LAB MANUAL

Aircraft Production Technology

DEPARTMENT OF AERONAUTICAL ENGINEERING
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Introduction To Aircraft Production Technology Lab

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INTRODUCTION OF GENERAL PURPOSE OF MACHINES
INTRODUCTION OF GENERAL PURPOSE OF MACHINES

Various machining purpose used these all type of mechanical machining machines are Lathe machine, Shaper machine, Slotting machine, Planning machine, Drilling machine, Boring machine, Milling machine, Grinding machine, Lapping machine Honing machine and Broaching machine.

These machines are to producing various operations like namely Facing, Chamfering, Step turning, Taper turning, Plain turning, Knurling, Grooving, Thread cutting, Drilling, Tapping, Precision grinding, Cylindrical grinding, Surface grinding, grinding of tool angles e.t.c.

LATHE MACHINE:
A lathe is a machine tool which rotates the work piece on its axis to perform various operations such as cutting, sanding, knurling, drilling, or deformation with tools that are applied to the work piece to create an object which has symmetry about an axis of rotation.

Lathes are used in woodturning, metalworking, metal spinning, and glass working. Lathes can be used to shape pottery, the best-known design being the potter's wheel. Most suitably equipped metalworking lathes can also be used to produce most solids of revolution, plane surfaces and screw threads or helices. Ornamental lathes can produce three-dimensional solids of incredible complexity. The material can be held in place by either one or two centers, at least one of which can be moved horizontally to accommodate varying material lengths. Other work holding methods include clamping the work about the axis of rotation using a chuck to a faceplate, using clamps or dogs.

**LATHE MACHINE PARTS**

- **Bed:** Supports all other machine parts.
- **Carriage:** Slides along the machine ways.
- **Head stock:** Power train of system (spindle included).
- **Tail Stock:** Fixes piece at end opposite to the head stock.
- **Swing:** Maximum diameter of the machinable piece.
- **Lead screw:** Controls the feed per revolution with a great deal of precision.
LATHE TOOLS: Left handed, Right handed, Threading, Boring, Groove, Parting (Cut-Off)

CUTTING SPEEDS:

Typical Lathe Cutting Speeds:

- **Nominal cuts**
  - 30 - 800 ft./min.

- **Roughing cuts**
  - Depth of cut greater then .02 in
  - Feed speed of .008 - .08 in/rev.

- **Finishing Cuts**
  - Lower than roughing cuts

TURNING OPERATIONS:

- Turning (Performed on lathe)
  - Part is moving and tool is stationary.

- Used to make parts of round cross section
  - Screws, shafts, pistons

- Number of various lathe operations
  - Turning, facing, boring, drilling, parting, threading
LATHE OPERATIONS:

(a) Straight turning

(b) Taper turning

(c) Profiling

(d) Turning and external grooving

(e) Facing

(f) Face grooving

(g) Form tool

(h) Boring and internal grooving

(i) Drilling

(j) Cutting off

(k) Threading

(l) Knurling
A shaper is a type of machine tool that uses linear relative motion between the work piece and a single-point cutting tool to machine a linear tool path. Its cut is analogous to that of a lathe, except that it is linear instead of helical. (Adding axes of motion can yield helical tool paths, as also done in helical planning.) A shaper is analogous to a planer, but smaller, and with the cutter riding a ram that moves above a stationary work piece, rather than the entire work piece moving beneath the cutter. The ram is moved back and forth typically by a crank inside the column; hydraulically actuated shapers also exist. A shaper is a type of machine tool that uses linear relative motion between the work piece and a single-point cutting tool to machine a linear tool path. Its cut is analogous to that of a lathe, except that it is linear instead of helical. (Adding axes of motion can yield helical tool paths, as also done in helical planning.) A shaper is analogous to a planer, but smaller, and with the cutter riding a ram that moves above a stationary work piece, rather than the entire work piece moving beneath the cutter. The ram is moved back and forth typically by a crank inside the column; hydraulically actuated shapers also exist.
PLANNING MACHINE:

A planer is a type of metalworking machine tool that uses linear relative motion between the work piece and a single-point cutting tool to machine a linear tool path. Its cut is analogous to that of a lathe, except that it is linear instead of helical. (Adding axes of motion can yield helical tool paths; see "Helical planing" below.) A planer is analogous to a shaper, but larger, and with the entire workpiece moving on a table beneath the cutter, instead of the cutter riding a ram that moves above a stationary work piece. The table is moved back and forth on the bed beneath the cutting head either by mechanical means, such as a rack and pinion drive or a lead screw, or by a hydraulic cylinder.
DRILLING MACHINE:

A drill or drill motor is a tool fitted with a cutting tool attachment or driving tool attachment, usually a drill bit or driver bit, used for drilling holes in various materials or fastening various materials together with the use of fasteners. The attachment is gripped by a chuck at one end of the drill and rotated while pressed against the target material. The tip, and sometimes edges, of the cutting tool does the work of cutting into the target material. This may be slicing off thin shavings
(twist drills or auger bits), grinding off small particles (oil drilling), crushing and removing pieces of the work piece (SDS masonry drill), countersinking, counter boring, or other operations.

Drills are commonly used in woodworking, metalworking, construction and do-it-yourself projects. Specially designed drills are also used in medicine, space missions and other applications.

3. DRILLING MACHINE

Drilling machine is a machine tool designed for drilling holes in metallic and non metallic materials. The cutting tool is a multi-point cutting tool, known as drill.

PRINCIPAL PARTS OF THE DRILLING MACHINE

1. Head: Head contains the electric motor, v pulleys and v belt which transmit rotary motion to the drill spindle at a no. of speeds.

2. Spindle: Spindle is made up of alloy steel. It rotates as well as moves up and down in a sleeve.

3. Drill chuck: It is held at the end of the drill spindle and in turn it holds the drill bit.

4. Adjustable table: It is supported on the column of the drilling machine and can be moved vertically and horizontally. It also carries slots for bolts clamping.

5. Base: It supports the column, which, in turn, supports the table, head etc.

6. Column: It is a vertical round or box section, which rests on the base and supports the head and the table.
WORKING PRINCIPLE AND OPERATION OF DRILLING MACHINE

Drilling machine is used to produce holes in the work piece. The end cutting tool used for drilling holes in the work piece is called the drill. The drill is placed in the chuck and when the machine is ‘ON’ the drill rotates. The linear motion is given to the drill towards the work piece, which is called feed. In order to remove the chips from the hole, drill is taken out from the hole so the combination of rotary and linear motion produces the hole in the work piece.

DRILLING OPERATIONS

The following are the most common operations performed on the drilling machine:

1. Drilling: it is an operation of producing a circular hole in a work piece by forcing a drill in the work piece.
2. Boring: it is an operation of enlarging a hole that has already been drilled. Single point cutting tool is used in boring.
3. Reaming: Reaming is done with reamers. It is done to generate the hole of proper size and finish after drilling
4. Tapping: It is an operating of producing internal threads in a hole by means of a tap.
5. Counter Boring: It is an operation of enlarging the entry of a drilled hole to accommodate the bolt head etc. Counter boring tool does it.
6. Spot Facing: It is an operation done on the drilled hole to provide smooth seat for bolt head.
7. Counter Sinking: It is an operation to bevel the top of a drilled hole for making a conical seat. A counter sunk drill is used in this operation.
DRILLING (CUTTING) SPEED AND FEED

Cutting Speed: Cutting speed in drilling is the peripheral speed of the drill relative to the work.

\[
\text{Cutting speed} = \frac{D \times N}{1000} \text{ m/min}
\]

Where 
\[D = \text{Diameter of drill in mm}\]
\[N = \text{Work speed in r.p.m}\]

Feed: Feed of a drill is the distance it moves into the work with each revolution of the spindle. It is generally measured in mm/revolution of the spindle.

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

Spindle: The spindle is mounted on the upper part of the column. It receives power from the motor through belts, gears, clutches etc. and can be rotated at different speeds by the step cone pulley drive or by gearing arrangement and transmits it to arbor or sub-arbor.

Arbor: The arbor is the extension of the spindle on which all the various cutters are mounted. It is tapered at one end to fit the spindle nose and has two slots to fit the nose keys for locating and driving it.
4. BORING MACHINE:

In machining, boring is the process of enlarging a hole that has already been drilled (or cast), by means of a single-point cutting tool (or of a boring head containing several such tools), for example as in boring a cannon barrel. Boring is used to achieve greater accuracy of the diameter of a hole, and can be used to cut a tapered hole.

There are various types of boring. The boring bar may be supported on both ends (which only works if the existing hole is a through hole), or it may be supported at one end. Line boring (line boring, line-boring) implies the former. Backboring (back boring, back-boring) is the process of reaching through an
existing hole and then boring on the "back" side of the work piece (relative to the machine headstock).

**MILLING MACHINE:**

A milling machine (also see synonyms below) is a machine tool used to machine solid materials. Milling machines are often classed in two basic forms, horizontal and vertical, which refers to the orientation of the main spindle. Both types range in size from small, bench-mounted devices to room-sized machines. Unlike a drill press, this holds the work piece stationary as the drill moves axially to penetrate the material, milling machines also move the work piece radially against the rotating milling cutter, which cuts on its sides as well as its tip. Work piece and cutter movement are precisely controlled to less than 0.001 in (0.025 mm), usually by means of precision ground slides and lead screws or analogous technology. Milling machines may be manually operated, mechanically automated, or digitally automated via computer numerical control (CNC).
Milling machines can perform a vast number of operations, from simple (e.g., slot and keyway cutting, planing, drilling) to complex (e.g., contouring, die sinking). Cutting fluid is often pumped to the cutting site to cool and lubricate the cut and to wash away the resulting swarf.

5. GRINDING MACHINE:

A grinding machine, often shortened to grinder, is a machine tool used for grinding, which is a type of machining using an abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the work piece via shear deformation.

The grinding machine consists of a power driven grinding wheel spinning at the required speed (which is determined by the wheel’s diameter and manufacturer’s rating, usually by a formula) and a bed with a fixture to guide and hold the work-piece. The grinding head can be controlled to travel across a fixed work piece or the work piece can be moved whilst the grind head stays in a fixed
position. Very fine control of the grinding head or tables position is possible using a Vernier calibrated hand wheel, or using the features of numerical controls.

6. LAPPING MACHINE

Lapping is a machining operation, in which two surfaces are rubbed together with an abrasive between them, by hand movement or by way of a machine.

This can take two forms. The first type of lapping (traditionally called grinding), typically involves rubbing a brittle material such as glass against a surface such as iron or glass itself (also known as the "lap" or grinding tool) with an abrasive such as aluminum oxide, jeweller's rouge, optician's rouge, emery, silicon carbide, diamond, etc., in between them. This produces microscopic concordat fractures as the abrasive rolls about between the two surfaces and removes material from both.

The other form of lapping involves a softer material such as pitch or a ceramic for the lap, which is "charged" with the abrasive. The lap is then used to cut a harder material—the work piece. The abrasive embeds within the softer material which holds it and permits it to score across and cut the harder material. Taken to the finer limit, this will produce a polished surface such as with a
polishing cloth on an automobile, or a polishing cloth or polishing pitch upon glass or steel.

7. HONING MACHINE

![Honing Machine Diagram]

Typical applications are the finishing of cylinders for internal combustion engines, air bearing spindles and gears. Types of hone are many and various but all consist of one or more abrasive stones that are held under pressure against the surface they are working on.

In everyday use, a honing steel is used to hone knives, especially kitchen knives, and is a fine process, there contrasted with more abrasive sharpening. Other similar processes are lapping and super finishing.
8. BROACHING MACHINE:

Different Types Of Broaching Tools
Broaching is a machining process that uses a toothed tool, called a broach, to remove material. There are two main types of broaching: linear and rotary. In linear broaching, which is the more common process, the broach is run linearly against a surface of the work piece to effect the cut. Linear broaches are used in a broaching machine, which is also sometimes shortened to broach. In rotary broaching, the broach is rotated and pressed into the work piece to cut an axis symmetric shape. A rotary broach is used in a lathe or screw machine. In both processes the cut is performed in one pass of the broach, which makes it very efficient.

Broaching is used when precision machining is required, especially for odd shapes. Commonly machined surfaces include circular and non-circular holes, spines, keyways, and flat surfaces. Typical work pieces include small to medium sized castings, forgings, screw machine parts, and stampings. Even though broaches can be expensive, broaching is usually favored over other processes when used for high-quantity production runs.

9. Welding:-

INTRODUCTION TO WELDING PROCESSES

Solid materials need to be joined together in order that they may be fabricated into useful shapes for various applications such as industrial, commercial, domestic, art ware and other uses. Depending on the material and the application, different joining processes are adopted such as, mechanical (bolts, rivets etc.), chemical (adhesive) or thermal (welding, brazing or soldering). Thermal processes are extensively used for joining of most common engineering materials, namely, metals. This exercise is designed to demonstrate specifically: gas welding, arc welding, resistance welding, brazing.
WELDING PROCESSES

Welding is a process in which two materials, usually metals, and is permanently joined together by coalescence, resulting from temperature, pressure, and metallurgical conditions. The particular combination of temperature and pressure can range from high temperature with no pressure to high pressure with any increase in temperature. Thus, welding can be achieved under a wide variety of conditions and numerous welding processes have been developed and are routinely used in manufacturing.

To obtain coalescence between two metals following requirements need to be met:-
(1) Perfectly smooth, flat or matching surfaces.
(2) Clean surfaces, free from oxides, absorbed gases, grease and other contaminants.
(3) Metals with no internal impurities.

These are difficult conditions to obtain. Surface roughness is overcome by pressure or by melting two surfaces so that fusion occurs. Contaminants are removed by mechanical or chemical cleaning prior to welding or by causing sufficient metal flow along the interface so that they are removed away from the weld zone friction welding is a solid state welding technique. In many processes the contaminants are removed by fluxing agents.

The production of quality welds requires
(1) A satisfactory heat and/or pressure source,
(2) A means of protecting or cleaning the metal, and
(3) Caution to avoid, or compensate for, harmful metallurgical effects.

ARC WELDING

In this process a joint is established by fusing the material near the region of joint by means of an electric arc struck between the material to be joined and an electrode. A high current low voltage electric power supply generates an arc of intense heat reaching a temperature of approximately 3800°C. The electrode held externally may act as a filler rod or it is fed independently of the electrode. Due to higher levels of heat input, joints in thicker materials can be obtained by the arc welding process. It is extensively used in a variety of structural applications.
There are so many types of the basic arc welding process such as shielded metal arc welding (SMAW), gas metal arc welding (GMAW), gas tungsten arc welding (GTAW), submerged arc welding.

![Fig 4.1: The Basic circuit for arc welding](image1)

**RESISTANCE SPOT WELDING**

The tips of two opposing solid cylindrical electrodes touch a lap joint of two sheet metals, and resistance heating produces a spot weld. In order to obtain a strong bond in the weld nugget, pressure is applied until the current is turned off. Accurate control and timing of the electric current and of the pressure are essential in resistance welding.

The strength of the bond depends on surface roughness and on the cleanness of the mating surface. Oil, paint, and thick oxide layers should, therefore, be removed.
before welding. The presence of uniform, thin layers of oxide and of other contaminants is not critical.

The weld nugget is generally 6 to 10 mm in diameter. The surface of the weld spot has a slightly discolored indentation. Currents range from 3000 A to 40000 A: the level depends on the materials being welded and on their thicknesses.

**PROCESS CAPABILITIES:**

Spot welding is the simplest and the most commonly used resistance-welding process. Welding may be performed by means of single or multiple pairs of electrodes, and the required pressure is supplied through mechanical or pneumatic means. Rocker-arm type spot-welding machines are normally used for smaller parts; press type machines are used for larger work pieces. The shape and surface condition of the electrode tip and the accessibility of the site are important factors in spot welding.

Spot welding is widely used for fabricating sheet metal parts. Examples range from the attaching of handles to stainless-steel cookware to the spot welding of mufflers.

10. **CNC programming**

Safety Notes

- Hands should be kept clear of the area while the mill is running or enabled.
- The toggle switch on the right side of the mill “enables” the spindle motor. This toggle switch can also be used as an emergency stop. The spindle will stop if the toggle switch is in the down position.
G Codes

Default G codes used on most machines types. User customizable G codes will change based on application and user definition. You can add, modify, edit, delete and customize your own G and M codes.

Special characters that can be used from within your program are:
( ) Enter user notes between the two parentheses.
{ } Enter math functions between the two braces.

G00 Rapid move G0 X# Y# Z# up to eight axes or G0 Z# X#
G01 Feed Rate move G1 X# Y# Z# up to eight axes or G1 Z# X#
G02 Clockwise move
G03 Counter Clockwise move
G04 Dwell time G04 L#
G08 Spline Smoothing On
G09 Exact stop check, Spline Smoothing Off
G10 A linear feedrate controlled move with a decelerated stop
G11 Controlled Decel stop
G17 XY PLANE
G18 XZ PLANE
G19 YZ PLANE
G28 Return to clearance plane
G33 Threading (Lathe)
G35 Bypass error checking on next line
G40 Tool compensation off
G41 Tool compensation to the left
G42 Tool compensation to the right
G43 Tool length compensation - negative direction
G44 Tool length compensation - positive direction
G49 Tool length compensation cancelled
G53 Cancel work coordinate offsets
G54-G59 Work coordinate offsets 1 through 6
G61 Spline contouring with buffering mode off
G64 Spline contouring with buffering mode on
G65 Mill out rectangular pocket
G66 Mill out circular pocket
G67 Flycut
G68 Mill out rectangular pocket with radius corners
G70 Inch mode
G71 Millimeter mode
G74 Peck drilling (Lathe) G83 Z# X# R#
G81 Drill cycle G81 X# Y# Z# R#
G82 Dwell cycle G82 X# Y# Z# R#
G83 Peck cycle G83 X# Y# Z# R#
G84 Tapping cycle G84 X# Y# Z# R# C#
G85 Boring cycle 1 G85 X# Y# Z# R#
G86 Boring cycle 2 G86 X# Y# Z# R#
G88 Boring cycle 3 G88 X# Y# Z# R#
G89 Boring cycle 4 G89 X# Y# Z# R#
G90 Absolute mode
G91 Incremental mode
G92 Home coordinate reset G92 X# Y# Z#
G94 IPM mode (Lathe) default
G95 IPR mode (Lathe)
G96 Constant Surface Feed On (Lathe)
G97 Constant Surface Feed Off (Lathe)
G110 Lathe Groove Face
G111 Lathe Groove OD
G112 Lathe Groove ID
G113 Lathe Thread OD
G114 Lathe Thread ID
G115 Lathe Face Rough
G116 Lathe Turn Rough
G120 Mill Outside Square
G121 Mill Outside Circle or Island
G122 Mill Out Counter Bore
G123 Mill Outside Ellipse pocket
G124 Mill Inside Ellipse pocket
G125 Mill Outside Slot
G126 Mill Inside Slot pocket
G130 3D tool compensation with gouge protection
G131 3D offset parallel to 3D profile
G132 3D tool compensation with gouge protection in the Z axis only
G135 5 axis tool compensation with gouge protection
G136 Included angle limit for gouge protection. G136 L#
G140 3D part rotation and plane tilting G140 U# V# W# R#
G141 Scale factor for the X axis only. G141 L#
G142 Scale factor for the Y axis only. G142 L#
G143 Scale factor for the Z axis only. G143 L#
G160 Mill 3D Cylinder
G162 Mill 3D Sphere
G163 Mill 3D Ramped Plane
G170 Set soft limits and crash fixture/chuck barriers to defaults
G171 Set backward crash fixture/chuck barriers G171 U# V# W#
G172 Set forward crash fixture/chuck barriers G172 U# V# W#
G181 Bolt Hole Drill  
G182 Bolt Hole Dwell  
G183 Bolt Hole Peck  
G184 Bolt Hole Tap  
G185 Bolt Hole Bore  

**M Codes**

Default M codes used on most machines types. User customizable M codes will change based on application and user definition.

M01 Program Stop  
M02 End of Program  
M03 Spindle On Clockwise, Laser, Flame, Power ON  
M04 Spindle On Counter Clockwise  
M05 Spindle Stop, Laser, Flame, Power OFF  
M06 Tool Change  
M08 Coolant On  
M09 Coolant Off  
M10 Reserved for tool height offset  
M13 Spindle On, Coolant On  
M30 End of Program when macros are used  
M91 Readout Display Incremental  
M92 Readout Display Absolute  
M97 Go to or jump to line number  
M98 Jump to macro or subroutine  
M99 Return from macro or subroutine  
M100 Machine Zero Reset  
M199 Mid program start
LATHE - PLAIN TURNING, STEP TURNING, TAPER TURNING, KNURLING AND CHAMFERING

1. AIM:

To perform various lathe operations such as plain turning, step turning, taper turning, knurling and chamfering on a given material made of Mild steel.

2. MATERIAL REQUIRED:

A mild steel bar of 22 mm diameter and 95 mm length.

3. TOOLS AND EQUIPMENT USED:

H.S.S. single point cutting tool,
Parting tool,
Knurling tool,
Chuckey,
Tool post key,
Outside caliper,
Steel rule.

4. OPERATION CHART:

<table>
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<th>SEQUENCE OF OPERATIONS</th>
<th>CUTTING TOOL USED</th>
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<tr>
<td>1.</td>
<td>Facing</td>
<td>H.S.S Single Point tool</td>
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<td>2.</td>
<td>Rough turning</td>
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<td>3</td>
<td>Finish turning</td>
<td>H.S.S Single Point tool</td>
</tr>
<tr>
<td>4</td>
<td>Step turning</td>
<td>Parting tool</td>
</tr>
<tr>
<td>5</td>
<td>Taper turning</td>
<td>H.S.S Single Point tool</td>
</tr>
<tr>
<td>6</td>
<td>Knurling</td>
<td>Knurling tool</td>
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<tr>
<td>7</td>
<td>Chamfering</td>
<td>H.S.S Single Point tool</td>
</tr>
<tr>
<td>7</td>
<td>Drilling</td>
<td>H.S.S Drill bit</td>
</tr>
</tbody>
</table>
5. TYPES OF OPERATION:

Facing Operation
Facing is the operation of machining the ends of a piece of work to produce a flat surface square with the axis. The operation involves feeding the tool perpendicular to the axis of rotation of the work piece.

A regular turning tool may be used for facing a large work piece. The cutting edge should be set at the same height as the center of the work piece. The tool is brought into work piece from around the center for the desired depth of cut and then is fed outward, generally by hand perpendicular to the axis of rotation of the work piece.

Rough Turning Operation
Rough turning is the operation of removal of excess material from the work piece in a minimum time by applying high rate of feed and heavy depth of cut. The depth of cut for roughing operations in machining the work ranges from 2 to 5 mm and the rate of feed is from 0.3 to 1.5 mm per revolution of the work.

Finish Turning Operation
It requires high cutting speed, small feed, and a very small depth of cut to generate a smooth surface. The depth of cut ranges from 0.5 to 1 mm and feed from 0.1 to 0.3 mm per revolution of the work piece.

Step Turning
Is the operation of making different diameters of desired length. The diameters and lengths are measured by means of outside caliper and steel rule respectively.
Taper Turning
A taper may be defined as a uniform increase or decrease in diameter of a piece of work measured along its length. In a lathe, taper turning means to produce a conical surface by gradual reduction in diameter from a cylindrical work piece.

A taper may be turned by any one of the following methods:

a) Form tool method
b) Tail stock set over method
c) Swiveling the compound rest and
d) Taper turning attachment

Taper turning by swiveling the compound rest:

This method employs the principle of turning taper by rotating the work piece on the lathe axis and feeding the tool at an angle to the axis of rotation of the work piece. The tool mounted on the compound rest is attached to a circular base, graduated in degrees, which may be swiveled and clamped at any desired angle. Once the compound rest is set at the desired half taper angle, rotation of the compound slide screw will cause the tool to be fed at that angle and generate a corresponding taper.

The setting of the compound rest is done by swiveling the rest at the half taper angle. This is calculated by the equation.

\[ \tan \alpha = \frac{(D-d)}{2L} \]

Where \( \alpha \) = Half taper angle

Knurling

Knurling is the process of embossing a diamond shaped pattern of the surface of a work piece. The purpose of knurling is to provide an effective gripping surface on a work piece to prevent it from slipping when operated by hand. Knurling is
performed by a special knurling tool which consists of a set of hardened steel rollers in a holder with the teeth cut on their surface in a definite pattern. The tool is held rigidly on the tool post and the rollers are pressed against the revolving surface of work piece to squeeze the metal against the multiple cutting edges, producing depressions in a regular pattern on the surface of the work piece. Knurling is done at the slowest speed and oil is flowed on the tool and work piece. Knurling is done at the slowest speed and oil is flowed on the tool and work piece to dissipate heat generated during knurling. The feed varies from 1 to 2 mm per revolution.

**Chamfering**

Chamfering is the operation of beveling the extreme end of a work piece. This is done to remove the burrs, to protect the end of the work piece from being damaged and to have a better look. The operation may be performed after the completion of all operations. It is an essential operation after thread cutting so that the nut may pass freely on the threaded work piece.

6. **METAL CUTTING PARAMETERS**

The cutting speed of a tool is the speed at which the metal is removed by the tool from the work piece. In a lathe, it is the peripheral speed of the work past the cutting tool expressed in meters/minute

\[
(i) \text{ Cutting speed (V)} = \pi \frac{DN}{1000}, \text{ m/min}
\]

Where, \( D \) = Diameter of the work in min
\( N \) = RPM of the work

(ii) **Feed:**
The feed of a cutting tool in a Lathe work is the distance the tool advances for each revolution of the work. Feed is expressed in mm/rev.
(iii) **Depth of cut:**

The depth is the perpendicular distance measured from the machined surface to the uncut surface of the work piece.

\[
\text{Depth of cut} = \frac{(d_1 - d_2)}{2}
\]

Where, 
- \( d_1 \) = Diameter of the work surface before machining
- \( d_2 \) = Diameter of the work surface after machining

While using HSS tool for turning mild steel work piece. The following parameters are to be chosen.

(iv) **Rough Turning Operation:**

- Cutting speed \( (V) \) = 25m/min,
- Feed \( (f) \) = 0.2 mm/rev,
- Depth of cut \( (t) \) = 1 mm

(v) **Finish turning operation:**

- Cutting speed \( (V) \) = 40m/min,
- Feed \( (f) \) = 0.1 mm/rev,
- Depth of cut \( (t) \) = 0.2 mm

(vi) **Tool geometry:**

- Back rake angle = 7°
- End relief angle = 6°
- Side relief angle = 6°
- End cutting edge angle = 15°
- Side cutting edge angle = 15°
- Nose radius = 2 mm
PROCEDURE:

1. The work piece and HSS single point cutting tool are securely held in the chuck and tool post respectively.

2. Operations such as facing, rough turning and finish turning are performed on a given mild steel bar one after the other in sequence up to the dimensions shown. Then the step turning is performed using parting tool.

3. Then the compound rest is swiveled by calculated half taper angle and taper is generated on the work piece. Rotation of the compound slide screw will cause the tool to be fed at the half-taper angle.

4. HSS single point cutting tool is replaced by the knurling tool and knurling operation is performed at the slowest speed of the spindle.

5. The knurling tool is replaced by the HSS single point tool again; the work piece is removed from the chuck and refixed with the unfinished part outside the chuck. This part is also rough turned, finish turned and facing is done for correct length.

6. Finally, the chamfering is done at the end of the work piece.

PRECAUTIONS:

1. Operate the machine at optimal speeds
2. Do not take depth of cut more than 2 mm.
3. Knurling should be done at slow speeds and apply lubricating oil while knurling
4. Care should be taken to obtain the required accuracy.
LATHE - THREAD CUTTING

1. AIM:

V-thread cutting on a lathe forming right hand and left hand metric threads as shown in fig.

2. MATERIAL REQUIRED

Mild steel bar of 24 mm diameter and 100 mm length

3. TOOLS AND EQUIPMENT

H.S.S. single point cutting tool,
Grooving tool,
Threading tool thread gauge,
Outside caliper,
Chuck key,
Tool post key,
Steel rule.

4. OPERATION CHART

<table>
<thead>
<tr>
<th>S no.</th>
<th>Sequence of Operations</th>
<th>Cutting tool used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Facing</td>
<td>H.S.S Single Point cutting tool</td>
</tr>
<tr>
<td>2</td>
<td>Rough turning</td>
<td>H.S.S Single Point cutting tool</td>
</tr>
<tr>
<td>3</td>
<td>Finish turning</td>
<td>H.S.S Single Point cutting tool</td>
</tr>
<tr>
<td>4</td>
<td>Step turning</td>
<td>H.S.S Single Point cutting tool</td>
</tr>
<tr>
<td>5</td>
<td>Grooving</td>
<td>Grooving tool</td>
</tr>
<tr>
<td>6</td>
<td>Thread cutting</td>
<td>Threading tool</td>
</tr>
<tr>
<td>7</td>
<td>Chamfering</td>
<td>H.S.S Single Point cutting tool</td>
</tr>
</tbody>
</table>
5. PRINCIPLE OF THREAD CUTTING

The principle of thread cutting is to produce a helical groove on a cylindrical or conical surface by feeding the tool longitudinally when the job is revolved between centers or by a chuck. The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the work piece. The lead screw of the lathe, through which the saddle receives its traversing motion, has a definite pitch. A definite ratio between the longitudinal feed and rotation of the head stock spindle should therefore be found out so that the relative speeds of rotation of the work and the lead screw will result in the cutting of a screw of the desired pitch.

This is affected by change gears arranged between the spindle and the lead screw or by the change gear mechanism or feed box used in a modern lathe.

Calculation of change-wheels, metric thread on English lead screw:

To calculate the wheels required for cutting a screw of certain pitch, it is necessary to know how the ratio is obtained and exactly where the driving and driven wheels are to be placed. Suppose the pitch of a lead screw is 12 mm and it is required to cut a screw of 3 mm pitch, then the lathe spindle must rotate 4 times the speed of the lead screw that is

\[
\frac{\text{Spindle turn}}{\text{Lead screw turn}} = \frac{\text{Driven teeth}}{\text{Driver teeth}}
\]

Hence we may say,

\[
\frac{\text{Driven teeth}}{\text{Driver teeth}} = \frac{\text{Lead screw turn pitch of the screw to be cut}}{\text{Spindle turn pitch of the lead screw}}
\]
In BRITISH SYSTEM

\[
\frac{\text{Driven teeth}}{\text{Driver teeth}} = \frac{\text{Threads per inch on lead screw}}{\text{Threads per inch on work}}
\]

Often engine lathes are equipped with a set of gears ranging from 20 to 120 teeth in steps of 5 teeth and one translating gear of 127 teeth. The cutting of metric threads on a lathe with an English pitch lead screw may be carried out by a translating gear of 127 teeth.

\[
\frac{\text{Driven teeth}}{\text{Driver teeth}} = \frac{5 \, \text{p n}}{127}
\]

Where,

\( p \) = pitch of the thread to be cut and
\( N \) = threads per inch on lead screw

This is derived as follows:

\[
\frac{\text{Driven teeth}}{\text{Driver teeth}} = \frac{\text{pitch of the work}}{\text{pitch of the lead screw}} = \frac{p}{(1/n) \times (127/5)} = \frac{5 \, \text{pn}}{127}
\]

Since, pitch = \( \frac{1}{\text{No. of threads per inch}} \)

**THREAD CUTTING OPERATION:**

In a thread cutting operation, the first step is to remove the excess material from the work piece to make its diameter equal to the major diameter of the screw thread. Change gears of correct size are then fitted to the end of the bed between the spindle and the lead screw.

The shape or form of the thread depends on the shape of the cutting tool to be used. In a metric thread, the included angle of the cutting edge should be ground exactly 60°. The top of the tool nose should be set at the same height as the
center of the work piece. A thread tool gauge is usually used against the turned surface to check the cutting tool, so that each face of the tool may be equally inclined to the center line of the work piece as shown.

The speed of the spindle is reduced by one half to one – fourth of the speed require for turning according to the type of the material being machined and the half – nut is then engaged. The depth of cut usually varies from 0.05 to 0.2 mm is given by advancing the tool perpendicular to the axis of the work.

After the tool has produced a helical groove up to the desired length of the work, the tool is quickly withdrawn by the use of the cross slide, the half-nut disengaged and the tool is brought back to the starting position to give a fresh cut. Before re-engaging the half-nut it is necessary to ensure that the tool will follow the same path it has traversed in the previous cut, otherwise the job will be spoiled. Several cuts are necessary before the full depth of thread is reached arising from this comes the necessity to “pick-up” the thread which is accomplished by using a chasing dial or thread indicator.

**Chasing dial or thread indicator**

The chasing dial is a special attachment used in modern lathes for accurate “picking up” of the thread. This dial indicates when to close the split of half nuts. This is mounted on the right end of the apron. It consists of a vertical shaft with a worm gear engaged with the lead screw. The top of the spindle has a revolving dial marked with lines and numbers. The dial turns with the lead screw so long the half nut is not engaged.

If the half-nut is closed and the carriage moves along the dial stands still. As the dial turns, the graduations pass a fixed reference line. The half-nut is closed
for all even threads when any line on the dial coincides with the reference line. For all odd threads, the half-nut is closed at any numbered line on the dial determined from the charts. If the pitch of the thread to be cut is an exact multiple of the pitch of the lead screw, the thread is called even thread, if otherwise the thread is odd thread.

In a chasing dial, the rule for determining the dial division is: In case of metric threads, the product of the pitch of lead screw and the no. of teeth on the worm wheel must be an exact multiple of the pitch of the threads to be cut. In case of English threads, the product of the threads per inch to be cut and the number of teeth on the worm wheel must be an exact multiple of the number of threads per inch of the lead screw. For example, if the pitch of the lead screw is 6 mm and the worm wheel has 15 teeth.

The product will be 90. so any pitch which is exactly divisible by 90, such as 1, 1.25, 2.25,3,3.75,4.5,5,6,7.5,9,10,15,30,45,90 may be picked up when any line of the dial coincides with the reference line.

**Right hand and left-hand thread:**

If the bolt advances into the nut when rotated in clockwise direction, the thread is called right-hand thread. When cutting a right-hand thread the carriage must move towards the head stock.

If the bolt advances into the nut when rotated in counter-clockwise direction, the thread is called left-hand, for a left hand thread the carriage moves away from the head stock and towards the tail stock. The job moves as always in the anti-clock wise direction when viewed from the tail stock.
end. The direction at which the carriage moves in relation to lathe head stock is controlled by means of the tumbler gears or bevel gear feed reversing mechanism.

**PROCEDURE:**

1. The work piece and HSS single point cutting tool are fixed in chuck and tool post respectively.
2. Operations such as facing, rough turning finish turning and step turning are performed on the given mild steel bar one after the other in sequence up to the dimensions shown.
3. Single point cutting tool is replaced by a grooving tool and grooving operation is performed at half of the normal spindle speed.
4. The grooving tool is replaced by a threading tool. Right hand and left hand metric threads are cut on the work piece up to the required length at 1/4 th of the normal speed of the spindle.
5. Threading tool replaced by a single point cutting tool again and finally chamfering is done at right end of the work piece at normal spindle speed.

**PRECAUTIONS:**

1. Low spindle speeds should be used for accurate threads in thread cutting operation.
2. Ensure correct engage and dis-engage of half-nut.
3. Plenty of oil should be flowed on the work and tool during thread cutting.
Drilling and taping operation

1. **AIM:** To drill the given work piece as required and then to perform drilling and taping operations on the given specimen.

2. **MATERIALS REQUIRED:** mild steel specimen, coolant (oil and water mixture), lubricant oil, nut and bolt.

3. **MACHINE REQUIRED:** Drilling machine

4. **MEASURING INSTRUMENTS:** Vernier calipers

5. **CUTTING TOOLS:**
   - Button pattern stock,
   - Dies,
   - Drill bids,
   - Hand taps,
   - Tap wrench.

6. **MARKING TOOLS:** Dot punch

   **Work holding fixtures:**
   - Bench vice,
   - V-Block

   **Miscellaneous tools:**
   - Brush,
   - Allen Keys

7. **SEQUENCE OF OPERATIONS:**
a. Mark the center of hole and center punching

b. Drill bid

\[ D_h = d_b - p \]

Where,

- \( D_h \) - dia. of the hole,
- \( d_b \) - dia. of drill bit,
- \( p \) = pitch

c. Use the suitable drill size for required tapping

\[ D = \text{Dia. of tap} \]

Tap Drill size = \((D-1.3p)+0.2\) – for metric threads

d. Chamfering of specimen

e. Use the sequential tapping as tap set 1,2,3

f. Internal taping of drilled specimen

g. Filling of specimen on which external threading to be done

h. Measuring the diameter of the specimen & choosing of dies according to it

i. Dieing operation (external threading) of the specimen.

**PRECAUTIONS:**

1. Coolant has to be sued while drilling

2. Lubricating oil has to be used to get smooth finish while tapping.
DRILLING AND TAPPING OPERATION

Drill and tap to size M10 X 1.5 pitch two holes as per the sketch given below.

All Dimensions are in "mm"
SHAPING

1. **AIM**: To perform V and Dovetail machining & U-cut on the given work piece.

2. **MATERIALS REQUIRED**: Mild steel / Cast iron / Cast Aluminum.

3. **MACHINE REQUIRED**: Shaping machine

4. **MEASURING INSTRUMENTS**:
   - Vernier calipers,
   - Vernier height gauge,
   - Dial indicator,
   - Required steel ball.

5. **CUTTING TOOLS**
   - H.S.S tool bit,
   - V tool,
   - Plain tool,
   - Grooving tool.

6. **SEQUENCE OF OPERATIONS**:
   1. Measuring of specimen.
   2. Fixing of specimen in the machine vice of the shaping machine.
   3. Giving the correct depth and automatic feed for the slot is to be made.
   4. Check the slot with the Vernier calipers & precision measurement by slip gauges at the end.
7. THEORY

The shaper also called shaping machine, is a reciprocating type of machine tool in which the ram moves the cutting tool backward and forward in a straight line to generate the flat surface. The flat surface may be horizontal, inclined or vertical.

Principal Parts Of A Shaper

i. Base: It is a heavy and robust cast iron body which acts as a support for all other parts of the machine which are mounted over it.

ii. Column (body): it is a box type iron body mounted upon the base. It acts as housing for the operating mechanism of the machine, electrical, cross rail and ram. On the top it is having two guide ways open which the ram reciprocates.

iii. Cross-rail: it is a heavy cast iron construction, attached to the column at its front on the vertical guide ways. It carries two mechanisms, one for elevating the table and the other for cross travel of the table.

iv. Table: it is made of cast iron and used for holding the work piece. T slots are provided on its top and sides for securing the work on to it. It slides along the cross rail to provide feed to the work.

v. Ram: It reciprocates on the guide ways provided above the column. It carries the tool head and mechanism for adjusting the stroke length.

vi. Tool Head: It is attached to the front portion of the ram and is used to hold the tool rigidly. It also provides the vertical and angular movement to the tool for cutting.

Working principle and operation of a Shaper:
In a shaper, a single point cutting tool reciprocates over the stationary work piece. The work piece is rigidly held in a vice or clamped directly on the table. The tool is held in the tool head mounted on the ram of the machine. When the ram moves forward, cutting of material takes place. So, it is called cutting stroke. When the ram moves backward, no cutting of material takes place so called idle stroke. The time taken during the return stroke is less as compared to forward stroke and this is obtained by quick return mechanism. The depth of cut is adjusted by moving the tool downward towards the work piece.

**Principle of Quick return motion:**
*(Crank and Slotted level type)*

In the extreme position, the slotted lever AL occupies the positions AL₁, and AL₂ and the cutting tool is at the end of the stroke. The forward or cutting stroke occurs when the crank rotates from the position CB₁ to CB₂ (or through an angle) in the clockwise direction. The return stroke occurs when the crank rotates from the position CB₁ to CB₂ (or through an angle) in the clockwise direction. Since the crank rotates at a uniform speed, so

\[
\text{Time of cutting stroke} = \frac{\beta}{\alpha} = \frac{\alpha}{(360° - \beta)} \text{ or } \frac{(360° - \alpha)}{\alpha}
\]

\[
\text{Travel of tool or length of stroke} = R_1R_2 = L1L2 = 2AI \times CB/AC
\]

It can easily be seen that the angle \( \beta \) is more than \( \alpha \). Since the crank rotates with uniform angular speed, therefore from equation (1), it can be concluded that the return stroke is completed with in shorter time. Thus, it is a quick return motion mechanism.

**8. PRECAUTIONS:**

1. The shaping machine must be stopped before setting up or removing the work piece
2. All the chips should be removed from the cutter.
Machine V Groove of 45° for the given specimen and dimensions

SHAPING OPERATION

All dimensions are in "mm"
SLOTTING

1. **AIM:** to make a slot on the given work piece.

2. **MATERIALS REQUIRED:** mild steel, aluminum.

3. **MACHINE REQUIRED:** slotting machine

4. **MEASURING INSTRUMENTS:**
   - Vernier calipers slip gauges.

5. **CUTTING TOOLS:** H.S.S. Tool bit of the required slot size.

6. **SEQUENCE OF OPERATIONS:**
   - Fix the specimen in the three-jaw chuck of the slotting machine
   - By giving the required feed and depth of cut, the required slot is being made progressively

7. **PROCEDURE:**
   1. Drilled work piece is fixed on slotting machine.
   2. A slot of required depth is made

**PRECAUTIONS:**

1. Choose proper feed and depth of cut.
2. Feed should be controlled to avoid any damage to the cutting tool
3. Lock the index table before starting the operation.
4. Care has to be taken so as to maintain the right feed of the material.
5. Work-wheel interface zone is to be flooded with coolant
6. Dressing of grinding wheel to be done before commencement of cutting action, intermittent dressing also to be done if wheel is loaded.
PARTS OF SLOTTING MACHINE:

Slottor and its various parts

EXPERIMENTAL DIAGRAM:

SLOTTING OPERATION

Make a slot in cast iron pulley as per sketch given dimensions

All dimensions are in "in"
PLANE MILLING OPERATION

1. **AIM:** To perform plane milling operation on the given specimen (mild steel) & get to its correct dimensions.

2. **MATERIALS REQUIRED:** mild steel specimen.

3. **MACHINE REQUIRED:** milling machine

4. **MEASURING INSTRUMENTS:** Vernier calipers

5. **CUTTING TOOLS:** Face milling cutter.

6. **MARKING TOOLS:** steel rule, scriber

   1. Work holding fixtures: work piece supporting fixtures
   2. Miscellaneous tools: Hammer, brush, Allen keys

7. **SEQUENCE OF OPERATIONS:**
   1. Measuring of specimen
   2. Fixing of specimen in the milling m/c.
   3. Giving the correct depth and automatic feed cut the specimen
   4. Check the specimen with Vernier caliper at the end.

8. **THEORY:**

Milling machine is a machine tool in which metal is removed by means of a revolving cutter with many teeth (multipoint), each tooth having a cutting edge which removes the metal from the work piece. The work may be fed to the cutter, longitudinally, transversely or vertically, the cutter is set to a certain depth of cut by raising the table. This machine is very much suitable in tool room work due to its variety of operations, better surface finish and accuracy.
**Specification:** The milling machine is specified by its table working surface, its longitudinal, cross and vertical transverse, knee movement in degrees, range and number of spindle speeds, available power of the machine and machine type.

1. The dimensions of the given MS flat are checked with the steel rule.

2. The given flat is fixed in the vice provided on the machine table such a, one end of it is projected outside the jaws of the vice.

3. A face milling cutter is mounted on the milling machine spindle and one end of the flat is face milled, by raising the table so that the end of the rod faces the cutter.

4. The flat is removed from the vice and fitted in the reverse position.

5. The other end of flat is face milled to the dimensions given in the sketch.

**PRECAUTIONS:**

1. The milling machine must be stopped before setting up or removing a work piece, cutter or other accessory

2. Never stop the feeding of job when the cutting operation is going on, otherwise the tool will cut deeper at the point where feed is stopped.

3. All the chips should be removed from the cutter. A wiping cloth should be placed on the cutter to protect the hands.

4. The work piece and cutter should be kept as cool as possible (i.e. coolant should be used where necessary to minimize heat absorption).

5. The cutter should be rotated in the clockwise direction only for right handed tools.

**RESULT:** The MS flat is machined as per the sketch.
1. **AIM:**
   
   To perform surface grinding operation on the given work piece.

2. **MATERIALS REQUIRED:** mild steel specimen.

3. **MACHINE REQUIRED:** surface grinding machine

4. **MEASURING INSTRUMENTS:**
   
   Vernier calipers,
   
   Micrometer.

5. **CUTTING TOOLS:**

6. **WORK HOLDING FIXTURES:** Magnetic chuck

7. **MISCELLANEOUS TOOLS:**
   
   Wire brush (for cleaning the formed chips),
   
   Diamond point dressing block
   
   Coolant

8. **SEQUENCE OF OPERATIONS:**
   
   - Measuring of specimen using Vernier caliper, screw gauge micro meter
   
   - Fix the work piece on to specimen & lock the magnetic chuck
   
   - Move the specimen close to the moving grinding wheel so that it touches the specimen.
   
   - Perform the surface grinding operation.

**RESULT:** The MS flat is machined as per the sketch
CNC program for step turning

1. AIM:

   To write a CNC program for step turning for a billet as per the sketch.

2. MATERIALS REQUIRED: Aluminum round bar. Of 32 mm diameter and 70 mm long.

3. MACHINE REQUIRED: CNC lathe

4. MEASURING INSTRUMENTS:

   Vernier calipers, Micrometer.

5. CUTTING TOOLS: Single point turning tool

6. WORK HOLDING FIXTURES: Three jaw chuck

7. MISCELLANEOUS TOOLS:

   Wire brush (for cleaning the formed chips),
   Coolant

8. PROGRAM:

   G21 G98
   G28 U0 W0
   M03 S1500
   M06 T3
   G00 X32Z5
   G90 X31 Z-30 F100
RESULT: The billet is machined as per the sketch
1. **AIM:** To write a CNC program for taper turning for a billet as per the sketch.

2. **MATERIALS REQUIRED:** Aluminum round bar. Of 25 mm diameter and 70 mm long.

   Taper angle = \( \tan \alpha = \frac{(25 - 19)}{2 \times 30} \)

3. **MACHINE REQUIRED:** CNC lathe

4. **MEASURING INSTRUMENTS:**
   - Vernier calipers, Micrometer.

5. **CUTTING TOOLS:** Single point turning tool

6. **WORK HOLDING FIXTURES:** Three jaw chuck

7. **MISCELLANEOUS TOOLS:**
   - Wire brush (for cleaning the formed chips),
   - Coolant

8. **PROGRAM:**
   
   G21 G98
   
   G28 U0 W0
   
   M03 S1500
   
   M06 T3
   
   G00 X25 Z5
G90 X25 R-0.5 Z-30 F100
X25 R-1
X25 R-1 .5
X25 R-2
X25 R-2.5
X25 R-3
G28 U0 W0
M05
M30

RESULT: The billet is machined as per the sketch
CNC program for multiple turning

1. AIM:

To write a CNC program for multiple turning cycle for a billet as per the sketch.

2. MATERIALS REQUIRED: Aluminum round bar. Of 25mm diameter and 70 mm long.

3. MACHINE REQUIRED: CNC lathe

4. MEASURING INSTRUMENTS:

Vernier calipers,
Micrometer.

5. CUTTING TOOLS: Single point turning tool

6. WORK HOLDING FIXTURES: Three jaw chuck

7. MISCELLANEOUS TOOLS:

Wire brush (for cleaning the formed chips),
Coolant

8. THEORY:

G 70 Finishing cycle
G 71 For multiple turning

G71 U , R
U Depth of cut
R Retraction
P Starting point of profile
Q Ending point of profile
U    Finishing allowance
W    Finishing allowance in Z Axis
S    Cutting speed
F    Cutting Feed

9. PROGRAM:

G21 G98
G28 U0 W0
M03 S1500
M06 T6
G00 X25 Z5
G71 U0.5 R1
G71 P8 Q16 U0.1 W0.1 F100
G01 X10
G01 Z0
G01 X13 Z-2
G01 X13 Z-12
G03 X17 Z-16
G01 X17 Z-24
G02 X21 Z-28
G01 X21 Z-33
G03 X25 Z-44
G70 P8 Q16 S1800 F60
G28 U0 W0

M05

M30

**RESULT:** The billet is machined as per the sketch
ARC WELDING

Aim:-
To prepare a butt joint with mild steel strip using MMAW technique.

Equipment and materials:-
Welding unit, consumable mild steel Electrodes, , mild steel flats (140 x 25 x 5 mm),
Wire brush, Tongs, Chipping hammer etc.

Procedure:-
- Clean the mild steel flats to be joined by wire brush
- Arrange the flat pieces properly providing the gap for full penetration for butt joint (gap ½ thicknesses of flats).
- Practice striking of arc, speed and arc length control
- Set the welding current, voltage according to the type of metal to be joined.
- Strike the arc and make tacks at the both ends to hold the metal pieces together during the welding process
- Lay beads along the joint maintaining proper speed and arc length (Speed 100-150 mm/min).
- Clean the welded zone and submit.

Result:  The but joint is made as per the sketch
A. SQUARE BUTT JOINT

B. SINGLE-V BUTT JOINT

C. DOUBLE-V BUTT JOINT
SOLID STATE WELDING

1. **AIM:** To make a lap joint from a given G.I sheet by using spot welding.

2. **MATERIALS REQUIRED:** G.I. sheet

3. **EQUIPMENT:** spot welding machine

4. **SEQUENCE OF OPERATIONS:**
   1. G.I sheet is sheared to required dimensions.
   2. The plates are hammered using a mallet in order to minimize unevenness and distortion.
   3. The two plates are placed in between the electrodes.
   4. Thus spot welding nugget is formed.

5. **THEORY:**

   Resistance welding: the category resistance welding (RW) covers a number of processes in which the heat required for welding is produced by means of electrical resistance across the two components to be joined. These processes have major advantages, such as not requiring consumable electrodes, shielding gases, or flux.

   The heat generated in resistance welding is given by the general expression

   \[ H = I^2RT, \]
Where

\[
H = \text{heat generated (in joules (watt-seconds))} \\
I = \text{current (in amperes)}, \\
R = \text{resistance (in ohms)}, \text{and} \\
T = \text{time of current flow (in seconds)}
\]

The actual temperature rise at the joint depends on the specific heat and on the thermal conductivity of the metals to be joined.

6. **PROCEDURE:**

1. The job should be clean. It should be free from grease, dirt, paint, scale, oxide etc.

2. Clean the electrode tip surface. Very fine emery cloth may be used for routine cleaning.

3. Water is kept running through the electrodes in order to cool the weld and avoid the electrodes from getting overheated.

4. Proper welding current has been set on the current selector switch

5. Proper time has been set on weld timer.

6. Electrodes are brought together against the overlapping work pieces and pressure is applied so that the surfaces of the two work pieces come in physical contact with each other.

7. Welding current is switched on for a definite period of time.

8. As the current passes, a small area where the work pieces are in contact is heated and spot weld takes place. The temperature of this weld zone is approx. 815°C to 930°C.

9. After the welding takes place, the welding current is cut off. Extra electrode force is then applied or the original force is prolonged. Hold until the metal cools down and gains strength.

10. After that, electrode pressure is released to remove the spot welded work pieces.
Sandwich structured composite

**AIM:** - To study the properties of structured sandwich composite

**Apparatus:** - structured sandwich composite

**Theory:**

A sandwich-structured composite is a special class of composite materials that is fabricated by attaching two thin but stiff skins to a lightweight but thick core.

The core material is normally low strength material, but its higher thickness provides the sandwich composite with high bending stiffness with overall low density.

The core material is normally low in strength material but its higher thickness provides the sandwich composite with high bending stiffness with overall low density.

**SANDWICH**

Whenever new materials or production methods appear there is a resistance to use them. Mostly the resistance originates in conservation and ignorance. The only way to overcome the resistance is to try to teach and convince the opponents.

**Concept of sandwich structure**

Sandwich construction has found extensive application in aircraft, missile and spacecraft structures due to high strength to weight ratio. This type of construction consists of thin, stiff and strong sheets of metallic or fiber composite material separated by a thick layer of low density material as shown in Fig.1.16. The thick layer of low density material commonly known as core material may be light
foam type (e.g. Nomex core or Rohacell as shown in Fig1.17a). The details of foam is shown in Fig1.17a metallic honeycomb as shown in Fig1.17b or corrugated core as shown in Fig1.17c. The core material is generally adhesively bonded to the face sheets.

In some sandwich construction the core may be made of metallic or composite material corrugations. The corrugated core may be adhesively bonded, rivet bonded or weld bonded if the face sheets are metallic material. For sandwich construction using composite face sheets, the core may be bonded or co-cured with face sheets. A sandwich construction has following advantages-

- High ratio of bending stiffness to weight as compared to monolithic construction.
- High resistance to mechanical and sonic fatigue.
- Good damping characteristic.
- Improved thermal insulation.
- No mechanical fasteners, hence, no crack initiation sites.

The mains disadvantages of honeycomb construction are-

- In-service trapped moisture in the core material causes corrosion problems. Hence, degradation in the structural integrity of the parts.
- A good quality control is needed during the fabrication process to make sure that there is no disbonding in the adhesive layer.
- Disbonds may initiate and propagate in the adhesive layer during service and thereby reduce the load carrying capacity of structures.

**MAIN PRINCIPLES**

Sandwich structures are a special kind of laminated composite. Laminated composites consist of layers of at least two different
materials that are bonded together. A structural sandwich consists of three elements, as shown in Fig 1.18;

1) Face sheets
2) Core
3) Adhesive

Sandwich structure
Honeycomb Construction

(a) Foam  (b) Honeycomb  (c) Corrugated
Types of Cores

1. The Face

   The faces carry the tensile and compressive stresses in the sandwich. The local flexural rigidity is so small that it can often be ignored. Conventional materials such as steel, stainless steel and aluminum are often used for face material. In many cases it is also suitable to choose fibre- or glass- reinforced plastics as face materials. These materials are very easy to apply. Reinforced plastics can be tailored to fulfill a range of demands like anisotropic mechanical properties, freedom of design, excellent surface finish etc.

   Faces also carry local pressure. When the local pressure is high the faces should be dimensioned for the shear forces connected to it.

2. The Core

   The core has several important functions. It has to be stiff enough to keep the distance between the faces constant. It must also be so rigid in shear that the faces do not slide over each other. The shear rigidity forces the faces to cooperate with each other. If the core is weak in shear the faces do not cooperate and the sandwich will lose its stiffness.

   This presentation demonstrates that it is the sandwich structure as a whole that gives the positive effects. However, it should be mentioned that the core has to fulfill the most complex demands. Strength in different directions and low density are not the only properties that the core has to have. Often there are special demands for buckling, insulation, absorption of moisture, ageing resistance, etc.
3. Adhesive (Bonding layer)

To keep the faces and the core co-operating with each other the adhesive between the faces and the core, must be able to transfer the shear forces between the faces and the core. The adhesive must be able to carry shear and tensile stresses. It is hard to specify the demands on the joints. A simple rule is that the adhesive should be able to take up the same shear stress as the core.

PROPERTIES OF MATERIALS USED IN SANDWICH CONSTRUCTION

No single known material or construction can meet all the performance requirements of modern structures. Selection of the optimum structural type and material requires systematic evaluation of several possibilities. The primary objective often is to select the most efficient material and configuration for minimum-weight design.

(a) Face Materials

Almost any structural material which is available in the form of thin sheet may be used to form the faces of a sandwich panel. Panels for high-efficiency aircraft structures utilize steel, aluminum or other metals, although reinforced plastics are sometimes adopted in special circumstances. In any efficient sandwich the faces act principally in direct tension and compression. It is therefore appropriate to determine the modulus of elasticity, ultimate strength and yield or proof stress of the face material in a simple tension test. When the material is thick and it is to be used with a weak core it may be desirable to determine its flexural rigidity.
(b) Core Materials

A core material is required to perform two essential tasks; it must keep the faces the correct distance apart and it must not allow one face to slide over the other. It must be of low density. Most of the cores have densities in the range 7 to 9.5 lb/ft$^3$. Balsa wood is one of the original core materials. It is usually used with the grain perpendicular to the faces of the sandwich. The density is rather variable but the transverse strength and stiffness are good and the shear stiffness moderate. Modern expanded plastics are approximately isotropic and their strengths and stiffness are very roughly proportional to density. In case of aluminum honeycomb core, all the properties increase progressively with increases in thickness of the foil from which the honeycomb is made.

(c) Adhesives

Adhesives’ (or the bounding layer) role in the sandwich structures is to keep the faces and the core co-operating with each other. The adhesive between the faces and the core must be able to transfer the shear forces between the faces and the core. The adhesive must be able to carry shear and tensile stresses. It is hard to specify the demands on the joints; a simple rule is that the adhesive should be able to take up the same shear stress as the core. Some adhesive types, such as phenolic, give out vapor during curing reaction. The vapour can cause several problems if this vapor is trapped; it may cause little or no bond in some areas, the pressure may damage the core material or it may cause the core to move to an undesired position. Common adhesives in current use are:

1. Nitrile Pheonolic
2. Vinyl Pheonolic
3. Epoxy
4. Urethane
5. Polyimide
6. Polyamide

The design and development of satellite launch vehicle and missile are driven by the need for minimum weight structures. Preliminary design of these structures requires many optimizations to select among competing structural concepts. Accurate models and analysis methods are required for such structural optimizations. Model, analysis, and optimization complexities have to be compromised to meet constraints on design cycle time and computational resources.

A 3-D finite-elements model was also built which takes into consideration the exact geometric configuration and the orthotropic properties of the composite plate. Altering the ply sequence for given working conditions alters the deflection of the particular material. Hence analysis is carried out on such various orientations to select the most suitable orientation.

The design concept can be applied to design of sandwich composite structure using number of composite plates and wings by filament winding process can be applied in various missile structures like fins, canard and weight saving up to 45% can be achieved against metallic structures.
Air craft wood gluing practices

The modern airplane requires 200 Square Feet to 2000 Square Feet of wood and considerable quantities of glue and plywood. In Air craft manufacturing, wood is used in the manufacture of different part parts such as wing beams (solid and box type, ribs, leading and trailing edges, bow ends, braces, reinforcing or shear blocks, propellers, fuselage construction, aileron ribs, pontoons, rudder stabilizer and elevator parts, seats, compartments, cabin heads, doors etc.

Types of Glues:

Most glues used by aircraft builders require curing temperatures of 70°F and above in order to produce reliable joints. One exception is System three T-88 epoxy. It will cure, although somewhat slower, in temperatures as low as 35°F. This makes T-88 an ideal choice for builders who have to work in colder climates.

Ideally, a 1:1 mix is as close to being foolproof as you can get. A couple of good adhesives using this mix are T-88 epoxy and APCP Structural Adhesive.

Other popular glues include:

1. Resorcinol (Weldwood, Borden, etc.) . . . an excellent two-part waterproof glue. Mix by weight is 4 parts liquid to 1 part powder.
Resorcinol glues require excellent joints and considerable clamping pressure to ensure good joints. Temperatures must be above 70° for a reliable cure. It is considered to be the most durable and best proven glue in the world.

2. FPL-16A . . . a 10:1 mix epoxy . . . tricky to mix in small amounts. (Since it is a white glue an inspector might mistake it for an unacceptable white carpenter’s glue.)

3. Urea-formaldehyde glues have lost favor in Australia. These include:

   a. Aerolite, a urea-formaldehyde resin. Good but tricky to use. The British built bombers using this glue in WW-II. Mix powder with water to form paste. Apply paste to one surface and brush on a catalyst hardener on the other surface. If you forget to brush on the catalyst you may never realize it until a joint fails later.

   b. Plastic Resin (Weldwood, etc.) is also a urea-formaldehyde glue.

   This tan colored powder when mixed with water is ready for use. This has long been considered to be a good, easy to use glue, but it is only water resistant, not waterproof. It is the least expensive glue and is available in many hardware stores. Plastic resin glue has been widely used in thousands of homebuilts like the Fly Baby and Pietenpol.

   Unfortunately, as seems to be the rule lately, familiar old products are often "discovered" to be suspect and "no good no more." So it is with Aerolite and plastic resin.
Acid Catalyzed Phenolic (ACP) or Urea Formaldehyde (UF) glues (as a class) should not be used in powered homebuilt aircraft because structural failure of ACP glue joints has been the cause of several accidents.
The circumstantial evidence against plastic resin is not as strong although it is known that it too reacts chemically to changes in humidity and their long term durability under outdoor climatic conditions is suspect. Anyhow, now it seems that the FAA will agree with Australia that the glue should not be used in homebuilt aircraft because it could deteriorate badly in hot, humid climates. Therefore, if you want to use either urea formaldehyde glue in your project, check with your local FAA office to determine their current attitude about the glues use.

Epoxies, in general, are expensive and can be fairly toxic if used carelessly. A number of builders will surely suffer from skin rash and worse due to its use. Working in poorly ventilated enclosed areas is to be avoided.

NOTE: Epoxies that most builders use cure at room temperatures and epoxied structures are generally sensitive to heat. That is, they tend to soften (weaken) with higher temperatures.

Whatever glue that is used, making test samples of each batch used and later demolish them with a hammer to see if the glue joint separates or the wood fibers fail. The wood fibers should fail, not the glue line.

**Grain Orientation**

This is another area of uncertainty for some builders. The grain orientation in wood parts, plywood webs, gussets and the like is important especially in components like wing spars and other highly stressed locations.
Usually, the designer will indicate on the drawings the preferred orientation of the surface grain. However, if that information is not depicted consider the merits of the following:

In general, plywood bends easier along the direction of the surface grain. This is because three layer plywood will have the grain of the two surface plies running in the same direction. Only the center ply will be oriented in a crosswise direction. It is, therefore, sometimes called 90° plywood.

Plywood whose surface grain runs at an angle is termed 45° plywood. Because of its grain orientation it is stiffer and doesn’t bend easily in any direction. It is more expensive but only slightly stronger than ordinary 90° plywood.

Forty-five degree plywood is used for box spars and wing and fuselage skins where stiffness is important. It is less likely to show signs of bulging or sagging between ribs and uprights due to changes in humidity - an annoying cosmetic condition that does not affect the plywood’s serviceability.

In general, plywood is somewhat stronger along its external grain direction. This is taken into consideration when fitting and attaching gussets and plywood webs to wing ribs and other structure. Grain orientation in solid wood parts is equally important and can affect the strength of a glued assembly. Keep in mind the fact that when joining (gluing) two solid wood pieces together, the strongest joint results when the grain in each part is more or less parallel.
Box spars are enclosed by gluing plywood shear webs to each side of the solid wood structure. This plywood web is generally laid on with the grain oriented at a 45° angle to the span. There is some difference of opinion as to the most effective grain. It recommends that 45° plywood shear webs on a box spar or I beam have the grain oriented in the direction which will provide stiffening against buckling due to compression loads. In effect, this means the face grain in the plywood would run from the bottom outward to the top inboard of the spar.

They go on to say that if 45° plywood is used it could result in a structure five times stiffer although only slightly stronger. However, it is conceded that the spar webs are often laid on with the face grain perpendicular to the long axis of the spar simply because there is little or no reduction in strength and because of cost considerations. One can find in most wood designs the plywood shear webs on stabilizer, elevator, fin and rudder spars, to be oriented at 90° to their center lines.
Cavity type EDM or volume EDM. Sinker EDM consists of an electrode and workpiece that are submerged in an insulating liquid such as oil or dielectric fluid. The electrode and workpiece are connected to a suitable power supply. The power supply generates an electrical potential between the two parts. As the electrode approaches the workpiece, dielectric breakdown occurs in the fluid forming an ionization channel, and a small spark jumps. The resulting heat and cavitation vaporize the base material, and to some extent, the electrode. These sparks strike one at a time in huge numbers at seemingly random locations between the electrode and the workpiece. As the base metal is eroded, and the spark gap subsequently increased, the electrode is lowered automatically by the machine so that the process can continue uninterrupted. Several hundred thousand sparks occur per second in this process, with the actual duty cycle being carefully controlled by the setup parameters. These controlling cycles are sometimes known as "on time" and "off time". The on time setting determines the length or duration of the spark. Hence, a longer on time produces a deeper cavity for that spark and all subsequent sparks for that cycle creating a rougher finish on the workpiece. The reverse is true for a shorter on time. Off time is the period of time that one spark is replaced by another. A longer
off time for example, allows the flushing of dielectric fluid through a nozzle to clean out the eroded debris, thereby avoiding a short circuit. These settings are maintained in micro seconds. The typical part geometry is to cut small or odd shaped angles. Vertical, orbital, vectorial, directional, helical, conical, rotational, spin and indexing machining cycles are also used.

Applications of EDM

1. **Prototype production**

The EDM process is most widely used by the mould-making tool and die industries, but is becoming a common method of making prototype and production parts, especially in the aerospace, automobile and electronics industries in which production quantities are relatively low. In Sinker EDM, a graphite, copper tungsten or pure copper electrode is machined into the desired (negative) shape and fed into the workpiece on the end of a vertical ram.

2. **Coinage die making**

For the creation of dies for producing jewelry and badges by the coinage (stamping) process, the positive master may be made from sterling silver, since (with appropriate machine settings) the master is not significantly eroded and is used only once. The resultant negative die is then hardened and used in a drop hammer to produce stamped flats from cutout sheet blanks of bronze, silver, or low proof gold alloy. For badges these flats may be further shaped to a curved surface by another die. This type of EDM is usually performed submerged in an oil-based dielectric. The finished object may be further refined by hard (glass) or soft (paint) enameling and/or
electroplated with pure gold or nickel. Softer materials such as silver may be hand engraved as a refinement.

EDM control panel (Hansvedt machine). Machine may be adjusted for a refined surface (electropolish) at end of process.
Master at top, badge die workpiece at bottom, oil jets at left (oil has been drained). Initial flat stamping will be "dapped" to give a curved surface.
Lathe Machine

1. Accumulated metal chips and dirt are cleaned from the lathe with a _____, never with _____.

2. In most lathe operations, you will be using a single-point cutting tool made of _____.

3. Cutting speeds can be increased 300% to 400% by using_____ tools.

4. _____ is used to indicate the distance that the cutter moves longitudinally in one revolution of the work.

5. Back gear mechanism in a lathe is used to reduce ________________

6. In which of the following operation on lathe, the spindle speed will be minimum
   a) Knurling (b) Fine finishing (c) Taper turning (d) Thread cutting

7. Which of the following lathe operation requires that the cutting edge of a tool bit is placed exactly on the work-center line
   a) Boring (b) Facing (c) Drilling (d) Chamfering

Answers: 1. Brush, not with hand   2. HSS (High Speed Steel)   3. Carbide tipped tools
Milling Machine

1. __________ is used to hold the milling cutter.

2. Climb milling is also known as __________

3. Up milling is also known as ________

4. In ______ milling, the direction cutter motion and the feed motion will be in the same direction of feed motion

5. In up milling, the direction cutter motion and the feed motion will be in the ______ direction of feed motion


DRILLING MACHINE

1. Drilling is an example of __________
   a) Simple cutting (b) Uniform cutting (c) Oblique cutting (d) Intermittent cutting

2. The helical grooves which extend to full length of the drill bit is called as __________
   a) Lip (b) Cutting edges (c) Flute (d) Shank
3. When \( N = \) Spindle speed in r.p.m, \( L = \) length of depth of the hole, \( f = \) feed per revolution of drill then the drilling time in minutes (\( T \)) is ____________________

4. The point angle for the drill bit for machining brass and bronze __________________

5. ___________ taper is given on the drilling machine spindle for holding the drilling tools.


**Shaping Machine**

1. The tool head of a shaper is mounted on ___________ face of the ram.

2. ___________ is used in shaper to perform return stroke quickly.

3. The length of stroke adjusted should be ___________than the adjusted length.

4. _______ is use full in prevention of rubbing of tool on the work, during the return stroke of the ram.

5. Shaping machines are used to produce ___________ Surfaces.
Gas welding

1. _________ is used to remove slag formed on the welding.

2. The maximum temperature in obtained with neutral flame is _________

3. Oxidizing flame with excess of oxygen is used for welding _________

4. Neutral flame with the excess of Acetylene is used for welding _________

5. Oxygen cylinder is painted in _________ color, Acetylene cylinder is painted in _________ color

Answers: 1. Chipping hammer  2. 3200 Degrees centigrade, 3. Brass,
         4. Steel, Stainless steel, CI, Copper etc  5. Red , Blue
1. Too high current leads to ________ bead with __________ penetration,

2. The movement of welding rod for bead is known as ________________

3. The deflection DC arc by the magnetic fields set up due to the flow of the welding current is known as ________

4. The minimum welding load voltage $V_m$ is given by __________________

5. In ________ welding, work is connected to positive and electrode connected to negative terminal, and deep weld penetration is possible.

4. $V_m = 20 + 0.04 I$ Where $I = \text{current in Amps.}  \quad 5. \text{DC Straight polarity}$
CNC MACHINE

1. The preparatory functions referring to a particular machine activity are given by _______
2. Non machining or Miscellaneous functions are described by _________________
3. The lead screw used in the CNC machine is _____.
4. The computer languages that are available for NC machines are ___________
5. _____ is the combination of machine moves resulting in particular machining function such as drilling, boring etc.

Soldering

1. _______ is the operation joining two or more metal parts by molten etal.

2. While doing hard soldering ___________ is the chief flux used.

3. The melting point temperature of the filler metal for soldering is less than ________.

4. Soft Solder is the alloy of ________ and ___________, and hard Solder is the alloy of ________ and __________metals.

5. Generally the clearance used in solder joint is in the range of __________

Answers: 1. Soldering  2. Borax  3. 420 °C  4. Soft solder =Lead, Tin, Hard solder =Silver, Tin  5. 0.075mm to 0.25mm
Spot Welding

1. The foot pedal pressure used in spot welding is in the range of ________

2. The low voltage current used in spot welding is in the range of ____

3. The weld time i.e. duration of current passage in spot welding is _____

4. The welded spot between two plates is known as ________

5. If the thickness of the plates to be spot welded is ‘t’, then the tip diameter of the electrode ______

Answers: 1. 700 – 1000 Kg/Cm²
2. 120 - 300 A/mm²
3. about 0.3 to 2 seconds
4. Nugget
5. $t^{1/2}$
Brazing

1. The melting point temperature of the filler metal for brazing is more than ________ but less than the melting point of the parent metal.

2. ________ is a joining operation using brass as a joining medium.

3. Generally the clearance used in Brazed joint is in the range of ________

4. The Lap length of the joint is __________ times the thickness of the plate.

5. In brazing, the filler metal is drawn in between the joining surfaces by ________

Answers: 1. 420 °C  
   2. Brazing  
   3. 0.08mm to 0.25mm  
   4. 1.5  
   5. Capillary action