WORKSHOP PRACTICE

LABORATORY MANUAL

DEPARTMENT OF MECHANICAL ENGINEERING

LAB INCHARGE:

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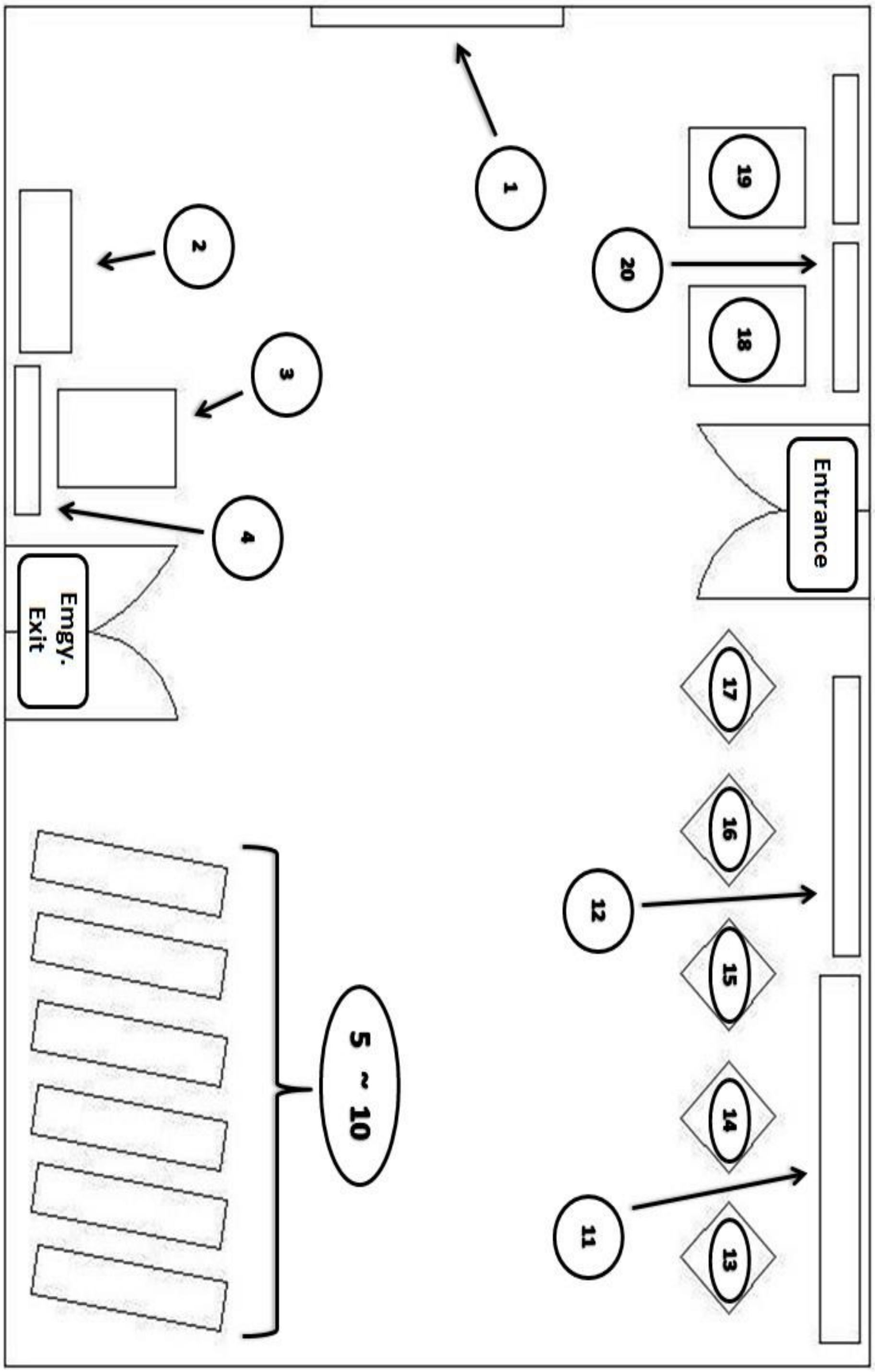
LAHORE (CITY CAMPUS)

Preface

In most of the engineering institutions, the laboratory course forms an integral form of the basic lab at undergraduate level. The experiments to be performed in a laboratory should ideally be designed in such a way as to reinforce the understanding of the basic principles as well as help the students to visualize the various phenomenon encountered in different conventional machining operations.

The objective of this manual is to familiarize the students with practical skills, hands on practice of machining and interpretation of results. It is intended to make this manual self-contained in all respects, so that it can be used as a laboratory manual.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LAY OUT OF MACHINE SHOP

Sr. #	**Name**
1	**White Board**
2	**Tool Cabinet**
3	**Working Table**
4	**Notice Board**
5 to 10	**Center Lathe Machines**
11	**Material Store Cabinet**
12	**Tool Display Board**
13	**Milling Machine**
14	**Surface Grinding Machine**
15	**Shaper Machine**

16	**Vertical Drilling Machine**
17	**Bench Tool Grinder**
18	**CNC Turning Center**
19	**CNC Milling Center**
20	**Tool Display Board**

Lab Safety Instructions

Never eat, drink, or smoke while working in the laboratory.	
Use of mobile phone is not allowed in the premises of lab	
Obtain permission before operating any high voltage equipment.	
Do not stand near rotating elements with loose fitting clothes. Do not touch any rotating/translating element. Do not try to stop energised machine with hand.	

LIST OF EXPERIMENTS:

1.Introduction & Layout of Lab.
2.To investigate the single-point cutting tool.
3.To investigate the multi-point cutting tool.
4.To investigate the characteristic features of Lathe machine + (Lab Assignment)
5.To determine the effect of length/diameter ratio on accuracy of machining by varying depth of cut.
6.To determine the effect of length/diameter ratio on accuracy of machining by varying the diameter of workpiece.
7.To determine the variation of power with depth of cut, feed, spindle speed and rake angle
8.To investigate the characteristic features of Shaper
9. 10.To investigate the characteristic features of Milling machine.
10.To machine a spur gear by Milling machine.

LAB

EVALUATION criteria

Total = 50 Marks

Lab Assignment	05Marks
Lab Performance /Experiment	10Marks
Mid-term Lab Performance	10Marks
Final-term. Lab Performance	10Marks
Lab Manual	15Marks

Note to the Students:

Internal Assessment marks will be based on the performance of the student in the lab and the punctuality of the student along with the behavior of the individual. If found not punctual to the lab, the shortage of attendance will be coincided severely.Every time the student should bring the lab manual cum record to the lab. Students should behave according to the rules and procedure of the lab with all conditions.

EXPERIMENT # 1

To investigate the single-point cutting tool

Scope:-

To study the nomenclature, geometry, materials and how to grind the single-point cutting tool of a Lathe machine

Theory:-

Machining is the process of removing unwanted material from a work piece in the forms of chips. If the work piece is metal, the process is often called metal cutting or metal removal .Vast majority of manufactured products require

machining at some stage in their production. There are seven basic chip formation processes which are turning,

milling, drilling, sawing, broaching, shaping and grinding. Among these processes turning and shaping use single

point cutting tool while rest of the processes uses multipoint cutting tool. In this experiment we will study single-

Point cutting tool of a lathe machine.

1. Lathe Tool Nomenclature:-

Cutting tools used on a lathe machine are generally single - point, and although the shape of the tool is changed

for various applications, the same nomenclature applies to all cutting tools.

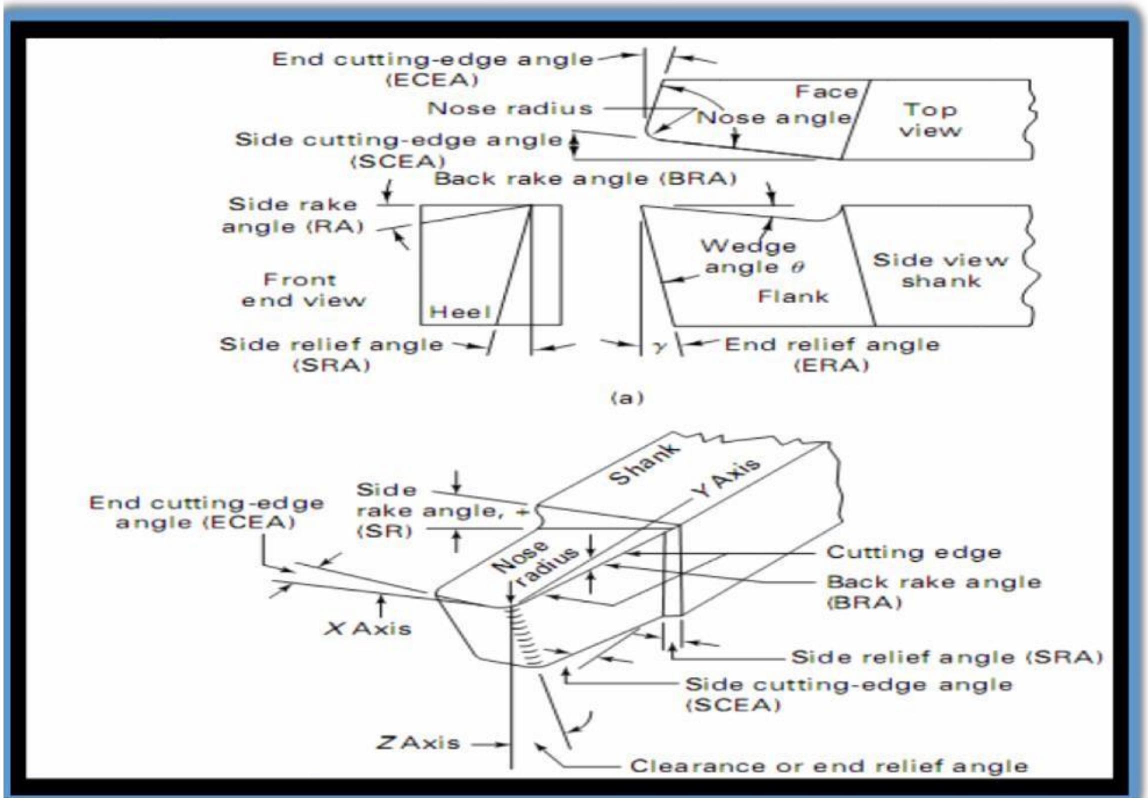


Figure 1.1: Single point cutting tool

Shank is that part of the tool bit which is not ground to form cutting edge. Shank is rectangular in cross-section and is the portion of the tool bit which is held in the tool holder.

Point or Tool Tip is end of the tool, which is shaped to produce the cutting edges and face.

Base is the bottom surface of tool and takes the tangential pressure of the cut.

Face is that surface against which the chip slides.

Flank: The flanks are the surfaces below and adjacent to the cutting edges. These are the surfaces of the tool facing the work.

Cutting Edge: It is the edge on face of the tool which removes the material from work piece. The cutting edge usually comprises the nose radius, the side cutting edge, and the end cutting edge.

The Side (Primary) Cutting Edge: This is the edge formed by intersection of the tool face and side flank. It is mainly responsible for shearing of the work material during cutting. **The End (Auxiliary) Cutting Edge:** This is the edge formed by intersection of the tool face and end flank.

Nose: The nose of a tool is the conjunction of the side and end cutting edges **Heel:** It is the intersection of the flank and the base of the tool.

2. Lathe Tool Angles and Clearances:-

Proper tool bit performance depends on the clearances and angles, which must be ground on the tool bit. Although these angles vary for different materials, the nomenclature is same for all tool bits.

The side cutting edge angle is the angle the cutting edge forms with the side of the tool shank. Side cutting edge angles for general purpose lathe cutting tool may vary from 10° to 20° depending on the material to be cut. If the angle is too large (over 30°) the tool will tend to chatter.

The end cutting edge angle is the angle formed by the end cutting edge and a line at right angle to the centerline of the tool bit. The angle may vary from 5° to 30°, depending upon the type of the cut and the finish desired. An angle of 5° to 15° is satisfactory for roughing cuts and angles 15° to 30° are used for general purpose turning tools.

The side relief (clearance) angle is the angle ground on the side flank of the tool below the side cutting edge. This angle is generally 6° to 10°. The side clearance on the tool bit permits the cutting tool to advance lengthwise into the rotating work and prevents the flank from rubbing against the work piece.

The end relief (clearance) angle is the angle ground on the end flank below the end cutting edge and it permits the cutting tool to be fed into the work. It is generally 10° to 15° for general purpose tools. The end relief angle varies with the hardness and the type of material and the type of cut. The end relief angle is smaller for harder materials, providing support under the cutting edge.

The side rake angle is the angle at which the face is ground away from the side cutting edge. For general purpose tool bits, the side rake is generally 14°. Side rake creates a keener cutting edge and allows the chips to flow away quickly. For softer materials, the side rake angle is generally increased. Side rake angle may be either positive or negative, depending on the material being cut.

The back rake angle is the backward slope of the tool face away from the nose. The back rake angle is generally about 20°. Back rake permits the chips to flow away from the point of cutting tool.

The angle of keenness is the included angle produced by grinding side rake and side clearance on a tool bit. This angle may be altered; depending on the type of material machined, and will be greater (closer to 90°) for harder materials.

Types of Rake Angles:-

Rake angle (side and back) may be either positive, negative or zero.

Positive rake angle is when the cutting edge contacts the metal first and the chip moves down the face of the tool bit. Positive rake angle is considered best for the efficient removal of metal. It reduces friction, heat and power consumption and allows the chip to flow freely along the chip-tool interface. Positive rake angle cutting tools are generally used for continuous cuts on ductile materials that are not too hard or abrasive. Positive rake-angle tools are not suitable for hard materials as the large stresses on the cutting edge will cause the cutting edge to break.

Negative rake angle is when the face of the cutting tool contacts the metal first and the chip is forced up the face of the tool bit. Negative rake angle causes less heat, friction and power loss. Since the cutting operation is performed by the face of the tool , the forces are distributed over an area (contrary to positive rake angle cutting tools in which the forces are distributed over cutting edge) causing less stresses on the face of negative rake-angle tools as compared to stresses on cutting edge in positive rake-angle tools. As a result it is used for interrupted cuts and when the metal is hard, tough or abrasive.

Zero Rake Angle has properties between that of positive rake angle and negative rake angle.

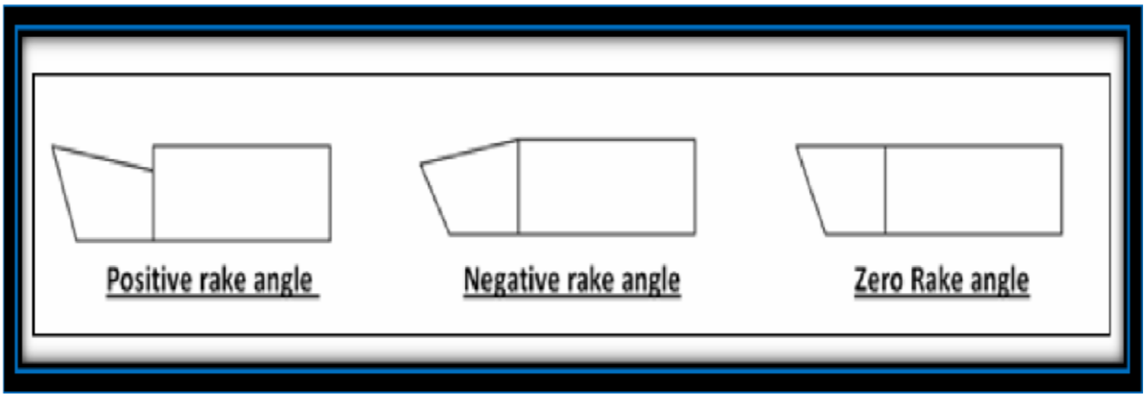


Figure 1.2: Types of rake angles

3. Tool Materials:-

The selection of proper tool material depends on the type of service to which the tool will be subjected. No one material is superior in all respects, but rather each has certain characteristics which limits its field of applications. In general the material of cutting tool must have the following characteristics to do the cutting operations properly.

1. High hardness
2. High Hot hardness
3. High toughness
4. High modulus of elasticity
5. Resistance to abrasion, wear due to severe sliding friction
6. Good chemical stability

Brief description of materials that are used to make lathe tool bits is given below. These materials include Carbon Steels, Medium Alloy Steels, High Speed Steels, Stellites, Cemented Carbides, Ceramics, Cermet’s and Diamonds.

Carbon Steels:-

Carbon steels contain carbon in amounts ranging from 0.80 to 1.50%. A disadvantage of carbon tool steel is their comparatively low-heat and wear resistant. They lose their required hardness at temperatures from 200° to 250° Celsius. Therefore they may only be used in manufacture of tools operating at low cutting speeds (about 12m/min) and for hand operated tools. But they are comparatively cheap, easy to forge and easy to harden.

Medium Alloy Steel:-

The high carbon medium alloy steels have carbon content akin to plain carbon steels but in addition there is, say, up to 5% alloy content consisting of tungsten, molybdenum, chromium and vanadium. Some additions of one or more of these elements improves the performance of carbon steels in respect of hot hardness, wear resistance, shock ,impact resistance and resistance to distortion during heat treatment. The alloy carbon steel, therefore, broadly occupy a midway performance position between plain carbon steel and high speed steel. They lose their required hardness at temperatures from 250 to 350° Celsius. **High Speed Steels:-**

High Speed Steel (HSS) is a general purpose metal for low and medium cutting speeds owing to its superior hot hardness and resistance to wear. High speed steels operate at cutting speeds 2- 3 times higher than for carbon steels and retain their hardness up to about 900° Celsius. There are generally 3 types of high speed steels; high tungsten, high molybdenum and high cobalt. Tungsten in HSS provides hot hardness and form stability, molybdenum and vanadium maintains keenness of the cutting edge, while addition of cobalt improves hot hardness and makes the cutting tool more wear resistant.

Stellites:-

Stellite is the trade name of a non-ferrous cast alloy composed of cobalt, chromium and tungsten. The range of elements in these alloys is 40-48% cobalt, 30-35% chromium and 12-19% tungsten. In addition to one or more carbide forming elements, carbon is added in amounts of 1.8-2.5%. They cannot be forged to shape, but may be deposited directly on the tool shank in an oxyacetylene flame; alternately, small tips of cast satellite can be brazed into place. Stellite preserves hardness up to 1000° Celsius and can be operated on steel at cutting speeds 2 times higher than for high speed steel. These materials are not widely used for metal cutting since they are very brittle. They are mostly used in some non-metal cutting applications such as rubber and plastics.

Cemented Carbide:-

Cemented Carbides are so named because they are composed principally of carbon mixed with other elements. The basic ingredients of most cemented carbides are tungsten carbide which is extremely hard. Boron, Titanium and Tantalum are also used to form carbides.

The amount of Cobalt used will regulate the toughness of tool. A typical analysis of carbide suitable for steel machining is 82 % tungsten carbide, 10 % titanium carbide and 8 % cobalt. Carbide tools are made by brazing or silver soldering. The most important properties of cemented carbides are their very high red hardness, heat resistance and wear resistance. Cemented carbide tool tips can machine metals even when their cutting elements are heated to a temperature of 1000° Celsius. They can withstand cutting speed 6 or more than 6 times higher than those of tools of high speed steels. Cemented carbide is the hardest manufactured material and has extremely high compressive strengths. However it is very brittle has low resistance to shock and must be very rigidly supported to prevent cracking. The two types of cemented carbides that are used are tungsten type cemented carbide and tungsten titanium type cemented carbide.

Ceramics:-

Ceramic is a heat resistant material produced without a metallic bonding agent such as cobalt. Aluminum oxide is the most popular material used to make ceramic cutting tools. Titanium oxide or titanium carbide may be used as an additive, depending on the cutting tool application. Ceramic tools permit higher cutting speeds, increased tool life and better surface finish than carbide tools. Furthermore they have low heat conductivity and high compressive strength. However they are brittle and much weaker than the carbide or coated carbide tools and must be used in shock free or low shock situations.

Cermets:-

Cermet is a cutting tool insert composed of ceramics and metal. Most cermets are made from aluminum oxide, titanium carbide and zirconium oxide compacted and compressed under intense heat. The advantages of cermet tools are that they exceed the equivalent tool life of coated and uncoated carbides, they can be used for machining at high temperatures, they produce an improved surface finish which eliminates the need for grinding and provides greater dimensional control and they may be used to machine steel of up to 45 Rockwell hardness.

Diamond:-

Diamond is the hardest known material and can be run at cutting speeds 50 times greater than HSS tools and at temperatures up to 1650° Celsius. In addition to its hardness, diamond is incompressible, is of large grain structure, readily conducts heat and has a low coefficient of friction. Diamonds tools are used mainly to machine nonferrous metals, glass, plastics, ceramics and abrasive materials for producing fine finishes.

4. Grinding Lathe Tools:-

We will use a simple four-step procedure to make our cutting tool

1. Grind the end relief
2. Grind the left side relief
3. Grind the top rake
4. Round the tip

Grinding the End Relief:-

First we will grind the end of the tool blank. Use the coarse wheel of your bench grinder and hold the tool blank angled downwards from the tip to the rear and with the tip pointing to the left about 10-15 degrees.. The tip of the tool blank should be a little below the center line of the wheel. Remember to use a **wheel-dressing tool** from time to time to freshen up the surface of the grinder wheels. Doing so will make the job of tool grinding go more quickly and with a better result?

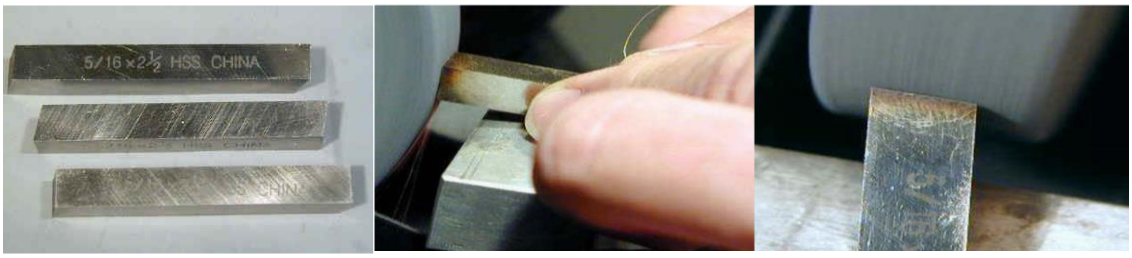
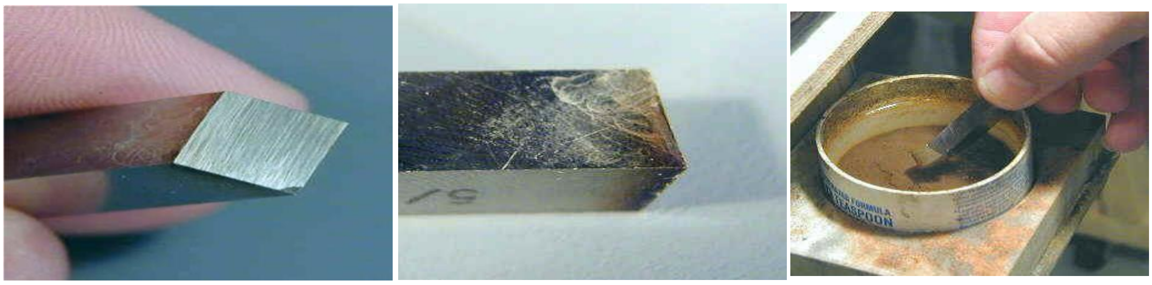


Figure 1.3: Grinding the end relief angle

Grinding causes the tool blank to get quite hot so you will need to dip the end of the tool into a water bath every 15 seconds or so during the grinding operation. When you see the tip of the tool start to discolor from the heat it’s a good time to make a cooling dip. Fortunately, HSS does not conduct the heat to your fingers very fast, but you can get burned if you go too long between cooling dips.

My water cup was cut from the end of a plastic bottle. Here's a picture of the tool after grinding the end:



<u>Grinding the Left Side Relief:-</u>

Now we'll grind the left side of the tool. The procedure is essentially the same except that we hold the tool with the side at about a 10 degree angle to the grinding wheel

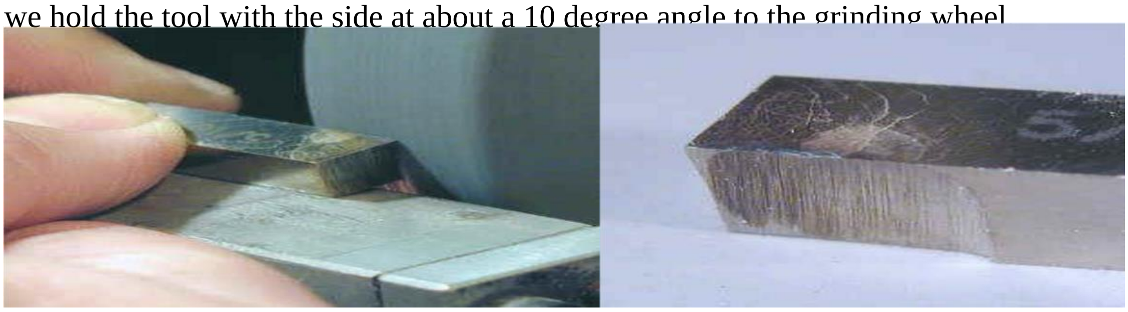


Figure 1.4: Grinding the left side relief

Grinding the Top Rake:-

Now we grind the top surface to form the rake. Be careful during this operation not

to grind down the cutting edge or you will end up with a tool whose tip is below the center line of the lathe. If this happens, the tool will leave a little nub at the center of the work piece when you make a facing cut. The usual remedy is to use a thin piece of shim stock or **feeler gages** under the tool to bring it back up to the center line. A much nicer solution is an **adjustable-height tool holder**.

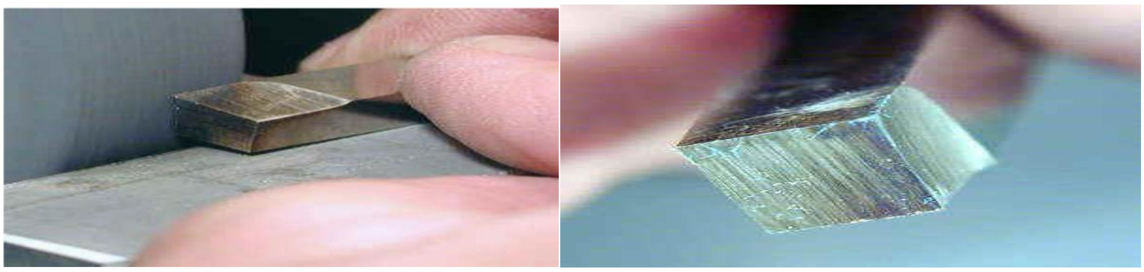


Figure 1.5: Grinding the top rake

After this operation we have a working tool with a very sharp tip. This tool is useful asis for operations that need a sharp tip to turn down to an interior edge such as a shoulder.

Rounding the Tip:-

We will round the tip to form a tool that is useful for facing and turning. Hold the tool so the tip touches the wheel and with the tool tilted downward. Rotate the tool gently against the wheel to round the tip to about a 1/32" to 1/16" radius.

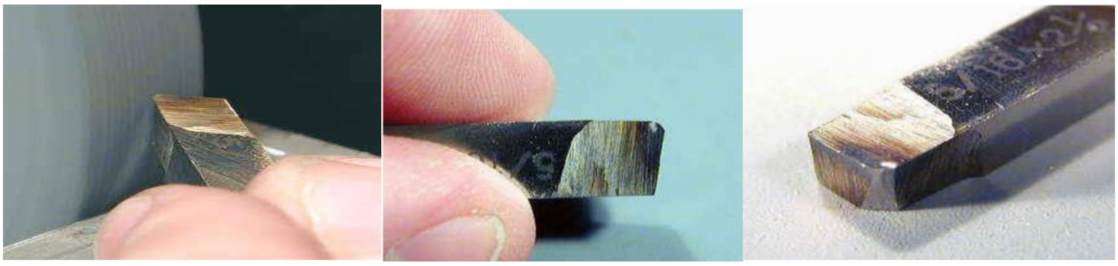


Figure 1.6: Rounding the tip

Here's the finished tool in action making a finishing cut on a facing operation.

1. PRACTICE EXERCISE:-

Grind the single point lathe cutting tool whose tool signature is given below and also draw three orthogonal views (in the space provided below). For ease of drawing, take the cross section of the shank as a square of side 5cm.

Tool Signature: 8 – 14 – 6 – 6 – 20 – 15 – 4mm

Back rake angle	**8°**
Side rake angle	**14°**
End relief angle	**6°**
Side relief angle	**6°**
End cutting edge angle	**20°**
Side cutting edge angle	**15°**
Nose radius	**4mm**

Lathe Tool Notation:-

TOP VIEW

FRONT VIEW

RIGHT SIDE VIEW

EXPERIMENT # 2

To investigate the multi-point cutting tool

Scope:-

To study the nomenclature and geometry of multi-point cutting tools of milling machine and drill machine.

Theory:-

1. Milling cutters:-

The Milling cutters are revolving tools having one or several cutting edges of identical form equally spaced on the circumference of the cutter. The cutting elements are called teeth which intermittently engage the work piece and remove material by relative movement of the work piece and the cutter. We will discuss three types of horizontal milling cutters and also one type of vertical milling cutter in this experiment.

1. **Plain Milling cutters**
2. **Side Milling cutters**
3. **Angle Milling cutters**

1. End Mills

Plain milling cutters:-

The plain milling cutters are cylindrical in shape and have teeth on the circumferential face only. The cutters are intended for the production of flat surfaces parallel to the axis of rotation of the spindle. The cutter teeth may be straight or helical according to the size of the cutter. Figure on the right illustrates a helical teeth plain milling cutters. Very wide plain milling cutters are termed as slabbing cutters. These cutters have nicked teeth. The nicks are uniformly distributed on the

Figure 2.1
Plain Milling Cutter

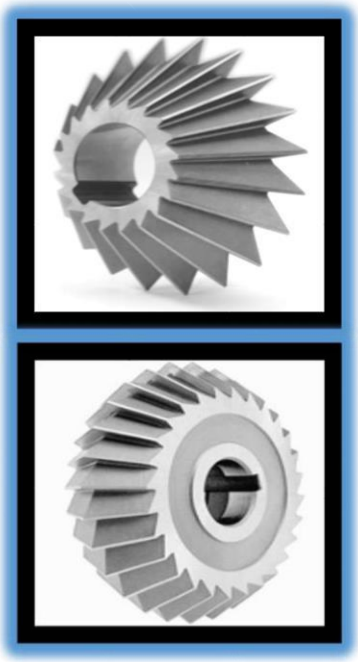
entire periphery of the cutter. The object of the nicks is to break up the chips and enable the cutter to take a coarse feed.

Side milling cutters:-

The side milling cutters have teeth on its periphery and also on one or both of its sides. The side milling cutters are intended for removing material from side of a work. Figure on the right illustrates a side milling cutter.

Figure 2.2 Side Milling Cutter

Angle milling cutters:-



The angle milling cutters are made as single or double angle cutters and are used to machine angles other than 90°. The cutting edges are formed at conical surface around the periphery of the cutter. They can be either single angle milling cutter or double angle milling cutter. The single angle milling cutters have teeth on the conical or angular face of the cutter and also on the large flat side. The angle of the cutter is designated by the included angle between the conical face and the large flat face of the cutter. The double angle milling cutter has V shaped teeth with both conical surfaces at an angle to their end faces. The angle of teeth may not be symmetrical with respect to a plane at right angles to the cutter axis. Single angle milling cutters and double angle milling cutters are shown in the figure.

Figure 2.3 Angle Milling Cutters

End mills:-

The end mills have cutting teeth on the end as well as on the periphery of the cutter. The peripheral teeth may be straight or helical and the helix may be right handed or left handed. The end mills are used for light milling operations like cutting slots, machining accurate holes, producing narrow flat surfaces and for profile milling operations. The figure on the right illustrates a number of end mills.

Elements of milling cutters

For this experiment, plain milling cutters has been chosen for the study of the elements and geometry. Refer to the figures below to study the nomenclature, elements and geometry of plain milling cutters the teeth are attached.

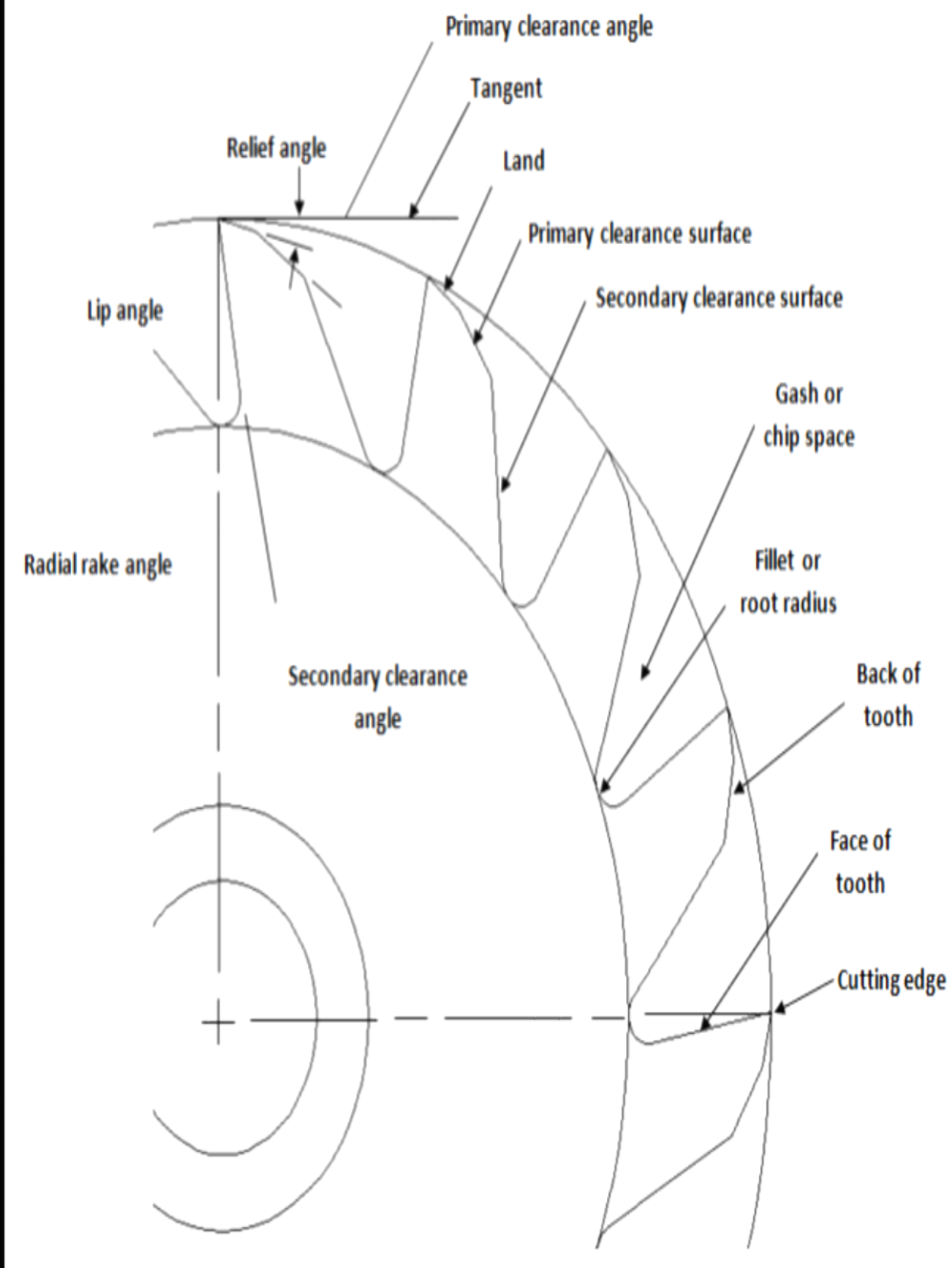

Primary clearance angle
Tangent
Relief angle
Land
Primary clearance surface
Lip angle
Secondary clearance surface
Gash or
chip space
Radial rake angle
Fillet or
root radius
Secondary clearance
angle
Back of
tooth
Face of
tooth
Cutting edge

Figure 2.517

Elements of a Milling Cutter

Body of cutter: The part of the cutter left after exclusion of the teeth.

Cutting edge: The edge formed by the intersection of the face and the land, or the surface left after grinding relief angle.

Face: The forward facing surface of the tooth adjacent to the cutting edge on which the chip impinges as it is cut from the work.

Gash: The chip clearance between the back of one tooth and the face of the next tooth.

Fillet: The curved surface at the bottom of gash which joins the face of one tooth to the back of the tooth immediately ahead.

Land: The part of the back of tooth adjacent to the cutting edge which is relieved to avoid interference between the surface being machined and the cutter.

Lead: The axial advance of the helix of the cutting edge in one complete revolution of the cutter.

Outside diameter: The diameter of the circle passing through the peripheral cutting edge.

Root diameter: The diameter of the circle passing through the bottom of the fillet.
Relief angle: The angle in a plane perpendicular to the axis, which is the angle between the land of a tooth and the tangent to the outside diameter of cutter at the cutting edge of the tooth.

Primary clearance angle: The angle formed by the primary clearance surface of the tooth with a line drawn tangent to the periphery of the cutter at the cutting edge.

Secondary clearance angle: The angle formed by the secondary clearance surface of the tooth with a line drawn tangent to the periphery of the cutter at the cutting edge.

Rake angle (Radial): The angle measured in the diametric plane between the face of the tooth and a radial line passing through the tooth cutting edge. The rake angle may be positive, negative or zero.

Positive rake: if the tooth face is tilted so that the face and the tooth body are on the same side of the radial line, then the rake angle contained by the radial line and the tooth face is positive.

Negative rake: If the tooth face is tilted so that the face and the tooth body are on the opposite side of the radial line, then the rake angle contained by the radial line and the tooth dace is negative.

Zero rake: If the radial line and tooth face coincide in the diametric plane, the rake angle is zero.

Axial rake angle (for helical teeth): The angle between the line of peripheral cutting edge and the axis of the cutter when looking radially at the point of intersection.

Lip angle: The included angle between the land and the face of the tooth, or alternatively the angle between the tangent to the back at the cutting edge and the face of the tooth.

Helix angle: The cutting edge angle which a helical cutting edge makes with a plain containing the axis of a cylindrical cutter

These definitions of different tooth elements are applied to side milling cutters also. The cutting edges on the periphery are called peripheral cutting edges and those on the face of the cutter are called face cutting edges. The side milling cutters have relief angles, clearance angles, and rake angles on the periphery as well as on the face of the cutters.

2. Drills

A drill is a fluted cutting tool used to originate or enlarge a hole in a solid material. The most common type of drill in use today is the twist drill. It was originally manufactured by twisting a flat piece of tool steel longitudinally for several revolutions, then grinding the diameter and the point. The present day twist drills are made by machining two spiral flutes or grooves that run lengthwise around the body of the drill.

Elements of twist drill

The elements and geometry of a twist drill is given below.

Refer to the figure below while studying the elements and the geometry.

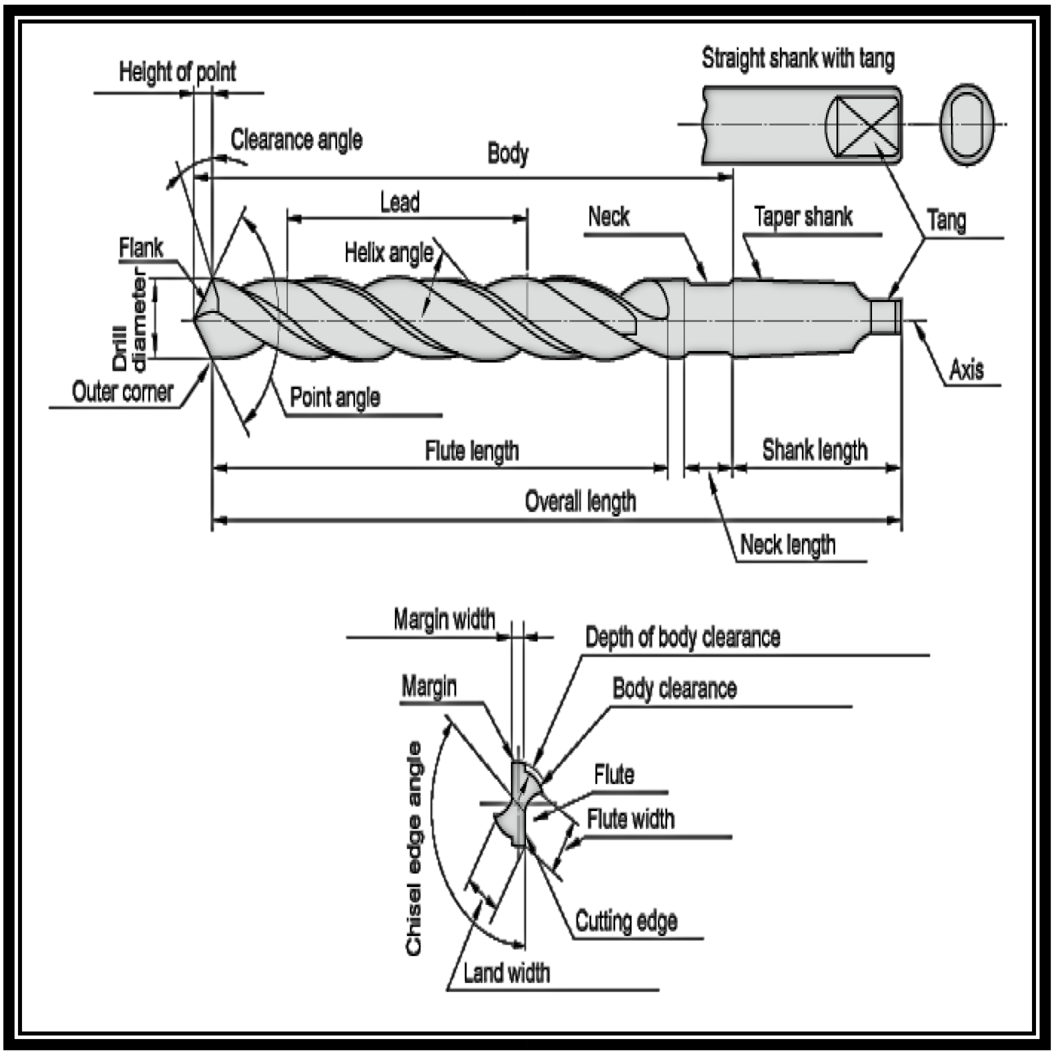


Figure 2.6
Elements of a Twist Drill

Axis: The longitudinal centerline of the drill

Shank: The part of the drill by which it is held and driven

Neck: The diametrically undercut portion between the body and the shank of the drill

Body: The portion of the drill extending from the shank or neck to the outer corners of the cutting lips

Point: The sharpened and cutting end of a drill, consisting of all that parts of the drill which is shaped to produce lips, faces, flanks and chisel edge .It resembles a cone, but departs from a true cone to furnish clearance behind the cutting lips

Overall Length: The length over the extreme ends of the point and the shank of the drill.

Flutes: Grooves cut or formed in the body of the drill to provide cutting lips.

The functions of the flutes are

1. To form the cutting edge on the point
2. To allow the chip to escape
3. To cause the chip to curl
4. To permit the cutting fluid to reach the cutting edges

Flute Length: The axial length from the outer corners of the cutting lips to the extreme back end of the flutes

Land: The peripheral portion of the body between adjacent flutes

Margin: The cylindrical portion of the land which is not cut away to provide clearance. **Body Diameter Clearance or cleared diameter or depth of body clearance:** The depth of the portion of the land that has been cut away so it will not rub against the walls of the hole and hence prevents friction and heat generation.

Body Clearance diameter: The diameter over the surface of land behind the margins. **Cutting Diameter:** Largest diameter measured across the margins at the outer corner of the lips.

Back Taper (longitudinal clearance): It is the reduction in diameter of the drill from the point towards the shank. This permits all parts of the drill behind the point to clear and not rub against the sides of the holes being drilled.

Core or web: It is the central portion of the drill situated between the roots of the flutes and extending from the point end towards the shank; the point end of the core forms the chisel edge.

Web (core) taper: The increase in the web or core thickness from the point of the drill to the shank end of the drill. The increasing thickness gives additional rigidity to the drill and reduces the cutting pressure at the point end.

Lip (cutting edge): The edge formed by the intersection of the flank and face. These edges perform the primary cutting operation. The cutting edges of a two flute drill extends from the chisel edge to the periphery

Face: The portion of the flute surface adjacent to the lip on which the chip impinges as it is cut from the work.

Flank: The surface on a drill point which extends behind the lip to the following flute.

Lead of helix: The distance measured parallel to the drill axis between the corresponding points on the leading edge of the flute in one complete turn of the flute. **Chisel edge:** The edge formed by the intersection of the flanks. The chisel edge is also sometimes called dead center. The dead center or the chisel edge acts as a flat drill and cuts its own hole in the work piece. A great amount of thrust is required to cut a hole by the chisel edge.

Chisel edge corner: The corner formed by the intersection of a lip and the chisel edge
Heel: Trailing edge of the land is known as heel

Chisel Edge Angle: The angle included between the chisel edge and the cutting lip, as viewed from the end of the drill.

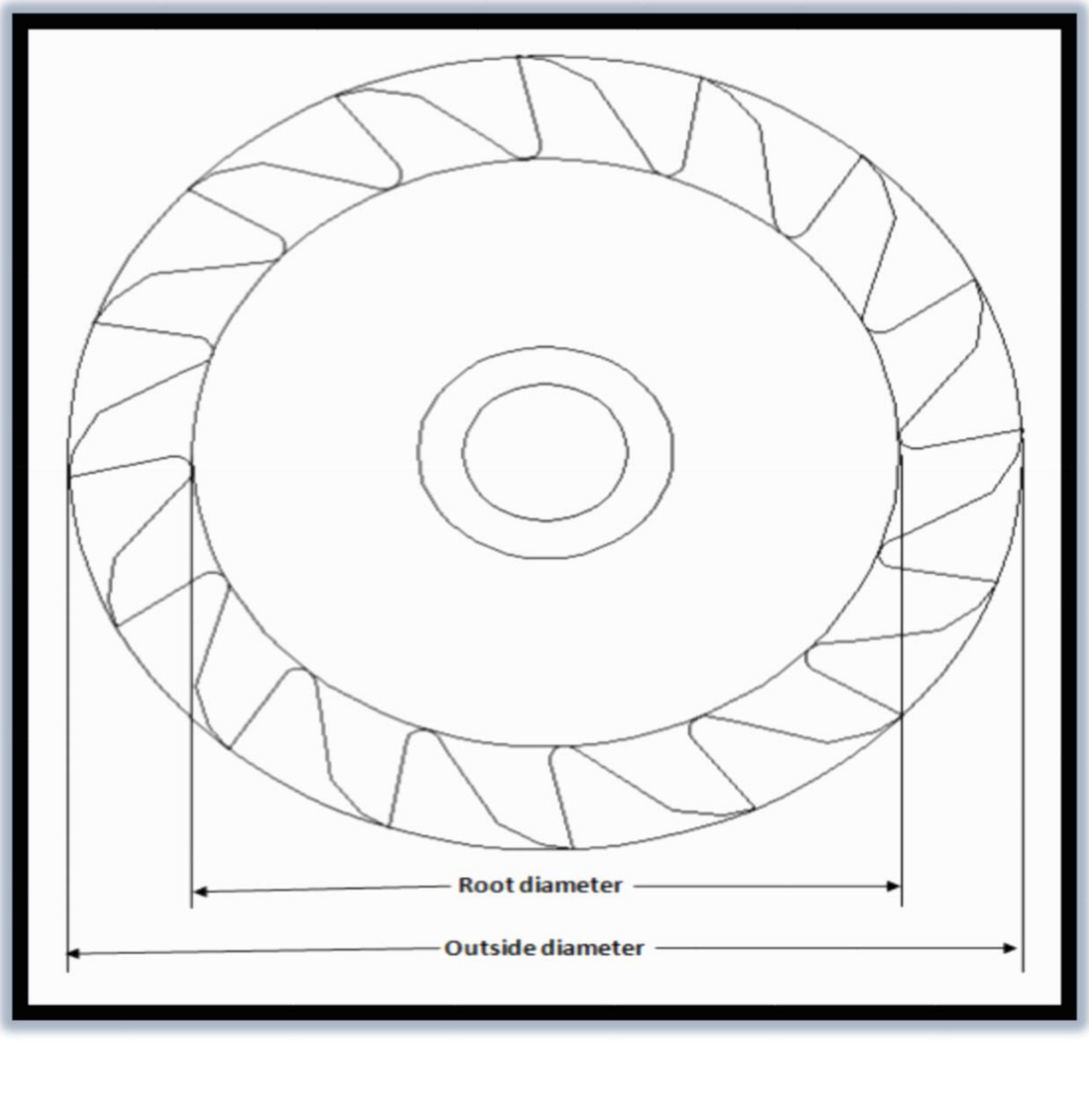
Point Angle: The angle included between the cutting lips projected upon a plane parallel to the drill axis and parallel to the two cutting lips.

Helix angle or rake angle: The helix or rake angle is the angle formed by the leading edge of the land with a plane having the axis of the drill. If the flute is right handed then it is positive rake; and if it is left handed then the rake is negative. The usual value of rake angle is 30°, although it may vary up to 45° for different materials. Smaller the rake angle, greater will be the torque required to drive the drill at a given feed.

Lip relief angle: Lip clearance angle is the angle formed by the flank and a plane at right angles to the drill axis; the angle is normally measured at the periphery of the drill. Lip clearance is the relief that is ground to the cutting edge in order to allow the drill to enter metal without interference.

3. PRACTICE EXERCISE:-

Draw the elements of milling cutter, whose sketch is given below.



EXPERIMENT# 4

To determine the effect of length/diameter ratio on accuracy machining by varying depth of cut. Scope:-

The accuracy of machining of a turning operation performed by the lathe machine depends on a number of parameters. The scope of this experiment is to find out what is the effect of depth of cut considering the length/diameter ratio on the accuracy of a turning process performed by the Lathe machine.

Apparatus:-

Centre Lathe machine

Micrometer

Dial indicator

Magnetic stand

Theory:-

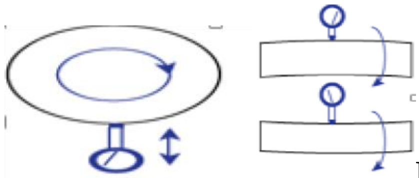
The advancement of the lathe and subsequent modern technologies was made possible through research leading to the development of optimization tables that list specific feed rates, spindle speeds, and depth of cut for different materials. These tables are the standard used in industry as a source of reference when making a change from one job to another where the machining parameters of each may be quite different. The time, material, and tooling costs associated with the experimental steps needed to find the appropriate machining parameters for each new job are eliminated, giving the company the advantage of a reduction in setup costs and improved product quality.

While there are many machining optimization parameters that have been developed and put into tables, an area that has been overlooked is that of correlation between the length, at a specific diameter, and surface roughness of bar stock in turning operation. Surface roughness plays an important role in product quality and is an especially important design characteristic in many products that are subject to precision fits, fastener holes, fatigue loads, and aesthetic requirement. Dimensional accuracy also together surface roughness greatly affect useful part life, especially in cases in which the components will be in moving contact with other elements or material.

Kalpak Jian Inc., (2006) illustrates a regressing relationship between dimensional tolerance and work piece length, but does not adequately differentiate the surface roughness correlation between a supported and unsupported work piece in relation to its length. The practice of choosing appropriate process parameters can be quite difficult. To make this determination currently requires time consuming trial and error experimentation which is costly in time and material resources. Due to the differing opinions among industry professionals about a common work piece extension length/diameter ratio(Kennametal Inc.,2005:Western Machine Tool &Die,2005:and Accubar,2005),various work piece extension lengths that would encompass all currently examined industry guidelines from one extreme to the other, and beyond, were tested. This experiment challenged the traditionally accepted boundaries by exceeding the previously maximum work piece extension length/diameter ratio i.e. ‘10:1’(in supported condition) to nearly double that figure as well as considering the effect of depth of cut on the accuracy of a turning process performed by the conventional Lathe machine.

Before starting the experiment, we should calculate the shaft run out. Shaft run out is a common measurement especially for condition monitoring. According to ASMEI B5.542005 *Methods for performance evaluation of machining centers,* “run out” is the total indicator reading(TIR) of an instrument measuring against a moving surface. This is usually a rotary motion and is measured for a full rotation. This means the run out value is a combination of several types of error motions, form errors, and form factor.

Listed as:



1) Shape of the shaft **Figure 4.1**
2) Straightness of the shaft
3) Centering error in the location of the shaft relative to the axis of rotation(eccentricity),and
4) Error in the axis of rotation itself which itself is a product of several factors:
   I. Drive bearing performance
   II. Machine structure
   III. Drive alignment(tilt)
5) Measuring instrument error(indicator or sensor)

Experimental portion:- Procedure:-

4-1. Mount the blank (having dimension 12inch length & 1/2inch diameter) on the Lathe Machine and holding it like 2inch grip length plus 10inch working length. Note:-Length/diameter ratio 20:1

4-2. Divide and mark the working length into five equally spaced L/D ratios, i.e. (1”:1/2”, 3’:1/2”, 5”:1/2”, 7”:1/2”, 9”:1/2”).

4-3. now check the total run out error by installing the magnetic stand with dial indicator **(Lever type)** on the slide as briefed.

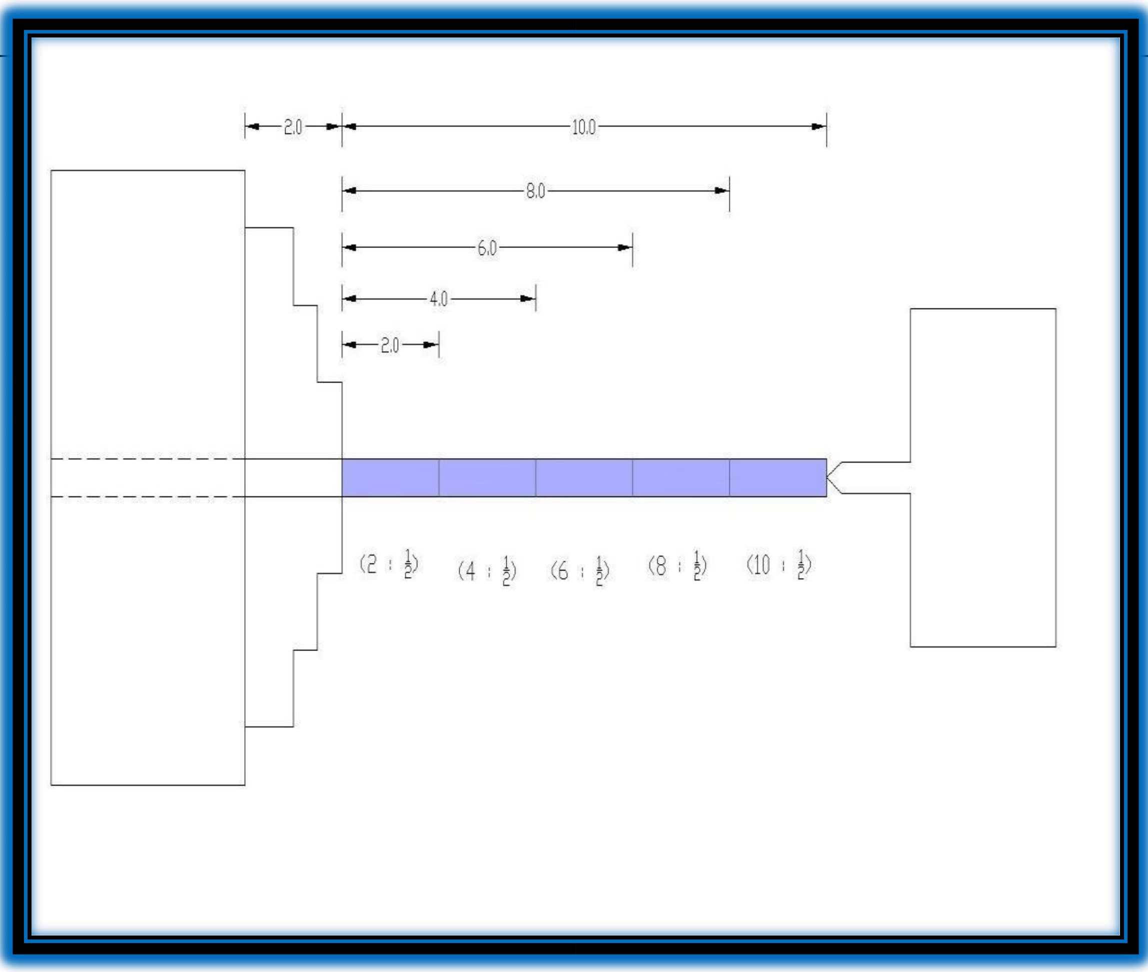
4-4. Install the lever of dial indicator with some tension by taking first position (i.e.1”:1/2”) On the work piece extension length then rotate the bezel (revolving scale) to zero.
4-5. after positioning the dial indicator, rotate the chuck by hand at 360°and note the total Indicating reading in the table.

4-6. Repeat the same procedure by taking four L/D ratios further and note down The total indicating reading in the table accordingly.

4-7. after calculating the maximum run out (‘TIR’total indicating reading) apply the depth Of cut accordingly and machine the whole working length.

4-8. Now, measure the initial diameter at five equally spaced L/D ratios and note the Measurement in the table provided.

4-9. Now give ‘0.5mm’ depth of cut and machine the job.



4-10. after machining whole working length measure and note the required, obtained Diameters of job also difference of reading at five equally spaced length/diameter Ratios in the table (1st observation).

4-11. Now take 2nd blank and achieve the same initial diameter for comparing the Difference by changing the depth of cut (0.5mm & 1mm).

4-12. after achieving the same initial diameter, apply the ‘1mm’depth of cut and machine The whole length.

4-13. after machining measure and note the required, obtained diameter of job and Difference of reading at five equally spaced L/D ratios (2nd observation table).

4-14. Compare the difference by changing the depth of cut and conclude the remarks Accordingly

4-15. each time cutting conditions should remain constant except depth of cut.

Figure 4.2

Relationship between the work piece extension length /diameter ratio in turning application

OBSERVATION – I

Depth of Cut________________________ **Feed** ____________________ **Spindle Speed** ____________________

Measuring Instrument ______________________________ **Least Count** ______________________________

Measuring Indicator ______________________________ **Least Count** ______________________________

Work Piece	**Length / Dia.[1: ½] (inch)**			**Length / Dia.[3: ½](inch)**			**Length / Dia.[5: ½](inch)**			**Length / Dia.[7: ½](inch)**			**Length / Dia.[9: ½] (inch)**		
Blank run-out error	**TIR:**			**TIR:**			**TIR:**			**TIR:**			**TIR:**		
Initial diameter	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.
Final diameter required															
Final diameter obtained	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.

Difference between required and obtained diameters															

OBSERVATION – II

Depth of Cut______________________________ Feed ________________________________ Spindle Speed ________________________

Measuring Instrument ____ Least Count ____

Measuring Indicator ____ Least Count ____

Work Piece	**Length / Dia.[1: ½] (inch)**	**Length / Dia.[3: ½](inch)**	**Length / Dia.[5: ½](inch)**	**Length / Dia.[7: ½](inch)**	**Length / Dia.[9: ½] (inch)**

Blank run-out error															
Initial diameter	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia. 2	Avg. Dia.
Final diameter required															
Final diameter obtained	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia. 2	Avg. Dia.
Difference between required and obtained diameters															

COMMENTS:-

EXPERIMENT# 5

To determine the effect of length/diameter ratio on accuracy of machining by varying the diameter of work piece.

Scope:-

The accuracy of machining of a turning operation performed by the lathe machine depends on a number of parameters. The scope of this experiment is to find out how the effect of length/diameter ratio on accuracy of a turning process performed by the lathe machine varies with diameter.

Apparatus:-

Lathe machine

Micrometer

Dial indicator

Magnetic stand

Experimental portion:-

Procedure:-

5-1. Mount the blank (having dimension 12inch length & 1/2inch diameter) on the Lathe

Machine and holding it like 2inch grip length plus 10inch working length. **Note:-**

Length/diameter ratio 20:1

5-2. Divide and mark the working length into five equally spaced L/D ratios,

i.e. (1”:1/2”,   3’:1/2”, 5”:1/2”, 7”:1/2”,   9”:1/2”).

5-3. now check the total run out error by installing the magnetic stand with dial indicator **(Lever type)** on the slide as briefed.

5-4. Install the lever of dial indicator with some tension by taking first position (i.e.1”:1/2”) on the work piece extension length then rotate the bezel (revolving scale) to zero. 5-5. After positioning the dial indicator, rotate the chuck by hand at 360°and note the total Indicating reading in the table.

5-6. Repeat the same procedure by taking four L/D ratios further and note down the total indicating reading in the table accordingly.

5-7. After calculating the maximum run out (‘TIR’total indicating reading) apply the depth of cut accordingly and machine the whole working length.

5-8. Now, measure the initial diameter at five equally spaced L/D ratios and note the measurement in the table provided.

5-9. Now apply ‘1mm’ depth of cut and machine the job.

5- 10.After machining whole working length measure and note the required, obtained diameters of job also difference of reading at five equally spaced L/D ratios in the table (1st observation).

5-11 Now apply ‘1mm’ depth of cut again and machine the job.

5-l2 After machining measure and note the required, obtained diameter of job and difference of reading at five equally spaced L/D ratios in the 2nd observation table. 5-13.Compare the difference by changing the length/diameter ratio and conclude the remarks accordingly

5-14. Each time cutting conditions should remain constant except diameter of job.

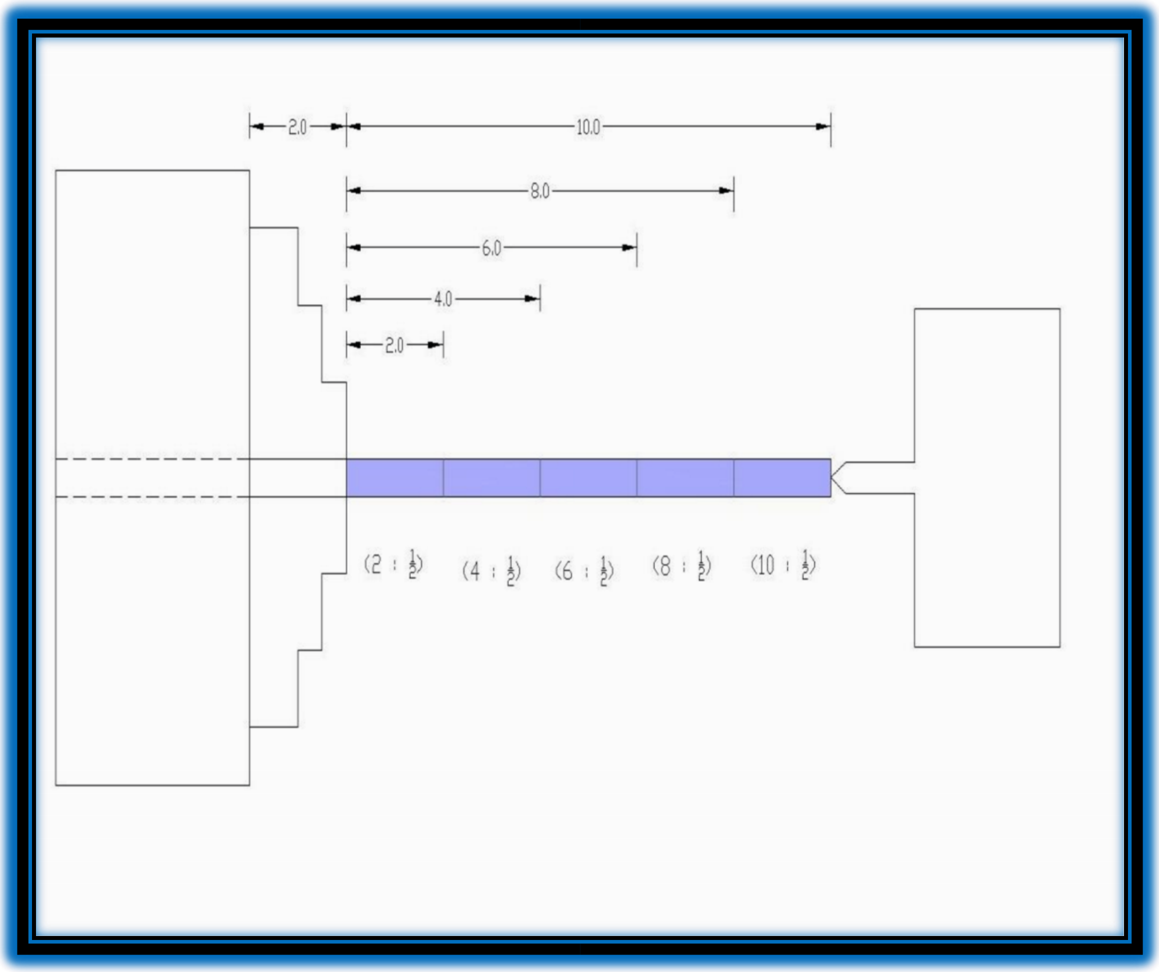


Figure 5.1

Relationship between the work piece extension length /diameter ratio in turning application

OBSERVATION – II

Depth of Cut________________ **Feed** ________________ **Spindle Speed** ____________ **Measuring Instrument** ______________________ **Least Count** ______________________

Measuring Indicator ______________________ **Least Count** ______________________

Work Piece	Length / Dia.[1: ½](inch)			Length / Dia.[3: ½](inch)			Length / Dia.[5: ½](inch)			Length / Dia.[7: ½](inch)			Length / Dia.[9: ½](inch)		
Blank run-out error	TIR:			TIR:			TIR:			TIR:			TIR:		
Initial diameter	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.	Dia.1	Dia.2	Avg. Dia.
Final diameter required															
Final diame	Dia.	Dia.	Avg.	Dia.	Dia.	Avg.	Dia.	Dia.	Avg.	Dia.	Dia.	Avg.	Dia.	Dia.	Avg.

ter obtained	1	2	Dia.	1	2	Dia.	1	2	Dia.	1	2	Dia.	1	2	Dia.
Difference between required and obtained diameters															

40

COMMENTS:-

EXPERIMENT 6

To determine the variation of power with depth of cut, speed, feed and rake angle.

<u>Scope</u>:-

To determine how the power required by the lathe machine varies when speed, feed, depth of cut (DOC) and rake angle is varied individually and find out whether the trend of power variation conforms to theoretical trend.

Apparatus:-

Lathe Machine

Three Phase Power meter

Vernier Caliper

Theory:-

The cutting force system in a conventional, oblique-chip formation process is shown schematically in Figure below. Oblique cutting has three components:

1. **Primary cutting force (Fc)** acting in the direction of the cutting velocity vector. This force is generally the largest force and accounts for 99% of the power required by the process.
2. **Feed force (*F_f*)** acting in the direction of the tool feed. This force is usually about 50% of *Fc* but accounts for only a small percentage of the power required because feed rates are usually small compared to cutting speeds.
3. **Radial or thrust force (*Fr*)** acting perpendicular to the machined surface. This force is typically about 50% of 'F_f' and contributes very little to power requirements because velocity in the radial direction is negligible.

Figure below shows the general relationship between these forces and changes in speed, feed, and DOC. Note that these figures cannot be used to determine forces for a specific process.

The power (P) required for cutting is

P = Fc x V (N-m/s) ------------- (i)

Where, Fc = Cutting force in Newton (N)

V = Surface Speed in meter per second (m/s)

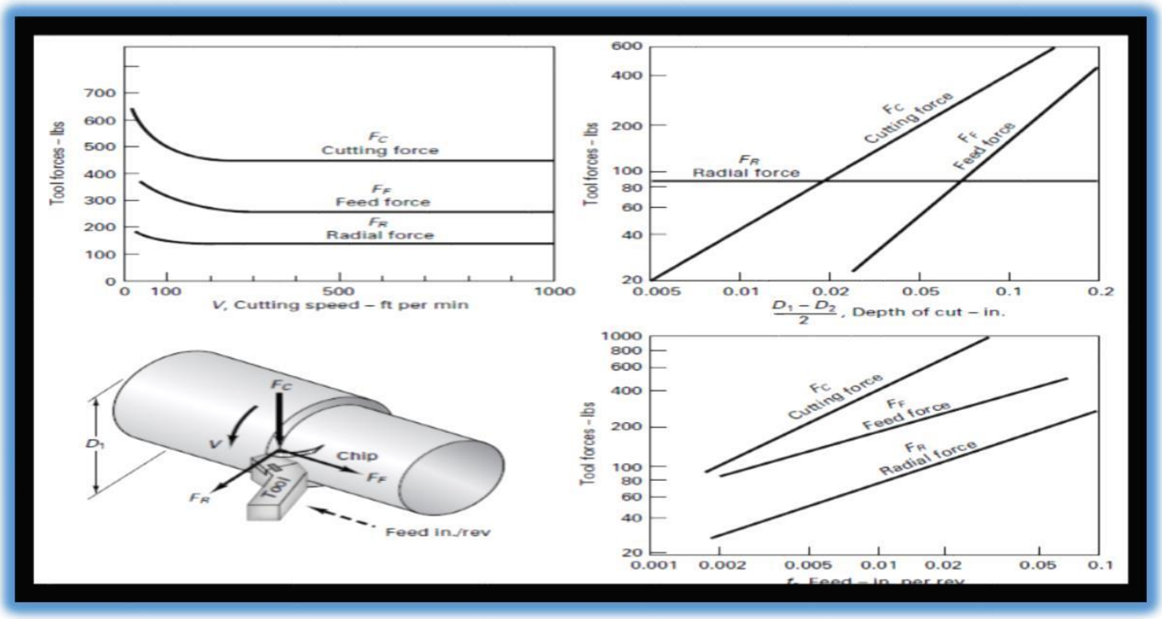


Figure 6.1

The Cutting force system

Variation of power with depth of cut (DOC)

From the graph on previous page of Fc against DOC, it is seen that as DOC increases cutting force also increases. Hence from formula (i) power required for cutting increases with increase in DOC.

Variation of power with feed

From the graph on previous page of Fc against feed, as feed increases cutting force also increases. Hence from formula (i) power required for cutting increases with increase in feed.

Variation of power with speed

The graph shown above of 'Fc' against speed has two portions. As speed increase first cutting force decreases and then it remains constant. Let the portion in which Fc decreases be 'A' and the portion in which 'Fc' remains constant be 'B'. In portion 'A' Fc decreases while speed increases. According to formula (i) the power will either increase or decrease in this portion depending upon which is dominant factor, either increase in speed or decrease in 'Fc'. In portion 'B' 'Fc' remains constant and speed increases, hence according to Formula (i), Power will increase.

Variation of Power with rake angle

Greater the positive rake angle of a tool, greater is the efficiency and lesser is the power required for cutting operation.

For this experiment, we have to measure power consumed by the lathe machine while varying speed, feed, and depth of cut individually. To measure the power mechanically, We use formula (i) to use this formula, we need to measure 'Fc' and 'V'. 'Fc' is measured by force dynamometer.

'V' in meter per second (m/s) is measured by using the formula

$$V= \pi DN \text{--------------- (ii)}$$

Where, D= diameter of job in meters (m)

N=Spindle rotational speed in rev/min. (rpm)

Force dynamometer is not available in our workshop. So we will measure the power utilized by the lathe machine electrically. The motor installed in the lathe machine has a three phase connection. The power, in watts (W) utilized by the machine is given by the formula $P = 3^{½} V_{LL} I \cos \varphi$----------------- (iii)

Where, V = voltage between two phases in volts (V)

I = Current running through one of the three phases in amperes (A)

Cos φ = Power factor

Phase Voltage (V_{LN}) essentially remains constant at 230 volts whereas phase to phase voltage range vary between 380-430 volts. Power factor (Cos φ) is not constant and vary depending upon the motor its loaded & unloaded value ranges from 0 to 1. The value of current will change when depth of cut, speed, feed and rake angle will change individually. The current will be measured by using clamp ampere meter. We have also power meter to monitor inductive loaded and unloaded condition.

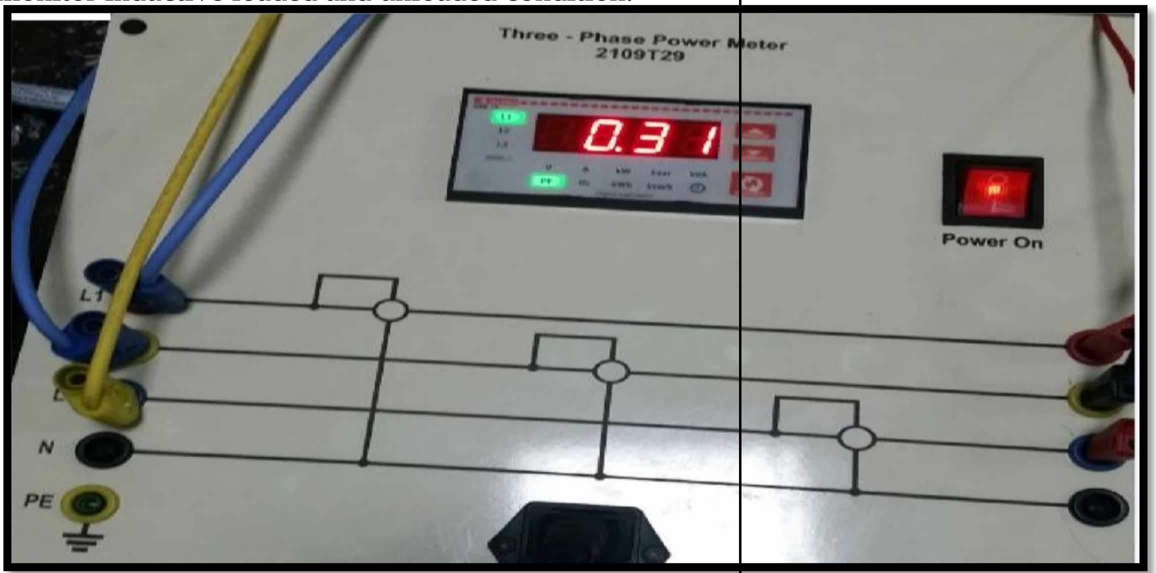


Figure 6.2

Three-Phase Power Meter

Experimental portion

Power against depth of cut:-

Procedure:-

6-1 Measure the diameter of the blank and hold it into the chuck.

6-2 Install the tool bit in the tool post having positive rake angle.

6-3 By varying depth of cut in this condition keep all the parameters like surface speed, feed and rake angle constant.

6-4 Measured the current in loaded and unloaded condition by using the three phase power meter.

6-5 Calculate the power electrically because we did not have the force dynamometer.

Table of calculations:-

Inductive Unloaded Condition

Work piece material =	**Work piece diameter =**
Measuring Instrument	**Least Count =**
Current Measuring Instrument = power meter	**AC Current Range Selected =**
Induction Motor power = Hp & KW	**Frequency =**
Terminal Box Connection Type= wye **Phase =**	**Power Factor=**
Apparent power= kVA Reactive power = kVAR	**Active power= kW**
Reactive Power consumption = kvarh	**Active power consumption = kWh**
Line 1, Voltage Phase to Phase V_{LL} =	**Phase Voltage V_{LN} =**
Lathe Pulley Combination =	**RPM =**
Lathe Feed lever Combination =	**Feed =**

Inductive Loaded Condition

Sr. No.	Depth of cut (mm)	Current (A)	Voltage (V)	Power Factor Cosø	Phase Angle (ø)	Power (W)
1						
2						
3						
4						

Inductive Loaded Condition

Apparent power = kVA **Reactive power = kVAR**	**Active power =** kW
Reactive Power consumption = kvarh	**Active power consumption =** kWh

<u>Sample Calculations</u>:-

Graph:

Draw the graph of power against DOC

Power against surface speed:-

Procedure:-

6-1 Measure the diameter of the blank and hold it into the chuck.

6-2 Install the tool bit in the tool post having positive rake angle.

6-3 By varying (pulley combination) surface speed in this condition keep all the parameters like feed, depth of cut and rake angle constant.

6-4 Measured the current in loaded and unloaded condition by using the three phase power meter.

6-5 Calculate the power electrically because we did not have the force dynamometer. **Table of Calculations:-**

Inductive Unloaded Condition

Work piece material =	**Work piece diameter =**
Measuring Instrument	**Least Count =**
Current Measuring Instrument = power meter	**AC Current Range Selected =**
Induction Motor power = Hp & KW	**Frequency =**
Terminal Box Connection Type= wye Phase =	**Power Factor=**
Apparent power= kVA Reactive power = kVAR	**Active power= kW**
Reactive Power consumption = kvarh	**Active power consumption = kWh**
Line 1, Voltage Phase to Phase V_{LL} =	**Phase Voltage V_{LN} =**
Lathe Pulley Combination =	**RPM =**
Lathe Feed lever Combination =	**Feed =**

Inductive Loaded Condition

Sr. No.	Surface speed (m/s)	Current (A)	Voltage (V)	Power Factor (Cosø)	Phase Angle Ø	Power (W)

Apparent power = kVA	**Reactive power = kVAR**	**Active power =** kW
Reactive Power consumption = kvarh	**Active power consumption =** kWh	

Sample calculations:-

Graph

Draw the graph of power against surface speed

Power against feed:-

Procedure:-

6-1 Measure the diameter of the blank and hold it into the chuck.

6-2 Install the tool bit in the tool post having positive rake angle.

6-3 By varying feed in this condition keep all the parameters like surface speed, depth of cut and rake angle constant.

6-4 Measured the current in loaded and unloaded condition by using the three phase power meter.

6-5 Calculate the power electrically because we did not have the force dynamometer. **Table of Calculations:-**

Inductive Unloaded Condition

Work piece material =	**Work piece diameter =**
Measuring Instrument	**Least Count =**
Current Measuring Instrument = power meter	**AC Current Range Selected =**

Induction Motor power =	**Hp &**	**KW**	**Frequency =**
Terminal Box Connection Type=	**wye**	**Phase =**	**Power Factor=**
Apparent power= kVA	**Reactive power = kVAR**		**Active power= kW**
Reactive Power consumption = kvarh		**Active power consumption = kWh**	
Line 1, Voltage Phase to Phase V_{LL} =			**Phase Voltage V_{LN} =**
Lathe Pulley Combination =			**RPM =**
Lathe Feed lever Combination =			**Feed =**

Inductive Loaded Condition

Sr. No.	feed (mm/rev)	Current (A)	Voltage (V)	Power Factor (Cosø)	Phase Angle (ø)	Power (W)
1						
2						
3						
4						

Apparent power = kVA	**Reactive power = kVAR**	**Active power =** kW
Reactive Power consumption = kvarh	**Active power consumption =** kWh	

<u>Sample calculations</u>:-

<u>Graph:</u>

Draw the graph of power against feed.

<u>Power against rake angle</u>:-

Procedure:-

6-1 Measure the diameter of the blank and hold it into the chuck.

6-2 Install the tool bit in the tool post having positive rake angle.

6-3 By varying rake angle in this condition keep all the parameters like surface speed, depth of cut constant.

6-4 Measured the current and related parameters in loaded and unloaded condition by using the three phase power meter.

6-5 Calculate the power electrically because we did not have the force dynamometer.

Table of Calculations:-

Inductive Unloaded Condition

Work piece material =	**Work piece diameter =**
Measuring Instrument	**Least Count =**
Current Measuring Instrument = power meter	**AC Current Range Selected =**
Induction Motor power = Hp & KW	**Frequency =**
Terminal Box Connection Type= wye Phase =	**Power Factor=**
Apparent power= kVA Reactive power = kVAR	**Active power= kW**
Reactive Power consumption = kvarh	**Active power consumption = kWh**
Line 1, Voltage Phase to Phase V_{LL} =	**Phase Voltage V_{LN} =**
Lathe Pulley Combination =	**RPM =**
Lathe Feed lever Combination =	**Feed =**

Inductive Loaded Condition

Apparent power = kVA **Reactive power = kVAR**	**Active power =** kW
Reactive Power consumption = kvarh	**Active power consumption =** kWh

Sr. No.	Rake Angle (°)	Current (A)	Voltage (V)	Power Factor (Cosø)	Phase Angle (ø)	Power (W)
1						
2						

3						

Sample Calculations:-

Graph

Draw the graph of power against rake angle

COMMENTS:

EXPERIMENT# 7

Study the characteristic features of shaper Scope:-

The scope of this experiment is to understand the quick return mechanism of a shaper machine they will also understand, measure and/or calculate the following things

Basic shaper machine parameters including maximum axial and vertical travel of the bed, maximum vertical tool slide, maximum swivel tool head, and available range of ram

strokes, power of the main drive. Automatic feed mechanism range of the table

Least counts of down feed (tool slide) handle, cross feed collars

Theoretical and experimental machining time for a particular shaping operation task, effect of surface speed, feed, depth of cut on surface finish also determine metal removal rate using depth of cut as 2mm and 0.25mm

Apparatus:-

Horizontal Shaper

Tachometer

Stop watch

Vernier caliper

Meter rule

Theory:-

Introduction to Shaper

Shaper is a machine tools which produce a flat surface. It is capable of machining a horizontal, vertical or inclined flat surface. It employs single-point cutting tools which are essentially similar to single-point cutting tools used on lathe. The cutting tool is subjected to interrupted cuts, the tools cuts in forward direction and is idle in the return direction.

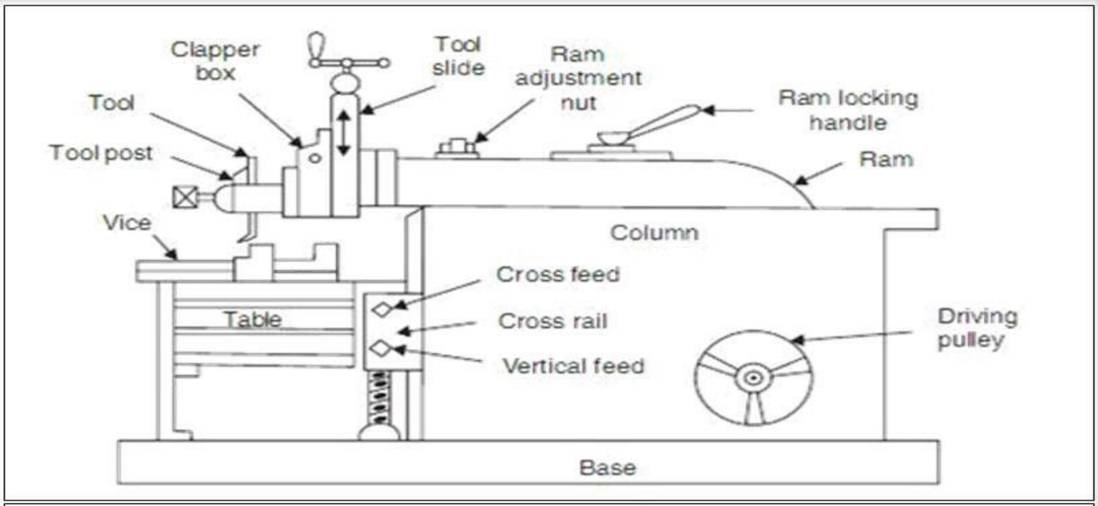


Figure 10.1: Principle parts of shaper machine

Principle of Working:-

Principal parts of shaper are shown in figure 10.1. Shaper consists of a base which rests on the ground. To the base, a hollow column is mounted. Inside the hollow portion the machine drive mechanism is housed. This mechanism is called slotted lever quick return mechanism and it drives a horizontal ram which reciprocates in the guide ways provided on the top surface of the machine frame. In the front face of the ram, a tool post is fitted. This is a very special kind of tool post. It carries a slide which can be operated by a hand wheel and the entire tool post can be lowered or raised. Besides, the tool slide can be swiveled in a vertical plane and its inclination to the vertical (amount of swiveling) can be read off on a scale marked in degrees. The tool is inclined, when an inclined surface has to be machined. In the front portion of the base, a table is fitted. The table can be raised or lowered to vary its height. It can also be moved horizontally to left or right. A vice to hold the work piece is provided on the table top. The tool does useful work i.e., cutting only in the forward stroke of the ram. It does not cut i.e.; it is idle during the return stroke of ram. In order that while returning, the tool may not rub and spoil the strip of the metal machined in the forward stroke, a special device called the “clapper box” is provided in the tool post. It lifts the tip of the tool during the return stroke. On a shaping machine, relatively small jobs can be machined. The size of a shaper is denoted by the maximum length of stroke of its ram and work pieces longer than the maximum stroke cannot be machined. The first step in machining a job is to mount the job on the shaper-table and clamp it tightly in the vice or on the table by means of T -bolts etc. The second step is to adjust the stroke of ram according to the length of work piece. The ram stroke is kept about 60–70 mm longer than job. The stroke can be reduced or increased by altering the length of the crank AB (refer to Fig.10.2). Now by changing the position of the location where short link arm is connected to the ram, the stroke is made to overlap the job, so that the stroke starts 30–35 mm before the job and covers the whole length of work piece and ends 30–35 mm beyond it. A tool is now selected and clamped in the tool post. The depth of cut is given by rotating the hand wheel and lowering the tool slide. Depth of cut is not given by raising the table height.

Table height is adjusted only at the time of fixing the job according to the height of job. Feed is given by shifting the table laterally. The feed to the table can be given either manually or automatically. The feed is given during the return stroke of ram.

Mechanism

Since useful work is done only during the forward stroke of ram, the mechanism driving the ram is so designed that the return stroke is completed in much less time than the forward stroke. The slotted lever quick return mechanism is shown in figure 10.2 (a) and figure 10.2(b).

The crank AB (of adjustable length R) rotates with a uniform angular speed. The crank pin

B is in the shape of a die block which is free to slide inside the slot in the slotted lever OBC. This slotted lever is pivoted at O and the other end C is connected to the ram by a short link arm as shown in Fig. 2.2 (a). When the crank AB rotates clockwise from position AB1to AB2, the ram moves forward from left to right and when it rotates from position AB2to AB1the ram returns back to its original position. Clearly the time taken to complete forward stroke is proportional to angle α (refer to Fig. 10.2 (b)) and the return stroke is completed in less time

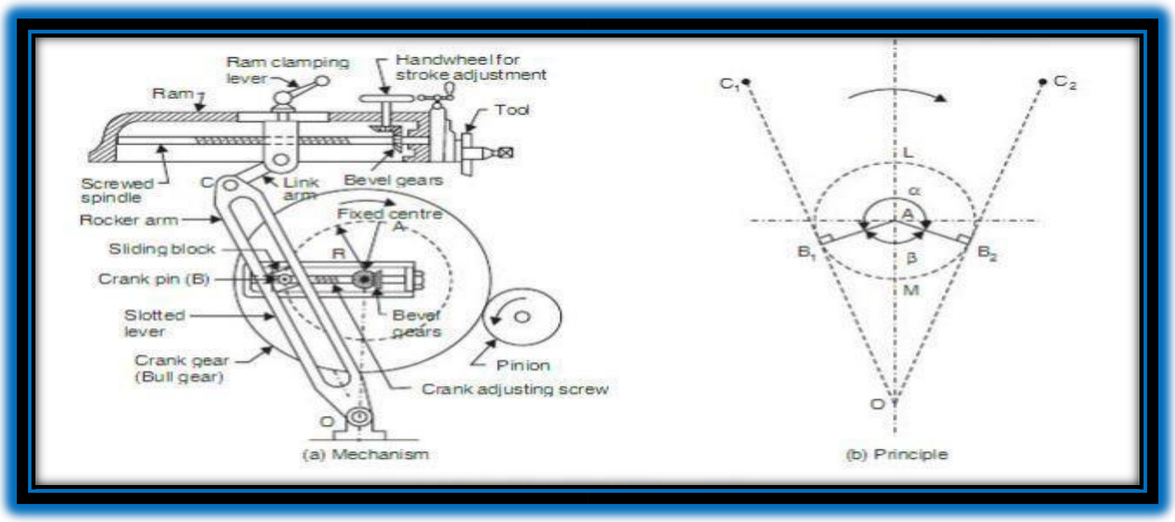


Figure 10.2
Quick Return Mechanism

which is proportional to angle β.

Cutting Tools Used In Shaping:-

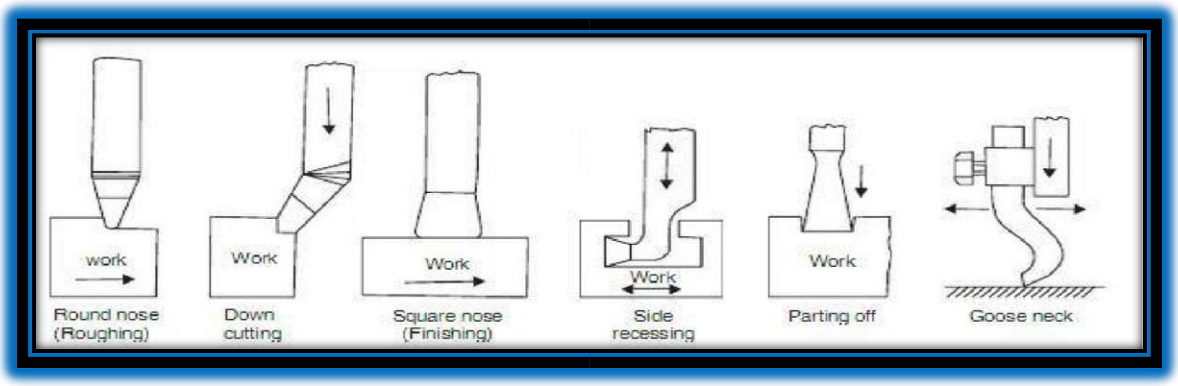


Figure 10.3
Tools used in shaper

The cutting tools for shapers are generally made of H.S.S., either solid or with brazed tips. Due to interrupted cuts, tungsten carbide tools are not preferred for shaping work. These tools are made sturdy with fairly generous size for shank and tip. Various types of tools useful for shaping are shown in figure 10.3.

SPECIFICATION OF A SHAPER:-

The size of a shaper is specified by the maximum length of strokes or cut it can make. Usually the size of shaper ranges from 175 to 900mm. Besides the length of stroke, other particulars, such as the type of drive (belt drive or individual motor drive), floor space required, weight of the machine, cutting to return stroke ratio, number and amount of feed, power input etc. are also sometimes required for complete specification of a shaper.

Metal cutting parameters-shaper.

Cutting speed 'V_c':

The distance an object travels in a particular period of time is known as speed. In a shaper, the cutting speed is the speed at which the metal is removed by the cutting tool in a period of one minute. In a shaper, the cutting speed is considered only during the forward cutting stroke. This is expressed in meter per minute. The cutting speed differs to suit different machining conditions like work material, the finish required, and the type of the tool and the rigidity of the machine.

Depth of cut'd':

Depth of cut (d) is the thickness of metal that is removed during machining. It is the perpendicular distance measured between the machined surface and the uncut surface of the work piece. It is expressed in mm or in inches.

Feed ‘So’:

Feed (So) is the relative movement of the work or tool in a direction perpendicular to the axis of reciprocation of the ram per double stroke. It is expressed in mm per stroke.

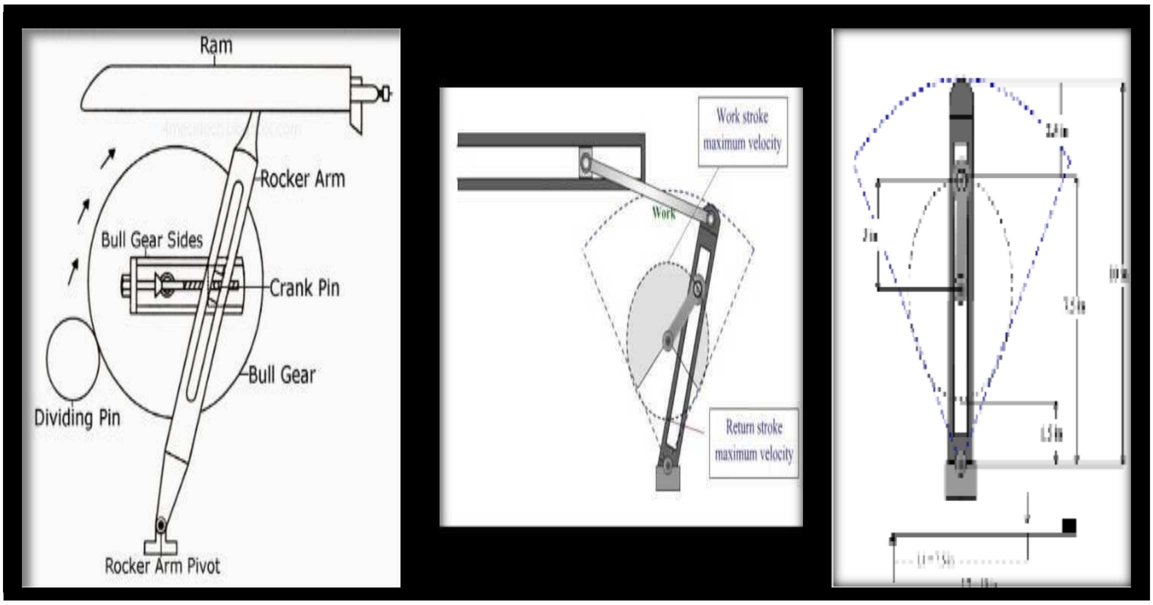
Feed drive mechanism:

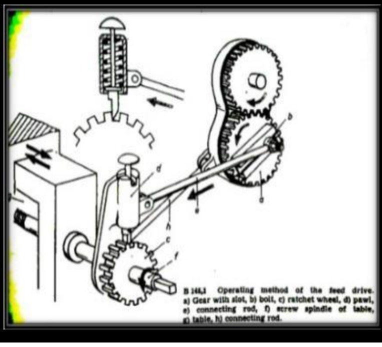
The amount of feed can be adjusted by shifting the bolt (b)

During roughing operation the pawl shifts the ratchet wheel by several teeth and during finishing operation it moves tooth by tooth.

Example of feed calculation:

If the screw spindle of the table has a pitch of 4mm, it turns once and the ratchet wheel has 20 teeth, what distance will the table move while the ratchet rotates by one tooth. = 0.2mm





B 144,1 Operating method of the feed drive. a) Gear with slot, b) bolt, c) ratchet wheel, d) pawl, e) connecting rod, f) screw spindle of table, g) table, h) connecting rod.

Material	Strength/ hardness	Roughing				Finishing			
		Depth of cut, mm	feed/stroke, mm	Speed, m/min HSS	Speed, m/min Carbide	Depth of cut, mm	feed/stroke, mm	Speed, m/min HSS	Speed, m/min Carbide
Low and plain carbon steels	< 60 kg/mm²	5-10	up to 1.5	20-30	50-80	0.15	depends on tool 2/3 the width of square nose finishing tool	20-25	50-70
Plain-carbon steels	> 60 kg/mm²	"	"	15-25	40-70	"		15-20	50-60
Alloy steels	< 80 kg/mm²	"	"	15-25	50-70	"	"	15-20	50-60
	> 80/kg/mm²	"	up to 1.2	8-20	30-60	"	"	10-15	40-50
Cast iron	< 180 BHN	"	up to 1.5	15-20	50-80	0.20	"	15-18	50-60
	> 180 BHN	"	up to 1.2	6-15	30-60	0.15	"	8-12	30-40
Aluminium and its alloys	–	"	up to 2.5	60-100	50-90	0.25	"	60-100	60-80

Example 10.1:

Calculation: work (Forward) stroke maximum velocity

Step 1: Calculate the circumference of the crank,

$C = 2\pi r$

$C = 2\pi 3$

$C = 18.85$in.

Step 2: Calculate the velocity (in/sec) of the crank.

$V_1 = C \times rpm$

$V_1 = 18.85 \times 30$

$V_1 = 565.5$in/min.

Divide by 60 to convert to velocity (in/sec).

$V_1 = 9.425$in/sec

Step 3: Identify the points on the quick return mechanism that correspond with the fulcrum, L_1, L_2, V_1 and V_2 of a class 3 lever.

Use the lever ratio to calculate V_2,

$L_1/L_2 = V_1/V_2$

7.5 in/10 in = 9.425in/sec/V_2 $V_2 = 12.57$in/sec.

Work (Forward) stroke maximum velocity = V_2 = 12.57in/sec.

Calculation: Idle (Return) stroke

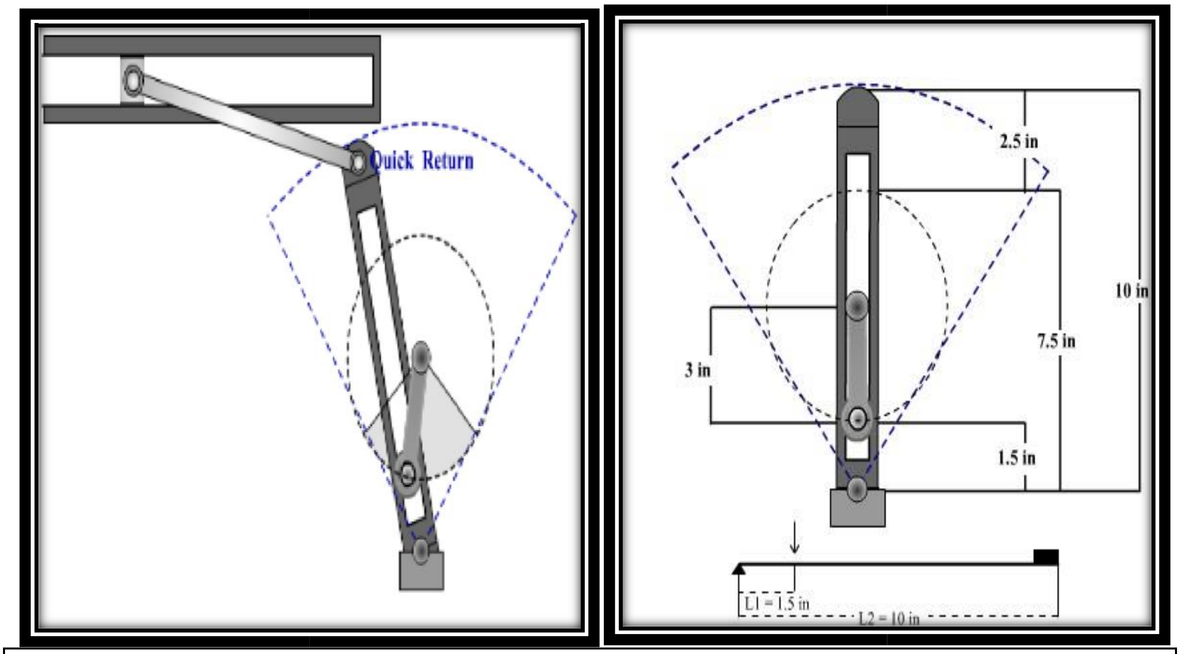


FIGURE 10.6

Example 10.2:

Calculation: Idle (Return) stroke maximum velocity

Step 1: Calculate the circumference of the crank,

$C = 2\pi r$

$C = 2\,(3)\,\pi$

$C = 18.85$ in.

Step 2: Calculate the velocity (in/sec) of the crank.

$V_1 = C \times rpm$

$V_1 = 18.85 \times 30$

$V_1 = 565.5$in/min.

Divide by 60 to convert to velocity (in/sec).

$V_1 = 9.425$in/sec

Step 3: **Identify the points on the quick return mechanism that correspond with the fulcrum,**

L_1, L_2, V_1 and V_2 of a class 3 lever.

Use the lever ratio to calculate V_2,

$L_1/L_2 = V_1/V_2$

1.5 in/10 in = 9.425 in/sec/V_2 $V_2 = 62.83$in/sec.

- **Idle (Return) stroke maximum velocity = V_2 = 62.83in/sec.**

<u>Machining time in shaping</u>:-

Machining time in shaping can be estimated using the scheme given in Fig. 10.7 which shows the length of tool- work travels required to remove a layer of material from the top

flat surface of a block in a shaping machine.

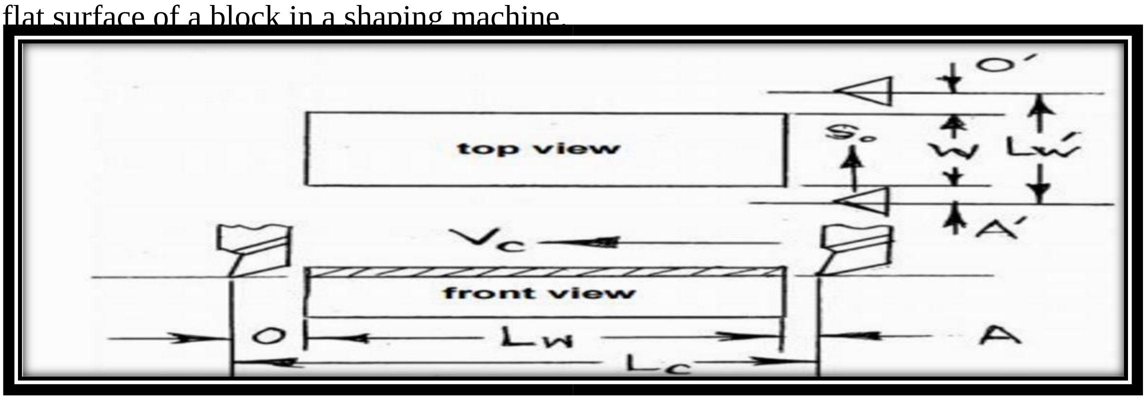


Figure 10.7
Machining Time in Shaper

Using Fig. , the total machining time, T_c can be determined from the expression,

$$T_c = L_w'/N_sS_o \quad \text{min.}$$

Where,

L_w'= Total length of travel of the job= w+A'+O'= Width of work piece+ Approach' + Overrun'

N_s = Number of double strokes (one cutting and one return stroke) of the ram per minute

S_o = Feed of the job, mm/stroke

'N_s' has to be determined from,

Cutting Velocity= V_c= $N_s [L_c (1+Q)]/1000$ m**/min.**

Therefore,

N_s=$V_c \times 1000/L_c (1+Q)$ **stroke/min.**

Practically the speed that is available nearest to the calculated value is to be taken up.

Stroke Length= Lc = (Lw + A+ O) **mm → (Length of work piece + Approach + Overrun)**

Quick return ratio=Q=time of return stroke ÷ time of cutting stroke

=time idle stroke/time of working stroke

The values of V_c and S_o are to be selected or decided considering the relevant factors already mentioned.

Material removal rate= MMR= $S_o \times d \times L \times N (1+Q)$**mm3/min**

Example10.2

Estimate the time required to machine a cast iron surface 250mm long and 150mm wide on a shaper with return to cutting time ratio of 2/3. Use a cutting speed of 21m/min, a feed of 2mm/stroke and clearance at each end is 25mm & 2mm. The available ram strokes on the shaper are: 28, 40, 60 and 90strokes/min. Also, determine MRR assuming depth of cut as 4mm.

Solution: Given data,

Work piece Length= L_w = 250mm

Work piece width= w = 150mm

Work piece Clearance= C = 25mm&2mm → Approach+ Overrun=25+25=50mm

→ Approach'+ Overrun'=2+2 = 4mm

Feed= S_o = 2mm/double stroke

Depth of cut d= 4mm

Available ram strokes = 28,40,60,90 Stroke/min Cutting time=3Sec. & Return time=2Sec.

Return to cutting time ratio= 2/3

Quick Return Ratio = Q= 2/3

Given work piece clearance is 25mm & 2mm, hence

$L_c = L_w + A + O = 250+25+25= 300$mm

$L_w' = w + A' + O' = 150+2+2 = 154$mm

We know that,

Cutting speed= $V_c = N_s \times L_c (1+Q)/1ooo$ m/min From the above equation,

We find number of double strokes N_s per minute

$N_s = V_c \times 1000/L_c (1+Q) = 21 \times 1000/300(1+2/3)$ =42strokes/min

Nearest available ram strokes is 40 strokes/min. Since calculated value is more than 40, this is chosen. Normally, we should not exceed the specified cutting speed, as it will affect the tool life adversely. Hence select N=40strokes/min.

$$T_c = L_w'/N_s \times S_o = \text{Work piece width} + A' + O'/\text{number of strokes} \times \text{feed}$$

T_c = 150+2+2/40×2 = 1.92min.

Material removal rate= MMR= $S_o \times d \times L \times N\ (1 + Q)$ **mm^3/min**

= **2** × 4 × 250 ×40 (1+2/3) **mm^3/min**

=133,333 **$mm^3/min = 133 cm^3/min = 2.21 cm^3/sec$**

<u>EXPERIMENTAL PORTION</u>:-

Basic shaper measurements

Maximum stroke length (of the ram/tool)	__________
Range of number of strokes per minute	__________
Max. axial and vertical travel of the bed	__________
Range of the table feed mechanism	__________
Maximum vertical tool slide	__________
Least count of tool slide (Down feed) collar	__________
Maximum swivel tool head	__________
Quick return ratio	__________
Power of the main drive	__________

Space occupied by the machine

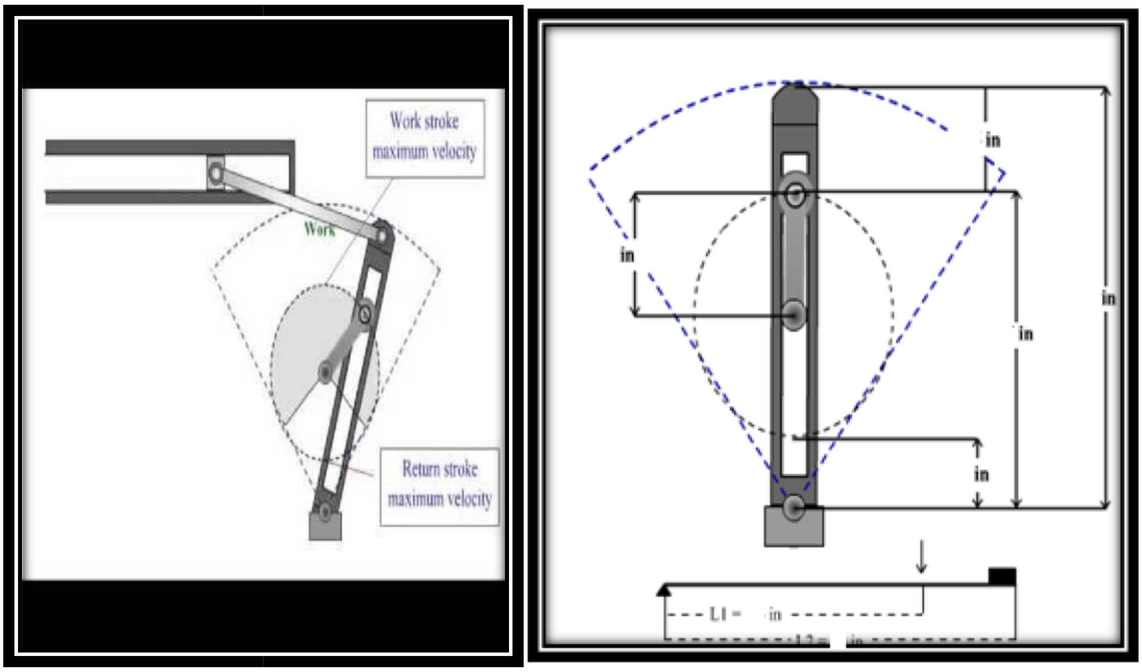


FIGURE 10.8 →LABEL THE FIGURE

Calculation: work (Forward) stroke maximum velocity

Step 1:

Step 2:

Step 3:

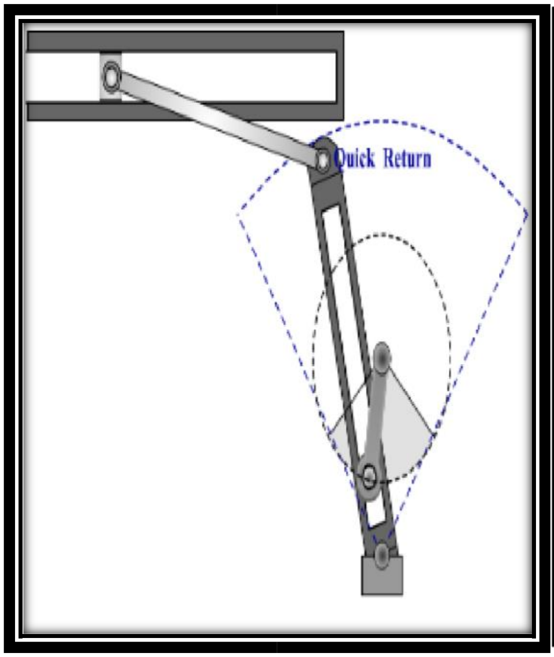
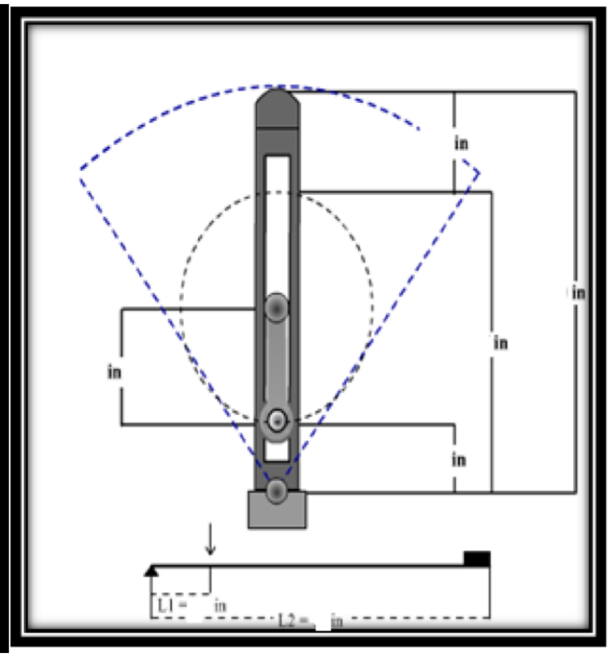


FIGURE 10.9



→LABEL THE FIGURE

Calculation: Idle (Return) stroke maximum velocity

Step 1:

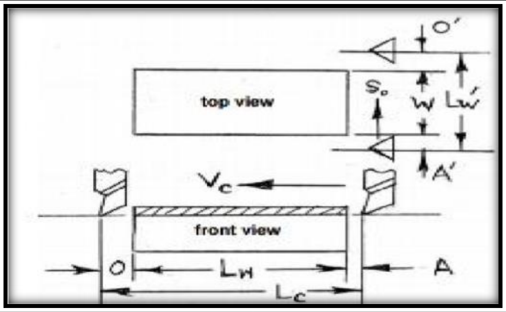
Step 2:

Step 3:

<u>Machining time calculations and surface finish demonstration task:</u>- Roughing cut Task:

Estimate the time required to machine a mild steel surface ____mm long and ____mm wide on a shaper with return to cutting time ratio is ‘Q’_____. Use a cutting speed of __m/min, a feed of __mm/stroke and a clearance of _____ &_____. The available ram strokes on the

shaper are: and strokes/min. Also determine MRR assuming depth of cut as mm



Material	Strength/ hardness	Roughing: Depth of cut, mm	Roughing: feed/stroke, mm	Roughing: Speed, m/min HSS	Roughing: Speed, m/min Carbide	Finishing: Depth of cut, mm	Finishing: feed/stroke, mm	Finishing: Speed, m/min HSS	Finishing: Speed, m/min Carbide
Low and plain carbon steels	< 60 kg/mm²	5-10	up to 1.5	20-30	50-80	0.15	depends on tool 2/3 the width of square nose finishing tool	20-25	50-70
Plain-carbon steels	> 60 kg/mm²	"	"	15-25	40-70	"		15-20	50-60
Alloy steels	< 80 kg/mm²	"	"	15-25	50-70	"	"	15-20	50-60
	> 80/kg/mm²	"	up to 1.2	8-20	30-60	"	"	10-15	40-50
Cast ir on	< 180 BHN	"	up to 1.5	15-20	50-80	0.20	"	15-18	50-60
	> 180 BHN	"	up to 1.2	6-15	30-60	0.15	"	8-12	30-40
Aluminium and its alloys	–	"	up to 2.5	60-100	50-90	0.25	"	60-100	60-80

Material	MATERIAL IN TOOL: High-Speed Tool Steel — Roughing Cut	High-Speed Tool Steel — Finishing Cut *	Carbon Tool Steel — Roughing Cut	Carbon Tool Steel — Finishing Cut *
	Cutting Speed in Feet Per Minute			
Aluminum	150	Max. Safe Speed	100	150
Brass	150	Max. Safe Speed	100	150
Bronze (Hard)	60	100	30	50
Cast Iron	60	100	30	50
Machine Steel	80	120	40	60
Annealed Tool Steel	50	60	25	35

SELECTED REFERENCES

Burghardt, Henry D.
Machine Tool Operation, Part II

Colvin & Stanley
American Machinists' Handbook

Distance traveled by the crank pin during the cutting stroke=220°

Distance traveled by the crank pin during the return stroke=140°

Let the missing term be expressed by ‘X’

Then, Let X= the ratio

220:140=X:1

140X=220

X=1.57

The ratio can then be expressed as 220:140 = 1.5:1 or 3:2

This means that the ratio of the cutting sroke time to the return stroke time is 3:2, and that it takes approximately 1-1/2 times as long to make a cutting stroke as it dose to make a return stroke. The sum of the terms of this ratio (3:2) equals t5 and represents the time required to make one complete stroke :3/5 of this time equals the time of the cutting stroke and reminder, 2/5, equals the time of the return stroke.

Finishing cut task:

Estimate the time required to machine a mild steel surface ____mm long and ____mm wide on a shaper with return to cutting time ratio is 'Q'_____. Use a cutting speed of __m/min, a feed of __mm/stroke and a clearance of _____ & ______. The available ram strokes on the shaper are: __, __, and _ strokes/min. Also determine MRR assuming depth of cut as ___mm.

Theoretical roughing time: ____

Theoretical finishing time: ____

Experimental roughing time: ____

Experimental finishing time: ____

Difference in roughing theoretical and experimental time: ___________________________

Difference in finishing theoretical and experimental time:

____

Roughing Cut	Finishing Cut

COMMENTS:-

EXPERIMENT # 8

To machine a component by shaper

Scope:-

The scope of this experiment is to familiarize the students with the basic characteristic features of shaper like surface (cutting) speed, feed, and depth of cut and by using these features machining a V- block. **Apparatus:-**

Horizontal shaper

Scriber

Vernier caliper

Work piece material=Teflon

Blank Dimension =Length × width × Height______________

Work piece Length=L_{w}=

Work piece width = w =

Work piece Clearance= Approach+ Overrun=

Finishing feed=S_o =____________________________mm/double stroke

Finishing Depth of cut'd'=_____________________mm

Available ram strokes=________________________Stroke/min

Quick Return Ratio=Q=_______________________

Finish Cutting speed=V_c =______________________m/min

Ram Strokes for finishing=_____________________strokes/min

Cutting speed= V_c = $N_s \times L_c$ (1+Q)/1ooo__________ m/min

N_s= V_c×1000/L_c (1+Q) =______________________strokes/min

Procedure:-

11-a Mark the piece at given dimensions with the help of scriber.

11-b Hold the work piece in a vice and machine the bottom surface shown in the sketch.

11-c Invert the casting in the vice and machine the top surface till the desired height is obtained.

11-d Machine the inclined faces using right and left hand tools.

11-e Finally machine the groove.

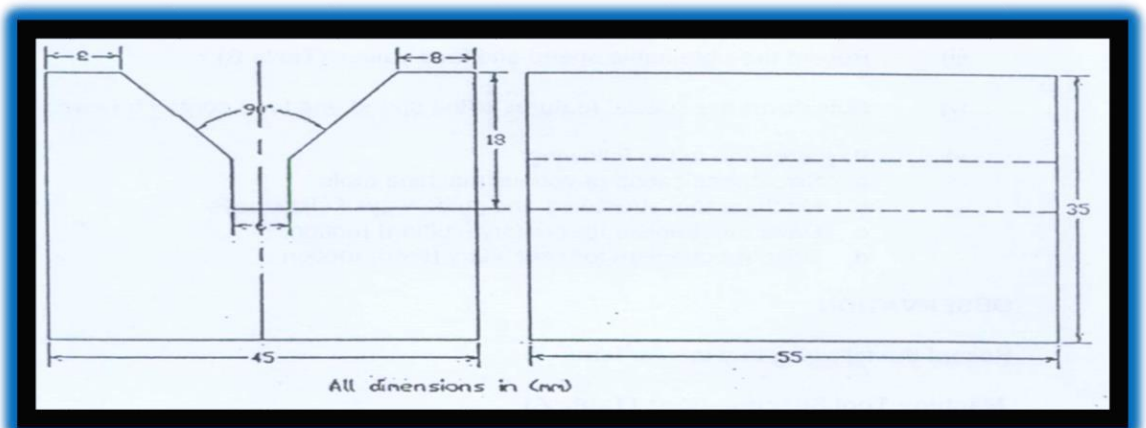
Safety Precaution:-

Apron must be worn, when working in work shop.

Do not take the measurement of job during running machine.

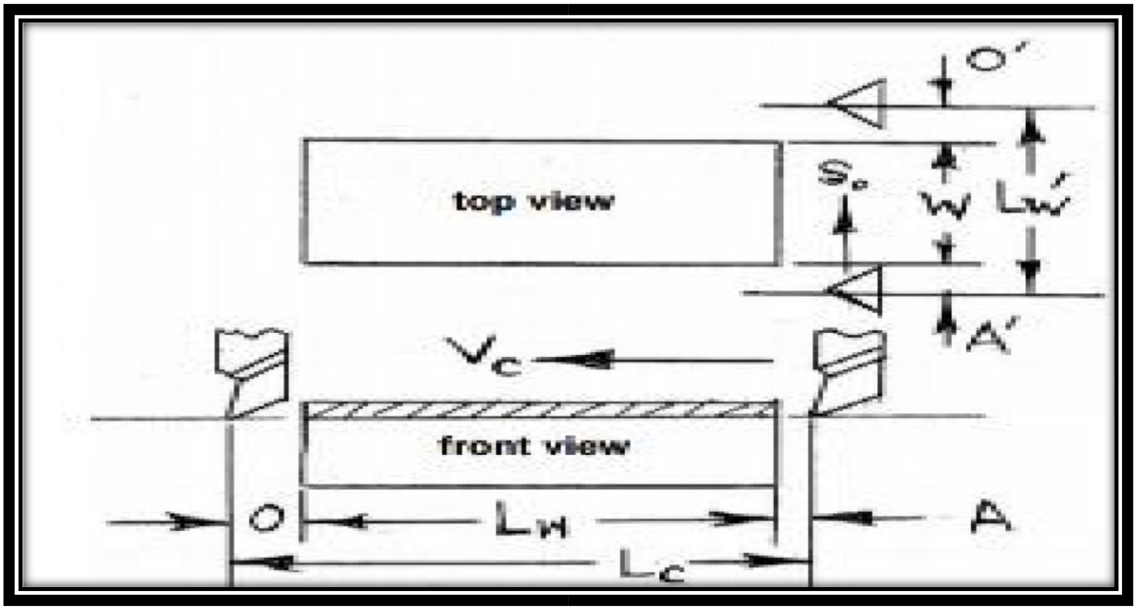
Do not remove the metal chips while machine is in operation. Concentrate yourself on work.

To machine a v- block as shown in the sketch.



Attach the picture of the V-block made by shaper on the space provided below

FIGURE - 11.1



Experimental portion:-

<u>COMMENTS:</u>

EXPERIMENT# 9

Study the characteristic features of milling machine

Scope:-

The scope of this experiment is to familiarize the students with the basic characteristic features like feed, depth of cut, surface speed and by using these feature calculating the theoretical and experimental machining time also metal removal rate for a particular slab milling task.

Apparatus:-

Universal milling machine

Vernier caliper

Meter rule

Stop watch

Theory:-

Introduction

Milling is one of the important machining operations. In this operation the work piece is fed against a rotating cylindrical tool. The rotating tool consists of multiple cutting edges (multipoint cutting tool). Milling operation is distinguished from other machining operations on the basis of orientation between the tool axis and the feed direction; however, in other operations like drilling, turning, etc. the tool is fed in the direction parallel to axis of rotation.

The cutting tool used in milling operation is called milling cutter, which consists of multiple edges called teeth. The machine that performs the milling operations by producing required relative motion between work piece and tool is called milling machine. It provides the required relative motion under very controlled conditions.

Normally, the milling operation creates plane surfaces. Other geometries can also be created by milling machine. Milling operation is considered an interrupted cutting operation. Teeth of milling cutter enter and exit the work during each revolution. This interrupted cutting action subjects the teeth to a cycle of impact force and thermal shock on every rotation. The tool material and cutter geometry must be designed to bear the above stated conditions.

Types of Milling Machines

Milling machines can be classified into different categories depending upon their construction,

specification and operations. The choice of any particular machine is primarily determined by nature

of the work to be done, its size, geometry and operations to be performed. The typical classification

of milling machines on the basis of its construction is given below.

1. **<u>Column and Knee Type Milling Machine</u>**

Main shape of column knee type of milling machine is shown in figure12.1. This milling machine

consists of a base having different control mechanisms housed there in. The base consists of a vertical

column at one of its end. There is one more base above the main base and attached to the column that

serves as worktable equipped with different attachments to hold the work piece. This base having

worktable is identified as “knee” of the milling machine. Column and knee type milling machines are

classified according to the various methods of supplying power to the table, different movements of

the table and different axis of rotation of the main spindle. These are described in brief as below.

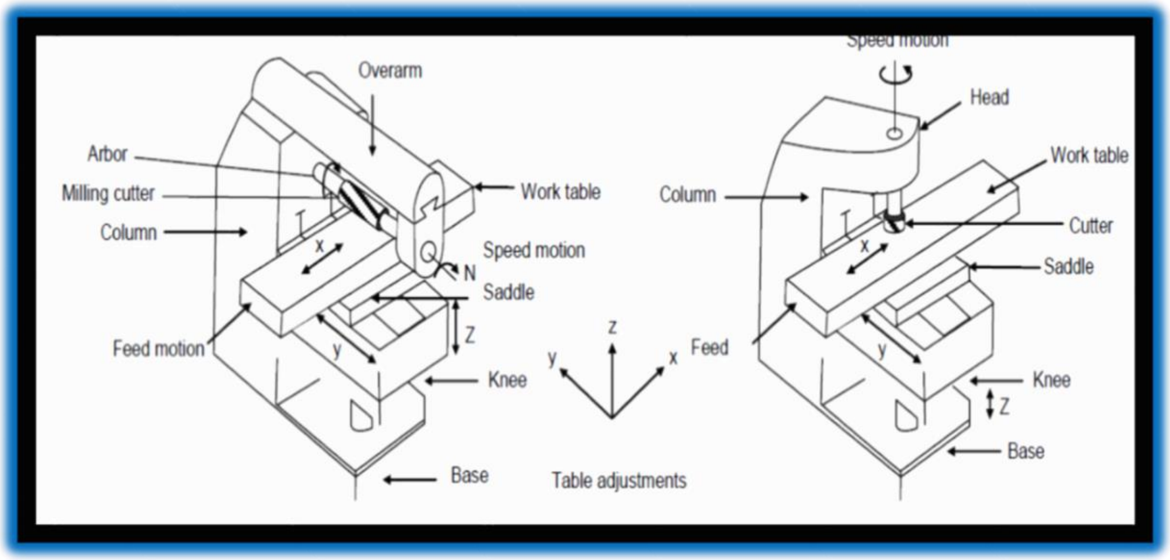


Figure 12.1

a)Hand Milling Machine

In case of head milling machine feed motion is given by hand and movements of the machine are provided by motor. This is simple and light duty milling machine meant for basic operations.

b)Plain Milling Machine

Plain milling machine is similar to hand milling machine but feed movement can be powered controlled in addition to manual control. **c)Universal Milling Machine**

A universal milling machine is named so as it is used to do a large variety of operations. The distinguishing feature of this milling machine is its table which is mounted on a circular swiveling base which has degree graduations. The table can be swiveled to any angle up to 45o on either side of normal position. Helical milling operation is possible on universal milling machine as its table can be fed to cutter at an angle. Provision of a large number of auxiliaries, like dividing head, vertical milling attachments, rotary table, and others make it suitable for wide variety of operations. **d)Omniversal Milling Machine**

Omniversal milling machine is like a universal milling machine with additional feature that its table can be tilted in a vertical plane by providing a swivel arrangement at the knee. This enables it to make taper spiral grooves in reamers, bevel gears, etc.

e)Vertical Milling Machine

Position of spindle is kept vertical or perpendicular to the worktable in case of vertical milling machine.

2. **Fixed Bed Type Milling Machine**

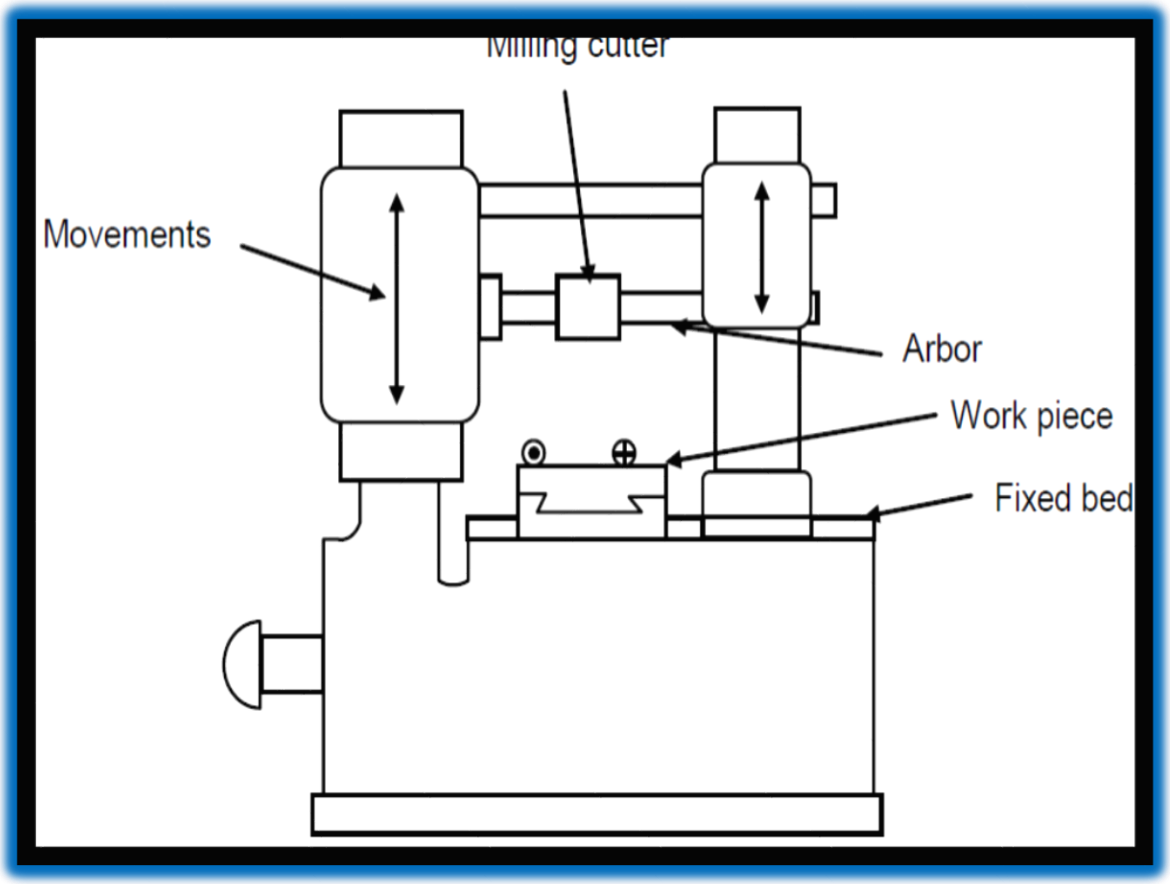
It is also known as manufacturing type milling machine. Its table is mounted directly on the ways of fixed bed. Table movement is restricted to reciprocation only. Cutter is mounted on the Spindle head which can move vertically on the column. Duplex milling machine has double spindle heads, one on each side of the table. Triplex milling machine has three spindle heads one each side of the table and third one is mounted on the cross rail. Bed type milling machine is shown in the figure 12.2.

3. **Planer Type Milling Machine**

It is a heavy duty milling machine, its spindle head is adjustable in vertical and transverse directions. It is different from planner as feed is given to the worktable. This can accommodate a number of independent spindles carrying milling cutters on the rail. Independent driving of the different spindles is possible so multiple operations are possible simultaneously.

Figure 12.2

Fixed Bed Type Milling Machine



4. **Special Type Milling Machines**

These are the special purpose milling machines, entirely different in design and construction from the conventional milling machines. In case of rotary table milling machine face milling cutters are mounted on two or more vertical spindles and a number of work pieces are clamped on the horizontal surface of a circular table which rotates about a vertical axis. Different milling cutters are mounted at different heights. Loading and unloading are possible while milling is in progress. In case of drum milling machine the worktable rotates about a horizontal axis and is called drum. In a planetary milling machine, the work is held stationary while the revolving cutters in a planetary path. It is used to finish cylindrical surface of a work piece internally or externally or both. Pantograph milling machine reproduced the work piece at any desired scale of pre-decided model. Profiling machine duplicates full size of the template attached to the machine. Tracer milling machine can produce any pre-decided irregular or complex shapes of dies, molds by synchronizing movements of the cutter and tracing elements.

Principal parts of a milling machine

Principal parts of a typical milling machine are described as below.

Base

It provides rest for all parts of milling machine including column. It is made of grey iron by casting.

Column

It is a type of rigid vertical long box. It houses driving mechanism of spindle. Table knee is also fixed to the guide ways of column.

Knee

Knee can be adjusted at a height on the column. It houses the feed mechanism of the table and other controls.

Saddle

Saddle is placed at the top of the knee. Saddle provides guide ways for the movement of the table. **Table** Table rests on the saddle. It consists of "T" shaped slots for clamping the work piece.

Movements of the table (feed motions) are given in very controlled manner be lead screw.

Overhanging Arm

Overhanging arm is mounted on the column and serves a bearing support for the arbor. This arm is adjustable so that the bearing support may be provided near to the milling cutter. There can be more than one bearing supports to the arbor.

Arbor

It holds rotating milling cutters rigidly and is mounted on the spindle. Sometimes arbor is supported at maximum distance from support of overhanging arm like a cantilever, it is called stub arbor. Locking provisions are provided in the arbor assembly to ensure its reliability.

Milling Front Brace

Front base is used to adjust the relative position of knee and overhanging arm. It is also an extra support fixed between the knee and overhanging arm for rigidity.

Spindle

Spindle is projected from the column face and provided with a tapered hole to accommodate the arbor. Performance of a milling machine depends on the accuracy, strength and rigidity of the spindle. Spindle also transfer the motive power to arbor through belt or gear from column.

Specifications of a milling machine

Along with the type of a milling machine, it has to be specified by its size. Generally size of a typical milling machine is designated as given below:

(a) Size (dimensions) of the worktable and its movement range.

Table size: Table length X table width as 900 X 275 mm.

Table movements: Longitudinal travel X Cross X Vertical as 600 X 200 X 400 mm.

Above travels indicate maximum movement in a direction.

(b) Number of feeds available (specify their values).
(c) Number of spindle speeds (specify their values).
(d) Total power available.
(e) Spindle nose taper.
(f) Floor space required.
(g) Net weight.

Cutting parameters

There are three major cutting parameters to be controlled in any milling operation. These three parameters are cutting speed, feed rate and depth of cut. These parameters are described below.

Cutting Speed

Cutting speed of a milling cutter is its peripheral linear speed resulting from operation. It is expressed in meters per minute. The cutting speed can be calculated from the above formula.

$$V = \frac{\pi DN}{1000}$$

Where D = Diameter of milling cutter in mm, V = Cutting speed (linear) in meter per minute, and N = Cutter speed in revolution per minute.

Spindle speed of a milling machine is selected to give the desired peripheral speed of cutter.

Feed Rate:-

It is the rate with which the work piece under process advances under the revolving milling cutter. It is known that revolving cutter remains stationary and feed is given to the work piece through worktable. Generally feed is expressed in three ways.

1.Feed per Tooth

It is the distance traveled by the work piece (its advance) between engagements by the two successive teeth. It is expressed as mm/tooth (*ft.*).

2.Feed per Revolution

It is travel of work piece during one revolution of milling cutter. It is expressed as mm/rev. and denoted by *f* (rev).

3.Feed per unit time

Feed can also be expressed as mm/minute or mm/sec. It is the distance advances by the work piece in unit time (f/m).

Depth of Cut

Depth of cut in milling operation is the measure of penetration of cutter into the work piece. It is thickness of the material removed in one pairs of cutter under process. One pairs of cutter means when cutter completes the milling operation from one end of the work piece to another end. In other words, it is the perpendicular distance measured between **Figure 12.3 shows the scheme of plain or slab milling cutter and indicates how the machining time is to be calculated.**

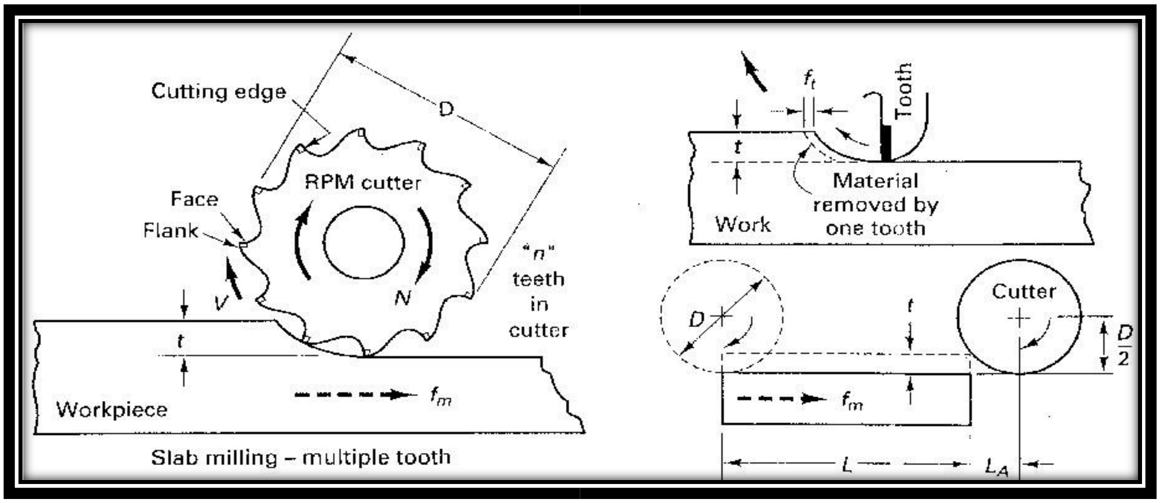


Figure 12.3 Plain or Slab Milling

Terms Used:

N: RPM of Cutter

n: Number of Teeth on Cutter

W: Width of cut (may be full cutter or partial cutter) t: depth of cut

V: cutting speed -- a Handbook value

L: Length of pass or cut f_m: Table (machine) Feed

f_t: feed/tooth of cutter -- a Handbook value

D: Cutter Diameter

CuttingSpeed:

$$N = \frac{1000V}{\pi D}$$

If Cutting Speed for a given RPM rate is desired, solve above equation for $V = \pi ND/1000$ **A.**

Table Feed Rate:

$$f_m = f_t * N * n$$

B. Cutting Time:

$$CT = \frac{L + L_A}{f_m}$$

L_A is Length of Approach of Tool to Work

$$L_A = \sqrt{t(D - t)}$$

C. Material Removal Rate:

$$MRR = \frac{\text{Vol. Removed}}{CT} = \frac{L*W*t}{CT} = W*t*f_m$$

Remember that the length of approach calculated here puts the cutter against the work at the start, we will add a small additional air gap to spin the tool to speed and allow the table to achieve target feed rate before chip making begins. When determining cutting time and MRR, care must be exercised. Ask yourself if total cutting time or time to make one pass across the part is being requested, i.e. is a single or multiple pass operation to be studied. Also, note that in the MRR equation the "cutting time" term does not include the time of partial engagement (L_A). Again, if a multi-pass operation is being employed, the appropriate width term should be used in the MRR equation.

EXPERIMENTAL PORTION:

Fill the following portion:

Table dimensions

Length of table =________________________________

Width of table = ________________________________

Table movements

Table movement along x-axis = _______________

Least count of x-axis hand wheel collar=_______________

Table movement along y-axis = _______________

Least count of y-axis hand wheel collar=_______________

Table movement along z-axis = _______________

Least count of z-axis hand wheel collar= _______________

Automatic feed

Is an automatic feed along x-axis available?	Yes	No
Is an automatic feed along y-axis available?	Yes	No
Is an automatic feed along z-axis available?	Yes	No

<u>Values of automatic table feeds</u>

<u>Experimental readings and calculations Feed per revolution:</u>

Sr. #.	**Feed Levers' Combination**	**Distance travelled by x-axis** (mm)	**Time** (sec)	**Spindle Speed** (rpm)	**Feed** (mm/rev)

1	**1A**				
2	**2A**				
3	**3A**				
4	**1B**				
5	**2B**				
6	**3B**				

Feed per unit time

Sr. No.	**Feed Levers' Combination**	**Distance travelled by x-axis** (mm)	**Time** (sec)	**Spindle Speed** (rpm)	**Feed** (mm/sec)
1	**1A**				
2	**2A**				
3	**3A**				
4	**1B**				
5	**2B**				
6	**3B**				

Spindle Speeds

Sr. No.	**Lever**	**Spindle speed (rpm)**
	Fast	
	Slow	

Motor Power: ________H.P ________KW ____RPM **Machining time calculations and surface finish demonstration task**

Estimate the machining time that will be required to finish an aluminum horizontal flat surface of length 100mm and depth 4mm by a 7 teeth helical plain HSS milling cutter of 57mm diameter and 38mm length in a milling machine.

V_c=119m/min, f_t = 0.08mm/tooth.

Experimental Time: ____

Theoretical time: ____

Difference in theoretical and experimental time:_________________________

Attach the picture of the slab milling made by horizontal milling on the space provided below

COMMENTS:

EXPERIMENT # 10

To machine a spur gear by milling machine

Scope:-

The scope of this experiment is to familiarize the students with the basic characteristic features of horizontal milling and by using these features with the help of universal indexing head machining a spur gear.

Figure 13.1

Spur Gear Cutting

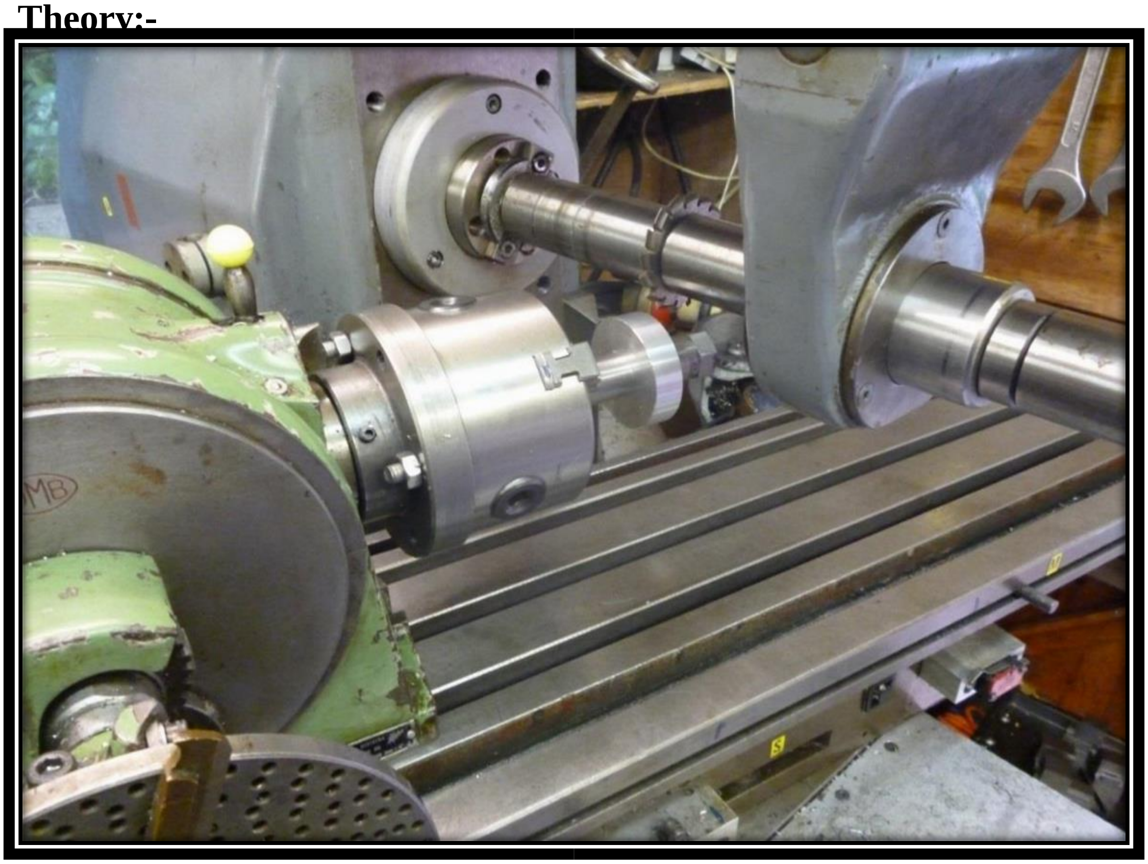
Apparatus:-

Universal milling machine
Universal Indexing head

Gear cutter

Vernier caliper

Theory:-



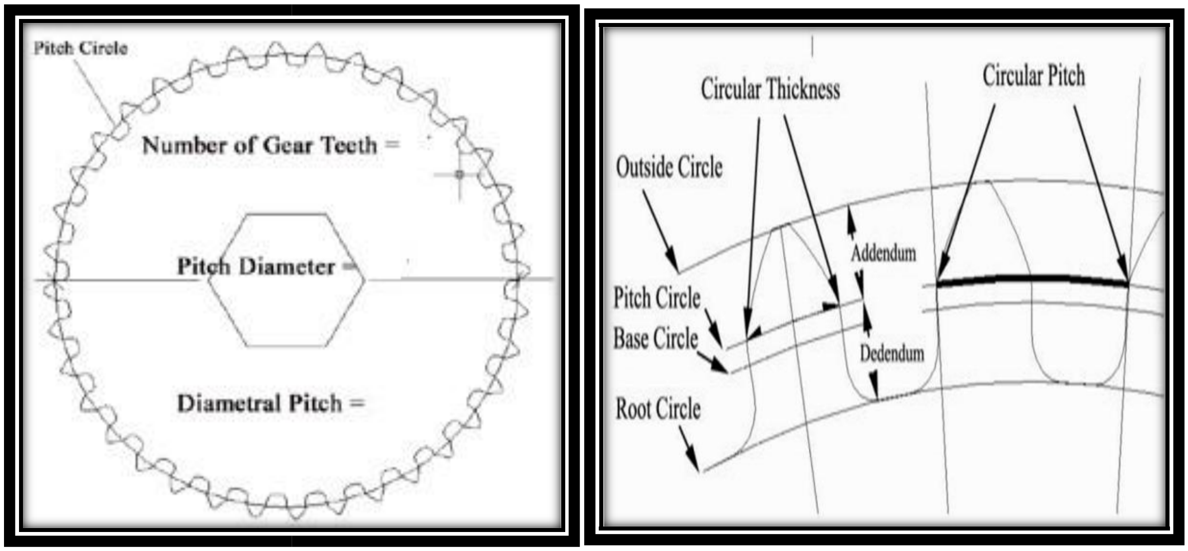


Figure 13.2

Nomenclature of Spur Gear

Nomenclature of spur gear:-

Terms	Definition	Calculation
Pitch Diameter (D)	The diameter of the pitch circle from Which the gear is designed. An imaginary Circle, which will contact the pitch circle Of another gear when in mesh.	**D=N/P**
Diametral Pitch (P)	A ratio of the number of teeth per inch of Pitch diameter.	**P=N/D**
Addendum (A)	The radial distance from the pitch circle To the top of the gear tooth.	**A=1/P**
Deddendum (B)	The radial distance from the pitch circle To the bottom of the tooth.	**B=1.157/P**

Outside Diameter (OD)	The overall diameter of the gear	**OD = N+2/P**
Root Diameter (RD)	The diameter at the bottom of the tooth	**RD = N-2/P**
Base Circle (BC)	The circle used to form the involute section of the gear tooth.	**BC=D*Cos PA**
Circular Pitch (CP)	The measured distance along the Circumference of the pitch diameter From the point of one tooth to the Corresponding point on an adjacent tooth.	**CP = 3.1416D/N** **CP = 3.1416/P**
Circular thickness (T)	Thickness of a tooth measure along the circumference of the pitch circle	**T = 3.1416D/2N** **= 1.57/P**

PROCEDURE:-

____

____

____

____

____

____

____

____

Safety Precaution:-

Apron must be worn, when working in work shop.

Do not take the measurement of job during running machine.

Do not remove the metal chips while machine is in operation.

Concentrate yourself on work.

EXPERIMENTAL PORTION:-

Make a spur gear with 21 teeth on the milling machine using universal dividing head.

Simple Indexing of 21 teeth= 40/N =40/21 x 2/2=1 38/42

Full Turns= ____________

No. of holes= ____________

Hole circles plate= ____________

Blank diameter= ____________

Teeth depth required= ____________

Helical slab milling cutter:

Cutter Diameter= ____________

Module= ____________

Pressure Angle= ____________

Cutter teeth=Z= ____________

Feed f_t= ____________

Depth of cut d= ____________

Available machine RPM= ____________

Nearest available RPM= ____________

$V_c = \frac{\pi D N}{1000}$ ____________

Where ***D*** = Diameter of milling cutter in mm,

V_C = Cutting speed (linear) in meter per minute, and ***N*** = Cutter speed in revolution per minute.

Cutting speed= V_c = ____________ **f_m=** Table feed, mm/min

f_m $=f_t \times n \times N$ ____________

Vc and So have to be selected in the usual way considering the factors stated previously.

Since milling is an intermittent cutting process, Vc should be taken lower (20~40%) of that recommended for continuous machining like turning. So should be taken reasonably low (within 0.10 to 0.5mm) depending upon the tooth- size, work material and surface finish desired.

Pitch Diameter (D)	D=N/P	
Diametral Pitch (P)	P=N/D	
Addendum (A)	A=1/P	
Dedendum (B)	B=1.157/P	
Outside Diameter (OD)	OD = N+2/P	
Root Diameter (RD)	RD = N2/P	
Base Circle (BC)	BC=D*Cos PA	
Circular Pitch (CP)	CP = 3.1416D/N CP = 3.1416/P	
Circular thickness (T)	T = 3.1416D/2N	

~~**Attach the picture of the spur gear made by horizontal milling on the space provided below**~~

COMMENTS:-