A Laboratory Manual for

Manufacturing Processes (BE0400091)

B.E. Semester 4 (Mechanical)

Institute logo

Directorate of Technical Education, Gandhinagar, Gujarat

Manufacturing Processes
(BE0400091)

Lab Manuals

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This is to certify that Mr./Ms. ____ _________ Enrollment No. _________________ of B.E. Semester ______ Mechanical Engineering of this Institute (GTU Code: _____) has satisfactorily completed the Practical / Tutorial work for the subject **Manufacturing Processes (BE0400091)** for the academic year 2025-26.

Place: ___________
Date: ___________

Name and Sign of Faculty member

Head of the Department

Preface

Main motto of any laboratory/practical/field work is for enhancing required skills as well as creating ability amongst students to solve real time problem by developing relevant competencies in psychomotor domain. By keeping in view, GTU has designed competency focused outcome-based curriculum for engineering degree programs where sufficient weightage is given to practical work. It shows importance of enhancement of skills amongst the students and it pays attention to utilize every second of time allotted for practical amongst students, instructors and faculty members to achieve relevant outcomes by performing the experiments rather than having merely study type experiments. It is must for effective implementation of competency focused outcome-based curriculum that every practical is keenly designed to serve as a tool to develop and enhance relevant competency required by the various industry among every student. These psychomotor skills are very difficult to develop through traditional chalk and board content delivery method in the classroom. Accordingly, this lab manual is designed to focus on the industry defined relevant outcomes, rather than old practice of conducting practical to prove concept and theory.

By using this lab manual students can go through the relevant theory and procedure in advance before the actual performance which creates an interest and students can have basic idea prior to performance. This in turn enhances pre-determined outcomes amongst students. Each experiment in this manual begins with competency, industry relevant skills, course outcomes as well as practical outcomes (objectives). The students will also achieve safety and necessary precautions to be taken while performing practical.

This manual also provides guidelines to faculty members to facilitate student centric lab activities through each experiment by arranging and managing necessary resources in order that the students follow the procedures with required safety and necessary precautions to achieve the outcomes. It also gives an idea that how students will be assessed by providing rubrics.

Manufacturing Processes is the fundamental course which deals with various types of Machine tools used for the machining process and machining science. The machining processes are the material subtraction process. It provides a platform for students to demonstrate various operations performed on the machine tools for the different shape generation by removing material. Students also learn various cutting tool and machine tool selection based on the part drawing. The fundamentals for the machining time and other calculations are also incorporated.

Utmost care has been taken while preparing this lab manual however always there is chances of improvement. Therefore, we welcome constructive suggestions for improvement and removal of errors if any.

Practical – Course Outcome matrix

Course Outcomes (COs):

1. Interpret basics of cutting tools and metal cutting mechanism.
2. Make use of their skill in manufacturing of workshop job by using different machine tools.
3. Illustrating different cutting parameters and calculation of machining time for different metal cutting operations.
4. Illustrating different cutting forces acting while machining and its importance for economic manufacturing.
5. Evaluate Monitoring and testing of machine tools for better performance.

Sr. No.	Objective(s) of Experiment	CO 1	CO 2	CO 3	CO 4	CO 5
1.	Study of Machine Tools (Lathe, Shaper, Slotter, Planner, Milling, Drilling, Grinding)		√			
2.	To understand the effect of chosen parameters on the type of chip produced	√				
3.	To determine chip thickness ratio and shear plane angle under various cutting conditions	√				
4.	Job making on lathe machine		√			
5.	Job making on milling machine		√			
6.	Demonstration of Job making on Drilling, Grinding, Shaper and Slotter machine		√			
7.	To measure the various cutting forces during turning operation on Lathe machine using Lathe tool dynamometer				√	
8.	Machining time calculation for different machining operations			√		
9.	Alignment test on lathe machine					√
10.						

Industry Relevant Skills

The following industry relevant competencies are expected to be developed in the student by undertaking the practical work of this laboratory.

1. To be able to select an appropriate tools and machine for the product.
2. To be able to select the appropriate cutting parameters for the different operations.
3. To be able to analyze the selection of operations for the machining.
4. To be able to prepare the operation route sheet.
5. To be able to set and operate the machine tools.

Guidelines for Faculty members

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain basic concepts/theory related to the experiment to the students before starting of each practical
3. Involve all the students in performance of each experiment.
4. Teacher is expected to share the skills and competencies to be developed in the students and ensure that the respective skills and competencies are developed in the students after the completion of the experimentation.
5. Teachers should give opportunity to students for hands-on experience after the demonstration.
6. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by concerned industry.
7. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions or not.
8. Teacher is expected to refer complete curriculum of the course and follow the guidelines for implementation.

Instructions for Students

1. Students are expected to carefully listen to all the theory classes delivered by the faculty members and understand the COs, content of the course, teaching and examination scheme, skill set to be developed etc.
2. Students shall organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Students shall attempt to develop related hand-on skills and build confidence.
5. Students shall develop the habits of evolving more ideas, innovations, skills etc. apart from those included in scope of manual.
6. Students shall refer technical magazines and data books.
7. Students should develop a habit of submitting the experimentation work as per the schedule and s/he should be well prepared for the same.

Common Safety Instructions

1. Students are expected to take all safety precaution and perform practical.

Index
(Progressive Assessment Sheet)

Sr. No.	Objective(s) of Experiment	Page No.	Date of performance	Date of submission	Assessment Marks	Sign. of Teacher with date	Remarks
1.	Study of Machine Tools (Lathe, Shaper, Slotter, Planner, Milling, Drilling, Grinding)						
2.	To understand the effect of chosen parameters on the type of chip produced						
3.	To determine chip thickness ratio and shear plane angle under various cutting conditions						
4.	Job making on lathe machine						
5.	Job making on milling machine						
6.	Demonstration of Job making on Drilling, Grinding, Shaper and Slotter machine						
7.	To measure the various cutting forces during turning operation on Lathe machine using Lathe tool dynamometer						
8.	Machining time calculation for different machining operations						
9.	Alignment test on lathe machine						
Total							

Experiment No: 1
Study of Machine Tools (Lathe, Shaper, Slotter, Planer, Milling machine, Drilling machine, Grinding machine)

Date:

Competency and Practical Skills:

1. Basic understanding of machine tools.
2. Identification of elements of machine tools and its functions.
3. Different tool and work holding devices and operations will be identified.

Relevant CO: CO2

Objectives: (a) To show and demonstrate the working of the machine tool.
(b) To show the operations performed on the machine tool.

Equipment/Instruments: Lathe, Shaper, Slotter, Planner, Milling, Grinding, Drilling, Single point cutting tool, Multi point cutting tools, drilling tool, grinding wheels, Different work holding devices.

Theory: A machine tool is a non-portable power operated and reasonably valued device or system of devices in which energy is expended to produce jobs of desired size, shape and surface finish by removing excess material from the preformed blanks in the form of chips with the help of cutting tools moved past the work surfaces. The basic functions of the machine tools are

1. Firmly holding the raw material and the tool.
2. Transmit the motions to the tool and the work.

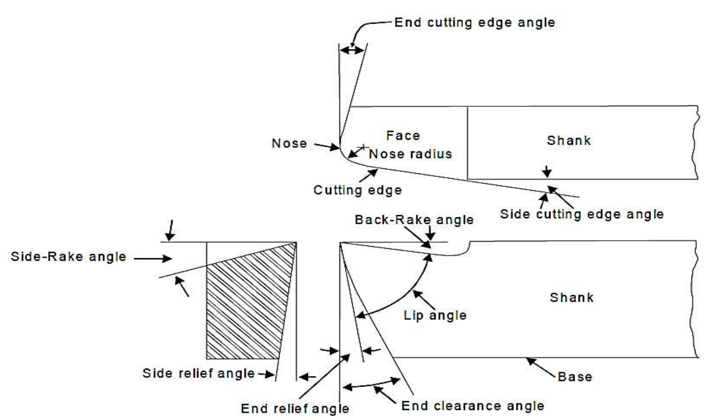
Lathe:

Lathe was the first Machine tool which came into being as a useful machine for metal cutting. Thus, it formed the basis of production of all the other Machine tools which are results of later developments. Though primarily it is designed to produce cylindrical surfaces with a single point tool, a lathe can be used for most other operations done on general purpose machine tools.

<u>Types of Lathe:</u>

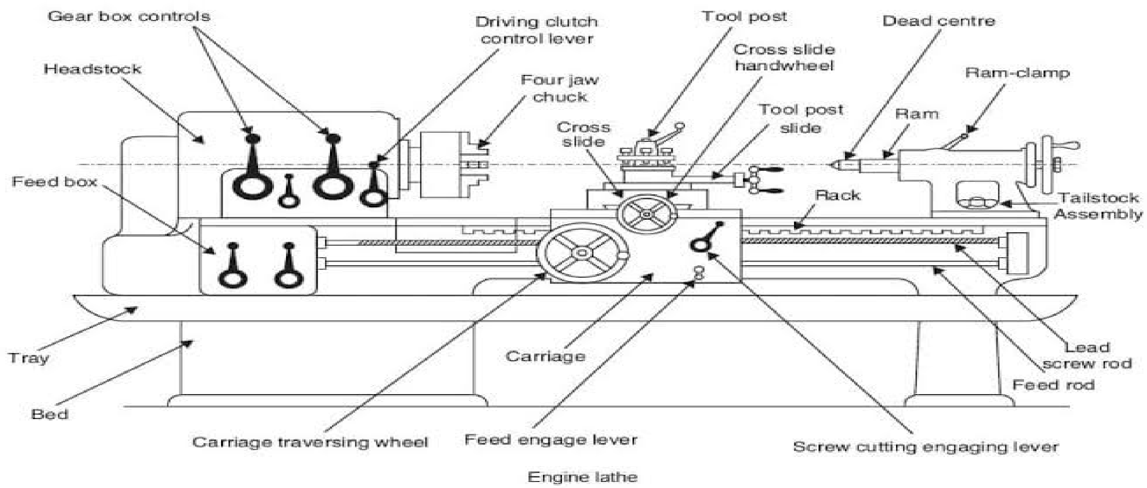
1. Speed lathe
2. Engine lathe
3. Bench lathe
4. Tool room lathe
5. Production lathe
6. Special purpose lathe

<u>Single point Cutting tool Geometry:</u>



Single point cutting tool geometry

Constructional Details of Lathe:



Construction of Lathe

1. Bed: The bed of the lathe forms the base of the machine. It is supported on two legs at a convenient height. It carries the headstock and the tailstock for supporting the work and provides a base for the movement of the carriage assembly which carries the tool. Lathe beds are designed with a box like cross section and provided with diagonal ribbing to improve their stiffness.
2. Head stock: The head stock houses the spindle and the means for supporting and rotating the spindle. It is rigidly fixed on the bed. The spindle which is made of steel is made hollow so that long bars which are being machined at the end may pass through it. The right hand end of the spindle which projects out of the head stock body has a threaded outside and a tapered bore.
3. Tail stock: Tail stock is the counter part of the head stock and is fitted on the right hand side of the bed. The tail stock base is machined to fit the ways of the bed and be adjusted anywhere along its length to accommodate jobs of different lengths being turned. It is provided with a quill which can be moved in and out bt means of a screw and then locked in position.
4. Carriage Assembly: The carriage assembly consists of a saddle, cross slide, compound rest, top slide, tool post and apron. Movement of the entire carriage assembly along the bed provides feed for the tool parallel to the lathe axis; movement of the cross slide along its guides on the saddle provides feed for the tool across the lathe axis and the movement of the top slide along its guide over the compound rest provides the motion to the tool along a direction set by the compound rest. The compound rest can be swiveled on the cross slide in the horizontal plane about a vertical axis.
5. Feed Mechanism: The automatic feed mechanism and the split nut receive their power from the head stock through the end gear train, quick change gear box if there is one and the feed rod or lead screw. The end gear train transfers power from the head stock to the input gear of the feed box. The lead screw is a long threaded shaft running along the length of the lathe and is used for powering the split nut during screw cutting. Tool room lathes are provided with separate feed rod running parallel to the lead screw which is used only for automatic feeding.

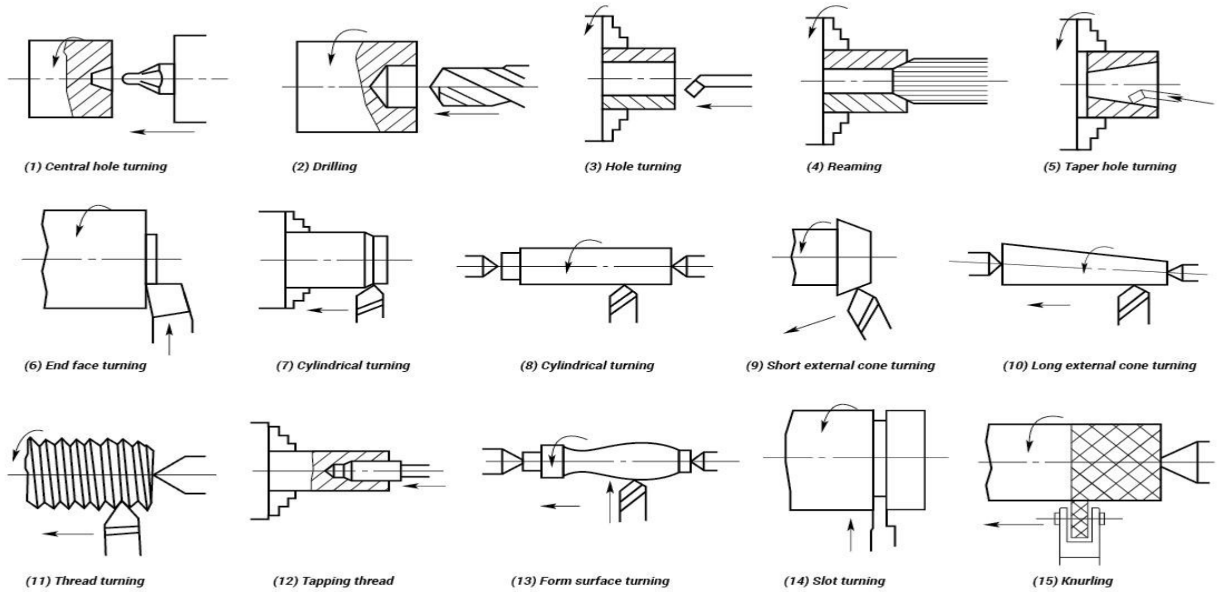
Work holding devices:

The work holding devices are required to hold and support the work piece during cutting. The selection of the particular device to be used depends on the size and shape of the work piece, nature of operation and accuracy desired.

On a lathe, the work piece may be held and rotated using any one of the following methods.

1. Between head stock and tail stock
2. In a chuck or collet
   (a)Three jaw chuck (b) Four jaw chuck (c) magnetic chuck
3. On a face plate
4. On a mandrel

Operations Performed on lathe:

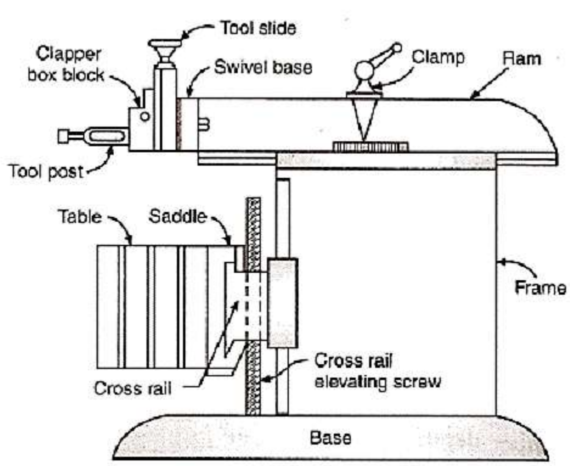


Shaper and Slotter:
A shaper is a machine tool that uses reciprocation straight line motion of the tool and a perpendicular feed of the job or the tool. By moving the work piece across the path of the reciprocating tool a flat surface is generated regardless of the shape of the tool.

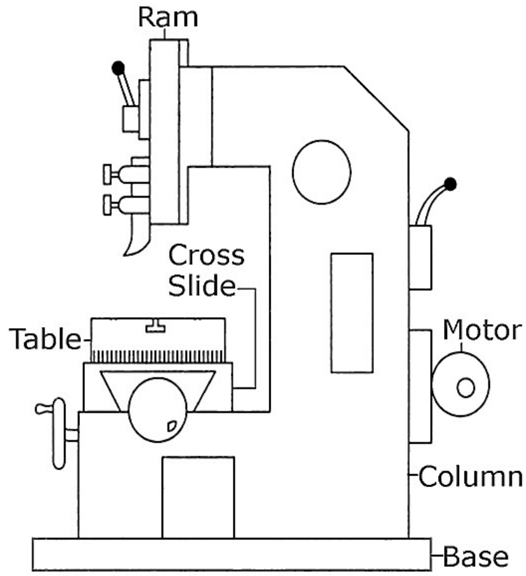
Shaping is essentially an inefficient method of metal removal but the simplicity of the process coupled with short set up time and cheap tooling makes it extremely useful for one of type of jobs.

Types of Shapers:
1. Horizontal push cut shaper
2. Horizontal draw cut shaper
3. Special purpose shapers
4. Vertical shaper - slotter

Constructional details of Shaper and Slotter:



(a) Shaper



(b) Slotter

1. Horizontal Shaper: The most common type of horizontal shapers is the production push cut shaper. This type of shaper consists of a frame supported on a base, a reciprocating ram and a work table. The frame houses the drive mechanism of a shaper. The top of the frame provides guide ways for the ram. The front of the frame provides guide ways for a cross rail which can be moved up and down. Sliding along the cross rail, perpendicular to the line of motion of the ram is a saddle which carries the work table. On the front end of the ram is fitted a tool head which holds the tool and is provided with means for feeding the tool into the work.

   The reciprocating motion of the ram provides the straight line motion to the tool which is the speed for cutting. The vertical movement of the cross rail permits the job of different heights to be accommodated below the tool and is a machine setting. Motion of the table along the cross rail provides the feed motion for horizontal shaping. The motion of the tool slide on the tool head in conjunction with the swivel base provides feed motion for vertical and angular cuts. The motion of the table along the cross rail for feeding is powered by a Paul and Ratchet arrangement and timed by actuating the paul by the shaper ram drive. The feed is provided at the end of return stroke.
2. Vertical shaper – Slotter: Vertical shapers have a ram which operates vertically and has the usual quick return feature like the horizontal type machine. They are used principally for internal cutting like cutting key ways and for operations that require vertical cuts because of the position in which the work must be held. The work to be machined is supported on a round table having a rotary feed in addition to movement in two mutually perpendicular horizontal directions. The circular feed permits machining of curved surfaces.

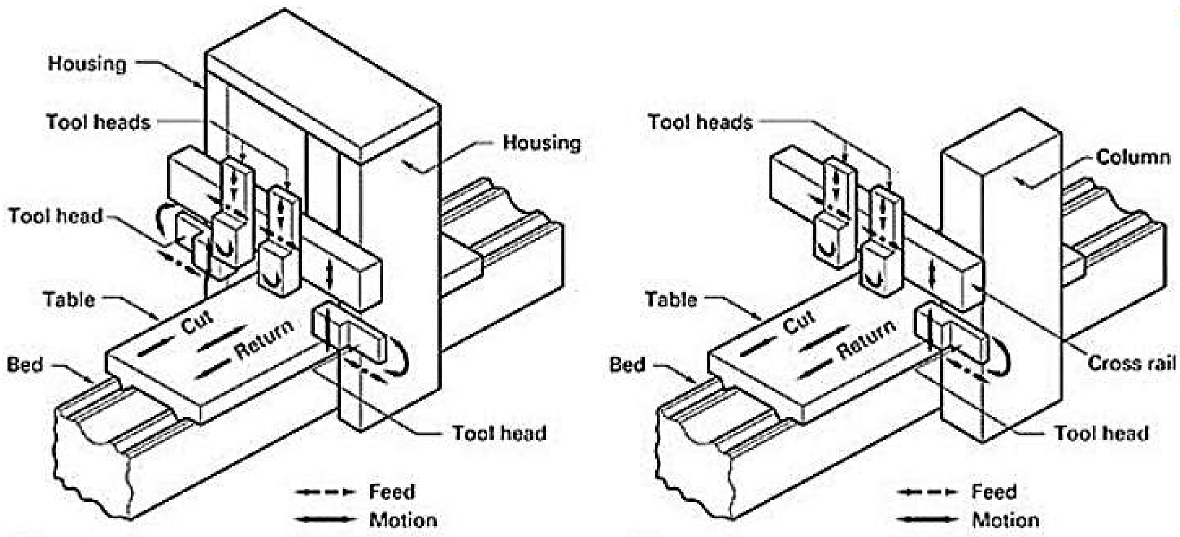
Planer:

A common planer is a machine tool designed to machine metal by combining the line motion of a job and the perpendicular feed of the tool. The type of work is similar to that done on a shaper except that the planer can take larger work pieces. A planer generally produces plane surfaces which may be horizontal, vertical or inclined.

Types of Planers:

1. Double housing planer
2. Open side planer
3. Universal Planer
4. Pit type planer
5. Plate or edge planer

Constructional details of Planer:



Block diagram showing the basic components of a double-housing planer.

Block diagram of an open-side planer.

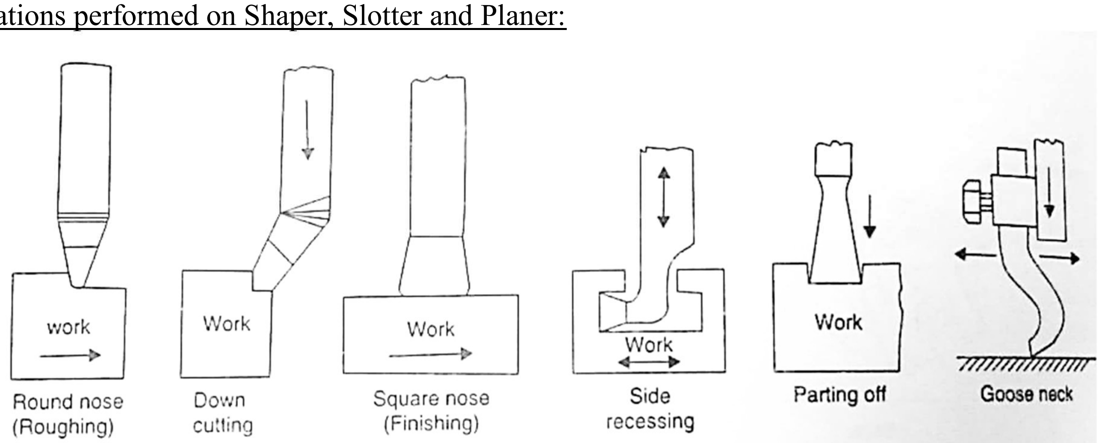
The double housing planer consists of a long heavy bed on which the table is reciprocated. On either side of the bed near the centre are located the upright housings. The housings support the cross rails upon which one or more tool heads are supported and guided. In modern double housing planers a tool head is provided on each of the housings also. All these tool heads may simultaneously work on a surface each. The feed of the tool may be adjusted to be horizontal, vertical or at an angle by hand or by power. The motor drive is usually on one side of the planer and the drive mechanism is located under the table.

Open side planer has only one housing on one side and is used to handle wider work pieces. This planer is not as rigid as a double housing planer.

Work holding devices (Shaper, Slotter, Planer):

1. Vice
2. Chuck
3. Fixtures
4. Clamp on machine table using bolts, clamps, wedge blocks, stop pins, angle plates and parallels

Operations performed on Shaper, Slotter and Planer:

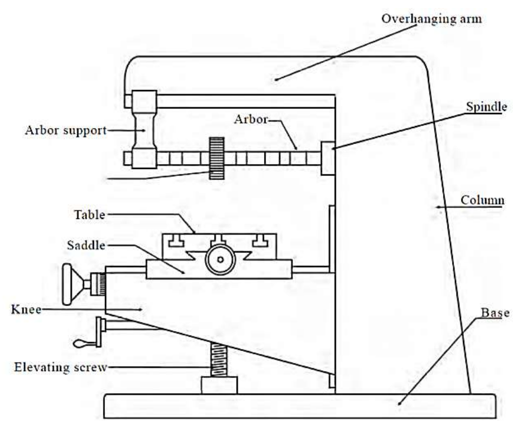


Operations performed on Shaper, Slotter and Planer

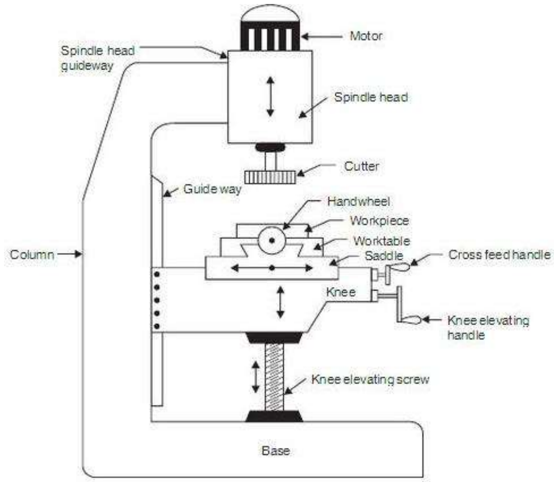
Milling Machine:
Milling machine performs the machining operation for removing excess material from a work piece with a multi-tooth rotating cutter. Flat or curved surfaces of many shapes can be machined by milling with good finish and accuracy. Interrupted cutting, small size of the chip and variation of chip thickness within the chip are the characteristic features of the milling operation.

Types of Milling machines:
1. Column and Knee type milling machine
2. Fixed bed type milling machine
3. Planer type milling machine
4. Production milling machine
5. Special purpose milling machines

Constructional details of Milling machine:



Horizontal milling machine



Vertical milling machine

1. Horizontal Milling machine: The vertical column serves as housing for electrical system, main drive, spindle bearings, spindle, etc. The knee acts as a support for the saddle, work table and other elements like Indexing head, etc. Overarm provides support for the arbor support which supports the free end of arbor. The arbor carrying the cutter rotates about a horizontal axis. The table can be given straight motions in three directions; longitudinal, cross and vertical but cannot be swiveled. For giving vertical movement to the table the knee itself, together with the whole unit above it, slides up and down along the ways provided in front of the column. To provide the cross movement to the table, the saddle is moved towards or away from the column along with the whole unit above it. Both hand and power feeds can be employed for the work.
2. Vertical Milling machine: It is named because of the vertical position of the spindle. It carries a vertical column on a heavy base. The overarm in this machine is made integral with the column and carries housing at its front. This housing, called head, can be fixed or swiveling type.

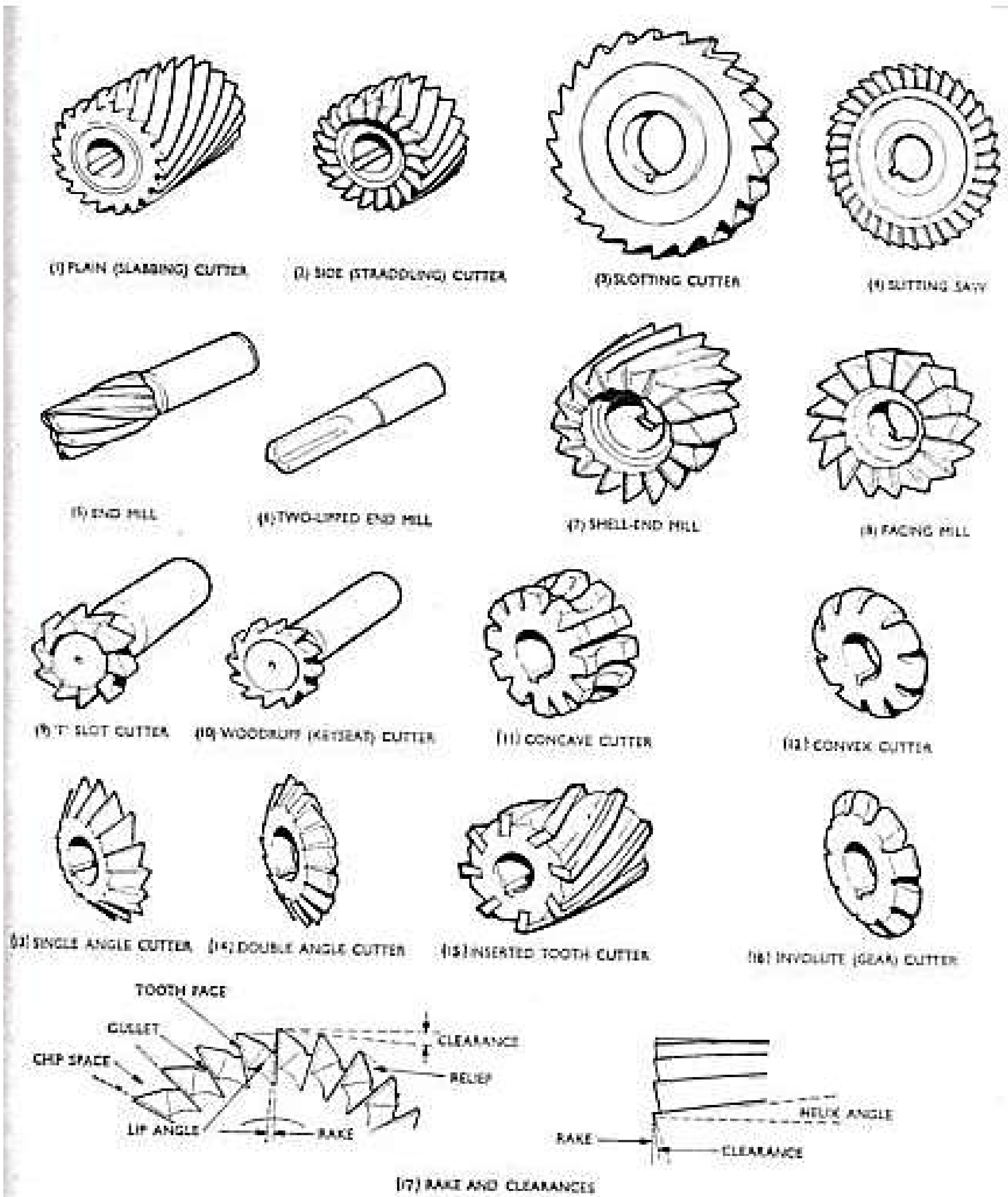
The knee carries an enclosed screw jack, by means of which it is moved up and down along the parallel vertical guide ways on the front. The saddle is mounted on the knee and can be moved along or away from the column. This enables the table to move in cross direction. The table is mounted on the guide ways, provided on the saddle, which are in direction normal to the direction of the guide ways on the knee. By means of the lead screw, provided under the table, the table can be moved in longitudinal direction. Power feeds can be employed to both the saddle and the table.

<u>Work holding devices:</u>

The most commonly used work holding devices of the milling machine are listed below.

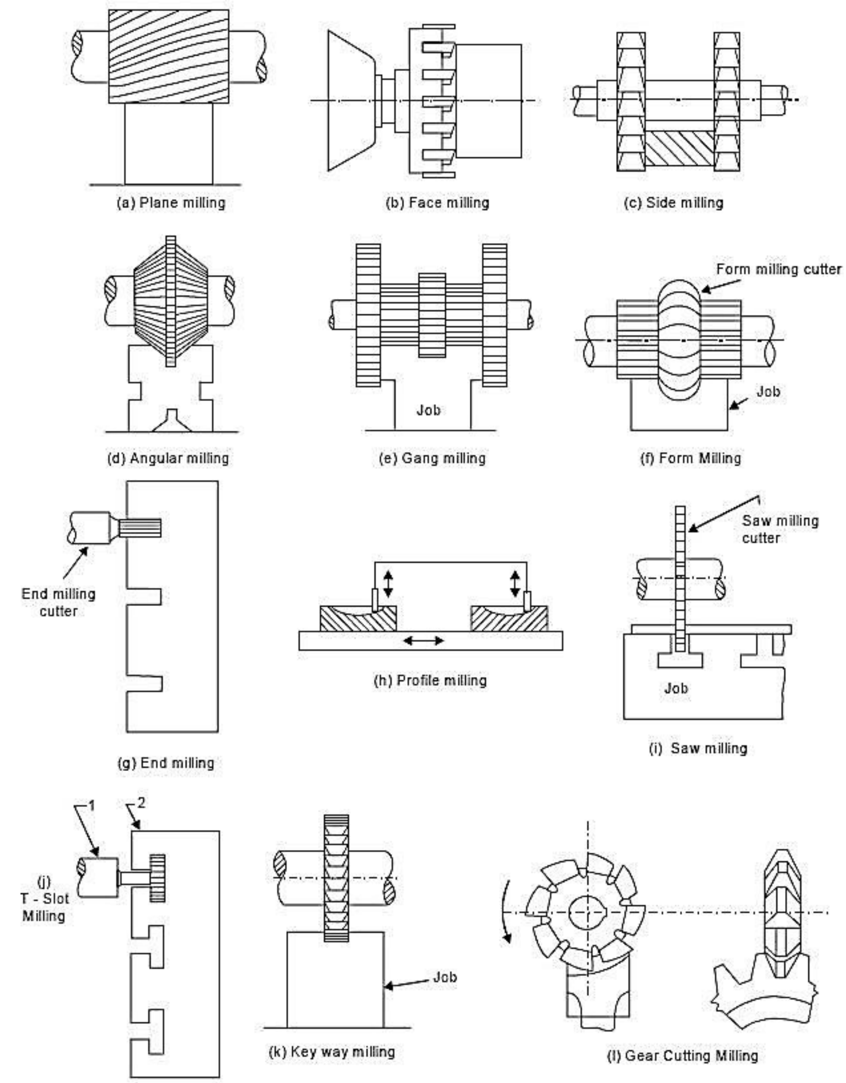
1. Different types of vice
2. Rotary table
3. Clamps, straps, bolts and nuts
4. Angle plates and V-blocks
5. Milling fixtures

<u>Different Milling cutters:</u>



Different Milling cutters

Operations performed on the Milling machine:



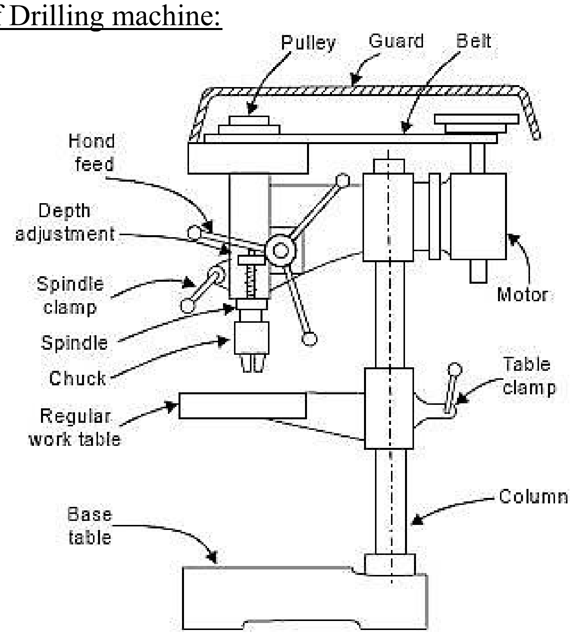
Drilling Machines:

Drilling is a machining operation by which holes are produced or enlarged in a workpiece with the help of a fluted end cutting tool called drill. Holes are needed on the workpieces for fasteners like screws, bolts and rivets and for reducing the weight of the jobs. Other processes allied to drilling are done after the drilling operation with special tools.

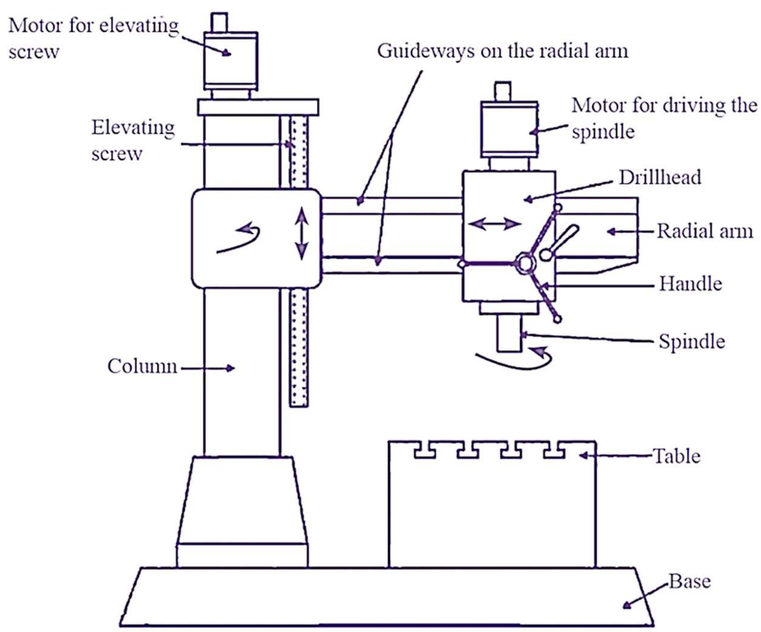
Types of Drilling machines:

1. Upright drilling machine
2. Radial drilling machine
3. Gang drilling machine
4. Turret drilling machine
5. Multi spindle drilling machine

Constructional Details of Drilling machine:



Upright Drilling machine



Radial Drilling machine

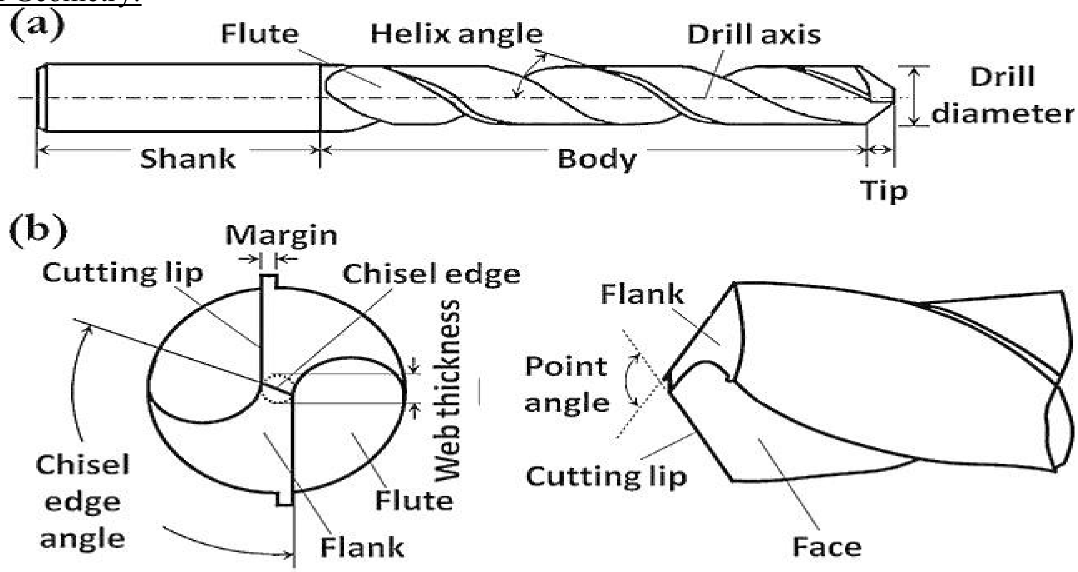
1. Upright Drilling machine: It is also known as Standard, Vertical or Pillar drilling machine. It is used for heavier work than the sensitive drill machine and has back gear arrangement. A standard upright drill press has a column mounted on a base. The column may be round or box section. It provides support for a work table and a spindle head. The work table supports the work piece. It can be raised or lowered along the pillar depending upon the height of the job and clamped in position for rigidity. In drilling machines with round column the table may be round and carried on a frame which can be swiveled about the pillar. The swivel of the table arm about the pillar and rotation of the table about its centre permits easy location of the job under the drill for drilling. The spindle head of the machine provides means for supporting the drill and giving it rotary and feed motions. Simultaneous rotation and feeding of the drill into the work piece is accomplished by letting the spindle rotate in the quill and moving the quill down. The end of the spindle has a hole with a Morse taper to hold taper shank drills or sleeves. In smaller sizes a drill chuck with tapered shank is permanently fitted in the spindle. The drills are held in this chuck.
2. Radial Drilling machine: The machine has a base and a column that supports a radial arm. The radial drill slide or drill head is carried on the radial arm. The arm can be moved up and down

the column and swiveled about the column. The drill head slide can be moved along the radial arm. The rotating spindle can be moved up and down relative to the arm through the quill assembly. The motion of the head along with the drill spindle permits positioning of holes in a circle with a radius almost as large as the length of the radial arm. Radial drilling machines are convenient for heavy jobs which cannot be moved around easily and for drilling number of holes in a job. Jobs of this type require positioning of the drill over hole locations which can be done more easily than adjusting the job under the drill as required in upright drilling machine.

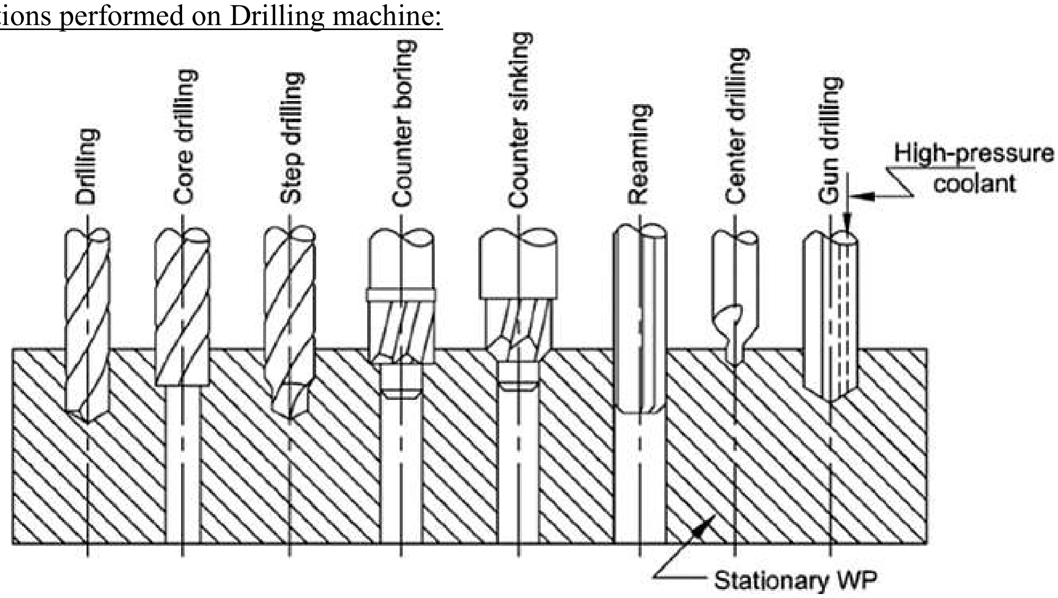
Work holding devices:

1. V-block and Angle plates
2. Clamps and bolts
3. Jigs and Fixtures
4. Vices

Drill Geometry:



Operations performed on Drilling machine:



Drilling Operations

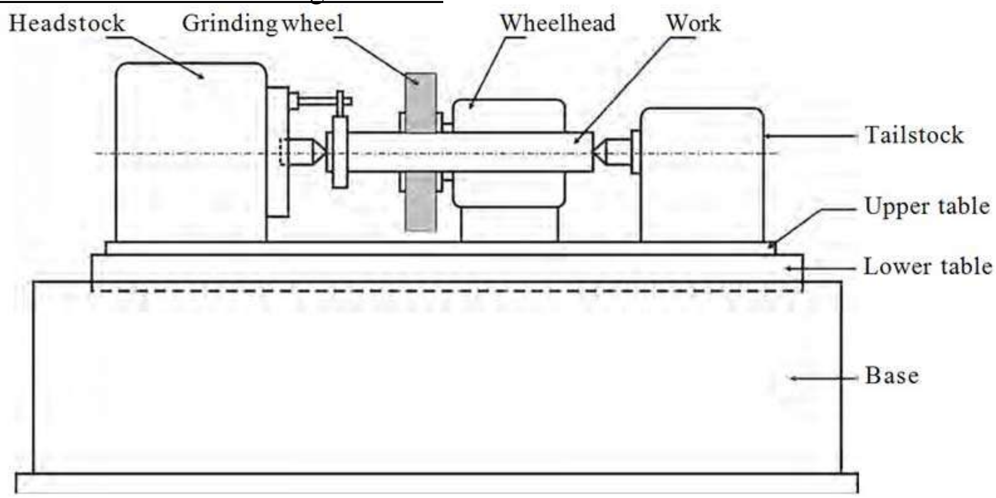
Grinding Machines:

Abrasive machining processes are metal cutting processes that use abrasive as tool material for precision grinding and surface finishing operations. Abrasives are hard substances with adequate toughness capable of machining materials too hard to be cut by most other tool materials. They can also produce better surface finish and closer dimensional tolerances on most materials.

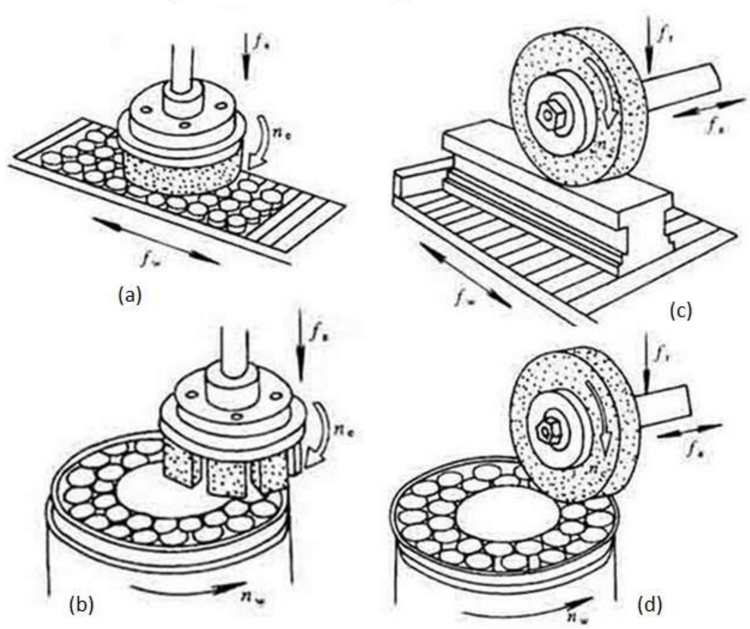
Grinding is the abrasive machining process done with the help of a grinding wheel mounted on a suitable machine. Materials having hardness more than Rockwell C45 cannot be machined by machining processes which use cutting tools. They must be machined by grinding or some other abrasive machining process.

Types of Grinding machines:
1. Bench, Pedestal or Floor grinders
2. Cylindrical grinding machine
3. Surface grinding machine
4. Centreless grinding machine
5. Tool and cutter grinding machine
6. Special grinding machines

Constructional Details of Grinding machine:



Cylindrical Grinding Machine



Surface Grinding Machine

1. Cylindrical Grinding machine: The frame or base of the machine houses the hydraulic drive for the table and provides guideways for table reciprocation. The control levers and buttons are located at handy positions on the front of the frame. Mounted on the lower table is an upper or swivel table which carries the head stock and the tail stock or foot stock of the machine. The

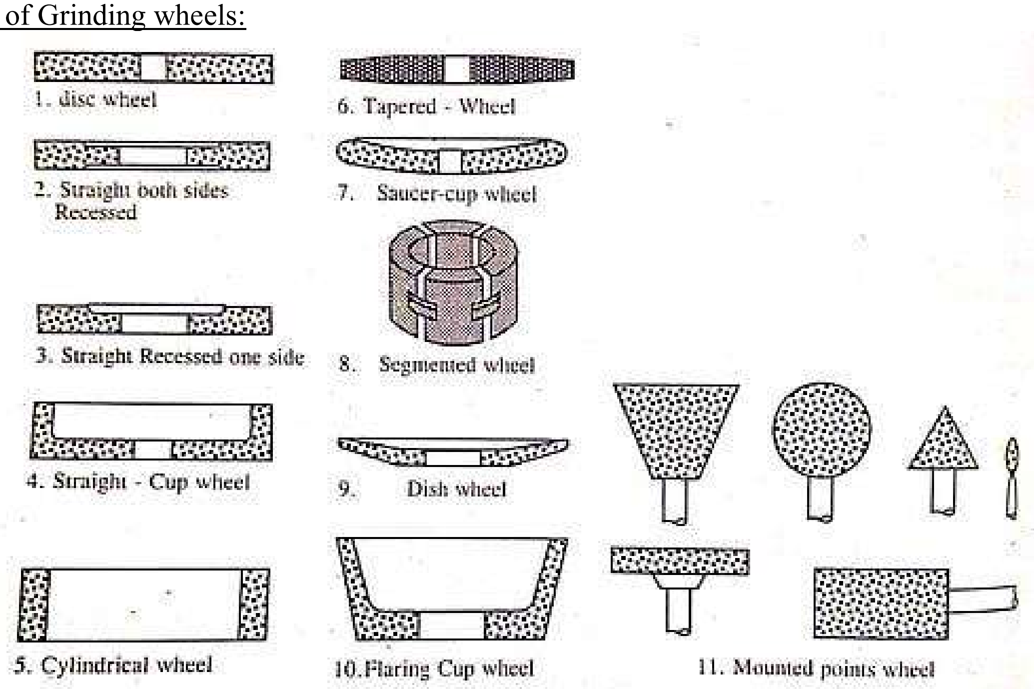
rear portion of the frame provides guideways for a wheel head slide carrying the rotating grinding wheel. The head stock, the wheel head, the hydraulic table drive system and the coolant system have their own motors of suitable capacity. The head stock and tail stock centres are made as dead centres as this provides the most rigid work piece support and accuracy of work axis eliminating errors due to run-out of the centres. The lower table carrying the top table traverses on the frame in front of the wheel head to present the job along its length for grinding. The table reversal is controlled by adjustable trip dogs operating on a table reversing lever which in turn operates a control valve. The wheel head is moved into the work with an accurate screw for infeed. The wheel head drive is designed to give automatic controlled infeeds at the end of table traverse and has a setting to stop after a desired total infeed.

2. <u>Surface Grinding machine:</u> Surface grinding machines are designed primarily for grinding flat surfaces but may also be used for grinding irregular surfaces with uniform right section profiles. Surface grinding machines can be classified as horizontal or vertical spindle machines with rotating or reciprocating tables. Surface grinders with reciprocating tables are suitable for grinding long surfaces or surfaces with profiles at right angle to the motion of the spindle. Surface grinders with rotating tables are suitable for grinding a number of small jobs together. Horizontal spindle grinding machine use straight grinding wheels which cut on the periphery. The area of contact between the wheel and the work piece is small and the speed is uniform over the grinding surface. Vertical Spindle grinding wheels use cylindrical, solid, sectored or segmented grinding wheels which cut on their sides. The area of contact is large and results in high rate of metal removal.

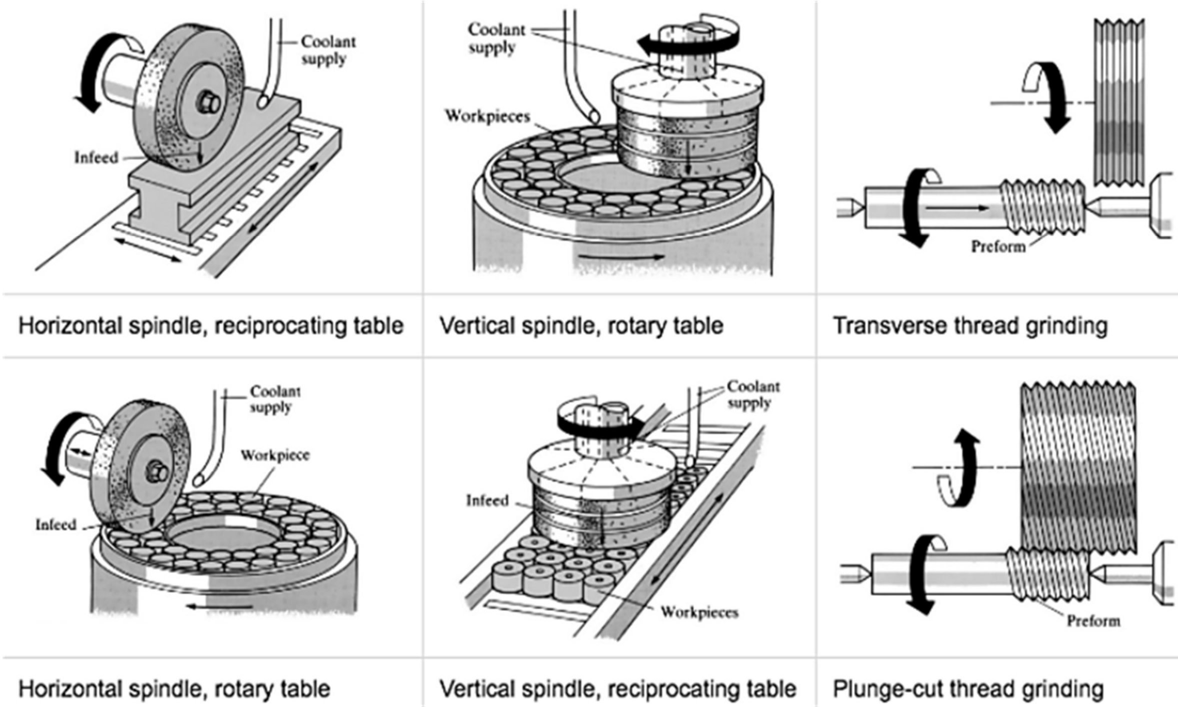
<u>Work holding devices:</u>

1. Chuck and centres
2. Magnetic table
3. V-block and Angle plates
4. Clamps and Bolts
5. Mandrels

<u>Types of Grinding wheels:</u>



Operations performed on Grinding machine:



Report:

Prepare the machine specification sheet of the machine tools (Lathe, Shaper, Slotter, Milling machine, Drilling machine, Grinding machine) available in your workshop.

Quiz:

1. State the purpose of each of the following lathe parts: face plate, compound rest, feed rod, lead screw.
2. How knurling is different than the turning?
3. How is feeding done on a shaper?
4. How does a planer differ from a shaper?
5. List the various methods of making holes in a work piece.
6. What is meant by a self-holding taper?
7. Distinguish between arbor mounted and shank mounted cutters.
8. List the most common abrasives used for grinding.
9. Why are the teeth of some milling cutters made helical?

Suggested Reference:
1. Workshop Technology Vol. I, II & III, WAJ Chapman.
2. Workshop Technology Vol. II, Hajra & Choudhari.
3. Production Technology, R. K. Jain.

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No: 2

To understand the effect of chosen parameters on the type of chip produced

Date:

Competency and Practical Skills:

1. To operate the machine and setting of cutting parameters.
2. To understand the materials and their machining conditions.

Relevant CO: CO1

Objectives: To study the effect of different parameters on the type of chip produced during machining.

Equipment/Instruments: Lathe, Single point cutting tool, Workpiece materials (Mild steel, Brass, Cast iron), Vernier Caliper.

Theory: During metal cutting, material ahead of the cutting tool deforms plastically and forms chips. The type of chip formed depends on:

- Workpiece material
- Cutting speed
- Feed rate
- Depth of cut
- Rake angle
- Cutting environment (dry or lubricated)

Types of Chips

1. **Continuous Chips**
   - Produced while machining ductile materials (e.g., mild steel, aluminum).
   - Occur at high cutting speeds and large rake angles.
   - Provide good surface finish.
2. **Discontinuous Chips**
   - Produced while machining brittle materials (e.g., cast iron).
   - Occur at low cutting speeds and small rake angles.
   - Rough surface finish.
3. **Continuous Chips with Built-Up Edge (BUE)**
   - Occur at medium cutting speeds.
   - Material sticks to tool tip.
   - Affects surface finish and tool life.

Procedure:

1. Mount the workpiece securely in the chuck.
2. Set initial cutting parameters (speed, feed, depth of cut).

3. Perform turning operation.
4. Collect and observe the chip produced.
5. Note the chip type and surface finish.
6. Change one parameter at a time (speed/feed/depth/rake angle).
7. Record observations.
8. Repeat for different materials.

Observation Table:

Sr. No.	Material	Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)	Rake Angle	Chip Type	Surface Finish
1							
2							
3							

Result observed:

Quiz:
1. How does cutting speed affect chip formation?
2. How does rake angle affect chip formation?
3. How can BUE be reduced?

Suggested Reference: 1. A Textbook of Production Engineering, by P C Sharma

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No: 3
To determine chip thickness ratio and shear plane angle under various cutting conditions

Date:

Competency and Practical Skills:

1. Basic understanding of machining conditions.
2. The impact of machining in the change in the chip thickness.
3. The effect of change of cutting parameters on the shear plane angle.

Relevant CO: CO1

Objectives: (a) To determine the chip thickness ratio for the orthogonal machining.
(b) To determine the shear plane angle for the orthogonal machining.

Equipment/Instruments: Lathe, Orthogonal cutting tool, Different materials (like Aluminium, Brass, Mild steel, etc.), vernier caliper, thread, scale, protractor.

Theory: The shear angle is the plane made by the shear plane with the direction of tool travel. The value of this angle depends on the cutting conditions, tool geometry, tool material and work material. If the shear angle is small, the plane of shear is larger, the chip is thicker and therefore, higher force is required to remove the chip.

During orthogonal cutting:

- The uncut chip thickness (**t_1**) is the feed per revolution.
- The chip thickness after cutting (**t_2**) is measured using a vernier caliper.
- The **chip thickness ratio (r)** is:

$$r = \frac{t_1}{t_2}$$

Since the chip becomes thicker after cutting, $r < 1$.

Shear plane angle (ϕ):

The shear plane angle is calculated using

$$\tan\phi = \frac{r\cos\propto}{1 - r\sin\propto}$$

Where:
r = chip thickness ratio
α = rake angle of the tool

Then,

$$\emptyset = \tan^{-1}\left(\frac{r\cos\propto}{1 - r\sin\propto}\right)$$

Procedure:

1. Mount the workpiece securely in the lathe chuck.
2. Set the desired cutting speed.
3. Adjust feed (this becomes uncut chip thickness **t_1**).
4. Perform orthogonal cutting with constant depth of cut.
5. Collect the produced chip.
6. Measure chip thickness (**t_2**) at multiple points and calculate the average.
7. Measure rake angle (**α**) of the tool.
8. Calculate:
    - Chip thickness ratio (r)
    - Shear plane angle (φ)

9. Repeat the experiment for different:
    - Cutting speeds
    - Feeds
    - Depths of cut

Observation Table:

Sr. No.	**Cutting Speed (rpm)**	**Feed (mm/rev) t_1**	**Chip Thickness t_2 (mm)**	**$r = t_1/t_2$**	**Rake Angle α (°)**	**Shear Angle φ (°)**
1						
2						
3						

Sample Calculation: (Calculation of r and ϕ)

Conclusion:

Suggested Reference: 1. Fundamentals of Machining and Machine tools, by Geoffery Boothroyd and Winston.
2. A Textbook of Production Engineering, by P C Sharma.

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

Experiment No: 4
Job making on lathe machine

Date:

Competency and Practical Skills:
1. To operate the machine tool.
2. Selection of cutting parameters and operations based on the part drawing.
3. Different tool and work holding devices associated to the operations.

Relevant CO: CO2

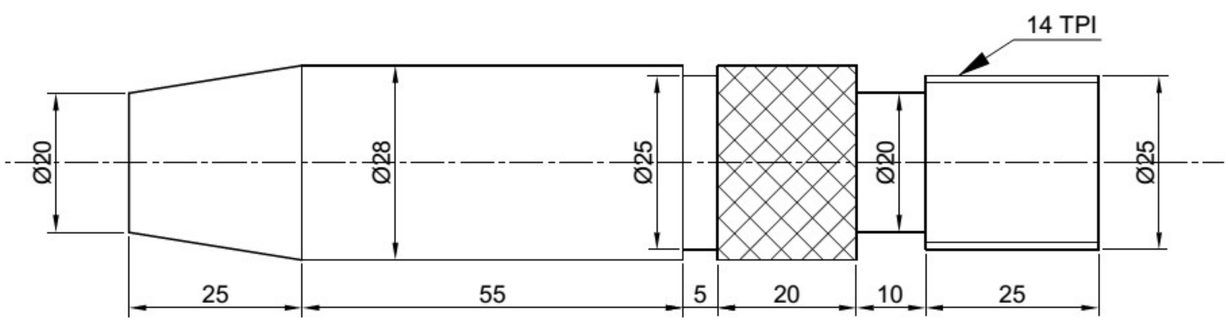
Objectives: (a) To practice and perform machining on the machine tool.
(b) To develop the skill to understand the setting required to make a job.

Equipment/Instruments: Lathe, Single point cutting tool, Threading tool, Knurling tool, Grooving tool, Different work holding devices, MS round bar.

Theory: The exercise on the lathe is representative of machining jobs, lathe being a fundamental machine, which will help to create an awareness of the importance of the skill.

Safety and necessary Precautions:
1. Do not start the machine before checking all the set ups required for the machining.
2. Wear full sleeve cotton shirt, Jeans trouser, shoes and protecting eye glasses.

Part Drawing: (Raw material – MS bar ϕ30 mm X 150mm)



All dimensions are in mm

Procedure:
1. Examine the part drawing and decide the optimum sequence of operations required to be performed.
2. Make an operation sequence in a suitably designed format indicating the machining parameters and tools.
3. Examine the machine in the context of the job and decide the setting required for each operation in the sequence.
4. Set the machine.
5. Produce the job according to the requirement given in the part drawing.

Calculation: (on separate sheet)
1. Calculate the speed required to be set for the machining.
2. Calculate the angle of taper for taper turning operation.
3. Calculate and select the set of change gears for the threading operation.

Conclusion:
Comment on the limitations of taper turning method you have used.

Quiz:

1. What is the importance of the operation sequencing in the machining process?
2. What is the difference between turning and grooving?
3. Why chamfering is performed at the work piece edge?

Suggested Reference:

1. Workshop Technology Vol. I, II & III, WAJ Chapman.
2. Workshop Technology Vol. II, Hajra & Choudhari.
3. Production Technology, R. K. Jain.

References used by the students:

Rubric wise marks obtained:

Rubrics	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

ROUTE SHEET

DATE:

ITEM CODE: ASSEMBLY CODE:

RAW MAT. SIZE:

OP. NO.	M/C Name	Operation Description	Tools	Speed	Feed	DOC	Time in min		Process Picture
							setting	processing	

Experiment No: 5
Job making on milling machine

Date:

Competency and Practical Skills:
1. To operate the machine tool.
2. Selection of cutting parameters and operations based on the part drawing.
3. Different tool and work holding devices associated to the operations.

Relevant CO: CO2

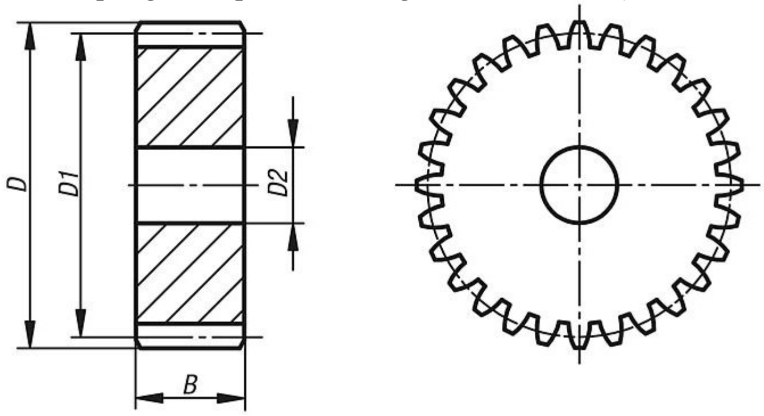
Objectives: (a) To practice and perform machining on the machine tool.
(b) To develop the skill to understand the setting required to make a job.

Equipment/Instruments: Milling machine, gear cutting tool, MS round blank, vice, Indexing attachment.

Theory: The milling machine is as important as Lathe in the field of machining. The milling machine is the most versatile producers for the production of plane surfaces. The milling machine uses different multi point cutting tools to perform the cutting. There are variety of milling cutters are available which can produce different shapes as per requirement.

Safety and necessary Precautions:
1. Do not start the machine before checking all the set ups required for the machining.
2. Wear full sleeve cotton shirt, Jeans trouser, shoes and protecting eye glasses.

Part Drawing: (35 teeth spur gear as per available gear module cutter)



Procedure:
1. Examine the part drawing and decide the appropriate indexing method to be performed for the given gear cutting operation.
2. Examine the machine in the context of the job and decide the setting required for each operation in the sequence.
3. Set the machine, gear blank and the cutter by selecting the appropriate work holding device, milling cutter, speed and feed.
4. Cut at least five teeth on the gear blank.
5. Check the job produced with respect to the data given and make an evaluation of the operation performed.

Calculation:

1. Calculate the gear blank size for the given module and number of teeth.
2. Calculate the desired number of turns of the worm and work necessary for the required indexing to cut the teeth.

Conclusion:
Comment on the different indexing methods and its importance for the machining.

Quiz:
1. Comment on the limitation of the gear cutting method used.
2. Justify the feed and speed selected for the operation.

Suggested Reference:
1. Workshop Technology Vol. I, II & III, WAJ Chapman.
2. Workshop Technology Vol. II, Hajra & Choudhari.
3. Production Technology, R. K. Jain.

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No: 6
Demonstration of Job making on Drilling, Grinding, Shaper and Slotter machine

Date:

Competency and Practical Skills:
1. Basic understanding of machine tools.
2. Identification of elements of machine tools and its functions.
3. Different tool and work holding devices and operations will be identified.

Relevant CO: CO2

Objectives: (a) To practice and perform machining on the machine tool.
(b) To develop the skill to understand the setting required to make a job.

Equipment/Instruments: Drilling machine, Relevant Drill bit, vice, try square, punch, hammer, Shaper, Single point cutting tool, MS flat, Cylindrical Grinding machine, Grinding wheel, Different work holding devices

Theory: The drilling machines are used to produce the holes for different purposes. The drilling of multiple holes enables the proper marking skills and required tooling selection for the product manufacturing.

The exercise on the Shaper is representative of machining jobs for the flat surface generation. Shaper machine is meant to produce the flat surfaces by reducing the cost of machining and to get faster production. The higher depth of cut can be used to make deeper cuts which faster the material removal.

The development in the grinding has led to the changes into the machine tool production and improvement in the degree of accuracy and finish possible. The effects of these changes have been to raise the quality of the engineering produces and through these the products of other industries.

Safety and necessary Precautions:
1. Do not start the machine before checking all the set ups required for the machining.
2. Wear full sleeve cotton shirt, Jeans trouser, shoes and protecting eye glasses.

Procedure:
1. Set the appropriate tool used for the operation on the relevant machine tool.
2. Set the workpiece with proper work holding device on the machine tool.
3. Set the machine tool by selecting the appropriate cutting parameters.
4. Check the job produced with respect to the data given and make an evaluation of the operation performed.

Quiz:
1. What is the difference between pillar type of drilling machine and radial drilling machine?
2. What are the advantages of boring over drilling?
3. With neat sketch explain the working of crank and slotted lever quick return motion mechanism.
4. What is the difference in the single point cutting tool used in turning and shaping?
5. Identify the grinding wheel used on your grinding machine with its marking system.

Suggested Reference:

1. Workshop Technology Vol. I, II & III, WAJ Chapman.
2. Workshop Technology Vol. II, Hajra & Choudhari.
3. Production Technology, R. K. Jain.

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No: 7
To measure the various cutting forces during turning operation on Lathe machine using Lathe tool dynamometer

Date:

Competency and Practical Skills:

1. To use the lathe tool dynamometer.
2. To measure the cutting forces using lathe tool dynamometer.

Relevant CO: CO4

Objectives: To measure the cutting force components during orthogonal turning operation on a lathe machine using a lathe tool dynamometer and to analyze the effect of cutting parameters on these forces.

Equipment/Instruments: Lathe, 2 component lathe tool dynamometer, Orthogonal single point cutting tool, Mild steel hollow workpiece, Digital force indicator, Vernier Caliper.

Theory: Orthogonal Cutting

In orthogonal turning, the cutting edge of the tool is perpendicular (90°) to the direction of feed. The chip flows in a direction normal to the cutting edge.

In orthogonal cutting, only **two force components** are considered:

1. Cutting Force (Fc)

- Acts in the direction of cutting velocity.
- Largest component.
- Responsible for power consumption.

2. Thrust Force (Ft)

- Acts perpendicular to cutting velocity (in feed direction).
- Smaller than cutting force.

(Radial force is negligible in pure orthogonal cutting.)

Working Principle of Lathe Tool Dynamometer

The lathe tool dynamometer works on the principle of strain measurement.

- Cutting forces produce elastic deformation in the dynamometer structure.
- Strain gauges mounted on elastic members sense this deformation.
- Change in electrical resistance is converted into electrical signals.
- Signals are amplified and displayed as force values (in Newtons).

Most dynamometers use a Wheatstone bridge circuit for accurate measurement.

Procedure:

1. Mount the lathe tool dynamometer rigidly on the tool post.
2. Fix the single-point cutting tool ensuring 0° side cutting edge angle.
3. Connect dynamometer to digital display unit.
4. Mount the workpiece in the chuck securely.

5. Set desired cutting parameters:
    - Speed
    - Feed
    - Depth of cut
6. Start the lathe and perform orthogonal turning.
7. Record:
    - Cutting force (Fc)
    - Thrust force (Ft)
8. Collect the chips to measure the chip thickness.
9. Repeat experiment by varying feed and speed.
10. Tabulate observations.

Observation Table:

Sr. No.	Speed (rpm)	Feed (mm/rev)	Cutting Force Fc (N)	Thrust Force Ft (N)	Cutting power P (watt)	Shearing power P_s (watt)	Friction power P_f (watt)
1							
2							
3							

Sample Calculations:

1. Graphical method (By Merchant's circle diagram)
2. Analytical method (By equations)

Conclusions:

Suggested Reference: 1. A Textbook of Production Engineering, by P C Sharma

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No: 8
Machining time calculation for different machining operations

Date:

Relevant CO: CO3

Objectives: To practice and understand the time taken for every operation on the machine.

Machining Time Calculation:

1. A hollow workpiece of 60 mm outside diameter and 150 mm length is held on a Mandrel between centres and turned all over in 4 passes. If the approach length is 20 mm and over travel is 12 mm, feed – 0.8 mm/rev, cutting speed – 0.5 m/s, calculate the machining time.
2. Estimate the time required to machine a cast iron surface 275 mm long and 100 mm wide in one cut using cutting speed of 0.33 m/s and a feed rate of 0.25 mm per stroke on a shaper with a cutting to return time ratio of 3:2. The available ram strokes on the machine are 28, 40, 60 and 90 strokes/min.
3. Calculate the time required to drill a hole 25 mm diameter in a gray cast iron workpiece 75 mm thick using a HSS drill. The cutting speed and the feed rate for the operation may be assumed to be 0.5 m/s and 0.5 mm/rev of the drill respectively.
4. Calculate the time required to mill the 250 X 100 mm surface of a cast iron block 250 X 100 X 75 mm in one cut. A HSS helical slab mill 100 mm diameter and 125 mm long is to be used. The number teeth on the cutter is 16. The allowable cutting speed for the operation is 0.5 m/s, feed is 0.25 mm/tooth and depth of cut is 5 mm.
5. Calculate the time required to grind a 50 mm diameter, 200 mm long portion of a shaft 250 mm long, with a grinding over size of 0.5 mm. A 200 mm X 600 mm plain cylindrical grinder is to be used with a 50 mm wide grinding wheel. A work speed of 0.5 m/s and a traverse feed rate of half wheel width per revolution of the job are recommended for the cut. An infeed rate of 0.025 mm per pass may be used.

Suggested Reference: 1. Workshop Technology Vol. II, B S Raghuvanshi.

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

Experiment No: 9
Alignment test on lathe machine

Date:

Competency and Practical Skills:

1. Understanding of machine errors.
2. Methods to find the inaccuracy developed in the machine tools.

Relevant CO: CO5

Objectives: (a) To perform alignment test of the available Lathe machine.

Equipment/Instruments: Lathe, Dial gauge, Special test mandrels, stand, straight edge.

Theory: The accuracy of the work piece on a machine tool depends on its capacity to produce various movements and relationships. For example the chief requirement of a lathe is that it should turn and bore straight and parallel and face flat. In order that these conditions must be satisfied, the tool must move in a straight line which is parallel to the axis joining head stock and tail stock centers. In order to produce flat face the cross slide used and which requires the tool move perpendicular to the axis of rotation of the work.
Every machine tool is designed with specific relative motions to produce features with desired geometry and interrelations. The alignments are tested by standard established procedures for every type of machine tool. The standard procedures are given in the form of standard alignment test charts. In the absence of such charts the essential alignments of a machine tool can be logically established.

Safety and necessary Precautions:

1. Do not start the machine before checking all the set ups required for the machining.
2. Wear full sleeve cotton shirt, Jeans trouser, shoes and protecting eye glasses.

Procedure:

Perform the alignment tests on the given lathe to check the following

1. Spindle axis parallel to bed (vertical and horizontal planes)
2. Cross slide perpendicular to spindle axis
3. Parallelism of upper side of the spindle (only in vertical plane)
4. Parallelism of quill movement with bed (vertical and horizontal plane)
5. Line of centers parallel to bed.

Conclusion:

Comment on the accuracy of the lathe on which the tests are performed and suggest corrective measures.

Quiz:

1. Write a report showing the stepwise procedure followed in carrying out the tests.
2. Mention the precautions to be taken in performing the tests.

Suggested Reference:

1. Workshop Technology Vol. I, II & III, WAJ Chapman.
2. Workshop Technology Vol. II, Hajra & Choudhari.
3. Production Technology, R. K. Jain.

References used by the students:

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						