Channabasaveshwara Institute of Technology
(Affiliated to VTU, Belagavi & Approved by AICTE, New Delhi)
(**NAAC Accredited & ISO 9001:2015 Certified Institution**)
NH 206 (B.H. Road), Gubbi, Tumakuru – 572 216. Karnataka

Department of Mechanical Engineering

MACHINING SCIENCE & METROLOGY

(BME402)

IV Semester, B.E., (Mechanical Engineering)

(2023–2024)

Name : ____

U S N : ____

Sem & Sec :______________ **Batch :** ____________________

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Department of Mechanical Engineering

CERTIFICATE

This is to certify that Mr. / Ms. .... has satisfactorily completed the course of ***Machining Science & Metrology*** *Prescribed by* ***Vishvesvaraya Technological University*** *for the IV* ***semester B.E.*** *in the year ....*

Mr. / Ms.: ____

U S N.: ____

Semester & Section:________________**Batch No.:** _______________

IA Marks			
Particulars	Max.	Min.	Obtained
Record & Observation	15	06	
Internal Assessment	10	04	
Total	**25**	**10**	

Signature of Staff in-charge Signature of HOD

College Vision

To create of excellence in education and to serve the society by enhancing the quality of life through value based professional leadership.

College Mission

- ❖ To provide high quality technical and professionally relevant education in a diverse learning environment.
- ❖ To provide the values that prepare students to lead their lives with personal integrity, professional ethics and civic responsibility in a global society.
- ❖ To prepare the next generation of skilled professionals to successfully compete in the diverse global market.
- ❖ To promote a campus environment that welcomes and honors women and men of all races, creeds and cultures, values and intellectual curiosity, pursuit of knowledge and academic integrity and freedom.
- ❖ To offer a wide variety of off-campus education and training programmes to individuals and groups.
- ❖ To stimulate collaborative efforts with industry, universities, government and professional societies.
- ❖ To facilitate public understanding of technical issues and achieve excellence in the operations of the institute.

Department Vision

To create state of the art learning environment to nurture the learning, blending human values, academic professionalism and research process in the field of mechanical engineering for the betterment of society.

Department Mission

The mission of the department is to

- ❖ Provide requisite foundation to our students in Mechanical Engineering
- ❖ Provide cutting edge laboratory resources to bridge the gap between theoretical and practical concepts
- ❖ Provide exposure to various mechanical industries through periodic industrial visits
- ❖ Enhance our students skill set and to make them industry ready by systematic skill development program

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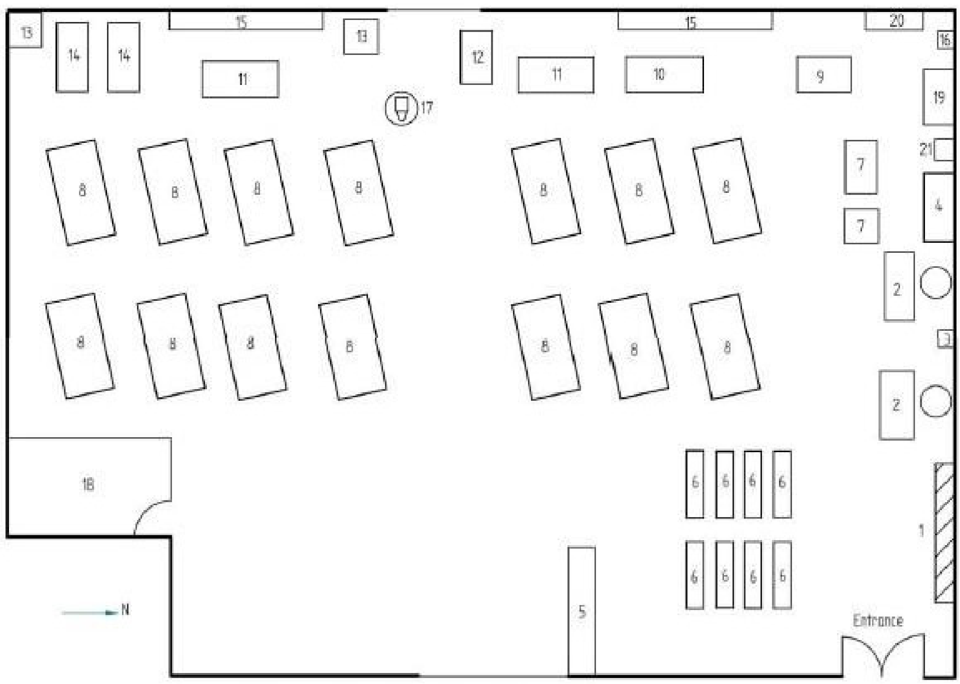
DEPARTMENT OF MECHANICAL ENGINEERING

Layout Of Machine Shop



1. Green Board.
2. Staff Table.
3. First Aid Box.
4. Almerha.
5. Students Bags Rack.
6. Student Desks.
7. Surface Plates.
8. Lathe Machines.
9. Radial Drilling Machine.
10. Surface Grinding Machine.
11. Milling Machines.
12. Power Hack Saw Machine.
13. Bench Grinding Machines.
14. Shaping Machines.
15. Raw Material Storage Area.
16. Scrap Area.
17. Anvil.
18. Tool Crib.
19. Coolant Storage Area.
20. Hand Wash Basin.
21. Fire Extinguisher.

Total Area: $19.63 \times 19.63 = 385.33 \text{ M}^2$

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B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – IV

MACHINING SCIENCE & METROLOGY(IPCC)

Course Code	**BME402**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:2	SEE Marks	50
Credits	04	Exam Hours	03

Course objectives:

- To enrich the knowledge pertaining to relative motion and mechanics required for various machine tools.
- To introduce students to different machine tools to produce components having different shapes and sizes.
- To develop the knowledge on mechanics of machining process and effect of various parameters on machining.
- To understand the basic principles of measurements
- To enrich the knowledge pertaining to gauge , comparator and angular measurement.

Sl. No.	Experiments
1	Preparation of one model on lathe involving - Plain turning, Facing, Knurling, Drilling, Boring, Internal Thread cuts and Eccentric turning.
2	Preparation of One model on lathe involving - Plain turning, Facing , Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning.
3	One Job, Cutting of V Groove/ dovetail / Rectangular groove using a shaper.
4	Cutting of Gear Teeth using Milling Machine.
5	Simple operations and One Job on the drilling and grinding machine.
6	Cutting force measurement with dynamometers (Demonstration) for turning, drilling, grinding operations.
7	Analysis of chip formation and chip reduction coefficient in turning of mild steel by HSS tool with different depth of cut, speed, and feed rate.
8	Experiment on anyone advanced machining process
9	Study & Demonstration of power tools like power drill, power hacksaw, portable hand grinding, cordless screw drivers, production air tools, wood cutter, etc., used in Mechanical Engineering.
10	Demonstration/Experimentation of simple programming of CNC machine operations.
11	Demonstration / Experiment on tool wears and tool life on anyone conventional machining process.
12	To study the tool geometry of a single point turning tool (SPTT) in the American Standards Association (ASA) system.

Course Outcomes: At the end of the course, the student will be able to:

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- CO1: Analyze various cutting parameters in metal cutting.
- CO2: Understand the construction of machines & machine tools and compute the machining time of various operations.
- CO3: Understand the concept of Temperature in Metal Cutting, forms of wear in metal cutting and Cutting fluids
- CO4: Understand the objectives of metrology, methods of measurement, standards of measurement & various measurement parameters. Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design
- CO5: Understand the working principle of different types of comparators, gauges, angular Measurements

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DEPARTMENT OF MECHANICAL ENGINEERING

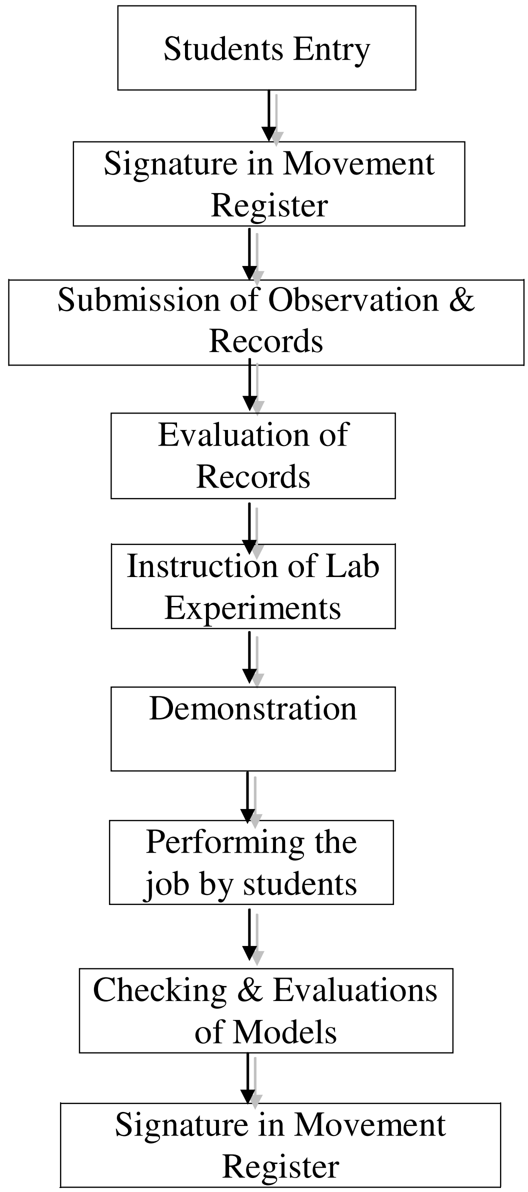
LECTURE PLAN

Sem. & Sec.: **IV & A / B**
Sub.: **Machining Science & Metrology** Lab. Code: **BME402**

Sl. No.	Date	Lesson Plan No.	Name of the Experiment	Remarks
			Batch : B1	
1		LP.1	Preparation of one model on lathe involving - Plain turning, Facing, Knurling, Drilling, Boring, Internal Thread cuts and Eccentric turning.	
2		LP.2	Preparation of One model on lathe involving - Plain turning, Facing , Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning.	
3		LP.3	One Job, Cutting of V Groove/ dovetail / Rectangular groove using a shaper.	
4		LP.4	Cutting of Gear Teeth using Milling Machine.	
5		LP.5	Simple operations and One Job on the drilling and grinding machine.	
6		LP.6	Cutting force measurement with dynamometers (Demonstration) for turning, drilling, grinding operations.	
7		LP.7	Analysis of chip formation and chip reduction coefficient in turning of mild steel by HSS tool with different depth of cut, speed, and feed rate.	
8		LP.8	Experiment on anyone advanced machining process	
9		LP.9	Study & Demonstration of power tools like power drill, power hacksaw, portable hand grinding, cordless screw drivers, production air tools, wood cutter, etc., used in Mechanical Engineering.	
10		LP.10	Demonstration/Experimentation of simple programming of CNC machine operations.	
11		LP.11	Demonstration / Experiment on tool wears and tool life on anyone conventional machining process.	
12		LP.12	To study the tool geometry of a single point turning tool (SPTT) in the American Standards Association (ASA) system.	
14			**LAB INTERNAL**	

Staff In-charge **HOD, Dept. of Mech. Engg**

FLOW CHART OF LAB CONDUCTION



CONTENTS

Experiment No. 1

Preparation of one model on lathe involving - Plain turning, Facing, Knurling, Drilling, Boring, Internal Thread cuts and Eccentric turning

Construction of a Lathe

The lathe basically consists of a **bed** to provide support **head stock**, the **spindle** is driven by **electric motor** through **gear box** to obtain a range of speed.

The **carriage** moves on the bed guide ways parallel to work piece. The carriage consists of the **saddle** the **cross slide, compound slide with tool holder and apron**.

The **saddle** should move in guide ways freely feed and adjustment motion can be manually controlled by the handle.

The **automatic feed** also obtained by engaging feed shaft which is rotated from the head stock through feed gear box.

The **Apron** is fixed to the saddle it carries controls e.g. Levers, hand wheels etc. on the outside.

The **Apron** carries the mechanism to convert the rotary motion of the feed shaft into longitudinal and transverse motion. There are different designs of these gear system. The feed drive is actuated by main drive.

Gears are guarantee reliable transmission and therefore accurate feed.
The **tail stock** also moves on bed guide ways to support the work for concentric turning.

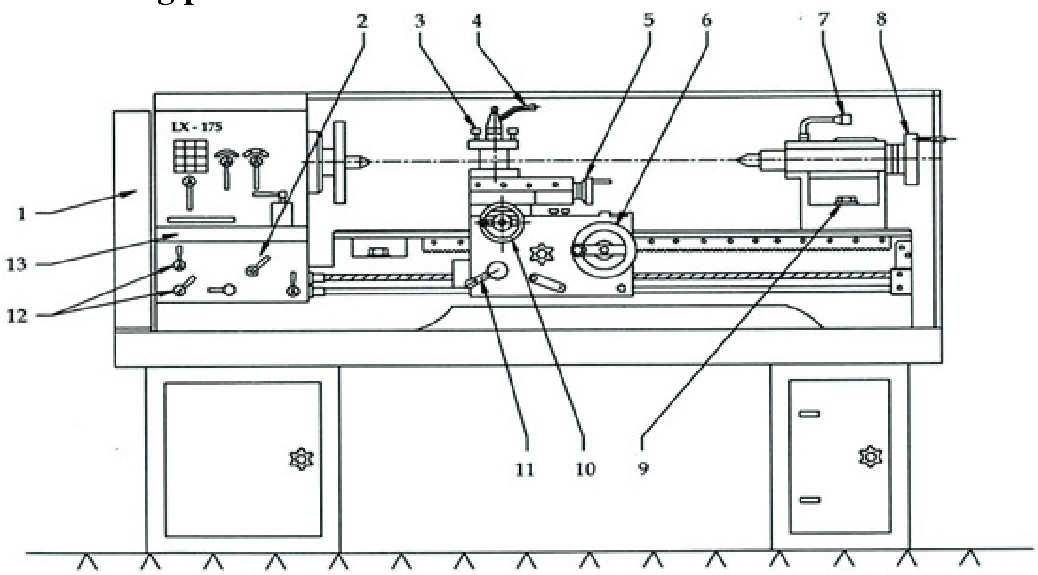
The **Norton gear** box is also driven by power from main drive through gear box to obtain range of thread pitches both right and left hand.

A **feed shaft** and **lead screw** are also provided to power the carriage for auto movement and thread cutting respectively.

Specification

	BALAJI LATHE	**LX-175 All geared head Lathe**	
Qty	7	7	
Type	All geared	All geared	
Height of center over flat bed ways	200 mm	175 mm	
No. of spindle speed and range	8 40 – 1200 rpm	8 45 – 900 rpm	
No. of feed in mm/revolution and range	Long 0.25 Cross 0.05	Long 0.25 Cross 0.05	
		Long 0.42 to 0.85 Traverse 0.11 to 0.21	BC
		Long 0.21 to 0.54 Traverse 0.05 to 0.14	AC
Treading range	0.5 to 15	0.5 to 7.5	
Pitch of the head screw	4TPI	4TPI	
Length of bed	6’ 0”	6’ 0”	
Motor Capacity	2 HP	2 HP	

Basic controlling parts:

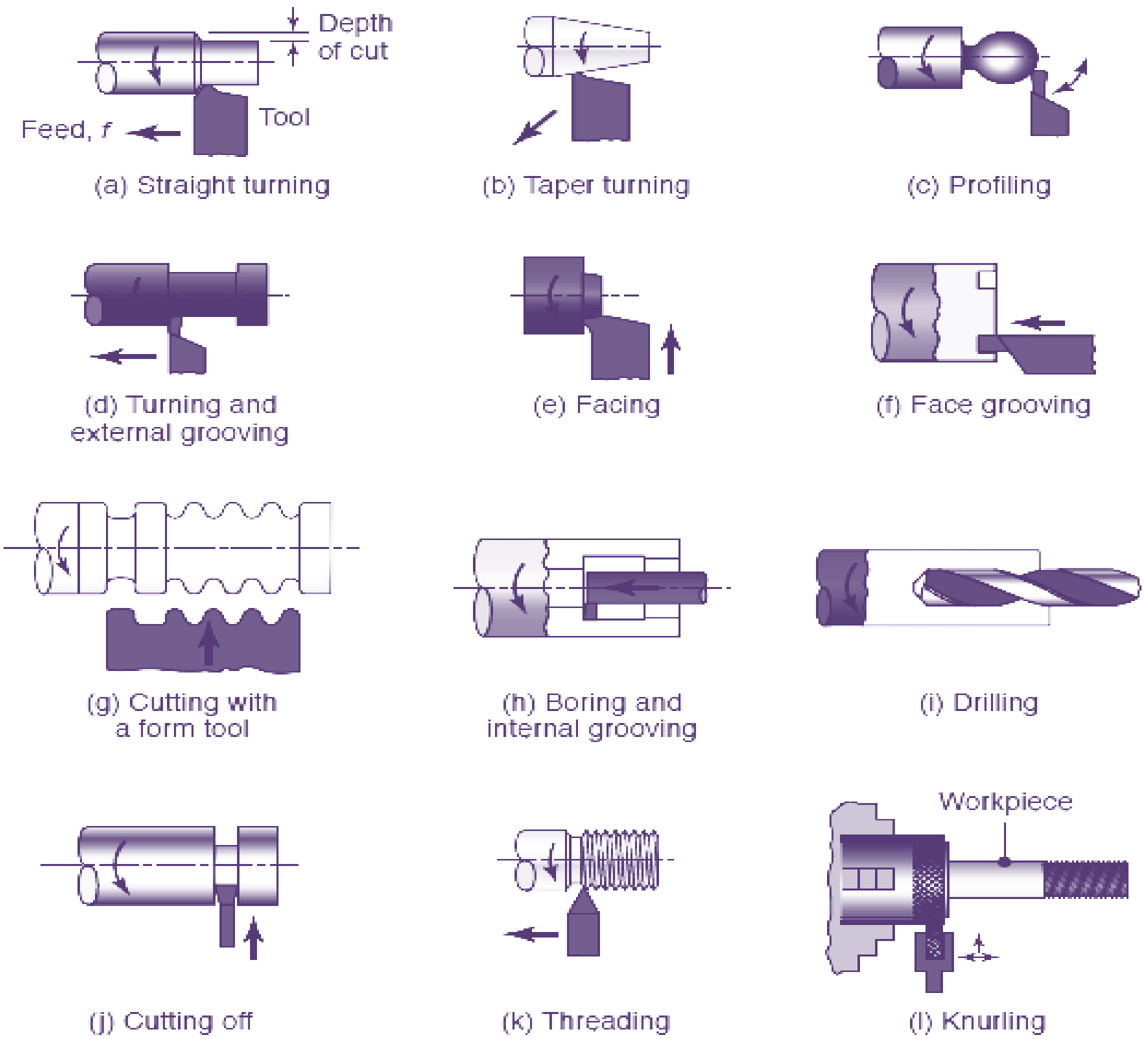


1 R / F switch to Start & Stop
2 Speed Change Lever
3 Tool Post Bolt
4 Tool Post Handle
5 Compound Hand Wheel
6 Apron Hand Wheel
7 Quill Clamping Lever
8 Tail Stock Hand Wheel
9 Clamping Bolt
10 Surface Hand Wheel
11 Half Nut Operating Lever
12 Norton Gear Box Opeating Levers
13 Operating Pannel

1) **R/F Switch to start forward, Stop and reverse:** The function of this lever is to change the direction of motion of lead screw. It is advisable to operate this lever only after the machine stops.
2) **Speed Change Lever: We** can obtain 8 various speed as per our requirement by operating this lever. Don’t operate this lever when themachine is in running condition.
3) **Tool Post Bolt: The** cutting tool is holding by these bolts. Always use spanner to tighten & loosen these bolts.
4) **Tool Post Handle:** During the turning process sometimes it is necessary to give an angle to the cutting tool. Bymeans of this lever we can clamp the tool post at required position.
5) **Compound Hand Wheel:** This hand wheel in longitudinal direction operatesthe compound upperside. Agraduated dialringis providedwith this hand wheel. On this dial ring1 division =0.021mm.
6) **Apron Hand Wheel:** This hand wheel is used to give longitudinal travelto the carriagewith surfaceand compound slide on thebed guideways. On apron hand wheel 1 division =0.200 mm.
7) **Quill Clamping Lever:** By means of this lever, tailstock quill can be clamped in required position.
8) **Tail Stock Hand Wheel:** This hand wheel operates the tail stock quill. The graduated dial ring is provided on this hand wheel. On this dial ring1 division =0.050 mm.
9) **Clamping Bolt:** The function of this bolt is to locate the tail stock body at required position on the bed guide ways.
10) **Surface Hand Wheel:** This handle operates the surface in transverse direction. A graduated dial ring is provided on this hand wheel. On this dial ring1 division =0.10 mm.
11) **Half Operating Lever:** This lever is used to engage or disengage the lead screw while threading operation is performed.

12) **Norton Operating Levers:** Norton gear box is operated by means of this lever so that various pitch of thread can be selected.

Lathe Operations:



1. **Facing:** Facing is the operation of machining from the work-face by feeding the tool at right angles to the work axis at end of a work piece to produce flat surface.

   Purpose:
   - ❖ To remove the rough surface on the face of the work and have finished faces.
   - ❖ To have a face at right angles to the axis of the work.
   - ❖ To have a reference plane to mark and measure the lengths of the work.
   - ❖ To maintain the total length of the work.

2. **Center drilling:**
   - ❖ Centering is the operation of producing conical holes in work pieces at the ends to provide bearing surface for lathe centers.
   - ❖ The axis of the work coincides with the lathe axis.

3. **Plain turning:** The plain turning operation involves removal of metal diametrically from the raw material by feeding the tool parallel to the axis of the work to bring the work to required size.

4. **Taper turning:** Taper is a gradual increase or decrease in diameter along the length of the job.
   Uses:
   - Easy assembly and disassembly of parts.
   - Giving self-alignments in assembled parts.
   - Transmission of power.(Clutch plates.)

5. **Step turning:** Wherever more than one diameter is machined on a shaft, the section joining each diameter is called step or shoulder.

6. **Thread cutting on lathe by using single point cutting tool:** The principle of thread cutting is to produce helical groove on a cylindrical or conical surface by rotating the job at a constant speed and moving the tool longitudinally at the rate equal to pitch of the thread per revolution of the job.

   Uses of thread:
   - Transmission of motion (Half nut with lead screw)
   - Fastening purpose (Nut and Bolt)
   - Precision measuring instruments. (Micrometer)
   - Lifting of load (Screw Jack)
   - Elevating arm of drilling, milling and shaping machines.

7. **Knurling:** Knurling is the operation of producing straight lined diamond shaped or cross lined pattern on a cylindrical external surface by pressing a tool called knurling tool. Knurling is not cutting operation, but it is a forming operation.
   Purpose of knurling:
   - A good grip and make positive handling
   - Good appearance
   - For raising the diameter to a small range

8. **Drilling:** Drilling is the production of cylindrical holes of definite diameter in a work piece by using multipoint cutting tool called drill. It is the first operation done internally for any further operations.

9. **Boring:** Boring is the process of enlarging and turning an existing drilled or core hole with a single point cutting tool.

10. **Eccentric turning:**
    Concentricity: when different diameters are turned in a same axis, it is said to be concentric turning.
    Eccentricity: When different diameters are turned on different axes, it is said to be eccentric turning.
    Uses of eccentric turned jobs:
    - Used in automobiles industry to convert rotary motion in to reciprocating motion
    - Used in power press and press breaks.
    - Used in automatic controls.

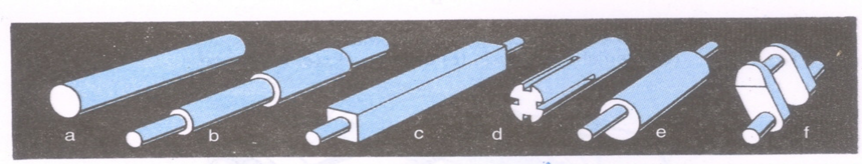
11. **Chamfering:** Chamfering is the operation of beveling the extreme end of the work piece.

12. **Grooving:** Grooving is the process of reducing the diameter of a work piece over a very narrow surface.
13. **Undercutting:** Undercutting is similar to grooving operation performed inside a hole called undercut.

Safety precautions during working on lathe:

1. Before receiving the instruction from instructor or foreman, do not attempt to operate the machine.
2. Before staring any operation always see that the work and cutting tool secured first.
3. Before starting all operating levers are place them in neutral position.
4. Before starting see that the chuck key is removed after the work has been clamped in the chuck.
5. Never mount or remove the work/tool when machine is in running position.
6. Sometimes the handle of the F/R switch may come out to hand during operations. Immediately see another switch provided on the left side bottom to make use of this switch to stop in case emergency.
7. Do not try to stop the chuck with your hands.
8. Never wear loose clothing, Tie your sleeve up at wrist and wear shoes.
9. Tools should never be placed over bed ways.
10. Do not take measurements of the work, when the machine is running.Measurements should not mix with cutting tool.
11. Turning tool must not be clamped when the lathe is running.

Practical application on lathe:



B 46, 2, Examples for various shapes of shafts, (*a*) Cylindrical shaft, (*b*) stepped shaft, (*c*) shaft with square cross-section, (*d*) multiple splined shaft, (*e*) eccentric shaft, (*f*) crank-shaft.

Work holding and supporting devices in machining process includes attachments in lathe work:

❖ **Chucks**

✓ Three jaw self-centering chuck – Used for holding round and other symmetrical works.

✓ Four jaw independent chuck – used for irregular shapes (Ex: Square etc)

❖ **Centers (Live centre and Dead centre)**

Used for support work pieces and take up the thrust due to metal cutting.

❖ **Carriers (Driving plate, lathe dog and catch plate)**

Used to drive the work pieces when it is held between the two centers.

❖ **Faceplates**

Used for machining of flat plates.

❖ **Follower and Steady rests**

Used to hold long work piece is machined.

❖ **Mandrels**
Used to hold rotating a hollow piece of work.

❖ **Drill chuck**
Used to hold in a tail stock center.

Turning tool materials:

1) High speed steel (HSS)

- It is highly alloyed steel contains, carbon, tungsten, chromium, vanadium, molybdenum as alloys, having high resistance to wear.
- It loses its hardness at 600^0 c.
- It enables turning with high cutting speed.

2) Carbide tipped tool (CT tool)

- It increases considerably the working capacity of the tool. The chief constituents of the tool of the tungsten or molybdenum, besides cobalt and carbon.
- It loses its hardness at 900^0c.
- It can be used for operations which require high number of revolution.
- This reduces the working time and increase the cutting speed to producing smooth surface of the work piece.

Turning tool properties:

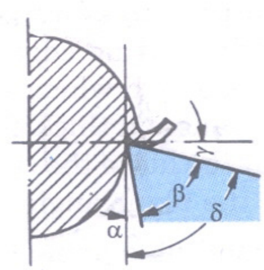
1) **Hardness:** It is essential so that the cutting edge can penetrate into the material.
2) **Toughness:** Poor toughness causes breaking of the cutting edge.
3) **Heat resistance:** It enables the cutting edge to maintain its hardness, when it gets heated due to friction caused in chip removal.
4) **Wear resistance:** It prevents fast wear of cutting edge.

Turning tool cutting angle:

1) **Wedge angle:** The wedge angle 'β' is situated between top face and clearance face.
To prevent breakage of cutting edge hard material requires a large wedge angle (60^0 - 75^0) than soft ones.

2) **Clearance angle:** The clearance angle 'α' is the angle between the cut face and clearance face. This angle is kept in such way that the clearance face does not rub on the work piece (8^0 - 12^0).

3) **Rake angle:** The rake angle 'γ' is the angle between normal cut face and the top face.
A large rake angle is essential to remove chips (10^0 - 14^0)



α – clearance angle (8^0 - 12^0)
e – cut face on workpiece
β – wedge angle (60^0 - 75^0)
f – clearance face (on tool)

γ – rake angle $(10^0 - 14^0)$g – top face (on tool)
δ – cutting angle
Clearance, Wedge and rake angle add up to 90^0.

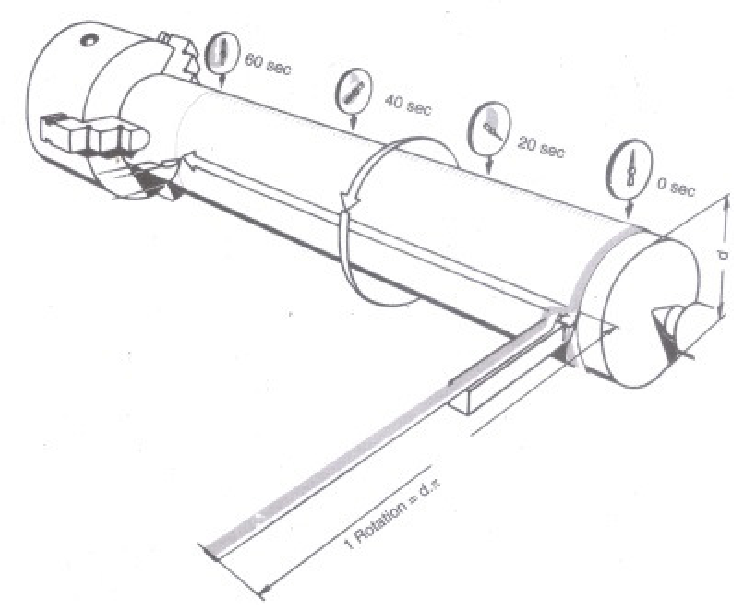
Selection of cutting parameters and cutting time calculation on lathe machine:

- **Cutting Speed for turning operation:** Cutting speed means the number of meters measured on the circumference of the job that passes the cutting tool edge in one minute of time. It is denoted by a letter 'v'.

  Unit: Meter per minute

  Calculation of Cutting Speed = $v = \frac{\pi \, x \, d \, x \, n}{1000}$

  Where, v = Cutting speed, m/min
  d = Diameter of the work piece in mm,
  n = Number of revolutions of the workpiece in RPM.



B 26, 1 Cutting speed for turning operations.

Example: Calculate the cutting speed by which a work piece is to be machined on a lathe. Diameter of work piece 'd' = 50mm, Speed in rpm 'n' = 160rpm

Result: $v = \frac{\pi \, x \, d \, x \, n}{1000} = \frac{3.142 \, x \, 50 \, x \, 160}{1000}$

Cutting Speed = 25 m/min

If the cutting speed is too low the machining time is too long, if it is high the cutting edge of turning tool loses its hardness, the cutting edge wear out quickly.

For the determination of cutting speed the following points to be observed

1. Material of the work piece
2. Material of the turning tool
3. Cross section of chips
4. Cooling
5. Design of the machine

- **Speed:** Speed is the number of circular motion of the spindle /work piece in one minute of time.
  Unit in RPM

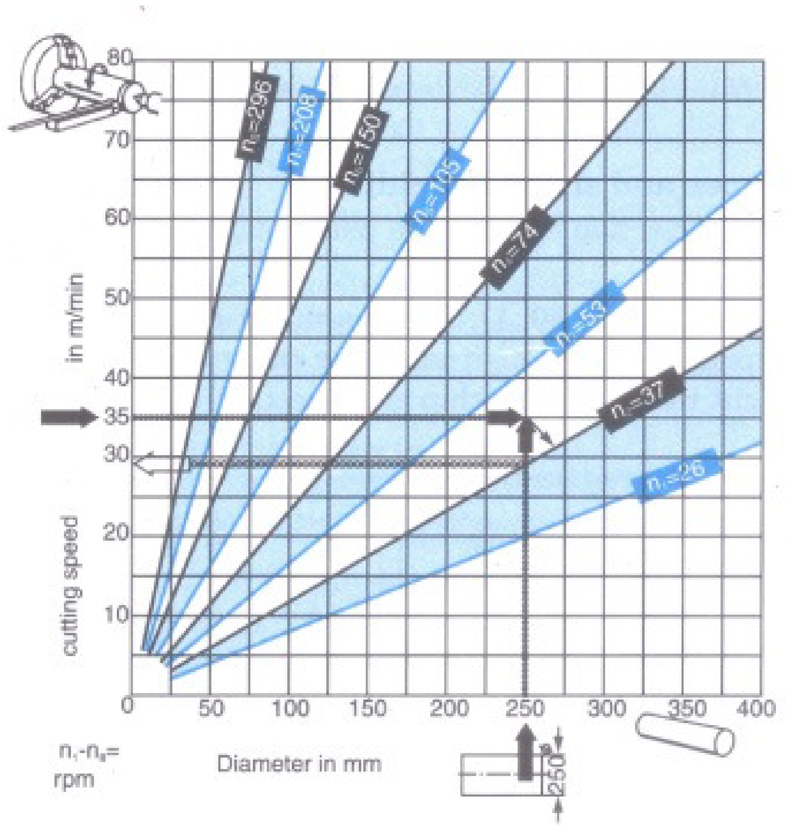
  Calculation of rpm; $n = \dfrac{1000\, x\, v}{\pi\, x\, d}$

Example 1: The rpm has to be calculated. Given d=125mm; v=20m/min.

Result: $n = \dfrac{1000\, x\, v}{\pi\, x\, d} = \dfrac{1000\, x\, 20}{3.142\, x125} = 51 rpm$

Example 2: The rpm has to be calculated. Given d=55mm; v=20m/min.

Result: $n = \dfrac{1000\, x\, v}{\pi\, x\, d} = \dfrac{1000\, x\, 20}{3.142\, x55} = 116 rpm$



B 29, 2 Cutting speed diagram.

Reading the rpm from the cutting speed diagram

The calculation of the rpm is time consuming. In the workshop, the rpm is gemerally read straight from diagram.

- **Feed:** The length (in mm) at which the tool travels at one revolution of the workpiece during longitudinal or transversal turning is called feed.

  Unit: mm/rev

  S^1= s x n mm/min
  Where, S^1= mm/min

s = mm/rev

n = rpm

Calculation of selecting longitudinal feed: 0.25 mm/division.

Cross feed:0.05 mm/division

0.25 x 4 = 1mm

For 20mm; 20 x 4 = 80 division

- **Depth of Cut:**
  - It is the advancement of the tool in the job in a direction perpendicular to the surface being machined. It is denoted as 'a'.
  - **Depth of cut is generally expressed in mm**
  - In a lathe, depth of cut is expressed as,

Depth of cut = $a = \frac{D_1 - D_2}{2} = \frac{25-19}{2} = 3mm$

Where, D_1 – Diameter of the work piece before machining, (mm)

D_2 – Diameter of the machined work piece.(mm)

Cross feed: 0.05 mm/division

0.05 x 20 = 1mm

For 3mm = 3 x 20 = 60 division

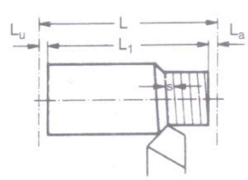
- **Selection of Chip Cross Section:** Feed multiplied by depth of cut results in chip cross section. It is denoted as 'A'

s – feed in mm/rev Data : s = 0.8mm, a = 3mm

a – depth of cut in mm

Result: Chip cross section = A = s x a = 0.8 x 3 = 2.4 mm^2

- ## Calculation of Machining Time for turning operations:

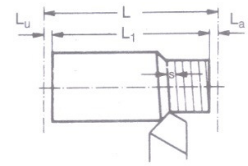


Machining Time = $\frac{Turning\ lengtht(L)}{Feed\,(s)\,/\,Minute} = \frac{L}{s\,x\,n}$

Terms, L = Turning length = Length of the workpiece (L_w) + starting allowance (L_a) + allowance after turning (L_u)

L = $L_w + L_a + L_u$; s = Feed, mm/rev ; n= Speed, rpm ; S^1= feed per minute = s x n.

Longitudinal turning



Example: d = 80mm, L_w= 490mm,L_a = L_u= 5mm, v = 20m/min, s = 0.5mm/rev.

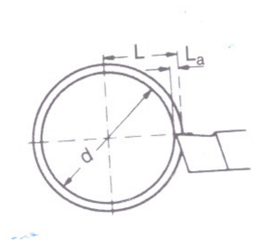
L = L_w+L_a+ L_u

= 490 + 5 + 5 = 500mm

n = $\frac{1000\,x\,20}{3.142\,x\,80} = 79 rpm (refer\ table)$

Machining time = t_m= $\frac{L}{s\,x\,n} = \frac{500}{0.5x79} = 12.5\,\text{min}$

Facing: The turning length (L) correspond with the radius plus starting allowance



L = r x l_a

Terms, L = turning length; r = radius of workpiece; l_a = allowance starting

Example: Calculate the machining time for facing

d = 190mm, l_w= 95, l_a= 5mm, v = 20m/min, s = 0.5mm/rev

L = l_w+l_a

= 95 + 5 = 100mm

n = $\frac{1000\ x\ v}{\pi\ x\ d}$

= 33rpm , But available 37 rpm (refer table)

Machining time = t_m= $\frac{L}{s\,x\,n} = \frac{100}{0.5x37} = 5.4\,\text{min}$ S

Advantages of using cutting fluids during machining

The advantages of cutting fluids in machining operations are:

i. Increase of tool life by cooling the cutting edge.
ii. Decrease tool chip friction.
iii. Provide better finish on the workpiece.
iv. Reduce forces on tool hence economic power consumption.
v. To maintain its dimensional accuracy.
vi. Discourage corrosion of newly machined surface.
vii. Lubricate machine movements.

Maintenance

1. Careful maintenance will increase the life and efficiency of the machine.

2. Any defect however small it should be immediately rectified otherwise this will lead to a major breakdown of the machine resulting in loss of prevention and high cost of repair.

Preventive maintenance and its advantages:

Preventive maintenance means planning and scheduling the maintenance in advance.

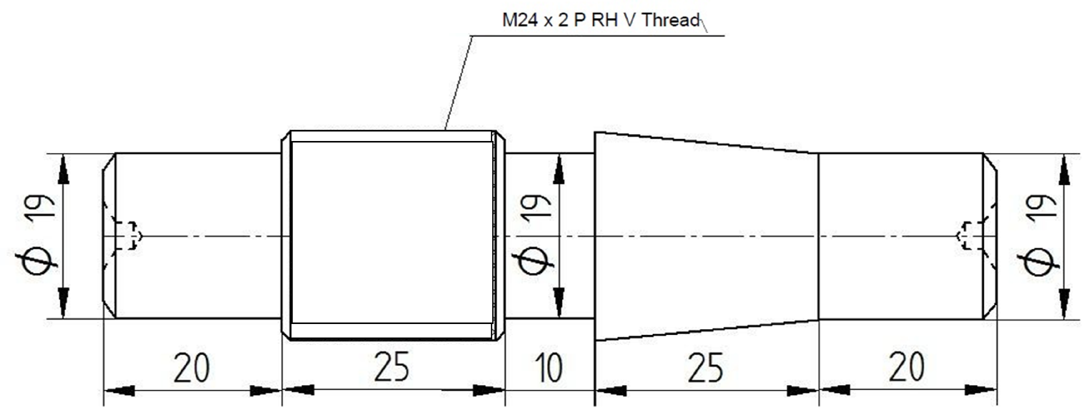
1. To avoid sudden break down of machine.
2. Damage of costly parts are avoided.
3. Shut down of production is avoided.
4. Longer life of the equipment is ensured.
5. Possibility of serial accidents is minimized.
6. Preventive maintenance is less cost than break down maintenance.

Attachment used on a lathe:

1) Grinding attachment
2) Taper turning attachment
3) Milling attachment

Experiment No. 1

Preparation of one model on lathe involving - Plain turning, Facing, Knurling, Drilling, Boring, Internal Thread cuts and Eccentric turning



Note: All dimensions are in mm only

Material: M S bright rod
Size: Ø25 x105Length
Tolerance:±0.50

Taper Turning Calculation

$\tan\theta = (D-d)/2l$

$\theta = \tan^{-1}(D-d)/2l$

$= \tan^{-1}(24-19)/2l$

$= \tan^{-1}(24-19)/2(25)$

$\theta =$

Inspection Instruments: Steel scale, Vernier caliper, micrometer.

Sl No.	Dimension as per drawing in mm	Actual dimension in mm	Deviation (±)	Remarks
1				
2				

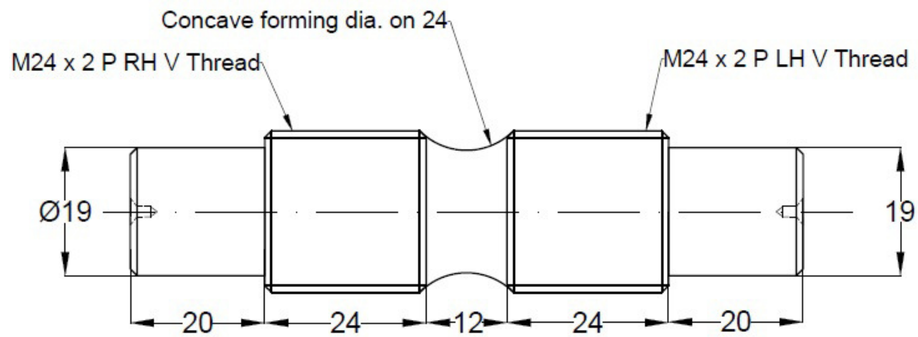
Total No. of deviations:

Working procedure to perform Model No. 01 in a lathe machine

<table>
<tr><th>Sl. No.</th><th>Detail of work</th><th>Operation</th><th>Tool Setting in Correct position</th></tr>
<tr><td>1</td><td>Prepare and study the drawing.</td><td>DRAWING</td><td>To draw sketch using all conventions and notations</td></tr>
<tr><td>2</td><td>Hold the workpiece in work holding device by (3 jaw chuck) keeping 15-20 mm away from chuck.</td><td>HOLDING</td><td>3 jaw self-centering chuck with chuck key</td></tr>
<tr><td>3</td><td>Mount the tools in tool post and centering the tool to work axis.</td><td>TOOL CENTERING</td><td>1) C.T. Tool/Turning tool
2) Grooving / parting tool.
3) Revolving center spanners.
4) Packing Pieces.</td></tr>
<tr><td>4</td><td>To remove rough surface on the face of the work by feeding the tool at Right Angle to axis of the work</td><td>FACING</td><td>1) C.T. Turning tool
2) Spindle speed 500–600 rpm</td></tr>
<tr><td>5</td><td>• To provide axis of the work coincides with lathe axis.
• To provide bearing surface for lathe center</td><td>CENTRE DRILLING OR COUNTER SINKING</td><td>1) 3.15 x 8mm counter sink bit with drill chuck.
2) Spindle speed : 500 – 600 rpm</td></tr>
<tr><td>6</td><td colspan="3">• Remove and reverse work piece.
• Maintain the total length of the work piece.
• Repeat the operations of facing, centre drilling.
• Work piece has to be held between chuck and tailstock center.</td></tr>
<tr><td>7</td><td>Turning more than one diameter on a shaft</td><td>STEP TURNING</td><td>1) C.T. Turning tool
2) Spindle speed: 500 – 600 rpm</td></tr>
<tr><td>8</td><td>Reducing the diameter of the work piece over a very narrow surface</td><td>GROOVING 25ϕ TO 19ϕ</td><td>1) Grooving tool / parting tool
2) Spindle speed : 250 rpm</td></tr>
<tr><td>9</td><td>Gradual increase or decrease in diameter</td><td>TAPER TURNING 25ϕ TO 19ϕ</td><td>1) Swivelling compound rest method Taper Angle
$\tan\theta = \frac{D-d}{2l} = \frac{25-19}{2x25} =$
2) Spindle speed: 500 – 600 rpm
3) Feed is given with compound slide feed handle duly.</td></tr>
<tr><td>10</td><td>Beveling the extreme end of the work</td><td>CHAMFERING</td><td>1) Turning tool
2) Spindle speed: 500 – 600 rpm</td></tr>
<tr><td>11</td><td>Finishing the knurling part. Removal of material by feeding the tool parallel to the axis and the work</td><td>PLAIN TURNING</td><td>1) CT turning tool
2) Spindle speed: 500 – 600 rpm</td></tr>
<tr><td>12</td><td>Preparation of lathe for thread cutting and mounting the H.S.S. thread cutting 'V' tool with thread gauge.</td><td>'V' TOOL CENTERING</td><td rowspan="2">1) H.S.S. threading tool
2) Thread cutting gauge
3) Spindle Speed : 40 – 45 rpm
4) Thread direction: RH/LH.
5) Ref to : Norton gear box chart of required pitch and set the levers.
6) Support with Tail stock centre
7) Depth of cut for metric thread
= 0.6134 x pitch
= 0.6134 x 2 = 1.22/0.05 = 24.5 divn.
8) To engage half nut lever
9) Use of cutting fluid
10) Keep your left hand on "ON & OFF" Switch during threading.</td></tr>
<tr><td>13</td><td>To produce uniformly helical grooves on cylindrical part</td><td>THREAD CUTTING</td></tr>
</table>

Experiment No. 2

Preparation of one model on lathe involving - Plain turning, Facing, Knurling, Drilling, Boring, Internal Thread cuts and Eccentric turning



Note: All dimensions are in mm only

Material: M S bright rod

Size: Ø25 x 105 Length

Tolerance: ±0.50

<u>Blank size for thread cutting</u>

Blank size = Major diameter ________________ Blank size = Major diameter ________

= 24 =24

= 24 – 0.2 =24 – 0.25

= 23.8 mm =23.75 mm

Inspection Instruments: Steel scale, Vernier caliper, micrometer.

Sl No.	Dimension as per drawing in mm	Actual dimension in mm	Deviation (±)	Remarks
1				
2				

Total No. of deviations:

Working procedure to perform Model No. 02 in a lathe machine

Sl. No.	Detail of work	Operation	Tool Setting in Correct position
1	Prepare and study the drawing.	DRAWING	To draw sketch using all conventions and notations
2	Hold the work piece in work holding device by keeping 15-20 mm away from chuck.	HOLDING	3 jaw self-centering chuck with chuck key
3	Mount the tools in tool post and centering the tool to work axis.	TOOL CENTERING	1) C.T. Turning, Grooving. 2) Revolving centrre. 3) Spanners and packing pieces.
4	To remove rough surface on the face of the work by feeding the tool at Right Angle to axis of the work	FACING	1) C.T. tool 2) Spindle speed 500–600 rpm
5	To provide axis of the work coincides with lathe axis.	CENTER DRILLING	1) 3.15 x 8mm counter sink drill bit with drill chuck. 2) Spindle speed : 500 – 600 rpm
6	• Remove and reverse work piece. • Maintain the total length of the work piece. • Repeat the operations of facing, centre drilling. • Work piece has to be held between chuck and tailstock center.		
7	Turning more than one diameter on a shaft	STEP TURNING	1) C.T. Turning tool 2) Spindle speed: 500 – 600 rpm
8	Reducing the diameter of the workpiece over a very narrow surface	GROOVING	1) Grooving / Parting tool 2) Spindle speed : 250 rpm 3) Support with tailstock center
9	Finish the threading part 25mmϕ to 23.8 mm Feeding the tool parallel to work axis	PLAIN TURNING	Blank size for thread cutting $\tan MajorDia - \frac{Pitch}{10} = 24 - \frac{2}{10} = 23.8$
10	Beveling extreme end of the work piece	CHAMFERING	1) C.T. tool 2) Spindle speed 500–600 rpm
11	Preparation of lathe for thread cutting and mounting the H.S.S. thread cutting 'V' tool with thread gauge.	'V' TOOL CENTERING	1) H.S.S. threading tool 2) Thread cutting gauge 3) Spindle Speed : 40 – 45 rpm 4) Thread direction: RH/LH. 5) Ref to : Norton gear box chart of required pitch and set the levers. 6) Support with Tail stock centre 7) Depth of cut for metric thread = 0.6134 x pitch = 0.6134 x 2 = 1.22/0.05 = 24.5 divn. 8) To engage half nut lever 9) Use of cutting fluid 10) Keep your left hand on "ON & OFF" Switch during threading.
12	To produce uniformly helical grooves on cylindrical part	THREAD CUTTING	

Experiment No. 3

One Job, Cutting of V Groove/ dovetail / Rectangular groove using a shaper.

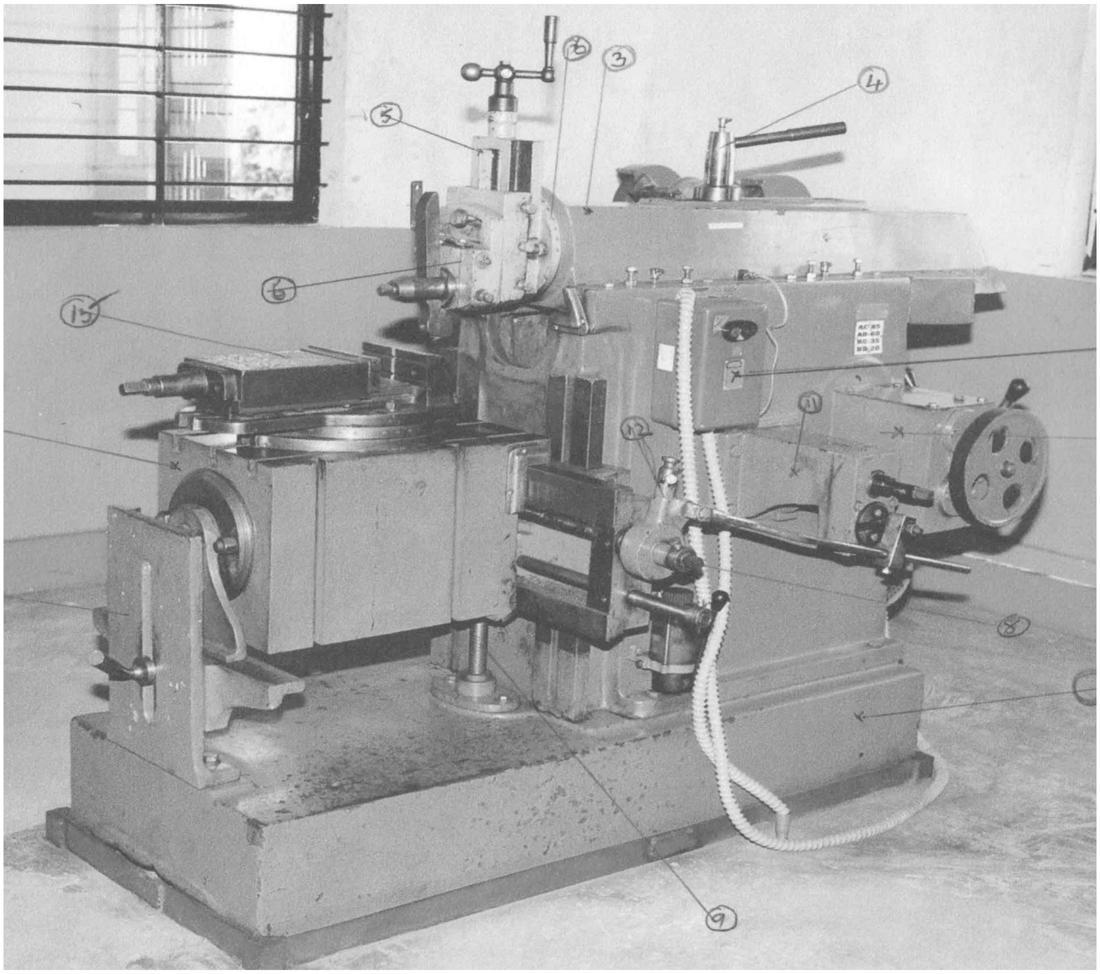


Fig. Shaping Machine

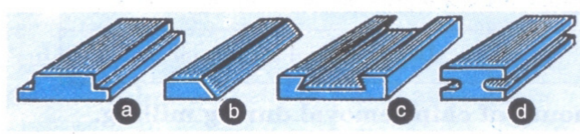
Parts of Shaping Machine:

1	Base
2	Motor switch
3	Ram
4	Ram clamp
5	Tool feed / slide
6	Tool post swiveling
7	Table
8	Hand crank for table horizontal movement
9	Table traverse vertical
10	Main drive with motor with gear box
11	Feed gear box
12	Pawl and ratchet wheel mechanism
13	Rocker arm mechanism

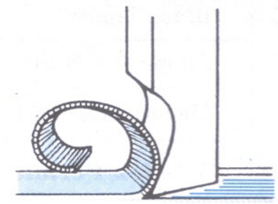
14 Table support
15 Machine Vice

Shaping: Shaping is a process of removing metal from surface in horizontal by use of a single pointed cutting tool held in a ram that reciprocates the tool in linear direction across the work piece.

Practical applications: To manufacture of rectangular grooves. Dove tail, and 'V' grooves etc.



B 148, 1 Examples of shaped and planed parts. (*a*) and (*b*) Guide gibs, (*c*) dovetail slide, (*d*) blanking punch.


B 148, 2 Cutting off chips during shaping process.

Principal parts of shaping machine

a) **Main body:** The main body supports table, ram and the main and feed drive.

b) **Ram:** The ram seated in the guide way and perform the main motion. On its head it carries the tool slide. The shaping tool s clamped in the tool post which has its position fixed.

c) **Table:** The table is used for clamping the work piece. It can be adjusted horizontally and vertically by means of spindles.

d) **Tool slide:** This can be adjusted for the snapping of bevels, and for this purpose, it is provided with graduations. The spindle within the ram is used for setting the stroke position.

e) **Main drive:** This drive actuates the reciprocating motion of the ram. Generally the rotary motion is converted into a straight line motion of the ram by a rocker arm mechanism.

f) **Feed drive:** The feed motion has tobe timed to the end of the backward stroke.

While manipulating the feed spindle by hand rough surface can resume from un even turning of hand wheels. This disadvantage is avoided by the positive feed. By means of ratchet wheel and pawl mechanism which transmit to screw spindle of the table in positive feed.

g) **Length of stroke:** is adjusted by shifting the pivot of the gear.

Technical data of 18"457.2 mm shaper.

Sl. No.	Particulars	Size in inches	Size in mm.
1	Length of stroke	18"	457.2 mm
2	Max. horizontal travel of table	24"	600 mm
3	Max. vertical travel of the table	10"	250mm
4	Max. vertical travel of tool slide	5"	120mm
5	Length and width of table top	18 ½ " x 11 ¾ "	470 x 300 mm
6	Length and depth of table side	18 ½ " x 11 ¾ "	470 x 300 mm
7	Power of the motor	2 HP	2 HP

8	Range of ram cycle per min	-	-

Working procedure:
The work can be clamped in different places on the machine table. Therefore, the position of the stroke must be set in relation to the work piece.

In order to set the stroke forward or backward, the locking screw is loosened and the ram shifted to the desired position by rotating the spindle for the setting of the stroke position.

The table is used for clamping the work piece.

It can be adjusted horizontally and vertically by means of spindles.

The main drive: Actuates the reciprocating motion of the ram. Generally, the rotary motion is converted into a straight line motion of the ram by rocker arm.

The electric motor gives a uniform rotary motion over a gear drive to the gear where a pivot is fixed which can be adjusted towards the center by means of a screw spindle.

The pivot carries a sliding block.
This block slides in the guide way of the rocket arm through the rotary movement of the gear, the rocker arm which has its fulcrum in the base of the machine, swings to and fro with its free end. A joint transmits the swinging motion of the ram.

The length of stroke: Is adjusted by shifting the pivot of the gear. The return stroke of the arm takes a shorter time than the forward stroke.

The feed drive: the feed motion has to be timed to the end of the backward stroke while manipulating the feed spindle be hand rough work surface can resume from uneven turning of hand wheel. The disadvantage is avoided by the positive feed.

The gear with guiding 'T' slot is driven by the gear shaft. In the slot, a bolt can be shifted and locked in any position. A Ratchet wheel is mounted on the spindle of table.
A pawl engages with the teeth of the ratchet wheel.

Bolt and pawl are connected by a in time connecting rod during the forward motion the latter impart communicate a short rotary motion to the ratchet wheel by actuating the pawl which transmit the motion to the screw spindle of the table.

During further movement of the gear the connecting rod moves back again, while the chamfered paws slides over the ratchet wheel and meshed again between two teeth. By turning the pawl 180 degree the feed direction can be reversed.

Experiment No. 3

One Job, Cutting of V Groove/ dovetail / Rectangular groove using a shaper.

Shaping model and its working procedure:

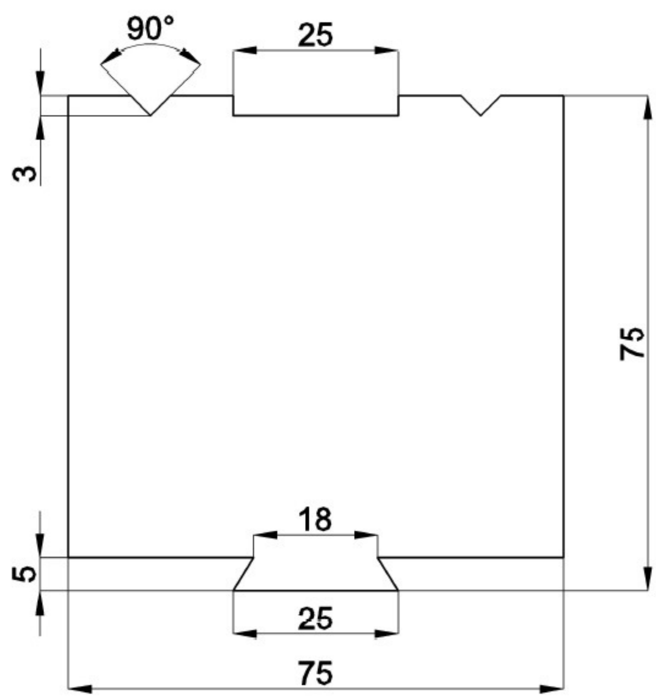
Aim–Prepare V-groove, rectangular groove, and dovetail groove on the give work piece by using shaping machine

Apparatus–Vernier height gauge, steel rule, shaping tool, center punch, hammer,spanner set, and Vernier caliper.

Operation –Marking, shaping

Procedure

1. Take the rectangular block of standard size and mark the dimension on the work.
2. Hold the job on the work holding device on a worktable of a shaping machine.
3. For producing rectangular groove, V-groove, dovetail groove as per the sketch by using required tools.
4. Finish the job as per the sketch.



Note: All dimensions are in mm only

Material: MS / CI

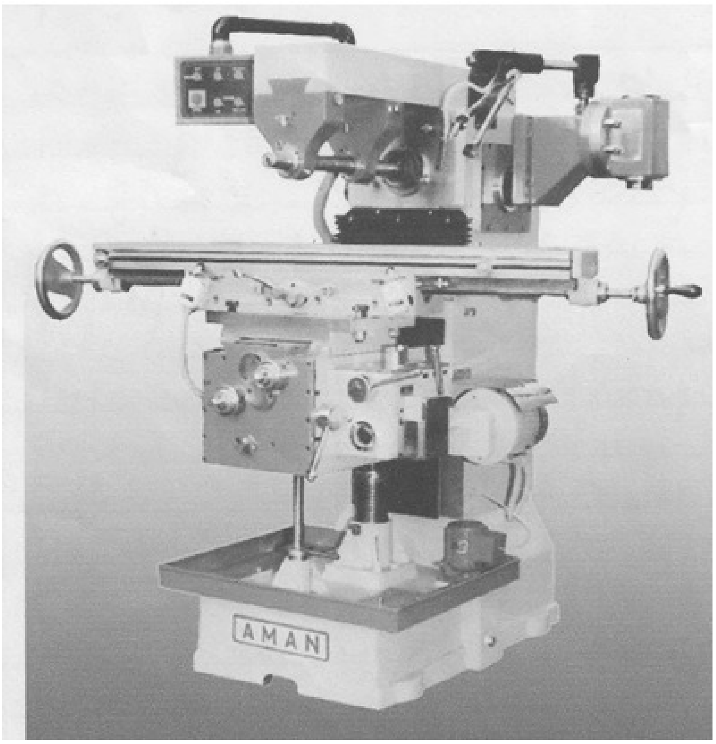
Size: 75 x 75

Experiment No. 4

Cutting of Gear Teeth using Milling Machine

Milling is a machining process in which the material is removed by means of rotating multiple tooth cutters with the work supports and fed by an adjustable power driven table or hand movement.

Aman Horizontal Milling Machine with Vertical milling attachment

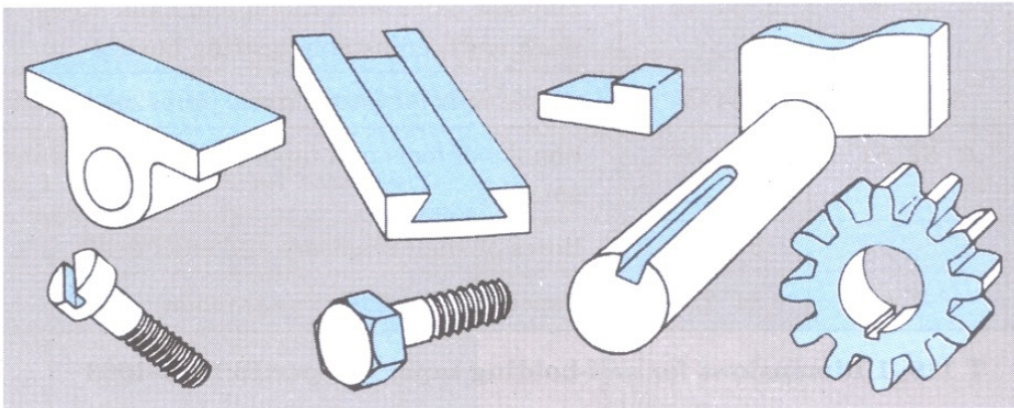


SlNo.	Parts and Operating Controls
1	Panel for starting and stopping of spindle rotation
2	Base with cutting fluids
3	Knee supports cross slide and milling table
4	Hand crank for vertical feed movement
5	Hand crank for cross feed movement
6	Hand wheel for longitudinal feed of milling table
7	Feed gear box with levers for selecting power feed
8	Oil level gauge for power feed gear box
9	Lever for engaging power feed
10	Stops for longitudinal feed
11	Pins for stopping longitudinal feed of milling table
12	Bolts for locking the milling table in the swivelled position
13	Feed gear box fitted with universal joint or with a separate motor
14	Supervision glass for main drive gear box
15	Levers for engaging spindle speed main drive. 50 – 740 rpm 55-540 rpm
16	Bearing and locking nuts for arbor support bracket front & back
17	Hand crank for over arm movement front & back
18	Arbor, spacers, locking nut with main spindle
19	Electrical panel
20	Vertical milling attachment

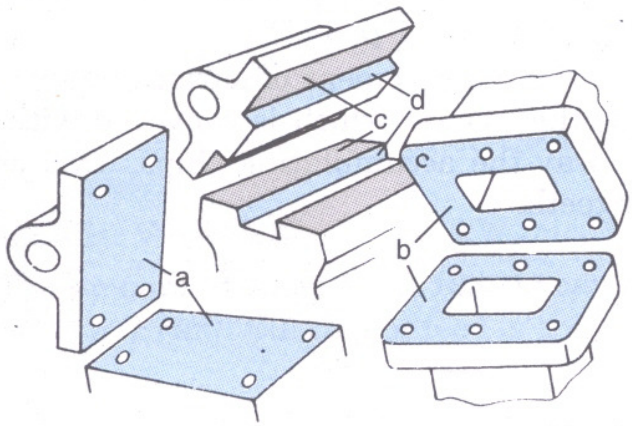
CAPACITY	AMAN 1020	AMAN 1140
	Inche MM	Inche MM
Table		
Working Surface	9 x40 230 x1020	10 x45 255 x1140
Sewivel	45	45 ......
T.Slot Nos./Size	3-1/2 3-12	3-5/8 3-16
Distance between T.Slot	3-1/2 3-12	3-5/8 3-16
Spindle		
No.Of Spindle Speeds	6	9 ......
Range of Spindle Speeds	50 to 750	40 to 750
Spindle Taper	ISO - 40	ISO - 40
Arbour Diameter	1 25.4	1 25.4
Feeds		
Longitudinal (Manual/Auto)	21 535	24 610
Cross (in all geared only)	6 128	7 152
Vartical (in all geared only)	12 305	14 330
No of Auto Feeds	6	6 ......
Feeds Range P/M Longi.	10mm to 120mm	10mm to 120mm
Electrical		
Main Motor	1 HP -1440 RPM	1 HP -1440 RPM
Feed Motor	1 HP -1440 RPM	1 HP -1440 RPM
Feed Motor (in all geared only)	....	....
Coolant Pump	0.1 HP	0.1 HP
Machine Weight	850 Kg	1150 Kg

Practical application of milling machine:

1. Milling of bearing surface (surfaces of bearing part in mutual contact)
2. Sealing surface (used to control the leakage of fluids into or out of parts of machining)
3. Milling of sliding surface: Guide way and surface finish (A piece of mechanism which moves in a linear direction over a flat or smooth face between guides.)
4. Milling of key ways and slots.
5. Milling of rectangular, dovetail and ‘V’ shaped slides (A piece of mechanism which moves in a linear direction over a flat, dovetail and ‘V’ shaped face between guides)
6. Milling of guide ways. (An attachment which controls the movement of any parts of mechanism along a pre determined path).
7. Guide Gibbs: A metal piece which transmits the thrust of a wedge as in some bearing.
8. Milling of spur gears, splined shaft. A shaft provided with several long feather ways or resembling like long gear teeth.
9. Milling of hexagon, ring nut set.
10. Forging and punch press dies.



B 120, 1 Examples of parts manufactured by milling.



B 136, 1 Examples of plane surface, (*a*) bearing surface, (*b*) sealing surface, (*c*) sliding surface, (*d*) guide way.

Milling Machine

A machine tool having a horizontal arbor or vertical spindle to carry a rotating multiple tooth cutter with the work supported fed by an adjustable power driven table or by hand driven.

Principle parts of milling machine:

Base: It is the foundation of the machine and is that part upon which all parts are mounted. It gives the machine rigidity and strength. Some times it also serves as a reservoir for cutting fluid.

Column: It is a main supporting frame. The motor and other driving mechanism are contained in it. The front is a machined surface called column face. It supports and guide the Knee in its vertical travel.

Knee: The knee projects from the column and slides up and down on its face. It supports the saddle and table and is partially supported by elevating screw which adjusts its height.

Saddle: The saddle supports and carries the table and is adjustable traversely on ways on to of the knee. It is provided with graduation for exact movement and can be operated by hand or power.

Milling table: The table rest on way on the saddle and travel longitudinally in horizontal plane.It supports the work piece fixture and all other equipment.

Over-arm: The over arm is mounted on and guided by the top of the column. It is adjusted in and out by the hand to the position of maximum support for the arbour and then clamped.

Spindle: The spindle obtains its power from the motor through gears and a clutch and transmits it to an arbor or stub arbor cutters are mounted directly in the spindle nose.

Arbor: The arbor is an accurately machined shaft for holding and driving the arbour-type cutter. It is taper at one end to fit spindle nose and has two slots to fit the nose keys for locating and driving it.

Milling attachment:

Vertical milling attachment.
The milling spindle is mounted vertically in the milling head. The milling head can be swivelled, thus the spindle can also be set in an oblique position.

The main drive and feed drive do not differ from those of the horizontal milling machine. Generally this attachment is used to perform end milling and face milling operation.

Milling cutters

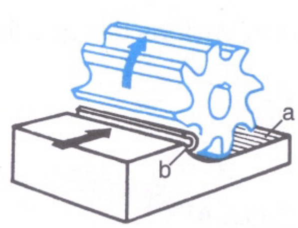
1. Cylindrical milling cutter
2. End mills
3. Side and face milling cutter
4. Circular saws
5. Milling cutter with shank
6. Form cutters: i) Angular milling for 'V' guides ii) Angular milling for dovetail guides
7. Gear milling cutters has the shape of a tooth (using dividing head indexing method) space
8. Gang milling cutters etc.

Work holding devices used in milling machine

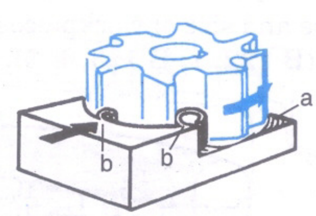
1. Machine vice 2) Universal dividing head 3)Clamps with bolt and nuts.

Spindle orientation is one of the means of classifying the milling machine as Horizontal, Vertical and Angular spindle.

MILLING METHODS



B 121, 1 Milling (cylindrical milling). (*a*) Surface (milling marks), (*b*) shape of chips.



B 121, 2 End milling (face milling). (*a*) Cylindrical surface (no milling marks), (*b*) shape of chips.

Sl No.	Cylindrical Milling with Horizontal milling machine	End Milling with vertical milling machine
1	The cylindrical axis situated parallel to the machined surface	The end mill cutter axis is situated vertical to the machined surface.
2	The cutter has the shape of cylinder and removes chips with peripheral cutting edge.	The cutter does not only cut with the teeth on the circumference but also with the front teeths
3	The chips have the shape of a wedge	The chips are of even thickness
4	In case of cylindrical milling at each rotation of the cutter a milling mark is produced.	In case of end milling the cutting capacity is 15 to 20% higher than that of cylindrical milling
5	During face milling each tooth cut off an evenly thick chips, therefore the milling machine is evenly stressed	In case of end milling machined surface have a better grade of planeness, wherever possible plane surface should be machined y end milling
6	A key way has to be milled into a shaft by means of key-way cutter. A spur gear, splined shaft, ring nut etc. are milling in horizontal milling machine with use of dividing head by indexing methods	Plane surface, bearing surface, sealing surface, sliding surface. Guide ways has to be milled in vertical milling machine. Rectangular, dovetail and V-slides.

Safety precautions during milling:

The work piece has to be clamped tightly and safely. The correct no. of revolution and feed have to be selected. Before setting the feed check that the work piece or milling table do not knock against anything. Never touch the running cutter with your fingers. Do not remove chips with your finger but with brush or hook only. Measure only when the machine is at rest.

Selection of machining parameters on a milling machine:

- **Cutting Speed:** Cutting speed of the cutter means the travel of one cutting teeth in m/min. It is denoted by a letter 'v'.
  Cutting speed too low: Low cutting capacity
  Cutting speed too high: Cutter teeth will become blunt permanently. So a most favorable cutting speed should be selected.

  Unit: Meter per minute

  Cutting Speed = $v = \frac{\pi \, x \, d \, x \, n}{1000}$

  Where, v = Cutting speed in m/min

  d = Diameter of cutter in mm,

  n = Number of revolutions per minute.

- **Selection of rpm / Speed:**The number of revolution depend on the permissible cutting speed and diameter of cutter. Rearranging the formula is given by

$$n = \frac{1000 \, x \, v}{\pi \, x \, d}$$

T 146, 2 Number of revolutions of milling cutters min.

Cutting speed v in m/min.	*Cutter diameter d in mm*									
	40	50	60	75	90	110	130	150	175	200
6	48	38	32	26	21	17	15	13	11	10
8	64	51	42	34	28	23	20	17	15	13
10	79	64	53	42	35	29	24	21	18	16
12	96	76	64	51	42	35	29	25	22	19
14	112	89	73	60	50	40	34	30	26	22
18	145	115	96	76	64	52	44	38	33	29
22	175	140	117	93	77	64	54	47	40	35
26	210	165	140	110	91	75	65	56	48	42
30	240	190	160	128	105	87	73	64	55	48
35	280	225	185	150	125	100	86	74	64	56
40	320	255	210	170	140	116	98	86	72	64
45	360	287	240	190	160	130	110	95	82	72
50	400	318	265	212	177	145	122	106	91	80

Example: *Cutting speed v = 22 m/min., cutter diameter d = 60 mm.*
Required: No. of revolutions of the cutter per min.

Example: A plate has to be machined with a plane milling cutter rough milling. Calculate the no. of revolution of the cutter. i) Material plate thickness is 50mm ii) Diameter of cutter is 75mm iii) Cutting speed as per table is 17m/min

$$n = \frac{1000\,x\,v}{\pi\,x\,d} = 72rpm$$

As a rule only certain no of speed (rpm) can be set on a milling machine.
Ex: 37,39,64,86,113,147,197,260,338,455,600,700 rpm at the present case 64 rpm is selected.

- **Selection of Feed:** Feed is the distance in mm which the milling machine table hence the work piece travel in one minute of time.

  The rate of feed (s^1) depends on the cutter, material of the work piece, the cutting depth and required surface quality.

  To avoid over loading of the machine, the rate of feed is to be calculated.

  Feed is based on the biggest possible of chips which the cutter is able to cut off in one minute of time.
  The permissible amount of chips has been ascertained in cm/kw machine capacity. (refer table)

  v – Biggest possible amount of chips in cm^3/min
  v^1 – Permissible amount of chips in cm^3/kw.min (refer table)
  p – Machine power in kw

  Hence $v = v^1 x\ p$

The amount of chips 'v' can also be calculated from depth of cut (a) the milling width (b) and the rate of feed (s')

$$V = \frac{a\,x\,b\,x\,s'}{1000} \text{ in cm}^3\text{/min}$$

Rearranging the equation

Rate of feed in mm/min: $s' = \dfrac{v\,x1000}{a\,x\,b}$

a – Depth of cut in mm
b – Width of milling in mm

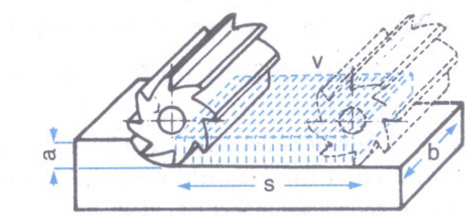
v – Cutting speed in m/min

Example: A plate of thickness 50mm has to be machined by cylindrical milling. The cutting depth (a) – 4mm, milling width (b) – 80mm, v^1 – 12 cm^3/kw.min, driving capacity of machine – 3kw, Calculate the biggest possible rate of feed.

$$\mathbf{v} = v^1 x\ p = 12 \times 3 = 36 cm^3/min$$

Result: Rate of feed (s') = $s' = \frac{v x 1000}{a x b} = \frac{36 x 1000}{4 x 8} = 112 mm/\min$

Usually only certain rate of feed can be set on the milling machine. Ex: 12-20-33-57-99-167-276-480mm/min. Thus a rate of feed of 99mm/min has to be selected.



B 133, 1 Chips are produced by taking into consideration the folloiwng factors :
(*a*) depth of cut (in mm), (*b*) milling width (in mm)
s′ : rate of feed (in mm/min), V : amount of chips.

Permissible amount of chips removal during milling

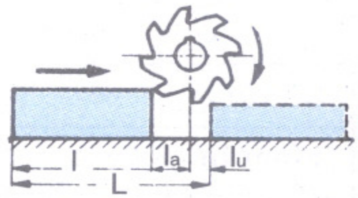
Permissible amount of chips V^1 in cm^3/kw driving capacity of machine	
Milling Method	**Carbon steel 35.60kgf/mm²**
Plain Milling	12
End Milling	15

Reference values for cutting speed (v) and feed (s') in mm/min both in Cylindrical and End milling cutter

<table>
<tr><th colspan="5">Cylindrical milling cutter</th><th colspan="5">End milling cutter</th></tr>
<tr><td rowspan="3">Milling width (b)
Depth of cut (a)</td><td colspan="4">b = 100mm</td><td rowspan="3">Milling width (b)
Depth of cut (a)</td><td colspan="4">b = 25mm</td></tr>
<tr><td colspan="2">Roughing
a = 5mm</td><td colspan="2">Finishing
a = 0.5mm</td><td colspan="2">Roughing
a = 5mm</td><td colspan="2">Finishing
a = 0.5mm</td></tr>
<tr><td>v</td><td>s'</td><td>v</td><td>s'</td><td>v</td><td>s'</td><td>v</td><td>s'</td></tr>
<tr><td>Carbon steel up to 65kgf/mm² (MS)</td><td>17</td><td>100</td><td>22</td><td>60</td><td>Carbon steel up to 65kgf/mm² (MS)</td><td>17</td><td>50</td><td>22</td><td>120</td></tr>
<tr><td>Alloy steel 75 kgf/mm²</td><td>14</td><td>80</td><td>18</td><td>50</td><td>Alloy steel 75 kgf/mm²</td><td>15</td><td>40</td><td>19</td><td>100</td></tr>
<tr><td>Cast Iron (CI)</td><td>12</td><td>20</td><td>18</td><td>60</td><td>Cast Iron (CI)</td><td>15</td><td>60</td><td>19</td><td>120</td></tr>
</table>

Calculate the machining time for milling

Machining time (t_m) = $\frac{\text{Travelling distance of milling table in mm (L)}}{\text{Rate of feed in mm/minute } (s')}$ = $tm = \frac{L}{s'}$



B 135, 1 Travelling distance for milling.

Example: A strip of thickness 42mm with a length of 250mm has to be rough milled by plain milling. Calculate the machining time.

Given

L_a= Feed allowance = 30mm

L_u= over travel = 5mm

L_w= Length of work piece = 250mm

s' = Rate of feed = 100mm/min.

Result: L = $L_w + L_a + L_u$

= 250 + 30 + 5 = 285mm

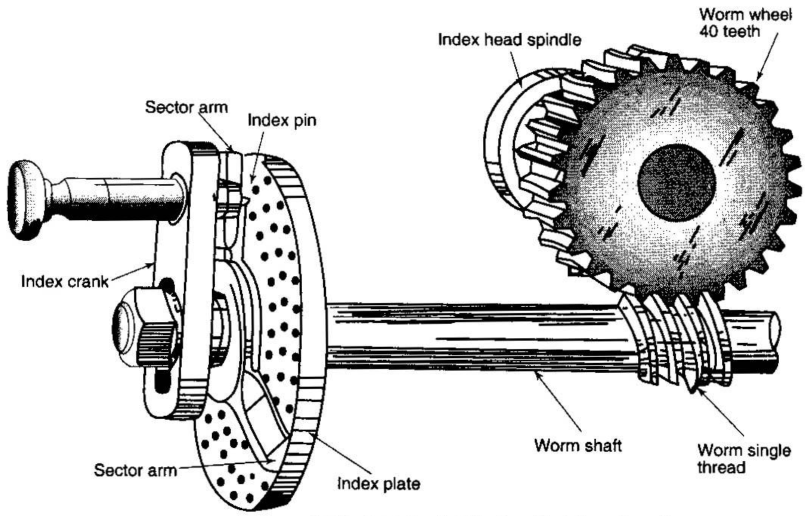
Machining time = t_m= $\frac{L}{s'} = \frac{285}{100} = 2.85\text{min}$

Main parts of the dividing head:

1	Index spindle and worm gear	:	i) The worm gear is fitted tightly on the index spindle. ii) The worm gear with the ratio of 40:1 is installed. iii) The work piece is shifted by means of worm gear. iv) The spindle is rotated by turning the handle which is keyed to the worm shaft.
2	Worm	:	The worm gear is always driven by the worm. The worm is rotated by the turning the handle. Handle: The worm shaft makes 40 rotations, the job makes one rotation. Worm shaft: The handle for turning the worm is adjustable towards the center, it has an index pin. Index Pin: By means of which the division of index plate is set.
3	Index plate	:	The inter changeable index plate is fixed and connected with housing. The dividing head has three index plates the hole circle of which have a different no. of holes.
4	Sector arm	:	It saves the counting of holes while in indexing.
5	3 Jaw chuck & Tail stock	:	3 Jaw chuck used for work holding tail stock used for supporting the work piece

Indexing: The operation of rotating the job through a required angle between two successive cuts is termed as indexing.

Dividing head: It is an attachment used on horizontal milling machine table for accurately dividing the circumference of components for grooving gear cutting, splined shaft and other indexing requirements on milling machine without marking.



Indexing method of a dividing head

Calculation for the required number of Index lever rotations

1.Full number of Index lever rotations are achieved when divisions of 40 by the required number of divisions, gives the full number.

D =IS/T

Example: Divisions required: 10

D - Number of Index lever rotations
IS – Dividing head constant
T - Divisions required

D =IS/T=40/10 = 4

i.e., 4 rotation of the Index lever represents 1/10 rotation of DH Spindle

2. No full number is achieved, if the divisions are 40 from the required divisions. Then the index lever rotation must be further divided by using corresponding hole circle.

The hole circles of the double-sided index plate are as follows:

15-17-19-21-27-37-41-47

16-18-20-23-29-33-39-49

Example 1: Required number of division t = 29

Constant ratio =1:40, Dividing head is Constant =40

No. of Index lever rotations =D =IS/t=40/29 = $1\frac{11}{29}$ i.e.

To achieve the desired no. of 29 division on the dividing head spindle, the Index lever must be rotated by1 full rotation and 11 holes extra on the 29 hole circle.

Example 2: Required Numberof Divisionst = 132

$$D = \frac{IS}{T} = \frac{40}{132} = \frac{\frac{40}{4}}{\frac{132}{4}} = \frac{10}{33}$$

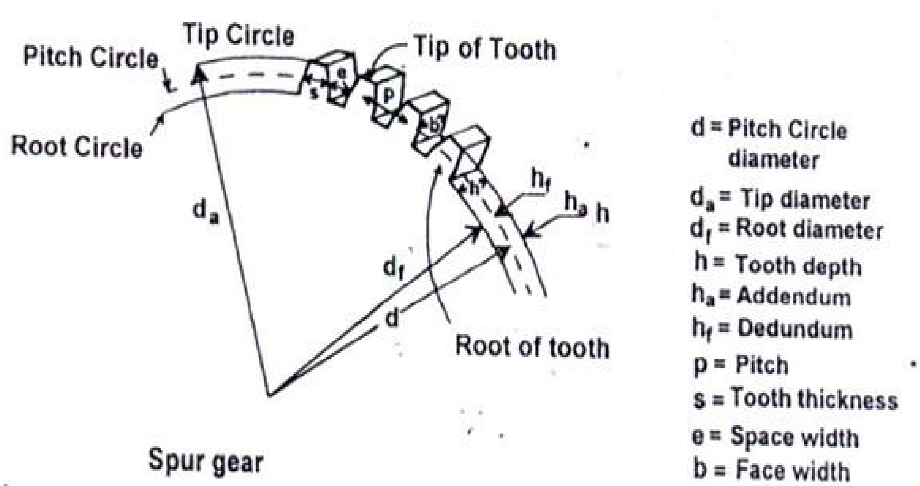
Toachievethedesirednumberof132divisionsonthedividingheadspindle,the

Indexlever must be rotated by10 holes on the33-hole circle.

Example 3: Required numberof divisions t =9

$$D = \frac{IS}{T} = \frac{40}{9} = \frac{40(3)}{9(3)} = \frac{120}{27} = 4\frac{12}{27}\ i.e$$

Toachievethedesirednumberofdivisions9onthedividingheadspindle,theIndex lever must be rotated by4 rotation +12 holes extraon the 27 holes circle.



Dimensions of Spur Gear

The tooth form is limited by the tip and root circle. On the pitch circle tooth are spaced. The distance between the two teeth measured on the pitch circle is called the PITCH. The pitch is the product of constant and fig π. The number with which π is multiplied is the MODULE (m). Modules are standardized to a selected series. The Module is an absolute figure and the product in pitch is specified in mm.

Pitch =Module ×π

P=m × π in mm
Module=___________

Circular Pitch= ____________________

Example 1: Calculate the pitch in mm foramodule2 =2 ×3.14 =6.28 mm Since the pitch is a multiple of π simple figures are obtained for the pitch circle diameter.

Pitch circle diameter = module ×no. of teeth d =m × z **Note:** m = module, Z=no. of teeth

Teeth depth h = 13/6 m =2.166 m = 0.7 p
Addendum h_a=6/6 mm = 1 m =0.3 p
Addendum h_f=7/6 m=1.166 m = 0.4 p
Tip diameter =d_a=d+2h_a (or) d_a = d + 2m(or) d_a = m × z + 2 x m(or) d_a = m (z + 2) (mm)
Outside diameter OD = m (z + 2) (mm) of the blank

Example 2: Calculate the following dimensions for a gear with module 2 and30 teeth

Results: Pitch circle diameter =d =m ×z=2 ×30 =60 mm
Addendum, h_a=1 m = 1×2 =2mm
Dedundum, h_f=1.66 ×m=1.166 ×2 =2.332 mm Tooth
depth h = 2.166 ×m = 2.166 ==2 =4.332mm Tip
diameter =d_a=m(z+2) =2(30+2)=64 mm

Classification of the set of cutters

Cutter No.	1	2	3	4	5	6	7	8
No. ofteeth to be cut	135 To rack	55 To 135	35 To 54	26 To 34	21 To 25	17 To 20	14 To 16	12 To 13

A cutter for milling a particular type of gear is specified by diametrical pitch, pressure, angle, cutter no., and bore size of cutter.

Experiment No.4

Cutting of Gear Teeth using Milling Machine

Working procedure for milling of spur gear by indexing method using horizontal milling machine.

<table>
<tr><th>Sl. No.</th><th>Details of work</th><th>Tools/other information required</th></tr>
<tr><td>1</td><td>Mounting and aligning of the dividing head and tail stock on horizontal milling machine table.</td><td rowspan="4">i) Dividing head
ii) Tail stock
iii) Dial indicator
The cutter will be selected from 8 pieces cutter set
• Cutter no. 3
• Module : 2
• No. of teeth to be cut Z=?
• Gear blank size dia 80mmϕ
d_a= m(Z+2)
80 = 2(Z+2)
80=Z+2 = 80/2 = 40s
Z=40-2 = 38 teeth
Pitch =M x π = 2x 3.14 =6.28 mm
Milling depth =2.16 x m =4.33mm</td></tr>
<tr><td>2</td><td>Mounting gear milling cutter on the arbour and checking the concentric running</td></tr>
<tr><td>3</td><td>Clamping of work piece/gear blank between center and setting to the centre of cutter</td></tr>
<tr><td>4</td><td>Adjusting the sector arm of the index head</td></tr>
<tr><td>5</td><td>Setting of RPM and depth of teeth cut for milling.</td><td rowspan="3">$v = \frac{\pi dn}{1000} = 12 m/m = \frac{3.14 x 65 n}{1000}$
$3.14 x 65 n = 12 x 1000$
$n = \frac{12000}{204.1} = 58.79 rpm$
Tooth depth =4.33
Depth of cut 5 steps
1 rotation = 4 times = 4mm
16 divn. X 0.02 = 0.32 mn</td></tr>
<tr><td>6</td><td>Cutter should share slightly on the work piece.</td></tr>
<tr><td>7</td><td>With drawing of work piece out of range of the cutter.
Lifting the milling table by the height of the tooth depth in five stages.</td></tr>
<tr><td>8</td><td>Milling of the 1st tooth space</td><td rowspan="3">To find the index lever rotation
$D = \frac{IS}{T} = \frac{40}{38} = 1\frac{2}{38} = 1\frac{1}{19}$
One complete rotation further one hole in a 19 hole circle of the index plate</td></tr>
<tr><td>9</td><td>Withdrawing the work piece from the cut.
Turning the index handle by tooth pitch
Milling of the next tooth space</td></tr>
<tr><td>10</td><td>Milling of remaining teeth.</td></tr>
<tr><td colspan="3">Milling of indexing method in generally applied for single part production.</td></tr>
</table>

Working procedure to perform surface milling using vertical milling attachment.

Sl. No.	Details of work	Tools/other information required
1	Mounting and aligning of shell end mill cutter on main spindle of vertical milling machine	1 shell end mill cutter size
2	The work piece has to be clamped tightly and safety using machine vice, fix on the milling table with bolts and nuts.	Machine vice with bolts and nuts
3	Set the work piece to the centre of the cutter	
4	Before starting the cutting operations, the milling table with the work piece has to be moved close towards the cutter then the feed is engaged and coolant pump is started.	Coolant pump
5	The milling depth is set by moving the table upwards using gradual collar	$v = \frac{\pi dN}{1000}$ V=cutting speed 12/min d=diameter of cutter n=?
6	The number of revolution of cutter depends on the cutting speed and the diameter of the cutter and rate of feed should be ascertained.	
7	Upto 100 mm/min feed can be selected	
8	During milling the machine must not be stopped, otherwise, undesired steps may be caused.	

* Plane surface are found on almost all machine parts and serves various purposes.
* The surface quality depends on the respective applications ex. Bearing surface, sealing surface, sliding surface etc.
* In case of end milling and cutting capacity is 15-20% higher than that of cylindrical milling.
* The machine surface have therefore a better grade of planeness
* Wherever possible plane surface should be machined by end milling.

End mill: A milling cutter with radially disposed cutting teeth on its circular end face for facing or surface milling operations.

Working procedure to perform keyways/slot on a shaft using horizontal milling machine.

Sl. No.	Details of work	Tools/other information required
1	Mounting and aligning of slitting saw or a form relieved cutter on the arbour and testing of run.	Slitting saw or form relieved cutter
2	The shaft is to be aligned carefully in horizontal and longitudinal direction in a machine vice and fit on the milling machine table with bolts and huts	Shaft machine vice bolts and nuts mallet.
3	Set the workpiece to the center of the cutter	
4	Before starting the cutting operation the milling table with fitted shaft on the machine vice is moved close to the cutter and then feed is engaged.	
5	The milling depth is set by moving the table upwards using graduated collar	
6	The no. of revolution of cutter depends on the cutting speed and the diameter of the cutter and rate of feed should be ascertained.	$v = \frac{\pi d N}{1000}$ V=cutting speed 12m/min d=diameter of cutter
7	Upto 100mm/min feed can be selected.	
8	During milling the machine should not be stopped otherwise undesired steps may be caused.	

The hubs of clutches, belt pulleys, gears etc. are connected with the shaft by parallel keys. Taper keys and wood ruff keys. These are used for fastening. Chucking of keyways. By slip gauge, depth gauge, vernier caliper etc.

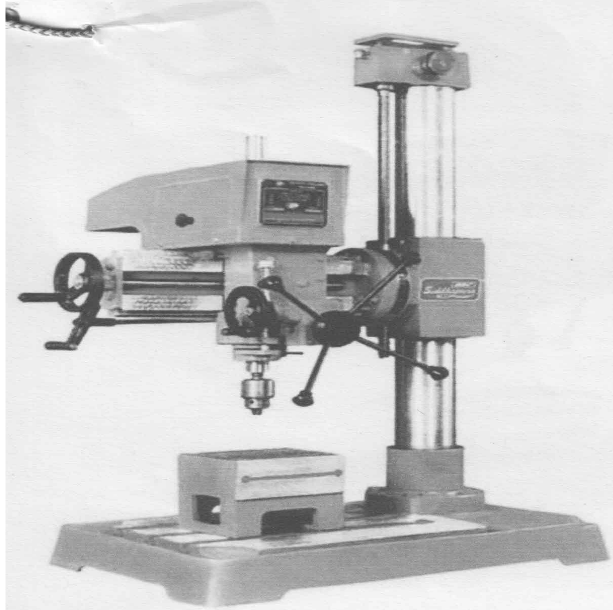
Experiment No. 5(A)

Simple operations and One Job on the drilling machine

25mm Capacity Universal Radial Drilling Machine

Sl No.	Principle Parts
1	Base
2	Column
3	Radial arm
4	Motor for spindle
5	Elevating screw
6	Guide ways
7	Motor for elevating the arm
8	Hand wheel for spindle feed
9	Spindle head
10	Spindle
11	Drill
12	Table
13	Fine feed hand wheel
14	Hand wheel for horizontal movement drill head

25mm cap Universal Radial Drilling



25mm cap Universal Radial Drilling Machine

Product Description

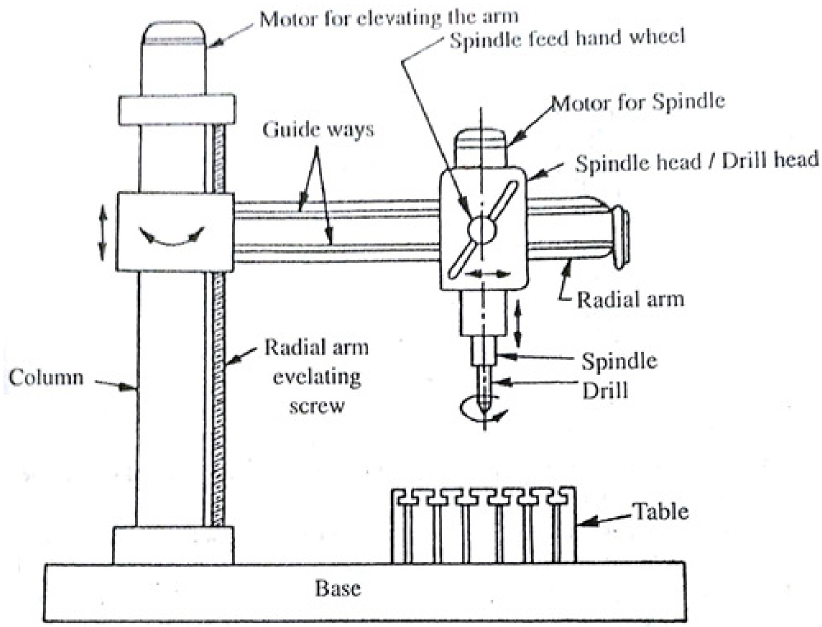
Technical Specification :

Model No.	SEW / S-25
Drilling Cap. (in steel)	25 mm
Column Dia.	87.60 mm
Centre of Spindle to table	255 mm
Max, Spindle to table	650 mm
Max, Spindle to base	1050 mm
Taper in spindle	M.T.3
Spindle Travel	185 mm
No. of speed	8
Range of Speed	73 to 1800 RPM
Table size	345 X 345mm Dia.
Base size (machined area)	350 X 325 mm
Overall base size	625 X 420 mm
Overall height with guard	1675 mm
V-Belt selection	B-52
Elec. Motor-1440 RPm	1 H.P.
Wooden Case Size	950 X 500 X 1525 mm

Radial drilling machine:

- The drill spindle head is carried by the arm and can be shifted in radial direction.
- The arm can be swung around the column and adjusted in height.
- The drill spindle is driven by a flange motor which is seated on the drill spindle head.
- A large speed range enables the drilling of big holes and small holes.
- The work piece is clamped on the work table which is provided with T-slot.
- Because of many adjusting possibilities drilling can be done in different position without re clamping being necessary.
- It is a single spindle machine intended for handling large and heavy work or work which is beyond the capacity of the small drilling machine.

This type of drilling machine is designed for drilling medium to large and heavy work piece. The following figure shows principle parts of a Radial drilling machine



Radial Drilling Machine

1. **Base**: It is the part of the machine which supports the entire structure. It is made of cast iron or mild steel.
2. **Column:** It is the vertical member of the machine which supports the table and head containing all the driving mechanism. It may be of round section or box section.
3. **Radial arm**: The sleeve end arm is housed in the column. The horizontal portion of the arm has guise ways on which the drill head and other attachments are located. The drill head can be moved on the guide ways along its length

   The radial arm can be swivelled about the column to cover a large angle. It is made of CI.
4. **Motor:** Motor to lift the radial arm is located above the column.
5. **Elevating screw:** To facilitate lifting of arm.
6. **Guide ways:** As in the lathe guide way serves the purpose of movement of the drill head long the length of the arm.
7. **Drill spindle motor:** A motor located on the drill head helps rotational movements of the spindle.

Experiment No. 5(B)

Simple operations and One Job on the grinding machine

Grinding is the most common form of abrasive machining. It is a material cutting process that engages an abrasive tool whose cutting elements are grains of abrasive material known as grit. These grits are characterized by sharp cutting points, high hot hardness, chemical stability and wear resistance. The grits are held together by a suitable bonding material to give shape of an abrasive tool.

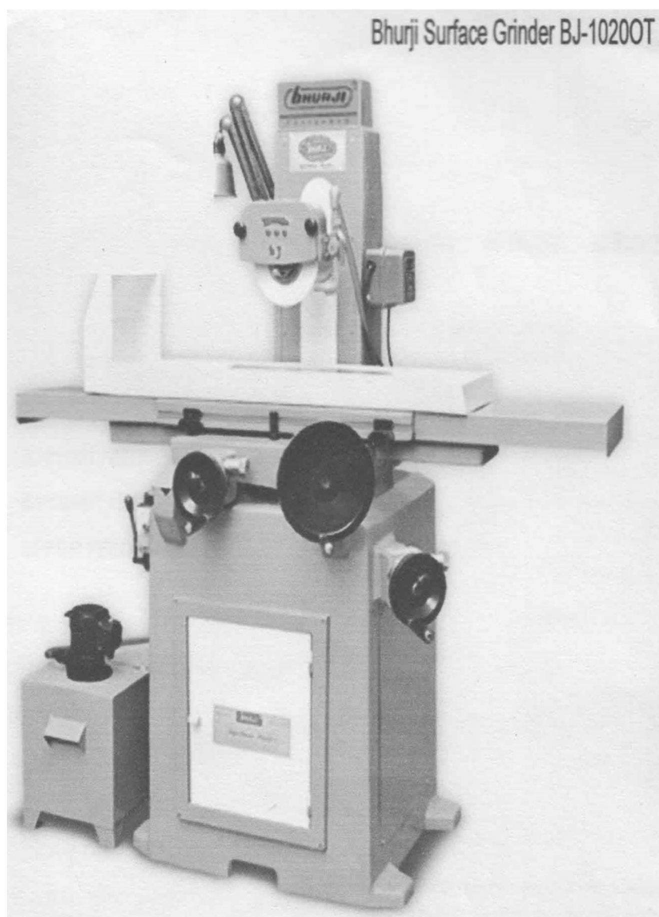
Practical applications

Surface finishing, slitting and parting, descaling, deburring, stock removal (abrasive milling) finishing of flat as well as cylindrical surface and grinding of tools and cutters and re sharpening of the same.

Bench Grinding Machine

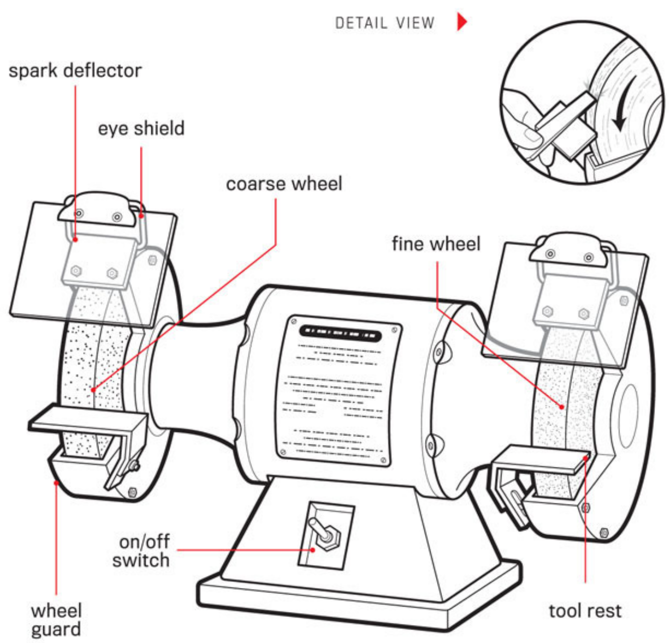
A bench grinder is manually operated and normally has two wheels of different grain sizes that are fixed on a floor stand or work bench; to perform roughing and finishing operations. It is mainly used to shape tool bits; and repair or make various tools.

Sl No.	Principle Parts
1	Base
2	Hand Wheel for vertical feed
3	Hand wheel for to and fro motion of the table
4	Carriage
5	Magnetic Chuck
6	Button for starting and stopping the grinding wheel
7	Grinding wheel spindle with mounted motor
8	Grinding wheel head
9	Grinding wheel
10	Vertical slide flat guide ways
11	Guard for protecting red hot chips
12	Hand wheel for cross feed
13	Centralized lub tank
14	Coolant pump
15	Stoppers



Technical Specifications

Model	BJ-914OT	BJ-1020OT
Max. Table Grinding	200 x 350	200 x 450
Max. Magnetic Table Travel	250 x 360	250 x 525
Magnetic Chuck Suitable (optional)	200 x 300	200 x 450
Max. Grinding Height under wheel	240	240
Vertical Feed Graduaton	0.01	0.01
Cross Feed Graduation	0.05	0.05
Elevator movement with Microfeed	0.002	0.002
Grinding Wheel Head Motor Speed	2800rmp	2800rmp
Grinding Wheel Head Motor	0.75 HP - 3 phase	1 HP - 3 phase
Grinding Wheel Size (D x B X W)	178 x 31.75 x 12.7	178 x 31.75 x 12.7
Diamond Dresser with Holder	0.5 CR	0.5 CR
Wooden Case Dimension (L x W X H)	1070 x 1200 x1700	1070 x 1200 x1700



GRINDING OPERATION:

- The sharpening of tools and the grinding of hardened and unhardened work piece are typical grinding operation.
- The grinding of work piece has the purpose to plane parts to high accuracy of size and surface quality.
- Grinding is a chip-forming operation. Generally a rotating grinding wheel is used as grinding tool.
- The grinding wheel consists of bounded abrasives the grains of which are projected and cut-off the chips.

- The high circumferential speed of the grinding wheel causes a strong friction and the chips become red hot.
- The grinding wheel consists of hard and sharpened abrasive grains, which are embedded in a bounding material.

Major component of surface grinding with horizontal grinding spindle are Bed, table, column with head stock slide. The grinding spindle carries the grinding wheel and is supported in the head stock slide.A motor gives the main motion to the spindle for adjustment towards the work piece, the head stock is vertically adjustable on the column. A fine adjustment effects the down feed. The table is used for clamping the work piece. It slides in the guide ways of the bed and moved to and fro through bed ways. The fed motion is limited by stops. The table or wheel can be shifted at right angle to the reciprocating motion by the traverse feed.

The contact surface between work piece and grinding wheel is very small. Therefore, only a small cutting capacity can be obtained. But on the other hand the cut become very fine. This method is particularly suitable for finish grinding of long and narrow surfaces of guide ways. Clamping of work piece for surface grinding must be done carefully. Magnetic chucks are used for clamping of work piece. This contributes considerably to decrease of the clamping time. There are also clamping plates with permanent magnets. These require no power supply.

Experiment No. 6

Cutting Force Measurement with Dynamometers (Demonstration) for Turning, Drilling, Grinding Operations.

Construction and working principle of some common tool – force dynamometers.

The dynamometers being commonly used now-a-days for measuring machining forces desirably accurately and precisely (both static and dynamic characteristics) are either • strain gauge type or • piezoelectric type Strain gauge type dynamometers are inexpensive but less accurate and consistent, whereas, the piezoelectric type are highly accurate, reliable and consistent but very expensive for high material cost and stringent construction. • Turning Dynamometer Turning dynamometers may be strain gauge or piezoelectric type and may be of one, two or three dimensions capable to monitor all of P X , P Y and P Z . For ease of manufacture and low cost, strain gauge type turning dynamometers are widely used and preferably of 2 – D (dimension) for simpler construction, lower cost and ability to provide almost all the desired force values. Design and construction of a strain – gauge type 2 – D turning dynamometer are shown schematically in Fig.(a) and photographically in Fig.(b) Two full bridges comprising four live strain gauges are provided for P Z and P X channels which are connected with the strain measuring bridge for detection and measurement of strain in terms of voltage which provides the magnitude of the cutting forces through calibration. Fig.(c) pictorially shows use of 3 – D turning dynamometer having piezoelectric transducers inside and its major component.

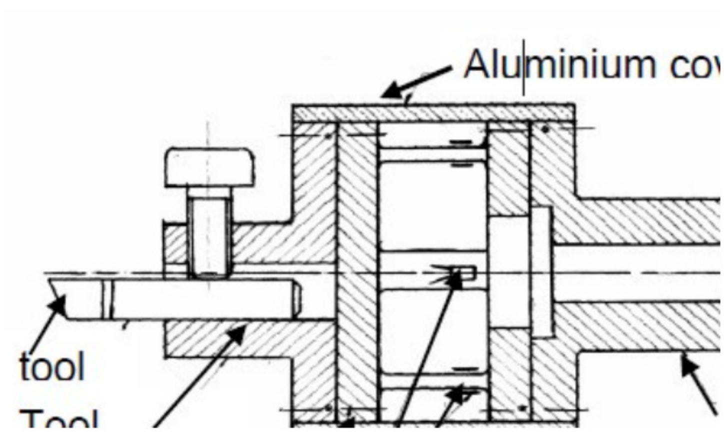


Fig.(a) Schematic view of a strain gauge

Fig.(b) Photograph of a strain gauge

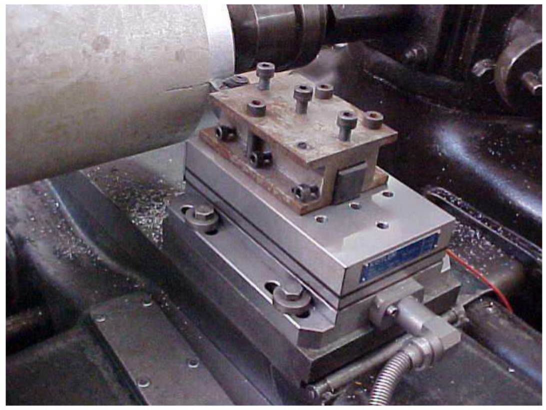


Fig.(c) 3 – D turning dynamometer having piezoelectric transducers

• Drilling dynamometer

Physical construction of a strain gauge type 2 – D drilling dynamometer for measuring torque and thrust force is typically shown schematically in Fig.(d) and pictorially in Fig.(e). Four strain gauges are mounted on the upper and lower surfaces of the two opposite ribs for P X – channel and four on the side surfaces of the other two ribs for the torque channel. Before use, the dynamometer must be calibrated to enable determination of the actual values of T and P X from the voltage values or reading taken in SMB or PC.

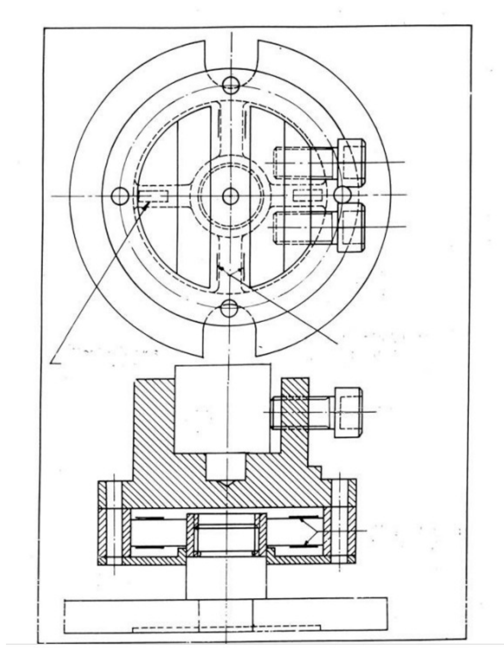


Fig.(d) Schematic view of construction of a strain gauge type drilling dynamometer.

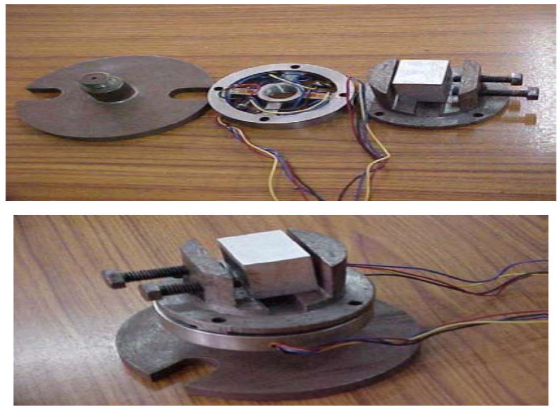


Fig. (e) Strain gauge type drilling dynamometer and its major components.

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

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

Experiment No. 7

Analysis of Chip Formation and Chip Reduction Coefficient in Turning of Mild Steel by HSS Tool with Different Depth of Cut, Speed, and Feed Rate.

Mechanism of chip formation in machining

Machining is a semi-finishing or finishing process essentially done to impart required or stipulated dimensional and form accuracy and surface finish enabling the product to

- fulfill its basic functional requirements
- provide better or improved performance
- render long service life. Machining is a process of gradual removal of excess material from the preformed blanks in the form of chips.

The form of the chips is an important index of machining because it directly or indirectly indicates :

- Nature and behavior of the work material under machining condition
- Specific energy requirement (amount of energy required to remove unit volume of work material) in machining work • Nature and degree of interaction at the chip-tool interfaces.

The form of machined chips depend mainly upon :

- Work material
- Material and geometry of the cutting tool
- Levels of cutting velocity and feed and also to some extent on depth of cut
- Machining environment or cutting fluid that affects temperature and friction at the chip-tool and work-tool interfaces. Knowledge of basic mechanism(s) of chip formation helps to understand the characteristics of chips and to attain favorable chip forms.
- Mechanism of chip formation in machining ductile materials During continuous machining the uncut layer of the work material just ahead of the cutting tool (edge) is subjected to almost all sided compression as indicated in Fig. 1

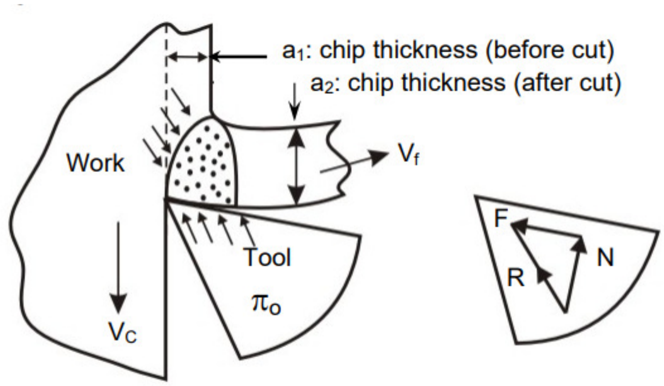
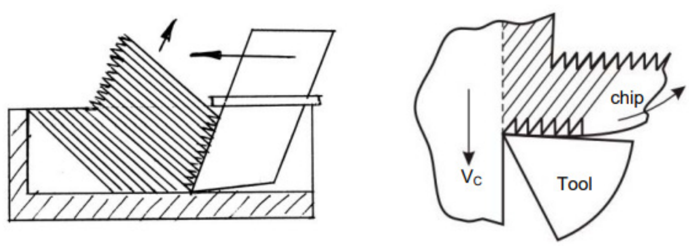


Fig.1 Compression of work material (layer) ahead of the tool tip

The force exerted by the tool on the chip arises out of the normal force, N and frictional force, F as indicated in Fig.1. Due to such compression, shear stress develops, within that compressed region, in different magnitude, in different directions and rapidly increases in magnitude. Whenever and wherever the value of the shear stress reaches or exceeds the shear strength of that work material in the deformation region, yielding or slip takes place resulting shear deformation in that region and the plane of maximum shear stress. But the forces causing the shear stresses in the region of the chip quickly diminishes and finally disappears while that region moves along the tool rake surface towards and then goes beyond the point of chip-tool engagement. As a result the slip or shear stops propagating long before total separation takes place. In the mean time the succeeding portion of the chip starts undergoing compression followed by yielding and shear. This phenomenon repeats rapidly resulting in formation and removal of chips in thin layer by layer. This phenomenon has been explained in a simple way by Piispannen [1] using a card analogy as shown in Fig.2. In actual machining chips also, such serrations are visible at their upper surface as indicated in Fig. 2. The lower surface becomes smooth due to further plastic deformation due to intensive rubbing with the tool at high pressure and temperature. The pattern of shear deformation by lamellar sliding, indicated in the model, can also be seen in actual chips by proper mounting, etching and polishing the side surface of the machining chip and observing under microscope.

The pattern and extent of total deformation of the chips due to the primary and the secondary shear deformations of the chips ahead and along the tool face, as indicated in Fig. 3, depend upon [1] Piispannen V., "Theory of formation of metal chips", J. Applied Physics, Vol. 19, No. 10, 1948, pp. 876. • work material • tool; material and geometry • the machining speed (VC) and feed (so) • cutting fluid application



(a) Shifting of the postcards by partial sliding against each other

(b) Chip formation by shear in lamella.

Fig. 2 Piispanen model of card analogy to explain chip formation in machining ductile materials

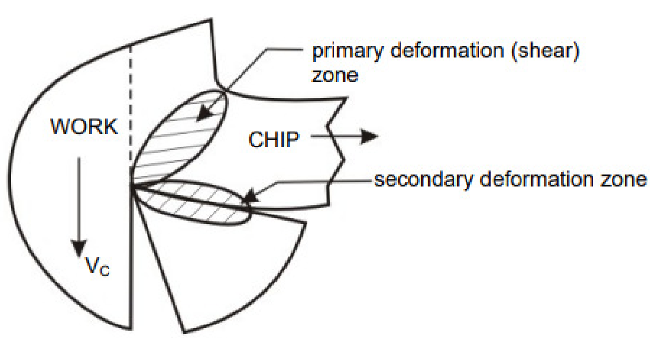


Fig.3 Primary and secondary deformation zones in the chip

The overall deformation process causing chip formation is quite complex and hence needs thorough experimental studies for clear understanding the phenomena and its dependence on the affecting parameters. The feasible and popular experimental methods [2] for this purpose are: • Study of deformation of rectangular or circular grids marked on the side surface as shown in Fig. 4

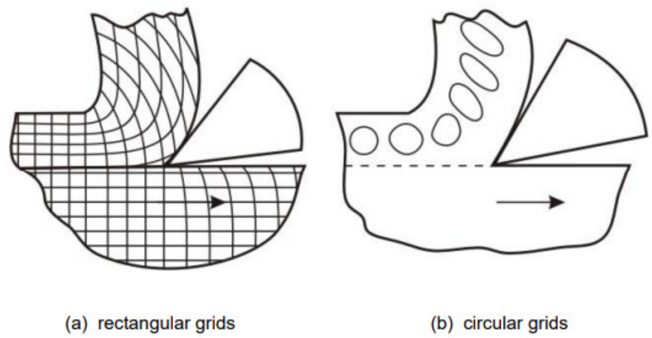


Fig.4 Pattern of grid deformation during chip formation.

It has been established by several analytical and experimental methods including circular grid deformation that though the chips are initially compressed ahead of the tool tip, the final deformation is accomplished mostly by shear in machining ductile materials. However, machining of ductile materials generally produces flat, curved or coiled continuous chips.

• Mechanism of chip formation in machining brittle materials

The basic two mechanisms involved in chip formation are

• Yielding – generally for ductile materials

• Brittle fracture – generally for brittle materials

During machining, first a small crack develops at the tool tip as shown in Fig. 5 due to wedging action of the cutting edge. At the sharp crack-tip stress concentration takes place. In case of ductile materials immediately yielding takes place at the crack-tip and reduces the effect of stress concentration and prevents its propagation as crack. But in case of brittle materials the initiated crack quickly propagates, under stressing action, and total separation takes place from the parent work piece through the minimum resistance path as indicated in Fig.5. Machining of brittle material produces discontinuous chips and mostly of irregular size and shape. The process of forming such chips is schematically shown in Fig. 6.

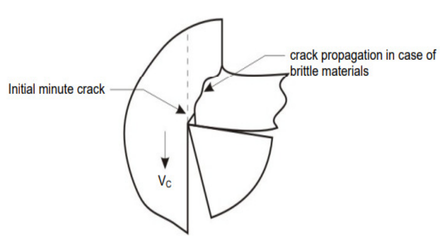


Fig. 5 Development and propagation of crack causing chip separation.

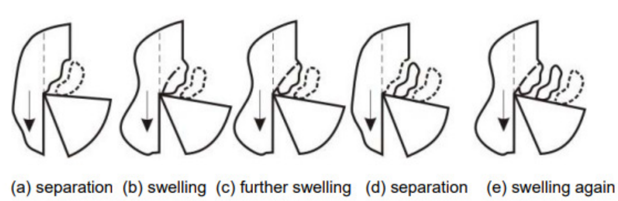


Fig.6 Schematic view of chip formation in machining brittle materials.

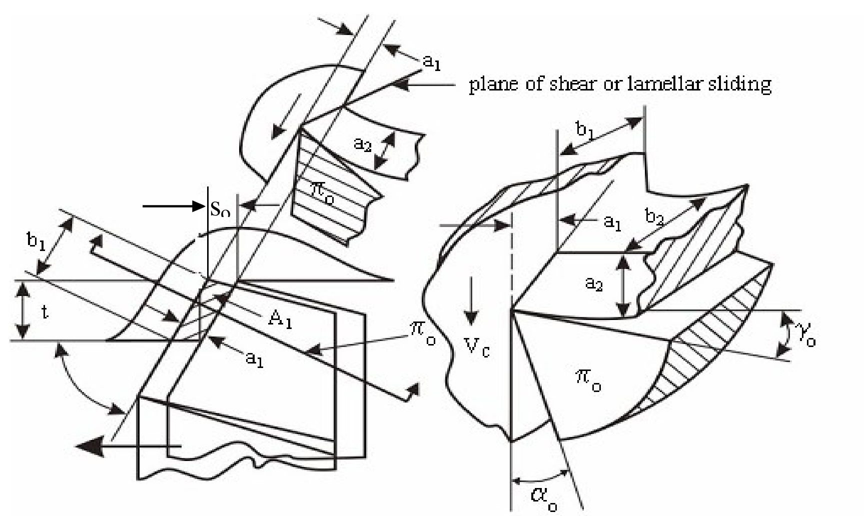
Geometry and characteristics of chip forms

The geometry of the chips being formed at the cutting zone follow a particular pattern especially in machining ductile materials. The major section of the engineering materials being machined are ductile in nature, even some semi ductile or semi-brittle materials behave ductile under the compressive forces at the cutting zone during machining. The pattern and degree of deformation during chip formation are quantitatively assessed and expressed by some factors, the values of which indicate about the forces and energy required for a particular machining work.

Chip reduction coefficient or cutting ratio

The usual geometrical features of formation of continuous chips are schematically shown in Fig. 7. The chip thickness (a2) usually becomes larger than the uncut chip thickness (a1). The reason can be attributed to

• Compression of the chip ahead of the tool
• Frictional resistance to chip flow
• Lamellar sliding according to Piispannen



(a) **(b)**

Fig. 7 Geometrical features of continuous chips' formation.

The significant geometrical parameters involved in chip formation are shown in Fig. 7 and those parameters are defined (in respect of straight turning) as:

t = depth of cut (mm) – perpendicular penetration of the cutting tool tip in work surface so = feed (mm/rev) – axial travel of the tool per revolution of the job

b1 = width (mm) of chip before cut

b2 = width (mm) of chip after cut

a1 = thickness (mm) of uncut layer (or chip before cut)

a2 = chip thickness (mm) – thickness of chip after cut

A1 = cross section (area, mm^2) of chip before cut T

The degree of thickening of the chip is expressed by $\zeta = a2/a1 > 1.00$ (since a2 > a1) (1) where, ζ = chip reduction coefficient

a1= sosinφ

(2)

where φ = principal cutting edge angle

Larger value of ζ means more thickening i.e., more effort in terms of forces or energy required to accomplish the machining work.

Types of chips and conditions for formation of those chips

Different types of chips of various shape, size, colour etc. are produced by machining depending upon

- type of cut, i.e., continuous (turning, boring etc.) or intermittent cut (milling)
- work material (brittle or ductile etc.)
- cutting tool geometry (rake, cutting angles etc.)
- levels of the cutting velocity and feed (low, medium or high)
- cutting fluid (type of fluid and method of application) The basic major types of chips and the conditions generally under which such types of chips form are given below:

- Discontinuous type
  - of irregular size and shape : - work material – brittle like grey cast iron
  - of regular size and shape : - work material ductile but hard and work hardenable
    - feed – large
    - tool rake – negative
    - cutting fluid – absent or inadequate
- Continuous type
  - Without BUE : work material – ductile
    - Cutting velocity – high
    - Feed – low
    - Rake angle – positive and large
    - Cutting fluid – both cooling and lubricating
  - With BUE : - work material – ductile
    - cutting velocity – medium
    - feed – medium or large
    - cutting fluid – inadequate or absent.
- Jointed or segmented type
  - work material – semi-ductile
  - cutting velocity – low to medium
  - feed – medium to large
  - tool rake – negative
  - cutting fluid – absent

Often in machining ductile metals at high speed, the chips are deliberately broken into small segments of regular size and shape by using chip breakers mainly for convenience and reduction of chip-tool c

Experiment No. 8

Experiment on anyone advanced machining process

Visit Industries or Some Other Institution

Experiment No. 9

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

Power Hacksaw Machine

The Power Hacksaw Machine is a type of Automatic Machine Tool whereas; the whole purpose is cutting the materials (metal or non-metal) that consists less and even high thickness or diameter. The Hacksaw is a simple cutting tool operated manually that requires more effort.

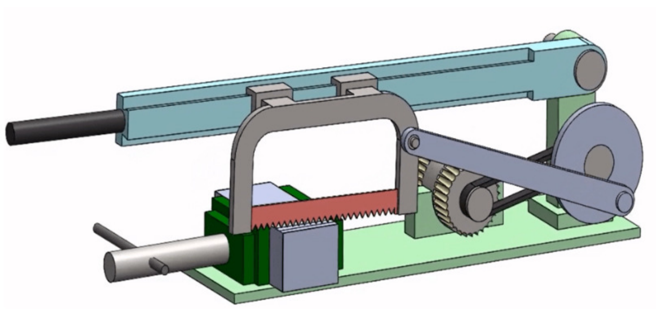
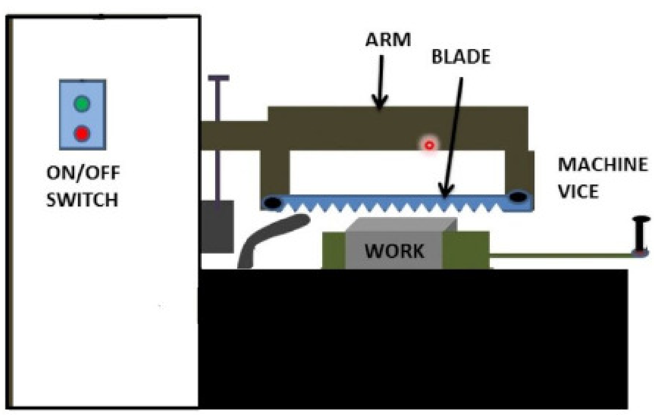


Fig. Power Hacksaw Machine

The simple hacksaw that runs on **electricity** or **power** to cut the materials is called **Power Hacksaw**. The hacksaw or power hacksaw machine consists of a **power hacksaw blade** to cut the materials.

Parts of the Power Hacksaw Machine



The **machine and machine tool** does consist of different parts and mechanism for its working. As the power hacksaw is an automatic machine tool; it requires a number of parts and a dedicated mechanism to achieve the purpose. So, power hacksaw machine parts are as follows

The Frame or Body or Base:

As we know, every **machine and machine tool** does consist of a frame or body to create a **structure** and dependency for the whole system. Similarly, the power hacksaw does consist of the base where the Power Hacksaw Blade Arm, Blade, Machine Vise, etc are rest and fixed.

DC Motor:

As the hacksaw machine is an automatic machine tool, it requires a source to run. The DC Motor is a **Direct Current** Electrical system that will convert Electrical Energy into Mechanical Energy we can say that the motor will utilize the electrical power to generate the **magnetic flux** between the coils and responsible for the revolution of the mechanical shaft.

Power Hacksaw Blade Arm:

The power hacksaw blade arm is the support for its **blade** that is fixed to the **arm**. The movement of the power hacksaw blade depends upon the arm itself.

Flywheel:

A Flywheel is a **round** and **rotating** component that is connected to the motor or gear output using a shaft. It will transmit the energy to the horizontal guide and also **stores the energy** according to the requirement.

Horizontal Guide:

The horizontal guide is a set that is connected to the **flywheel** and **the power hacksaw blade arm**. The horizontal guide is a hallow cylindrical component that will slide over a shaft **smoothly**.

Power Hacksaw Blade:

The blade is the component that does the cutting operation. It is **thin** and **long in length** with sharp cutting edges.

Switch on/off Power Box:

The switch on/off power box will help the operator to **start** and **stop** the operation of the power hacksaw machine according to his requirement.

Machine Vise:

The machine vise is the work piece **holding setup**. To prevent the movement of the work piece while operating the machine vise is used. We can place the work piece in between the two slides and can be tightened using the **screw movement**.

Working Of Power Hacksaw Machine:

The power hacksaw working is very as **simple** as like construction. The motor runs by electricity and the mechanical power from the motor to the **Flywheel** is transferred using a **mechanical shaft**.

At this stage, to control the power or speed we can arrange an electrical system or different types of gears of different sizes. So, the belt connection that transfers the power from the motor to the gear can be changed to **reduce** and **increase the speed.**

- If the belt is connected between the motor and small gear then the **output speed is more**.
- If the belt is connected between the motor and large gear then the **output speed is low**.

According to it, the speed will be transferred to the **flywheel** which is connected to the **horizontal movement** setup. Due to the flywheel rotation, the horizontal setup will move **back and forth** which results in arm and power hacksaw blade movement.

Whenever a material (metal or non-metallic) is placed in the **machine vise**, the blade movement and feed will cut the material. This is the working of the power hacksaw machine which is simple and faster.

Although, the working of power hacksaw depends upon the electricity the working speed will depend upon the **thickness** of the material that required cutting.

- If the thickness or diameter of the material is **more,** then it is supposed to perform the operation (or cutting) at **low speed** for saving the blade for **long life** and preventing the power hacksaw blade damage or breakage.
- Similarly, we can run the power hacksaw at **high speeds** for less thickness materials whereas; it will not affect its blade and at the same time it can durable for many cycles.

Note: The cutting operation generates the heat and leads to the breakage of the blade; to prevent this, water is used as the coolant.

Advantages of Power Hacksaw Machine:

The advantages of power hacksaw machine are

- The operation of power hacksaw is **simple**.
- The power hacksaw can cut the materials **very fast** even though the thickness or diameter is more.
- This type of machine tool can be operated at **high speeds** and even at **low speeds**.
- We can find a **portable** power hacksaw according to save working space.
- The power hacksaw machine blades are **easy to remove** and **fix** so, we use the different types of blades (according to the strength) for different types of materials.

Applications of Power Hacksaw Machine:

A power hacksaw is a automatic **machine tool** that can be used in **a vast area**. Its applications are

- It is used in **workshops** where the **high thickness** and of materials are used to the machine.
- Being an automatic machine, the power hacksaw can be used in **Automobile** Manufacturing Industries.
- The applications of Power Hacksaw are mostly in large materials **Welding industries** or **enterprises**.

Experiment No. 10

Demonstration/Experimentation of simple programming of CNC machine operations

Aim: Know the basic functions of a machine tool, concept of numerical control, historical development, definition, advantages of CNC machine tools Computer-aided Manufacturing (CAM) is the term used to describe the use of computerized systems to control the operations at a manufacturing plant.

These computerized systems assist manufacturers in various operations such as planning, transportation, management, and storage. CAM helps manufacturers improve their time to market capabilities, and create precise dimensions.

The History of Computer Numerical Control (CNC)
Computer numerical control is a modern concept in the manufacturing and production industries. However, the concept of CNC harkens back to the basic idea of NC, or numerical control. The idea of numerical control started when the automation of machine tools originally incorporated specific concepts of programmable logic. In the beginning, the first NC machines were built back in the 1940s. Slightly more advanced machines came along in the 1950s. These manufacturing machines were constructed based on existing tools that were modified with motors designed to move the controls of the machine. These controls followed specific points that were fed into the machine on punched tape. These early mechanisms were soon improved with both analog and digital computers. The introduction of computer technology into the concept of numerical control led to what we now know as computer numerical control.

Brief Introduction to Computer-aided Manufacturing As a process, CAM is used after Computer-aided Design (CAD) or Computer-aided Engineering (CAE). The model designed using CAD is sometimes used as the CAM input. This is why it is referred as CAD-CAM. The functions of this combination are divided into two main categories:

Manufacturing Planning: In this process, the computer delivers information for production planning as well as management.
This may include: Computer Aided Process Planning (CAPP)
- Computer Assisted NC Part Programming
- Computerized Machinability Data System
- Work Standards Development
- Inventory and Production Planning

Manufacturing Control: In the process, the computer is used to manage and control the physical operations of the manufacturing plant.

These may include: Shop Floor Controlling
- Process Monitoring and Controlling
- Inventory Controlling

Co-ordinate system: In order for the part programmer to plan the sequence of positions, moments, the cutting tool. Machine to the WIP, it is memory to establish a standard axis system by which the relative positions can be specified. Two axes “X & Y” are defined in the plane of the table, the ‘z’ axis in perpendicular. In this plane of the table the vertical motion of the spindle controls the ‘z’ direction. The positive and negative directions motion of the tool.

Programming methods

1) Incremental method
2) Absolute method

1) Incremental Method: In this method, every point is considered as origin from this point; the values are calculated, for example
2) Point A = (0, 0)
3) Point B = (20, 0)
4) Point C = (0, 10)
5) Point D = (-20, 0) 2)

Absolute method: In this absolute system, the set point is considered as a reference point as from that point, all the values are calculated, for example
Point A = (0, 0)
Point B = (20, 0)
Point C = (20, 10)
Point D = (0, 10) Programming methods:

In CNC machines program are programmed by two methods.
1) Manual part programming
2) Computer assisted part programming

1) **Manual part programming:** To prepare a part program using the manual method, the programmer writes the machining instruction is must be hence, menu script the instruction is must be prepared in a very precise manner because the typist prepares the NC type directory from the Manu script some in various form expending on the machine tool and tape format used.
2) **Computer assisted part programming:** In the more complicated point and in contour application using manual part programming because an extremely tedious basic and subject to errors. It is must more appropriate to employ the high speed digital computer to assist the part programming languages system have been developed to perform automatically most of the calculation which the programmer would otherwise be forced to do

PREPARATORY FUNCTIONS (G-CODE): Preparatory functions are used for cutting operations like facing, turning, thread cutting, drilling, etc.,

MISCELLANEOUS FUNCTIONS (M-CODE): Miscellaneous functions are used for other than cutting operations like spindle ON/OFF, coolant ON/OFF, tool change, etc

Preparatory Functions (G-Codes):

G00 - Positioning at rapid speed; Mill and Lathe
G01 - Linear interpolation (machining a straight line); Mill and Lathe
G02 - Circular interpolation clockwise (machining arcs); Mill and Lathe
G03 - Circular interpolation, counter clockwise; Mill and Lathe
G04 - Mill and Lathe, Dwell
G09 - Mill and Lathe, Exact stop

G10 - Setting offsets in the program; Mill and Lathe
G12 - Circular pocket milling, clockwise; Mill
G13 - Circular pocket milling, counterclockwise; Mill
G17 - X-Y plane for arc machining; Mill and Lathe with live tooling
G18 - Z-X plane for arc machining; Mill and Lathe with live tooling
G19 - Z-Y plane for arc machining; Mill and Lathe with live tooling
G20 - Inch units; Mill and Lathe
G21 - Metric units; Mill and Lathe
G27 - Reference return check; Mill and Lathe
G28 - Automatic return through reference point; Mill and Lathe
G29 - Move to location through reference point; Mill and Lathe
G31 - Skip function; Mill and Lathe G32 - Thread cutting; Lathe
G33 - Thread cutting; Mill
G40 - Cancel diameter offset; Mill. Cancel tool nose offset; Lathe
G41 - Cutter compensation left; Mill. Tool nose radius compensation left; Lathe
G42 - Cutter compensation right; Mill. Tool nose radius compensation right; Lathe
G43 - Tool length compensation; Mill
G44 - Tool length compensation cancel; Mill (sometimes G49)
G50 - Set coordinate system and maximum RPM; Lathe
G52 - Local coordinate system setting; Mill and Lathe
G53 - Machine coordinate system setting; Mill and Lathe
G54~G59 - Work piece coordinate system settings #1 to #6; Mill and Lathe
G61 - Exact stop check; Mill and Lathe
G65 - Custom macro call; Mill and Lathe G70 - Finish cycle; Lathe
G71 - Rough turning cycle; Lathe
G72 - Rough facing cycle; Lathe
G73 - Irregular rough turning cycle; Lathe
G73 - Chip break drilling cycle; Mill
G74 - Left hand tapping; Mill
G74 - Face grooving or chip break drilling; Lathe
G75 - OD groove pecking; Lathe
G76 - Fine boring cycle; Mill
G76 - Threading cycle; Lathe
G80 - Cancel cycles; Mill and Lathe
G81 - Drill cycle; Mill and Lathe
G82 - Drill cycle with dwell; Mill
G83 - Peck drilling cycle; Mill
G84 - Tapping cycle; Mill and Lathe
G85 - Bore in, bore out; Mill and Lathe
G86 - Bore in, rapid out; Mill and Lathe
G87 - Back boring cycle; Mill
G90 - Absolute programming
G91 - Incremental programming
G92 - Reposition origin point; Mill
G92 - Thread cutting cycle; Lathe
G94 - Per minute feed; Mill
G95 - Per revolution feed; Mill
G96 - Constant surface speed control; Lathe
G97 - Constant surface speed cancel
G98 - Per minute feed; Lathe
G99 - Per revolution feed;

Lathe Miscellaneous Functions (M-Code):

M00 - Program stop; Mill and Lathe
M01 - Optional program stop; Lathe and Mill
M02 - Program end; Lathe and Mill
M03 - Spindle on clockwise; Lathe and Mill
M04 - Spindle on counterclockwise; Lathe and Mill
M05 - Spindle off; Lathe and Mill
M06 - Tool change; Mill
M08 - Coolant on; Lathe and Mill
M09 - Coolant off; Lathe and Mill
M30 - Program end, return to start; Lathe and Mill
M97 - Local sub-routine call; Lathe and Mill
M98 - Sub-program call; Lathe and Mill M99 - End of sub program; Lathe and Mill
M00 - program stop
M01 - optional stop using stop button
M02 - end of program
M03 - spindle on CW
M04 - spindle on CCW
M05 - spindle off M06 - tool change
M07 - flood with coolant M08 - mist with coolant M09 - coolant off
M17 - subroutine end
M20 - tailstock back M21 - tailstock forward
M22 - Write current position to data file
M25 - open chuck M30 - end of tape
M71 - puff blowing on M72 - puff blowing off
M96 - compensate for rounded external curves
M97 - compensate for sharp external curves
M98 - subprogram call M99 - return from subprogram, jump instruction
M101 - move x-axis home
M102 - move y-axis home
M103 - move z-axis home

Experiment No. 11

Demonstration / Experiment on tool wears and tool life on anyone conventional machining process

AIM: To study tool wear and tool life measurements for machinability

Equipment & Materials:

1. Engine lathe
2. Tool maker's microscope
3. Cutting tool: Carbide insert and tool holder
4. Steel rule and caliper
5. Test work piece (MS bars)

Procedure:

1. Be familiar with the test lathe for different settings and operations. Calculate the cutting speed and verify the speed setting using a speed meter.
2. Cut the test workpiece at specified test condition (depth of cut : 0.030", feed: 0.003"/rev, speed: 500, 600, 650 ft/min). Stop the test at a certain time interval (1 or 2 min.) to measure flank wear using a tool maker's microscope. Read at least more than three readings and record the average value.
   Note: Choose the closest cutting speeds available on the machine
3. To stop cutting, first back off the tool, stop "feed" and stop the spindle. The remove the insert for measurement.
4. Continue the test until the flank wear reaches a critical value (0.015").
5. After each pass of the test work piece, measure diameter of the work piece. Make sure that the speed setting is correct at each different diameter.
6. For each different cutting condition, use a fresh edge of the test insert.

Test conditions:

1. Cutting Speeds: V_1 = _____ fpm, V_2 = ____ fpm, V_3 = ____ fpm
2. Depth of cut : ______ in, Feed: _____ ipr.

Computation:

1. Generate plots for measured tool wear values vs. cutting time.
2. Generate a plot of tool life vs. speed on a log-log scale.
2. Determine tool life equation: $VT^n=C$

Evaluation:

1. Flank wear rates and tool life curves.
2. Effects of speed on tool wear and tool life.

Experiment No. 12

To study the Tool Geometry of a Single Point Turning Tool (SPTT) in the American Standards Association (ASA) System.

Single Point Cutting Tool

Single point cutting tools are commonly used in lathe, players, Shapers machine for cutting operation. These tools are classified as left-handed and right-handed. A tool is said to be right-handed if their cutting edge is on the right side when the tool is viewed from the point end.

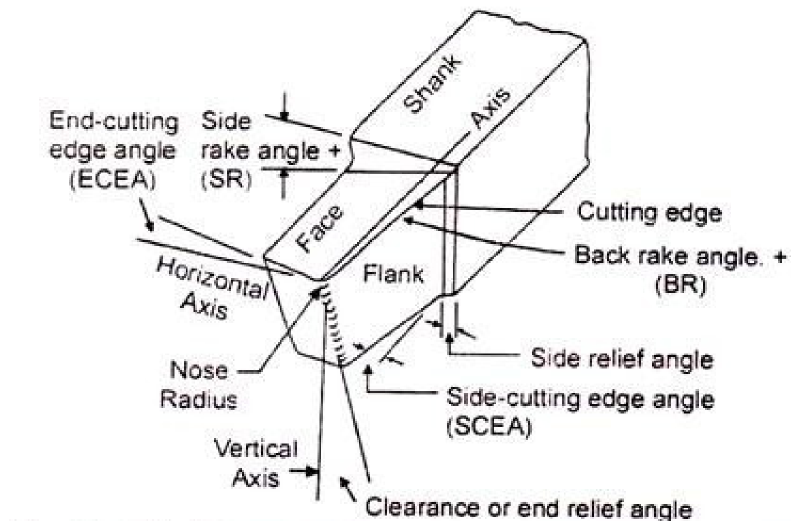


Fig. Tool geometry of single point cutting tool

Terminology or Nomenclature of Single Point Cutting tool.
This specification is according to the American Standards Association (ASN) Systems.>

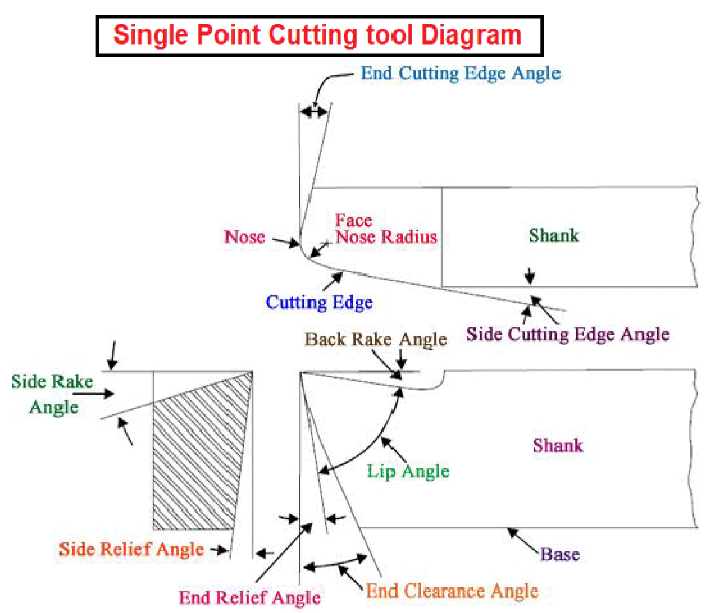


Fig. Single-point cutting tool diagram

1. **Shank:** The main body of the tool is known as the shank. It is the backward part of the tool which is held by tool post.

2. **Face:** The top surface tool on which chips passes after cutting is known as a face. It is the horizontal surface adjacent of cutting edges.

3. **Flank:** Sometime flank is also known as cutting face. It is the vertical surface adjacent to the cutting edge. According to cutting edge, there are two flank side flank and end flank.

4. **Nose or Cutting Point:** The point where both cutting edge meets known as cutting point or nose. It is in front of the tool.

5. **Base:** The bottom surface of the tool is known as the base. It is just the opposite surface of the face.

6. **Heel:** It is an intersecting line of face and base.

7. **End Cutting Edge Angle:**

- The angle between the end cutting edge or flank to the plane perpendicular to the side of the shank is known as the end cutting angle.
- This angle usually varies from 5 to 15 degree

8. **Side Cutting Edge Angle:**

The angle between the side cutting edge or flank to the plane parallel to the side of the shank known as side cutting edge angle.

9. **Back Rake Angle:**

- The angle form to smooth flowing of chips from the face, known as rack angle. It allows to smooth flow of chips.
- The back rack angle is the angle between the face and the plane perpendicular to the end cutting edge.
- Softer the material, greater should be the positive rake angle.
- The back rake angle may be positive negative or neutral.

10. **Side Rack Angle:**

- The angle between the face and plane perpendicular to the side cutting edge is known as the side rack angle. It allows chips to flow smoothly when material cut by side cutting edge.
- The amount by which a chip is bent depends upon this angle. When the side rack angle increases, the magnitude of chip bending decreases. Smoother surface furnish is produced by a larger side rake angle.

11. **End Relief Angle:**
It is also known as a clearance angle. It is the angle that avoids tool wear. It avoid the rubbing of flank with a work piece.
End cutting angle made by end flank to the plane perpendicular to the base. This angle may vary from 6 to 10 degrees.

12. Side Relief Angle:

It is the angle made by the side flank to the plane perpendicular to the base. It avoid rubbing of side flank with a work piece. This angle allows the tool to fed sideways into the job in order to cut the work material without rubbing.
When the side relief angle is very small, the tool will rub against the job and therefore it will get overheated and become blunt and the surface finish obtained will be poor.

13. Nose Radius: The intersecting area of both cutting edges is known as the nose of the tool.

Factors influencing rake angle of the single point cutting tool:

1. Type of material being cut: a harder material like cast iron may be machined with a smaller rake angle than that required by a soft metal like mild steel or aluminum.
2. Type of tool material being used: tool material like cemented carbide permits turning at a very high speed. It has been observed that in machining at a very high cutting speed rake angle has a little influence of cutting pressure.
3. Depth of cut: in rough turning, a high depth of cut is given to withstand severe cutting pressure. so the rake angle should be decreased to increase the lip angle that provides strength to the cutting edge.
4. The rigidity of the tool holder and condition of the machine: an improperly supported tool on an old and worn out machine can't take up severe cutting pressure. so machining under such conditions the tool used should have a larger rake angle than that at the normal condition to reduce the cutting pressure.

Tool Signature

The tool signature or tool designation is used to denote a standardized system of specifying the principal tool angles of a single-point cutting tool. Some common systems used for tool designation or tool nomenclature are the following-

1. American or (ASA) System.
It defines the principle angles like side rake, back rack, nose, etc. without any reference to their location concerning cutting edge. As such, this system of nomenclature does not give any indication of the tool behavior with regard to the flow of chip during the cutting operation the three reference planes adopted for designating different tool angles are similar to those used in conventional machine drawing i.e, x-x,y-y, and z-z the last one containing the base of the tool and the two plane being normal to this plane as well as mutually perpendicular. Thus, this system is a coordinate system of tool nomenclature.
2. British system:
This system, according to B-S1886-1952, defines the maximum rake. The various tool parameters in this system are indicated if the order of Back rake, Side rake, End relief angle, Side relief angle, End cutting angle, Side cutting edge angle, and Nose radius.
3. Continental systems:
This category of tool nomenclature systems includes the German or DIN System (DIN-6581), Russian Systems (OCT-BKC 6897and 6898), and Czechoslovakian System (CSN-1226). The various tool parameters in these systems are specified with reference to the tool reference to the tool reference planes.
4. International system:
It is an internationally adopted system, developed recently. It incorporates the salient features of tool nomenclature of different systems in it.

Questionnaire

Fill the questionnaire for state of learning in workshop practice.

1. Converting the natural resources for the benefit of mankind is called ______
2. _______ is a person having always creative thoughts & idea's to develop the technology for the noble cause of the society or nation.
3. _______ is a place of work for preparing varieties of product by using Hand Tools, Machine Tools & Instruments.
4. The information required to prepare the product are : i. _____________
   ii. ____________
   iii. ____________
5. is a process of removing unwanted materials with the help of tools from a given stock for making a component.
6. The shape is formed by pouring molten metal into a mould is called __________
7. The shape is formed by mechanically pressing or hammering in both hot and cold condition is called _______________
8. The shape formed by various machining operations by machines is called_______.
9. The process of making the product from pieces by joining is called_________.
10. The process of finding the dimensions of the work piece by using calipers, micrometer, and gauge is called________ (Marking, Punching, Chipping, Measuring)
11. Ferrous Metal contains _________. (Steel, Tungsten, Iron, Zinc)
12. Steel is an alloy of ____________ & _________(Iron & Carbon, Carbon & Steel, Steel & Iron)
13. __________ is not a Metal. (Iron, Mild Steel, Stone, Cobalt)
14. Iron containing metals are called __________(Non Metals, Ferrous Metals, Non ferrous metals)
15. Devices which are to use to perform work by hand are called (Machine Tools, Measuring Tools, Hand tools)
16. Devices which are to use to perform the work by Machine are called___________. (Measuring tools, machine Tools, Grinding Tools)
17. The operation of making series of dents on the marked lines is called ___________.
18. The operation of Producing a holes is called________
19. The operation of smoothening the inner surface of drilled hole is called _______.
20. The operation of enlarging the size of previously drilled hole is called _______.
21. The operation of increasing the size of the hole at one end through a small depth is called _______.
22. The operation of cutting flat, round rods, pipes are called_______.
23. The operation or removing thick layer of metal is called_______.
24. The operation of removing thin layer of metal is called _______.
25. The operation of cutting internal threads is called_______.
26. The operation of cutting external threads is called_______.
27. The process of removing metal using grinding wheel is called _______.
28. Least count of Vernier Caliper is_______mm.
29. Least Count of Micrometer is _______ mm.

30. Vernier Caliper Contains__________ & __________ scale.
31. Vernier Caliper Value of 1 VSD is _________ mm.
32. Micrometer contains ____________ & _________ scale.
33. Least count of Vernier Height Gauge is ________ mm.
34. Pitch of the Micrometer is ________mm.
35. A process of joining 2 pieces of metal by heating then to a suitable temperature with additions of filler metal with pressure is called _______ (Fitting, Welding' Drilling' Hack sawing)
36. ___________ welding, metals are heated up to plastic state
37. Melting temperature of welding is-.(10000,14000,12000,13000)
38. Melting temperature of Brazing are (5000 to 6000, 6000 to 850^o, 850^o to 900^o)
39. Melting temperature of soldering is (200^o to 300^o, 350^o to 900^o, 150^o to 350^o)

40. Filler metal of welding is called as________.
41. Filler metal of brazing is called as ________.
42. Filler metal of soldering is called as _______.
43. _______ is the first sequence of operation for fitting. (Drawing, Punching, Marking, Filing.
44. _______ is the last sequence of operation for fitting.(Filing, Chipping, Measurements' Drawing)
45. Why the electrodes are coating flux i) ii) iii)
46. Visible lines are drawn in continues line. (Thin, Thick)
47. Dimensioning line projection lines are drawn in _____________ lines. (Thin, Thick)
48. All hand cutting tools are made by ________steel. (Mild Steel, Hi Carbon, Steel, Stainless Steel)
49. Stainless steel contains _____,_____,_____ & _____.
50. High Speed steel used for ________(Hand Cutting Tool, Fast Cutting Tool & Woodcutting Tool)
51. Heating & cooling of metal in order to change the property is called __________.
52. Filing methods are ________, __________ & _______.
53. Drilling is an operation making for round holes with__________.(Reamer, Drill Bit, Hammer)
54. Sheet is cut to the particular shape, which is formed by development of surfaces and than after notching' bending and forming appropriately is finally joined by soldering / welding is called ______.
55. The complete surface of an object is opened to one plane is drawn on paper provided with suitable allowances for seam and hem is called _______.
56. The whole surfaces of right prisms, cylinders and cubes are prepared by _________method.
57. The whole surfaces of right circular cone' pyramids are prepared by ________ method.
58. Name some of the products manufactured in sheet metal industry.
59. Name some of common sheets used in sheet metal shop.
60. Hand snip / Tin Cutter are used for _________ operation.
61. Toggle Press is used for____________ operation.
62. Stakes are used for_________ operation.
63. Wire gauge is used for measuring __________& _________.

64. Mallet is made out of ________.
65. Two or more number of principle views is drawn to show the shape & size of the object is called _______
66. The object is viewed or seen from the front, the shape and size is formed in vertical plane is called _______.
67. The object is viewed or seen from the top, the shape and size is formed in horizontal plane is called ________.
68. The object is viewed or seen from the right or left, the shape and size is formed in profile plane is called ________.

Match the following

(a) Visualization	Being in time	[ ]
(b) Planning	Doing something repeatedly	[ ]
(c) Practice	Work is work ship	[ ]
(d) Hard Work	A set of preparation to perform perfect of work	[ ]
(e) Punctuality	Creating picture in mind	[ ]
(f) Work Place Environment	Ability to do the work accurately	[ ]
(g) Efficiency	2D	[ ]
(h) Engineering Drawing	3D	[ ]
(i) Orthographic Projection	Neat and Clean	[ ]
(j) Isometric Projection	It's a media of expression all technical details	[ ]
(k) Arc Welding	Source of heat by electric current	[ ]
(l) Gas Welding	Source of heat by gases of oxygen and acetylene	[ ]
(m) Forge Welding	Source of heat by electric arc	[ ]
(n) Resistance Welding	Source of heat by blacksmith fire or Gas fire	[ ]

TRUE or FALSE: TRUE [√] FALSE [x]

1) Metal is a good conductor of heat.	[ ]
2) Non Ferrous metal contains iron & carbon.	[ ]
3) Aluminum is a non ferrous metal.	[ ]
4) Cast iron is used for manufacturing the body of bench vice.	[ ]
5) Stainless steel contains silver & copper.	[ ]
6) Try square is used for measuring the diameter.	[ ]
7) Wire gauge is used for to measure the depth of the job.	[ ]
8) Pitch gauge is used to measure the pitch of the thread.	[ ]
9) Hammers are specified according to their length.	[ ]
10) Files are classified according to cross section of the file.	[ ]
11) Taps are used for cutting external threads.	[ ]
12) Taper shank drill bit is made of High Speed Steel.	[ ]
13) Screw driver is used for tightening of bolt & nut.	[ ]
14) Drills are used for enlarge & finish the circular hole.	[ ]
15) Mild steel is used for manufacturing of cutting tools.	[ ]
16) Electrodes are classified according to the diameter.	[ ]
17) Tack welding is made for aligning the2 pieces.	[ ]

Machining Science and Jigs & Fixture
Viva-Voce

1. **What is a machine tool?**
   A machine tool is a device in which energy is utilized for shaping the material into a product by removing the excess material in the form of chips.

2. **What is a machining?**
   Machining is process of shaping the material by performing various machining operations by machines.

3. **Define the term turning?**
   Turning is a machining process to bring the raw material to the required shape and size by metal removal. This is done by feeding a single point cutting tool against the direction of rotation of the work.
   The machine tool on which turning is carried out is known as lathe.

4. **What are the different types of lathes?**
   Centre lathe, Bench lathe, Capstan lathe, Combination lathe, Turret lathe, CNC lathes.

5. **What are the differences between the Center Lathe and Capstan Lathe?**
   Centre Lathe-It is a manually operated lathe, It has only one tool post tool changing time is more, It has tail stock, Only one tool can be fitted in the tail stock, Number of speeds is less, Tool changing time is more, The machine should be stopped for changing tool, It is not suitable for mass production, The tool is centered manually after changing the tool,
   Capstan/Turret Lathe- It is a semi-automatic lathe, Front and rear tool posts are available. Tool changing time is less, Number of speeds is more, Tool changing time is less, Tool can be changed without stopping the machine, It is suitable form as production, The tool is centered automatically,

6. **How the Center Lathe can be specified?**

- The maximum diameter of a work that can be held.
- The length of the bed.
- Distance of the between centers.
- The range of threads can be cut.
- Capacity of the lathe.
- Range of spindle speed.

7. **What are the functions of lead screw and feed rod?**
   Lead Screw– Lead Screw for thread cutting purpose.
   Feed Rod – Feed Rod to provide automatic feeding either for facing or turning.

8. What are the different methods of Taper turning?

1) Compound slide method
2) Tailstock offset method
3) Form tool method
4) Taper turning attachment method

9. What is meant by eccentric turning?

When different diameters are turned on different axis, it's said to be eccentric turning.

10. What is the difference between L.H. thread cutting R.H. thread cutting?

a) A right hand bolt threads screws into the nut when it is rotated clockwise.
b) A left hand bolt threads screws into the nut when it is rotated anticlockwise.

11. Why the knurling operations are necessary for the given models in m/c shop?

a) A good grip and make for positive handling
b) Good appearance
c) For raising the diameter to a small range for assembly to get a desired fit.

12. What are the differences between 3-jaw chuck and 4-jaw chuck?

3– Jaw chuck

Only cylindrical or hexagonal work center, internal and external jaws are available, setting of work is easy, less gripping power, work pieces can't be set for eccentric turning, concentric circles are not provided on the face.

4– Jaw chuck.

A wide range of regular and irregular shaped jobs can be held, jaws are reversible for external and internal holdings, setting of work is difficult, more gripping power, work pieces can be set for eccentric turning, concentric circles are provided.

13. What are the differences between lathe accessories and lathe attachments? Give examples.

a) The lathe accessories are machined, independent units supplied with the lathe, which are essential for the full utilization of the lathe,

Example,

1) Work holding accessories–4–jawchuck, 3–jawchuck,faceplates, lathe mandrels.
2) Work supporting accessories–catch plate, driving plate, lathe centers, lathe carriers, fixed and travelling steady rests.

b) Attachment is an optional extra attachment to produce tapers, contours, thread forming, grinding, etc…

Example;

1) Taper turning attachment
2) Forming attachment
3) Cylindrical, grinding, thread, grinding attachment

14. What is meant by single point cutting tool?

Single point cutting tools having two cutting edges (major & minor cutting edges) joining at a point called single point cutting tool. And these tools are used on lathe shaper & planner

15. What is meant by multi point cutting tool? Give examples.

These tools have more than one cutting edge and they remove metal from the work piece simultaneously by the action of all the cutting edges,

Ex. Files, hack saw blade, twist drills, reamers, milling cutters, hand taps, and spilt dies, grinding wheels.

16. What are the properties of cutting tool material?

The most important basic properties of only cutting tool is,

- Cold hardness
- Red hardness
- Toughness

17. What is meant by H.S.S. tool? What are the elements present in that?

HSS (High Speed Steel) is an alloy of high carbon steel with an alloying elements like Tungsten 18%, Chromium 4% and Vanadiumof 1%.

18. What is meant by carbide tipped tool?

These tools are made of two different metals, the cutting portions of the tools are tungsten carbide which are brazed to ordinary metal blank which are tough (low cost).

19. Define cutting speed. Feed and depth of cut?

a) Cutting speed–"The speed at which the cutting edge passes over material "which is expressed in meters per minute is called the cutting speed.

$V = \Pi DN/1000$ meter/min. (OR) $V = \Pi DN/12$ feet/min.

Where– V =cuttingspeed in meters/min

$\Pi = 3.14$

D =diameterofwork piecein mm

N =rpm

b) Feed–The feed of the tool is the distance it moves along the work for each revolution of the work and it is expressed in mm/revolution.

c) Depth of cut–It is the advancement of the tool at the beginning of the feed which is perpendicular to the type of feed.

20. What is the spindle speed during thread cutting operations?

Set the spindle speed to about $1/4^{th}$ of the normal turning speed.

20. What is difference between orthogonal cutting and oblique cutting?

Orthogonal cutting–Is a process of cutting operation where only two forces i.e. tangential and axial forces are acting on the tool while turning Oblique cutting- Is a process of cutting operation where three forces i.e. Tangential, axial and radial forces are acting on the cutting tool while turning.

22. Why steady rest and follower rest are used?

A steady rest and follower rest are the lathe accessories used to give extra support for along slender work piece in addition to the centre support during turning.

23. Why the mandrels are used?

Lathe mandrels are devices used to hold the job for machining on lathes. They are mainly used for machining outside diameters with reference to bores which have been duly finished by either reaming or boring on a lathe.

24. What are the measuring (limit) gauges used while doing/machining components on lathe?

Internal features check External features check

Cylindrical plug gauge
Plain ring gauge
Taper plug gauge
Taper ring gauge
Screw threaded plug gauge
Screw pitch gauge
Fillet gauge

Radius gauge

25. What is the formula for calculating the machining time on lathe?

Time to turn =length ofcut xno. of cuts /feed x r p m minutes

(OR)

T =Lxn/ f xN min.

Extra Questions

26. What is meant by taper turning?
27. List the work holding devices used on shaper?
28. What is meant by indexing? List the methods of indexing?
29. What is the formula for simple indexing method?
30. Name the milling cutter used for gear cutting operation?
31. Name the milling cutter used in vertical milling machine?
32. Why cutting fluids are used in machining operations?
33. What are the differences between shaper and planner?
34. What do you mean grinding operation?
35. What is meant by Surface grinding and Cylindrical grinding?

REFERENCES

01. **Work shop Technology, (Volume II) by Hazrachaudhary** Serope Kalpakjian, Steuen. R.Sechmid, Pearson Education Asia, 5th Ed. 2006.

02. **All about Machine Tools**, Heinrich Gerling, New Age International Publication, 2016.

03. **Production Technology,** R K JainKhannaPublications, 2003.

04. **Fundaments in Metal Machining and Machine Tools,** G Boothroyed, McGrawHill, 2001.

05. **Manufacturing Science,** Amitabha Ghosh and Mallik, affiliated East West Press, 2003.

06. **Production Technology,** HMT, Tata McGraw Hill, 2001.