

MACHINING SCIENCE AND TECHNOLOGY LAB MANUAL

DEPARTMENT OF MECHANICAL ENGINEERING

PREPARED BY: AJIT KUMAR PATTANAİK

AND

DEBANSHU SHEKHAR KHAMARI

GOVERNMENT COLLEGE OF ENGINEERING,
KALAHANDI, BHAWANIPATNA

CONTENTS

Sl No.	Experiment Name	Page No.
01	Performing step turning, taper turning, thread cutting and knurling on lathe	03
02	Gear cutting in milling machine	09
03	Working with shaper, planer and slotting machine	13
04	Working with surface and cylindrical grinding	26
05	Determination of cutting force using lathe tool and drill tool dynamometers	31
06	Study of non-conventional machining processes	36

STEP TURNING AND TAPER TURNING ON LATHE

Experiment No-01

AIM:

To perform Step turning and Taper turning operations on the given work piece

MATERIAL REQUIRED:

Mild steel rod of 25 mm diameter and 100 mm long.

TOOLS REQUIRED:

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

SPECIFICATION OF LATHE:

Length of bed 1390 mm

Width of bed 200 mm

Height of centers 165 mm

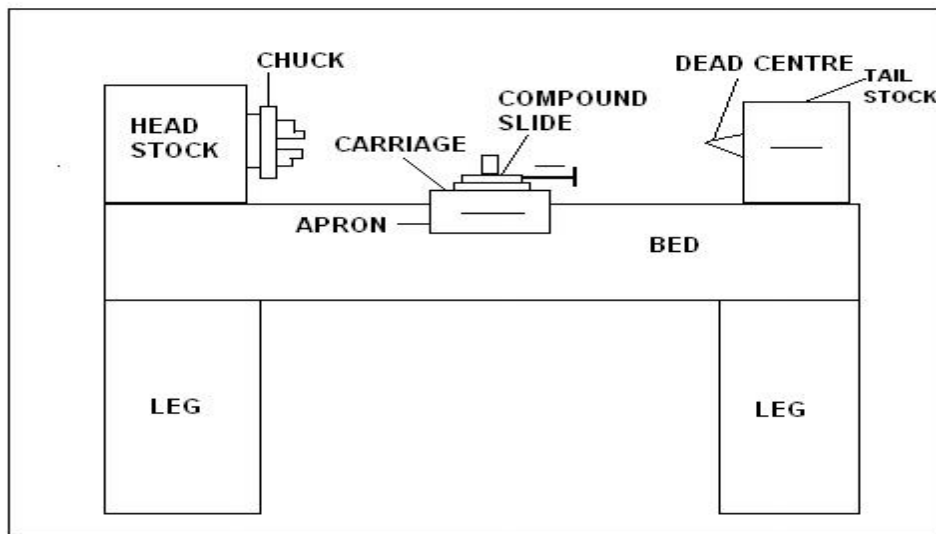
Admit between centers 700 mm

Lead screw pitch 4TPI

Power of the motor 1 h.p.

THEORY:

Lathe removes undesired material from a rotating work piece in the form of chips with the help of a tool which is traversed across the work and can be fed deep in work. The tool material should be harder than the work piece and the later help securely and rigidly on the machine. The tool may be given linear motion in any direction. A lathe is used principally to produce cylindrical surfaces and plane surfaces, at right angles to the axis of rotation. It can also produce tapers and bellows etc.



BLOCK DIAGRAM OF A LATHE

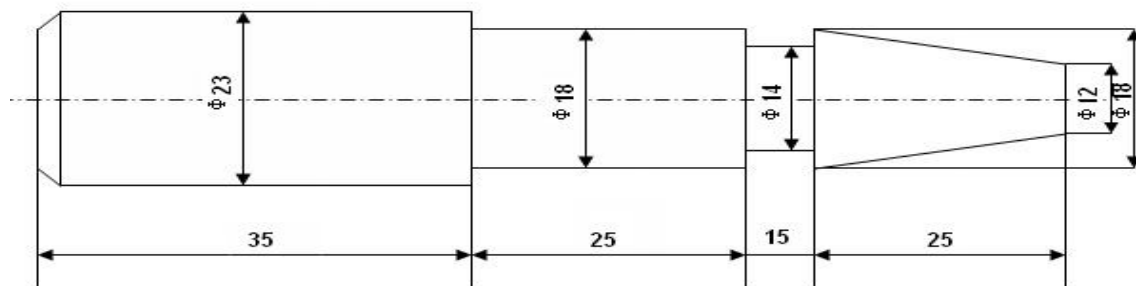
A lathe (shown in fig.) basically consists of a bed to provide support, a head stock, a cross slide to traverse the tool, a tool post mounted on the cross slide. The spindle is driven by a motor through a gear box to obtain a range of speeds. The carriage moves over the bed guide ways parallel to the work piece and the cross slide provides the transverse motion. A feed shaft and lead screw are also provided to power the carriage and for cutting the threads respectively.

SEQUENCE OF OPERATIONS:

- Centering
- Facing
- Plain turning
- Chamfering
- Step turning
- Grooving
- Taper turning



PROCEDURE:



STEP TURNING AND TAPER TURNING

ALL DIMENSIONS ARE IN MM

- The work piece is fixed in a 3-jaw chuck with sufficient overhang.
- Adjust the machine to run the job to a required cutting speed.
- Fix the cutting tool in the tool post and centering operation is performed so that the axis of the job coincides with the lathe axis.
- Give the feed and depth of cut to the cutting tool
- Facing operation is performed from the center of the job towards outwards or from the circumference towards the center.
- Plain turning operation is performed until the diameter of the work piece reduces to 23 mm.
- Check the dimensions by using vernier calipers.
- Then chamfering is done on the 23mm diameter surface.
- Reverse the work piece in the chuck and facing operation is performed to reduce the length of work piece to the required dimensions.
- Again Plain turning operation is performed until the diameter of the work piece reduced to 18mm.
- Using V-cutting tool grooving operation is performed according to the given dimensions and finish the groove using parting tool.
- Swivel the compound slide to the required angle and taper turning operation by rotating the compound slide wheel.
- The angle can be measured by using the formula.
- Finally check the dimensions by using vernier calipers.

PRECAUTIONS:

- The work piece should be held rigidly in the chuck before operating the machine.
- Tool should be properly ground, fixed at correct height and properly secured, and work also be firmly secured.
- Before operating the machine see whether the job and tool is firmly secured in devices or not.
- Optimum machining conditions should be maintained.
- Chips should not be allowed to wound around a revolving job and cleared as often as possible
- Apply cutting fluids to the tool and work piece properly.

RESULT: The job is completed successfully and safely.

THREAD CUTTING AND KNURLING ON LATHE

AIM:

To perform Thread cutting and Knurling operation on the given work piece.

MATERIAL REQUIRED:

Mild Steel rod of 25 mm diameter and 100 mm long

TOOLS REQUIRED:

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

SPECIFICATION OF LATHE:

Length of bed 1390 mm

Width of bed 200 mm

Height of centers 165 mm

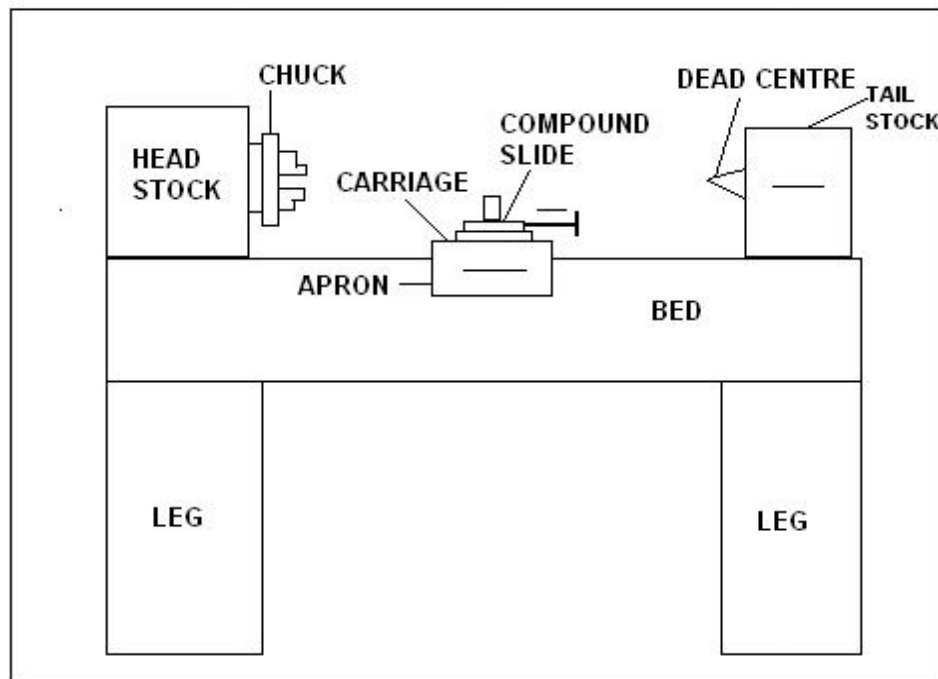
Admit between centers 700 mm

Lead screw pitch 4TPI

Power of the motor 1 H.P.

THEORY:

Lathe removes undesired material from a rotating work piece in the form of chips with the help of a tool which is traversed across the work and can be fed deep in work. The tool material should be harder than the work piece and the later help securely and rigidly on the machine. The tool may be given linear motion in any direction. A lathe is used principally to produce cylindrical surfaces and plane surfaces, at right angles to the axis of rotation. It can also produce tapers and bellows etc.



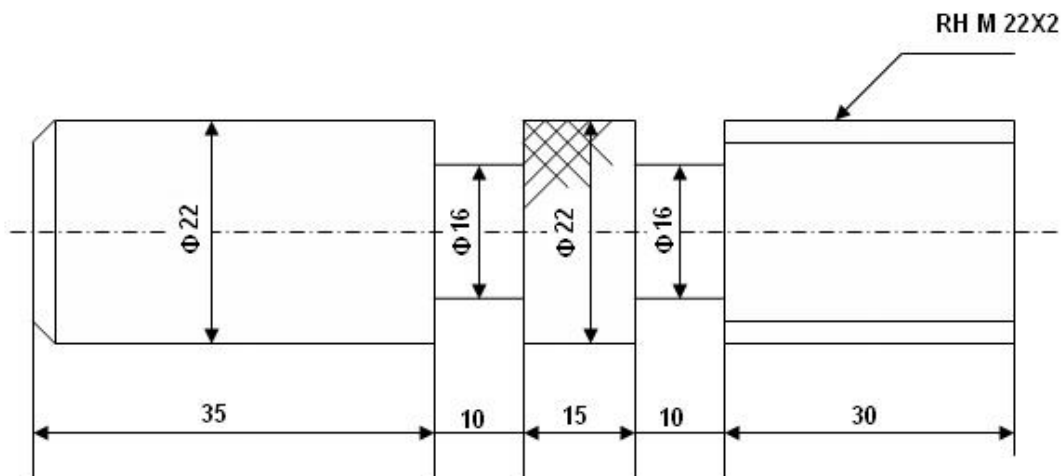
BLOCK DIAGRAM OF A LATHE

A lathe basically consists of a bed to provide support, a head stock, a cross slide to traverse the tool, a tool post mounted on the cross slide. The spindle is driven by a motor through a gear box to obtain a range of speeds. The carriage moves over the bed guide ways parallel to the work piece and the cross slide provides the transverse motion. A feed shaft and lead screw are also provided to power the carriage and for cutting the threads respectively.

SEQUENCE OF OPERATIONS:

- Centering
- Facing
- Plain turning
- Chamfering
- Step turning
- Grooving
- Thread cutting
- Knurling

PROCEDURE:



THREAD CUTTING AND KNURLING

ALL DIMENSIONS ARE IN MM

- The work piece is fixed in a 3 – jaw chuck with sufficient overhang.
- Adjust the machine to run the job to required cutting speed.
- Fix the cutting tool in the tool post and centering operation is performed so that the axis of the job coincides with the lathe axis.
- Facing is performed by giving longitudinal depth of cut and cross feed.
- Perform plain turning operation until the diameter of the work piece reduced to 20mm.
- Chamfering operation is done according to the given dimensions.

- Then reverse the work piece in the chuck and plain turning operation is performed according to the given dimensions.
- Using V-cutting tool and parting off tool perform grooving operation to the required dimensions.
- Reduce speed of the spindle by engaging back gear and use Tumbler
- feed reversing mechanism to transmit power through the lead screw.
- And calculate the change gears for the required pitch to be made on the work piece.
- Using half nut mechanism perform thread cutting operation(right hand threading) according to the given dimensions and continues it until required depth of cut is obtained.
- At the same speed knurling operation is performed using knurling tool.
- For every operation check the dimensions using vernier calipers.

PRECAUTIONS:

- Before starting the spindle by power, lathe spindle should be revolved by one revolution by hand to make it sure that no fouling is there.
- Tool should be properly ground, fixed at correct height and properly secured, and work also be firmly secured.
- Chips should not be allowed to wind around a revolving job and cleared as often as possible.
- Before operating threading operation, V-tool should be properly ground to the required helix angle.
- Apply cutting fluids to the tool and work piece property.
- No attempt should be made to clean the revolving job with cotton waste.
- On hearing unusual noise, machine should be stopped.

RESULT: The job is completed successfully and safely.

SPUR GEAR CUTTING IN MILLING MACHINE

Experiment No-02

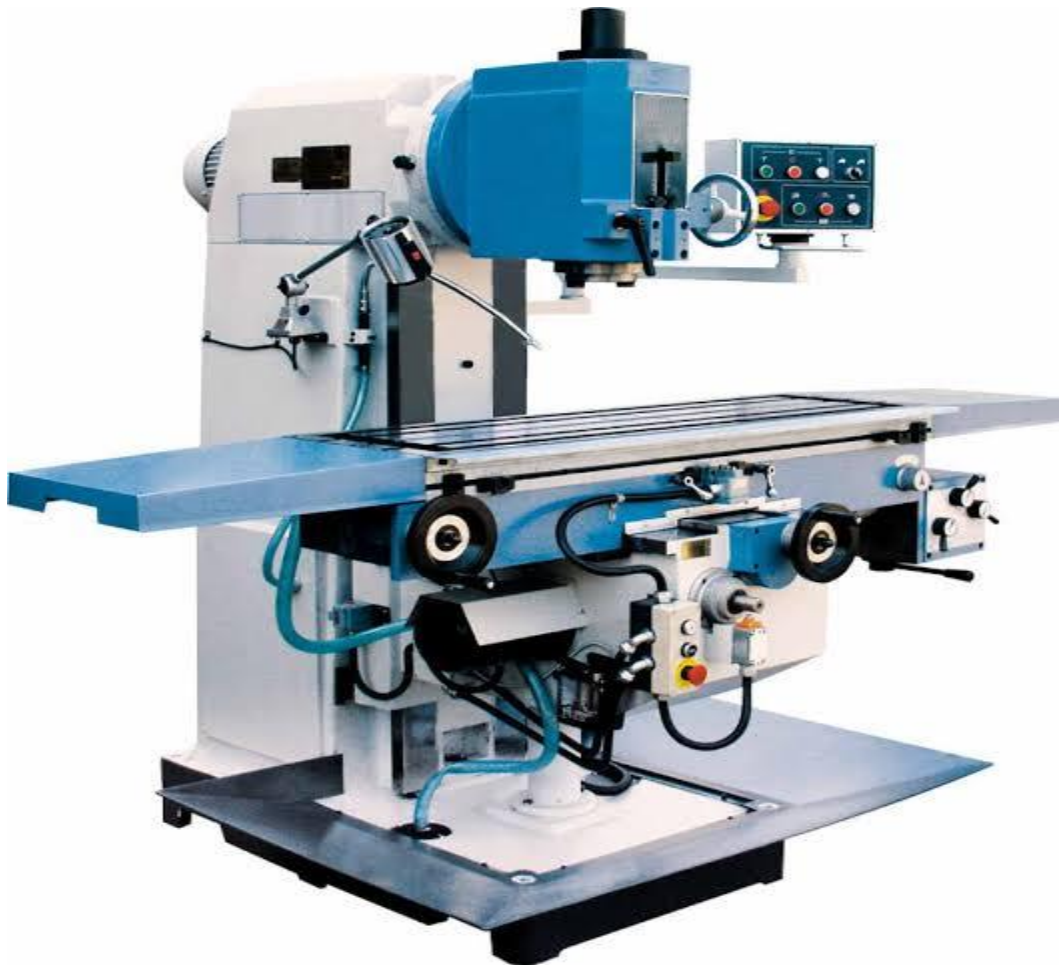
Aim: To produce a spur gear out of the given work piece using milling machine

Apparatus Required:

- Horizontal Milling machine
- M10 – End Mill Cutter (HSS)
- Gear tooth Vernier

Materials Required:

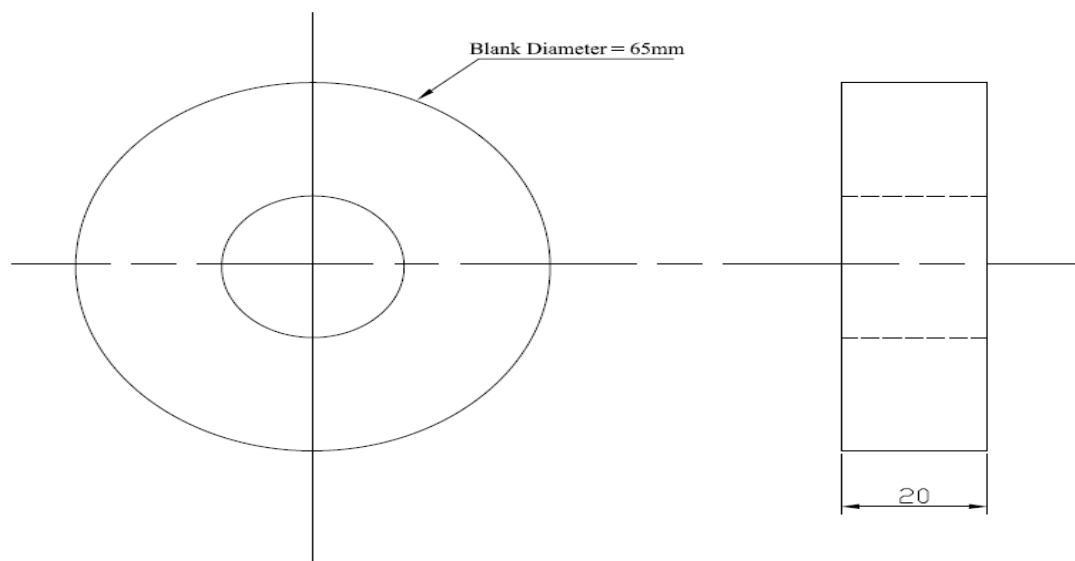
- Cast Iron Work piece – 55mm diameter, 20mm thickness



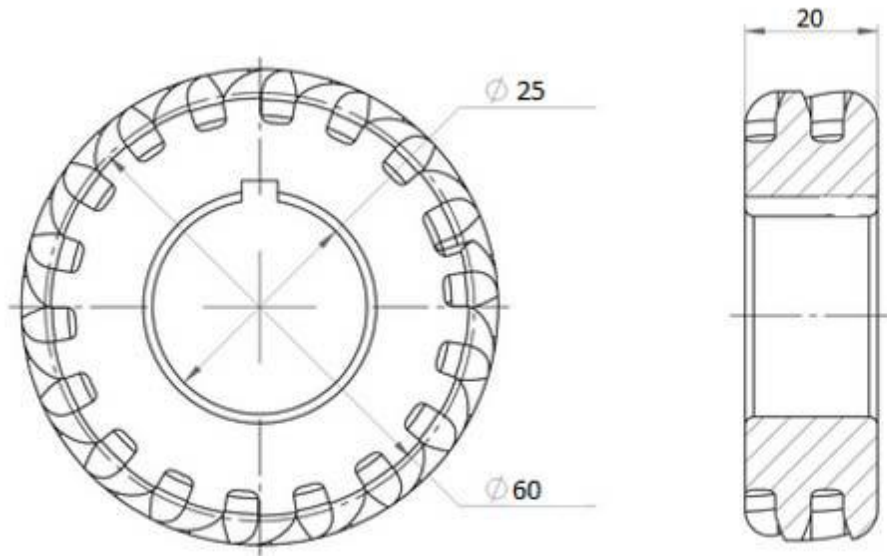
Milling Machine

Procedure:

- The gear blank is held between the dividing head and tailstock using a mandrel.
- The cutter is mounted on the arbor and the cutter is centred accurately with the gear blank
- Set the speed and feed for machining. For giving depth of cut, the table is raised till the periphery of the gear blank just touches the cutter
- The Micrometre dial of vertical feed screw is set to zero at this position. Then the table is raised further to give the required depth of cut
- The machine is started and feed is given to the table to cut the first groove of the blank.
- After the cut, the table is brought back to the starting position. Then the gear blank is indexed for the next tooth space. This is continued till all the teeth are cut
- Dimensions of the gear teeth profile are checked using the gear tooth Vernier.



Before Machining



After Machining

Calculation:

□ **Pitch circle Diameter DP** = Diameter of the Blank(**D**) – (2 X Module(**m**)) =
 $65 - (2 \times 2.5) = 60$

□ **Number of teeth Z** = Pitch circle Diameter / module = $60 / 2.5 = 24$

□ **Circular Pitch PC** = $\pi DP / Z$

□ The relationship between **normal pitch** and **transverse pitch** is given by

$$PN = PC \times \cos \alpha$$

Helical Gear considerations:

□ Helix Angle α is related to Pitch circle diameter (DP) and the lead of the helix (L) by the following relation

$$\tan \alpha = \pi DP / L$$

□ With any of the two known values, the third value can be found

Indexing Calculation: Indexing = $40 / Z$

Result: Thus a spur gear is made from the given work piece using milling machine.

HELICAL GEAR CUTTING IN MILLING MACHINE

Aim: To cut a helical gear out of the given blank in milling machine

Apparatus Required:

- Horizontal Milling machine
- M10 – End Milling cutter

Materials Required: Cast Iron Blank – 65mm diameter and 20mm thickness

Procedure:

- The M10 milling cutter is set on the mandrel
- The table is swivelled to an inclination of α (Helix Angle) with the axis of work piece
- The required gear ratio is set between the work table and the mandrel holding the work piece so that movement of the work table rotates the work piece through the proper helix angle progressively
- The spindle is switched on and the required depth of cut is set before the tool cuts the work piece.
- Single teeth cavity is cut through the work piece.
- After Indexing the next tooth is cut in similar fashion and so on
- The gear tooth dimensions are checked using a gear tooth Vernier.

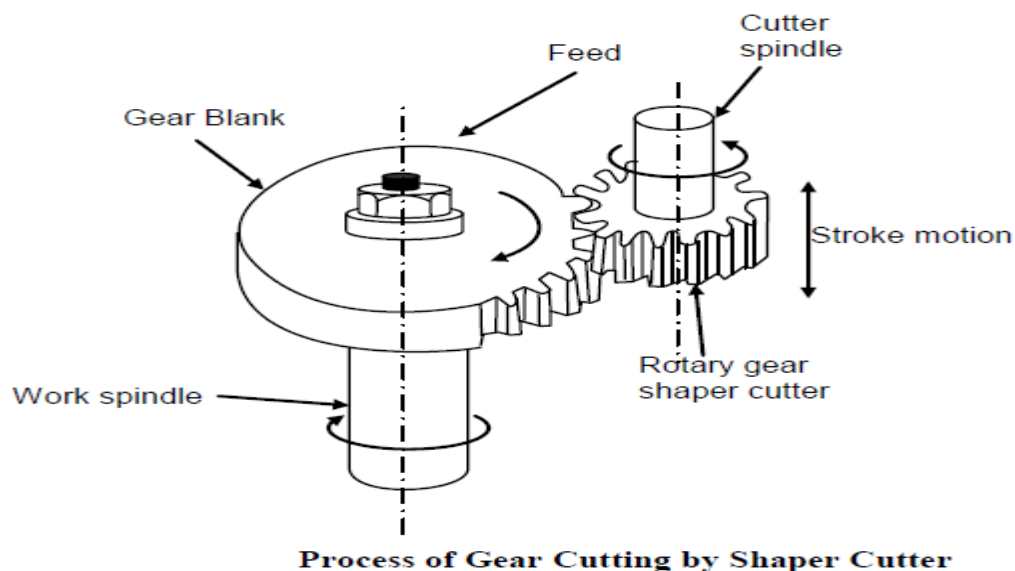
Result: Thus a helical gear is cut out of the given blank using horizontal milling machine.

GEAR SHAPER MACHINE

Experiment No-03

STUDY:

- This process uses a pinion shaped cutter carrying clearance on the tooth face and sides and a hole at its centre for mounting it on a stub arbor or spindle of the machine
- The cutter is mounted by keeping its axis in vertical position
- It is made to reciprocate up and down along the vertical axis up to a pre decided amplitude
- Both the cutter and the gear blank are set to rotate at a very low RPM about their axis
- The relative rpm of both (cutter and blank) can be fixed to any of the available value with the help of a gear train.
- This way all the cutting teeth of cutter come in action one-by-one giving sufficient time for their cooling and incorporating a longer tool life
- The principle of gear cutting by this process as explained above is depicted in the Figure below



SHAPING MACHINE



The main parameters to be controlled in the process are described below

Cutting Speed:

- Shaper cutter can move vertically upward and downward during the operation.
- The downward movement of the cutter is the cutting stroke and its speed (linear) with which it comes down is the cutting speed.
- Length of cutting stroke can be adjusted to any value out of available values on the machine

Indexing motion:

Indexing motion is equivalent to feed motion in the gear shaping operation. Slow rotations of the gear cutter and work piece provide the circular feed to the operation.

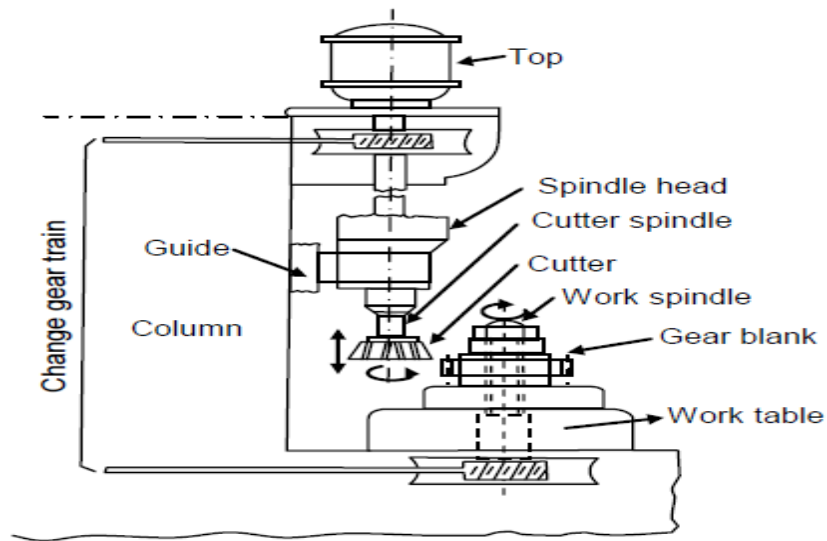
These two rpms are adjusted with the help of a gear train

Depth Of Cut:

The required depth is maintained gradually by cutting the teeth into two or three pass

In each successive pass, the depth of cut is increased as compared to its previous path

This gradual increase in depth of cut takes place by increasing the value of linear feed in return stroke.

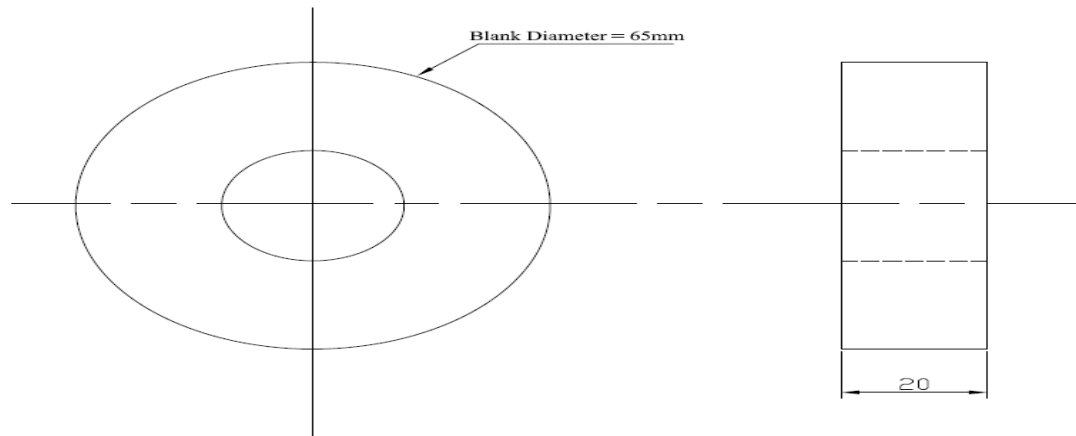


Setup for Gear Shaping Machine

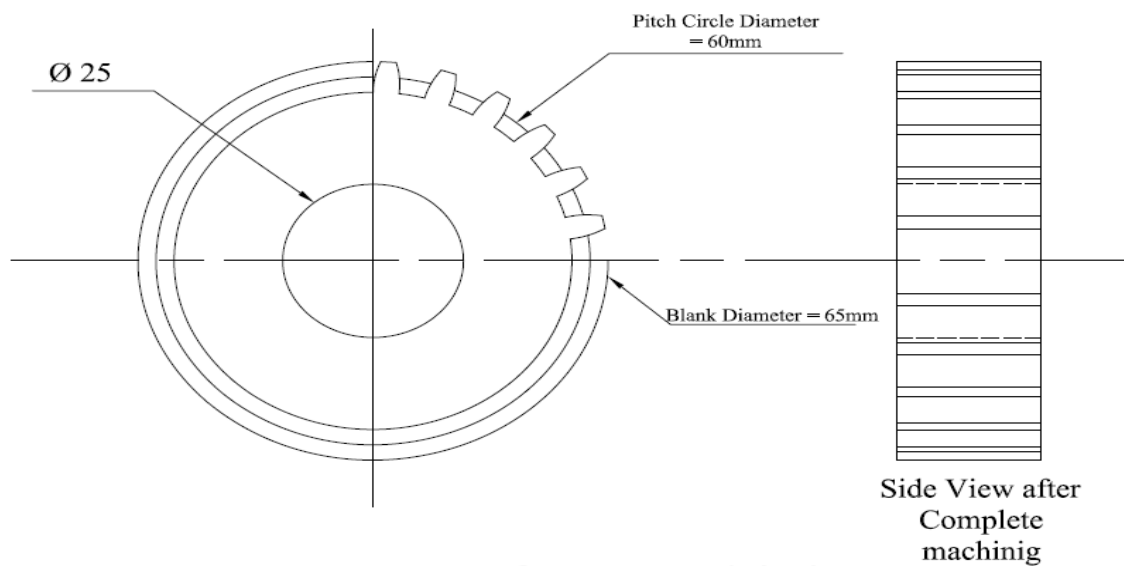
A Schematic representation of gear shaper is shown above with various parts

The main advantage of gear shaper is that the process can be used to make a variety of gears and the cycle time for producing one work piece is very less compared to many other processes. Close tolerances can be maintained

□ The main disadvantage is that there is no cutting in the return stroke. The process cannot be used to manufacture worm and worm wheel, which is a special type of gear.



Before Machining



After Machining

SPUR GEAR CUTTING IN GEAR SHAPER MACHINE

Aim: To machine the given gear blank into a spur gear in gear shaper machine

Apparatus Required:

- Gear Shaper Machine
- Shaper cutter

Material required:

- Cast iron blank

Procedure:

- The given gear blank is mounted on the work piece spindle
- The shaper cutter having the necessary cutting teeth in the shape if tooth spacing of the required work piece is mounted on the cutter spindle
- Necessary gear ratio is set between the work piece spindle and the cutter spindle for the purpose of indexing
- Machine is switched on and shaping process of the tooth spacing of the gear profile is done with the shaper cutter, in two to four passes per teeth. This feed motion is given during the return stroke
- With the indexing done through a gear train, the cutter gradually rotates and the work piece rotates in accordance with the cutter, as if they are two gears in mesh
- With one complete revolution of the work piece on its spindle the gear shaping process will be complete
- The dimensions of the gear teeth are checked using a gear tooth Vernier
- Result:** Thus the required spur gear is cut from the given blank by gear shaping process.

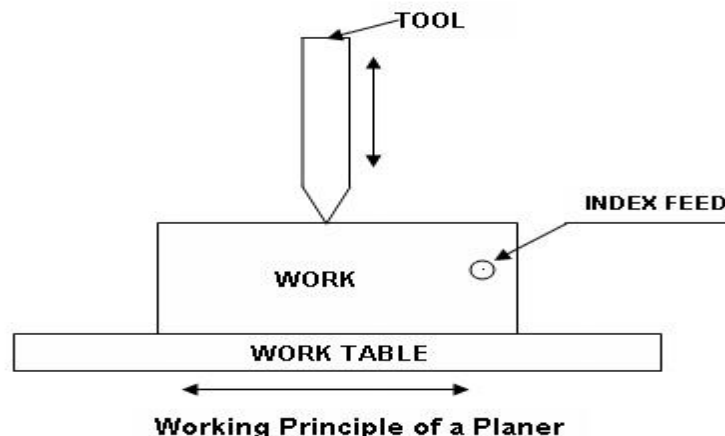
PLANING MACHINE

INTRODUCTION

Planing is one of the basic operations performed in machining work and is primarily intended for machining large flat surfaces. These surfaces may be horizontal, vertical or inclined. In this way, the function of a planing machine is quite similar to that of a shaper except that the former is basically designed to undertake machining of such large and heavy jobs which are almost impractical to be machined on a shaper or milling, etc. It is an established fact that the planing machine proves to be most economical so far as the machining of large flat surfaces is concerned. However, a planing machine differs from a shaper in that for machining, the work, loaded on the table, reciprocates past the stationary tool in a planer, whereas in a shaper the tool reciprocates past the stationary work.

WORKING PRINCIPLE OF A PLANER:

The principle involved in machining a job on a planer is illustrated in fig. Here, it is almost a reverse case to that of a shaper. The work is rigidly held on the work table or a platen of the machine. The tool is held vertically in the toolhead mounted on the cross rail. The work table, together with the job, is made to reciprocate past the vertically held tool. The indexed feed after each cut is given to the tool during the idle stroke of the table.



SPECIFICATIONS:

Horizontal distance between two vertical housings:
Vertical distance between table top and the cross rail: 800mm
Maximum length of table travel: 1350mm
Length of bed: 2025mm
Length of table: 1425mm
Method of driving – Individual
Method driving table – Geared
H.P. of motor: 3 H.P. & 1 H.P.

STANDARD OR DOUBLE HOUSING PLANER:

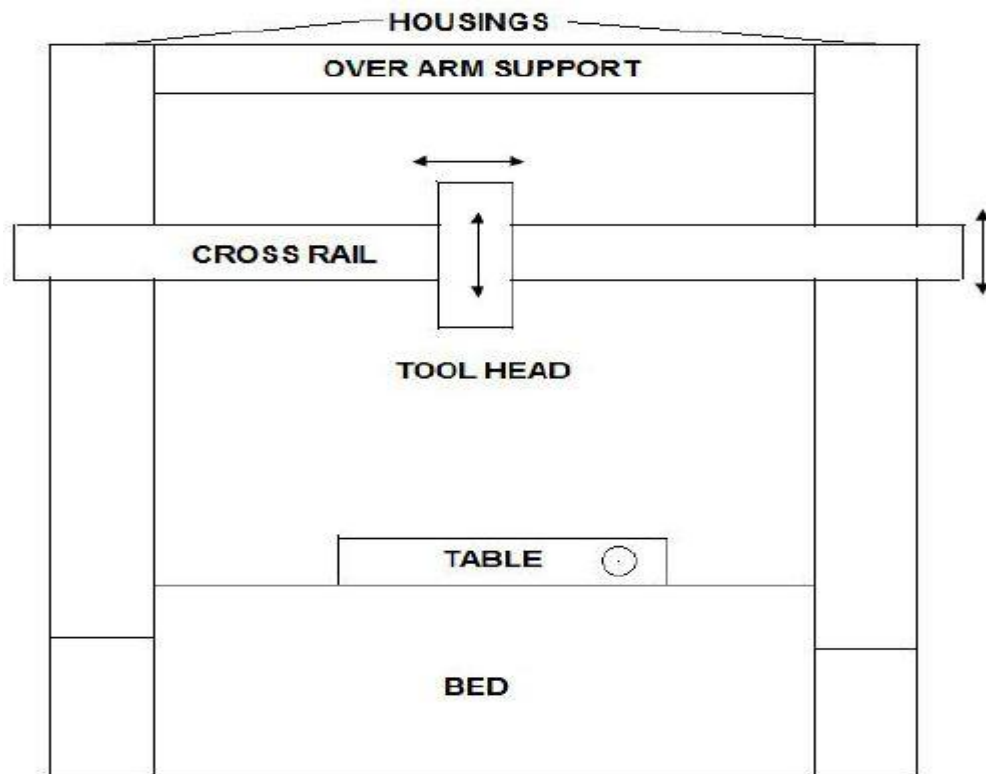
This is the most commonly used type of planer. It consists of two vertical housings or columns, one on each side of the bed. The housings carry vertical or scraped ways. The cross-rail is fitted between the two housings and carries one or two tool heads. The work table is mounted over the bed. Some planers may fit with side tool heads fitted on the vertical columns.

MAIN PARTS OF A PLANER

A planer consists of the following main parts as illustrated by means of a block diagram in fig.

- Bed
- Table
- Housings or columns
- Cross – rail
- Tool head
- Controls

These machines are heavy duty type and carry a very rigid construction. They employ high speeds for cutting but the size of work they can handle is limited to the width of their table i.e. the horizontal distance between the columns.



MAIN PARTS OF A PLANER

PLANING MACHINE



Extremely large and heavy castings, like machine beds, tables, plates, slides, columns, etc., which normally carry sliding surfaces like guide ways or dovetails on their longitudinal faces, are usually machined on these machines. Also because of long table and larger table travel, on either side of the columns, it is possible to hold a number of work pieces in a series over the bed length and machine them together. This will effect a substantial saving in machining time. Further because of no.of tool heads the surfaces can be machined simultaneously. This effects further reduction in machining time. Also because of high rigidity of high rigidity of the machine

and robust design of the cutting tools heavier cuts can be easily employed, which leads to quicker metal removal and reduced machining time. Thus an overall picture emerges that the employment of this type of machine apart from its capacity to handle such heavy and large jobs which are difficult to be handled on other machines, leads to faster machining and reduced machining time and hence to economical machining. However considerable time is used in setting up a planer.

DRIVE MECHANISMS:

Four different methods are employed for driving the table of a planer. They are:

- Crank drive
- Belt drive
- Direct reversible drive
- Hydraulic drive

SLOTTING

AIM:

To Make internal splines, space 90° apart on the given hollow cylindrical work piece by using slotting machine.

REQUIRED MATERIAL:

M.S. Hollow Cylindrical work piece of 65 mm diameter and 70 mm length

REQUIRED TOOLS:

H.S.S. Cutting tool, Adjustable wrench, Scriber

SPECIFICATION OF THE MACHINE:

Stroke 150 mm

Rotary table 275 mm

Longitudinal Movement 200 mm

Cross Movement 200 mm

Power of the motor 1 h.p.

THEORY:

A Slotting machine or slotter has its own importance for a few particular classes of work. Its main use is in cutting different types of slots and it certainly proves to be most economical so far as this kind of work is concerned. Its other uses are in machining irregular shapes, circular surfaces and other premarked profiles, both internal as well as external. Its construction is similar to that of vertical shaper. Its ram moves vertically and the tool cuts during the downward stroke only.

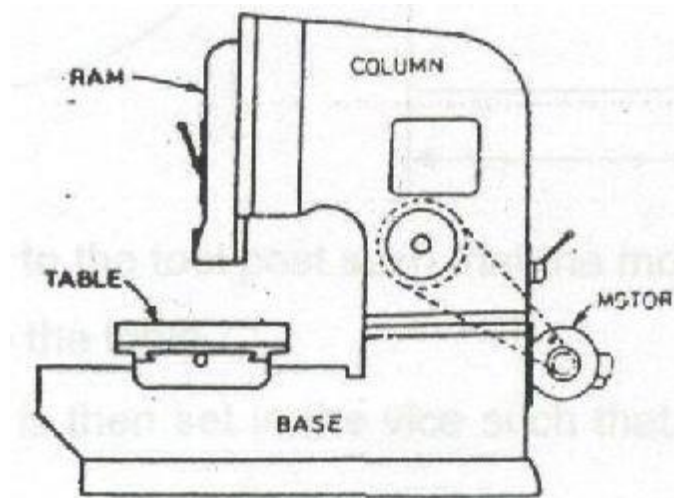


Fig. Main parts of a slotter.

Main Parts of a Slotter:

Base: It is heavy cast iron construction and is also known as bed. It acts as support for the column, the driving mechanism, ram, table and all other fittings. At its top it carries horizontal ways, along which the table can be traversed.

Column: It is another heavy cast iron body which acts as a housing for the driving mechanism. At its front carries vertical ways, along which the ram moves up and down.

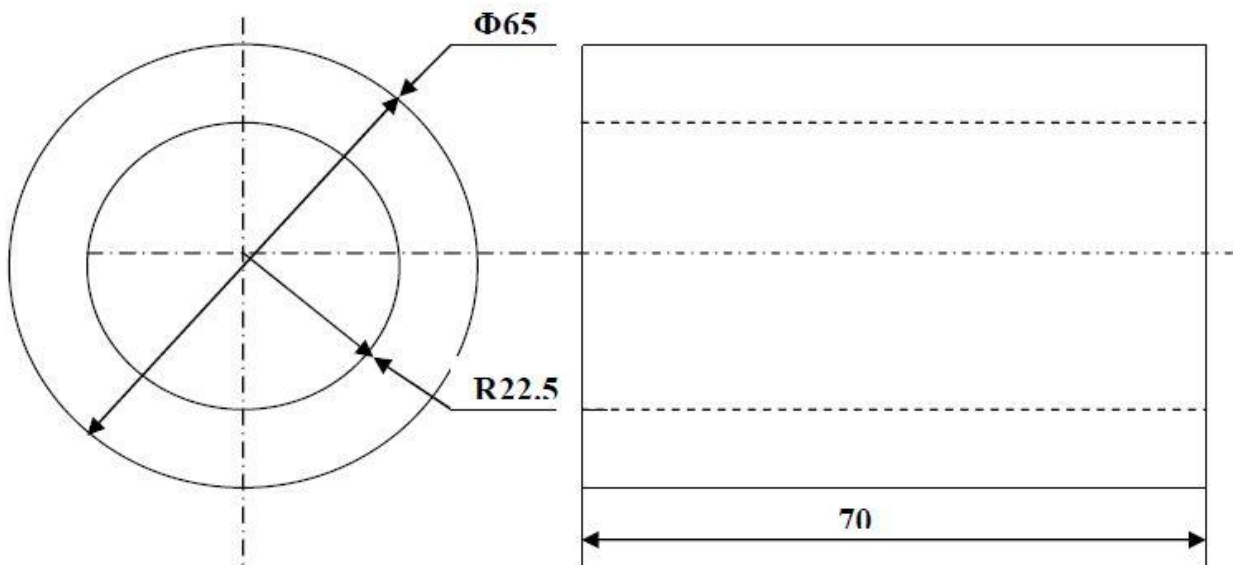
Table: Usually a circular table is provided on slotting machines. In some heavy duty slotters, either rectangular or circular table can be mounted. On the top of table are provided T- slots to clamp the work or facilitate the use of fixtures etc.

Ram: It moves in vertical direction on the guide ways provided in front of the column. At its bottom, it carries the tool post in which the tool is held. The cutting action takes place during the downward movement of the ram.



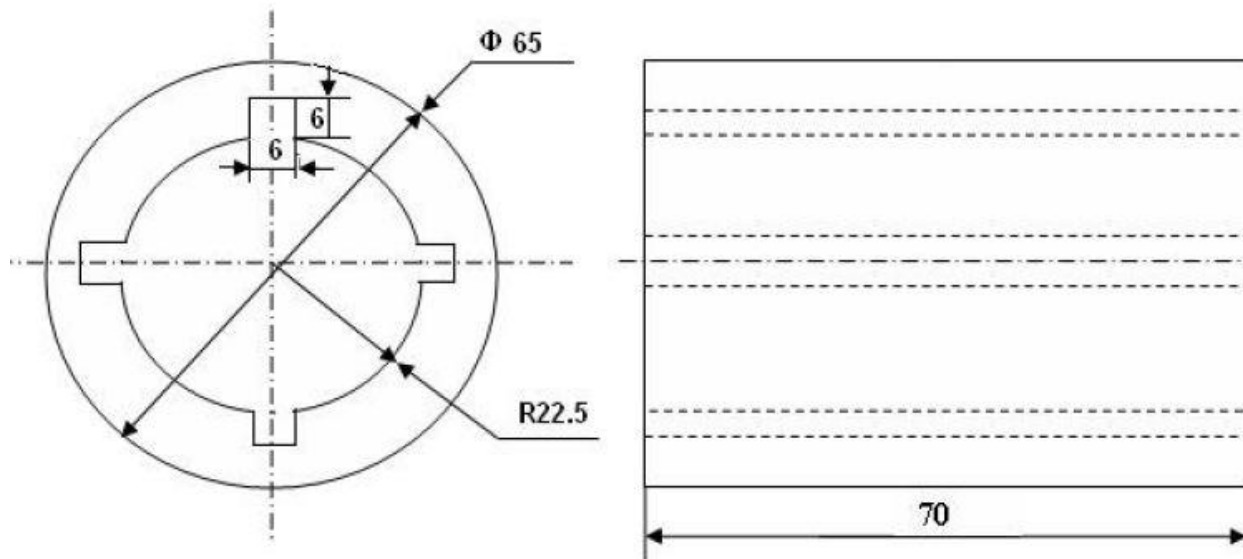
PROCEDURE:

GIVEN WORK PIECE



- The tool is fixed to the tool post such that the movement should be exactly perpendicular to the table.
- The work piece is then set in the vice such that the tool is just above the work piece. Adjust the length of the stroke of the ram.

REQUIRED WORK PIECE



ALL DIMENSIONS ARE IN MM

- Slotting operation is performed and make one slot on the work piece to the required dimensions.

- Then bring the tool to the initial position
- Rotate the work table by an angle 90° and continue the process for the second slot.
- Repeat the process for the remaining slots.

PRECAUTIONS:

- The work piece should be set securely and rigidly in the vice.
- Before starting the machine make sure that the work, vice, tool, and ram are securely fastened.
- Check that the tool and tool holder will clear the work and also clear the column on the return stroke.
- Make sure that the axis of the work piece is parallel to the line of action of tool.
- Never attempt to adjust a machine while it is in motion.
- Suitable feeds and depth of cut should be maintained uniformly.
- Always feed will be given to the work in the backward stroke only.

RESULT: The job is completed successfully and safely.

SURFACE GRINDING

Experiment No-04

INTRODUCTION:

It consists of the main driving motor situated over the housings. This motor drives the countershaft through an open V- belt. The countershaft, at its extreme carries two driving pulleys; one for open belt and the other for cross belt. The main driving shaft is provided below the bed. One end of it passes through the housing and carries a pinion, which meshes with the rack provided under the table of the machine as shown. The other end of this shaft carries two pairs of pulleys – each pair consisting of a fast pulley and loose pulley. One of these pairs is connected to one of the driving pulleys by means of a open belt and the other to the second driving pulley by means of a cross belt. A speed reduction gear box is mounted on the main driving shaft and the same is incorporated between the pinion and the pairs of driven pulleys. One set of the above pulleys is used for the forward motion of the table and the other set for backward or return motion. the cross belt will be used for forward motion and the open belt for return motion. Note that the driving pulley on the counter shaft for cross belt is smaller than the pair of fast and loose pulleys for the same. Against this the driving pulley on the countershaft for open belt is bigger than the pair of fast and loose pulleys for the same. Consequently therefore for the same speed or number of revolutions of the countershaft the main driving shaft will run faster when connected by open belt than when the cross belt is used. It is obvious therefore that the return stroke will be faster than the forward stroke. It should also be noted here that the pulleys are so arranged that when the cross belt is on the fast pulley, i.e. in forward stroke the open belt will be on the loose pulley and its reverse will take place during the return stroke. In order that this relative shifting of belt may take place automatically at the end of each stroke, without stopping the machine, a belt shifter and its operating lever are provided on the machine. Trip dogs are mounted one each at both ends, on the table. At the end of each stroke these dogs strike against the operating lever alternately and the belt shifted accordingly. Thus the table movement is reversed automatically.

OPERATION DONE ON A PLANER:

The common operations performed on a planer include the following:

- Machining horizontal flat surfaces.
- Machining vertical flat surfaces.
- Machining angular surfaces, including dovetails.
- Machining different types of slots and grooves.
- Machining curved surfaces.
- Machining along premarked contours.

PLAIN SURFACE GRINDING

Aim: To perform plain surface grinding on the given work piece to the required dimensions

Apparatus required:

- Grinding machine
- Grinding Wheel
- Vernier Calliper

Material Required:

- MS / CI plate 12mm X 50mm X 75mm



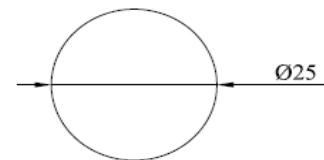
Procedure:

- First the work piece is placed on the magnetic chuck
- The positioning of the work piece is aligned at right angles to the grinding wheel and exactly parallel to the sides of the magnetic chuck by using slip gauges if necessary
- The magnetic chuck is switched on and the powerful electromagnet holds the job firmly in position
- Now the spindle is turned on and the grinding wheel is just touched the work piece surface to mark its zero / reference position
- Now the required feed, either totally or in steps, is given to the grinding wheel and the wheel is traversed all over the work piece
- Same procedure is repeated until the required dimensions are achieved
- Care should be taken for maintaining the surface finish
- Finally the dimensions are checked using either a Vernier calliper or a screw gauge.

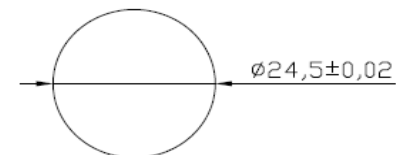
Result: Thus plain surface grinding is performed on the given work piece up to the required Dimensions.



Before Grinding



After Grinding



CYLINDRICAL GRINDING

Aim: To grind the cylindrical surface of the given work piece by cylindrical grinding

Apparatus Required:

- Grinding machine
- Cylindrical grinding wheel setup
- Steel Rule
- Vernier Calliper

Materials Required:

- Cast iron work piece

CYLINDRICAL GRINDING
MACHINE



Procedure:

- First the given work piece is preliminarily finished to the pre-required dimensions on a lathe before beginning the grinding process
- Now the work piece is fitted in the chuck of the cylindrical grinding machine
- The grinding wheel is just touched with the work piece and is taken as the zero reference
- Coolant circulation is switched on and the grinding wheel is engaged with the work piece.
- Both the work piece and the grinding wheel roll on contact with each other like two gears in mesh
- Now slowly the wheel is moved over the entire length of the work piece to get the grinded finish
- After one feed is over, the grinding wheel is moved further towards the axis of the work piece and the process is repeated until the required dimensions are achieved
- Finally the dimensions are checked using a Vernier calliper

Result: Thus cylindrical grinding is performed on the given work piece to the given dimensions.

TOOL DYNAMOMETERS

Experiment No-05

AIM:

To study the Lathe Tool Dynamometer and Drill Tool Dynamometer and determine the Resultant force act on the tool during turning operation and also estimate the force and thrust required to perform drilling operation.

APPARATUS REQUIRED:

Lathe tool Dynamometer and Drill tool dynamometer.

TOOLS & MATERIAL REQUIRED:

HSS tool with tool holder, $\Phi 25$ mm MS bar, and 10mm thick MS flat and 10mm drill.

THEORY:

In machining or metal cutting operation the device used for determination of cutting forces is known as a Tool Dynamometer or Force Dynamometer. Majority of dynamometers used for measuring the tool forces use the deflections or strains caused in the components, supporting the tool in metal cutting, as the basis for determining these forces. In order that a dynamometer gives satisfactory results it should possess the following important characteristics:

- It should be sufficiently rigid to prevent vibrations.
- At the same time it should be sensitive enough to record deflections and strains appreciably.
- Its design should be such that it can be assembled and disassembled easily.
- A simpler design is always preferable because it can be used easily.
- It should possess substantial stability against variations in time, temperature, humidity etc.
- It should be perfectly reliable.
- The metal cutting process should not be disturbed by it, i.e. no obstruction should be provided by it in the path of chip flow or tool travel.

Types of Dynamometers:

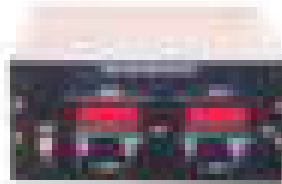
Irrespective of their design and the technique used for strain measurement, most of the force dynamometers used today carry a measuring system which is precalibrated for its stiffness. The cutting forces are measured by these dynamometers by measuring the strain or deflection caused in this system due to the force under measurement. The different types of commonly used dynamometers can be broadly classified as:

- Mechanical dynamometers
- Strain Gauge type dynamometers
- Pneumatic and Hydraulic dynamometers
- Electrical Dynamometers
- Piezoelectric dynamometers

Lathe



Drill



Tool Dynamometers

PROCEDURE:

Lathe Tool Dynamometer:

Lathe tool dynamometer is used to measure cutting forces acting at the machining zone during turning with a single point cutting tool. All the three directional forces are measured simultaneously.

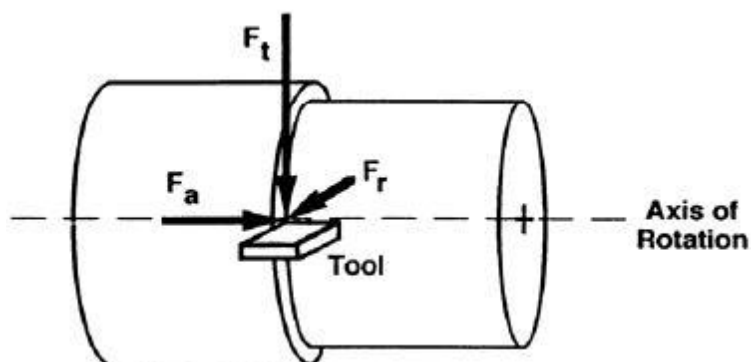
Forces on a single point tool in turning:

In case of oblique cutting in which three component forces act simultaneously on the tool point as shown. The components are:

F_t = The feed force or thrust force acting in horizontal plane parallel to the axis of the work.

F_r = The radial force, also acting in the horizontal plane but along a radius of Work piece i.e. along the axis of the tool.

F_c = The cutting force, acting in vertical plane and is tangential to the work surface. Also called the tangential force.



- The work piece is fixed in a 3-jaw chuck with sufficient overhang.
- Fix the dynamometer cutting tool in the tool post in such away that the tip of the tool coincides with the lathe axis.

- Select proper cutting speed, feed and depth of cut.
- Perform turning operation on the work.
- Directly measure the three components of forces acting on the tool using
- lathe tool dynamometer.
- Repeat the procedure for varying the above three parameters (CS, F & DC).
- The resultant force can be calculated by

$$R = \sqrt{F_c^2 + F_t^2 + F_r^2}$$

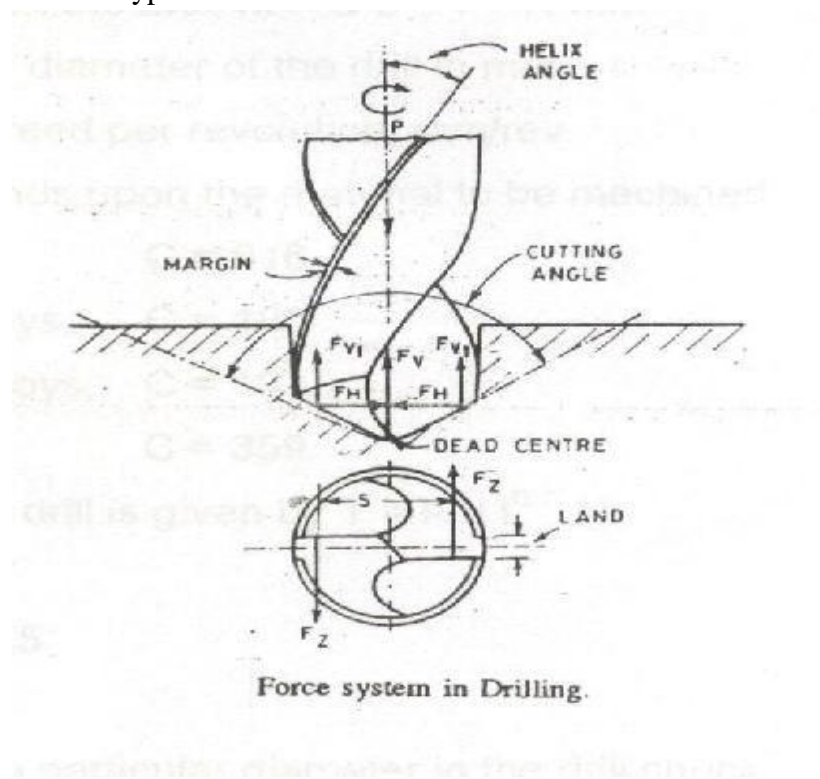
Observe the effect of cutting speed, feed and depth of cut on force.

Drill Tool Dynamometer:

This is strain gauge Drill Tool Dynamometer designed to measure thrust and torque during drilling operation. This dynamometer is suitable for drilling a hole up to 25mm size in Mild Steel. Drilling tool dynamometer is a Rigid in construction, Compact Unit, Easy in handling and Assessment of cutting forces by giving due consideration to various parameters like depth of cut, material, speed and feed.

Force system in drilling:

During the process of drilling a lot of axial pressure (Thrust force) is applied on it in order to make it penetrate into the material. On account of this pressure all the drill elements are subjected to one or other type of force.



The principal forces are:

F_H – An equal and opposite horizontal force acting on both lips of the drill and thus neutralizing each other.

F_v - Vertical force acting at the centre of the drill in a direction opposite to that of the applied pressure.

F_{v1} - Vertical force acting in the same direction as F_v , on the lips of the drill it is the main cutting force in the operation.

F_{f1} - Frictional force due to rubbing of upward flowing chips against wall of the hole and flutes of the drill.

F_{f2} - frictional force due to rubbing between the drill margin and the hole surface.

P – The applied axial pressure or thrust force acting along the axis of drill to press it into the work piece material.

In order that the drill penetrates into the work piece the applied pressure P , should be able to overcome all the resistive forces acting against it.

$$P > (F_v + 2F_{v1} + F_{f1} + F_{f2})$$

It is reckoned that as compared to F_v and F_{v1} the magnitudes of the frictional forces F_{f1} and F_{f2} are too small to be considered for practical purposes. Hence they are considered negligible.

$$\text{Therefore } P = F_v + 2F_{v1}$$

Thrust force acting on the drill, $M = C d^{1.9} f^{0.8}$ N-mm

Where d is the diameter of the drill in mm

f is the feed per revolution, mm/rev

C is a constant depends upon the material to be machined

For Steel, $C = 616$

Aluminium alloys, $C = 180$

Magnesium alloys, $C = 103$

Brasses, $C = 359$

Torque acting on the drill is given by $T = K d f^{0.7}$ N

For Steel, $K = 84.7$

Cast Iron = 60.5

- Fix the drill of a particular diameter in the drill chuck.
- Fix the work piece in vice mounted on the bed of the machine.
- Attach the drill tool dynamometer to the machine.
- Perform drilling operation on the work.
- Note down the values of thrust force and torque acting on the drill directly from drill tool dynamometer.
- Repeat the procedure by varying the speed, feed and depth of cut of the drill.
- Observe how these parameters will effects the force and torque.

PRECAUTIONS:

- The tool should be rigidly mounted on the lathe tool post.

- Make sure that there should not be any vibrations in the tool.
- Readings should be noted carefully.
- Select the cutting speed, feed and depth of cut properly.

RESULT: The job is completed successfully and safely.

UNCONVENTIONAL MACHINING PROCESSES

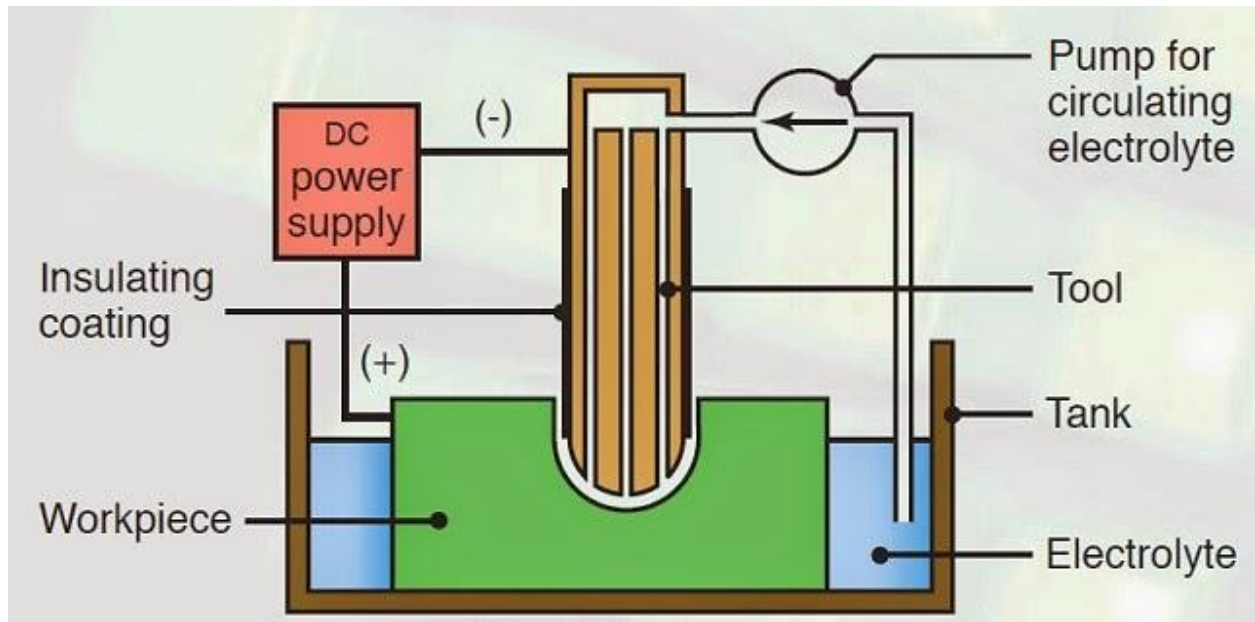
Experiment No-06

INTRODUCTION:

New machining methods have been developed mainly because of the difficulties in machining hard, high-strength, and temperature-sensitive materials. These processes have been used for removing excess materials from the work piece to obtain the desired shape and size and have come to be known as unconventional machining processes. Table 1 lists these processes and indicates the types of energies and methods of material removal.

Table 1 Unconventional machining processes

Energy type	Mechanics of material removal	Energy source	Process
Mechanical	Plastic shear	Mechanical motion of tool/job	Conventional Machining
	Erosion	Mechanical/ fluid motion	Abrasive jet machining (AJM) Ultrasonic machining (USM)
Electrochemical	Ion displacement	Electric current	Electrochemical machining (ECM)
Mechanical and electro-chemical	Plastic shear and ion displacement	Electric current and mechanical motion	Electrochemical grinding (ECG)
Chemical	Corrosive Reaction	Corrosive agent	Chemical machining (CHM)
	Fusion and vaporization	electric spark High speed electrons	Electric discharge machining (EDM) Electron beam machining (EBM)
Thermal		Powerful radiation Ionized substance	Laser beam machining (LBM) Ion beam machining (IBM) Plasma arc machining (PAM).



Electro-chemical Machining

The electrochemical machining process is illustrated in above Fig. The workpiece (Which must be a conductor of electricity) is placed in a tank on the machine table and connected to the positive terminal of a dc supply. The tool electrode, shaped to form the required cavity in the workpiece, is mounted in the tool holder and connected to the negative terminal of the supply. An electrolyte flows through the gap between the tool and the work piece and is then pumped back to the working zone; either through the tool or externally, depending on the application.

The action of the current flowing through the electrolyte is to dissolve the metal at the anode, i.e., the workpiece. The electrical resistance is lowest (and hence the current is highest) in the region where the tool and workpiece are closest. Since the metal is dissolved from the workpiece most rapidly in this region, the form of the tool will be reproduced on the workpiece.

There is no mechanical contact between the workpiece and the tool, and any tendency of the workpiece metal to be plated on the tool is counteracted by the flow of the electrolyte, which removes the dissolved metal from the working zone. Hence there is neither tool wear nor plating of the workpiece material on the tool so that one tool can produce a large number of components during its life. The voltage and current are constant in the electrochemical machining process.

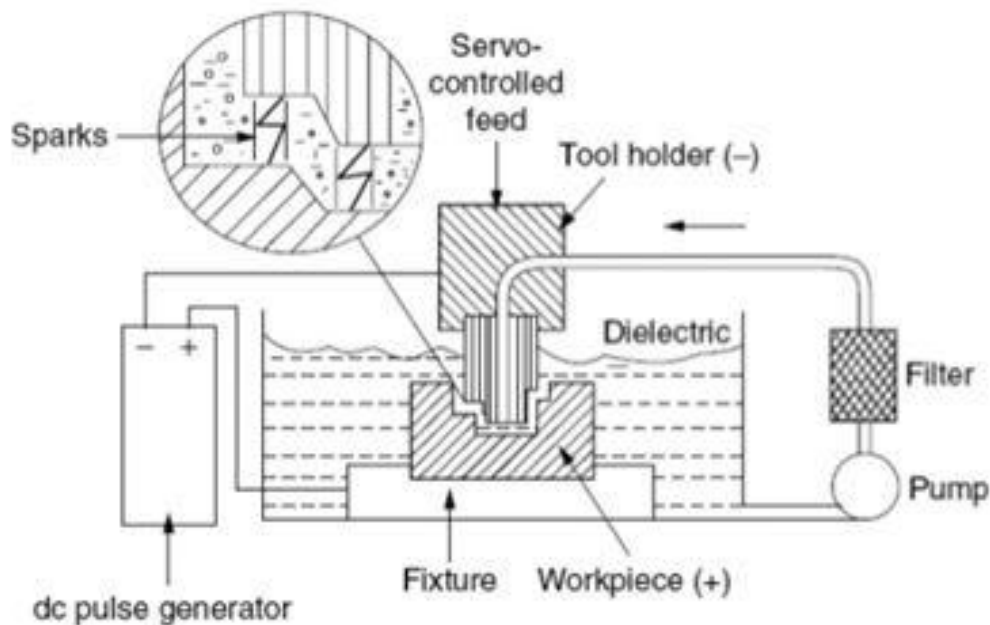
SUMMARY OF ECM CHARACTERISTICS

- Mechanics of material removal : Electrolysis
- Medium : Conducting electrolyte
- Tool Materials : Cu, brass, steel
- Gap : 50-300 μm
- Maximum material removal rate: $15 \times 10^3 \text{ mm}^3/\text{min}$
- Specific power consumption (typical) : $7 \text{ W/mm}^3/\text{min}$
- Critical parameters: Voltage, current, feed rate, electrolyte, and electrolyte conductivity
- Material application: All conducting metals and alloys

Shape application: Blind complex cavities, curved surfaces, through cutting, large through cavities

Limitations: High specific energy consumption (about 150 times that required for conventional processes), not applicable with electrically non-conducting materials and for jobs with very small dimensions, expensive machine.

ELECTRIC DISCHARGE MACHINING (EDM)



Electro discharge machining (EDM) Diagram

Electric-discharge machining (EDM), or spark machining, as it is also called, is based on the eroding effect of an electric spark on both the electrodes used to produce it. It has been found *from* observation that if both electrodes are made of the same material, greater erosion occurs on the positive electrode. Hence, to obtain maximum metal removal with minimum wear on the tool' electrode; the work is made the positive and the tool the negative electrode. The principle of the electric-discharge machining process is illustrated by the simplified diagram in Fig. 4. The tool is mounted on the chuck attached to the machine spindle whose vertical feed is controlled by the servomotor through a reduction gearbox; The workpiece is placed in a tank filled with a dielectric fluid; a depth of at least 50mm over the work surface is maintained to eliminate the risk of fire: The tool and work piece are connected to a dc relaxation circuit fed either from a dc generator, or more commonly, a mercury-arc or selenium-type rectifier. Dielectric fluid is circulated under pressure by a pump, usually through a hole (or holes) in the tool electrode. A spark gap of about 10-125 μm is maintained by the servomotor.

When the power supply is switched on, the condenser voltage V_c begins to increase exponentially toward the supply voltage V_s and no current flows. As the voltage V_c builds, it reaches the gap breakdown voltage V_g (determined by the gap width and the dielectric fluid); a spark is produced across the gap, the dielectric fluid ionizes and the condenser is discharged. The surrounding dielectric then deionizes so that it again becomes an effective insulator, and the

cycle is repeated. In this way a rapid succession of sparks is obtained, the interval between successive sparks being of the order of $100\mu\text{s}$.

Each spark generates a localized high temperature of the order of 12000°C in its immediate vicinity. This heat causes part of the surrounding dielectric fluid to evaporate; it also melts and vaporizes the metal to form a small crater on the work surface. Since the spark always occurs between the points of the tool and work that are close together, the high spots of the work are gradually eroded, and the form of the tool is reproduced on the work. The condensed metal globules, formed during the process, are carried away by the flowing dielectric fluid. As the metal is eroded, the tool is fed in by a servo controlled feed mechanism.

SUMMARY OF EDM CHARACTERISTICS

Mechanics of material removal Melting and evaporation aided by cavitations

Medium Dielectric fluid

Tool Materials Cu, brass, Cu-W alloy, graphite

Maximum material removal rate $5 \times 10^3 \text{ mm}^3/\text{min}$

Specific power consumption (typical) $1.8 \text{ W}/\text{mm}^3/\text{min}$

Material application All conducting metals and alloys

Shape application Blind complex cavities, micro holes for nozzles, through cutting of non-circular holes, narrow slots.

Limitations : High specific energy consumption (about 150 times that in conventional machining); when forced circulation of dielectric is not possible, removal rate is quite low; surface tends to be rough for larger removal rates not applicable to nonconducting materials.