the gear cutter number.

4. Selection of cutting speed, feed and depth of cut. The speed and feed of the machine of the machine is determined after considering various machining conditions, which is the tool depth of the gear.

RESULT:

DISCUSSION:

CONCLUSION:

Viva – Voce domain:

1) Machinability.
2) Cutting tool materials
3) Tool life
4) Measuring tooltip temperature.
5) Drilling, Reaming and boring operations.
6) Capstan and Turret lathes.
7) Shaper mechanisms.
8) Up and down milling.
9) Types of abrasives.
10) Grinding wheels.
11) Lapping and Honing operations.
12) Heat generation in tools.
13) Traditional and non-traditional machining.
14) Milling machines.
15) Tool layout.
16) Jigs and Fixtures.
17) Parameters of machining.
18) Dividing head mechanisms.
19) Job holding equipment.
20) Measuring tools.
21) Lubricants.

Questions with Answers:

1. What is a lathe?

Lathe is a machine, which removes the metal from a piece of work to the required shape &size

2. What are the various operations can be performed on a lathe?

- Turning
- Thread cutting
- Grooving
- Facing
- Drilling
- Forming
- Boring
- Knurling
- Recessing
- Chamfering
- Tapping

3. What are principle parts of the lathe?

Red, headstock, tailstock, carriage, cross slide, tool post

4. What are the types of headstock?

Back geared type, all geared type

5. State the various parts mounted on the carriage?

Saddle, compound rest, cross slide, tool post

6. What are the four types of tool post?

  - Single screw
  - Open side
  - Four bolt
  - Four way

7. What is an apron?

The integral part of several gears, levers clutches mounted with the saddle for moving the carriage along with lead screw while thread cutting

8. State any two specification of lathe?

- The height of centers from the bed
- The maximum length of the bed

9. List any four types of lathe?

- Engine lathe
- Bench lathe
- Tool room lathe
- Semi automatic lathe
- Automatic lathe

10. What is a semi-automatic lathe?

The lathe in which all the machining operations are performed automatically and loading and unloading of work piece, coolant on or off is performed manually

11. What is copying lathe?

The tool of the lathe follows a template or master through a stylus or tracer

12. State the various feed mechanisms used for obtaining automatic feed?

- Tumbler gear mechanism
- Quick change gearbox
- Tumbler gear- Quick change gearbox
- Apron mechanism

13. List any four holding devices?

- Chucks
- Centers
- Face plate
- Angle plate

14. What are the different operations performed on the lathe?

Centering, straight turning, rough turning, finish turning, shoulder turning, facing, chamfering, knurling, etc

15. Define the term 'Conicity'?

The ratio of the difference in diameters of tapers its length k= D-dl

D-smaller diameter

D-bigger diameter

l-length of the work piece

16. State any two specifications of capston lathe & turret lathe?

1. Number of spindle speed
2. Number of feeds for the turret or saddle

17. Compare the advantage of capston lathe & turret lathe?

1. Heavier & larger work piece chucking can be done
2. More rigid hence it withstand heavy cuts

18. What is tooling?

Planning of operations sequence & preparation of turret or capston lathe are termed as tool- layout or tooling

19. What are the three stage of a tool-layout?

- Planning & scheduling
- Detailed sketching of various machining operation sequence
- Sketching the plan showing varioustools

20. What are the different drives used in copying lathe?

- Mechanical drives
- Air drives
- Hydraulic drives

21. What are the components that can be turned on a copying lathe?

- Cam shaft
- Crank shaft
- Journal bearings

22. What is shaper?

The machine, which is having a reciprocating type of machine tool with a single point cutting tool, used to produce flat surfaces called as Shapers

23. List any four important parts of a Shaper?

Table, Tool head, Ram, Cross rail

24. How the feed & depth of cut is given to the shaper?

Feed is given by rotating the down feed screws of tool head depth of cut is given by rotating by raising or elevating the table

25. Mention any four-shaper specification?

- Maximum length of stroke
- Type of driving mechanism
- Power of the motor
- Speed &feed available

26. How the planer differs from the shaper?

- In planner-the work reciprocate while the tool is stationary
- In shaper-the tool reciprocate while the work is stationary

27. State the use of planer?

The planer is used for machining heavy & large casting Ex. lathe bed ways, machine guide ways

28. List the various types of planners?

- Double housing
- Open side planer
- Pit planer
- Edge planer
- Divided table planer

29. Name the various parts of a double housing planer?

- Bed
- Table
- Columns
- Cross rail
- Tool head

30. Mention any four specification of planer?

- Maximum length of the table
- Total weight of the planer
- Power of the motor
- Range of speeds & feed available
- Type of drive required

31. What is meant by drilling?

Drilling is the process of producing hole on the work piece by using a rotating cutter called drill

32. What is gang -drilling machine?

When a number of single spindles with essential speed & feed are mounted side by side on one base and have common worktable is known as gang –drilling machine

33. Mention any four specification of drilling machine?

- Maximum size of the drill in mm that the machine can operate
- Table size of maximum dimensions of a job can mount on a table in square meter
- Maximum spindle travel in mm
- Number of spindle speed & range of spindle speeds in rpm.

34. List any four machining operations that can be performed on a drilling machine?

- Drilling
- Counter sinking
- Tapping
- Trepanning

35. What are the different ways to mount the drilling tool?

- Fitting directly in the spindle
- By using a sleeve
- By using a socket
- By means of chucks

36. What is broaching?

Broaching is a process of machining a surface with a special multipoint cutting tool called broach which has successfully higher cutting edges in a fixed path

37. Indicate any two specification of a broaching machine?

- Maximum length of stroke in mm
- Maximum force developed by the slide in tones

38. What are the advantages and limitation of broaching?

Advantages:

- Roughing, semi finishing & finishing cuts are completed in one pass of the broach
- Broaching can be used for either external or internal surface finish

Limitation:

- High initial cost of the broach tool compare to other tools
- Job work or batch work is not advisable due to the high tool cost.

39. What are the different operations that can be performed on a broaching machine?

- Broaching splines
- Broaching a keyway

40. What is boring?

Boring is a process of enlarging &locating previously drilled holes with a single point cutting tool

41. What are the application of boring?

The boring machine is designed for machining large &heavy work piece in mass production work of engine frame, cylinder, machine housing etc

42. Specify the importance of jig boring machine?

- A jig boring machine is a precision boring machine used for boring accurate holes at proper center to center distances.
- The machining accuracy of holes produces by this machine tool lies within a range of 0.0025mm.

43. State the purpose of grinding?

- To remove small amount of metal from work pieces & finish then to close tolerances.
- To obtain the better surface finish.

44. What is the function of cutting fluids?

- It is used to cool the cutting tool & the work piece.
- It improves the surface finish as stated earlier.
- It causes the chips to break up into small parts.
- It protects the finish surface from corrosion.
- It prevents the corrosion of work & machine.

45. What are the properties of cutting fluid?

- High heat absorbing capacities.
- It should have good lubricant properties.
- High flash point.
- It should be odourless.
- It should be non-corrosive to work & tool.

46. What are causes of wear?

The tool is subjected to three important factors such as force, temperature and sliding action due to relative motion between tool and the work piece. So the tool is wear easily.

47. What are the specifications of the milling machine?

- The table length & width.
- Number of spindle speeds & feeds.
- Power of driving motor.

48. Mention the various movements of universal milling machine table?

- Vertical movement-through the knee.
- Cross vise movement-through the saddle.

49. State any two comparisons between plain & universal milling machine?

- In plain milling machine the table is provided with three movements, longitudinal, cross & vertical. In universal milling machine in addition to these three movements, there is a forth movement to the table. The table can be swiveled horizontally & can be fed at angles to the milling machine spindle.
- The universal milling machine is provided with auxiliaries such as dividing head, vertical milling attachment, rotary table etc. Hence it is possible to make spiral, bevel gears, twist drills, reamers etc on universal milling machine.

50. What are the cutter holding devices?

- Arbors
- Adaptors
- Collets

51. List the various type of milling attachment?

- Vertical milling
- Universal milling
- High speed milling
- Rotary
- Slotting
- Rack milling

52. Write any ten nomenclature of plain milling cutter?

Body of cutter, cutting edge, face, fillet, gash, lead, land, outside diameter, root diameter and cutter angles.

53. What are the advantages of milling process?

- It does not require a backlash eliminator.
- Mild surface does not have built up edge.

54. What are the down milling processes?

- Cutter with higher rake angle can be used. This reduces power requirements.
- Cutter wear is less because chip thickness is maximum at the start of cut.

55. List out the various milling operations?

- Plain or slab milling.
- Face milling.
- Angular milling.
- Gang milling.
- End milling.
- Gear cutting.

56. What does term indexing mean?

Indexing is the process of dividing the periphery of a job into equal number of Divisions.

57. What are the three types dividing heads?

- Plain or simple.
- Universal.
- Optical.

58. What is cam milling?

Cam milling is operation of producing cams in the milling machine by the use universal dividing head &a vertical milling attachment.

59. What are the different types of thread milling?

- Thread milling by single form cutter.
- Thread milling by multi form cutter.

60. What are the other forming methods for manufacturing gears?

- Gear cutting by single point form tool.
- Gear cutting by shear speed shaping process.
- Gear broaching.
- Template method.
- Gear milling using a formed end mill.

61. List the gear generating process?

- Gear shaping process.
- Gear planning process.
- Gear hobbing process.

62. Mention the applications of gear shaping process?

- Gear shaping used for generating both internal & external spur gears.
- Helical gears can also be generated using special attachments.

63. What are the limitations of gear hobbing?

- Internal gears cannot be generated.
- Hobbing process cannot be applied very near to shoulders.

64. What are the advantages of gear planning process?

- Any given model can be cut using a single cutter.
- It is a simple flexible &accurate method of generating gears.

65. List the various gear finishing processes?

- Gear shaving.
- Gear burnishing.
- Gear grinding.
- Gear lapping.

66. Mention the advantages &limitations of gear shaving process?

Advantage:

The process can be used for both internal & external gears.

Limitations:

This process is only applicable to unhardened gears.

67. What are the purposes of gear grinding process?

- To improve the surface finish of teeth.
- To increase the accuracy of the teeth.

68. What is gear lapping?

Gear lapping is also employed for hardened gear teeth by an abrasive action.

69. Explain the cutting shaping process?

The required shape of metal is obtained by removing the Unwanted material from the work piece in the form of chips is called cutting shaping. Ex: turning, drilling, milling, boring, etc

70. Mention the various parts of single point cutting tool?

- Shank
- Face
- Flank
- Base
- Nose
- Cutting edge

71. What is tool signature?

The various angles of tools are mentioned in a numerical number in particular order. That order is known as tool signature.

72. What is effect of back rake angle &mention the types?

Back rake angle of tool is increases the strength of cutting tool& cutting action. It can be classified in to two types

- Positive rake angle
- Negative rake angle

73. What is side rake angle & mention its effects?

The angle between the tool face & the line parallel to the base of the tool. it is used to control chip flow

74. What are all the conditions for using positive rake angle?

- To machine the work hardened materials
- To turn the long shaft of small dia

75. When will the negative rake angles be used?

- To machine high strength alloys
- The feed rates are high

76. Define orthogonal & oblique cutting?

- Orthogonal cutting:

The cutting edge of tool is perpendicular to the work piece axis.

- Oblique cutting:

The cutting edge is inclined at an acute angle with normal to the cutting velocity vector is called oblique cutting process

77. What is cutting force?

The sheared material begins to flow along the cutting tool face in the form of small pieces. The compressive force applied to form the chip is called cutting force

78. What is chip thickness ratio?

The ratio of chip thickness before cutting to chip thickness after cutting is called chip thickness ratio.

79. What are the purposes of chip breakers?

The chip breakers are used to break the chips in to small pieces for the removal, safety & to prevent to machine & work

80. Define machinability of metal?

Machinability is defined as the ease with which the material can be satisfactorily machine.

81. What are the factors affecting the machinability?

- Chemical composition of work piece material.
- Microstructure of work piece material

82. What is machinability index?

It is the comparison of machinability different material to standard material. US Material standards for 100% machinability are sae1112 hot rolled steel. Machinability index I=Cutting speed of metal investigated for 20 minutes tool life cutting speed of standard steel for 20 minutes tool life

83. How tool life is defined?

Tool life is defined as time elapsed between two consecutive tool re-sharpening. During this period tools serves effectively and efficiently.

84. What are the factors affecting tool life?

- Cutting speed
- Feed & depth of cut
- Tool geometry
- Tool material

85. Express the tailor's tool life equation?

Tailors tool life equation:

$VT^n = C$

V=Cutting speed in m/min

T=Tool life in minutes

C=Constant

n=Index depends upon tool & work.