# MANUFACTURING PROCESSES

## LAB MANUAL

| | | |
|---|---|---|
| **Subject Code** | : | **AMEB06** |
| **Regulations** | : | **IARE-R18** |
| **Class** | : | **II Year I Semester (ME)** |


Prepared by

**Mr. G. Aravind Reddy, Assistant Professor.**

**DEPARTMENT OF MECHANICAL ENGINEERING**

**INSTITUTE OF AERONAUTICAL ENGINEERING**

**(Autonomous)**

**Dundigal – 500 043, Hyderabad**

# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

| Program Outcomes | |
|---|---|
| PO1 | **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences. |
| PO3 | **Design / Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health, safety, cultural, societal and environmental considerations. |
| PO4 | **Conduct Investigations of Complex Problems**: Use research based knowledge and research methods ,design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions. |
| PO5 | **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| PO7 | **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development. |
| PO8 | **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO9 | **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| PO11 | **Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| PO12 | **Life - Long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life - long learning in the broadest context of technological change. |
| **Program Specific Outcomes** | |
| PSO1 | **Professional Skills:** Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work. |
| PSO2 | **Problem - Solving Skills:** Can explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally. |
| PSO3 | **Successful Career and Entrepreneurship:** The understanding of technologies like PLC, PMC, process controllers, transducers and HMI one can analyze, design electrical and electronics principles to install, test , maintain power system and applications. |

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## ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

| Exp. No. | Experiment | Program Outcomes Attained | Program Specific Outcomes Attained |
|---|---|---|---|
| 1 | Arc Welding (V-Butt joint) | PO1, PO2 | PSO1, PSO2 |
| 2 | Arc Welding (Lap joint) | PO1, PO3 | PSO1 |
| 3 | Spot Welding (Lap Joint) | PO1, PO2 | PSO1, PSO2 |
| 4 | TIG Welding | PO1, PO4 | PSO1, PSO2 |
| 5 | Pattern Design and Making-1 | PO1, PO2, PO3 | PSO2 |
| 6 | Pattern Design and Making-2 | PO1, PO2, PO3 | PSO1 |
| 7 | Sand Properties Testing | PO1, PO2 | PSO1, PSO2 |
| 8 | Casting (Solid Pattern) | PO1, PO3, PO4 | PSO2 |
| 9 | Casting (Split Pattern) | PO1, PO3, PO4 | PSO1, PSO2 |
| 10 | Study of Progressive Tool | PO1, PO2 | PSO1, PSO2 |
| 11 | Study of Compound Tool | PO1, PO2, PO4 | PSO1 |
| 12 | Drawing and Bending | PO1, PO2 | PSO2, PSO3 |
| 13 | Injection Moulding | PO1, PO3 | PSO2, PSO3 |
| 14 | Plasma Welding, Cutting and Brazing | PO1, PO2 | PSO2, PSO3 |

# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad

**Mechanical Engineering Department**


## MANUFACTURING PROOCESS LAB

### Course Overview:

This laboratory course builds on the lecture course "Signals and systems" which is mandatory for all students of electronics and communication engineering. The course aims at practical experience with the generation and simulation of basic signals, using standardized environments such as MATLAB. Experiments cover fundamental concepts of basic operation on matrices, generation of various signals and sequences, operation on signals and sequences, convolution, autocorrelation and cross correlation between signals and sequences. The objective of this laboratory is to enable the students to acknowledge with basic signals, and system responses. They can critically analyze the behavior of their implementation, and observe the specific limitations inherent to the computational platform like MATLAB

### Course Out Comes:

1) Understand the Pattern design and making, casting drawing.
2) Utilize and determination of Sand properties testing for strengths and permeability
3) Demonstrate practical understanding Moulding,melting and casting
4) Demonstrate practical understanding of ARC welding lap and butt joint
5) Demonstrate practical understanding of Spotwelding, TIG welding
6) Demonstrate practical understanding of Plasma welding and brazing (water plasma device).
7) Understand Blanking and piercing, operation and study of simple, compound and progressive press tool.
8) Demonstrate practical understanding of
9) Hydraulic press, deep drawing and extrusion operation.
10) Understand the Bending and other operation
11) Demonstrate practical understanding Injection moulding process
12) Demonstrate practical understanding Blow moulding process
13) Demonstrate practical understanding MIG welding exercises and Riveting of plates.

# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad

**MECHANICAL ENGINEERING DEPARTMENT**

## INSTRUCTIONS TO THE STUDENTS

1. Students are required to attend all labs.
2. Students should work individually in the hardware and software laboratories.
3. Students have to bring the lab manual cum observation book, record etc along with them whenever they come for lab work.
4. Should take only the lab manual, calculator (if needed) and a pen or pencil to the work area.
5. Should learn the prelab questions. Read through the lab experiment to familiarize themselves with the components and assembly sequence.
6. Should utilize 3 hour’s time properly to perform the experiment and to record the readings. Do the calculations, draw the graphs and take signature from the instructor.
7. If the experiment is not completed in the stipulated time, the pending work has to be carried out in the leisure hours or extended hours.
8. Should submit the completed record book according to the deadlines set up by the instructor.
9. For practical subjects there shall be a continuous evaluation during the semester for 25 sessional marks and 50 end examination marks.
10. Out of 25 internal marks, 15 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting an internal laboratory test.

## EXPERIMENT-1
## ARC WELDING (V-BUT JOINT)

**AIM:** Prepare a V – Butt Joint using Arc Welding Process.

**APPARATUS REQUIRED:** Wire Brush, Grinding Machine, Protective Equipment,

Welding Transformer, Electrodes, Tong, Chipping Hammer

**MATERIAL REQUIRED:** Mild steel flat of 60 x45 x 10 $mm^3$ – 2 No‟s.

**THEORY:**

**Definition:** Electric arc welding is "a welding process where in coalescence is produced by heating with an arc or arcs, with or without the application of pressure and with or without the use of filler metals". Electric arc welding is quite versatile and able to weld under many conditions. High quality welds are produced. Metal is deposited rapidly and it is competitive cost wise for many situations.

Electric arc welding is the most extensively used method of joining components of metallic parts, the source of heat being an electric arc. An electric arc is a continuous stream of electrons flowing trough some sort of medium between two conductors of an electric circuit and accompanied by intense heat generation and radiation.

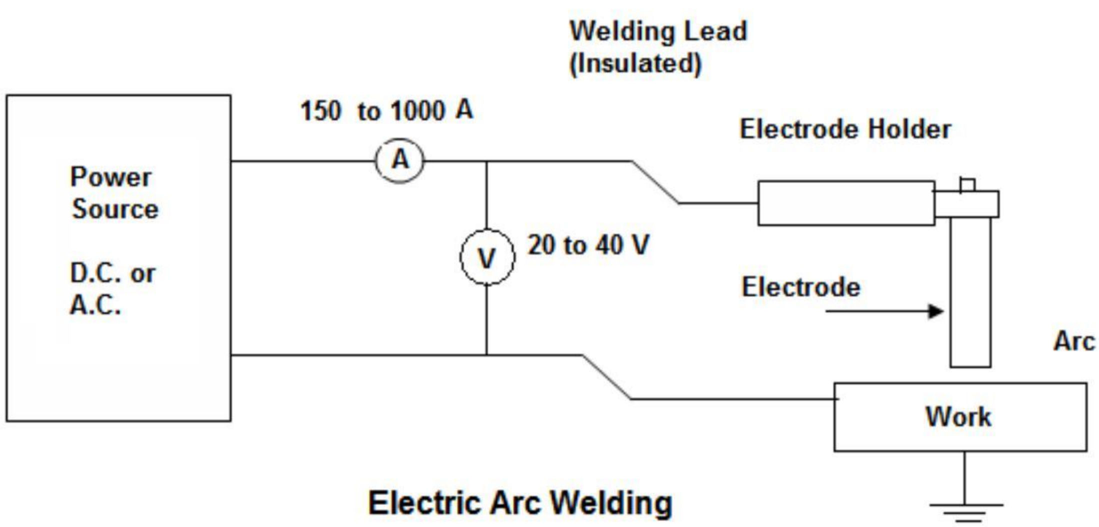
An electric arc for welding is obtained in the following ways:

1. Between a consumable electrode (which also supplies filler metal) and the work piece.
2. Between a non consumable electrode (carbon, graphite or tungsten etc.) and the work piece.
3. Between two non-consumable electrodes.

The most common electric arc welding method is the one in which the arc is struck between an electrode and the work. This is called as „Direct arc‟. The arc struck between two non consumable electrodes adjacent to the parts being welded is called as "Independent or Indirect arc". The metal is heated by the indirect action (by radiation) of the arc. Due to this, the thermal efficiency of the method is poor.

To strike an arc, the electrode is brought in contact with the work at the point where the welding is to be started, after connecting the work to the welding circuit. After a light contact, the electrode is immediately withdrawn to a distance of from 2 to 4 mm from the work. Only a comparatively low potential difference is required between the electrode and the work to strike an arc. From 40 to 45 V is usually sufficient for D.C. and from 50 to 60 V for A.C. This voltage available at the output terminals of a welding set, before the arc is struck, is known as open circuit voltage (OCV). The voltage falls after the arc is established this is normally less than half the OCV. A stable arc can be maintained between a metal electrode and the work metal with a voltage of 15 to 30 V while from 30 to 35V is needed to strike an arc between non consumable electrode and the work.

The stable arc required for high quality welding can be achieved with an arc length equal to 0.6 to 0.8 of the electrode diameter. The arc length is defined as the distance between the end of the electrode and the surface of the molten metal on the work. When the electrode first makes contact with the job, a large short circuit current flows. When the electrode later is immediately withdrawn, the current continues to flow in the form of spark across the air gap so formed. Due to this, the air gap gets ionized, that is, splits into electrons and positive ions. The lighter electrons flow from cathode to anode and the heavier positive ions flow from anode to cathode. Thus, the air gap becomes conducting and current is able to flow across the gap in the form of an arc.




**Electric Arc Welding**

When the lighter, high-velocity electrons strike the anode at great velocity, intense heat is generated at the anode. Heat generated at the cathode is much less, because of the low velocity of impinging positive ions. Thermal and luminous energy is not uniformly evolved in the welding arc. About 43 percent of the total amount of heat is evolved on the anode and about 36 percent on the cathode. The remaining 21 per cent is evolved by the arc.

The temperature of an electric arc depends upon the type of electrodes between which it is struck. It is about $3200^0$C on the cathode and about $3900^0$C on the anode for carbon electrodes and $2400^0$C and $2600^0$C respectively for metal electrodes. The temperature may reach $6000^0$ to $7000^0$C in the centre of the arc. Only from 60 to 70% of the heat is utilized an arc welding to heat up and melt the metal. The remaining 30 to 40% is dissipated into the surroundings.

**Welding Joint Design:**

Since welding joins metals, design for welding is chiefly concerned with joints i.e. when to use a joint, how to weld it, where to place it, what to do and what not to do. Selection and preparation of weld joint is an important step in the fabrication of a weldment. Selection of correct joint design is very essential if welded members are to perform within the load service, corrosive atmosphere and safety requirements. Not only must the product have sufficient strength to perform well under the load conditions expected but it must be pleasing in appearance also. Proper joint design is a vital part of a welding procedure because it helps to:

The weld joint design should be such that the welds can be tested non-destructively for necessary quality control, especially if the welds are in pressurized or contaminates and inaccessible areas. The consideration in joint includes safety, service, quality and cost.

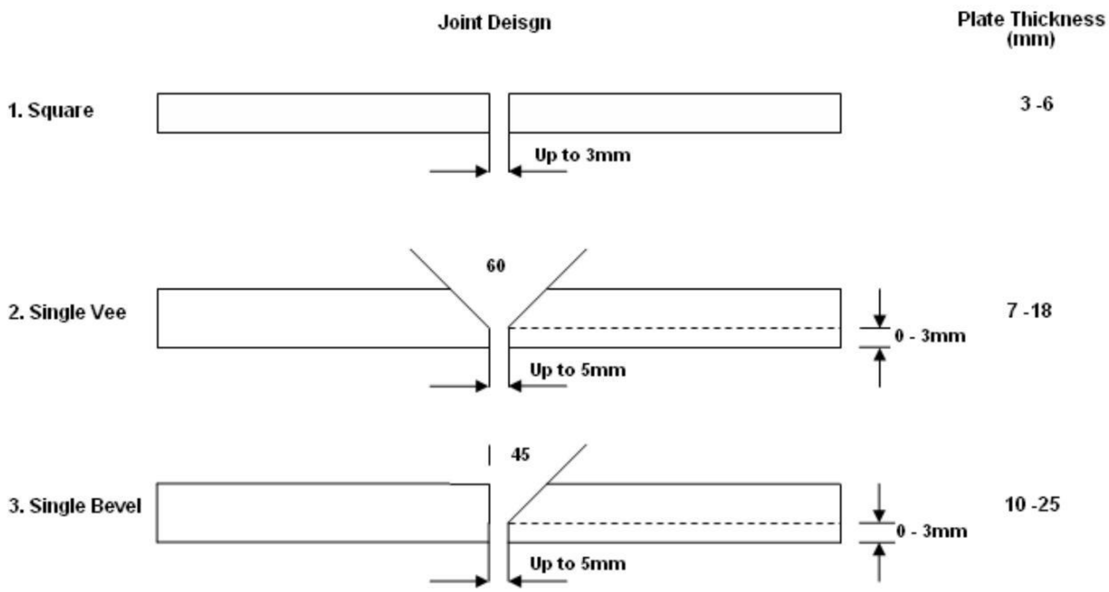
**Types of Welding Joints:**

While designing for welding it appears both logical nad fundamental to first consider the various forms of weld joints. A joint indicates the position where two or more members of a structure meet and are to be joined by welding.

Classification:

* Butt Joint
* Tee Joint
* Lap Joint
* Edge Joint
* Corner Joint

**Butt Joints:**



| | | |
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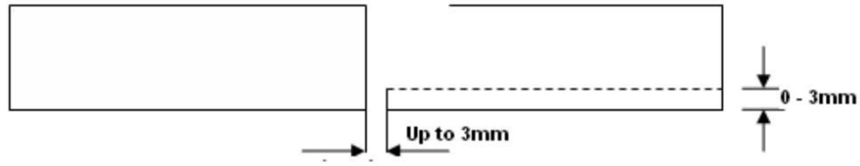
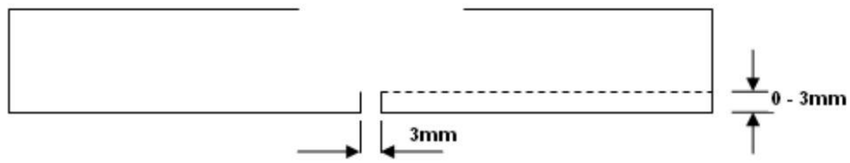
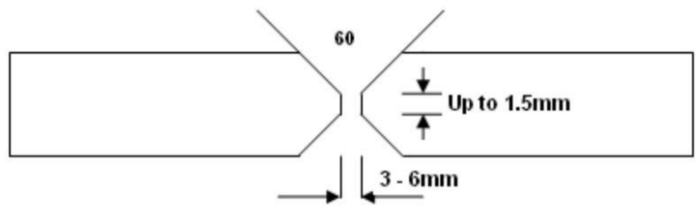
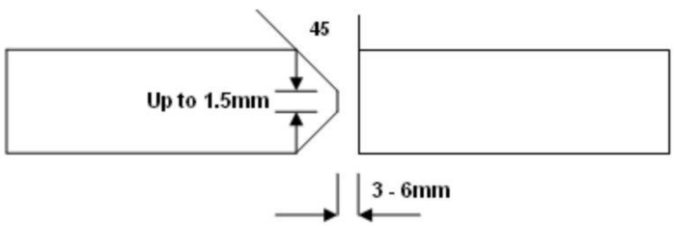
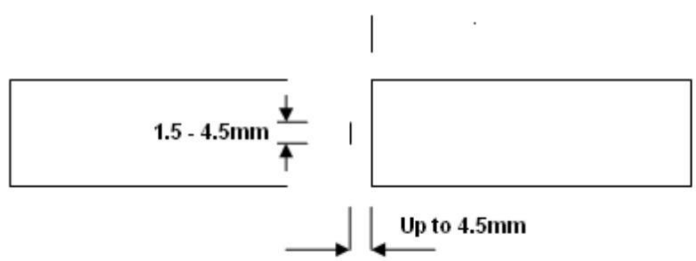
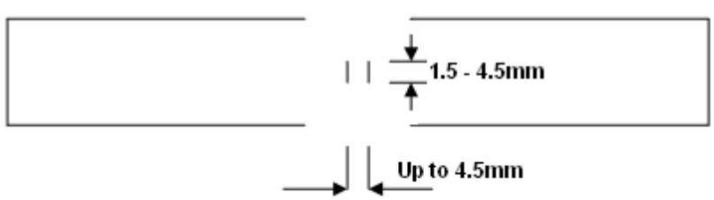
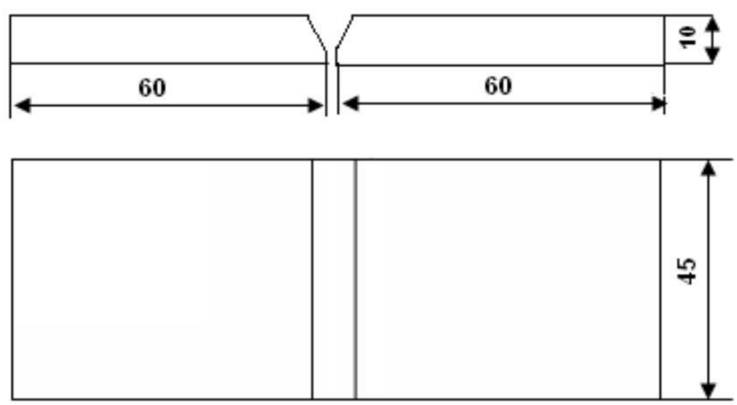
| 4. single J |  | 12 - 35 |
| 5. Single U |  | 10 -25 |
| 6. Double Vee |  | 10 - 50 |
| 7. Double Bevel |  | 10 -35 |
| 8. Double J |  | 15 - 50 |
| 9. Double U |  | 12 and above |

**Selection of Welding Joint:**

The selection of a suitable joint for a particular type of weldment depends upon the following factors:

- Base plate thickness
- Geometry of structure
- Magnitude of loading
- Type of loading, i.e. tension, shear, impact, bending etc..
- Cost of joint preparation
- Number of passes
- Electrode consumption
- Chances and magnitude of distortion
- Ease of welding

**PROCEDURE:**




V - BUTT JOINT

6. The edge of the given material is prepared to the required V-shape using grinding machine.
7. The machine is set to the required current (75 amps).
8. Place the two work pieces on the table with required position as shown in figure.
9. The work pieces are kept in the required position and tack welding is performed on the work pieces.
10. First run of welding is done to fill the gap and penetration of the weld ment by holding the electrode at about $70^0$ and moving the electrode to another end uniformly.

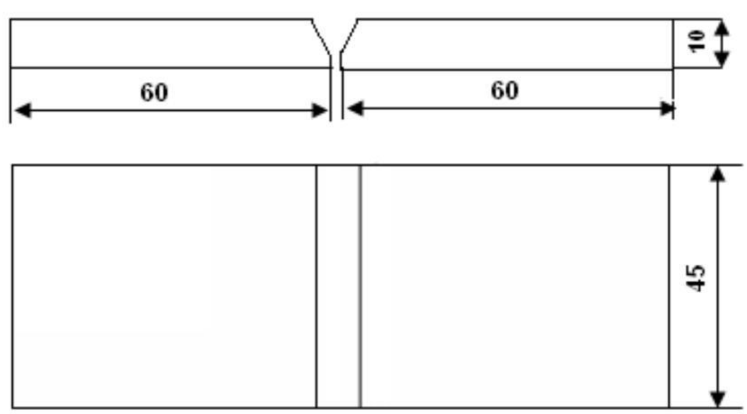
11. Second run of welding is done with proper weaving and uniform movement.

12. The scale formed is chipped with chipping hammer.
13. Filing is done to remove any spatter around the weld.

**PRECAUTIONS:**

1. Never look at the arc with the naked eye.  Always use a shield while welding.
2. Always wear the safety hand gloves, apron and leather shoes.
3. Ensure proper insulation of the cables and check for openings.
4. Care is taken to avoid arc blow, which will cause serious defect in the weldment.
5. Inflammable and combustible materials are removed from the vicinity of welding operations.

**RESULT:**




V - BUTT JOINT

## EXPERIMENT-II
# ARC WELDING (LAP JOINT)

**AIM:** Prepare a Lap Joint using Arc Welding Process.

**APPARATUS REQUIRED:** Wire Brush, Grinding Machine, Protective Equipment, Welding Transformer, Electrodes, Tong, Chipping Hammer

**MATERIAL REQUIRED:** Mild steel flat of 50 x45 x 10 $mm^3$ – 2 No's.

**THEORY:**

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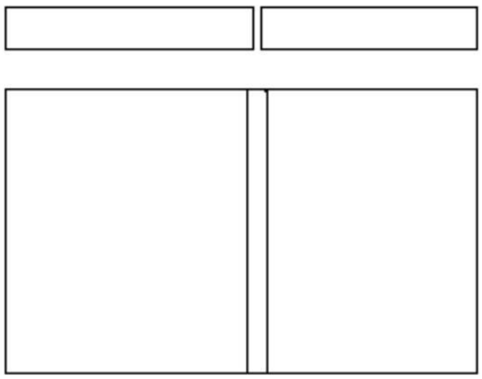
**Types of Welding Joints:**

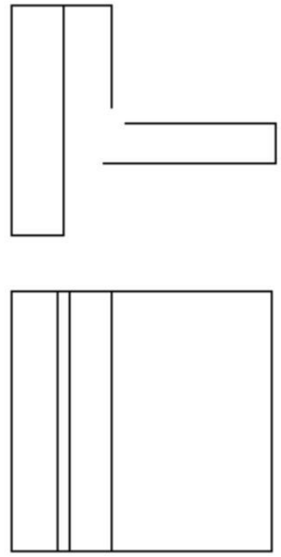
While designing for welding it appears both logical and fundamental to first consider the various forms of weld joints. A joint indicates the position where two or more members of a structure meet and are to be joined by welding.

**Classification**:

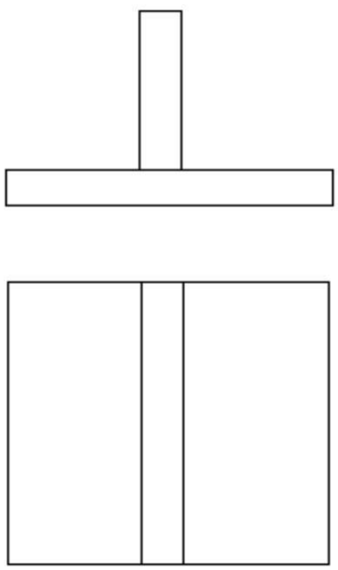
- Butt Joint
- Edge Joint
- Tee Joint
- Corner Joint
- Lap Joint



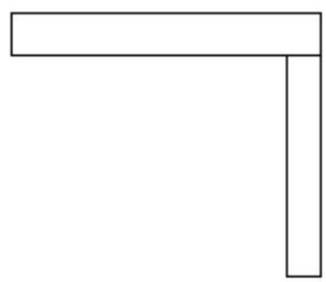
BUTT JOINT



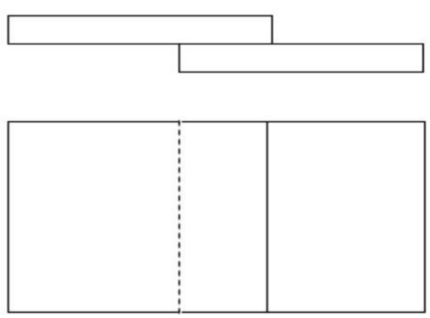
EDGE JOINT



TEE JOINT



CORNER JOINT

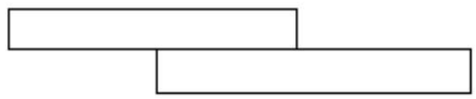


LAP JOINT

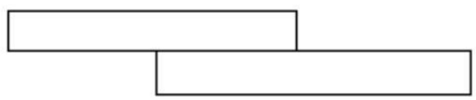
**Lap Joints**:

Single fillet and double fillet joints (shown in fig) are used on all thicknesses; double fillet joint is better as compared to single fillet when the joint is subjected to severe loading. Single fillet joints are not recommended on plates under bending, fatigue or impact loading conditions.

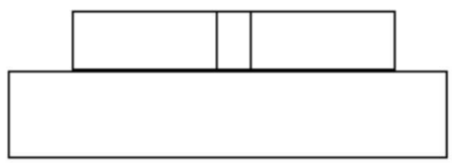
Plug weld (shown in fig) may be made without or with a hole in the upper member. This joint is used where bottom or second plate is not easily accessible for fillet welding. Plug weld can be employed to impart added strength to the structure.



Single Fillet

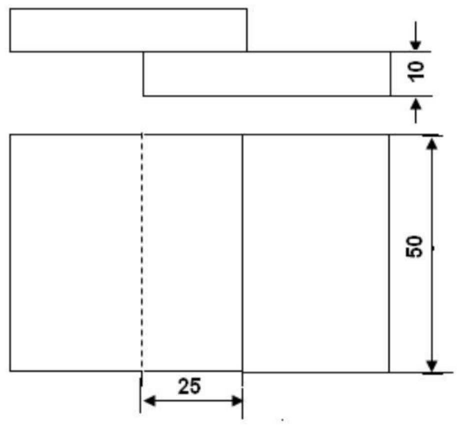


Double Fillet



Plug Weld

**PROCEDURE:**




LAP JOINT

1. The edges of the given material is prepared using wire brush and finish the same grinding machine to remove the rust and scales presented on the edges.
2. The machine is set to the required current (75 amps).
3. Place the two work pieces on the table with required position as shown in figure.
4. The work pieces are kept in the required position and tack welding is performed on the work pieces.
5. First run of welding is done to fill the gap and penetration of the weldment by holding the electrode at about $70^0$ and moving the electrode to another end uniformly.
6. Second run of welding is done with proper weaving and uniform movement.
7. The scale formed is chipped with chipping hammer.
8. Filing is done to remove any spatter around the weld.

**PRECAUTIONS:**

1. Never look at the arc with the naked eye. Always use a shield while welding.
2. Always wear the safety hand gloves, apron and leather shoes.
3. Ensure proper insulation of the cables and check for openings.
4. Care is taken to avoid arc blow, which will cause serious defect in the weldment.
5. Inflammable and combustible materials are removed from the vicinity of welding operations.

**RESULT:**

## EXPERIMENT-III

## SPOT WELDING (LAP JOINT)

**AIM:** To prepare a lap Joint on the given work pieces using spot welding equipment.

**MATERIAL REQUIRED** : GI Sheet of 50 x 50 mm --- 2 Nos.

**APPARATUS REQUIRED** : Spot Welding Equipment, Snips and Gloves

**THEORY:**

In resistance welding (RW) a low voltage (typically IV) and very high current (typically 15,000 A) is passed through the joint for a very short time (typically 0.25 s). This high amperage heats the joint, due to the contact resistance of the joint and melts it. The pressure on the joint is continuously maintained and the metal fuses together under this pressure. The heat generated in resistance welding can be expressed as

$$H = k I^2 R t$$

Where H = the total heat generated in the work, J

$I$ = electric current, A

$t$ = time for which the electric current is passing through the joint, s

$r$ = the resistance of the joint, ohms

and $k$ = a constant to account for the heat losses from the welded joint.

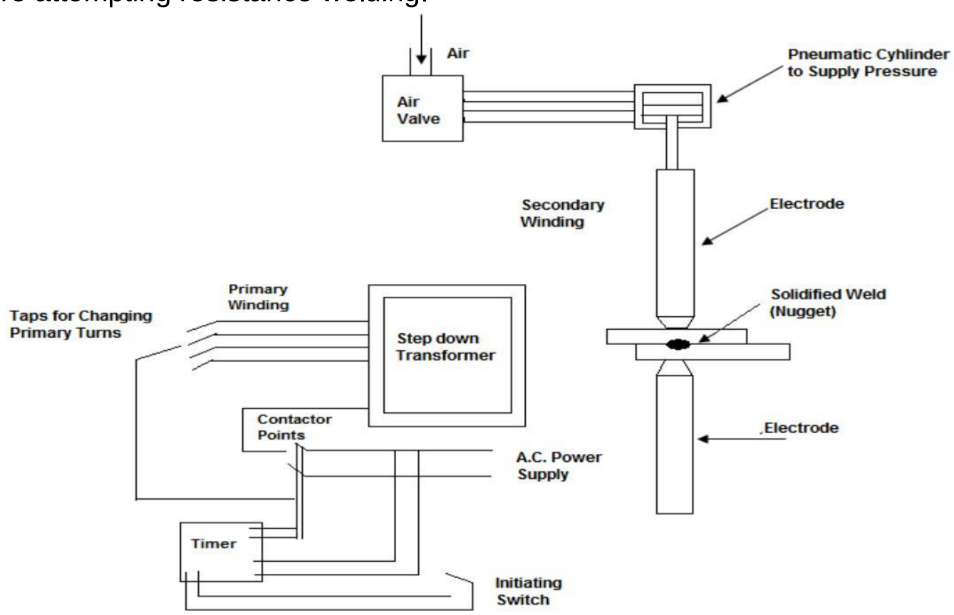
The resistance of the joint, $R$ is a complex factor to know because it is composed of

i. The resistance of the electrodes,
ii. The contact resistance between the electrode and the work piece,
iii. The contact resistance between the two work piece plates,
iv. The resistance of the work piece plates.

The amount of heat released is directly proportional to the resistance. It is likely to be released at all of the above-mentioned points, but the only place where a large amount of heat is to be generated to have an effective fusion is at the interface between the two work piece plates. Therefore, the rest of the component resistances should be made as small as possible, since the heat released at those places would not aid in the welding.

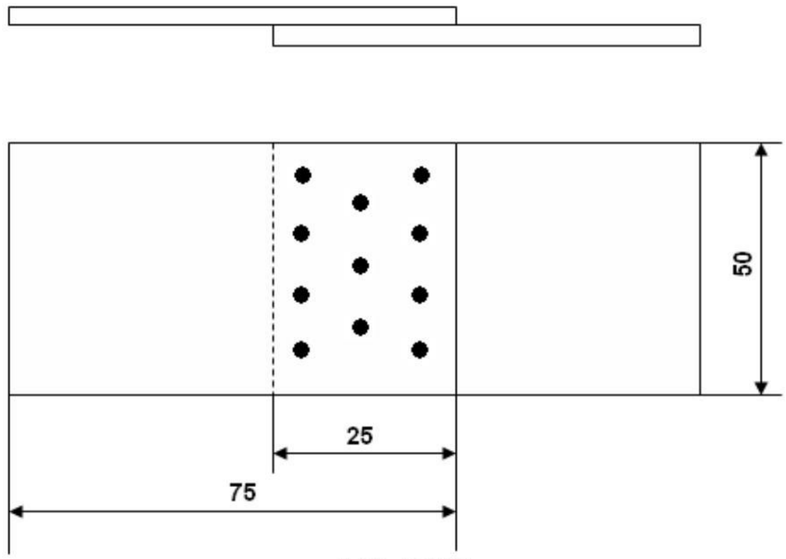
Because of the squaring in the above, equation, the current, i needs to be precisely controlled for any proper joint. The main requirement of the process is the low voltage and high current power supply. This is obtained by means of a step down transformer with a provision to have different tappings on the primary side, as required for different materials. The secondary windings are connected to the electrodes which are made of copper to reduce their electrical resistance. The time of the electric supply needs to be closely controlled so that the heat released is just enough to melt the joint and the subsequent fusion takes place due to the force (forge welding) on the joint. The force required can be provided either mechanically, hydraulically or pneumatically. To precisely control the time, sophisticated electronic timers are available.

The critical variable in a resistance welding process is the contact resistance between the two work piece plates and their resistances themselves. The contact resistance is affected by the surface finish on the plates, since the rougher surfaces have higher contact resistance. The contact resistance also will be affected by the cleanliness of the surface. Oxides or other contaminants if present should be removed before attempting resistance welding.




RESISTANCE WELDING SETUP

**PROCEDURE:**




LAP JOINT

1. The two pieces to be joined by spot welding are placed between the two electrodes in the required position.
2. Set the timer for which the current flows through the electrodes with reference to the thickness of the plates
3. Press the foot lever, so that the movable electrode moves towards the fixed electrode.
4. This causes to develop a pressure of about 200-1000 Kg / $cm^2$ on the sheets.
5. A low voltage and very high current is passed through the joint for a very short time. The duration of the current flow is for about 2 sec (This high amperage heats the joint, due to contact resistance at the joint and melts it).
6. Then the metal under electrodes pressure is squeezed and welded
7. Pressure is then released and the process is repeated until the job is completed.
8. The welding is carried out in a regular pattern as shown in fig.

**PRECAUTIONS:**

1. Proper pressure should be applied on the electrodes.
2. Correct electrode diameter needs to be chosen depending on the material thickness to be joined.
3. Proper weld time should be selected for welding.

## EXPERIMENT-IV

# TUNGSTEN INERT GAS (TIG) WELDING

**AIM:** To prepare a V – Butt Joint Using TIG Welding.

**MATERIAL AND APPARATUS REQUIRED**: MS flat 50 x 60 X 10 $mm^3$ ---2 No.s Tong, Chipping Hammer, goggles Tungsten Electrode, Ceramic Nozzle and Filler rod.

**EQUIPMENT REQUIRED**: Transformer, Rectifier and Argon gas cylinder.

**THEORY:**

The Endeavour of welder is always to obtain a joint which is as strong as the base metal and at the same time, the joint is as homogeneous as possible. To this end, the complete exclusion of oxygen and other gases which interfere with the weld pool to the detriment of weld quality is very essential. In manual metal arc welding, the use of stick electrodes does this job to some extent but not fully. In inert gas shielded arc welding processes, a high pressure inert gas flowing around the electrode while welding would physically displace all the atmospheric gases around the weld metal to fully protect it.

The shielding gases most commonly used are argon, helium, carbon dioxide and mixtures of them. Argon and helium are completely inert and therefore they provide completely inert atmosphere around the puddle, when used at sufficient pressure. Any contaminations in these gases would decrease the weld quality.

*Argon* is normally preferred over helium because of a number of specific advantages. It requires a lower arc voltage, allows for easier arc starting and provides a smooth arc action. A longer arc can be maintained with argon, since arc voltage does not vary appreciably with arc length.

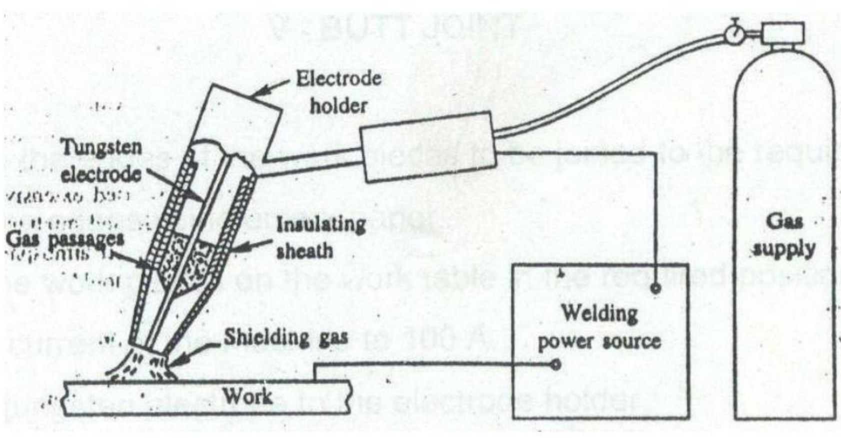
It is more economical in operation. Argon is particularly useful for welding thin sheets and for out of position welding.

The main advantage of *Helium* is that it can with stand the higher arc voltages. As a result it is used in the welding where higher heat input is required, such as for thick sheets or for higher thermal conductivity materials such as copper or aluminium. *Carbon dioxide* is the most economical of all the shielding gases. Both argon and helium can be used with AC as well as DC welding power sources. However, carbon dioxide is normally used with only DC with electrode positive.

**TUNGSTEN INERT GAS(TIG) WELDING**:

Tungsten inert gas (TIG) welding is as inert gas shielded arc welding process using non consumable electrode. The electrode may also contain 1 to 2% thoria mixed along with core tungsten or tungsten with 0.15 to 0.4% zirconia. The pure tungsten electrodes are less expensive but will carry less current. The thoriated tungsten electrodes carry high currents and are more desirable because they can strike and maintain stable arc with relative ease. The zirconia added tungsten electrodes are better than pure tungsten but inferior to thoriated tungsten electrodes.

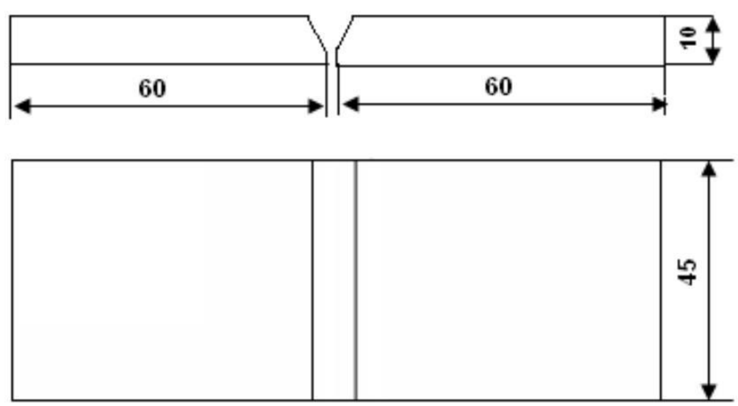
A typical TIG welding setup is shown in fig.



It consists of a welding torch at the centre of which is the tungsten electrode. The inert gas is supplied to the welding zone through the annular path surrounding the tungsten electrode to effectively displace the atmosphere around the weld puddle. The TIG welding process can be used for the joining of a number of materials though the most common ones are aluminium, magnesium and stainless steel.

The power sources used are always the constant current type. Both DC and AC power supplies can be used for TIG welding. When DC is used, the electrode can be negative (DCEN) or positive (DCEP). With DCEP is normally used for welding thin metals where as fro deeper penetration welds DCEN is used. An Ac arc welding is likely to give rise to a higher penetration than that of DCEP.

**PROCEDURE:**




V - BUTT JOINT

- Prepare the edges of the work pieces to be joined to the required V shape.
- Finish the edges using emery paper.
- Place the work pieces on the work table in the required position.
- Set the current of the machine to 100 A.
- Fix the tungsten electrode to the electrode holder.
- Required size of the nozzle is selected and it is fixed to the torch.

- Adjust the inert gas flow rate to the required rate.
- Select the filler rod (same as base metals) of required diameter.
- Touch the electrode to the work, so that current flow will be established and then separated by a small distance and the arc will be generated.
- First tack weld is done on the work pieces.
- Move the electrode slowly along the length of the joint with the filler rod, so that the filler metal will be deposited in the joint.
- Repeat the operation for the second pass, so that required amount of filler metal will be deposited on the work pieces.

**PRECAUTIONS:**

1. Never look at the arc with the naked eye. Always use a shield while welding.
2. Always wear the safety hand gloves, apron and leather shoes.
3. Ensure proper insulation of the cables and check for openings.
4. Select the parameters of the machine properly based on the metals to be welded.
5. Set these parameters properly before performing the operation.
6. Inflammable and combustible materials are removed from the vicinity of welding operations.

**RESULT:**

## EXPERIMENT-V

# PATTERN DESIGN AND MAKING

**AIM**: To Design and Manufacture a Wooden Pattern for a given Casting.

**MATERIAL REQUIRED**: Teak wood of 50 x 50 x 130 $mm^3$

**EQUIPMENT AND TOOLS REQUIRED**: Wood Turning Lathe, Vernier Calipers, Spanner, chuck spanner, and Single Point Cutting tool, Emery Paper

**THEORY**:

- A pattern is a mold forming tool in the hands of foundry men.
- Except for the various allowances a pattern exactly resembles the casting to be made.
- A pattern may be defined as a model or form around which sand is packed to give rise to a cavity known as mould cavity in which when molten metal is poured, the result is CAST OBJECT.

***<u>Functions of a Pattern:</u>***

- A pattern prepares a mold cavity for the purpose of making a casting.
- A pattern may contain projections known as core prints if the casting requires a core and need to be hallow.
- Runner, gates and risers (used for introducing and feeding molten metal to the mold cavity) may form the part of the pattern.
- A pattern may help in establishing locating points on the mold and therefore on the casting with a purpose to check the casting dimensions.
- Pattern establishes the parting line and parting surfaces in the mold.
- Patterns properly made and having finished and smooth surfaces reduce casting defects.
- Properly constructed patterns minimize overall cost of the castings.

***Pattern Materials:***

The following factors assist in selecting proper pattern material:

The number of castings to be produced. Metal patterns are preferred when the production quantity is large.

1. The dimensional accuracy and surface finish required for the castings.
2. Nature of molding process i.e., sand casting, permanent mold casting, shell molding, investment casting etc. Sand castings can be produced with the help of wooden patterns whereas investment castings needs wax patterns.
3. Method of molding i.e., hand or machine molding.
4. Shape, complexity and size of the pattern.
5. Casting design parameters (i.e., minimum section thickness) and the complexity of the cast part.
6. Type of the molding materials i.e., sand etc.
7. The chances of repeat orders.

***Materials for making patterns***:

Patterns may be constructed of the following materials. The different materials have their own advantages, limitations and the field of applications.

(a) Wood (b) Metal

(c) Plastic (d) plaster and

(e) Wax.

***Allowances***:

A pattern is always larger in size when compared to normal casting, because it carries certain allowances due to mechanical reasons and metallurgical reasons for example, shrinkage allowance is the result of metallurgical phenomenon whereas machining, draft, distortion, shake and other allowances are provided on the patterns because of mechanical reasons.

The various pattern allowances are:

(a) Shrinkage or contraction allowance.

(b) Machining or finishing allowance.

(c) Draft or topper allowance.

(d) Distortion or camber allowance.

(e) Shake or rapping allowance.

Shrinkage Allowance:

All most all cast metals shrink or contract volumetrically after solidification and therefore the pattern to be obtain a particular sized casting is made oversize by an amount equal to that of shrinkage or contraction. Different metals shrink at different rates because shrinkage is the property of the cast metal or alloy. The metal shrinkage depends upon the cast metal or alloy, pouring temperature of the metal or alloy, casting dimensions (size), and Molding conditions (i.e., mold materials and molding methods employed).

Machine Allowance:

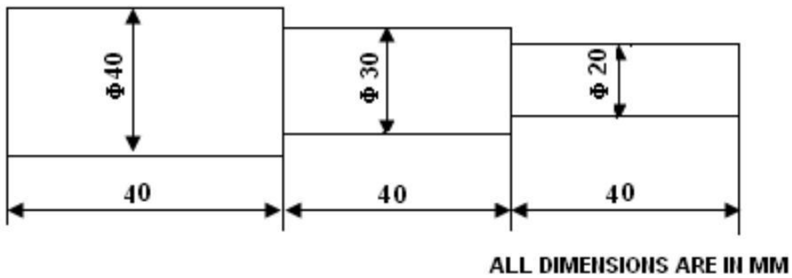
- A castings is given an allowance for machining, because Castings get oxidized in the mold and during heat treatment; scales etc., thus formed need to be removed.
- It is intended to remove surface roughness and other imperfections from the castings. It is required to achieve exact casting dimensions.
- Surface finish is required on the casting.

The above factors necessitate the provision of extra metal on the castings or the Machining/allowance. How much extra metal or how much machining allowance should be provided, depends upon the factors listed below:

- Nature of metal i.e., ferrous or non ferrous. Ferrous metals get scared while nonferrous metals do not.
- Size and shape of the casting. Long castings tend to warp and need more material (i.e., allowance) to be added to ensure that after machining the casting will be alright.
- The type of machining operation (i.e., grinding, milling, turning, boring etc).
- Casting conditions i.e., whether casting conditions result in a rough casting or a semi finished one.
- Molding process employed. Die casting produces parts which need little machining allowance whereas parts sand cast, require more machining allowance.
- Number of cuts to be taken. Machining allowance is directly proportional to the number of cuts required for finishing the casting.
- The degree of surface finish desired on the cast part.

**Problem**:

Design a Pattern for the casting shown in fig. which is to be made of steel by considering shrinkage and machining allowance.




<u>**Solution**</u>:

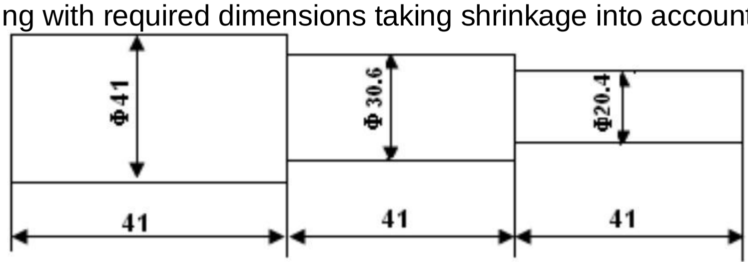
For Steel <u>Shrinkage Allowance</u> is 21mm/m.

For dimension 40, allowance is 40 x 21/1000 = 0.84 ~ 1.0

For dimension 30, allowance is 30 x 21/1000 = 0.63

For dimension 20, allowance is 20 x 21/1000 = 0.42

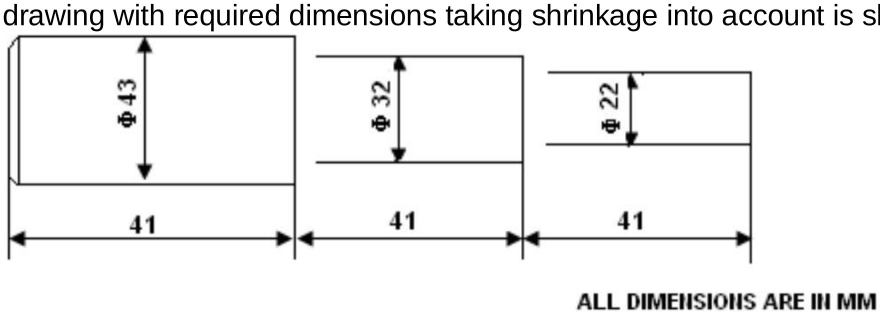
The pattern drawing with required dimensions taking shrinkage into account is shown in fig.




<u>Machining Allowance</u>:

Assume 2mm allowance on larger diameter size, 1.4mm on 30mm diameter size and 1.6mm on smaller diameter size.

The pattern drawing with required dimensions taking shrinkage into account is shown in fig.



**PATTERN MAKING**

**PROCEDURE:**

1. The work piece is fixed between live centre and dead center of wood working lathe.
2. Adjust the machine to run the job to a required cutting speed.
3. Fix the cutting tool in the tool post and make sure that the axis of the job coincides with the tip of the cutting tool.
4. Give the depth of cut and feed to the cutting tool.
5. Plain turning operation is performed until the diameter of the work piece reduces to 43 mm.
6. Step turning operation is performed according to the given dimensions.
7. Perform shoulder turning operation according to the dimensions shown in fig.
8. Frequently check the dimensions by using vernier calipers.
9. Finish the work piece using emery paper.

**PRECAUTIONS**:

1. The work piece should be held rigidly between the two centers before operating the machine.
2. Tool should be properly ground, fixed at correct height and properly secured, and work also be firmly secured.
3. Optimum machining conditions should be maintained.

**RESULT:**

## EXPERIMENT-VI

# PATTERN DESIGN AND MAKING

**AIM**: To Design and Manufacture a Wooden Pattern for a given Casting.

**MATERIAL REQUIRED**: Teak wood of 70 x 70 x 70 $mm^3$

**EQUIPMENT AND TOOLS REQUIRED**: Hack Saw, Jack Plane, Steel Rule, Wood Working Lathe, Drill bit, Boring Tool, Vernier Calipers and Emery Paper.

**THEORY**:

- A pattern is a mold forming tool in the hands of foundry men.
- A pattern is the model or the replica of the object to cast.
- Except for the various allowances a pattern exactly resembles the casting to be made.
- A pattern may be defined as a model or form around which sand is packed to give rise to a cavity known as mould cavity in which when molten metal is poured, the result is CAST OBJECT.

***Functions of a Pattern:***

- A pattern prepares a mold cavity for the purpose of making a casting.
- A pattern may contain projections known as core prints if the casting requires a core and need to be hallow.
- Runner, gates and risers (used for introducing and feeding molten metal to the mold cavity) may form the part of the pattern.
- A pattern may help in establishing locating points on the mold and therefore on the casting with a purpose to check the casting dimensions.
- Pattern establishes the parting line and parting surfaces in the mold.
- Patterns properly made and having finished and smooth surfaces reduce casting defects.
- Properly constructed patterns minimize overall cost of the castings.

Pattern Making Machines:

Besides the hand tools, a modern pattern makers shop needs some power-driven machines also. These machines help the pattern maker in

- Increasing production.
- Improving accuracy and maintaining consistency in the patterns.

- Performing many more operations easily and conveniently.

The following tools are used for different purposes by a pattern maker.

(a) Measuring, Making and Layout Tools

(i) Steel rule
(ii) Shrinkage rule
(ii) Caliper
(iv) Divider
(v) Marking gauge
(vi) Trammels
(vii) Try square
(viii) T-bevel
(ix) Combination square.

(b) Tools for clamping purposes:

(i) Hand vice
(ii) Pattern makers vice
(iii) Bar clamp
(iv) C-clamp
(v) Hand screw
(vi) Pinch dog ( to hold wooden pieces together for joining etc.).

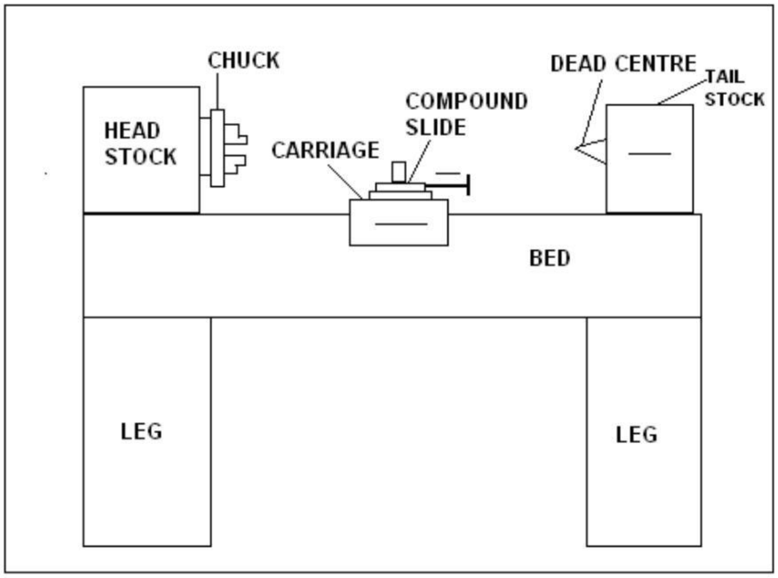
(c) Sawing Tools:

(i) Coping saw
(ii) Bow saw
(iii) Compass saw
(iv) Rip saw
(v) Crosscut saw
(vi) panel saw
(vii) Back saw
(viii) Dovetail saw
(ix) Miter saw with miter box.

*Wood Working Lathe*:

The woodworking lathe is one of the most important machines used in a carpentry shop. This is employed primarily for turning jobs in making cylindrical parts. However, by suitably manipulating the tools, tapers, radii, and other irregular shapes can also be easily turned.

It resembles the „engine lathe" most frequently used in the machine shop and consists of a cast iron bed, a head stock, tail stock, tool rest, live and dead centers, and a speed control device (shown in Fig). The drive, in modern lathes, is individual motor driven; and a cone pulley on the head stock spindle is connected by a belt to a cone pulley on the motor shaft.



BLOCK DIAGRAM OF A WOOD WORKING LATHE

In practice, the work piece is either clamped between two centers or on a face plate. Long jobs are held between the centers and turned with the help of gouge, skew chisel, parting tool, etc. Generally, the lathe is supplied together with a number of accessories for making it useful for a variety of jobs. The size of a woodworking lathe, as in the engine lathe, is usually specified in terms of the so-called “swing” of the lathe and the maximum distance between centers.

***Allowances***:

A pattern is always larger in size when compared to normal casting, because it carries certain allowances due to mechanical reasons and metallurgical reasons for example, shrinkage allowance is the result of metallurgical phenomenon whereas machining, draft, and other allowances are provided on the patterns because of mechanical reasons.

The various pattern allowances are:

(a) Shrinkage or contraction allowance.
(b) Machining or finishing allowance.
(c) Draft or topper allowance.
(d) Distortion or camber allowance.
(e) Shake or rapping allowance.

## Draft or Taper Allowance

It is given to all surfaces perpendicular to the parting line. Draft allowance is given so that pattern can be easily removed from molding material which is tightly packed around it with out damaging the mold cavity. The amount of Taper depends upon

- Shape and size (length) of the pattern in the depth direction in contact with the mold cavity.
- Molding methods.
- Mold materials.

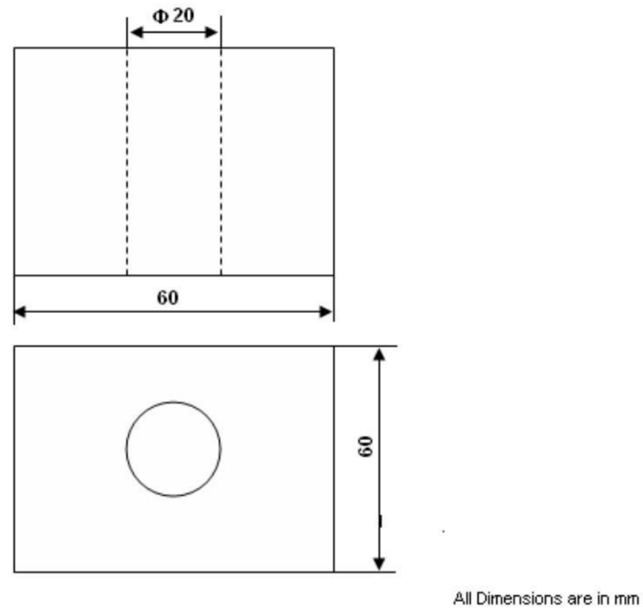
Draft allowance is imparted on internal as well as external surfaces; of course it is more on internal surfaces.

Taper on external surfaces = 10 to 25 mm/meter or $1^0$ - $2^0$.

Taper on internal surfaces = 40 to 65 mm/meter or $3^0$ – $4^0$.

**Problem**:

Design a Pattern for the casting shown in fig. which is to be made of steel by considering Shrinkage and Draft allowance.



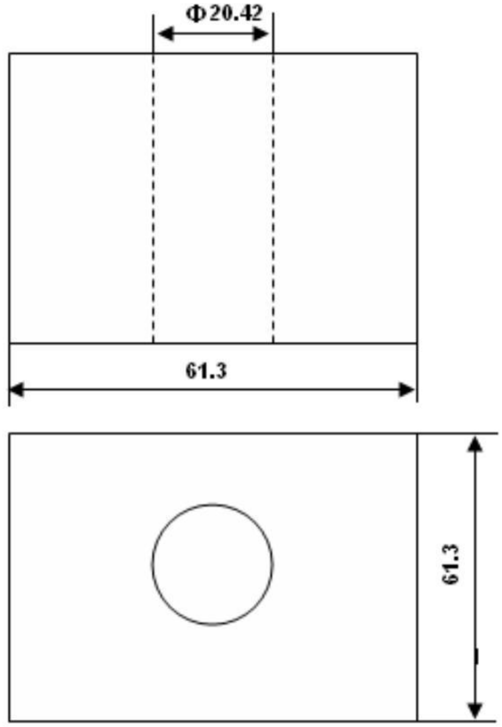

**Solution**:

For Steel Shrinkage Allowance is 21mm/m.

For dimension 60, allowance is 60 x 21/1000 = 1.26 ~ 1.3

For dimension 20, allowance is 20 x 21/1000 = 0.42

The pattern drawing with required dimensions taking shrinkage into account is shown in fig.




All Dimensions are in mm

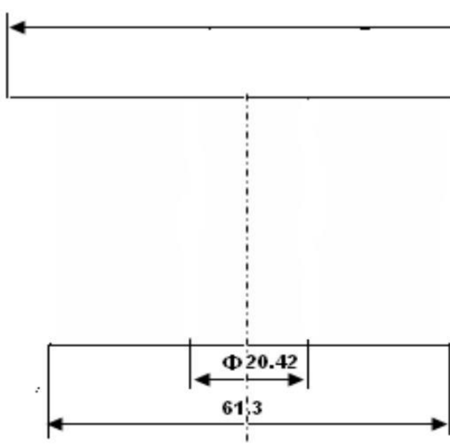
*Draft Allowance*:

Assume $2^0$ taper for external details and $4^0$ for internal details. For the above casting taper required is

External = 61.3 x tan $2^0$ = 2.14 mm.

Internal = 61.3 x tan $4^0$ = 4.3 mm.

After providing this taper the pattern drawing is as shown in fig. The procedure for preparing the pattern is given below.



**PROCEDURE**:

1. The given work piece is prepared using the Jack plane.
2. The work piece is cut by using sawing tools according to the dimensions shown in fig 2 & 3.
3. Finish the same using wood rasp file
4. Fix the work piece on wood working lathe.
5. Fix a drill of required diameter in the tail stock.
6. Perform drilling operation according to the dimensions shown in fig 2.
7. Fix a boring tool in tool post.
8. Swivel the compound rest to the required angle and perform boring operation according to the dimensions shown in fig3.
9. Finish the work using emery paper.

**PRECAUTIONS**:

1. The work piece should be held rigidly in the vice while performing cutting operation.
2. The work piece should be held rigidly in the chuck of lathe.
3. Make sure that the axis of drill coincides with the axis of work.
4. Optimum machining conditions should be maintained.

**RESULT**:

## EXPERIMENT-VII

# SAND PROPERTIES TESTING

**AIM**: To Determine the Grain size, Permeability and Compressive Strength of the Moulding Sand.

**APPARATUS REQUIRED**: Sieves of different numbers and cubical block

**EQUIPMENT REQUIRED**: Sieve Shaker, Permeability Apparatus and Compression Strength Testing Machine.

**MATERIAL REQUIRED**: Moulding Sand.

**THEORY:**

**PROPERTIES OF MOULDING SAND:**

Moulding sand must possess some properties like permeability, flowability collapsibility, adhesiveness, cohesiveness or strength and refractoriness. The properties are determined not only by the chemical composition, but by the amount of clayey matter in the sand, by its moisture content, and lastly by the shape and size of the silica sand grains.

*Porosity:* Molten metal always contains a certain amount of dissolved gases, which are evolved when the metal freezes. Also, the molten metal ,coming in contact with the moist sand, generates steam or water vapour .If these gases and water vapour evolved by the moulding sand do not find opportunity to escape completely through the mould they will form gas holes and pores in the casting. The sand must, therefore, be sufficiently porous to allow the gases or moisture present or generated with in the moulds to be removed freely. When the moulds are poured. This property of sand is called porosity or permeability.

*Flowability*: Flowability of moulding sand refers to its ability to behave like a fluid so that, when rammed it will flow to all portions of a mould and pack all-round the pattern and take up the required shape. The sand should respond to different moulding processes. Flowability increases as clay and water content increases.

*Collapsibility*: After the molten metal in the mould gets solidified the sand mould must be collapsible so that free contraction of the metal occurs, and this would naturally avoid the tearing or cracking of the contracting metal.

*Adhesiveness*: The sand particles must be capable of adhering to another body, i.e.. they should cling to the sides of the moulding boxes. It is due to this property that the sand mass can be successfully held in a moulding box and it does not fall out of the box when it is removed.

*Cohesiveness or Strength*: This is the ability of sand particles to stick together. Insufficient strength may lead to a collapse in the mould or its partial destruction during conveying, turning over or closing. The closing may also be damaged during pouring the molten metal. The strength of moulding sand must, therefore, be sufficient to permit the mould to be formed to the desired shape and to retain this shape even after the hot metal is poured in the mould. This property of sand in its green or moist state is known as green strength. A mould having adequate green strength will retain its shape and will not distort or collapse even after the pattern is removed from moulding box. The strength of sand that has been dried or baked is called dry strength .It must have then strength to withstand erosive forces due to molten metal, and retain its shape.

*Refractoriness*:-The sand must be capable of withstanding the high temperature of the molten metal with out fusing. Moulding sands with poor refractoriness may burn on to the casting. Refractoriness is measure by the sinter point of the sand rather than its melting point.

## SAND TESTING:

### Grain Size:

Grain size of sand is designated by a number called "Grain Fineness Number" that indicates the average size as well as proportions of smaller and larger grains in the mixture.

- The apparatus required for determining grain fineness consists of a number of standard sieves mounted one above the other, on a power driven shaker. The shaker vibrates the sieves and the sand placed on the top sieve gets screened and collects on different sieves depending upon the various sizes of grains present in the moulding sand.

- In this test place five standard sieves mounted one above the other on a stand and under the bottom most sieve is placed a pan. The top sieve is the coarsest and bottom most sieve is the finest of all the sieves.
- A sample of dry sand is placed in the upper most sieve and place the sieve stand on the vibrator.
- Then vibrate the sieve stand for a definite period of time.
- An amount of sand may be retained on each sieve and same is weighed.
- Calculate the AFS grain fineness number.

**OBSERVATIONS AND CALCULATIONS**:

| Sieves – Mesh | % of Sand retained | Factor | Product of col.2 & 3 |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

AFS Grain Fineness number = $\dfrac{Sum of \Pr oducts}{Tota \ln umber of percetage of sand retained on pan and each sieve}$

**PERMEABILITY TEST:**

- 2000 cc of water held in the inverted bell jar is allowed to pass through the sand specimen.

- A situation comes when the liquid entering the specimen equals the air escaped through the specimen.
- This gives a stabilized pressure reading on the manometer and the same can be read on the vertical scale.
- Simultaneously, using as top watch the time required for 2000cc of water to pass through the sand of specimen is also recorded.

Permeability number can be determined by the following relation;

Permeability Number= $\frac{V.H}{A.P.T.}$

Where V = volume of air passed through the specimen

H = height of the specimen

A = area of the specimen

T = time taken by the air to pass through the sand

specimen P = pressure recorded by manometer.

**COMPRESSION STRENGTH TEST**:

- The specimen is held between the grips.
- Hand wheel when rotated actuates a mechanism which builds up hydraulic pressure on the specimen.
- Dial indicator fitted on the tester measures the deformation occurring in the specimen.
- As the applied load is continues, the specimen breaks at a particular load.
- At this point note down the reading of dial indicator which directly gives the compression strength of the sand.

**PRECAUTIONS**:

- For calculating grain size of sand, sand taken should be free from dirt particles.
- For calculating the compression strength, load is applied gradually on the specimen.

**RESULT:**

## EXPERIMENT-VIII
## CASTING FOR A SOLID PATTERN

**AIM**: To Prepare a Casting for the given Solid Pattern using Green Sand Moulding Processes.

**MATERIAL REQUIRED:** Moulding sand

**TOOLS REQUIRED:** Pattern, Shovel, Riddle, Rammer, Trowel, Slick, Lifter, Strike – Off bar, Draw – spike, Mallet, Moulding Boxes, Vent rod, Runner, Riser, and Swab

**THEORY**:

**MOULDING SAND**:

The principal material used in the foundry shop for moulding is the sand. This is because it possesses the properties vital for foundry purposes.

**Sources:** All sands are formed by the breaking up of rocks due to the action of natural sources such as frost, wind, rain, heat and water currents. Rocks however are very complex in their composition and sands contain most of the elements of the rocks of which they fragment. For this reason, sands in different parts of the world vary considerably. Today, sand is obtained from places which probably once were bottoms and banks of rivers and sand dunes.

***PRINCIPAL INGREDIENTS***:

The principal ingredients of moulding of sands are:

- Silica sand grains
- clay
- moisture and
- miscellaneous materials

Silica in the form of granular quartz, itself sand is the chief constituent of moulding sand. Silica sand contains from 80 to 90 percent silicon dioxide and is characterized by a high softening temperature and decomposition of granite, which is composed of feldspar and quartz. The feldspar, when decomposed, becomes clay (hydrous aluminium silicate). However, silica sand grains impart refractoriness, chemical resistivity, and permeability to the sand. They are specified according to their average size and shape.

Clay is defined as those particles of sand (under 20 microns in diameter) that fail to settle at a rate of 25mm per minute, when suspended in water. Clay consists of two ingredients: fine silt and true clay. Fine silt is a sort of foreign matter or mineral deposit and has no bonding power. It is the true clay which imparts the necessary bonding strength to the mould sand, so that the mould does not lose its shape after ramming. True clay is found to be made up of extremely minute aggregates of crystalline, usually flake-shaped, particles called clay minerals. Most moulding sands for different grades of work contain 5-20 percent clay.

Moisture, in requisite amount furnishes the bonding action of clay; it penetrates the mixture and forms a microfilm which coats the surface of flake-shaped clay particles. The bonding quality of clay depends on the maximum thickness of water film it can maintain .The bonding action is considered best if the water added is the exact quantity to form the film. On the other hand the bonding action is reduced and the mould gets weakened if the water is in excess .The water should be between 2-8percent.

Miscellaneous materials that are found in addition to silica and clay, in mouding sand are oxide of iron, limestone, magnesia, soda, and potash .The impurities should be below 2 percent.

**Gating system**:

Gating system refers to all those elements which are connected with the flow of molten metal from the ladle to the mould cavity. The various elements that are connected with a gating system are:

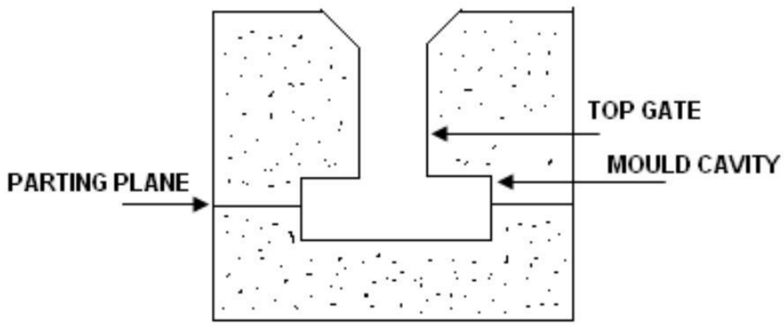
- Pouring basin
- Sprue
- Sprue base well
- Runner
- Runner extension
- Ingate
- Riser

**Gates**:

Also called the ingates, these are the openings through which the molten metal enters the mould cavity. Depending on the application, various types of gates are used in the casting design. They are:

- Top Gate
- Bottom Gate
- Parting Gate

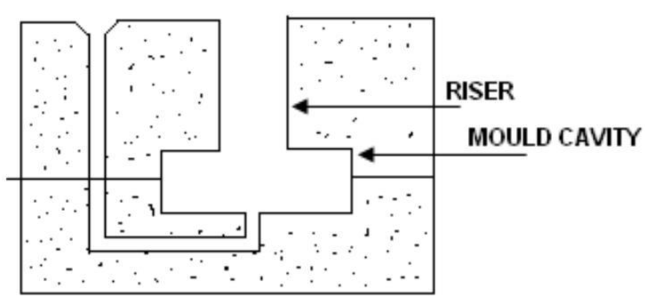
*Top Gate*:




TOP GATE

This is the type of gating through which the molten metal enters the mould cavity from the top as shown in fig. since the first metal entering the gate reaches the bottom and hotter metal is at the top, a favourable temperature gradient towards the gate is achieved. Also the mould is filled very quickly. But as the metal falls directly into the mould cavity through a height, it is likely to cause mould erosion. Also because it causes turbulence in the mould cavity it is porne to form dross and as such top gate is not advisable for those materials which are likely to form excessive dross. It is not suggested for non – ferrous alloys and is suggested only for ferrous alloys. It is suitable only for simple casting shapes which are essentially shallow in nature.

*Bottom Gate*:

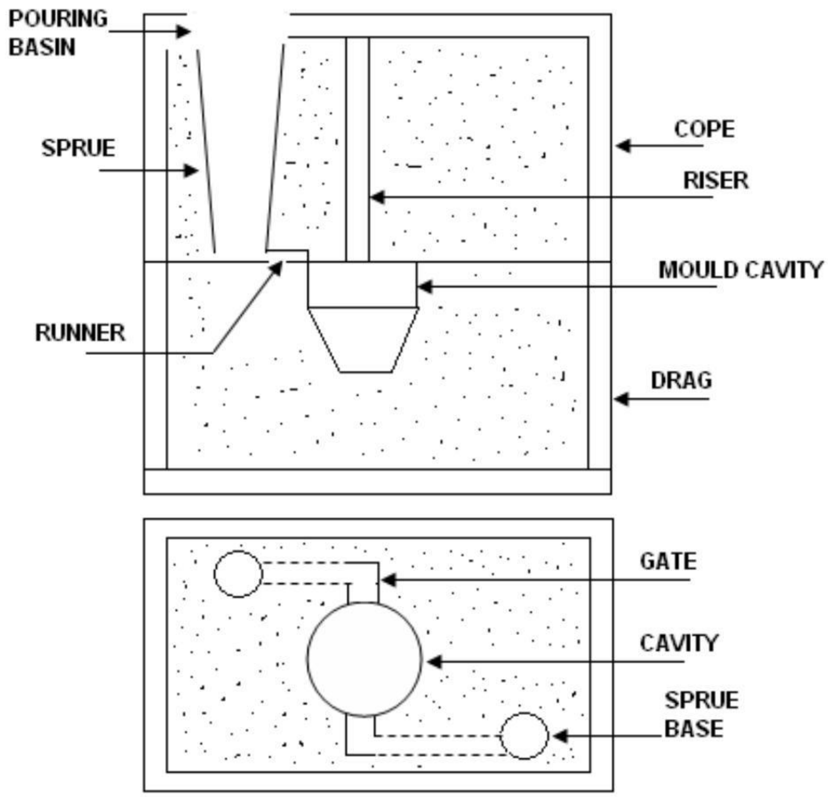



BOTTOM GATE

When molten metal enters the mould cavity slowly as shown in fig., it would not cause any mould erosion. Bottom gate is generally used for very deep moulds. It takes higher time for filling the mould and also generates a very unfavourable temperature gradient.

**PROCEDURE**:

**MAKING A GREEN SAND MOULD**:




SECTIONAL FRONT VIEW AND TOP VIEW OF A GREEN SAND MOULD

- First the pattern is placed with its larger diameter side is on a mould board.
- The drag section of the flask is set over the pattern on same board.
- After powdering the pattern with lycopodium, talc or graphite, a 15 to 20 mm layer of facing sand is riddled over the pattern.
- The drag is then filled by layers of green sand mixture from 70 to 100 mm thick, compacting each layer with rammer.

- The top of the mould is rammed with the butt end of a rammer. The object of ramming the sand is to consolidate it, there by preventing the cavity of the mould from being enlarged by the metal.

- After the sand is rammed a strickle is used to scrape off the excess sand level with the top of the flask.

- The mould is then vented by sticking it with a fine stiff wire at numerous places (The vent holes should not reach the pattern by 15 to 20 mm as otherwise they may spoil the mould. Moreover, the metal may run in to the vent holes during pouring. These vent holes permit the escape of gases generated in the mould when the molten metal comes in contact with moist sand).

- A small amount of loose sand is sprinkled over the mould and bottom board is placed on the top. The drag is rolled over, the moulding board is removed, and the upper surface is sprinkled with parting sand (The parting sand is used to prevent the joints between the halves of a mould from adhering to one another when the two parts of the moulding box are separated).

- The cope section of the flask is then assembled.

- Tapered wooden pegs to serve as sprue and riser are placed in proper position as shown in figure on the pattern which is riddled over with facing sand and then cope is filled with green sand.

- The operation of filling, ramming and venting of the cope proceed in the same manner as in the drag.

- A funnel shaped opening is scooped out at the top of the sprue to from the pouring basin.

- Next the cope is lifted off and placed on a board with the parting line upward.

- An iron bar is now pushed down to the pattern and rapped sideways .So as to loosen the pattern and prevents any sand from sticking to the pattern.

- Next pattern is drawn out using draw spike.

- Runners are cut in the cope according to the dimensions shown in fig.
- Cut the gates in the drag according to the dimensions shown ( Use Top Gating System).
- If needed all the cavity edges are repaired.
- Finally the mould is assembled, the cope being carefully placed on the drag so that the flask pins fit into the bushes.
- The mould is then ready for pouring.
- Molten metal (Aluminium) is prepared in the high frequency electrical induction furnace.
- Take the molten metal from crucible in to the ladle.
- Pour the molten metal from the ladle into the pouring basin so that the molten metal will enter into the mould cavity through the sprue, runner and gate.
- Allow the molten metal to solidify.
- Then break the mould to obtain desired casting.

**PRECAUTIONS**:

1. Care must be taken to have proper alignment of the pattern as well as moulding boxes.
2. Sand should be rammed properly and evenly.
3. The pattern should be rapped gently and with drawn carefully with out damaging the mould cavity.
4. Care should be taken to avoid over cuts and corners.
5. Care should be taken while pouring the molten metal in to the cavity.

**RESULT:**

# EXPERIMENT-1X
# CASTING FOR A SPLIT PATTERN

**AIM**: To Prepare a Alluminium Casting for the given Split Pattern using Green Sand Moulding Processes.

**MATERIAL REQUIRED:** Moulding sand

**TOOLS REQUIRED:** Pattern, Shovel, Riddle, Rammer, Trowel, Slick, Lifter, Strike – Off bar, Draw – spike, Mallet, Moulding Boxes, Vent rod, Runner, Riser, and Swab

**THEORY**:

**MOULDING SAND**:

The principal material used in the foundry shop for moulding is the sand. This is because it possesses the properties vital for foundry purposes.

**TYPES OF MOULDING SANDS:**

*GREEN SAND:* It is a mixture of silica sand with 18 to 30 percent clay, having a total water of from 6 to 8 percent. The clay and water furnish the bond for green sand. It is fine, soft, light, and porous. Being damp, when squeezed in the hand, it retains the shape, the impression given to it under pressure. Moulds prepared in this sand are known as greensand moulds.

*DRY SAND*: Green sand that has been dried or baked after the mould is made is called dry sand. They are suitable for larger castings. Moulds prepared in the sand are known as dry sand moulds.

*LOAM SA:*: Loam sand is high in clay as much as 50 percent or so and dries hard. This is particularly employed for loam moulding usually for large castings

*FACING SAND:* Facing sand forms the face of the mould. It is used directly next to the surface of the pattern and it comes into contact with the molten metal when the mould is poured. Consequently, it is subjected to the severest conditions and must possess high strength and refractoriness. It is made up silica sand and clay, with out the addition of used sand. Different forms of carbon are used to prevent the metal from burning into the sand. They are some times mixed with 6 to15 times as much fine moulding sand to make facings.

The other types of sands are Backing Sand, System Sand, Parting Sand, and Core Sand.

SAND ADDITIVES:

Additives are the materials generally added to the sand mixture to develop special properties in the mould and consequently in castings.

MISCELLANEOUS MOULDING MATERIALS: These are the moulding materials that are used in foundry procedures. They include fire clay, clay wash, parting materials and core binders.

**Gating system**:

Gating system refers to all those elements which are connected with the flow of molten metal from the ladle to the mould cavity. The various elements that are connected with a gating system are:

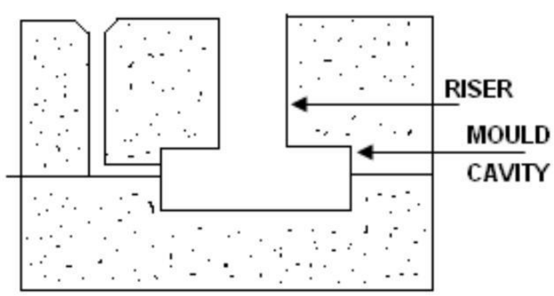
* Pouring basin
* Sprue
* Sprue base well
* Runner
* Runner extension
* Ingate
* Riser

**Gates**:

Also called the ingates, these are the openings through which the molten metal enters the mould cavity. Depending on the application, various types of gates are used in the casting design. They are:

- Top Gate *Bottom Gate *Parting Gate

*Parting Gate*:




PARTING GATE

This is the most widely used gate in sand castings. As the name implies, the metal enters the mould at the parting plane when part of the casting in the cope and a part in the drag as shown in fig. For the mould cavity in the drag, it is a top gate and for the mould cavity in the cope it is a bottom gate. Thus this type of gating tries to derive the best of both the types of gates. Of all the gates this is also the easiest and most economical in preparation. However, if the drag portion of the mould cavity is deep, it is likely to cause mould erosion and aggravate dross formation and air entrapment in the case of non ferrous alloys. This can be somewhat reduced by making the gate area large such that the liquid metal velocity is minimized and it flows slowly along the walls into the mould cavity.

**<u>Melting Furnaces and Practice:</u>**

A furnace is used to melt the metal. Different furnaces are employed for melting ferrous and non ferrous materials. A furnace contain high temperature zone surrounded by a refractory wall structure which with stands high temperatures and being insulating minimizes heat losses to the surroundings.

**Furnaces for Melting**:

1. Gray Cast Iron

   (a) Cupola (b) Air Furnace (c) Rotary Furnace (d) Electric Arc Furnace

2. Steel

   (a) Open Hearth Furnace (b) Electric Furnace (c)Converter

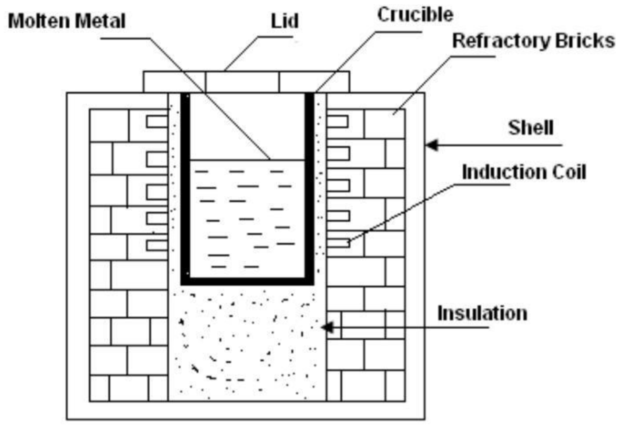
3. Non – Ferrous Metals

   (a) Crucible Furnaces (d) Pot Furnaces

   (b) Reverberatory Furnaces (e) Rotary Furnaces

   (c) Induction Furnaces (f) Electric Arc Furnaces.

**<u>Induction Furnace for Melting Aluminium</u>**: Induction furnace consists of a refractory crucible placed centrally inside water cooled copper coil and packed into position by ramming refractory bricks tightly between the crucible and copper coil which is precovered with wet refractory dried into a hard mass. Induction furnaces can be of two types:1) Tilting Type 2) Scooping type.



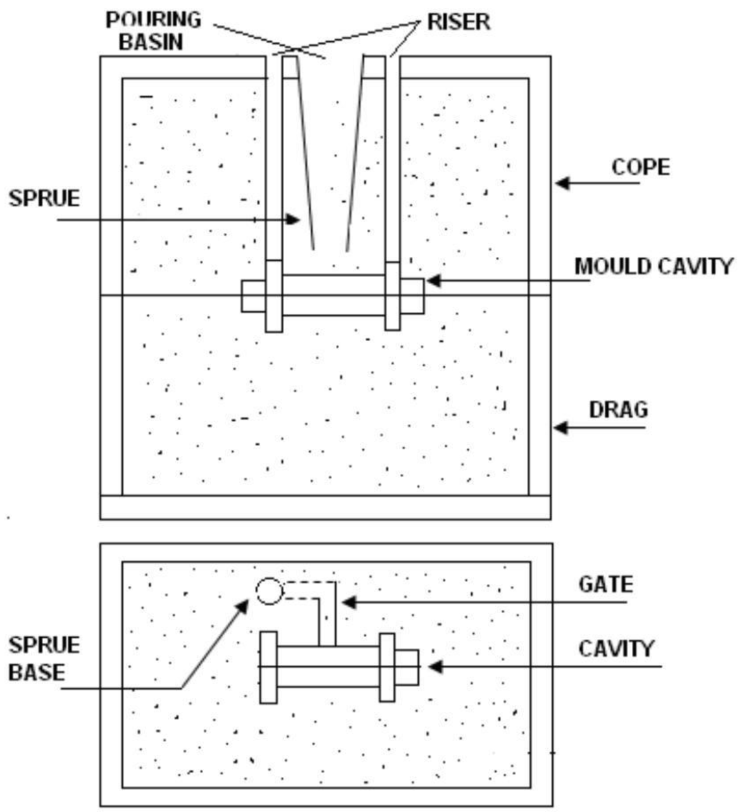

ELECTRIC INDUCTION FURNACE

*Operation*: Metal charge is placed in the crucible of furnace. A current is passed through the copper coils which act as the primary of a transformer and the metal charge becomes the secondary. Heavy alternating secondary currents thus induced in the metal charge by electromagnetic induction create heat because the metal charge offers resistance to the passage of secondary currents. This heat developed in the skin of metal charge reaches inside by conduction and melts the charge. After the melting has completed it is taken into ladles using a scoop.

**PROCEDURE**:

**MAKING A GREEN SAND MOULD**:

- To make the green-sand mould the sand must be properly tempered before it can be used. If the sand is too dry, additional water is added or if too wet, dry sand is added until it has the proper temper. To check the sand for proper temper, a handful is grasped in the first. The pressure is released, and sand is broken in two sections. The sections of sand should retain their shape and the edges of the break should be sharp and firm.
- The surface of the mould which comes in contact with molted metal forms the most important part in green-sand moulds. In order to give the casting a clean and bright surface and to prevent the sand from burning on the face of the mould a layer of facing sand is given surrounding the pattern.
- It is common practice to coat the surfaces of sand mould with refractory materiel to produce a smooth skin on the castings. The material ordinarily used for this purpose is graphite, coke, charcoal, gas carbon, etc.




MOULD FOR SPLIT PATTERN

- First one-half of the pattern is placed with its flat surface on a mould board, and the drag section of the flask is set over the pattern on same board.
- A 15 to 20 mm layer of facing sand is riddled over the pattern.
- The drag is then filled by layers of green sand mixture from 70 to 100 mm thick, compacting each layer with rammer. The top of the mould is rammed with the butt end of a rammer. The object of ramming the sand is to consolidate it, there by preventing the cavity of the mould from being enlarged by the metal.
- After the sand is rammed strike off bar is used to scrape off the excess sand level with the top of the flask.
- The mould is then vented by sticking it with a fine stiff wire at numerous places. The vent holes should not reach the pattern by 15 to 20 mm as otherwise they may spoil the mould. Moreover, the metal may run in to the vent holes during pouring. These vent holes permit the escape of gases generated in the mould when the molten metal comes in contact with moist sand.

- The drag is rolled over and the upper surface is sprinkled with parting sand. The parting sand is used to prevent the joints between the halves of a mould from adhering to one another when the two parts of the moulding box are separated.
- The remaining half of the pattern and the cope section of the flask are then assembled.
- Place the Sprues and Risers at the required places shown in fig.
- And then cope is filled with green sand.
- The operation of filling, ramming and venting of the cope proceed in the same manner as in the drag.
- Following these operations the wooden pegs are withdrawn from the cope and a funnel shaped opening is scooped out at the top of the sprue to form the basin.
- Next the cope is lifted off and placed on a board with the parting line upward.
- An iron bar is now pushed down to the pattern and rapped sideways .So as to loosen the pattern and prevents any sand from sticking to the pattern.
- Next the pattern is drawn out and the runners and gates are cut in the drag from the pattern to the sprue as shown in fig.
- Finally the mould is assembled, the cope being carefully placed on the drag so that the flask pins fit into the bushes.
- Before pouring the molten metal the cope is sufficiently loaded to prevent it from floating up when the metal is poured. The completed mould is shown in fig.
- Pour the molten metal from the ladle into the pouring basin so that the molten metal will enter into the mould cavity through the sprue, runner and gate.
- Allow the molten metal to solidify and break the mould to obtain desired casting.

**PRECAUTIONS**:

1. Care must be taken to have proper alignment of the pattern as well as boxes.
2. Sand should be rammed properly and evenly.
3. The pattern should be rapped gently and with drawn carefully with out damaging the mould cavity.
4. Care should be taken to avoid over cuts and corners.
5. Care should be taken while pouring the molten metal in to the cavity.

**RESULT:**

## EXPERIMENT-X

# STUDY OF PROGRESSIVE DIE

**AIM**: To study a progressive tool and perform blanking and piercing operations. To determine the punching force and blanking force theoretically and compare the same with obtained readings.

**TOOLS AND MATERIAL REQUIRED**: Progressive tool, Clamps and Blank.

**EQUIPMENT REQUIRED**: Hydraulic Press

**SPECIFICATIONS**:

- Capacity: 25 tons
- Distance between columns: 865x300 $mm^2$
- Distance between ram to bed: minimum 180mm and maximum 915mm
- Travel of ram: 180mm
- Power of motor: 5 H.P.

**THEORY**:

SHEET METAL WORKING OR PRESS WORKING OF SHEET METAL

Press working may be defined as a chip less manufacturing process by which various components are made from sheet metal. This process is also termed as cold stamping. A frame which supports a ram or a slide and a bed, a source of mechanism for operating the ram in line with and normal to the bed. The ram is equipped with suitable punch and a die block is attached to the bed .A stamping is produced by the down ward stroke of the ram when the punch moves towards and into the die block. The punch and die block assembly is generally termed as a"die set" or simply as a "die". Press working operations are usually done at room temperature. In this process, the wall thickness of the parts remains almost constant and differs only slightly from the thickness of the initial sheet metal. The initial material in cold press working is: low carbon steels, ductile alloy steels, copper and its alloys, aluminium and its alloys, as well as other ductile materials from $10^{th}$ of a mm to about 6 or 8 mm thick.

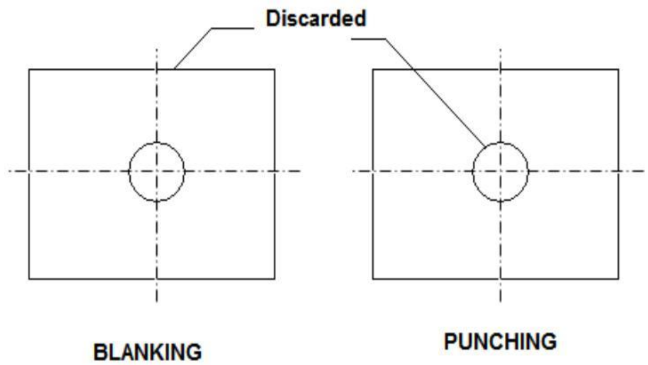
*Elastic recovery or spring back*. In metal working processes, the total deformation imparted to a work piece will be the sum of elastic deformation and plastic deformation. We also know the elastic deformation is recoverable where as plastic deformation is permanent. So, at the end of a metal working operation, when the pressure of metal is released, there is an elastic recovery by the material and the total deformation gets reduced a little. This phenomenon is called as “Springback”.This phenomenon is of more importance in cold working operations, especially in forming operations such as bending etc .Spring back depends upon the yield point strength of a metal. The higher the yield point strength of a metal, the greater the spring back. The amount of spring back for a forming operation is difficult to predict and cut- and try methods are most satisfactory to account for it. To compensate for spring back, the cold deformation must always be carried beyond the desired limit by an amount equal to the spring back.

Press operation: The sheet metal operations done on a press may be grouped into two categories, cutting operations and forming operations.

In ***cutting*** operations, the work piece is stressed beyond its ultimate strength. The stresses caused in the metal by the applied forces will be shearing stresses.

In ***forming*** operations, the stresses are below the ultimate strength of the metal. In this operation, there is no cutting of the metal but only the contour of the work piece is changed to get the desired product. The cutting operations include: blanking, punching, notching, perforating, trimming, shaving, slitting and lancing etc.The forming operations include: bending, drawing, redrawing and squeezing. The stresses induced in the metal during bending and drawing operations are tensile and compressive and during the squeezing operations these are compressive.

Blanking: Blanking is the operation of cutting a flat plate from sheet metal. The article punched out is called the „blank‟ and is the required product of the operation. The hole and metal left behind is discarded as waste. It is usually the first step of series of operations.




Punching: It is a cutting operation by which various shaped holes are made in sheet metal .Punching is similar to blanking except that in punching , the hole is the desired product , the material punched out to form the hole being waste.

Perforating: This is a process by which multiple holes which are very small and close together are cut in flat work material .

Trimming: This operation consists of cutting unwanted excess material from the periphery of a previously formed component.

Shaving: The edges of a blanked part are generally rough, uneven and un square. Accurate dimensions of the part are obtained by removing a thin strip of metal along the edges.

Slitting: It refers to the operation of making incomplete holes in a work piece.

Lancing: This is a cutting operation in which a hole is partially cut and then one side is bent down to form a sort of tab or louver. Since no metal is actually removed, there will be no scrap.

Bending: In this operation, the material in the form of flat sheet or strip is uniformly strained around a linear axis which lies in the neutral plane and perpendicular to the lengthwise direction of the sheet metal.

Drawing: This is a process of a forming a flat work piece into a hollow shape by means of a punch which causes the blank to flow into a die cavity.

**TYPES OF DIES**:

The dies may be classified according to the type of press operation and according to the method of operation.

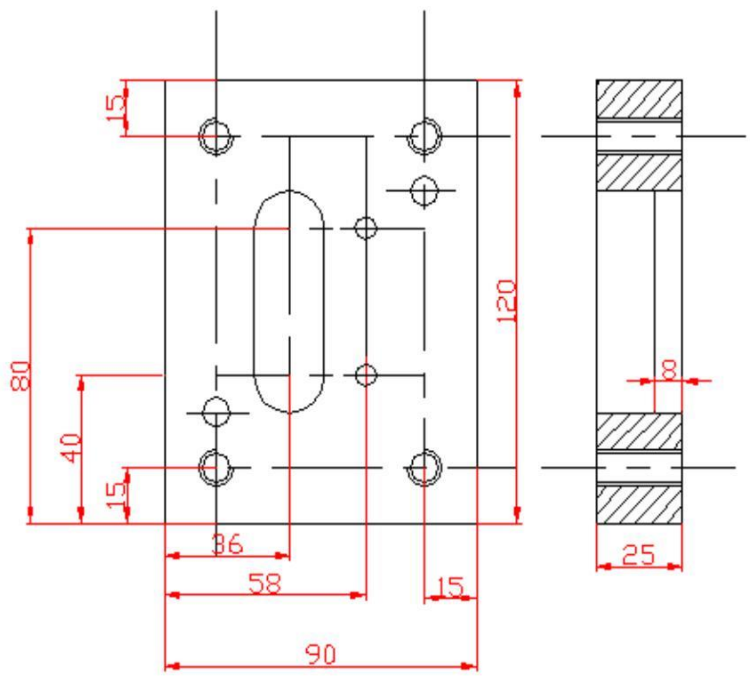
*<u>Types of press operation</u>*: According to this criterion, the dies may be classified as: cutting dies and forming dies.

<u>Cutting dies</u>: The dies are used to cut the metal. They utilize the cutting or shearing action. The common cutting dies are: blanking dies, piercing dies, perforating dies, notching, trimming, shaving dies etc.

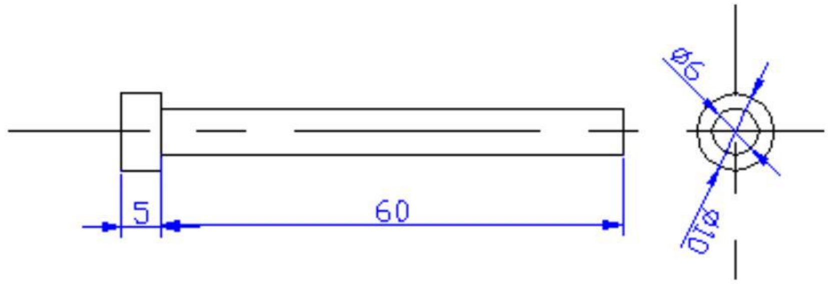
<u>Forming dies</u>: These dies change the appearance of the blank without removing any stock. These dies include bending dies, drawing dies, squeezing dies etc..

*<u>Method of operation</u>*: According to this criterion, the dies may be classified as: single operation dies or simple dies, compound dies, combination dies, transfer dies, progressive dies and multiple dies.

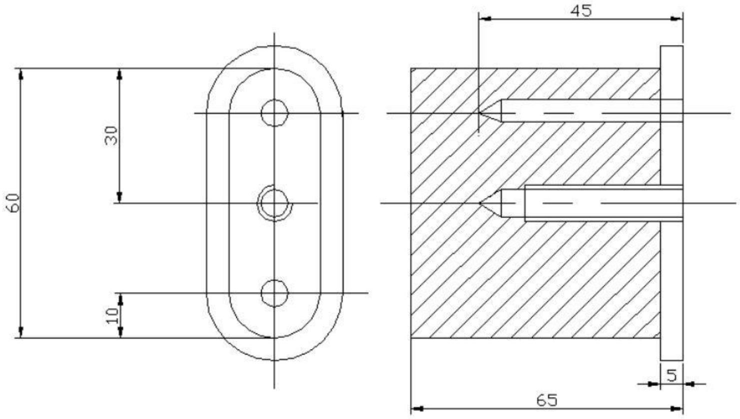
**STUDY OF PROGRESSIVE DIE**:




**Die Plate**



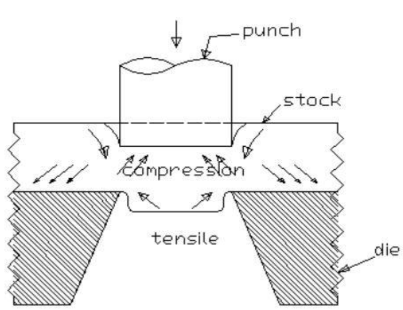

**Piercing Punch**




**Blanking Punch**

A progressive or follow on die has a series of stations. At each station an operation is performed on the work piece during a stroke of the press. Between strokes the piece in the metal strip is transferred to the next station. A finished work piece is made at each stroke of the press. A progressive die is shown in fig. while the piercing punch blanks out a portion of the metal in which two holes had been pierced at a previous station Thus after the stroke two holes will be punched each stroke of the press produces a required finished component.

*<u>Principle of metal cutting</u>*:

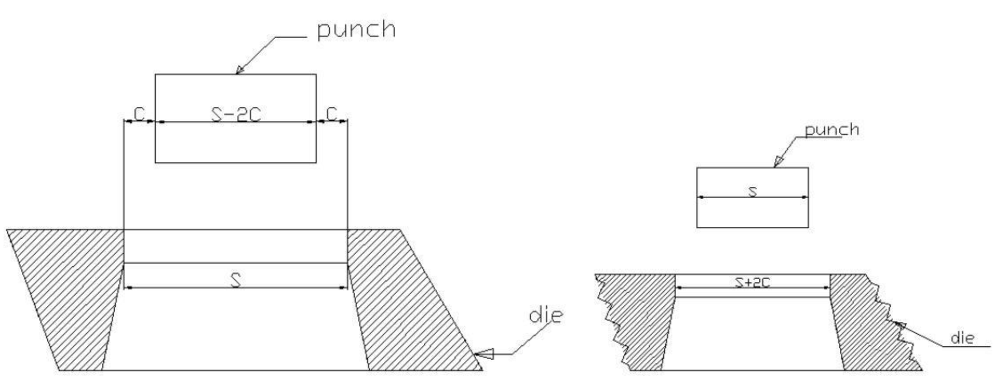



Stresses in Die Cutting

The cutting of sheet metal in the press work is a shearing process. The punch is of the same shape as of the die opening except that it is smaller on the each side by an amount known as „clearance‟. As the punch touches the material and travels downward, it pushes the material into the die opening. The material is subjected to both tensile and compressive stresses as shown in fig (a).

Stresses will be highest at the edges of punch and die and the material will start cracking there. The various steps in the rupture or facture of material can be written as stressing the material beyond the elastic limits; plastic deformation reduction in area fracturing starts in the reduced area and becomes complete. If the clearance between punch and die is correct, the cracks starting from the punch and die edges will meet and the rupture is complete as shown in fig (b). If the clearance is too large or too small the cracks do not meet and ragged edge results due to the material being dragged and torn through the die.

_Clearance_: The die opening must be sufficiently larger than the punch to permit a clean fracture of the metal. This difference in dimensions between the mating members of a die set is called „clearance‟. This clearance is applied in the following manner:




Blanking Clearance

Piercing Clearance

„c‟ is the amount of clearance per side of the die opening.

- When the hole has to be held to size, i.e. the hole in sheet metal is to be accurate, and slug is to be discarded the punch is made to the size of hole and the die opening size is obtained by adding clearance to the punch size shown in fig (a).

- In blanking operation where the slug or blank is desired part and has to be held to size the die opening size equals the blank size and the punch size is obtained by subtracting the clearance from the die opening size shown in fig (b).

The clearance is a function of the kind, thickness and temper of the work material harder materials requiring clearance than soft materials, the exception being aluminium. The usual clearances per side of the die, for various materials, are given below in terms of the stock thickness, t:

| | | | |
|---|---|---|---|
| For brass & soft steel, | c=5% of t | For mild steel, | c=6%of t |
| For hard steel, | c=7% of t | For Aluminium | c=10% of t |

The total clearance between punch and die size will be twice these figs these clearances are for blanking and piercing operations.

The clearance may also be determined with the help of the following equation: $c = 0.0032t \times \sqrt{\tau_s}$

Where $\zeta_s$ is the shear strength of the material in $N/mm^2$.

*Cutting forces*: In cutting operation as the punch in its downward movement enters the material it need not penetrate the thickness of the stock in order to affect complete rupture of the part. The distance which the punch enters in to the work material to cause rupture to take place is called "penetration" and is usually given as percentage of the stock thickness. The % penetration depends on the material being cut and also on the stock thickness. When a hard and strong material is being cut very little penetration of the punch is necessary to cause fracture. With softer the penetration will be greater. The percentage penetration is also depends upon the stock thickness, being smaller for thinner sheets.

The max force $F_{max}$ in newtons needed to cut a material is equal to :

For a circular blank of diameter D mm and of thickness t mm the maximum cutting force will be given as:

$$F_{max} = \pi D t \zeta_s = P t \zeta_s.$$

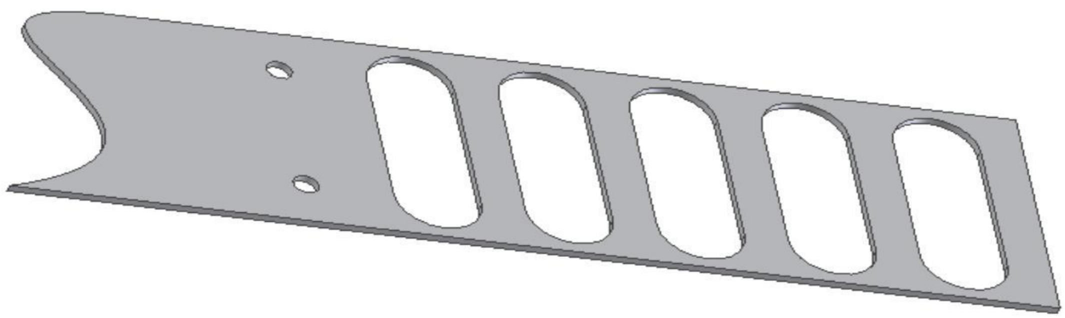
Where P is the perimeter of the section to be blanked

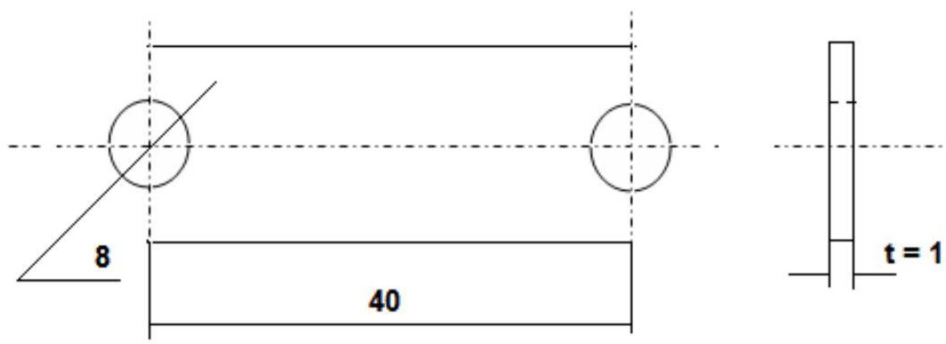
For rectangular blanks the length L and width b it is

$$F_{max} = 2(L+b) t \zeta_s.$$

**PROCEDURE**:

Component to be produced:






- Fix the punch to the ram of the press.
- Fix the die on the bed of the machine using clamps, bolts and nuts.
- Place the blank of required size between the die and punch.
- Apply pressure hydraulically on the blank through the punch so that piercing will takes place at the first station.
- Note down the reading of the pressure gauge which directly gives the force required to perform the piercing operation.
- Move the blank in forward direction until it touches the stopper on the die.

- Again apply pressure hydraulically on the blank so that piercing punch blanks out a portion of the metal in which already two holes had been pierced. At the same time piercing operation takes place at the first station.
- Note down the reading of the pressure gauge which directly gives the force required to perform the piercing and blanking operations.
- Difference of the two readings gives the force required to perform blanking operation.
- Compare the values with the theoretically obtained values.
- The process may be repeated to produce the components in mass production.

**OBSERVATIONS & CALCULATIONS**:

Piercing Force ($F_p$) =

Blanking & Piercing Force ($F_{bp}$) =

Blanking Force ($F_b = F_p - F_{bp}$) =

Maximum force needed to cut material is $F_{max}$ = P. t.

$\zeta_S$ Where P is the Perimeter of the blank

t is the thickness of the blank

$\zeta_S$ is the shear strength of the material.

**PRECAUTIONS**:

- The die should be properly clamped to the bed of the machine and it is not disturbed during the process.
- The punch is properly fixed to the ram of the machine.
- The load should be applied uniformly on the blank.
- The ram should be fed slowly towards the die and make sure that it is properly in line with the die.

**RESULT**:

## EXPERIMENT-XI

# STUDY OF COMPOUND DIE

**AIM**: To study a Compound tool and perform blanking and piercing operations. To determine the punching force and blanking force theoretically and compare the same with obtained readings.

**TOOLS AND MATERIAL REQUIRED**: Compound tool, Clamps and Blank.

**EQUIPMENT REQUIRED**: Hydraulic Press

**SPECIFICATIONS**:

- Capacity: 25 tons
- Distance between columns: 865x300 $mm^2$
- Distance between ram to bed: minimum 180mm and maximum 915mm
- Travel of ram: 180mm
- Power of motor: 5 H.P.

**THEORY**:

*<u>Press working</u>* may be defined as a chip less manufacturing process by which various components are made from sheet metal. This process is also termed as cold stamping. The process has got the following advantages:

Small weight of fabricated parts.

- High productivity of labour.
- High efficiency of technique as regards the fabrication of items of diversified shapes, both simple and complex, such as washers, bushings, retainers, of ball bearings, tanks and car bodies etc.
- The parts obtained by cold sheet metal working are distinguished for their size accuracy. In many cases, they require no subsequent machining and are delivered to the assembly shop.

**PRESSES**: These are classified in various ways:

1. Source of power.
2. Method of actuation of the rams
3. Number of slides
4. Type of frame
5. The type of work for which the press has been designed.

*Source of power*: Two kinds of sources of power for applying force to the ram are mechanical and hydraulic.

In **Mechanical Presses**, the energy of flywheel is utilized which is transmitted to the work piece by gears, cranks, eccentrics or levers. The flywheel rotates freely on the crankshaft and is driven from an electric motor through gears or V belts. The motor runs continuously and stores energy in the fly wheel. When the operator presses a foot treadle or actuates a button, the clutch gets engaged and the fly wheel is connected to the crank shaft. The crankshaft starts rotating and the stored up energy in the flywheel is transmitted to its ram on its downward stroke .The clutch to engage and disengage the flywheel to the driveshaft can be : a jaw clutch, an air operated clutch or an electromagnetic clutch. In manually operated mechanical presses, the clutch is engaged after each cycle. But in automatic presses in which the metal strip is fed to the die automatically, there is no need of single stroke clutch disengaging mechanism and the ram moves up and down continuously.

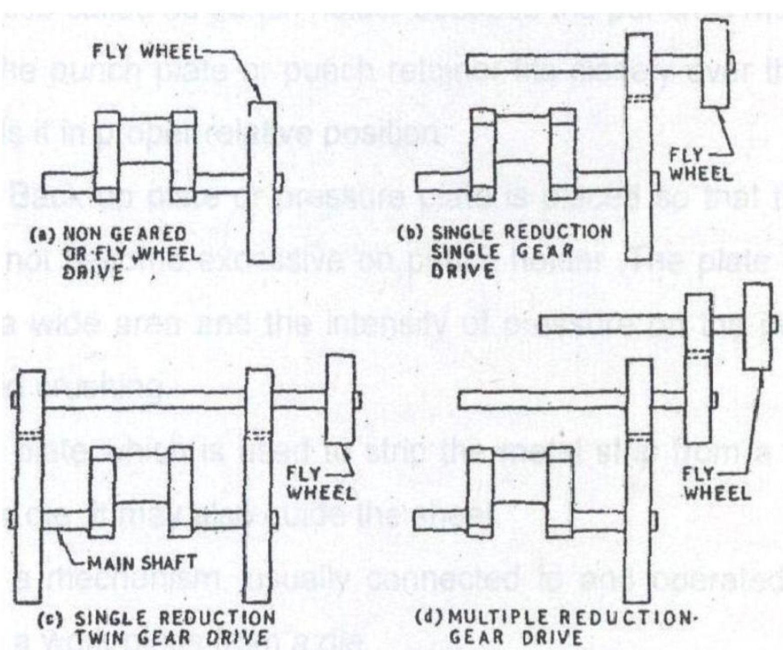



**Fig.** . Types of Mechanical Press Drives.

These presses can be classified as plain and geared . In the first design, the flywheel is mounted directly on the driveshaft .On a geared press, the flywheel is carried on an auxiliary shaft which is connected to the main shaft through one or more gear reductions, depending upon size and energy needed. In this arrangement, the flywheel stores considerably more energy than the plain drive as its speed is higher than main drive shaft.

In **hydraulic press**, the ram is actuated by oil pressure on a piston in a cylinder.

Mechanical presses have following advantages over the hydraulic press:

1. Run faster
2. Lower maintainance cost
3. Lower capital cost.

Advantages of Hydraulic presses are:

- More versatile and more easy to operate.
- Tonnage adjustable from zero to maximum.
- Constant pressure is maintained through out the stroke.
- Force and speed can be adjusted through out the stroke.
- More powerful than Mechanical presses.
- Safe as it will stop at pressure setting.

The main disadvantage of Hydraulic press is that it is slower than a Mechanical press.

A press is rated in tones of force, t is able to apply without undue strain . To keep the deflections small, it is a usual practice to choose a press rated 50 to 100% higher than the force required for an operation.

**Press selection**: The factors which should be considered while selecting a press for a given job are: the overall work size, the stock thickness and material, kind of operation to be performed, power required and speed of operation.

For punching, blanking and trimming operations, usually the crank or eccentric type mechanical press is used. This is due to their small working strokes and high production rates. In these operations, there is sudden release of load at the end of cutting stroke. This sudden release of load is not advisable in Hydraulic presses. So, Hydraulic presses are not preferred for these operations .If however these are inevitable, and then some damping devices are incorporated in press design. For coining and other squeezing operations, which require very large forces, knuckle joint mechanical press is ideally suited. Hydraulic presses, which are slower and more powerful, can also be used for these operations. Hydraulic presses are also better adapted to pressing, forming and operations, which are basically slower processes.

**Press Working Terminology**:

A simple cutting die used for punching and blanking operations is shown in fig. the following are the main components of die and press.

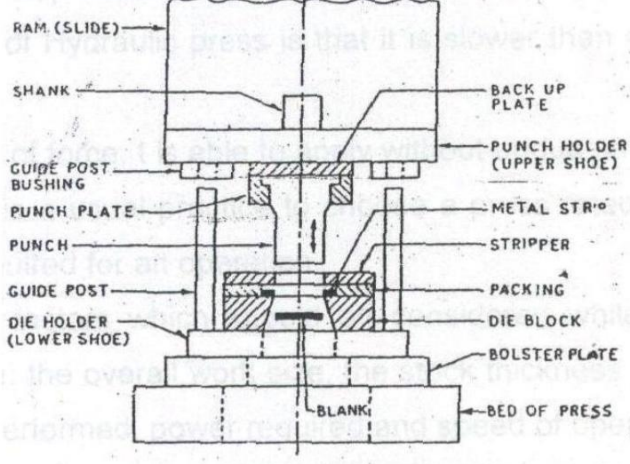



Fig. 1.12. A simple Cutting Die.

Bed: The bed is the lower part of a press frame that serves as a table to which a bolster plate is mounted.

Bolster Plate: This is a thick plate secured to the press bed, which is used for locating and supporting the die assembly. It is usually 5 to 12.5 cm thick.

Die set: It is unit assembly which incorporates a lower and upper shoe, two or more guide posts and guide post bushings.

Die: The die may be defined as the female part of a complete tool for producing work in a press. It is also referred to a complete tool consisting of a pair of mating members for producing work in a press.

Die Block: It is a block or a plate which contains a die cavity.

Lower Shoe: The lower shoe of a die set is generally mounted on the bolster plate of a press. The die block is mounted on the lower shoe. Also, the guide posts are mounted in it. It is also called as die holder.

Punch: This is the male component of the die assembly, which is directly or indirectly moved by and fastened to the press ram or slide.

Upper shoe: This is the upper part of the die set which contains guide post bushings. It is also called as punch holder because the punch is mounted on it.

Punch plate: The punch plate or punch retainer fits closely over the body of the punch and holds it in proper relative position.

Back up plate: Back up plate or pressure plate is placed so that the intensity of pressure does not become excessive on punch holder .The plate distributes the pressure over a wide area and the intensity of pressure on the punch holder is reduced to avoid crushing.

Stripper: It is a plate which is used to strip the metal strip from a cutting or non cutting punch or die. It may also guide the sheet.

Knockout: It is a mechanism, usually connected to and operated by the press ram, for freeing a work piece from a die.

Pitman: It is a connecting rod which is used to transmit motion from the main drive shaft to the press slide.

Shut height: It is the distance from top of the bed to the bottom of the slide, with its stroke down and adjustment up.

Stroke: The stroke of a press is the distance of ram movement from its up position to its down position. It is equal to twice the crankshaft throw or eccentric drives but is variable on the hydraulic press.

**STUDY OF COMPOUND DIE**:

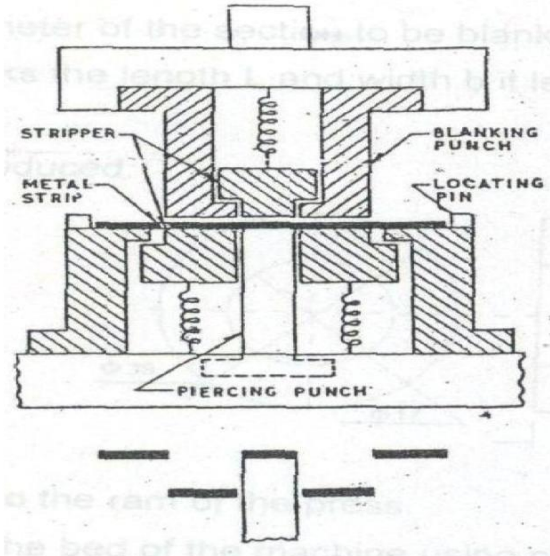



Fig. Compound Die.

In these dies two or more operations may be performed at one station. Such dies are considered as cutting tools since only cutting operations are carried out. Compound dies are more accurate and economical in mass production as compared to single operation dies.

*Cutting forces*: In cutting operation as the punch in its downward movement enters the material it need not penetrate the thickness of the stock in order to affect complete rupture of the part. The distance which the punch enters in to the work material to cause rupture to take place is called "penetration" and is usually given as percentage of the stock thickness. The % penetration depends on the material being cut and also on the stock thickness. When a hard and strong material is being cut very little penetration of the punch is necessary to cause fracture. With softer the penetration will be greater. The percentage penetration is also depends upon the stock thickness, being smaller for thinner sheets.

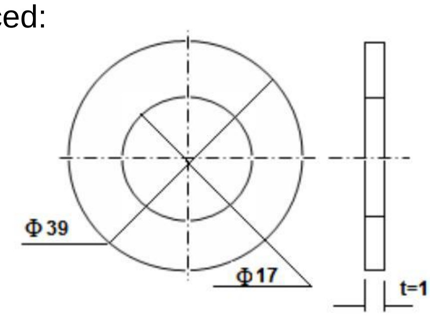
The max force $F_{max}$ in newtons needed to cut a material is equal to the area to be sheared times the shearing strength, $T_s$ in N/mm*2 for the material. For a circular blank of diameter D mm and of thickness t mm the cutting force will be given as: $F_{max} = \pi D t \zeta_s = P t \zeta_s$.

Where P is the perimeter of the section to be blanked

For rectangular blanks the length L and width b it is $F_{max} = 2(L+b)\ t\ ζ_S$.

**PROCEDURE**:

Component to be produced:




- Fix the punch to the ram of the press.
- Fix the die on the bed of the machine using clamps, bolts and nuts.
- Place the blank of required size between the die and punch.
- Apply pressure hydraulically on the blank through the punch so that blanking and piercing will takes place at one station.
- Note down the reading of the pressure gauge which directly gives the force required to perform both blanking and piercing operations.
- Compare the value with the theoretically obtained value.
- The process may be repeated to produce the components in mass production.

**OBSERVATIONS & CALCULATIONS**:

Force required to perform blanking and piercing operations

= Maximum force needed to cut material is $F_{max} = P.\ t.\ ζ_S$

Where P is the Perimeter of the blank

t is the thickness of the blank

$ζ_S$ is the shear strength of the material.

**PRECAUTIONS**:

- The die should be properly clamped to the bed of the machine and it is not disturbed during the process.
- The punch is properly fixed to the ram of the machine.
- The load should be applied uniformly on the blank.
- The ram should be fed slowly towards the die and make sure that it is properly in line with the die.

**RESULT**:

EXPERIMENT-XI1

# DRAWING AND BENDING

**AIM**: 1. To Determine the Blank Size, Drawing Force and Blank Holding Force for Producing a symmetrical cup of circular cross section using a Draw Tool and Perform Drawing Operation.

2. To perform Bending Operation

**MATERIAL REQUIRED**: Aluminium sheet of required size and MS round bar of 25mm diameter.

**EQUIPMENT AND TOOLS REQUIRED**: Hydraulic Press, Draw tool and Inclinometer.

**THEORY:**

**DRAWING:**

Drawing operation is the process of forming a flat piece of material into a hollow shape by means of a punch which causes the blank to flow into the die cavity. The depth of draw may be shallow, moderate or deep. If the depth of the formed cup is up to half of its diameter, the process is called “Shallow drawing”. If the depth of the formed cup exceeds the diameter it is termed as "Deep drawing". Parts of various geometries and sizes are made by drawing operation, two extreme examples being bottle caps and automobile panels.

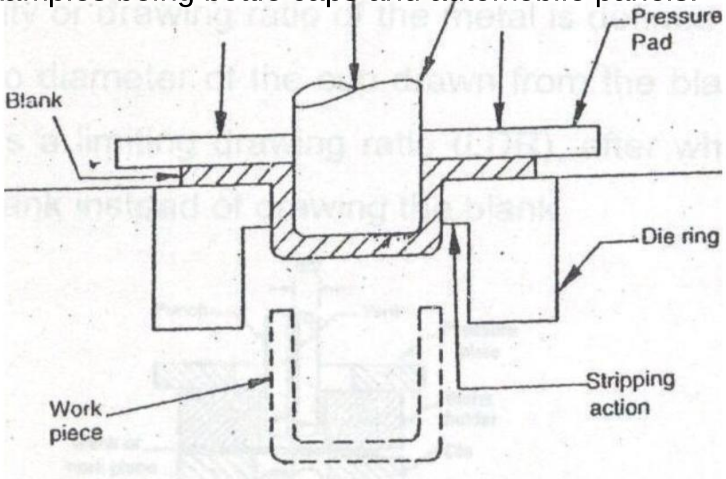



Fig. 4.86. Deep Drawing Operation.

As the drawing progress i.e. as the punch forces the blank into die cavity, the blank diameter decreases and causes the blank to become thicker at its outer portions. This is due to the circumferential compressive stress to which the material element in the outer portions is subjected. If this stress becomes excessive the outer portions of the blank will have the tendency to buckle or wrinkle. To avoid this, a pressure pad or blank holder is provided. The holding down of pressure is obtained by means of springs, rubber pad, compressed air cylinder or the auxiliary ram on a double action press.

The portion of the blank between the die wall and punch is subjected to nearly purely tension and tends to stretch and becomes thinner. The portion of the formed cup which wraps around the punch radius is under tension in the presence of bending. This part becomes the thinnest portion of the cup. This action is termed as 'necking' and in the presence of unsatisfactory drawing operation, is usually the first place to fracture. The outer portions of the blank under the blank holder become thicker during the operation. When these portions are drawn into the die cavity, 'ironing' of this section will occur if the clearance between the punch die is not enough to accommodate this increased thickness of the work piece. This ironing is useful if uniform thickness of the product is desired after the drawing operation.

*DEEP DRAWBILITY*:

Deep drawability or drawing ratio of the metal is defined as the ratio of the max blank diameter to diameter of the cup drawn from the blank, i.e. D/d. For a given material there is a limiting drawing ratio (LDR), after which the punch will pierce a hole in the blank instead of drawing the blank.

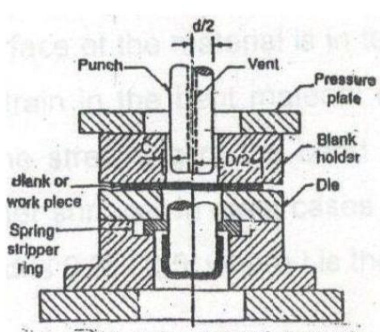



Fig. 4.87. A simple push through drawing die.

This ratio depends upon many factors, such as material, amount of friction present etc. The usual range of the max drawing ratio is 1.6 to 2.3.

A simple push through drawing die is shown. The drawing punch should be properly vented with drilled passengers. Venting serves double purpose it eliminates suction which would hot the cup on the punch and damage the cup when it is stripped from the punch. Secondly, venting provides passages for lubricants. Many presses are used for the deep drawing operations are hydraulically operated and these presses have an additional hydraulic cylinder and piston for the additional slide.

Product applications of deep drawing process are: cups, shells, automotive bodies, gas tanks, house hold hard ware etc.

*REDRAWING*:

In deep drawing the percentage reduction in one draw is defined as:

% reduction = [D-d)/D] X 100

Now D/d =1.6 to 2.3, d/D=0.435 to 0.625 = 0.5 (average)

The average reduction in deep drawing=

[1-d/D] X 100 = 50%

To make tall cups of smaller diameter it is necessary to use successive drawing operations. Reducing the drawn cup to the smaller diameter and increased height is known as "redrawing".

**BENDING**:

Bending is the metal working process by which a straight length is transformed in to the curved length. It is a very common forming process for changing sheet and plate into channels, drums, tanks etc. During the bending operation, the outer surface of the material is in tension and the inside surface is in compression. The strain in the bent material increases with decrease in the radius of curvature. The stretching of the bend causes the neutral axis of the section towards the inner surface. In most cases the distance of the neutral axis to the inside of the bend is 0.3t - 0.5t where t is the thickness of the part.

Bending terminology is illustrated in fig.

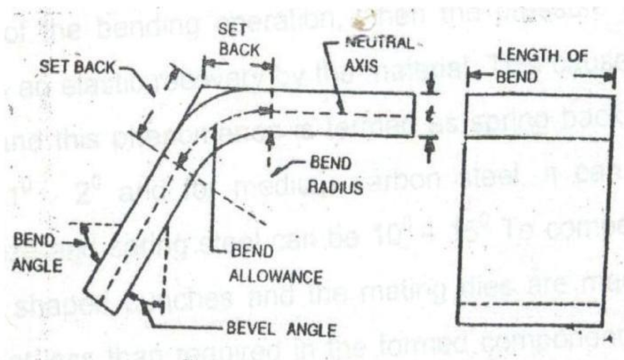


Fig. 4.90. Bending Terminology.

BENDING METHODS:

The three bending methods commonly used are V-bending, edge bending, and U bending

*V-BENDING*:

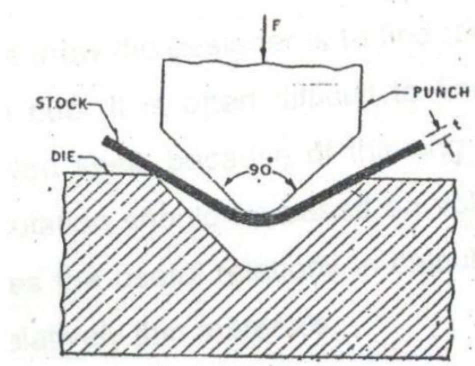


Fig. 4.91. V-Bending.

In V bending, a wedge shaped punch forces a metal sheet or strip in to a wedge shaped die cavity .The bend angle may be acute, $90^0$ or obtuse. As the punch descends the contact forces at the die corner produces a sufficiently large bending moment at punch corner to cause the necessary deformation.

To maintain the deformation to be plane - strain, the side creep of the part during its bending is prevented or reduced by incorporating a spring loaded knurled pin in the die. The friction between pin and the part will achieve this. Plane strain conditions will also be established in the center of the sheet if its width is more than 10 time its thickness.

*SPRING BACK*:

At the end of the bending operation, when the pressure on the metal is released, there is an elastic recovery by the material. This causes a decrease in the bend angle and this phenomenon is termed as spring back For low carbon steel it can be $1^0$ - $2^0$ and for medium carbon steel, it can be $3^0$ – $4^0$ for phosphorus bronze and spring steel can be $10^0$ – $15^0$ To compensate for spring back the wedge shaped punches and the mating dies are made with included angles some what less than required in the formed component. Due to this the component will be bent to a greater angle than desired but will spring back to the desired angle for other types of bending the part is over bent by an angle equal to the spring back angle by having the face of the punch undercut or relieved.

**Blank Size:**

One of the first jobs of the draw die designer is to find the size of the blank to be used for making a given cup. It is often difficult to find a blank of exact size required for making a given shell, because of thinning and thickening of sheet during drawing. The calculation should be based on volume, surface area or by layout. The following gives the useful relations in calculating the blank diameter for cylindrical shells for relatively thin materials.

$D = \sqrt{d^2 + 4dh}$ When d ≥ 20r

$D = \sqrt{d^2 + 4dh - 0.5r}$ When 15r ≤ d ≤ 20r

$D = \sqrt{d^2 + 4dh - r}$ When 10r ≤ d ≤ 15r

$D = \sqrt{(d - 2r)^2 + 4d(h - r) + 2\pi r(d - 0.7r)}$ When d < 10r

Where r = corner radius on the punch, mm

h = height of the shell, mm

d = outer diameter of the shell, mm

D = blank diameter, mm

**Drawing Force**:

The drawing force depends on the cup material, its dimensions and the configuration. The drawing force can empirically be calculated using the following equation for cylindrical shells.

$$P = \pi dts\left[\frac{D}{d} - C\right]$$

Where P = drawing force, N

t = thickness of the blank material, mm

s = yield strength of the metal, Mpa

C = constant to cover friction and bending. Its value is between 0.6 and 0.7

**Blank Holding Force**:

The blank holding pressure required depends on the wrinkling tendency of the cup, which is difficult to determine and hence it is obtained more by trail and error. The maximum limit is generally one-third of the drawing force.

**OBSERVATIONS AND CALCULATIONS:**

Using above relations calculate,

1. r = corner radius on the punch = mm

   h = height of the shell = mm

   d = outer diameter of the shell = mm

   d/r =

   then D = blank diameter = mm

2. Drawing Force = N

3. Blank Holding Force = N

:

*Drawing Operation*:

- Fix the punch to the ram of the press.
- Fix the die on the bed of the machine using clamps, bolts and nuts.
- Calculate the required blank size and place the same between the punch and die block.
- Apply the hydraulic pressure on the punch through ram so that the punch slowly descends on the blank and forces it take the cup shape formed by the end of the punch, by the it reaches the bottom of the die.
- When the cup reaches the counter bored portion of the die, the top edge of the cup formed around the punch expands slightly due to spring back.
- Observe the reading of the pressure gauge which directly gives the force required to perform the operation.
- Calculate the drawing force required, to perform the operation using above relations.
- Compare the two readings
- Then move the punch in the return direction so that the cup will be stripped by counter bored portion.

*Bending Operation:*

- Fix the wedge shaped punch to the ram of the press.
- Fix the wedge shaped die cavity on the bed of the press using clamps, bolts and nuts.
- Place the MS round bar between the punch and die.
- Apply pressure on the bar by moving the ram in downward direction through the punch.
- As the punch descends, the contact forces at the die corner produce a sufficiently large bending movement at the punch corner to cause the necessary deformation.
- Then the bar will take the shape of die cavity.

- Measure the included angle of the bar using inclinometer and repeat the process until the included angle reaches $90^0$.

**PRECAUTIONS:**

- The die should be properly clamped to the bed of the machine and it is not disturbed during the process.
- The punch is properly fixed to the ram of the machine.
- The load should be applied uniformly on the bar.
- The bar should be held properly on the die block.

**RESULT**:

# EXPERIMENT-XIII
# INJECTION MOULDING (AIR TIGHT BOTTLE CAP)

**AIM**: To Make an Air Tight Bottle Cap by Using Injection Moulding.

**APPARATUS REQUIRED**: Die, injection-moulding equipment.

**MATERIALS REQUIRED**: Plastic pellets

**THEORY**:

**Plastics**:

Polymers can be divided into three broad divisions: plastics, fibers and elastomers (polymers of high elasticity, for example, rubber). Synthetic resins are usually referred to as plastics. Plastics derive their name from the fact that in a certain phase of their manufacture they are present in a plastic stage (that is acquire plasticity), which makes it possible to impart any desired shape to the product. Plastics fall into a category known chemically as high polymers.

Thus Plastics is a term applied to compositions consisting of a mixture of high molecular compounds (synthetic polymers) and fillers, plasticizers, stains and pigments, lubricating and other substances. Some of the plastics contain nothing but resin (for instance, polyethylene, polystyrene).

**Types of Plastics**:

Plastics are classified on the broad basis of whether heat causes them to set( thermosetting) or causes them to soften and melt(thermoplastic).

***Thermosetting Plastics***: These plastics undergo a number of chemical changes on heating and cure to infusible and practically insoluble articles. The chemical change is not reversible. Thermosetting plastics do not soften on reheating and cannot be reworked. They rather become harder due to completion of any left over polymerization reaction. Eventually at high temperatures, the useful properties of the plastics get destroyed. This is called degradation. The commonest thermosetting plastics are: alkyds, epoxides, melamines, polyesters, phenolics and ureas.

***Thermoplastic Plastics***: These plastics soften under heat, harden on cooling, and can be resoftened under heat. Thus they retain their fusibility, solubility and capability of being repeatedly shaped. The mechanical properties of these plastics are rather sensitive to temperature and to sunlight and exposure to temperature may cause thermal degradation. Common thermoplastics are: acrylics, poly tetra fluoro ethylene (PTFE), polyvinyl chlorides (PVC), nylons, polyethylene, polypropylene etc.

**Properties:**

1. Their comparatively low density( 1- 2 g/cm ), substantial mechanical strength, higher strength to weight ratio and high anti friction properties have enabled plastics to be efficiently used as substitute for metals, for example, non –ferrous metals and alloys-bronze, lead, tin, babbit etc.
2. With certain special properties (silent operation, corrosion resistance etc), plastics can sometimes replace ferrous metals.
3. From the production point of view, their main advantage is their relatively low melting points and their ability to flow into their moulds.
4. Simple processing to obtain machine parts
5. In mass production plastics substituted for ferrous metals allow the production costs to be reduced by a factor 1.5 to 3.5 and for non – ferrous metals by a factor of 5 to 20.
6. Good damping capacity and good surface finish of the product.
7. The high heat and electric insulation of plastics permits them to be applied in the radio and electrical engineering industries as dielectrics and as substitutes for porcelain, ebonite, shellac, mica, natural rubber, etc.
8. Their good chemical stability, when subjected to the action of solvents and certain oxidizing agents, water resistance, gas and steam proof properties, enable plastics to be used as valuable engineering materials in the automobile and tractor, ship building and other industries.

**Disadvantages**:

1. Comparatively higher costs of materials.
2. Instability of most plastics to withstand even moderately high temperatures.

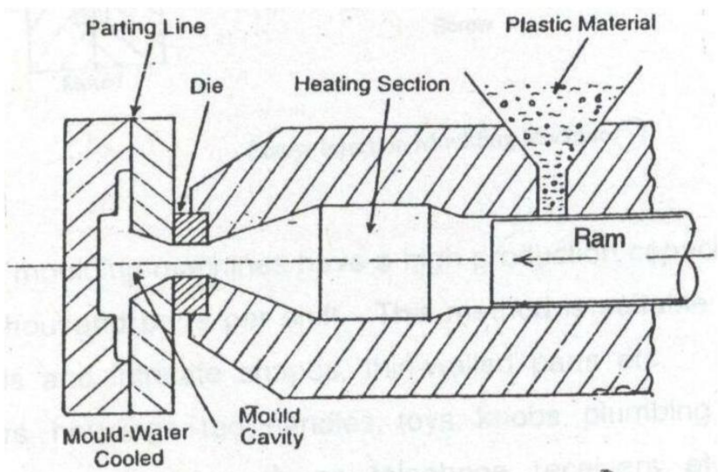
**Processing of Thermoplastic Plastics:**

The common forms of raw materials for processing plastics into products are: Pellets, Powders, Sheet, Plate, and Tubing. Liquid plastics are used especially in the fabrication of reinforced plastic parts.

Thermoplastics can be processed to their final shape by moulding and extrusion processes. However, extruding is often used as an intermediate process to be followed by other processes for example vacuum forming or machining.

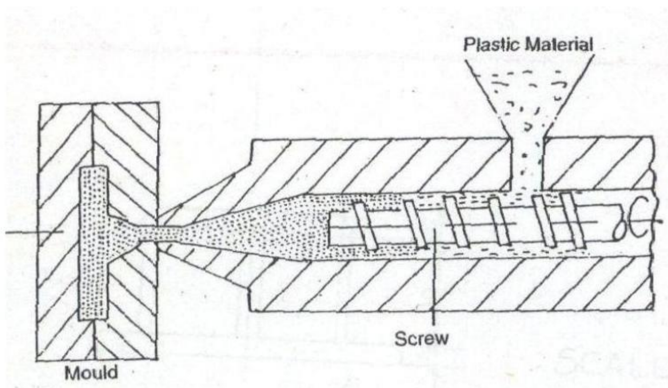
**Injection Moulding:**

An important industrial method of producing articles of thermoplastics is Injection Mouilding (shown in fig.). The process is essentially as follows:




The moulding material is loaded into a hopper from which it is transferred to a heating section by a feeding device, where the temperature is raised to $150^0$C – $370^0$C and pressure is built up. The material melts and is forced by an injection ram at high pressure through a nozzle and sprue into a closed mould which forms the part. The mould is in at least two sections, so that it may be split in order to eject the finished component. For the process to be competitive the mould must be fairly cool (between ambient temperature and the softening point of the plastic) and consequently the mould must be cooled by circulating water.

The improvement to the ram type injection moulding machine lies in the separation of the plasticizing and filling actions. The single – screw pre-plasticizer is probably the most successful design for injection moulding machines (shown in fig).The rotation of the screw provides the plasticizing action by shearing and frictional effects and the axial motion of the screw provides the filling action.




Injection moulding machines have a high production capacity: some can produce from 12 to 16 thousand parts per shift. This method is suitable for making parts with complex threads and intricate shapes, thin-walled parts etc. Typical parts include: Cups, containers, housings, tool handles, toys, knobs, plumbing fittings, electrical and communication components such as telephone receivers etc. Injection moulding machines range in size from an injection capacity of 12,000 $mm^3$ to $2.2 \times 10^6$ $mm^3$. The injection pressure may range from 100-150 MPa.

**PROCEDURE**:

1. The pellet form of plastic is introduced into the container through hopper.

2. The plastic pellet enters into the container. The container is heated with the coil, which is wounded around it.

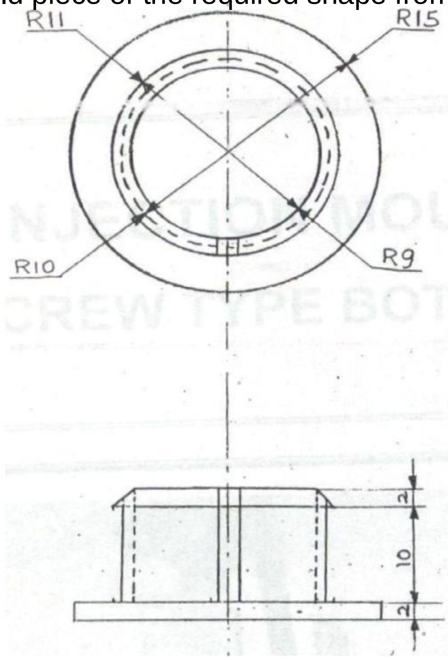
3. The plastic of powder form is converted into molten stage at a temperature of $80^0C$.

4. The die is placed exactly below the nozzle of the container.

5. The melted plastic is injected into the die with the help of lever arm and it is allowed to solidify say for about one minute.

6. Then retract the lever arm slightly and open the mould.

7. Then eject the mould piece of the required shape from the die.




**RECAUTIONS**:

1. The material should not be heated rapidly.

2. The die should be placed exactly below the nozzle.

3. Proper temperature should be maintained while heating the plastic.

**RESULT**:

## EXPERIMENT-IV

# PLASMA ARC WELDING

**AIM**: To Join two given work pieces using plasma arc welding and Brazing and cut the given plate into two parts using plasma cutting.

Apparatus required: Plasma Arc Welding System Material

Required: MS flat 50x50x10 mm – 3 Nos

**Theory**:

**Procedure:**

1. The edge of the given material is prepared to the required V-shape using grinding machine.
2. The machine is set to the required parameters( For Welding).
3. Place the two work pieces on the table with required position as shown in figure.
4. The work pieces are kept in the required position and tack welding is performed on the work pieces.
5. First run of welding is done to fill the gap and penetration of the weldment by holding the electrode at about $70^0$ and filler rod at $30^0$ and move the electrode to another end uniformly.
6. Second run of welding is done with proper weaving and uniform movement so that a uniform weld bead will be obtained.
7. The scale formed is chipped with chipping hammer.
8. Filing is done to remove any spatter around the weld.

**PRECAUTIONS**:

1. The material should not be heated rapidly.
2. The die should be placed exactly below the nozzle.
3. Proper temperature should be maintained while heating the plastic.

**RESULT**: