Ahsanullah University of Science and Technology (AUST)
Department of Mechanical and Production Engineering

LABORATORY MANUAL
For the students of
Department of Mechanical and Production Engineering
1st Year, 1st Semester

Student Name :
Student ID :

Department of Mechanical and Production Engineering
Ahsanullah University of Science and Technology (AUST)

IPE 1110: Machine Shop Practice I
Credit Hour: 1.5

General Guidelines:

1. Students shall not be allowed to perform any experiment without apron and shoes.
2. Students must be prepared for the experiment prior to the class.
3. Report of an experiment must be submitted in the next class.
4. Viva for each experiment will be taken on the next day with the report.
5. The report should include the following:
    - Top sheet with necessary information
    - Main objectives
    - Work material/machine/tool/equipment used (with their specifications)
    - Experimental procedures
    - Experimental results and discussions (Experimental setup, Experimental conditions, Data, Graph, calculation etc.)
    - Conclusions
    - Acknowledgements
    - References
6. A quiz will be taken on the experiments at the end of the semester.
7. Marks distribution:

Total Marks		
Report	Attendance and Viva	Quiz
30	30	40

Experiment 1:

Study of Electric Arc welding process and various types of joint

Arc welding is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, or slag. Arc welding processes may be manual, semi-automatic, or fully automated. First developed in the late part of the 19th century, arc welding became commercially important in shipbuilding during the Second World War. Today it remains an important process for the fabrication of steel structures and vehicles.

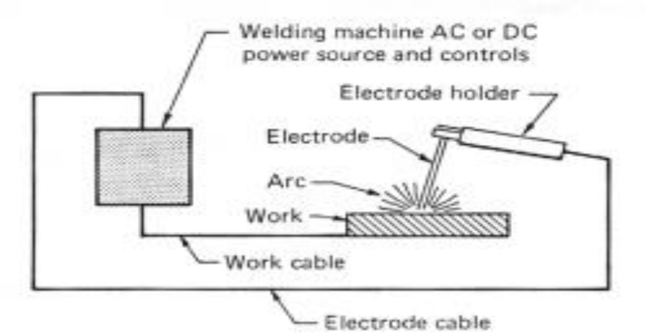


Fig. 1 The basic arc-welding circuit

In arc welding, the intense heat needed to melt metal is produced by an electric arc. The arc is formed between the actual work and an electrode (stick or wire) that is manually or mechanically guided along the joint. The electrode can either be a rod with the purpose of simply carrying the current between the tip and the work. Or, it may be a specially prepared rod or wire that not only conducts the current but also melts and supplies filler metal to the joint.

Basic Welding Circuit

The basic arc-welding circuit is illustrated in Fig. 1. An AC or DC power source, fitted with whatever controls may be needed, is connected by a work cable to the workpiece and by a "hot" cable to an electrode holder of some type, which makes an electrical contact with the welding electrode.An arc is created across the gap when the energized circuit and the electrode tip touches the workpiece and is withdrawn, yet still with in close contact.

The arc produces a temperature of about 6500ºF at the tip. This heat melts both the base metal and the electrode, producing a pool of molten metal sometimes called a "crater." The crater solidifies behind the electrode as it is moved along the joint. The result is a fusion bond.

Arc Shielding

However, joining metals requires more than moving an electrode along a joint. Metals at high temperatures tend to react chemically with elements in the air - oxygen and nitrogen. When metal in the molten pool comes into contact with air, oxides and nitrides form which destroy the strength and toughness of the weld joint. Therefore, many arc-welding processes provide some means of covering the arc and the molten pool with a protective shield of gas, vapor, or slag. This is called arc shielding. This shielding prevents or minimizes contact of the molten metal with air. Shielding also may improve the weld. An example is a granular flux, which actually adds deoxidizers to the weld.

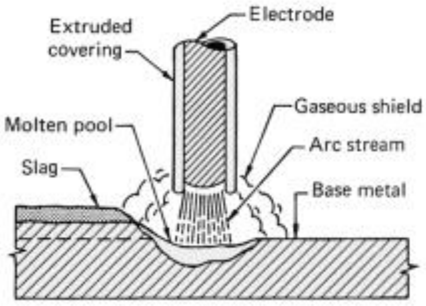


Fig. 2 This shows how the coating on a coated (stick) electrode provides a gaseous shield around the arc and a slag covering on the hot weld deposit.

Figure 2 illustrates the shielding of the welding arc and molten pool with a Stick electrode. The extruded covering on the filler metal rod, provides a shielding gas at the point of contact while the slag protects the fresh weld from the air.

Welding Joints:

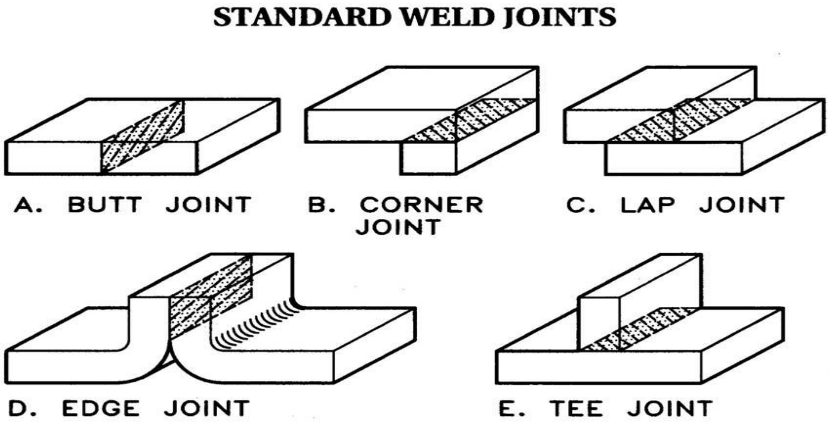


Figure 3: Standard Weld Joint

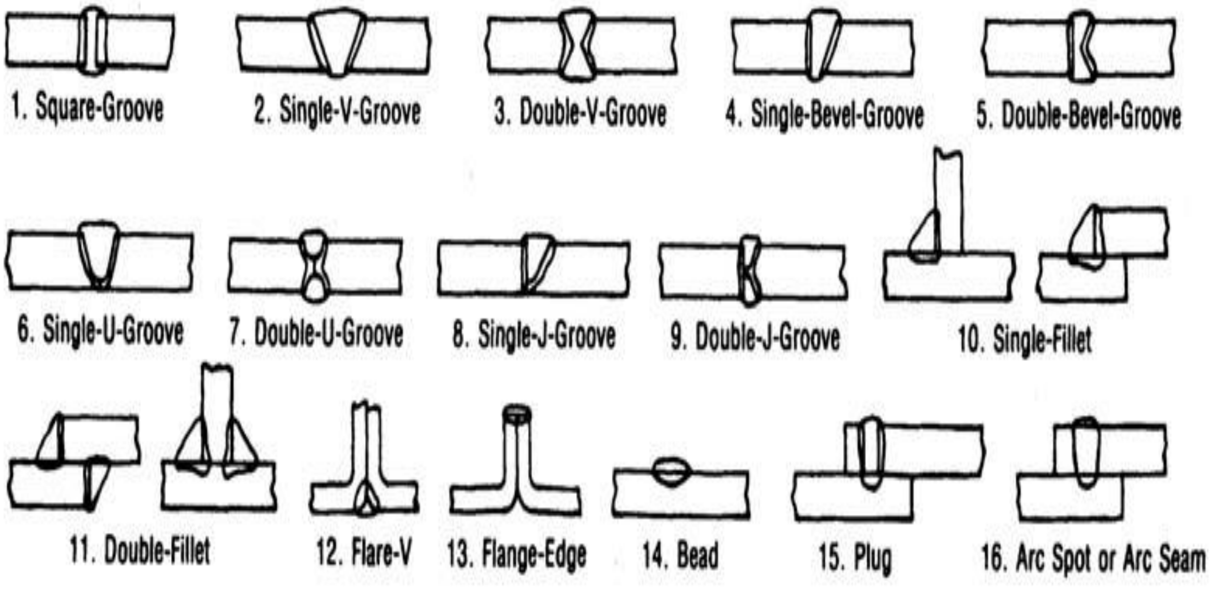


Figure 4: Other basic Weld Joints

Heat, fire, and explosion hazard

Because many common welding procedures involve an open electric arc or flame, the risk of burns from heat and sparks is significant. To prevent them, welders wear protective clothing in the form of heavy leathergloves and protective long sleeve jackets to avoid exposure to extreme heat, flames, and sparks.

Eye damage

Auto darkening welding hood with 90×110 mm cartridge and 3.78×1.85 in viewing area

Exposure to the brightness of the weld area leads to a condition called arc eye in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes. Welding goggles and helmets with dark face plates—much darker than those in sunglasses or oxy-fuel goggles—are worn to prevent this exposure.

Safety issues

Welding safety checklist

Welding can be a dangerous and unhealthy practice without the proper precautions; however, with the use of new technology and proper protection the risks of injury or death associated with welding can be greatly reduced.

Experiment 2:

Study on Sand Mold Preparation using single piece pattern

MANUFACTURING PROCESS:

Manufacturing processes are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the creation of the materials from which the design is made. These materials are then modified through manufacturing processes to become the required part.

Casting:

Casting refers to the process of creating a metal part (using cast iron or cast steel) by pouring liquid into a mold or die to form a solid shape. Once the part cools and solidifies, it is ejected or broken out of the mold.

Sand Casting:

Sand casting is considered the most common and can accommodate a wide range of object sizes. The three dimensional replica or “pattern” of the required object is held within a mold surrounded by compressed sand and binder additives which are used to form the final shape of the desired part.The Cavity in the cavity formed by using a pattern (an approximate duplicate of the real part), which are typically made of wood, sometimes metal is called mold. The cavity is contained in an aggregate housed in a box called the flask. Core or mold that is used to locate and support the core within the mold. A riser is an extra void created in the mold cavity as the molten metal solidifies and shrinks and thereby prevents voids the main casting. The following Figure shows the green sand mold.

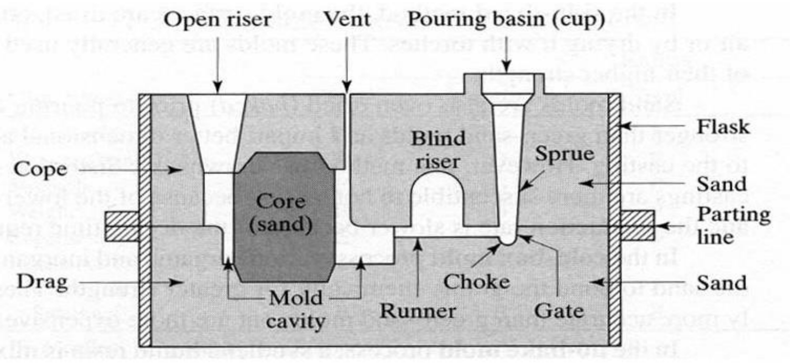


Figure 1: Gating System

Major components of sand molds as shown in Fig.1 are:

The mold itself, which is supported by a **flask**. A two-piece mold consists of a **cope** on top and a **drag** on the bottom. When more than two pieces are used, the additional parts are called **cheeks**.

1- **A pouring basin or pouring cup,** into which the molten metal, is poured.
2- **A sprue,** through which the molten metal flows downward.
3- **The runner system,** which has channels that carry the molten metal from the sprue to the mold cavity.
4- **Gated system –** It consists of the pouring basin, sprue, runner and gate. Its function is to fill the mold cavity in time so that the molten material does not solidify before filling the entire mold cavity. **Gates** are the inlets into the mold cavity.
5- **Riser** – A riser or feeder is a reservoir build into a metal casting mold to prevent cavities due to shrinkage. Because metals are less dense as liquids than as solids (with some exceptions), castings shrink as they cool. This can leave a void, generally at the last point to solidify. Risers prevent this by providing molten metal at the point of likely shrinkage, so that the cavity forms in the cavity forms in the riser, not the casting. **Risers,** which supply additional metal to the casting as it shrinks during solidification. Fig.2 shows two different types of risers: a blind riser and an open riser.
6- **Cores,** which are inserts made from sand. They are placed in the mold to form hollow regions or otherwise define the interior surface of the casting. **Core** – The term core, most often is referred to as a performed mass of sand introduced in the mold cavity to form a hole or recess in the casting.
7- **Caplets -** Chaplets are small metal props, placed in the mold cavity to support the core.
8- **Vents,** which are placed in the molds to carry off gases produced when the molten metal comes into contact with the sand in the molds and cores. They also exhaust air from the mold cavity as the molten metal flows into the mold

Mold Preparation:

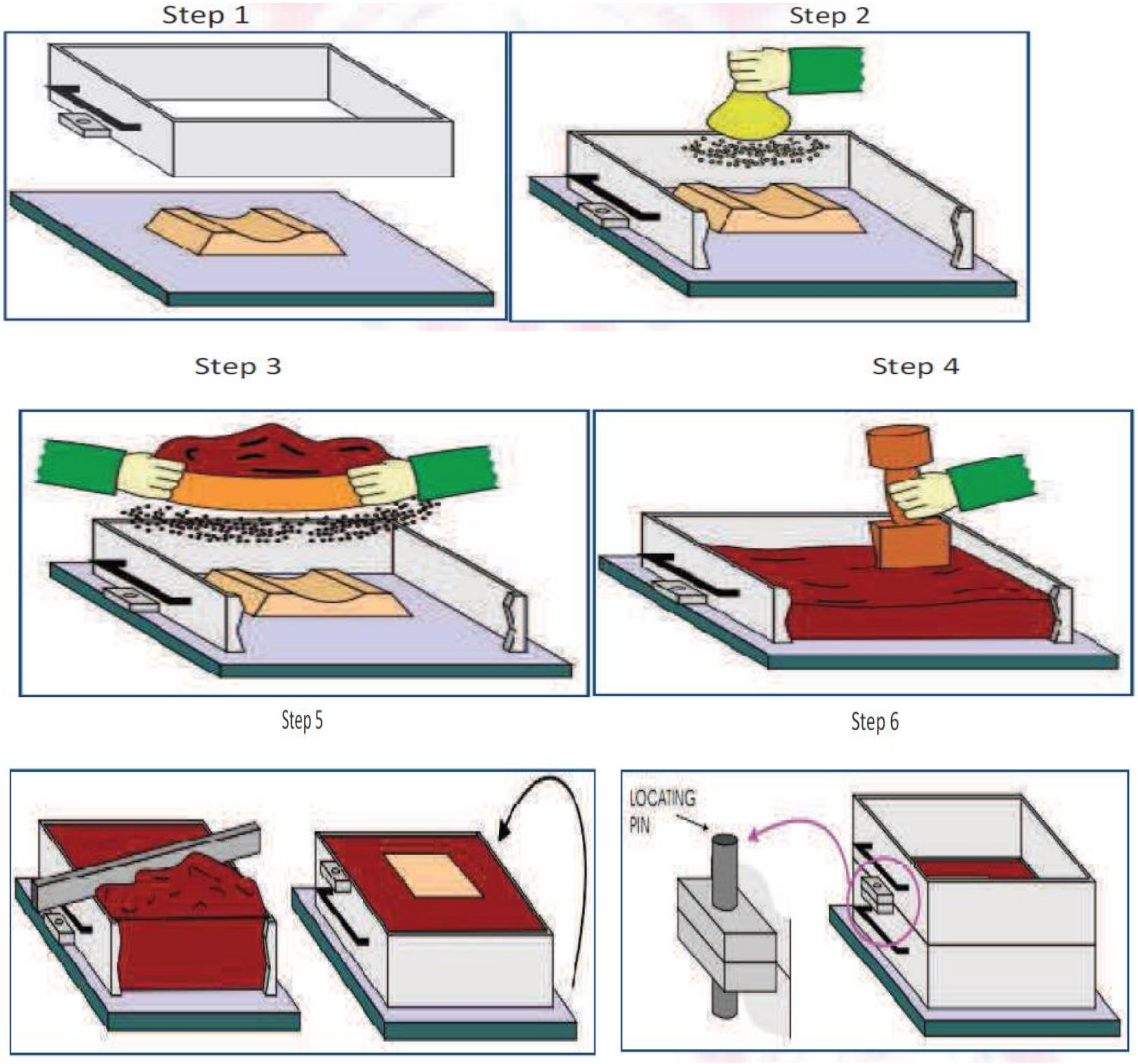
i. Prepare enough sand by riddling to fill the flask before it using facing sand.
ii. Place drag on molding board, guide pins pointing downward.
iii. Place pattern, large side down, in drag. Fill the flask with the molding sand over the pattern.
iv. Ramming with rammer. Don't ramming over the pattern.
v. Strike off excess sand to the level of drag using straight-edge or planner.
vi. Roll will be drag and replace cope part use parting sand on the drag part.
vii. Riser and runner will be replacing also then Ramming,. Strike off excess sand and use facing sand.
viii. Venting around and over pattern with vent wire.
ix. Remove riser and runner then cut pouring basin into cope. Separate cope and drag part.
x. Swap around the pattern, Rap and draw the pattern with draw spike or draw pin.
xi. Cut gate in drag ½" deep 1" wide with gate cutter and remove any loose sand form the mold.

xii. Remove extra sand and other foreign particle with Bellows. Put cope on drag in its original position.

xiii. Set mold level on the floor carrying it with bottom plate held firmly in place.

xiv. Uncover pouring basin and place suitable weight on cope to hold it down against the lift of the molten metal.

Schematic illustration of the sequence of operations for Sand Casting:



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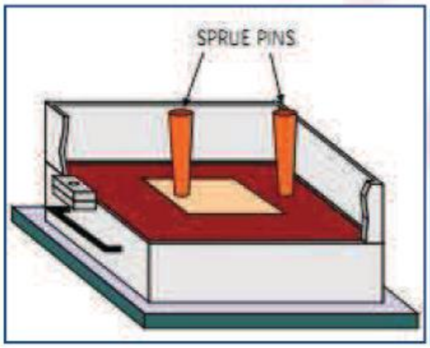

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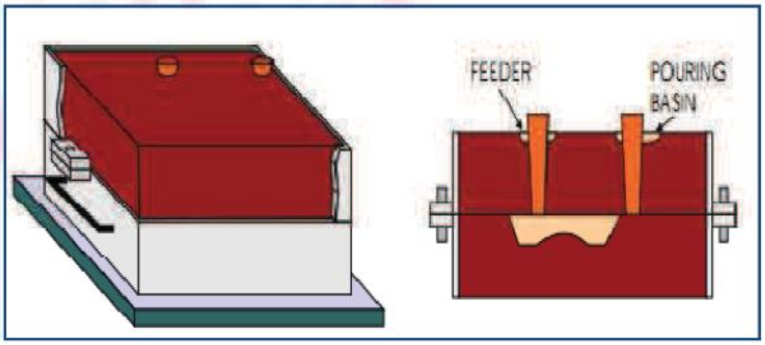

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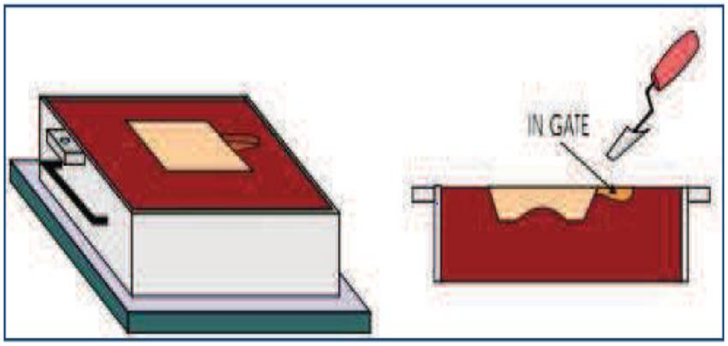

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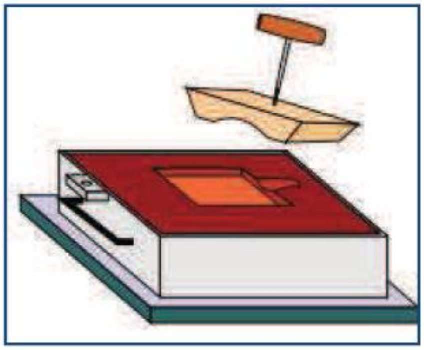

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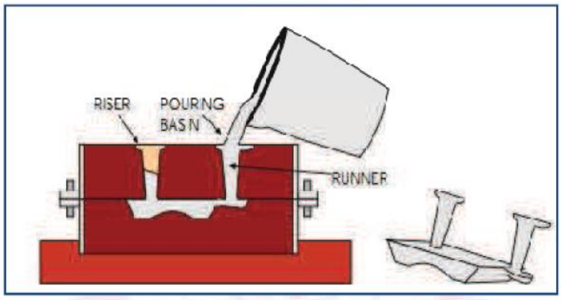

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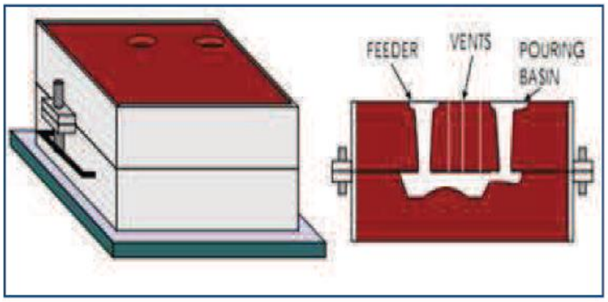
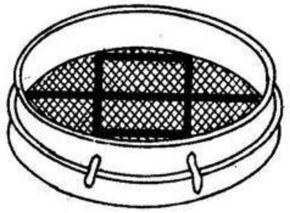
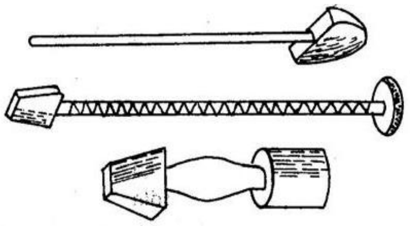


Molding Tool Kit:

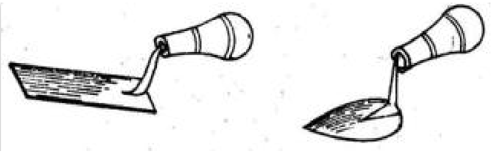
Riddle: A riddle of a standard mesh screen is used to remove lumps or foreign particles from the sand both hand and power riddles are available the letter being used where large volume of work is involved.



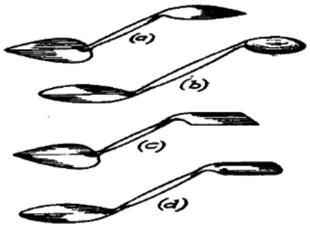
Rammer: A hand rammer generally made of wood is used to pack the sand in the mold. It has got two ends. One end is sharp and the other end is blunt. The sharp end of the rammer called the PEEN END which is used to pack the molding sand through the corner of the molding flask and the other end is called BUTT which is used to pack the sand finally.



Trowel: Small trowels of various shapes are used for finishing and repairing mold cavities as well as for smoothing over the parting sand off the mold. The usual trowels are rectangular in shape and have either round or square end.

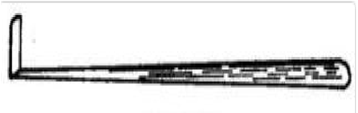


Slick-Spoon: The principal hand tools for repairing molds are called a slick-spoon. It is a small double ended tool having a flat on one end and a spoon on the other end. This tool is also made in variety of other shapes.



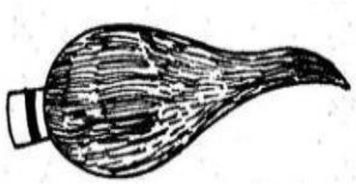
Bellows: A standard hand operated billows are used for blowing off loose sand from the mold verities and surface of the mold.

Lifter: Lifter is used for smoothing and clearing our loose sand depression in the mold. They are made of thin section of steel of various width and length with one end bent at right angles. A

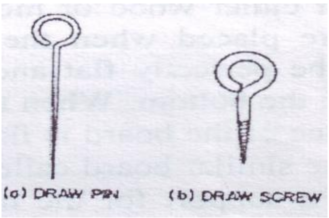


combination of slick and lifter is known as a Yankee-Lifter.

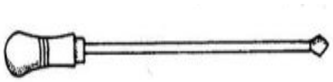
Swab: It is made of flux or hemp and used for applying water to the mould around the edge of the pattern. This prevents the sand edges from crumbling when the pattern is removed from the mould.



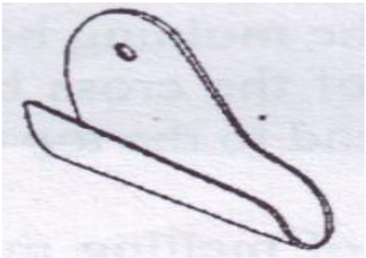
Draw Spike or Screw: The draw spike is a pointed steel rod with loops at one end. It is driven into a wooden pattern when it is withdrawn from the sand. The draw screw is similar in shape but threaded on the end to engage metal pattern.



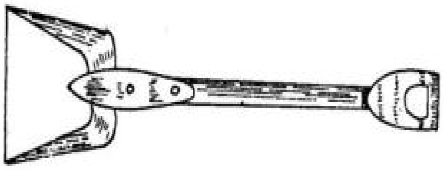
Vent wire: It is a wire rod used for making opening called ‘vents’ in the mould. In this manner the mold is provided with vents which carry off the steam and gases generated by the hot metal in contact with the sand.



Gate cutter: It is a piece of sheet metal used to cut the opening that connects the spruce with the mould cavity. This opening is called a ‘gate’.

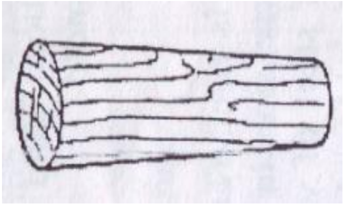


Shovel: It is long wooden handled tool generally made of thick sheet of hardened steel like as spade can be used shifting sand from one piece to another place or to mix sand and water properly for making mold.



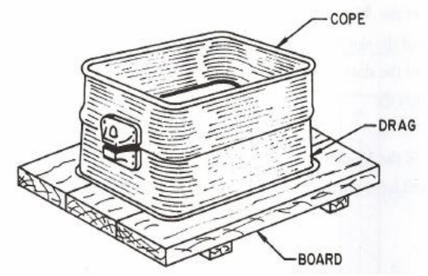
Runner: It is round or semi-round wooden bar which is used to provide a passage through which the molten metal will run into the mold cavity. The size of runner varies according to the size of the mold.

Riser or Sprue: Riser is often providing in the mold to feed molten metal into the main casting compensate for the shrinkage taking place at the time of solidification. It should be placed near

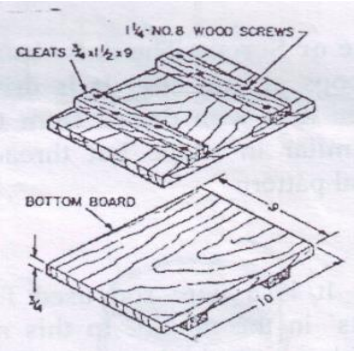


the heavy section that will be subjected to heavy shrinkage. Riser also serve as a large end for escaping a place for collecting loose sand or stage that may be the mold. Riser may be of two types, one is external or exposed and another is internal or build.

Molding Flask: Small or medium sized casting are made in a flask which is a box shaped container without top or bottom. It is made in 2 parts held in alignment by dowel pins. The top part of the flask is called the cope and the bottom parts of the flask are drag. If the flask is made in three parts then the center parts is called a cheek.



Molding Board: The molding board is a smooth surfaced board made of either wood or metal on which the flask and pattern are placed when the mold in started. The board should be perfectly flat and should be reinforced with clench on the bottom. When the mold is turned over the mold surface of the board is finished. When the mold is placed on the similar board called BOTTOM BOARD, which acts as a support for the mold until the metal is poured.



Sprue Cutter: This is a tool made of brass pipe in a various sized in diameter for cutting spruce or runner in the cope part of mold through with the molten metal will be poured into the mold cavity. It is used instead of providing runner for rapid work.

Gaggers or Lifter: These are iron rods bent at one end or both ends. These are used to reinforce sand in the two portion of the box and for supporting bidet of sand wash and then placed next to the one of the cross bar. The lower end should be placed to the pattern and the upper end should extend to the top of mold.

Types of Molding Sand:

The molding sands are classified according to their use in the following categories:

- **Green sand:** the sand in its natural condition with moisture to give it enough strength is formed as green sand.). Unlike the name suggests, "Green sand" is not a type of sand on its own, but is rather a mixture of:
  - Silica sand (SiO_2), or chromite sand ($FeCr_2O$), or zircon sand ($ZrSiO_4$), 75 to 85%, or olivine, or staurolite, or graphite.
  - bentonite (clay), 5 to 11%
  - water, 2 to 4%
  - inert sludge 3 to 5%
  - Anthracite (0 to 1%)
- **Dry sand:** the green sand mold is not very suitable for large casting. So they are dried in some suitable oven to evaporate the excess moisture and to give then extra strength.
- **Facing sand**: the sand which remains around the pattern is the facing sand. So it forms the face of the mold comes in direct contact with the molten metal.
- **Parting sand**: the cope and drag are placed over after the patterns are placed in the respective haves of the flask and the necessary operations of mold making done. There is every possibility that the sand in the cope half and drag half may stick together and with the pattern. To eliminate this possibility parting sand is sprinkled over the parting surface of the cope and drag and the pattern.
- **Baking or floor or black sand**: Around the pattern a layer of sufficient thickness of facing sand is given and the rest volume of the flask is filled with different type of sand called backing sand. The backing sand is meant to provide a good backing to the facing sand.
- **Core sand**: the sand used for making cores is called core sand. This sand has high silica content and is mixed with selected binders.
- **Loam sand**: this sand contains high percentage as high as 50 percent of clay and dried hard. It is specially prepared for loam molding for large casting.

Sand binder:binder is a one kind of extra element which is increasing binding capacity of molding sand such as clay, oil, dextrin, resin etc.

Sand additives: additives are an extra element also which is not increasing binding capacity of molding sand. It is increasing other properties of molding sand. Wood flower, straw flower, Portland cement, bentonite, coal dust, and silica flower is used as additives.

Composition of typical molding sand:

Silica sand	85-90%
Clay	10-12%
Coal dust	6-7%
Wood flower	0.5-0.8%
Water	4-5%
Others	0.5-0.8%

Patterns:

Patterns are used to mold the sand mixture into the shape of the casting. They may be **made of wood, plastic, or metal.** The **selection of a pattern material depends** on:

1- The size and shape of the casting
2- The dimensional accuracy
3- The quantity of castings required
4- The molding process to be used

Single piece pattern:

This is the simplest type of pattern, exactly like the desired casting. For making a mould, the pattern is accommodated either in cope or drag. Used for producing a few large castings, for example, stuffing box of steam engine.

Experiment 3:

Study on different types of joint by TIG welding and MIG welding

OBJECTIVE

- Become familiar with Tungsten Inert Gas (TIG) & Metal Inert Gas(MIG) welding processes

Student will be introduced to:

- The TIG, MIG welding equipment, related tools and the essential process safety considerations
- Types of work materials, filler rods, shielding gases etc.

BACKGROUND

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

WELDING PROCESSES

Tungsten Inert Gas (TIG): Tungsten Inert Gas (TIG) or Gas tungsten arc welding (GTAW) is an arc welding process that uses a non-consumable tungsten electrode and an inert gas for arc shielding. Under the correct conditions, the electrode does not melt, although the work does at the point where the arc contacts and produces a weld pool. The TIG process can be implemented with or without a filler metal. Figure 1 illustrates the latter case.When a filler metal is used, it is added to the weld pool from a separate rod or wire, being melted by the heat of the arc rather than transferred across the arc as in the consumable electrode arc welding processes. Tungsten is a good electrode material due to its high melting point of 34100C (61700F).

Since tungsten is sensitive to oxygen in the air, good shielding with oxygen-free gas is required. Typical shielding gases include argon, helium, or a mixture of these gas elements. TIG welding is easily performed on a variety of materials, from steel and its alloys to aluminum, magnesium, copper, brass, nickel, titanium, etc. Virtually any metal that is conductive lends itself to being welded using GTAW. Its clean, high-quality welds often require little or no post-weld finishing. This method produces the finest, strongest welds out of all the welding processes. However, it’s also one of the slower methods of arc welding.

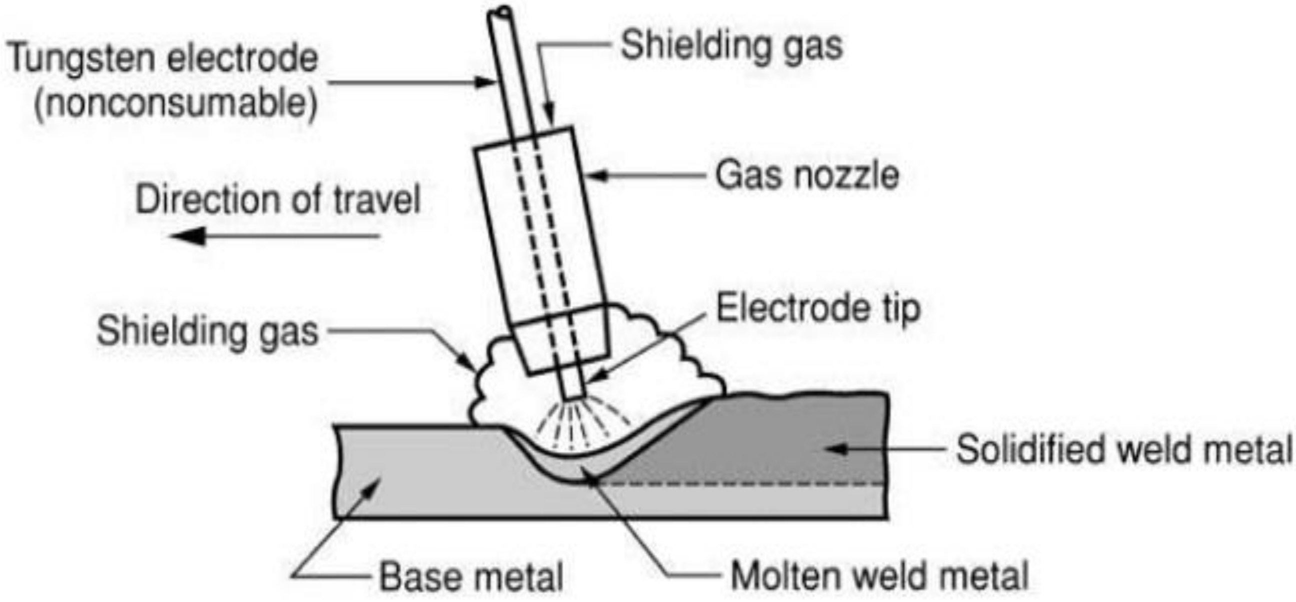


Figure 1: Tungsten Inert Gas (TIG)

Consumable electrode methods

Main articles: Shielded metal arc welding, Gas metal arc welding, Flux-cored arc welding and Submerged arc welding

Shielded metal arc welding

One of the most common types of arc welding is shielded metal arc welding (SMAW), which is also known as manual metal arc welding (MMAW) or stick welding. An electric current is used to strike an arc between the base material and a consumable electrode rod or *stick*. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that gives off vapors that serve as a shielding gas and provide a layer of slag, both of which protect the weld area from atmospheric contamination. The electrode core itself acts as filler material, making a separate filler unnecessary. The process is very versatile, requiring little operator training and inexpensive equipment.

Gas metal arc welding (GMAW):

commonly called *MIG* (for *metal/inert-gas*), is a semi-automatic or automatic welding process with a continuously fed consumable wire acting as both electrode and filler metal, along with an inert or semi-inert shielding gas flowed around the wire to protect the weld site from contamination. Constant voltage, direct current power source is most commonly used with GMAW, but constant current alternating current are used as well. With continuously fed filler electrodes, GMAW offers relatively high welding speeds, however the more complicated equipment reduces convenience and versatility in comparison to the SMAW process. Originally developed for welding aluminium and other non-ferrous materials in the 1940s, GMAW was soon economically applied to steels.

Flux-cored arc welding (FCAW):

It is a variation of the GMAW technique. FCAW wire is actually a fine metal tube filled with powdered flux materials. An externally supplied shielding gas is sometimes used, but often the flux itself is relied upon to generate the necessary protection from the atmosphere. The process is widely used in construction because of its high welding speed and portability.

Submerged arc welding (SAW):

It is a high-productivity welding process in which the arc is struck beneath a covering layer of granular flux. This increases arc quality, since contaminants in the atmosphere are blocked by the flux. The slag that forms on the weld generally comes off by itself and, combined with the use of a continuous wire feed, the weld deposition rate is high. As the arc is not visible, it is typically automated. SAW is only possible in the 1F (flat fillet), 2F (horizontal fillet), and 1G (flat groove) positions.

Non-consumable electrode methods

Gas tungsten arc welding (GTAW), or *tungsten/inert-gas* (TIG) welding, is a manual welding process that uses a non-consumable electrode made of tungsten, an inert or semi-inert gas mixture, and a separate filler material. Especially useful for welding thin materials, this method is characterized by a stable arc and high quality welds, but it requires significant operator skill and can only be accomplished at relatively low speeds. Because of its stable current, the method can be used on a wider range of material thicknesses than can the GTAW process and is much faster. It can be applied to all of the same materials as GTAW except magnesium; automated welding of stainless steel is one important application of the process. Other arc welding processes include atomic hydrogen welding, carbon arc welding, electroslag welding, electrogas welding, and stud arc welding.

Metal Inert Gas (MIG): Metal Inert Gas (MIG) is an arc welding process that uses a consumable electrode consisting of a filler metal rod coated with chemicals that provide shielding.The process is illustrated in Figure 2. Under the correct conditions, the wire is fed at a constant rate to the arc, matching the rate at which the arc melts it. The filler metal is the thin wire that’s fed automatically into the pool where it melts. The filler metal used in the rod must be compatible with the metal to be welded, the composition usually being very close to that of the base metal.

The coating on the rod consists of powdered cellulose mixed with oxides, carbonates, and other ingredients, held together by a silicate binder. Metal powders are also sometimes included in the coating to increase the amount of filler metal and to add alloying elements. The heat of the welding process melts the coating to provide a protective atmosphere and slag for the welding operation. It also helps to stabilize the arc and regulate the rate at which the electrode melts.

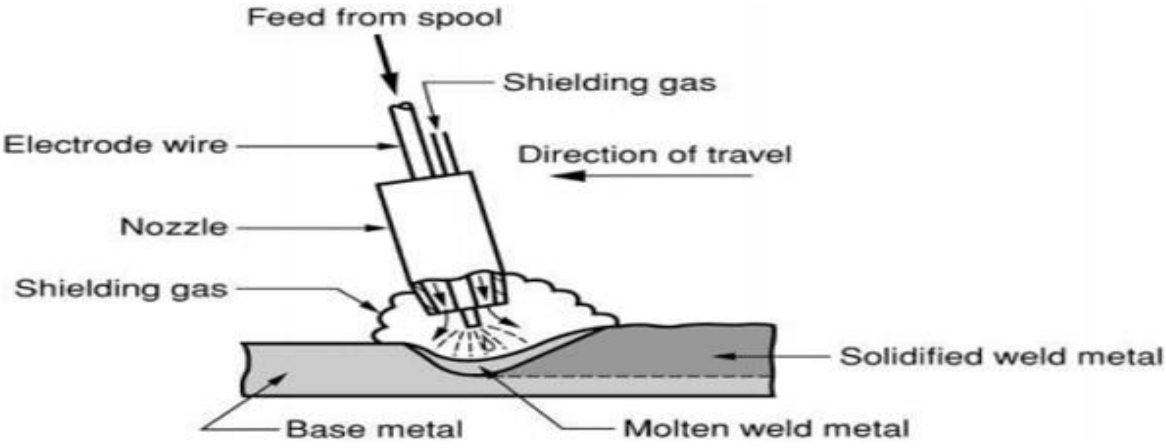


Figure 2: Metal Inert Gas (MIG)

Since fluxes are not used, the welds produced are sound, free of contaminants, and as corrosion-resistant as the parent metal.Argon, helium, and carbon dioxide can be used alone or in various combinations for MIG welding of ferrous metals.

Welding Joints:

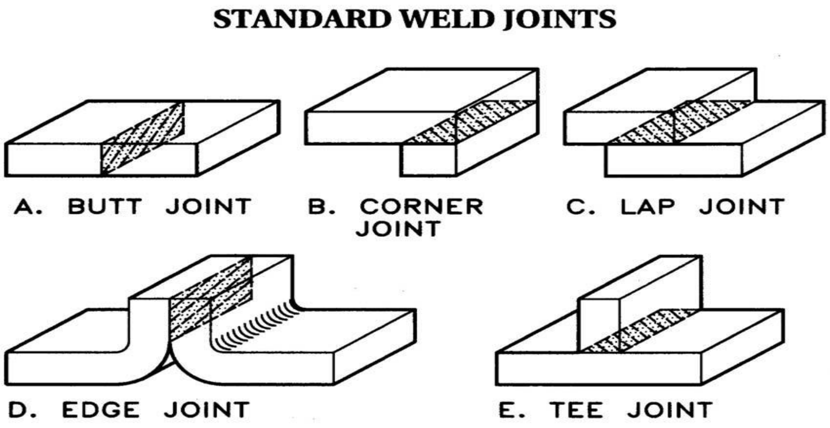


Figure 3: Standard Weld Joints

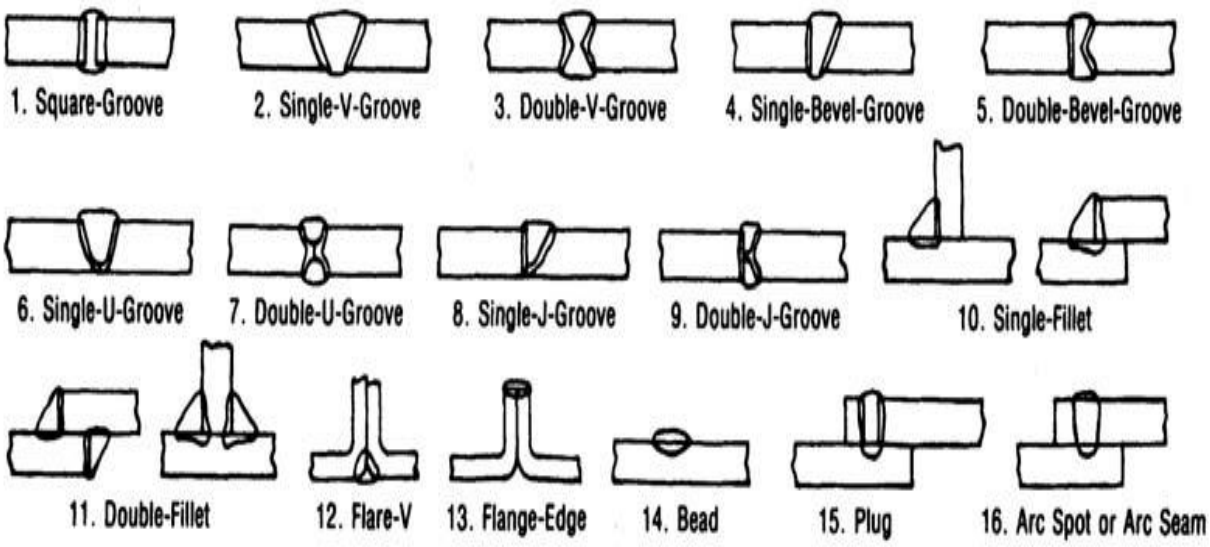


Figure 4: Other basic Weld Joints

Experiment No. : 4

Experiment Name: Study on Split Pattern and Various Types of Molding Sand Properties

Different types of patterns:

The common types of patterns are:

1) Single piece pattern
2) Split piece pattern
3) Loose piece pattern
4) Gated pattern
5) Match pattern
6) Sweep pattern
7) Cope and drag pattern

Split pattern:

These patterns are split along the parting plane (which may be flat or irregular surface) to facilitate the extraction of the pattern out of the mould before the pouring operation. For a more complex casting, the pattern may be split in more than two parts.

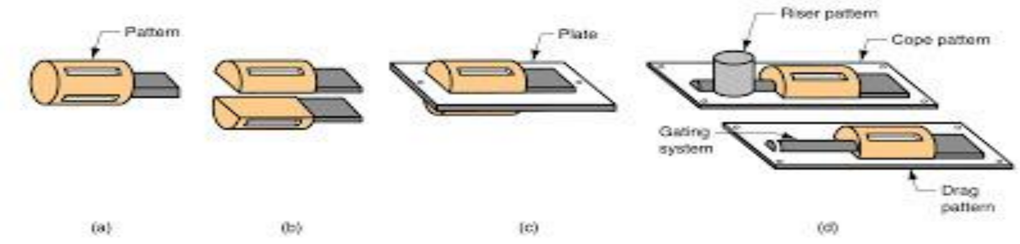


Figure 1: a) single piece pattern, b) split pattern, c) match plate pattern, d) cope and drag pattern

Loose piece pattern:

When a one piece solid pattern has projections or back drafts which lie above or below the parting plane, it is impossible to with draw it from the mould. With such patterns, the projections are made with the help of loose pieces. One drawback of loose feces is that their shifting is possible during ramming.

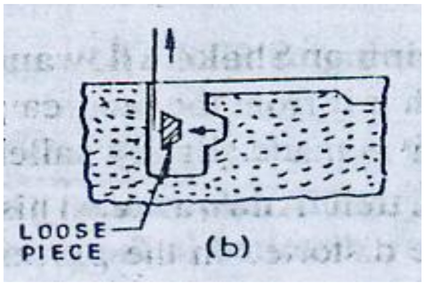


Figure: **Loose piece pattern**

Gated pattern:

A gated pattern is simply one or more loose patterns having attached gates and runners. Because of their higher cost, these patterns are used for producing small castings in mass production systems and on molding machines.

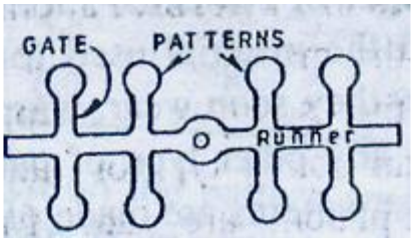


Figure: **Gated pattern**

Match plate pattern:

A match plate pattern is a split pattern having the cope and drags portions mounted on opposite sides of a plate (usually metallic), called the "match plate" that conforms to the contour of the parting surface. The gates and runners are also mounted on the match plate, so that very little hand work is required. This results in higher productivity. This type of pattern is used for a large number of castings. Piston rings of I.C. engines are produced by this process.

Sweep pattern:

A sweep is a section or board (wooden) of proper contour that is rotated about one edge to shape mould cavities having shapes of rotational symmetry. This type of pattern is used when a casting of large size is to be produced in a short time. Large kettles of C.I. are made by sweep patterns.

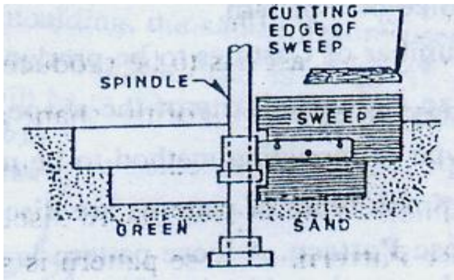


Figure: **Sweep pattern**

Cope and drag pattern:

A cope and drag pattern is a split pattern having the cope and drag portions each mounted on separate match plates. These patterns are used when in the production of large castings; the complete moulds are too heavy and unwieldy to be handled by a single worker.

Pattern Allowances:

To compensate for any dimensional and structural changes which will happen during the casting or patterning process, allowances are usually made in the pattern.

Contraction allowances / Shrinkage allowance:

The pattern needs to incorporate suitable allowances for shrinkage; these are called *contraction allowances*, and their exact values depend on the alloy being cast and the exact sand casting method being used. Some alloys will have overall linear shrinkage of up to 2.5%, whereas other alloys may actually experience no shrinkage or a slight "positive" shrinkage or increase in size in the casting process (notably type metal and certain cast irons). The shrinkage amount is also dependent on the sand casting process employed, for example clay-bonded sand, chemical bonded sands, or other bonding materials used within the sand. The actual shrinkage in the casting depends on the following factors:

- Dimension of the casting
- Design and intricacy of casting
- Resistance of mold to shrinkage
- Molding material used
- Pouring temperature of the molten metal
- Method of molding used

Draft or Taper Allowance:

The pattern needs to incorporate suitable allowances for draft, which means that its slides are tapered so that when it is pulled from the sand, it will tend not to drag sand out of place along with it. This is also known as taper which is normally between 1^0 and 3^0. The amount of the draft needed depends on the following factors:

- Shape of the pattern
- Length of the vertical side of the pattern
- Method of molding
- Intricacy of the pattern

Distortion allowance:

It is found that big castings tend to wrap or distort the cooling period due to their size, shape and type of metal. Uneven shrinkage also causes distortion. To overcome this effect, the pattern is made initially distorted in opposite direction. Such allowance depends on the judgment and experience of the pattern maker who knows the shrinkage characteristics of the metal.

Finishing or Machining Allowance:

The rough surfaces of the casting are to be finished or machined. Therefore, the rough casting must be made bigger than the actual component in size and hence the pattern should also be bigger in size than the actual components. The finishing allowance depends on the following factors:

- Machining operation
- Characteristics of metal
- Methods of casting
- Size and shape of the casting
- Degree of finish required in casting

Shake allowance:

When the pattern is rapped or shaken for easy removal from the cavity, it is found the cavity in the mold is slightly increased in size. To compensate this increase, the pattern should be initially made slightly smaller. In small and medium sized casting, this allowance can be ignored, but in large sized castings or in those that must fit together without machining or where high precision is required, shaking allowance is provided by making the pattern slightly smaller

Molding sands

Molding sands, also known as *foundry sands*, are defined by **eight characteristics**:

- **Refractoriness** — this refers to the sand's ability to withstand the temperature of the liquid metal being cast without breaking down. For example some sands only need to withstand 650 °C (1,202 °F) if casting aluminum alloys, whereas steel needs sand that will withstand 1,500 °C (2,730 °F). Sand with too low a refractoriness will melt and fuse to the casting.
- **Chemical inertness** — the sand must not react with the metal being cast. This is especially important with highly reactive metals, such as magnesium and titanium.
- **Permeability** — this refers to the sand's ability to exhaust gases. This is important because during the pouring process many gases are produced, such as hydrogen, nitrogen, carbon dioxide, and steam, which must leave the mold otherwise casting defects, such as blow holes and gas holes, occur in the casting. Note that for each cubic centimeter (cc) of water added to the mold 16,000 cc of steam is produced.
- **Surface finish** — the size and shape of the sand particles defines the best surface finish achievable, with finer particles producing a better finish. However, as the particles become finer (and surface finish improves) the permeability becomes worse.
- **Cohesiveness** (or **bond**) — this is the ability of the sand to retain a given shape after the pattern is removed.
- **Flowability** – The ability for the sand to flow into intricate details and tight corners without special processes or equipment.
- **Collapsibility** — this is the ability of the sand to be easily stripped off the casting after is has solidified. Sands with poor collapsibility will adhere strongly to the casting. When casting metals that contract a lot during cooling or with long freezing temperature ranges sand with poor collapsibility will cause cracking and hot tears in the casting. Special additives can be used to improve collapsibility.
- **Availability/cost** — the availability and cost of the sand is very important because for every ton of metal poured, three to six tons of sand is required. Although sand can be screened and reused, the particles eventually become too fine and require periodic replacement with fresh sand.

Results of Proper sand:

i. It distributes the binder uniformly around sand grains
ii. Control moisture content
iii. Eliminate foreign particles
iv. Delivers the sand at proper temperature

Experiment: 5

Study of Gas welding, Gas cutting, Soldering and Brazing

OBJECTIVE

- Become familiar with Gas welding, Gas cutting, soldering and brazing processes

Student will be introduced to:

- The gas welding equipment, related tools and the essential process safety considerations
- Types of work materials, filler rods and fluxes

THEORY

Gas Welding:

Gas Welding or Oxy-fuel gas welding is a general term used to describe any welding process that uses a fuel gas combined with oxygen to produce a flame. The most commonly used fuel is acetylene (C_2H_2) gas. The heat source is the flame obtained by combustion of oxygen and acetylene. When mixed together in correct proportions within a hand-held torch or blowpipe, a relatively hot flame is produced with a temperature of about 3300ºC (6000ºF). The chemical action of the oxyacetylene flame can be adjusted by changing the ratio of the volume of oxygen to acetylene.

The combustion of oxygen and acetylene ($C_2 H_2$) is a two-stage reaction. Chemical reactions are as follows: -

Stage 1: In the first stage, the supplied oxygen and acetylene react to produce Carbon Monoxide and Hydrogen. Approximately one-third of the total welding heat is generated in this stage.

$C_2H_2 + O_2 = 2CO + H_2 +$ heat

Stage 2: The second stage of the reaction involves the combustion of the CO and H_2. The remaining two-third of the heat is generated in Stage 2. The specific reactions of the second stage are:

$2CO + O_2 = 2CO_2 +$ heat

$H_2 + ½ O_2 = H_2O +$ heat

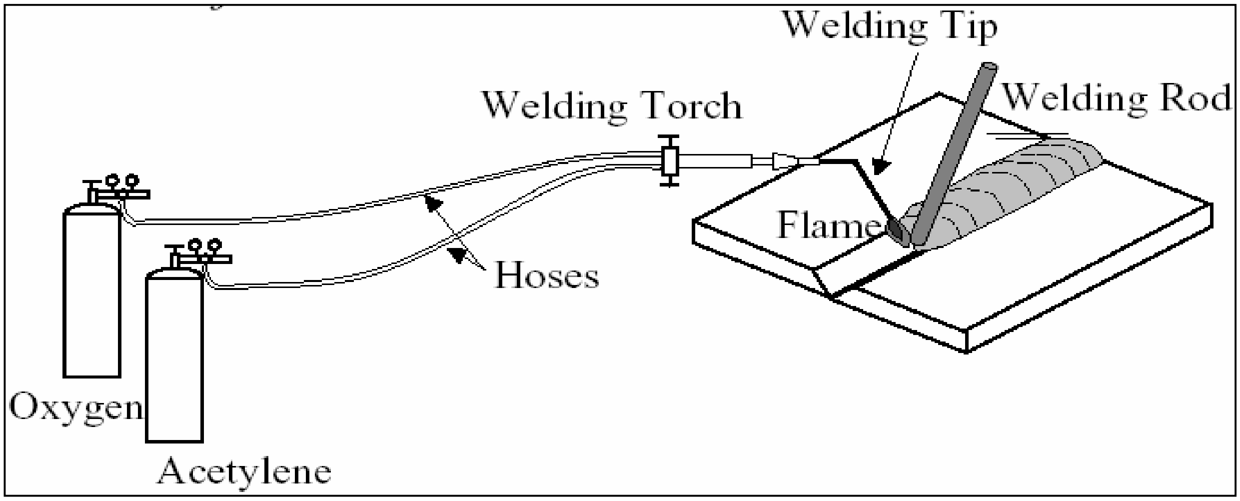


Figure 1: Gas Welding (Oxygen–fuel gas) process

<u>Types of flames:</u>

Three different types of flames can be obtained by varying the oxygen–acetylene (or oxygen–fuel gas) ratio.

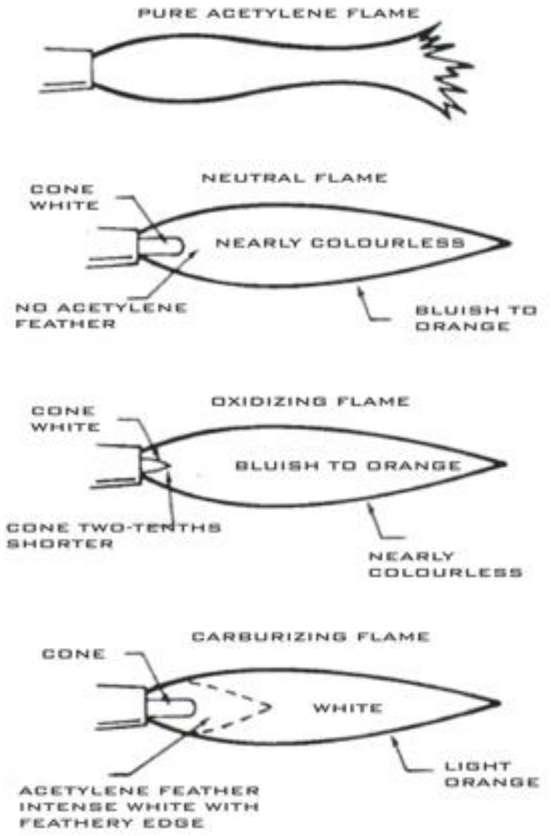


Figure 2: Gas Welding Flames

Neutral Flame: When the ratio of oxygen-acetylene (or oxygen–fuel gas) is between 1:1 and 1.15:1, all reactions are carried to completion and a neutral flame is produced. As the supply of oxygen to the blowpipe is increased, the flame contracts and the white cone become clearly defined, assuming a definite rounded shape. This type of flame is the one most extensively used by the welder, who should make himself thoroughly familiar with its appearance and characteristics.

Oxidizing flame: A higher ratio of oxygen-acetylene (or oxygen–fuel gas), such as 1.5:1, produces an oxidizing flame, which is hotter than the neutral flame (about 3600°C or 6000°F). With the increase in oxygen supply, the inner cone will become shorter and sharper, the flame will turn a deeper purple color and emit a characteristic slight "hiss". An oxidizing flame is only used for special applications.

Carburizing flame: Excess fuel compared to oxygen produces a carburizing flame. The excess fuel decomposes to carbon and hydrogen, and the flame temperature is not as great (about 3050°C or 5500°F). This type of flame is mainly used for hard surfacing and should not be employed for welding steel as unconsumed carbon may be introduced into the weld and produce a hard, brittle, deposit.

Filler Metals & Flux

Filler metals are used to supply additional material to the weld zone during welding. These consumable filler metals maybe bare or flux coated. The purpose of flux is to retard oxidation of the surfaces of the parts being welded, by generating a gaseous shield around the weld zone.

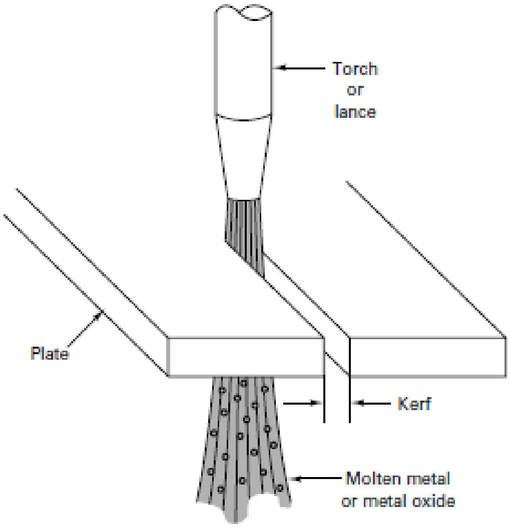


Figure 3: Gas cutting of a metal plate

<u>Gas Cutting</u>: Gas Cutting or Oxyfuel-gas cutting, commonly called flame cutting, is the most common thermal cutting process. The oxyfuel flame is first used to raise the metal to the temperature where burning can be initiated. Then a stream of pure oxygen is added to the torch (or the oxygen content of the oxyfuel mixture is increased) to oxidize the metal. The liquid metal oxide and any unoxidized molten metal are then expelled from the joint by the kinetic energy of the oxygen-gas stream.By moving the flame and oxygen jet (torch tip) progressively forward, fresh metal and oxygen are brought together forming oxide or slag in molten form and expelling it to form a gap, or kerf, as illustrated in figure 3. A balance must be achieved among speed of movement, oxygen jet size, and intensity of flame to achieve a continuous operation.

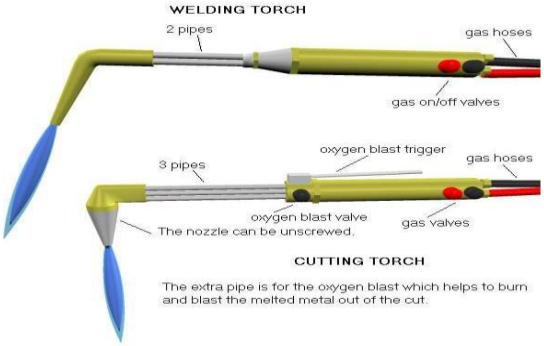


Figure 5: welding torch

Gas Welding/Cutting Equipment

The apparatus used in gas welding consists basically of an oxygen source and a fuel gas source, regulators, hoses, non-return valve, check valve and torches.

Regulator: The regulator is used to control pressure from the tanks by regulating pressure and flow rate of gas. It releases the gas at a constant rate from the cylinder despite the pressure in the cylinder becoming less as the gas in the cylinder is used.

Hoses: The hose is usually a double-hose design i.e. there are two hose joined together. The oxygen hose is green and the fuel hose is red.

Non-return valve: Between the regulator and hose and ideally between hose and torch on both oxygen and fuel lines, a non-return valve and/or flashback arrestor should be installed to prevent flame/oxygen-fuel mixture being pushed back into either cylinder and damaging the equipment.

Check valve: A check valve lets gas flow in one direction only. Not to be confused with flashback arrestor, a check valve is not designed to block a shockwave. A check valve is usually a chamber containing ball that is pressed against on end by a spring. Gas flow in a particular direction pushes the ball out of the way while no flow or flow on the other way lets the spring push the ball into the inlet thus blocking it.

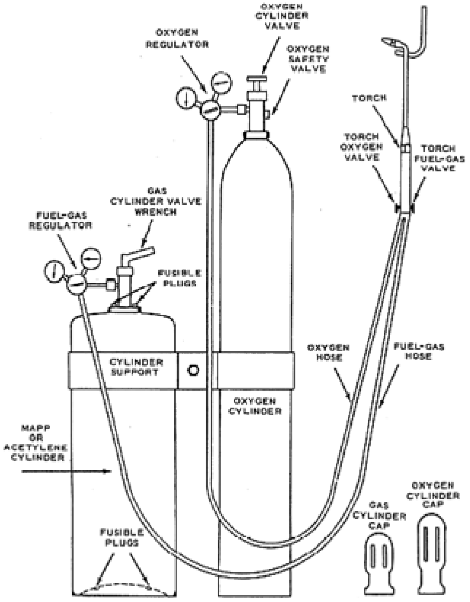


Figure 4: An Oxy-Acetylene welding outfit.

Torches: The torch is the part that the welder holds and manipulates to make the weld. It has a connection and valve for Oxygen and also a connection and valve for Fuel, a handle for grasp, a mixing chamber for mixing of the fuel and oxygen, a tip where the flame forms. A **welding torch** head is used to weld metals and can be identified by having only two pipes running to the nozzle and no oxygen blast trigger. A **cutting torch** head is used to cut metals and can be identified by having three pipes that go to an around 90^0 nozzle and also by oxygen-blast trigger that provides oxygen to blast away material while cutting.

<u>Soldering & Brazing</u>: In soldering & brazing, the surfaces to be joined are first cleaned, the components assembled or fixture, and a low-melting-point nonferrous metal (filler metal) is then melted, drawn into the space between the two solids by capillary action, and allowed to solidify.

Brazing is the permanent joining of similar or dissimilar metals or ceramics (or composites based on those two materials) through the use of heat and a filler metal whose melting temperature (actually, liquidus temperature) is above 450°C (840°F) but below the melting point (or solidus temperature) of the materials being joined.

Soldering is a brazing-type operation where the filler metal has a melting temperature (or liquidus temperature if the alloy has a freezing range) below 450°C (840°F). It is typically used for joining thin metals, connecting electronic components, joining metals while avoiding exposure to high elevated temperatures, and filling surface flaws and defects.

Flux is the substance added to the metal surface to stop the formation of any oxides or similar contaminants that are formed during the soldering and brazing processes. The flux increases both the flow of the filler metal and its ability to stick to the base metal.

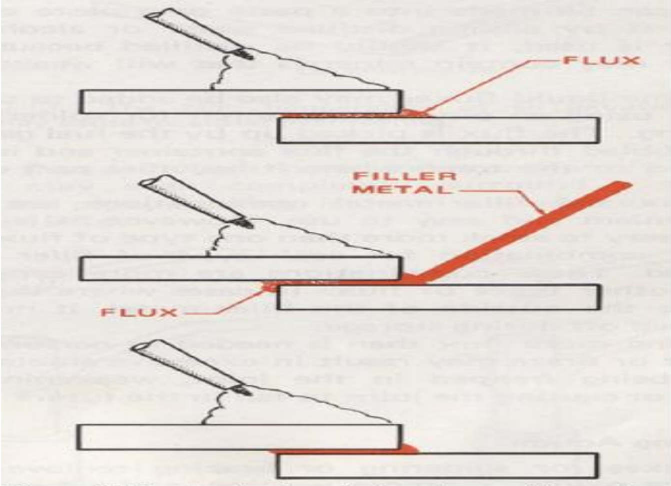


Figure 6: Flux flowing into a joint reduces oxides to clean the surfaces and gives rise to capillary action that causes the filler metal to flow.

Experiment 6:

Study on single pattern double mold preparation and various types of casting defects.

Casting Defects

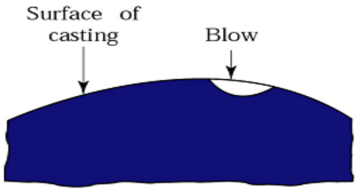
These defects may be the result of:

(a) Improper pattern design,
(b) improper mold and core construction,
(c) improper melting practice,
(d) improper pouring practice and
(e) Because of molding and core making materials.
(f) Improper gating system
(g) improper metal composition
(h) inadequate melting temp and rate of pouring it creates a deficiency or imperfection.

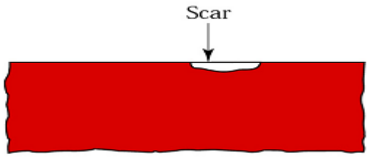
Exceeding quality limits imposed by design and service casting defects are mainly 3 categories. These are:

(1) Major or most severe defects
(2) Intermediate defects
(3) Minor defects

Surface defects:
Due to design and quality of sand molds and general cause is poor ramming.
Blow:
Blow is relatively large cavity produced by gases which displace molten metal form.

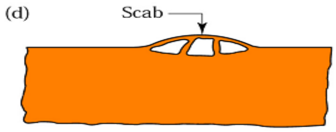


Scar:
Due to improper permeability or venting. A scare is a shallow blow. It generally occurs on flat surf; whereas a blow occurs on a convex casting surface. A blister is a shallow blow like a scar with thin layer of metal covering it.



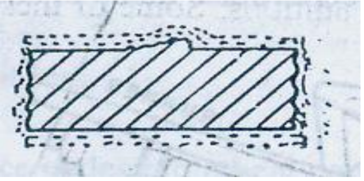
Scab:

This defect occurs when a portion of the face of a mould lifts or breaks down and the recess thus made is filled by metal. When the metal is poured into the cavity, gas may be disengaged with such violence as to break up the sand which is then washed away and the resulting cavity filled with metal. The reasons can be: - to fine sand, low permeability of sand, high moisture content of sand and uneven moulds ramming.



Drop:

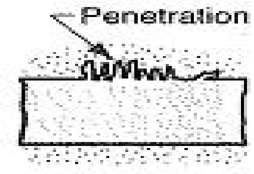
Drop or crush in a mold is an irregularly shaped projection on the cope surface of a casting. This defect is caused by the break-away of a part of mold sand as a result of weak packing of the mold, low strength of the molding sand, malfunctioning of molding equipment, strong jolts and strikes at the flask when assembling the mold. The loose sand that falls into the cavity will also cause a dirty casting surface, either on the top or bottom surface of the casting, depending upon the relative densities of the sand and the liquid.



Penetration:

It is a strong crust of fused sand on the surface of a casting which results from insufficient refractoriness of molding materials, a large content of impurities, inadequate mould packing and poor quality of mould washes.

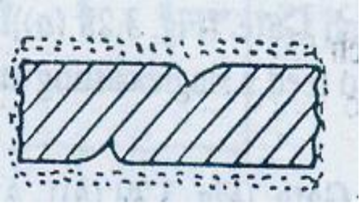
When the molten metal is poured into the mould cavity, at those places when the sand packing is inadequate, some metal will flow between the sand particles for a distance into the mould wall and get solidified.



Buckle:

A buckle is a long, fairly shallow, broad, vee depression that occurs in the surface of flat castings. It extends in a fairly straight line across the entire flat surface.

It results due to the sand expansion caused by the heat of the metal, when the sand has insufficient hot deformation. It also results from poor casting design providing too large a flat surface in the mold cavity. Buckling is prevented by mixing cereal or wood flour to sand.



Internal defects:

Blow holes:

Blow holes, gas holes or gas cavities are well rounded cavities having a clean and smooth surface. They appear either on the casting surface or in the body of a casting.These defects occur when an excessive evolved gas is not able to flow through the mold. So, it collects into a bubble at the high points of a mold cavity ad prevents the liquid metal from filling that space. This will result in open blows. Closed, cavities or gas holes are formed when the evolved gases or the dissolved gases in the molten metal are not able to leave the m ass of the molten metal as it solidifies and get trapped within the casting.

These defects are caused by:

i) Excessive moisture content (in the case of green sand moulds) or organic content of the sand, moisture on chills, chaplets or metal inserts,

ii) Inadequate gas permeability of the molding sand (due to fine grain size of sand, high clay content, hard ramming),

iii) Poor venting of mould, insufficient drying of mould and cores, cores not properly vented, high gas content of the molten metal,

iv) Low pouring temperature and incorrect feeding of the casting etc.

Pin holes:

Pin holes are small gas holes either at the surface or just below the surface. When these are present, they occur in large numbers and are fairly uniformly dispersed over the surface.

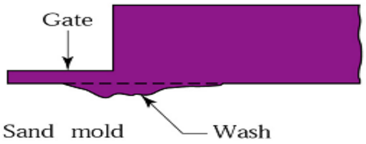
This defect occurs due to gas dissolved in the alloy and the alloy not properly degassed.

Visible defects:

Wash:

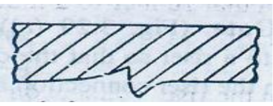
A cut or wash is a low; projection on the drag face of a casting that extends along the surface, decreasing in height as it extends from one side of the casting to the other end.

It usually occurs with bottom gating castings in which the molding sand has insufficient hot strength, and when too much metal is made to flow through one gate into the mold cavity.



Rat tail:

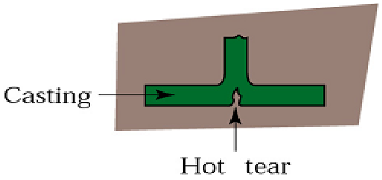
A rat tail is a long, shallow, angular depression in the surface of a flat rating and resembles a buckle, except that, it is not shaped like a broad vee. The reasons for this defect are the same for buckle.



Hot tear:

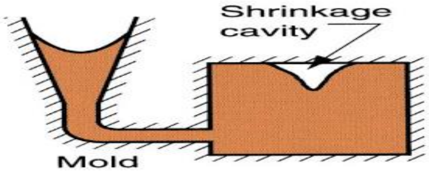
Hot tears are hot cracks which appear in the form of irregular crevices with a dark oxidized fracture surface. They arise when the solidifying met does not have sufficient strength to resist tensile forces produced during solidification.

They are chiefly from an excessively high temperature of casting metal, increased metal contraction incorrect design of the gating system and casting on the whole (causing portions of the casting to be restrained from shrinking freely during cooling which in turn causes excessive high intern resistance stresses), poor deformability of the cores, and non-uniform cooling which gives rise t internal stresses. This defect can be avoided by improving the design of the casting and by having a mould of low hot strength and large hot deformation.



Shrinkage:

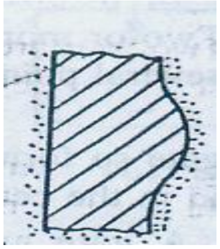
A shrinkage cavity is a depression or an internal void in a casting that results from the volume contraction that occurs during solidification.



(d)

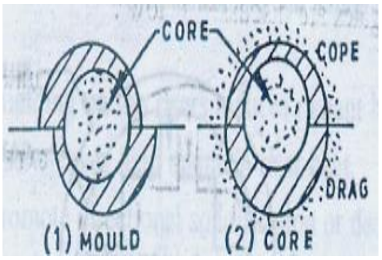
Swell:

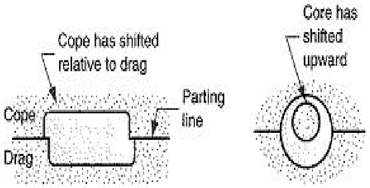
A swell is a slight, smooth bulge usually found on vertical faces of castings, resulting from liquid metal pressure. It may be due to low strength of mold because of too high a water content or when the mold is not rammed sufficiently.



Shift:

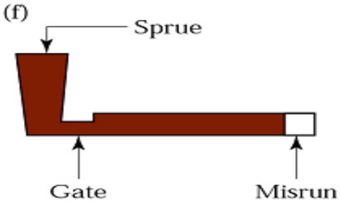
Mold shift refers to a defect caused by a sidewise displacement of the mold cope relative to the drag, the result of which is a step in the cast product at the parting line. Core shift is similar to mold shift, but it is the core that is displaced, and (the dis-placement is usually vertical. Core shift and mold shift are caused by buoyancy of the molten metal





Misrun or cold sheet or short run:

This defect is incomplete cavity filling. The reasons can be: - inadequate metal supply, too- low mold or melt temperature, improperly designed gates, .or length to thickness ratio of the casting is too large. When molten metal is flowing from one side in a thin section, it may loose sufficient heat resulting in loss of its fluidity, such that the leading edge of the stream may freeze before it reaches the end of the cavity.



REPORT CONTENTS:

1. Title
2. Equipment used
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5. Work (schematic diagram: before welding and after welding)
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8. Question answer