C. V. RAMAN POLYTECHNIC

Bidyanagar, Mahura, Janla, Bhubaneswar-752054

DEPARTMENT OF MECHANICAL ENGINEERING

LAB MANUAL

WORKSHOP PRACTICE-III (Pr-3)

(Semester- 4th semester Mechanical Engineering)

Prepared by:

- Soumya Dash, Assistant Professor, Mechanical Engineering Department, CVRP, Odisha (Workshop in-charge)
- Bibhu Prasad Padhi, Workshop Instructor, Mechanical Engineering Department, CVRP, Odisha

Outcome Based Education

For the implementation of an outcome based education the first requirement is to develop an outcome based curriculum and incorporate an outcome based assessment in the education system. By going through outcome based assessments, evaluators will be able to evaluate whether the students have achieved the outlined standard, specific and measurable outcomes. With the proper incorporation of outcome based education there will be a definite commitment to achieve a minimum standard for all learners without giving up at any level. At the end of the programme running with the aid of outcome based education, a student will be able to arrive at the following outcomes (as per NBA guidelines):

1. **Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.

2. **Problem analysis:** Identify and analyse well-defined engineering problems using codified standard methods.

3. **Design/ development of solutions:** Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

4. **Engineering Tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

5. **Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.

6. **Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

7. **Life-long learning:** Ability to analyse individual needs and engage in updating in the context of technological changes.

Department of Mechanical Engineering

C. V. Raman Polytechnic, Bhubaneswar

Vision, Mission, (PEOs) and PSOs Suggestion Format

Department Vision:

Mechanical department is committed to provide value based and quality education through highly qualified professionals with the cutting-edge technologies to meet industrial and social challenges.

Mission of the Department

MI: To equip Mechanical Engineering students for competitive challenges by imparting knowledge on modern technology and industry-oriented program.
M2: To encourage and empower students to enhance their skills by providing training through various Centres of Excellence.
M3: To foster a spirit of entrepreneurship through industrial visits, internships and seminars conducted by academic experts.
M4: To motivate students to pursue higher studies for betterment of society.

Program Educational Objectives (PEO):

PEO1: Understand and analyze the industrial needs through knowledge gained in Mechanical Engineering fundamentals.

PEO2: Pursue entrepreneurial opportunities by acquiring special knowledge in training programs.

PEO3: Creating technical solutions that successfully address environmental and societal issues.

PEO4: Understanding technical concepts, engage in lifelong learning, exhibit leadership qualities with ethics in their professional career.

Program Specific Outcomes (PSOs)

PSO-1	Discipline knowledge	Demonstration and understanding of tools with advanced software for design specification and operation of Mechanical Engineering systems, components and processes.
PSO-2	Professional Skills	Apply contextual knowledge to analyze social, environmental, health, safety, legal, and cultural issues with professional ethics as part of the lifelong learning process. To be equipped to lead a team or operate successfully alone as an individual managing tasks in disciplinary areas.

Workshop-III (4th semester) Code-Pr-3 **Full marks: 100**

Pr.3 Workshop-III		Levels
CO1	Acquire knowledge about machining practices and prepare job using lathe.	3
CO2	The student prepare job on taper turning and chamfering.	4
CO3	The student acquire knowledge about gear lathe and CNC lathe.	4
CO4	prepare V-block on CI or MS block using shaper machine.	4
CO5	prepare spur gear on CI or MS using milling machine.	3

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	Average PO
CO1	3.00	2.00	-	-	1.00	-	-	2.00
CO2	3.00	2.00	1.00	1.00	-	1.00	-	1.60
CO3	3.00	2.00	-	1.00	-	-	-	2.00
CO4	3.00	2.00	-	1.00	-	-	-	2.00
CO5	3.00	2.00	-	1.00	-	-	-	2.00
Average CO of individual PO	3.00	2.00	1.00	1.00	1.00	1.00	-	**1.92** / **1.50**

Sessional Rubrics (50)

	Attendance (5)		Record (10)		Experiment/Job (25)				Viva (10)		
	The student attends all the classes.		Report is well written. The Contents are equipped with neat sketch, error free calculations and free from grammatical errors.		Identifying equipment, instruments and material and setting up of machine tool. Exhibits proper knowledge of the lab procedure. Runs the machine independently. Takes all the readings from machine/apparatus during experiment. The obtained result is calculated correctly to find the result. Analyses if any error occurred with the reason. The experiment is completed within the time limit with taking proper safety precautions. Discipline and ethics is maintained while performing the experiment.				A set of questions is asked relating to the experiment and subject.		
Rating/Performance criteria	25	22	20	15	10	8	5	4	3	2	1
Attendance (5)							Answers to 100% of questions asked	Answers to 90% of questions asked	Answers to 70% of questions asked	Answers to 50% of questions asked	
Record (10)					Performs 100% of the criteria	Performs 90% of the criteria	Performs 80% of the criteria	Performs 70% of the criteria	Performs 60% of the criteria	Performs 50% of the criteria	Performs 30% of the criteria
Experiment/Job (25)	Performs 100% of the criteria	Performs 90% of the criteria	Performs 80% of the criteria	Performs 70% of the criteria	Performs 60% of the criteria	Performs 50% of the criteria	Performs 40% of the criteria	Performs 30% of the criteria	Performs 20% of the criteria		
Viva (10)					Performs 100% of the criteria	Performs 90% of the criteria	Performs 80% of the criteria	Performs 70% of the criteria	Performs 60% of the criteria	Performs 50% of the criteria	Performs 30% of the criteria

Sessional (50)

Sl. No.	Name of student	Registration number	Attendance (5)	Record (10)	Job (25)	Viva (10)	Total (50)

Practical Rubrics (50)

	Report (10)					Experiment/Job (25)			Viva (15)		
	Report is well written. The Contents are equipped with neat sketch, error free calculations and free from grammatical errors.					Identifying equipment, instruments and material and setting up of machine tool. Exhibits proper knowledge of the lab procedure. Runs the machine independently. Takes all the readings from machine/apparatus during experiment. The obtained result is calculated correctly to find the result. Analyses if any error occurred with the reason. The experiment is completed within the time limit with taking proper safety precautions. Discipline and ethics is maintained while performing the experiment.			A set of questions is asked relating to the experiment and subject.		
Rating/Performance criteria	25	24	21	18	15	12	10	8	6	4	2
Report (10)					Answers to 100% of questions asked	Answers to 75% of questions asked	Answers to 60% of questions asked	Answers to 50% of questions asked	Answers to 40% of questions asked	Answers to 30% of questions asked	
Experiment/Job (25)	Performs 100% of the criteria	Performs 90% of the criteria	Performs 80% of the criteria	Performs 70% of the criteria	Performs 60% of the criteria	Performs 50% of the criteria	Performs 40% of the criteria	Performs 30% of the criteria			
Viva (15)							Answers to 100% of questions asked	Answers to 90% of questions asked	Answers to 70% of questions asked	Answers to 50% of questions asked	Answers to 30% of questions asked

Practical (50)

Sl. No.	Name of student	Registration number	Report (10)	Job (25)	Viva (15)	Total (50)

<u>**Syllabus**</u>

PR-3 WORKSHOP PRACTICE-III

Name of the Course: Diploma in **Mech/ & Other Mechanical Allied Branches**			
Course code:		Semester	4th
Total Period:	90	Examination	4 hrs
Lab. periods:	6 P/W	Teamwork	50
Maximum marks:	100	End Semester Examination:	50

Course Objectives:

Students will develop an ability towards

- Preparing components and jobs using foundry, welding and machining
- Realizing process parameters involved and their effects

1 Machining Practices

1.1 Job in evolving drilling, boring

1.2 Internal/External threading on Turning jobs

1.3 Job in evolving use of Capstan and turret lathe (Taper Turning & Chamfering)

1.4 All gear lathe, CNC Lathe Trainer Practice

Job involving all turning process on MS Rod & aluminum rod for jobs using CNC Lathe trainer.

2 Metal Machining

2.1 Shaper

Preparation of V Block on CI or MS Blocks

2.2 Milling Machine

Preparation of Spur gear on CI or MS round

DO’S

- Students must always wear uniform and shoes before entering the lab.
- Proper code of conduct and ethics must be followed in the lab.
- Windows and doors to be kept open for proper ventilation and air circulation.
- Note down the specifications/drawings before working on the preparation of models.
- Receive the tools and materials required for preparation of models with signing in register.
- Properly fix hacksaw blade in frame with help of instructor.
- Use of safety goggles/ face shield during welding.
- Do the models under the supervision/guidance of a lecturer/lab instructor only.
- Keep the sufficient distance from other students while preparing models.
- In case of fire use fire extinguisher/throw the sand provided in the lab.
- In case of any physical injuries or emergencies use first aid box provided.
- Any unsafe conditions prevailing in the lab can be brought to the notice of the lab Be away from power tools while demonstrating.

DONT’s

- Do not touch electrical circuits of welding machine.
- Be cautious while fixing hacksaw blade in frame, that may cause injuries to hand.
- Don’t touch /operate power tools without aid from instructors.
- Don’t gather while preparing models, that may hurt other with tools.
- Don’t unlock snip/sheet metal cutter lock, without use.

CONTENTS PAGE

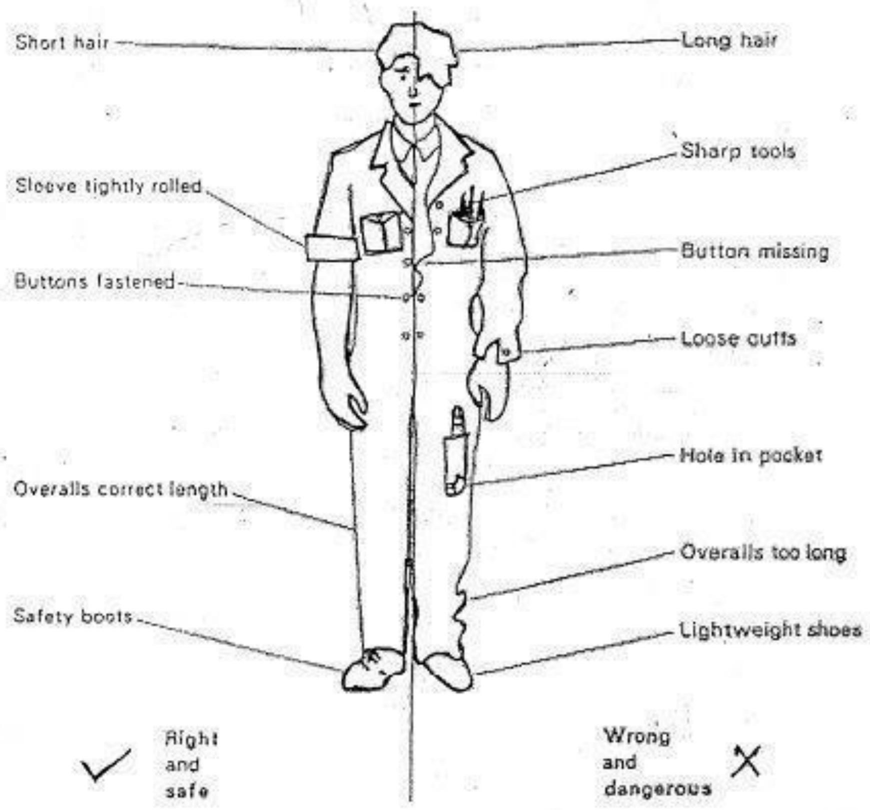
SAFETY PRACTICE

INTRODUCTION:

It is an action which organizes and controls all our acts in such a manner that we don't get involved, expose ourselves or others in accident. So, a technical person should have knowledge about safety.

Clothing and footwear

Suitable and unsuitable working clothing for use in an engineering machine shop is shown in Fig. Overalls or protective coats should be neatly buttoned and sleeves should be tightly rolled. Safety shoes and boots should be worn (*not* trainers!). Overalls and protective



Correct and incorrect clothing and footwear

Personal Protective Equipment:

Goggles, face-shields, earplugs, helmets, respirators, gloves and aprons are types of personal protective equipment that reduce worker's exposure to hazards.

MACHINE SHOP

INTRODUCTION TO METAL CUTTING

BASIC METAL CUTTING THEORY

The usual conception of cutting suggests clearing the substance apart with a thin knife or wedge. When metal is cut the action is rather different and although the tool will always be wedge shaped in the cutting area and the cutting edge should always be sharp the wedge angle will be far too great for it to be considered knife shaped. Consequently, a shearing action takes place when the work moves

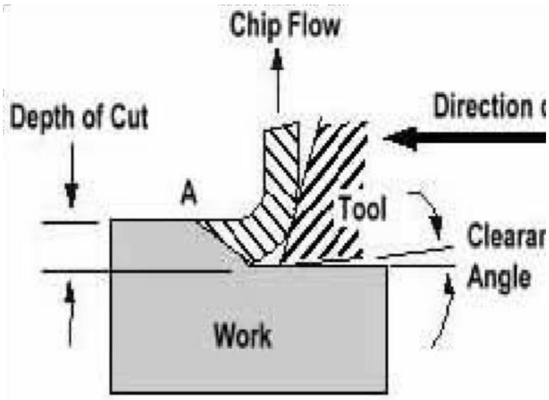


Figure 1: Basic Metal Cutting Theory against the tool.

Figure above shows a tool being moved against a fixed work piece. When the cut is in progress the chip presses heavily on the top face of the tool and continuous shearing takes place across the shear plane AB. Although the Figure shows a tool working in the horizontal plane with the work piece stationary, the same action takes place with the work piece revolving and the tool stationary.

MACHINE TOOL:

A machine tool may be defined as a power driven machine which accomplishes the cutting or machining operations on it. The fundamental machine tools that are used for most of the machining processes are lathe, drilling, tapping, shaping, milling and grinding machines.

CUTTING TOOLS

There are basically two types of cutting tools:

- Single point (e.g. turning tools).
- Multiple point (e.g. milling tools).

In general Single Point Cutting Tool is used which is made of HSS (high speed steel). The main alloying elements in H S S are l8-4-l (i.e.; l8% Tungsten, 4% chromium and l% vanadium, it has 0.75% carbon and l2% cobalt). Figure 2 shows the terminology of **single point cutting tool.**

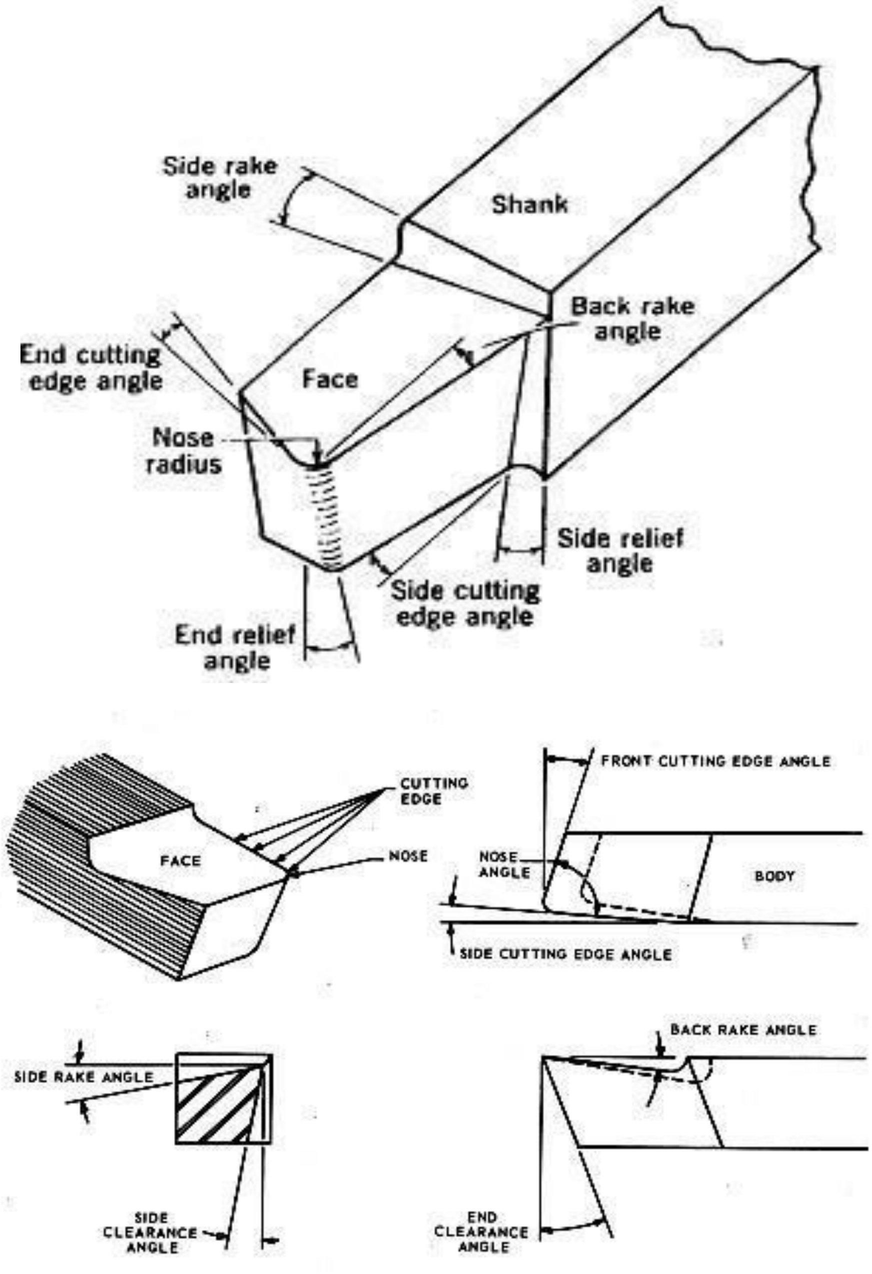


Figure 2 Cutting Tool Terminology

The figure 2 shows a typical cutting tool and the terminology used to describe it.

Shank: The shank is the portion of the tool bit which is not ground to form cutting edges and is rectangular in cross-section**.**

Face: The face of the cutting tool is that surface against which the chip slides upward**.**

Flank: The lank of a cutting tool is that surface which face the work piece.
Heel: The heel of a single point tool is the lowest portion of the side cutting edges.

Nose: The nose of a tool is the conjunction of the side-and end-cutting edges. A nose radius increases the tool life and improves surface finish.

Base: The base of a tool is the underside of the shank.

Rake: The rake is the slope of the top away from the cutting edge. The larger the rake angle, the larger the shear angle and subsequently the cutting force and power reduce.

End cutting edge angle: It is the angle between face of the tool and a plane perpendicular to the side of the shank. It varies from 5 to l5 degrees.

The actual geometry varies with the type of work to be done. The standard cutting tool shapes are shown in figure 3.

- Facing tools are ground to provide clearance with a center.
- Roughing tools have a small side relief angle to leave more material to support the cutting edge during deep cuts.
- Finishing tools have a more rounded nose to provide a finer finish. Round nose tools are for lighter turning. They have no back or side rake to permit cutting in either direction.
- Left hand cutting tools are designed to cut best when traveling from left to right.
- Aluminum is cut best by specially shaped cutting tools (not shown) that are used with the cutting edge slightly above center to reduce chatter.

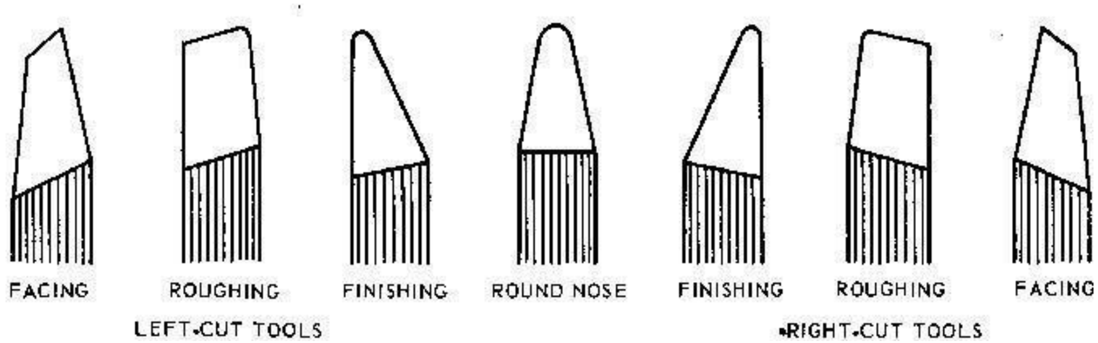


Figure 3 Standard Cutting Tools

TOOL ANGLES

There are three important angles in the construction of a cutting tool rake angle, clearance angle and plan approach angle.

Rake Angle

Rake angle is the angle between the top face of the tool and the normal to the work surface at the cutting edge. In general, the larger the rake angle, the smaller the cutting force on the tool. A large rake angle will improve cutting action, but would lead to early tool failure, since the tool wedge angle is relatively weak. A compromise must therefore be made between adequate strength and good cutting action.

Clearance Angle

Clearance angle is the angle between the flank or front face of the tool and a tangent to the work surface originating at the cutting edge. All cutting tools must have clearance to allow cutting to take place. Clearance should be kept to a minimum, as excessive clearance angle will not improve cutting efficiency and will merely weaken the tool. Typical value for front clearance angle is 6° in external turning.

TOOL MATERIALS IN COMMON USE

The different materials used for cutting tools are:

1. High carbon steel	5. Cemented carbides
2. Alloy steels	6. Ceramics
3. High speed steel	7. Diamonds
4. Stellites	8. Abrasives

High Carbon Steel: Contains 1 - 1.4% carbon with some addition of chromium and tungsten to improve wear resistance. The steel begins to lose its hardness at about 250° C, and is not favored for modern machining operations where high speeds and heavy cuts are usually employed.

High Speed Steel (H.S.S.): Steel, which has a hot hardness value of about 600° C, possesses good strength and shock resistant properties. It is commonly used for single point lathe cutting tools and multi point cutting tools such as drills, reamers and milling cutters.

Cemented Carbides: An extremely hard material made from tungsten powder. Carbide tools are usually used in the form of brazed or clamped tips. High cutting speeds may be used and materials difficult to cut with HSS may be readily machined using carbide tipped tool.

LATHE

INTRODUCTION

Lathe is one of the most versatile and widely used machine tools all over the world. It is commonly known as the mother of all other machine tool. The main function of a lathe is to remove metal from a job to give it the required shape and size. The job is securely and rigidly held in the chuck or in between centers on the lathe machine and then turn it against a single point cutting tool which will remove metal from the job in the form of chips.

TYPES OF LATHE

Lathes are manufactured in a variety of types and sizes, from very small bench lathes used for precision work to huge lathes used for turning large steel shafts. But the principle of operation and function of all types of lathes are same. The different types of lathes are:

- Speed lathe
- Centre or Engine lathe
- Bench lathe
- Tool Room Lathe
- Capstan and Turret lathe
- Special purpose lathe
- Automatic lathe

Speed Lathe

Speed lathe is simplest of all types of lathes in construction and operation. It consists of a Bed, Headstock, Tailstock and Tool post mounted on an adjustable slide. There is no feed box, leadscrew or conventional type of carriage. The tool is mounted on the adjustable slide and is fed into the work by hand control. The speed lathe finds applications where cutting force is least such as in wood working, spinning, centering, polishing, winding etc.

Centre or Engine Lathe

The term “engine” is associated with this lathe due to the fact that in the very early days of its development it was driven by steam engine. This lathe is the important member of the lathe family and is the most widely used. Similar to the speed lathe, the engine lathe has all the basic parts, e.g., bed, headstock, and tailstock. An engine lathe is shown in Fig. 4. Unlike the speed lathe, the engine lathe can feed the cutting tool both in cross and longitudinal direction with reference to the lathe axis with the help of a carriage, feed rod and lead screw. The power may be transmitted by means of belt, electric motor or through gears.

Bench Lathe

This is a small lathe usually mounted on a bench. It has practically all the parts of an engine lathe or speed lathe and it performs almost all the operations. This is used for small and precision work.

Tool Room Lathe

This lathe has features similar to an engine lathe but it is much more accurately built. It has a wide range of spindle speeds ranging from a very low to a quite high speed up to 2500 rpm. This lathe is mainly used for precision work on tools, dies, gauges and in machining work where accuracy is needed.

Capstan and Turret Lathe

The distinguishing feature of this type of lathe is that the tailstock of an engine lathe is replaced by a hexagonal turret, on the face of which multiple tools may be fitted and fed into the work in proper sequence. Due to this arrangement, several different types of operations can be done on a job without re-setting of work or tools, and a number of identical parts can be produced in the minimum time.

Special Purpose Lathes

These lathes are constructed for special purposes and for jobs, which cannot be accommodated or conveniently machined on a standard lathe. The wheel lathe is made for finishing the journals and turning the tread on railroad car and locomotive wheels. The gap bed lathe, in which a section of the bed adjacent to the headstock is removable, is used to swing extra-large- diameter pieces.

Automatic Lathes

These lathes are so designed that all the working and job handling movements of the complete manufacturing process for a job are done automatically. These are high speed, heavy duty, mass production lathes with complete automatic control.

PRINCIPLE FUNCTIONS OF LATHE PARTS

A simple lathe comprises of a bed made of grey cast iron on which headstock, tailstock, carriage and other components of lathe are mounted. Figure l shows the different parts of engine lathe or central lathe.

The major parts of lathe machine are given as under:

1. Bed
2. Head stock
3. Tailstock
4. Carriage
5. Feed mechanism

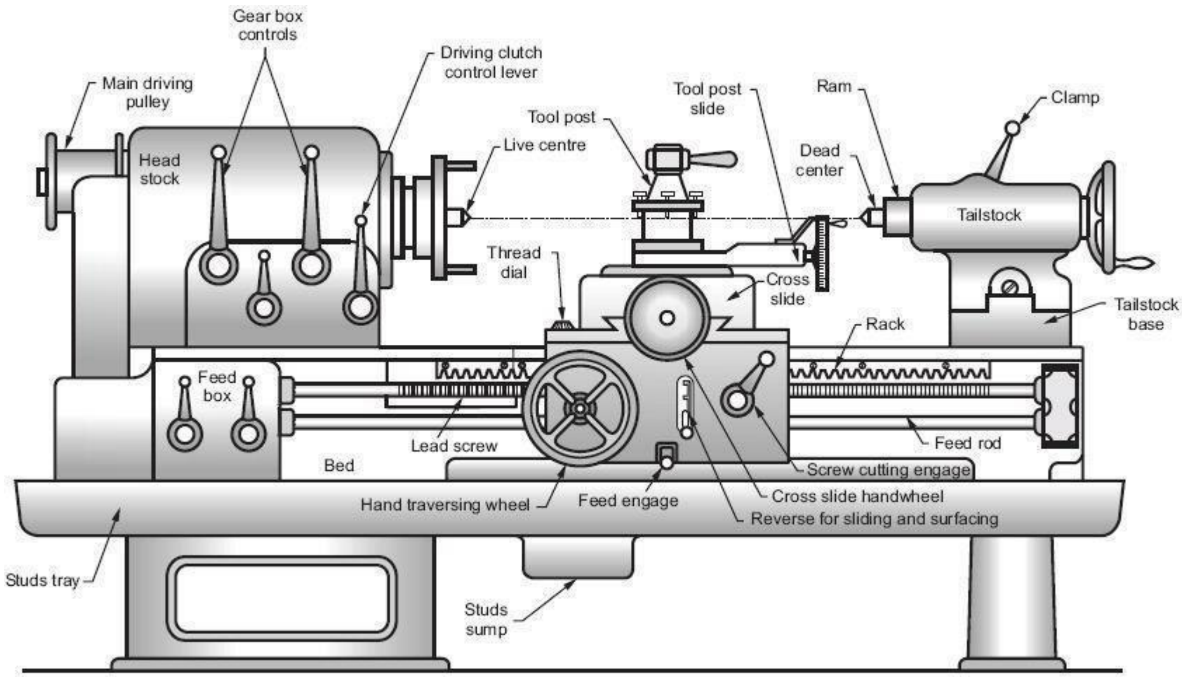


Figure 4: Different parts of engine lathe or central lathe

Bed

The bed of a lathe machine is the base on which all other parts of lathe are mounted. It is massive and rigid single piece casting made to support other active parts of lathe. On left end of the bed, headstock of lathe machine is located while on right side tailstock is located. The carriage of the machine rests over the bed and slides on it. On the top of the bed there are two sets of guideways - inner ways and outer ways. The inner ways provide sliding surfaces for the tailstock and the outer ways for the carriage. The guideways of the lathe bed may be flat and inverted V shape. Generally, cast iron alloyed with nickel and chromium material is used for manufacturing of the lathe bed.

Head Stock

The main function of headstock is to transmit power to the different parts of a lathe. It comprises of the headstock casting to accommodate all the parts within it including gear train arrangement. The main spindle is adjusted in it, which possesses live center to which the work can be attached. It supports the work and revolves with the work, fitted into the main spindle of the headstock. The cone pulley is also attached with this arrangement, which is used to get various spindle speed through electric motor. The back gear arrangement is used for obtaining a wide range of slower speeds. Some gears called change wheels are used to produce different velocity ratio required for thread cutting.

Tail Stock

Figure 5 shows the tail stock of central lathe, which is commonly used for the objective of primarily giving an outer bearing and support the circular job being turned on centers. Tail stock can be easily set or adjusted for alignment or non-alignment with respect to the spindle center and carries a center called dead center for supporting one end of the work. Both live and dead centers have 60° conical points to fit center holes in the circular job, the other end tapering to allow for good fitting into the spindles. The dead center can be mounted in ball bearing so that it rotates with the job avoiding friction of the job with dead center as it important to hold heavy jobs.

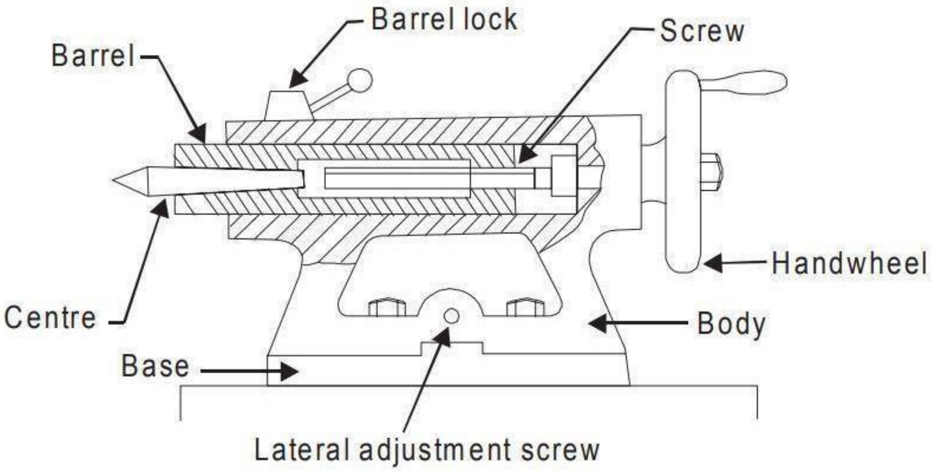


Figure 5: Tail stock of central lathe

Carriage

Carriage is mounted on the outer guide ways of lathe bed and it can move in a direction parallel to the spindle axis. It comprises of important parts such as apron, cross-slide, saddle, compound rest, and tool post. The lower part of the carriage is termed the apron in which there are gears to constitute apron mechanism for adjusting the direction of the feed using clutch mechanism and the split half nut for automatic feed. The cross-slide is basically mounted on the carriage, which generally travels at right angles to the spindle axis. On the cross-slide, a saddle is mounted in which the compound rest is adjusted which can rotate and fix to any desired angle. The compound rest slide is actuated by a screw, which rotates in a nut fixed to the saddle. The tool post is an important part of carriage, which fits in a tee-slot in the compound rest and holds the tool holder in place by the tool post screw.

Feed Mechanism

Feed mechanism is the combination of different units through which motion of headstock spindle is transmitted to the carriage of lathe machine. Following units play role in feed mechanism of a lathe machine.

1. End of bed gearing
2. Feed gear box
3. Lead screw and feed rod
4. Apron mechanism

The gearing at the end of bed transmits the rotary motion of headstock spindle to the feed gear box. Through the feed gear box the motion is further transmitted either to the feed shaft or lead screw, depending on whether the lathe machine is being used for plain turning or screw cutting.

The feed gear box contains a number of different sizes of gears. The feed gear box provides a means to alter the rate of feed, and the ration between revolutions of the headstock spindle and the movement of carriage for thread cutting by changing the speed of rotation of the feed rod or lead screw.

The apron is fitted to the saddle. It contains gears and clutches to transmit motion from the feed rod to the carriage, and the half nut which engages with the lead screw during cutting threads.

WORK HOLDING DEVICES:

1. Work is held between the centers
    a. Live center - head stock spindle and Dead center - tail stock spindle.
    b. Driven by catch plate and carrier

2. Work piece held in chuck
    a. four jaw independent chuck
    b. three jaw universal self-centering chuck
    c. magnetic chuck
    d. collet chuck
    e. Drill chuck

3. Work held in face plate.

4. Work held in mandrel
    a) Plain Mandrel
    b) Step Mandrel
    c) Collar Mandrel
    d) Screwed Mandrel
    e) Cope Mandrel
    f) Gang Mandrel
    g) Expansion Mandrel

5. Work held in turning fixture
    a) Steady Rest
    b) Follower Rest

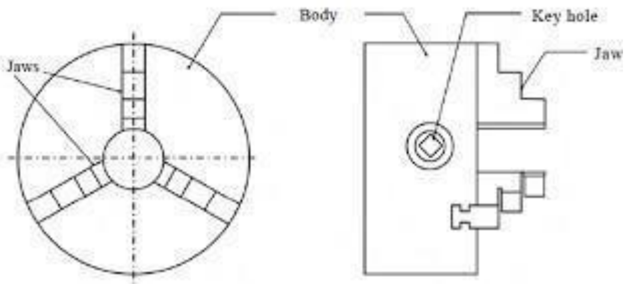


Figure 6: Three Jaw Universal Self Centering Chuck

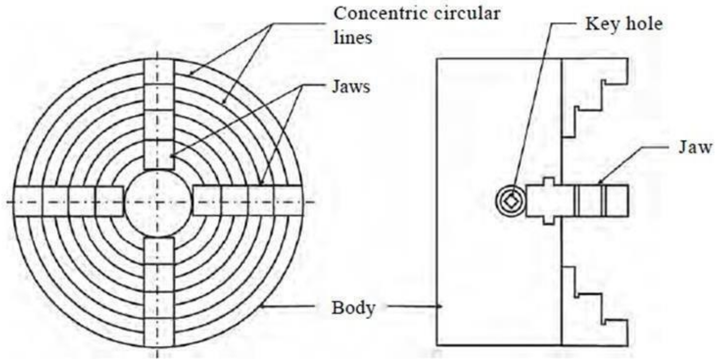
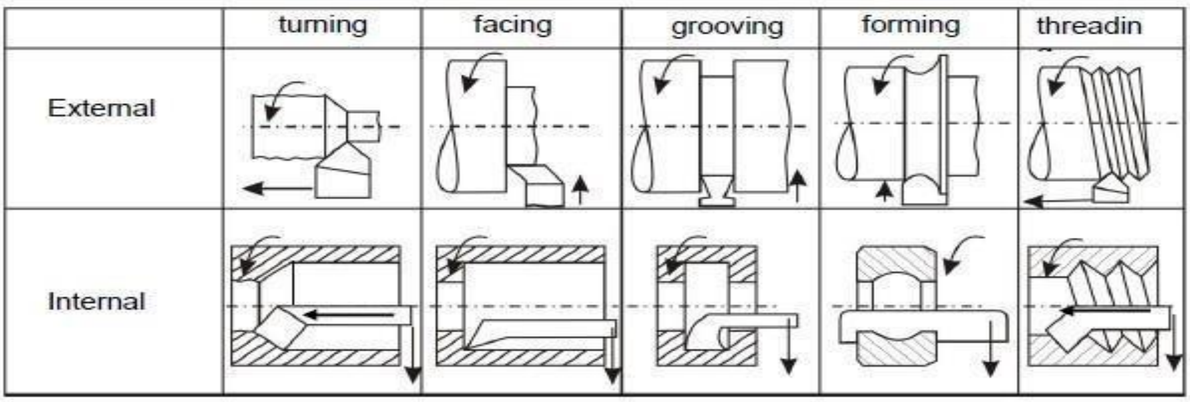


Figure 7: Four Jaw Independent Chuck

LATHE OPERATIONS:

1. Straight Turning or Plain Turning
2. Facing
3. Shoulder turning
4. Chamfering
5. Knurling
6. Forming
7. Parting off (grooving)
8. Spinning
9. Eccentric turning
10. Drilling
11. Boring
12. Centering
13. Thread cutting
14. Taper turning



Some common machining operations done in center lathes.

For performing the various machining operations in a lathe, the job is being supported and driven by anyone of the following methods.

1. Job is held and driven by chuck with the other end supported on the tail stock center.
2. Job is held between centers and driven by carriers and catch plates.
3. Job is held on a mandrel, which is supported between centers and driven by carriers and catch plates.
4. Job is held and driven by a chuck or a faceplate or an angle plate

The above methods for holding the job can be classified under two headings namely job held between centers and job held by a chuck or any other fixture. The various important lathe operations are depicted through figure 6.

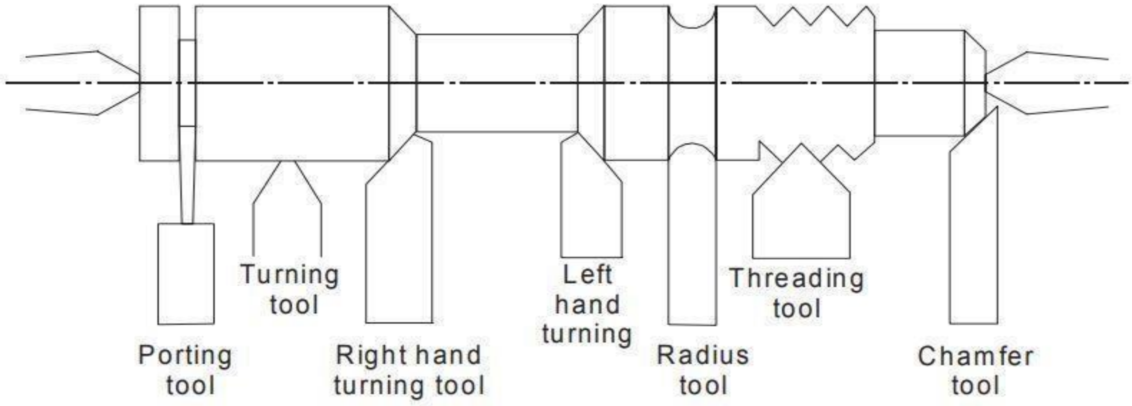


Figure 8: Various lathe operations

Taper Turning

A taper is defined as a uniform increase or decrease in diameter of a piece of work measured along its length. In a lathe machine, taper turning means to produce a conical surface by gradual reduction in diameter from a cylindrical job. The taper angle (α) for conical surface is given by;

$$\text{Tan}\ \alpha = \frac{(D - d)}{2l}$$

Where,

D is diameter of the large end, d is the dia. of the small end of the cylindrical job, l is the length of the taper of cylindrical job.

A taper is generally turned in a lathe by feeding the tool at an angle to the axis of rotation of the work piece. The angle formed by the path of the tool with the axis of the work piece should correspond to the half taper angle. A taper can be turned by anyone of the following methods:

1. By swiveling the compound rest,
2. By setting over the tailstock center,
3. By a broad nose form tool,
4. By a taper turning attachment,
5. By combining longitudinal and cross feed in a special lathe and
6. By using numerical control lathe

Taper Turning by Swiveling the Compound Rest

This method uses the principle of turning taper by rotating the work piece on the lathe axis and feeding the tool at an angle to the axis of rotation of the work piece. The tool is mounted on the compound rest which is attached to a circular base, graduated in degrees.

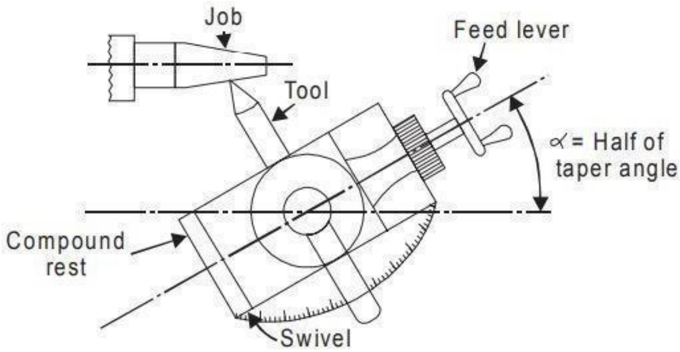


Figure 9: Taper turning by swiveling compound rest

The compound rest can easily be swiveled or rotated and clamped at any desired angle as shown in Fig. 7. Once the compound rest is set at the desired half taper angle, rotation of the compound slide screw will cause the tool to be fed at that angle and generate a corresponding taper. This method is limited to turn a short but steep taper because of the limited movement of the cross-slide. The positioning or setting of the compound rest is accomplished by swiveling the rest at the half taper angle, if this is already known. If the diameter of the small and large end and length of taper are known, the half taper angle can be calculated

Thread Cutting

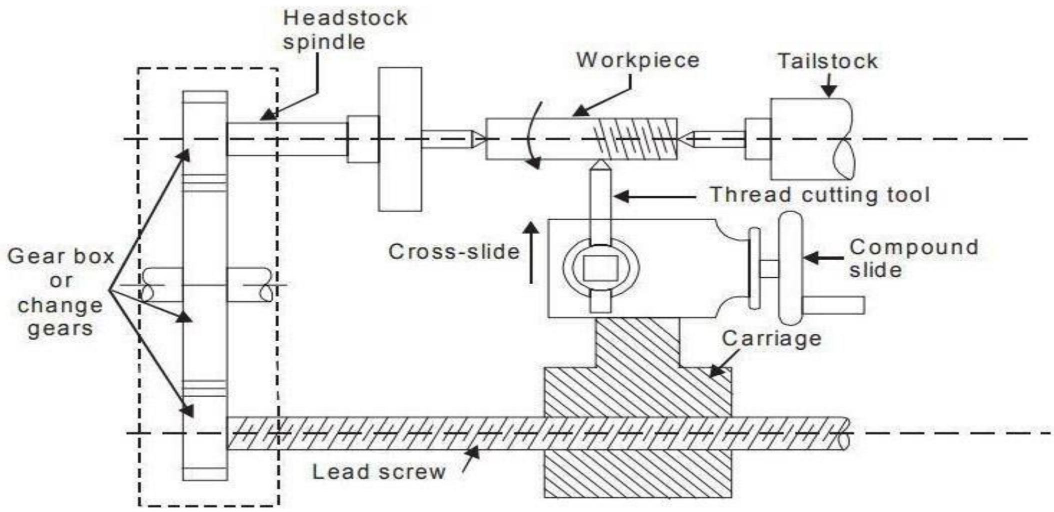


Figure 10: Thread Cutting

Figure 8 shows the setup of thread cutting on a lathe. Thread of any pitch, shape and size can be cut on a lathe using single point cutting tool. Thread cutting is operation of producing a helical groove on spindle shape such as V, square or power threads on a cylindrical surface. The job is held in between centers or in a chuck and the cutting tool is held on tool post. The cutting tool must travel a distance equal to the pitch (in mm) as the work piece completes a revolution. The definite relative rotary and linear motion between job and cutting tool is achieved by locking or engaging a carriage motion with lead screw and nut mechanism and fixing a gear ratio between head stock spindle and lead screw. To make or cut threads, the cutting tool is brought to the start of job and a small depth of cut is given to cutting tool using cross slide. The equation for thread cutting calculation is given by;

$$\frac{\text{No. of teeth on the driver gear}}{\text{No. of teeth on the driven gear}} = \frac{\text{Pitch of the screw to be cut}}{\text{Pitch of the lead screw}}$$

DRILLING ON A LATHE

For producing holes in jobs on lathe, the job is held in a chuck or on a face plate. The drill is held in the position of tailstock and which is brought nearer the job by moving the tailstock along the guide ways, the thus drill is fed against the rotating job as shown in Fig. 2l. l5.

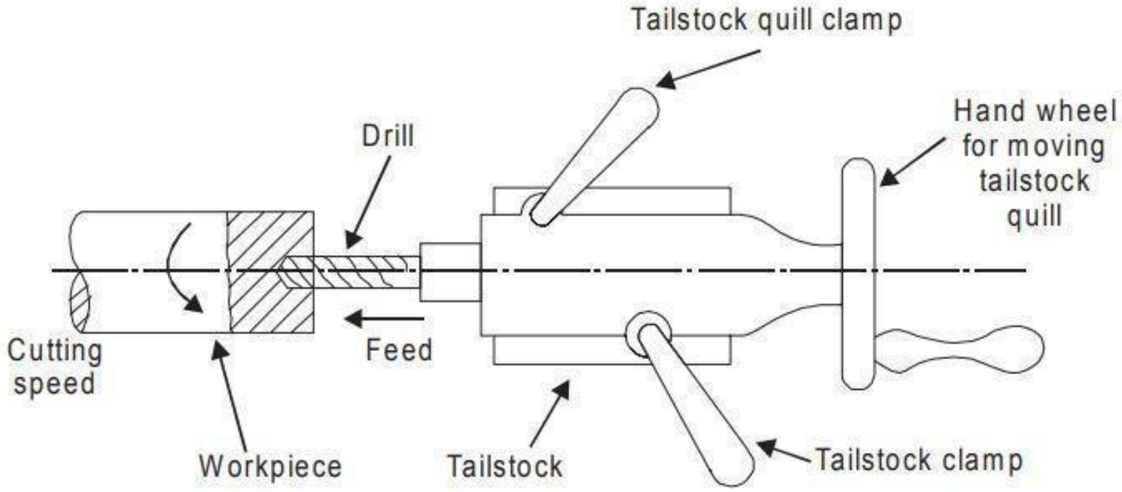


Figure 11: Drilling on lathe

CUTTING PARAMETERS

Cutting speed

Cutting speed for lathe work may be defined as the rate in meters per minute at which the surface of the job moves past the cutting tool. Machining at a correct cutting speed is highly important for good tool life and efficient cutting. Too slow cutting speeds reduce productivity and increase manufacturing costs whereas too high cutting speeds result in overheating of the tool and premature failure of the cutting edge of the tool. The following factors affect the cutting speed:

i. Kind of material being cut
ii. Cutting tool material
iii. Shape of cutting tool
iv. Rigidity of machine tool and the job piece and
v. Type of cutting fluid being used.

Cutting speed is the speed at which metal is removed by the tool from the work.

$$\text{cutting speed} = \frac{\pi DN}{1000} \text{ meters/min}$$

Where, D is diameter of job in mm

N is speed in RPM

Feed

It is the distance the tool advances for every revolution of the workpiece. It is expressed in mm/rev.

Depth of Cut

It is perpendicular distance measured from the machined surface to the uncut surface of work. It is expressed in mm

$$\text{Depth of cut} = \frac{D_1 - D_2}{2} \text{ mm}$$

Where,

D_1 is diameter of work before machining, D_2 is diameter of work after machining.

Machining Time

$$\text{Machining time taken for one pass of cutting} = \frac{\text{Length of the tool travel in mm}}{\text{Feed in mm/ min X RPM}}$$

DIFFERENT MECHANISMS:

2.7.l Apron Mechanism:

when a spindle rotates, the LEAD screw and the feed rod will rotate through the tumbler gear. This, Apron Mechanism provided in the carriage is connected to the LEAD Screw through the half nut engaged in the carriage, from which auto feed of the longitudinal and the cross feed mechanism is obtained.

Back Gear Mechanism:

Back gear arrangement is used for reducing the spindle speed, which is necessary for thread cutting and knurling.

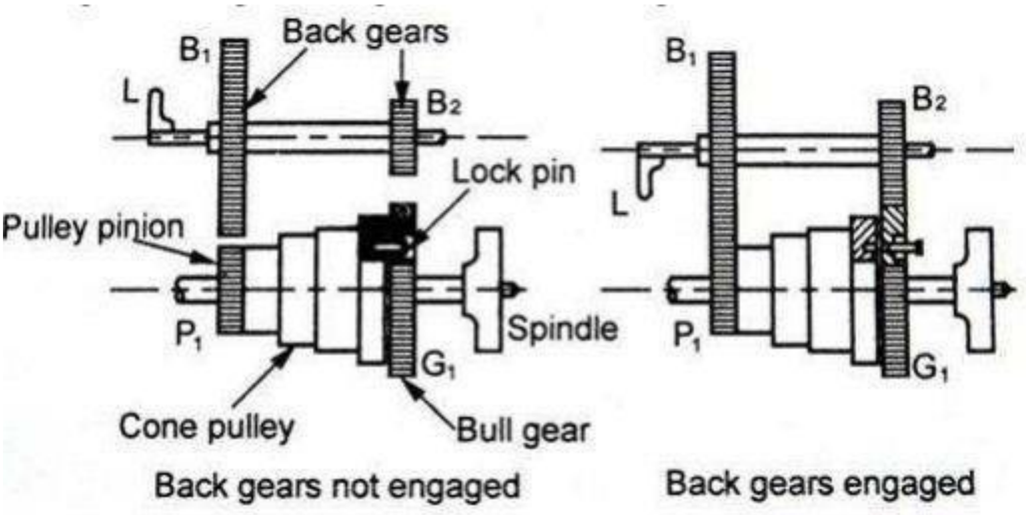


Figure 12: Back Gear Mechanism

There is one stepped cone pulley in the lathe spindle. This pulley can freely rotate on the spindle. A pinion gear P1 is connected to small end of the cone pulley. P1 will rotate when cone pulley rotates. Bull gear G1 is keyed to lathe spindle such that the spindle will rotate when Gear G1 rotates. Speed changes can be obtained by changing the flat belt on the steps. A bull gear G1 may be locked or unlocked with this cone pulley by a lock pin. There are two back gears B1 and B2 on a back shaft. It is operated by means of hand lever L; back gears B1 and B2 can be engaged or disengaged with G1 and P1. For getting direct speed, back gear is not engaged. The step cone pulley is locked with the main spindle by using the lock pin. The flat belt is changed for different steps. Thus three or four ranges of speed can be obtained directly. For getting slow or indirect speeds, back gear is engaged by lever L and lock pin is disengaged. Now, power will flow from P1 to B1. B1 to B2 (same shaft), B2 to G1 to spindle. As gear B1 is larger than P1, the speed will further be reduced at B1. B1 and B2 will have the same speeds. The speed will further be reduced at G1 because gear G1 is larger than B2. So, the speed of spindle is reduced by engaging the back gear.

Tumbler Gear Mechanism

Tumbler gear mechanism is used to change the direction of lead screw and feed rod. By changing tumbler gear, the carriage can be moved automatically from tailstock end to headstock end or moved from head stock end to tailstock end. Usually during thread cutting and automatic feed, tumbler gear is used.

<u>**Experiment no.-01**</u>

<u>Aim of the experiment</u>:

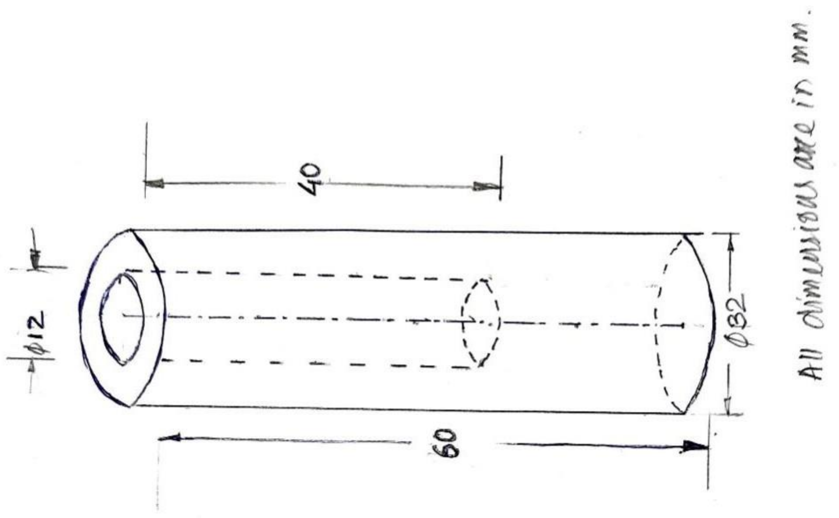
To make a drill on a round bar using lathe.

<u>Apparatus required</u>: -

Sl no	Name of the apparatus	Specification	Quantity
1	Drill bit	Ø16 mm	1
2	Drill chuck	1-12 mm	1
3	Socket/sleeve	1-2 “	1
4	Lathe	4’	1

<u>Raw material required</u>: -

MS ROD of diameter 32mm and length 60mm.



<u>Procedure</u>: -

- At first the round bar is fitted on the lathe chuck properly by the help of a surface gauge & chuck key.
- Then facing operation is done on the job and after that plain turning is done.

- Locate the center of the work piece by using tailstock.
- Now the dead center is removed from the tailstock and a socket with sleeve and a drill bit fitted into it.
- Now we run the lathe machine by making power switch on.
- After this the drill bit is required to move forward by the tail stock hand wheel which will penetrate into the rotated job and drilled the required sized hole.

Conclusion: -

Finally, we made a drill (Ø12 mm) on the given round bar.

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. The drill bit is made up which material?
2. What is the lip angle of drill bit?
3. On which type of guide ways the tail stock slides?
4. Which mechanism is used to lock & unlock the tail stock?

Space for answer

Experiment no.-02

Aim of the experiment:-

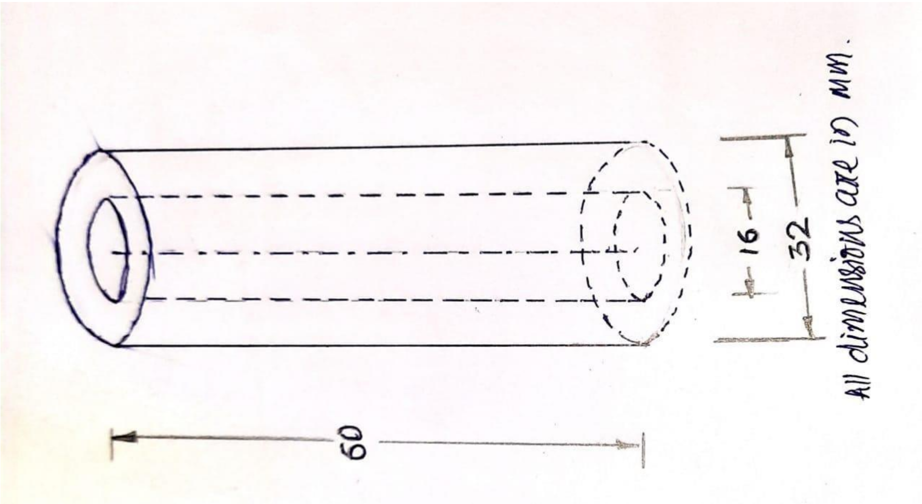
To do boring operation on a work piece using lathe.

Apparatus required: -

Sl no	Name of the apparatus	Specification	Quantity
01	Drill bit	Ø16 mm	1
02	Drill chuck	1-12 mm	1
03	Socket/Sleeve	1-2’’	1
04	Lathe	4’	1
05	Boring tool	4”	1

Raw material required: -

MS ROD of diameter 32mm and length 60mm.



Procedure: -

- At first the work piece is fitted properly on the lathe chuck by the help of a surface gauge & chuck key.
- Then facing and plain turning is done on the work piece.
- The center of the work piece is located by the help of tail stock.
- Now we run the lathe machine by making power switch on
- Now a drill bit is to be fitted with the tail stock and to be locked and then the drill will have penetrated in to the rotating work piece and sufficient feed is given until the required drilling is done.
- After drilling, the drill bit is removed and a boring tool is fitted into the tool post.

- Then the boring operation is done by the boring tool which is generally used to enlarge the drilled hole.

Conclusion: -

Finally, we did the boring operation on the given round bar.

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. The boring tool is made up which material?
2. What is boring operation?
3. What are the specification of boring tool?
4. What is the difference between drilling & boring?

Space for answer

Experiment no.-03

Aim of the experiment: -

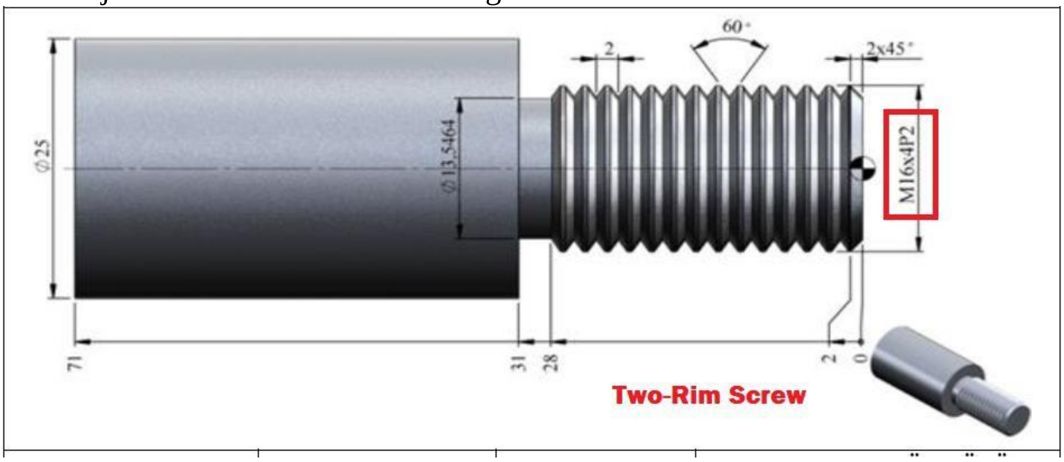
External V-thread cutting by the help of a V-thread cutting tool using lathe.

Apparatus required: -

Sl no	Name of the apparatus	Specification	Quantity
01	Drill bit	Ø16 mm	1
02	Drill chuck	1-12 mm	1
03	V-thread cutting tool	HSS 4”	1
04	Lathe	4’	1

Raw material required: -

MS ROD of major diameter 13.54mm and length 100mm.



Procedure: -

1. First of all, the job will have fitted in the lathe chuck and properly centered by surface gauge.
2. Then facing is done on the job and the center height was found out and marked by using dead center.
3. Fix the v-thread cutting tool on the tool post.
3. According to pitch we have to set the feed gear box.
4. Now we run the lathe machine by making power switch on.
5. Now we have to engage the half nut.
6. Now we start cutting with proper cutting depth from right side to left side.
7. Repeat the process till the thread will completely obtained.

Conclusion: -

Hence the external V-threading is done successfully by the help of required machine and tool.

Experiment no.-04

Aim of the experiment:

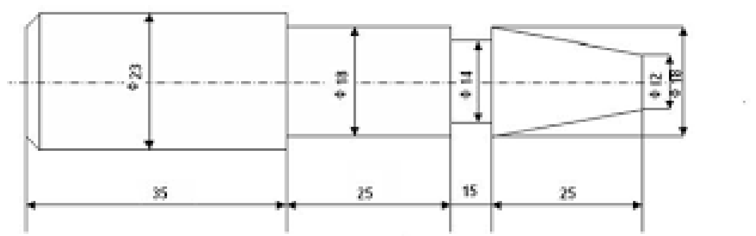
Job in evolving use of Capstan and turret lathe

Apparatus required:

Sl no.	Name of the apparatus	Specification	Quantity
01	Capstan turret Lathe	4’	01
02	Lathe Cutting Tool	4”	01
03	Chuck Key	100 mm	01
04	Box Spanner	10 mm	01

Raw material required:

M.S. Rod of Diameter 40mm and length 100mm.



STEP TURNING AND TAPER TURNING

ALL DIMENSIONS ARE IN MM

Procedure:

1. At first the round bar is fitted on the lathe chuck properly by the help of a surface gauge & chuck key.
2. Then checked out the centering of the job and tool by the help of surface gauge and dead center respectively.
3. Now we run the lathe machine by making power switch on.
4. Then various operations are done by the help of capstan and turret lathe successfully.

Conclusion:

From this practice we have done Taper Turning & Chamfering operation by using capstan & turret lathe.

Experiment no.-05

Aim of the experiment:

CNC Lathe Trainer Practice Job involving all turning process on MS Rod & aluminum rod for jobs using CNC Lathe trainer.

Theory:

Turning is a subtractive machining process that uses a cutting tool to remove material for creating cylindrical parts**.** The tool itself moves along the axis of the machined part while the part is rotating, creating a helical toolpath**.**

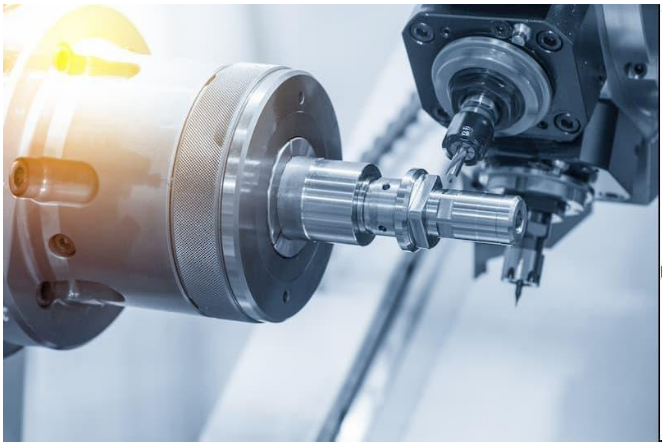
The lathe machine is historically one of the earliest of its kind for producing parts in a semi-automated fashion. Today, most companies provide CNC turning services. This means that the process is largely automated from start to finish.

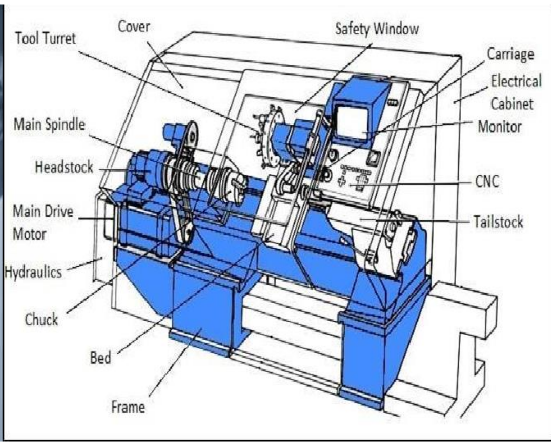
CNC refers to computer numerical control, meaning that computerized systems take control of the machinery. The input is digital code. This controls all the tool movements and speed for spinning as well as other supporting actions like the use of coolant.

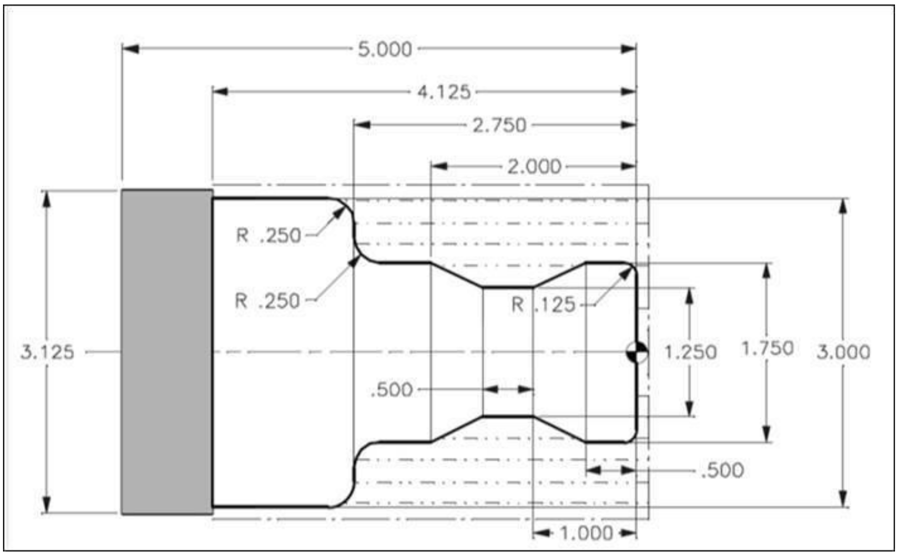
Procedure:

CNC Turning Process
What does the turning process actually comprise of? While the cutting itself is pretty straightforward, we are going to look at the whole sequence here which actually starts from creating a CAD file.
The steps of the process are:

- Creating a digital representation of the part in CAD
- Creating the machining code from the CAD files
- CNC lathe setup
- Manufacturing of the turned parts







Raw material required: MS Rod, Aluminum

CAD design & G code

The first 2 steps can be seen as separate or going hand-in-hand. One way is to just use a CAD program to create the files and send them into production. The manufacturing engineer will then create the G code and the M code for the machining job.

Another way is to just use CAD-CAM software which lets the design engineer test the producibility of the part. The powerful simulation tools can visualize the whole process from raw material to the final product, even using the input regarding finishing requirements.

Lathe setup

Next comes the machine setup. This is where the machine operator's role becomes evident. Although contemporary CNC lathes do most of the work automatically, the operator still plays a vital part.

Steps for setting up a CNC turning center:

- **Making sure the power is off**. CNC machining can be dangerous, so extra care is necessary and checking the power switch is the basis for that.
- **Securing the part into the chuck**. The chuck holds the part during the whole process. Improper loading can both pose dangers as well as result in a finished part with the wrong dimensions.
- **Loading the tool turret**. Turning comprises of many steps, so be sure to choose the right tooling for a certain finish. The turret can hold many tools at once for a seamless operation from start to finish.
- **Calibration**. Both the tool and part have to be set up in the right way. If anything is off, the result will not meet the demands.
- **Upload the program**. The last step before pushing the start button is uploading the code to the CNC machine.

Turning Parameters

The parameters of CNC turning depend on various aspects. These include the material of the part and tool, tool size, finishing requirements, etc.

The main parameters for CNC turning are:

- **Spindle speed**. The unit is rotations per minute (rpm) and it shows the rotational speed of the spindle (*N*), thus also the work piece. The spindle speed is in direct correlation with the cutting speed which also takes the diameter into account. Therefore, the spindle speed should vary to maintain a constant cutting speed if the diameter changes considerably.
- **Work piece diameter**. As said, this plays an important role to arrive at the right cutting speed. The symbol is *D* and the unit is mm.
- **Cutting speed**. The equation for calculating the cutting speed is $V=\pi DN/1000$. It shows the relative speed of the work piece to the cutting tool.
- **Feed rate**. The unit is mm/rev and the symbol is *s*. Cutting feed shows the distance the cutting tool moves per one turn of the work piece. The distance is measured axially.
- **Axial cut depth**. Pretty self-explanatory as it shows the depth of a cut in the axial direction. It is the primary parameter for facing operations. A higher feed rate puts more pressure on the cutting tool, shortening its lifetime.
- **Radial cut depth**. The opposite of axial cut, it shows the depth of cutting perpendicular to the axis. Again, lower feed rates help to lengthen the lifetime of tools and secure a better finish.

CNC Lathe Main Parts

Now, let’s see the main components of a turning center.

Headstock

The headstock of a CNC lathe makes up the front section of the machine. This is where the driving motor is along the mechanisms to power the spindle.

The chuck or collet attaches to the spindle. Either of them, in turn, holds the work piece during the turning operation.

Chuck and collet

The chuck grips the machined part by its jaws. It attaches directly to the spindle but is replaceable, so different sized parts can be machined.

Collet is basically a smaller version of a chuck. The part size suitable for collets is up to 60 mm. They provide a better grip for small parts.

Tailstock

The other end of a CNC turning center. A tailstock attaches directly to the bed and its purpose is to provide support for longer work pieces. The tailstock quill provides the support by hydraulic force.

The driving force still comes from the spindle and the tailstock just runs with the part. Using a tailstock is not suitable when face turning is necessary, as it will be in the way.

Lathe bed

The bed is just a base plate that rests on the table, supporting other machine parts. The carriage runs over the bed which is heat-treated to withstand the machining effects.

Carriage

The carriage rests on ways for sliding alongside the spinning work piece. It holds the tools, allowing for cutting process to take place.

Turret

Newer machines usually come with a turret that replaces the carriage. They can hold more tools at the same time, making the switching from one operation to the other less time-consuming.

Control panel

This is where computer numerical control kicks in. The brains of CNC turning machines are just behind the panel. The panel itself allows the operator to adjust the program and start it.

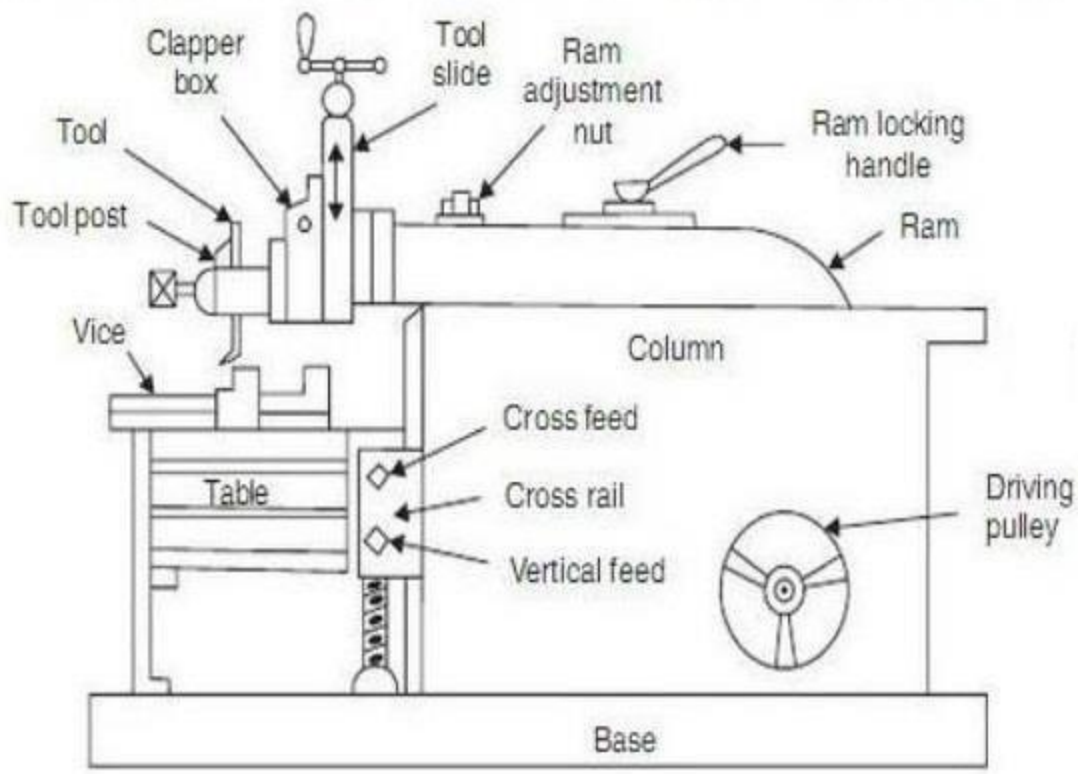
SHAPING MACHINE

The shaper is a machine tool used primarily for:

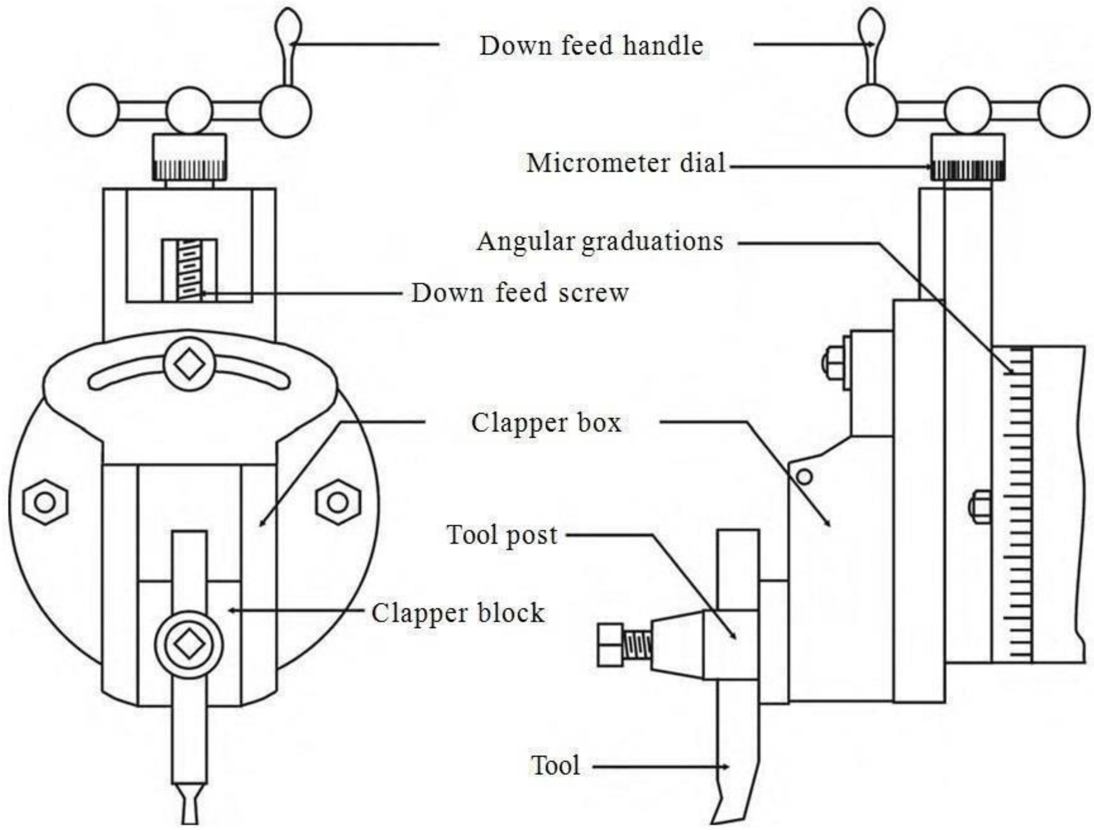
2. Producing a flat or plane surface which may be in a horizontal, a vertical or an angular plane.
3. Making slots, grooves and keyways
4. Producing contour of concave/convex or a combination of these

WORKING PRINCIPLE

The job is rigidly fixed on the machine table. The single point cutting tool held properly in the tool post is mounted on a reciprocating ram. The reciprocating motion of the ram is obtained by a quick return motion mechanism. As the ram reciprocates, the tool cuts the material during its forward stroke. During return, there is no cutting action and this stroke is called the idle stroke. The forward and return strokes constitute one operating cycle of the shaper.



Standard Shaping Machine



Shaper Tool Head

Construction: The main parts of the Shaper machine is Base, Body (Pillar, Frame, Column), Cross rail, Ram and tool head (Tool Post, Tool Slide, Clamper Box Block).

Base: The base is a heavy cast iron casting which is fixed to the shop floor. It supports the body frame and the entire load of the machine. The base absorbs and withstands vibrations and other forces which are likely to be induced during the shaping operations.

Body (Pillar, Frame, Column): It is mounted on the base and houses the drive mechanism compressing the main drives, the gear box and the quick return mechanism for the ram movement. The top of the body provides guide ways for the ram and its front provides the guide ways for the cross rail.

Cross rail: The cross rail is mounted on the front of the body frame and can be moved up and down. The vertical movement of the cross rail permits jobs of different heights to be accommodated below the tool. Sliding along the cross rail is a saddle which carries the work table.

Ram and tool head: The ram is driven back and forth in its slides by the slotted link mechanism. The back and forth movement of ram is called stroke and it can be adjusted according to the length of the workpiece to be-machined.

Shapers can be classified as below;

1) Based on the reciprocating Mechanism
   a) Crank type
   b) Geared type
   c) Hydraulic type
2) Based on the ram travel
   a) Horizontal
   b) Vertical
   c) Traveling head
3) Based on the table design
   a) Standard shaper
   b) Universal shaper
4) Based on the cutting stroke
   a) Push cut type
   b) Draw cut type

SPECIFICATIONS OF A SHAPER

A shaper can be specified based on the following factors:

a) Maximum stroke length: It is the maximum length that the ram can travel, hence the Length of cut the tool can take. It ranges from 175 to 900 mm.

b) Maximum height, Length of table travel: Maximum travel of the table- in vertical direction indicates the maximum height of the work piece that can be machined and the horizontal travel indicates the maximum width of the work-piece that can be machined.

c) Drive mechanism: The drive mechanism used to reciprocate the ram may be Mechanical type of hydraulic type. Hydraulic type is preferred because of its Advantages. The other parameters, which are used to specify a shaper, are cutting to return stroke ratio, belt/gear drive, power required, weight of the machine, etc.

DRIVE MECHANISM:

It provides the reciprocating motion to the ram, hence to the tool. In a standard shaper, the cutting action is provided in the forward stroke of the ram and the reverse stroke is the idle/ non-cutting stroke. For proper cutting action with minimum vibrations it needs a slower forward stroke and to save machining time a faster' idle reverse stroke of the ram. A shaper drive, mechanism is always designed to serve this purpose, and this is known as Quick Return

Mechanism: This type of drive can be obtained by any of the following mechanisms

1) Crank and slotted link mechanism .

2) Whitworth quick return mechanism

3) Hydraulic quick return mechanism

Whitworth - quick return mechanism

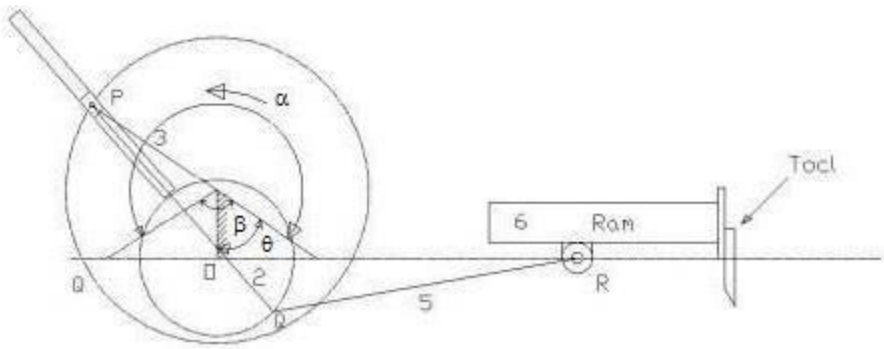
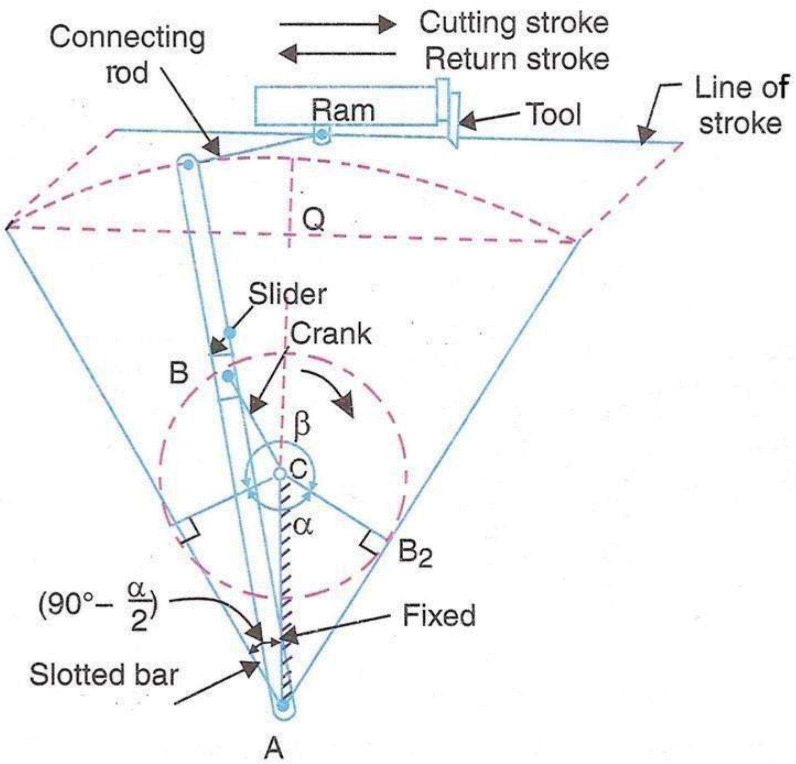


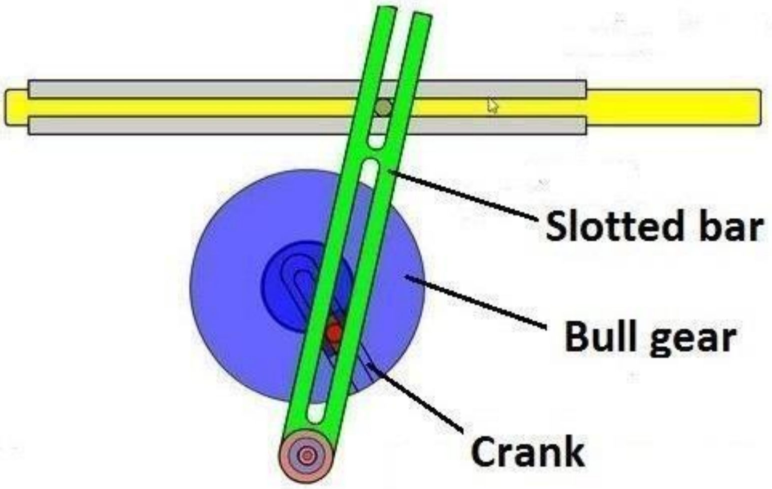
Figure 15: Whitworth - quick return mechanism

The Fig. 13 shows the whirtworth – quick return mechanism. The crank OC is fixed and OQ rotates about O. The slider slides in the slotted link and generates a circle of radius CP. Link 5 connects the extension OQ provided on the opposite side of the link 1 to the ram (link 6). The rotary motion of P is taken to the ram R which reciprocates. The quick return motion mechanism is used in shapers and slotting machines. The angle covered during cutting stroke from P1 to P2 in counter clockwise direction is α or 360 -2θ. During the return stroke, the angle covered is 2θ or β.

Crank and Slotted Link Mechanism

In this mechanism the ram is actuated by gear drives associated with electric motor. First, the electric motor drives the pinion gear. Next, the pinion gear drives the bull gear which rotates in opposite direction due to external gear meshing. A radial slide is provided on the bull gear. A sliding block is assembled on this slide. The block can be positioned in radial direction by rotating the stroke adjustment screw. The sliding block has a crank pin. A rocker arm is freely fitted to this crank pin. The rocker arm sliding block slides in the slot provided in the rocker arm called as slotted link. The upper end has fork which is connected to the ram block by a pin while the bottom end of the rocker arm is pivoted. When the pinion gear rotates along with the bull gear, the crank will also rotate. Due to this, the rocker arm sliding block also rotates in the same circle. Simultaneously, the sliding block slides up and down in the slot. This movement is transmitted to the ram which reciprocates. Hence, the rotary motion is converted in reciprocating motion.





Crank and slotted link mechanism

SHAPER OPERATIONS:

Generally, a shaper is used to machine flat horizontal surfaces. However, a shaper can be used also to machine vertical surfaces, inclined surfaces, splines, key ways, gear teeth and irregular contoured blanks. The operations performed in a shaper are as follows:

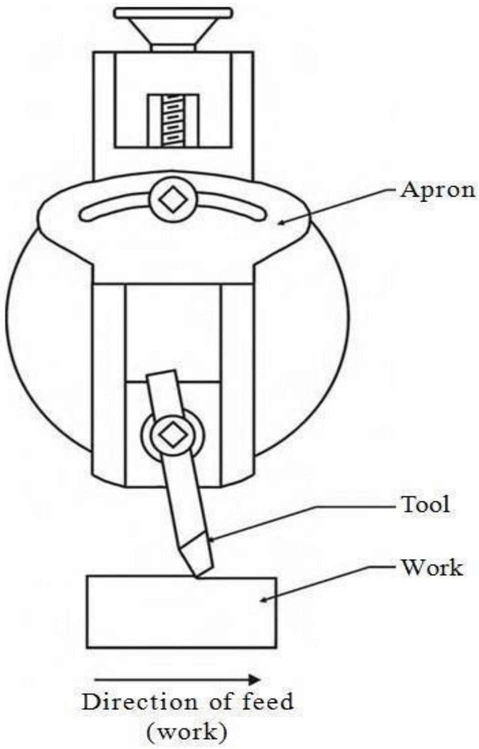
1) Machining horizontal surface

2) Machining vertical surface

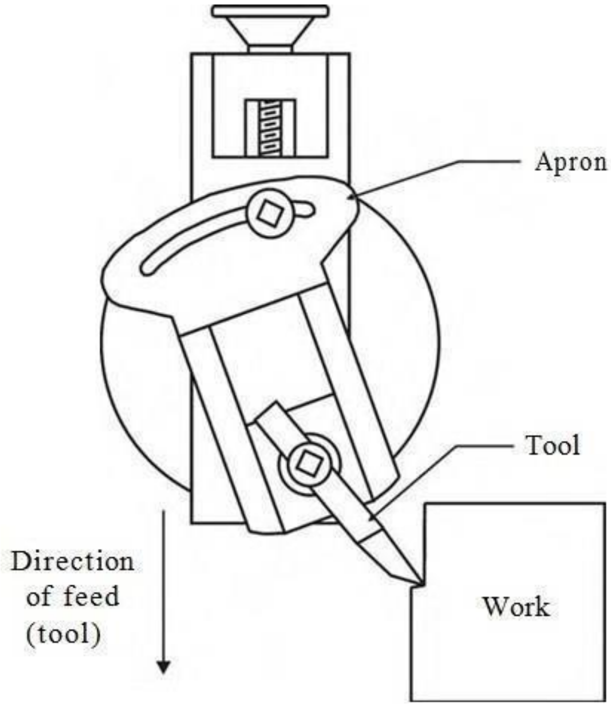
3) Machining inclined (angular) surface

4) Machining key ways

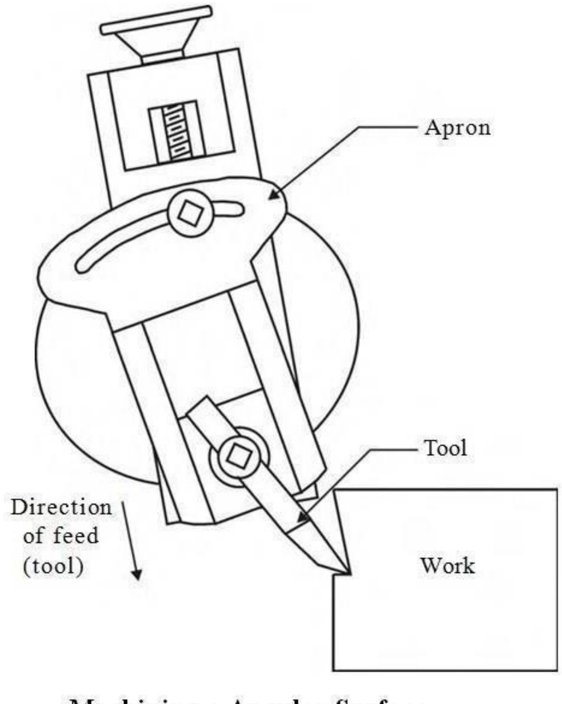
5) Machining splines and gear teeth



Machining a Horizontal Surface



Machining a Vertical Surface



Machining a Angular Surface

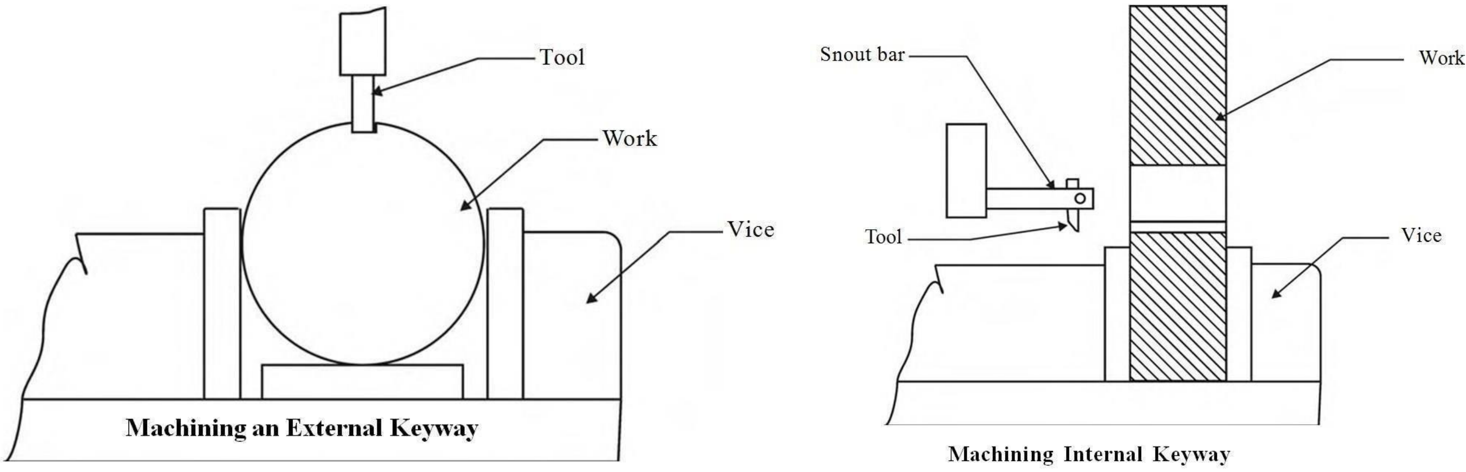


Figure 17: Shaper operations

WORK HOLDING DEVICES

i. Clamped in a vise
ii. Clamped directly on the table
   a. Using T-bolt and strap clamp
   b. Using strip and stop pins
   c. Using a wedge strip and stop pin
iii. Clamped on an angle plate
iv. Clamped over a vee block
v. Fixture

SHAPER TOOLS CLASSIFICATIONS

Shaper tools can be classified as;

i. According to the shape – straight, cranked, goose necked tool.
ii. According to the direction of cutting – left hand and right hand tool.
iii. According to the finish required – roughing tool, finishing tool. iv. According to type of operation – down cutting, parting, squaring, side recessing tools.
v. According to the shape of cutting edge – round nose, square nose tool.

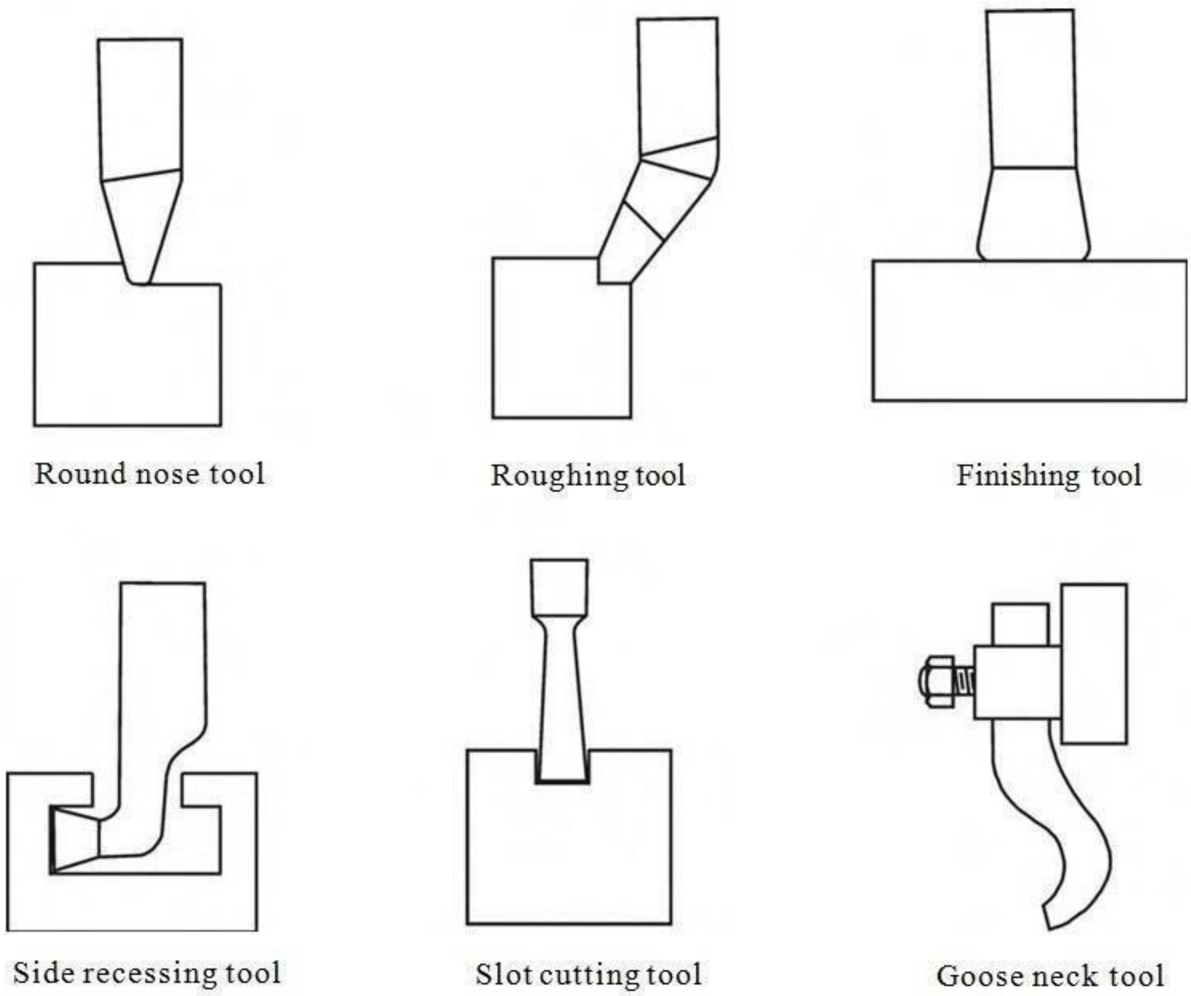


Figure 18: Shaper tools

CUTTING PARAMETERS

Cutting Speed

It is rate of speed at which the metal is removed by the tool. It is expressed in meter per minute.

$$\text{Cutting Speed} = \frac{\text{Length of the cutting stroke}}{\text{Time taken for cutting}}$$

$$V = \frac{[n\ L\ (1 + m)]}{1000}$$

Where, L is length of cutting stroke in mm, m is ration between return time and cutting time, n is RPM of the bull gear

Feed

Relative movement of the tool in a direction perpendicular to the movement of ram. Expressed in mm per stroke. Feed is given at the end of the stroke.

Depth of Cut

It is the thickness of metal removed in one cut. It is expressed in mm.

Machining Time

$$\text{Total time taken for completing the cut} = \frac{\mathrm{L\ B\ (1 + m)}}{1000\ \mathrm{v\ s}}$$

Where, L is length of stroke in mm

B is width or breadth of the workpiece in mm, S is the feed expressed in mm/double strok, m is the ratio between return and cutting time. v is cutting speed in meters/min.

Experiment no.-06

Aim of the experiment:

Preparation of V Block on CI or MS Blocks by using shaper machine.

Tools and equipment required:

- Shaper machine
- Manual operating handle
- Shaper single point cutting tool

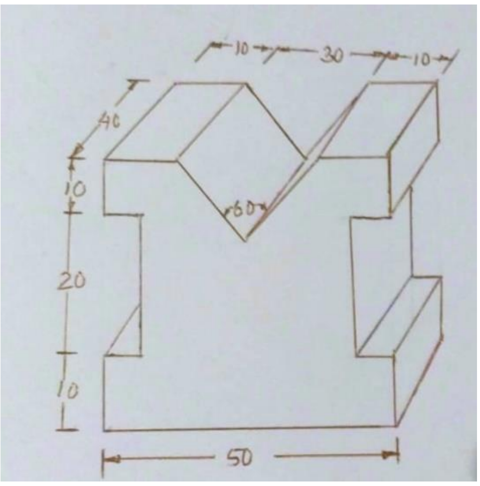
Marking and measuring tools:

- Scriber
- Dot punch
- Ball peen hammer
- Vernier caliper

Raw material required:

M.S block according to the given dimension in diagram (50×40 ×40) mm

Figure:



Procedure:

1. Take a block of dimension (50×50 ×50) mm then using proper marking media. Mark the block according to the given diagram.
2. Fix the raw material in the machine vice and also fix the required cutting tool in the tool post of the shaper machine
3. Set the swiveling tool post at proper angle
4. Then start the machine from zero feed depth to the required depth of raw material with the marking & make the v-block.

Conclusion:

From this practice we have done V Block on CI by proper machine tool & procedure.

MILLING MACHINE

Milling is a machining process in which metal is removed by a rotating multiple-tooth cutter against a fixed work piece, each tooth removing a small amount of metal with each revolution of the spindle. In this operation the cutter rotates at high speeds, and metal removal is very fast. Milling machines are employed for machining flat surfaces, contoured surfaces, external and internal teeth on gear blanks and helical surfaces.

CLASSIFICATION OF MILLING MACHINES:

5. Column and knee type
   a) Plain or Horizontal Milling Machine
   b) Universal milling machine
   c) Vertical milling machine
6. Fixed bed type
   a) Simplex milling machine
   b) Duplex milling machine
   c) Triplex milling machine
7. Planer type
8. Special type
   a) Rotary fable milling machine
   b) Drum milling machine
   c) Planetary milling machine.
   d) Profile tracer milling machine

Spindle orientation is one of the means of classifying milling machines. Horizontal milling machines have horizontal spindle and are most commonly used. Vertical milling machines have their spindle in vertical direction. Special milling machines have horizontal, vertical and angular spindles, which operate either one after the other, or all at the same time.

Column and Knee type Milling Machines:

These are so named because of two of their main structural elements, a column shaped main frame and knee shaped projection. Six principal parts of these machines are

1) The base, on which the milling machine structure is built.

2) The column, which contains the spindle and its driving mechanism.
3) The over arm mounted on the column, which supports the. other end of the arbor.
4) The knee, which is a structural member attached to the column and which moves vertically on the column.
5) The saddle, which is mounted on the knee and moves horizontally.
6) The table mounted on the saddle, which moves at right angles to the saddle. Work is clamped on the table. The column and knee type milling machines can have manual or power control for all movements. By the use of stops & other control devices the machine can be adopted for Automatic cycles.

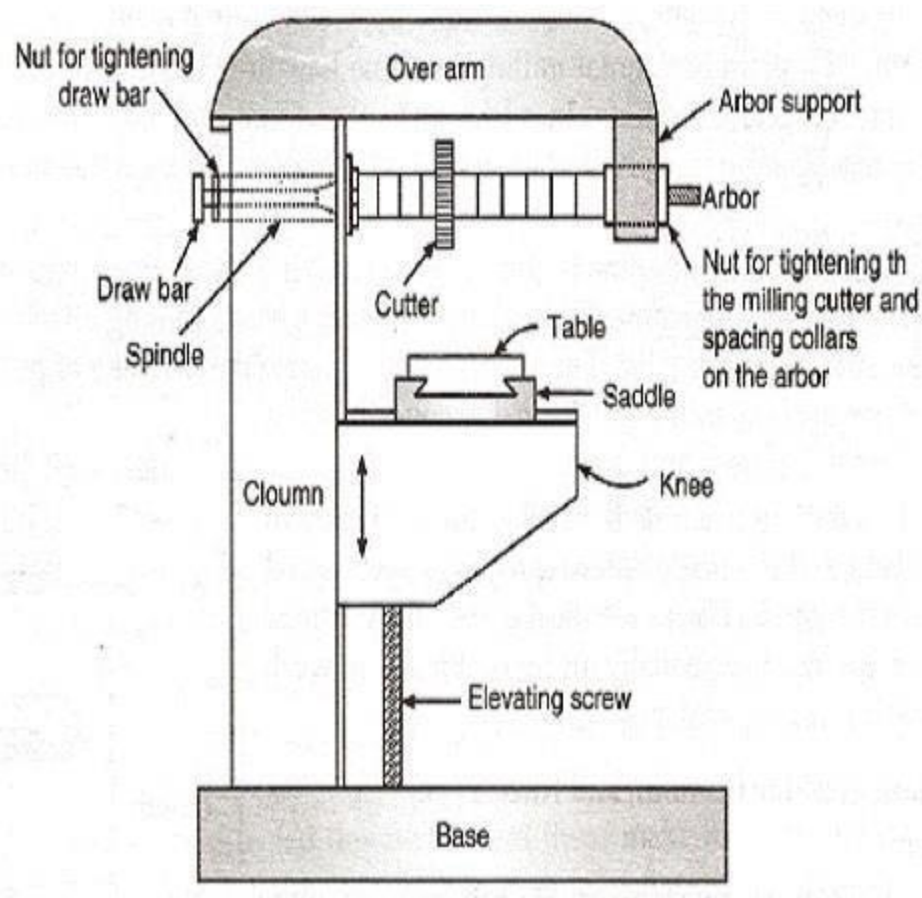


Figure 19: Column and Knee type Milling Machines

Horizontal Milling Machine:

Horizontal knee type milling machines are classified as plain or universal depending upon whether or not the table can be swiveled in a horizontal plane. The table on the universal machine can be swiveled up to 459 to the right or left, making possible angular and helical milling. These machines can also be converted into vertical type, if they have vertical spindle head. The feature of a horizontal or plain milling machine is illustrated in figure below.

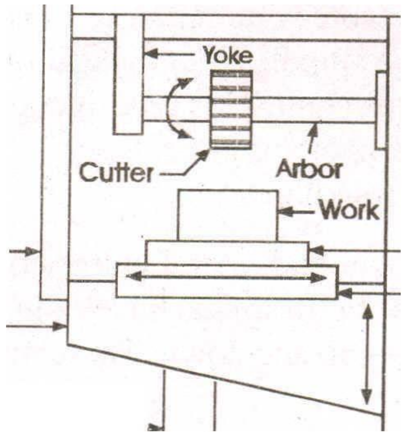


Figure 20: Horizontal Milling Machine

Parts:

Base, Column, Table. Saddle (upper and lower), Knee, arbor, adjustable bearing block.

Vertical Milling Machine:

Vertical knee type milling machines have a vertical spindle. They may be either of the fixed head, sliding head, swivel head type or they may be a combination of the last two. Vertical milling machines have neither over arm nor brace. All other features are substantially the same as in the Horizontal Milling Machine. A Vertical Milling Machine is especially suitable for operations with end mills and face mills. The basic feature of a vertical milling machine is illustrated in figure below:

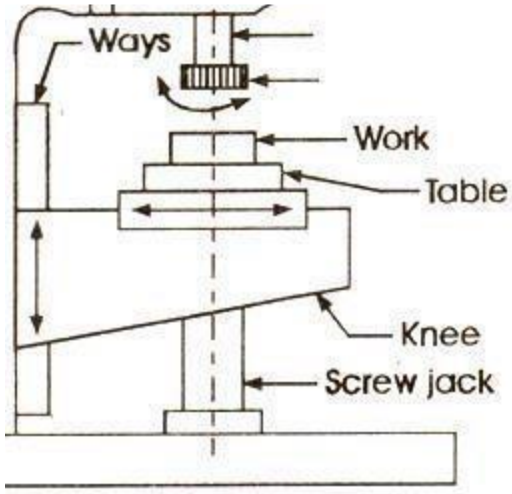


Figure 21: Vertical Milling machine

MILLING CUTTERS

Milling cutters are the rotating type cutting tools that are used in milling machines. They have multiple cutting teeth of similar shape equally spaced on the circumference of the cutter. These teeth intermittently engage with the work piece and cause cutting action upon continuous feeding. Milling cutters may be made of High Speed Steel, cast alloys or cemented carbide tips. Generally, HSS, tools are used for regular operations.

The different types of milling cutters, classified based on their constructional features and the type of operation performed, are as follows:

1) Plain Milling Cutters
   a) Straight teeth cutter
   b) Helical teeth cutter

2) Milling cutters
   Plain teeth
   a) Staggered teeth
   b) Half side teeth

3) Metal slitting Saw
   a) Plain teeth
   b) Staggered teeth

4) Angle Milling cutters
   a) Single angle type

b) Double angle type

5) End Milling Cutters

a) Straight shank

b) Taper shank

c) Shell end 6) Slot Milling Cutters 7) Fly cutters.

8) Formed cutters

9) Tip and Reamer cutters

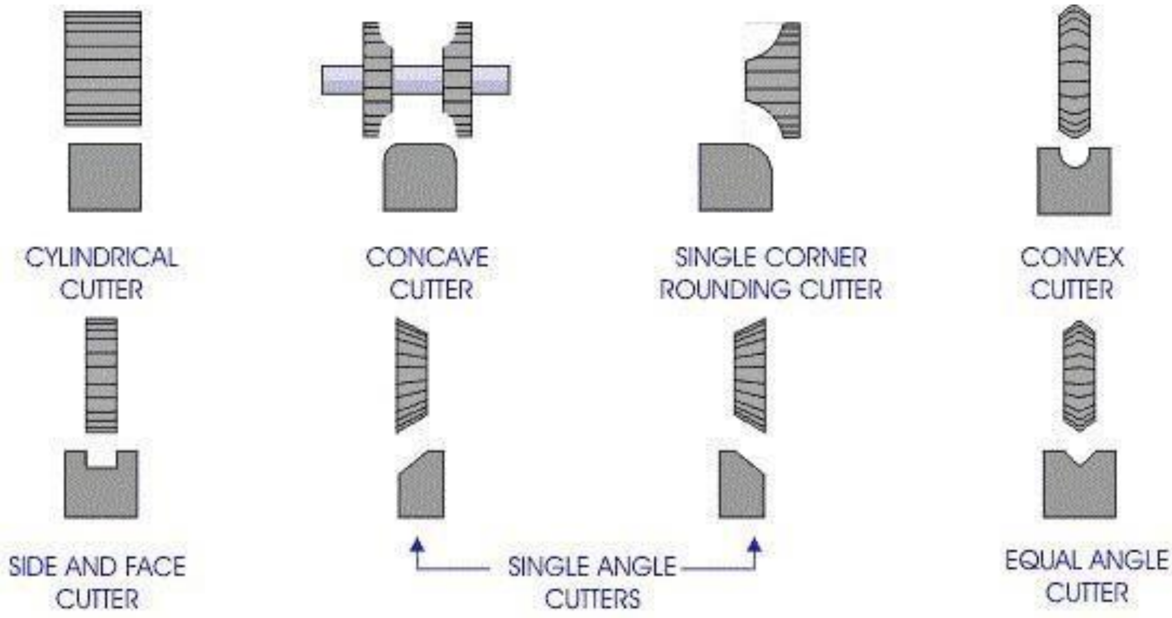


Figure 22: Different types of milling cutters

MILLING CUTTER NOMENCLATURE

It shows two views of a common milling cutter with its parts and angles identified. These parts and angles in some form are common to all cutter types.

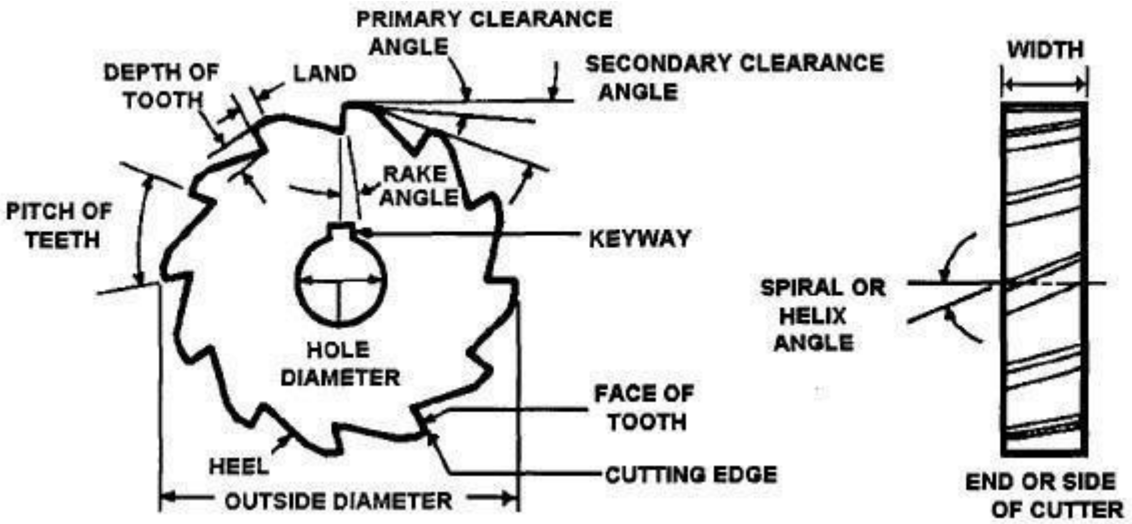


Figure 23: Nomenclature of Milling Cutter

- The pitch refers to the angular distance between like or adjacent teeth.
- The pitch is determined by the number of teeth. The tooth face is the forward facing surface of the tooth that forms the cutting edge.
- The cutting edge is the angle on each tooth that performs the cutting.
- The land is the narrow surface behind the cutting edge on each tooth.
- The rake angle is the angle formed between the face of the tooth and the centerline of the cutter. The rake angle defines the cutting edge and provides a path for chips that are cut from the work piece.
- The primary clearance angle is the angle of the land of each tooth measured from a line tangent to the centerline of the cutter at the cutting edge. This angle prevents each tooth from rubbing against the work piece after it makes its cut.
- This angle defines the land of each tooth and provides additional clearance for passage of cutting oil and chips.
- The hole diameter determines the size of the arbor necessary to mount the milling cutter.
- Plain milling cutters that are more than 3/4 inch in width are usually made with spiral or helical teeth. A plain spiral-tooth milling cutter produces a better and smoother finish and requires less power to operate. A plain helical-tooth milling cutter is especially desirable when milling an uneven surface or one with holes in it.

MILLING OPERATIONS

Milling operations can be classified as follows:

1. Plain milling
2. Face milling
3. Side milling
4. Straddle milling
5. Angular milling
6. Gang milling
7. Form milling
8. Profile milling
9. End milling
10. Slot milling
11. Saw milling
12. Helical milling
13. Cam milling
14. Thread milling
15. Gear cutting

INDEXING

The different methods of indexing are
1. Direct indexing
2. Plain or simple indexing
3. Compound indexing
4. Differential indexing
5. Angular indexing

Direct Indexing:

This consists of a index plate with an indexing arm connected directly to the work spindle without any gearing. Hence, rotation of the indexing arm is equal to the rotation of the work piece. The required number of divisions on the work is obtained directly by rotating the index arm through the index plate. Since, the method is very quick and direct it is termed as rapid or direct indexing.

When a rapid index plate with 24 holes is used, it is possible to index the work piece into equal parts of 2, 3,4,6,8, 12 and 24. Generally the index plate is provided with different number of holes on concentric circles to make' it convenient *to* obtain all possible divisions. To determine the number of holes to be moved in a direct indexing, the expression is

$$n = \frac{T}{N}$$

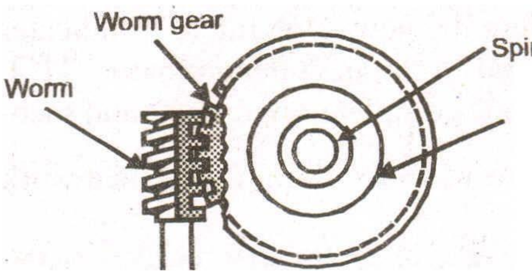
n = number of holes to be moved on the index plate

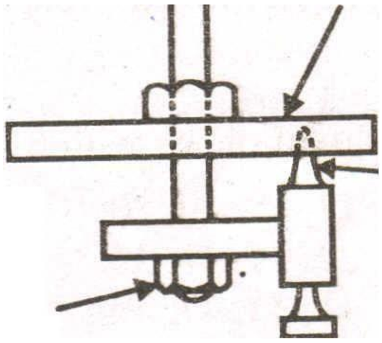
N = number of divisions required on the work

T = total number of holes available in one indexing circle.

Simple Indexing

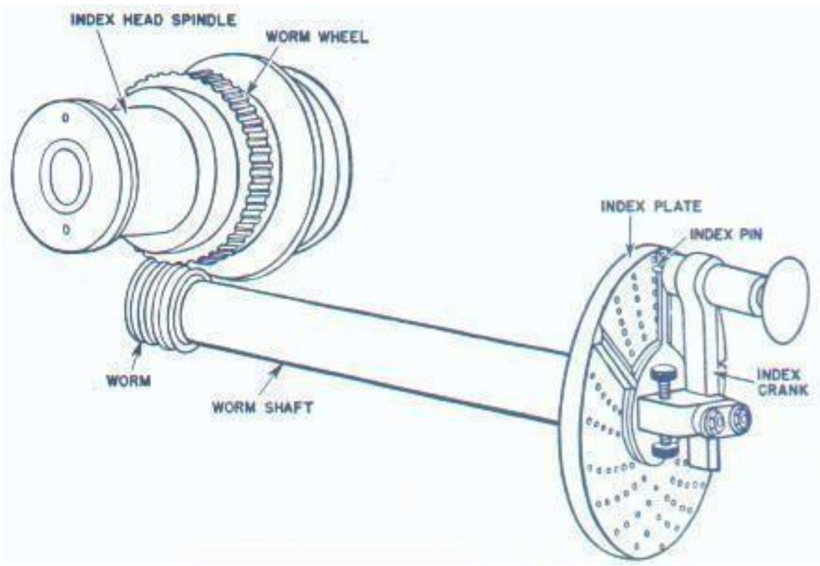
Simple or plain indexing incorporates a worm gear arrangement between the index crank and the spindle. This is suitable for divisions beyond the range of direct indexing. In this, method the crank arm is mounted on a single threaded worm, which meshes with a worm gear with 40 teeth. Thus 40 turns other crank *(worm)* are required to rotate the spindle (work) through one revolution. That is, one complete turn of the index crank will make the work to rotate through 1/40 of a revolution.





Spindle

Index plate Spring loaded pin



Simple Indexing Mechanism

Indexing Calculations

$$\text{Index cranck movement} = \frac{40}{\text{N}}$$

Where N is no. of division required.

Assume 15 teeth are to be cut.

$$\text{No. of turns the crank has to be rotated} = \frac{40}{15} = 2\ \frac{10}{15}$$

Experiment no.-07

Aim of the experiment:

Preparation of Spur gear on CI or MS round by using milling m/c.

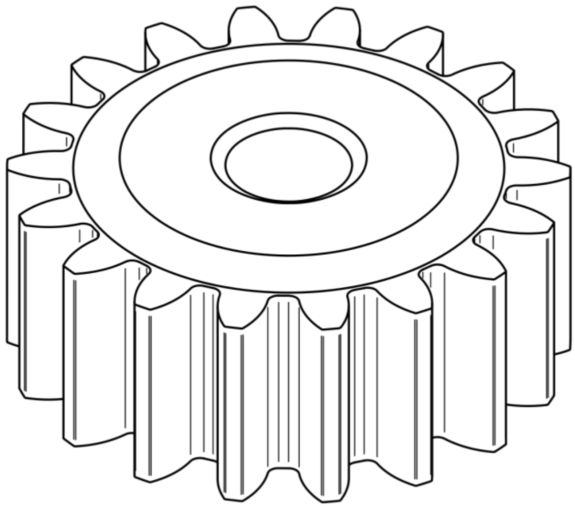
Apparatus required:

- Universal milling machine
- Spur gear milling cutter (Module 3)
- Spanner
- Indexing plate
- spindle rotating handles

Raw material required:

Circular M.S plate as per required diameter and thickness.

Figure:



(Take suitable dimension)

Procedure:

1. At first calculate the blank diameter of the material by selecting the required no. of teeth by the following formulae
   Blank diameter = m(T+2) m – Module
   T – No. of teeth
2. Make a hole at the center of the raw material for fixing at chuck according to the diameter of the spindle.
3. Fix the raw material in between the tail stock and chuck tightening.
4. Then fix the cutting tool in the arbor.
5. Calculate the depth of the teeth by the formula = $2.25 \times m$ and Pitch = $3 \times m$
6. Again calculate indexing hole and rotation of the indexing spindle = 40/ No. of teeth
7. Now fix the depth of cut according to calculation.
8. Cut the teeth accordingly by the simple indexing method

Conclusion:

From this practice we finally able to make a spur gear by following proper M/C tool and procedure.