Govt. Engineering college, Jhalawar
Department of Mechanical Engineering

Modal Question Paper

II Year III Sem

Subject:- Manufacturing Processes

Que.1 List the common defects found in casting. Also elaborate casting process.

Que.2 Write a short note on:-
   a) Sand Properties
   b) Pattern allowance
   c) Slush Casting

Que.3 Differentiate between Cold working and hot working.

Que.4 Explain Arc Welding Process.

Que.5 Write a short note on:-
   a) TIG Welding
   b) Brazing and soldering

Que.6 Explain sintering . Also explain importance of pre sintering.

Solution:- Midterm 1

Ans.1 A casting defect is an undesired irregularity in a metal casting process. Some defects can be tolerated while others can be repaired, otherwise they must be eliminated. They are broken down into five main categories: gas porosity, shrinkage defects, mold material defects, pouring metal defects, and metallurgical defects.

There are many types of defects which result from many different causes. Some of the solutions to certain defects can be the cause for another type of defect. The following defects can occur in sand castings. Most of these also occur in other casting processes.

Shrinkage defects

Shrinkage defects can occur when standard feed metal is not available to compensate for shrinkage as the thick metal solidifies. Shrinkage defects can be split into two different types: open shrinkage defects and closed shrinkage defects. Open shrinkage defects are open to the atmosphere, therefore as the shrinkage cavity forms air compensates. There are two types of open air defects: pipes and caved surfaces. Pipes form at the surface of the casting and burrow into the casting, while caved surfaces are shallow cavities that form across the surface of the casting.

Gas porosity

Gas porosity is the formation of bubbles within the casting after it has cooled. This occurs because most liquid materials can hold a large amount of dissolved gas, but the solid form of the same material cannot, so the gas forms bubbles within the material as it cools. Gas porosity may present itself on the surface of the casting as porosity or the pore may be trapped inside the metal, which reduces strength in that vicinity. Nitrogen, oxygen and hydrogen are the most encountered gases in cases of gas porosity.[5] In aluminum castings, hydrogen is the only gas that dissolves in significant quantity, which can result in hydrogen gas porosity.

Pouring metal defects

Pouring metal defects include misruns, cold shuts, and inclusions. A misrun occurs when the liquid metal does not completely fill the mold cavity, leaving an unfilled portion. Cold shuts occur when two fronts of liquid metal do not fuse properly in the mold cavity, leaving a weak spot. Both are caused by either a lack of fluidity in the molten metal or cross-sections that are too narrow. The fluidity can be increased by changing the chemical composition of the metal or by increasing the pouring temperature. Another possible cause is back pressure from improperly vented mold cavities.

Metallurgical defects

There are two defects in this category: hot tears and hot spots. Hot tears, also known as hot cracking, are failures in the casting that occur as the casting cools. This happens because the metal is weak when it is hot and the residual stresses in the material can cause the casting to fail as it cools. Proper mold design prevents this type of defect.

Ans.2 a) Properties of Molding sand

The basic properties required in molding sand and core sand are adhesiveness, cohesiveness, collapsibility, flowability, dry strength, green strength, permeability, refractoriness described as under.

1 Adhesiveness

Adhesiveness is a property of molding sand to get the stick or adhere to foreign material such sticking of molding sand with the inner wall of molding box.

2 Cohesiveness

Cohesiveness is property of molding sand by virtue which the sand grain particles interact and attract each other within the molding sand. Thus, the binding capability of the molding sand gets enhanced to increase the green, dry and hot strength property of molding and core sand.

3 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. In absence of collapsibility property the contraction of the metal is hindered by the mold and thus results in tears and cracks in the casting. This property is highly required in cores.

4 Dry strength

As soon as the molten metal is poured into the mould, the moisture in the sand layer adjacent to the hot metal gets evaporated and this dry sand layer must have sufficient strength to its shape in order to avoid erosion of mould wall during the flow of molten metal. The dry strength also prevents the enlargement of mould cavity cause by the metallostatic pressure of the liquid metal.

5 Flowability or plasticity

Flowability or plasticity is the ability of the sand to get compacted and behave like a fluid. It will flow uniformly to all portions of pattern when rammed and distribute the ramming pressure evenly all around in all directions. Generally sand particles resist moving around corners or projections. In general, flowability increases with decrease in green strength and vice versa. Flowability increases with decrease in grain size of sand. The flowability also varies with moisture and clay content in sand.

6 Green strength

The green sand after water has been mixed into it, must have sufficient strength and toughness to permit the making and handling of the mould. For this, the sand grains must be adhesive, i.e. they must be capable of attaching themselves to another body and. therefore, and sand grains having high adhesiveness will cling to the sides of the molding box. Also, the sand grains must have the property known as cohesiveness i.e. ability of the sand grains to stick to one another. By virtue of this property, the pattern can be taken out from the mould without breaking the mould and also erosion of mould wall surfaces does not occur during the flow of molten metal. The green strength also depends upon the grain shape and size, amount and type of clay and the moisture content.

7 Permeability

Permeability is also termed as porosity of the molding sand in order to allow the escape of any air, gases or moisture present or generated in the mould when the molten metal is poured into it. All these gaseous generated during pouring and solidification process must escape otherwise the casting becomes defective. Permeability is a function of grain size, grain shape, and moisture and clay contents in the molding sand. The extent of ramming of the sand directly affects the permeability of the mould. Permeability of mold can be further increased by venting using vent rods.

8 Refractoriness

Refractoriness is defined as the ability of molding sand to withstand high temperatures without breaking down or fusing thus facilitating to get sound casting. It is a highly important characteristic of molding sands. Refractoriness can only be increased to a limited extent. Molding sand with poor refractoriness may burn on to the casting surface and no smooth casting surface can be obtained. The degree of refractoriness depends on the SiO_2 i.e. quartz content, and the shape and grain size of the particle. The higher the SiO_2 content and the rougher the grain volumetric composition the higher is the refractoriness of the molding sand and core sand. Refractoriness is measured by the sinter point of the sand rather than its melting point.

9 Miscellaneous properties of molding sand

In addition to above requirements, the molding sand should not stick to the casting and should not chemically react with the metal. Molding sand need be economically cheap and easily available in nature. It need be reusable for economic reasons. Its coefficients of thermal expansion need be sufficiently low.

b) Types of allowances in pattern

1. Shrinkage allowance:

After solidification of the metal from further cooling (room temp.) dimensions of the patterns increases. So pattern size is bigger than that of the finished cast products. This is known as shrinkage allowance.

It depends on:

a) Dimensions of casting
b) Design and intricacy of casting
c) Resistance of mol to shrinkage
d) Molding materials used
e) Method of molding used
f) Pouring temp of the molten metal

2. Draft or taper allowance:

Pattern draft is the taper placed on the pattern surfaces that are parallel to the direction in which the pattern is withdrawn from the mould (that is perpendicular to the parting plane), to allow removal of the pattern without damaging the mould cavity.

It depends on:

a) the method of molding
b) the sand mixture used
c) the design (shape and length of the vertical side of the pattern)
d) economic restrictions imposed on the casting
e) intricacy of the pattern

3. Distortion allowance:

This allowance is taken into consideration when casting products of irregular shapes. When these are cooled they are distorted due to metal shrinkage.

4. Finishing or machining allowance:

Machining allowance or finish allowance indicates how much larger the rough casting should be over the finished casting to allow sufficient material to insure that machining will "clean up" the surfaces.

This machining allowance is added to all surfaces that are to be machined. Machining allowance is larger for hand molding as compared to machine molding.

It depends on:

a) Machining operation
b) Characteristics of metal
c) Methods of castings
d) Size, shapes and volumes of castings
e) Degree of finish required in castings
f) configuration of the casting

5. Shaking or rapping allowance:

To take the pattern out of the mould cavity it is slightly rapped to detach it from the mould cavity. So the cavity is increased a little.

c) Slush Casting

Slush casting is a variation of permanent mold casting that is used to produce hollow parts. In this method neither the strength of the part nor its internal geometry can be controlled accurately. This metal casting process is used primarily to manufacture toys and parts that are ornamental in nature, such as lamp bases and statues.

The Process

When producing a cast part using the slush casting method, a permanent mold is employed and set up. See basic permanent mold casting . The mold is clamped together and prepared for pouring.

MOLD FOR SLUSH CASTING
READY TO BE POURED

Properties And Considerations Of Manufacturing By Slush Casting

- Slush casting is a type of permanent mold casting, therefore many of the basic principles of a permanent mold process will apply.
- Slush casting is mainly suited to lower melting point materials, zinc, tin, or aluminum alloys are commonly slush cast in manufacturing industry.
- With this process you need to have a mechanical means of turning over the mold in order to pour out the molten metal from the cast part.
- When manufacturing by slush casting it is difficult to accurately control the metal casting's strength and other mechanical properties.
- The casting's internal geometry cannot be effectively controlled with this process.
- The hollow metal castings manufactured by this process are lighter than solid parts and save on material.
- Good surface finish and accurate exterior geometry are possible with the slush casting manufacturing process.

Ans.3 Difference between Hot Working and Cold Working:

S.No.	Cold working	Hot working
1	It is done at a temperature below the recrystallization temperature.	Hot working is done at a temperature above recrystallization temperature.
2.	It is done below recrystallization temperature so it is accomplished by strain hardening.	Hardening due to plastic deformation is completely eliminated.
3.	Cold working decreases mechanical properties of metal like elongation, reduction of area and impact values.	It increases mechanical properties.
4.	Crystallization does not take place.	Crystallization takes place.

5.	Material is not uniform after this working.	Material is uniform thought.
6.	There is more risk of cracks.	There is less risk of cracks.
7.	Cold working increases ultimate tensile strength, yield point hardness and fatigue strength but decreases resistance to corrosion.	In hot working, ultimate tensile strength, yield point, corrosion resistance are unaffected.
8.	Internal and residual stresses are produced.	Internal and residual stresses are not produced.
9.	Cold working required more energy for plastic deformation.	It requires less energy for plastic deformation because at higher temperature metal become more ductile and soft.
10.	More stress is required.	Less stress required.
11.	It does not require pickling because no oxidation of metal takes place.	Heavy oxidation occurs during hot working so pickling is required to remove oxide.
12.	Embrittlement does not occur in cold working due to no reaction with oxygen at lower temperature.	There is chance of embrittlement by oxygen in hot working hence metal working is done at inert atmosphere for reactive metals.

Ans.4 Arc welding is one of several fusion processes for joining metals. By applying intense heat, metal at the joint between two parts is melted and caused to intermix - directly, or more commonly, with an intermediate molten filler metal. Upon cooling and solidification, a metallurgical bond is created. Since the joining is an intermixture of metals, the final weldment potentially has the same strength properties as the metal of the parts. This is in sharp contrast to non-fusion processes of joining (i.e. soldering, brazing etc.) in which the mechanical and physical properties of the base materials cannot be duplicated at the joint.

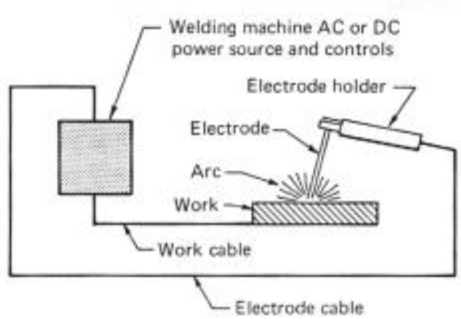


Fig. 1 The basic arc-welding circuit

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. Most welding in the manufacture of steel products uses the second type of electrode.

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.

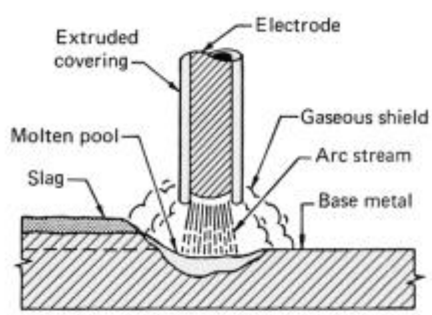


Fig. 2 This shows how the coating on a coated (stick) electrode provides a gaseous shield around the arc and a slag covering on the hot weld deposit.

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.

The arc itself is a very complex phenomenon. In-depth understanding of the physics of the arc is of little value to the welder, but some knowledge of its general characteristics can be useful.

Nature of the Arc:-
An arc is an electric current flowing between two electrodes through an ionized column of gas. A negatively charged cathode and a positively charged anode create the intense heat of the welding arc. Negative and positive ions are bounced off of each other in the plasma column at an accelerated rate.

In welding, the arc not only provides the heat needed to melt the electrode and the base metal, but under certain conditions must also supply the means to transport the molten metal from the tip of the electrode to the work. Several mechanisms for metal transfer exist. Two (of many) examples include:

1. Surface Tension Transfer® - a drop of molten metal touches the molten metal pool and is drawn into it by surface tension
2. Spray Arc - the drop is ejected from the molten metal at the electrode tip by an electric pinch propelling it to the molten pool (great for overhead welding)

If an electrode is consumable, the tip melts under the heat of the arc and molten droplets are detached and transported to the work through the arc column. Any arc welding system in which the electrode is melted off to become part of the weld is described as metal-arc. In carbon or tungsten (TIG) welding there are no molten droplets to be forced across the gap and onto the work. Filler metal is melted into the joint from a separate rod or wire.

More of the heat developed by the arc is transferred to the weld pool with consumable electrodes. This produces higher thermal efficiencies and narrower heat-affected zones.

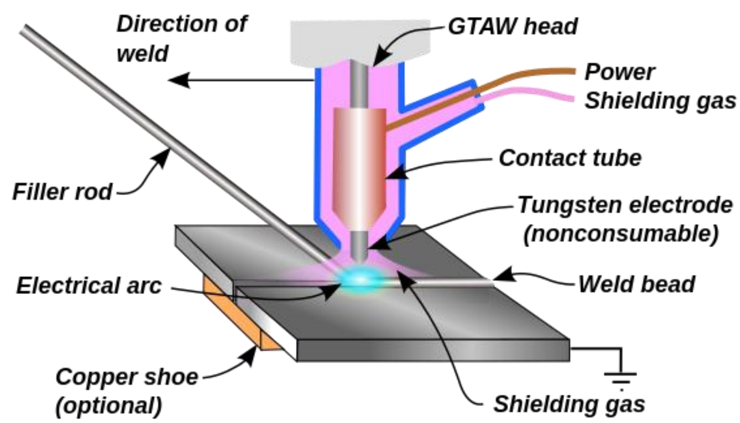
Since there must be an ionized path to conduct electricity across a gap, the mere switching on of the welding current with an electrically cold electrode posed over it will not start the arc. The arc must be ignited. This is caused by either supplying an initial voltage high enough to cause a discharge or by touching the electrode to the work and then withdrawing it as the contact area becomes heated.

Arc welding may be done with direct current (DC) with the electrode either positive or negative or alternating current (AC). The choice of current and polarity depends on the process, the type of electrode, the arc atmosphere, and the metal being welded.

Ans.5

a) TIG Welding
   The mechanism of the increasing of A-TIG welding penetration is studied by using the activating flux we developed for stainless steel. The effect of flux on the flow and temperature fields of weld pool is simulated by the PHOENICS software. It shows that without flux, the fluid flow will be outward along the surface of the weld pool and then down, resulting in a flatter weld pool shape. With the flux, the oxygen, which changes the temperature dependence of surface tension grads from a negative value to a positive value, can cause significant changes on the weld penetration.

Fluid flow will be inward along the surface of the weld pool toward the center and then down. This fluid flow pattern efficiently transfers heat to the weld root and produces a relatively deep and narrow weld. This change is the main cause of penetration increase. Moreover, arc construction can cause the weld width to become narrower and the penetration to become deeper, but this is not the main cause of penetration increase. The effects of flux on fluid flow of the weld pool surface and arc profiles were observed in conventional TIG welding and in A-TIG welding by using high-speed video camera. The fluid flow behavior was visualized in realtime scale by micro focused X-ray transmission video observation system. The result indicated that stronger inward fluid flow patterns leading to weld beads with narrower width and deeper penetration could be apparently identified in the case of A-TIG welding. The flux could change the direction of fluid flow in welding pool. Ithas a good agreement with the simulation



results.

c) Brazing and soldering:-

Brazing As a joining process brazing has certain advantages over mechanical fastening and welding. These advantages include:

• The joining of dissimilar metals, and materials
• Very thin material can be brazed which would otherwise be damaged by welding
• Inaccessible joints can more easily be brazed
• Brazing is easily and more economically automated than many welding processes

Most ferrous, non-ferrous, and many carbides and cermets can be joined by brazing. Fluxes used in brazing consist of fluorides, chlorides, borax, borates, fluoroborates, alkalis, wetting agents and water. The fluxes may be in the form of pastes, powders, liquids, and preforms and are applied by a variety of methods. Fluxes, especially when heated, can be toxic, so adequate ventilation and safeguards are required. The most common filler metals used in brazing include: • Aluminum-silicon • Copper • Copper-phosphorus • Magnesium • Silver • Nickel alloys Each of these flow at specific temperatures and are available as wire, foil, paste, powders, and preforms. Filler metals typically have significantly different compositions from the materials being joined, for this reason their selection is critical to successful brazing.

Brazing Methods

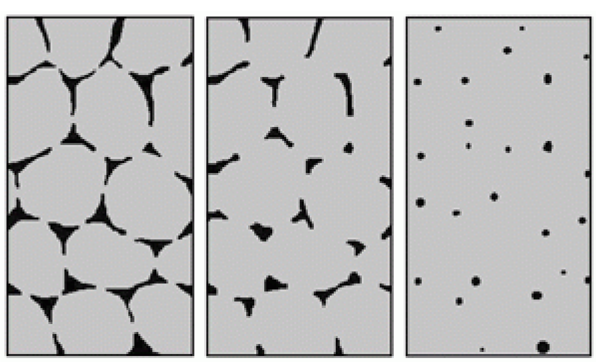
• Torch brazing - uses a oxyfuel gas on previously fluxed joints. Usually a manual operation, but can be automated. • Furnace brazing - a high production method where fixtured parts preloaded with filler metals and, when needed, flux are put in a furnace. The furnace may be either a single batch model or a conveyor model for continuous brazing. • Dip brazing - assembled parts are typically dipped in a heated chemical bath which serve as both fluxing agent and heat source to melt pre-applied filler material. • Induction brazing – a process that uses inductor coils to induce an alternating current into and around a pre-assembled part. The electrical resistance of the part generates the heat to melt the filler metal.

Soldering

Soldering is one of the oldest methods of joining metals. Because filler metals melt at low temperatures there is minimum part distortion and heat damage to sensitive parts. Many combinations of metal to metal, ceramic to metal, and glass to metal may be joined. Soldering is used extensively in the electronics industry where it's limited mechanical strength is not a major factor. Fluxes for soldering fall into three categories, the inorganic acid fluxes, organic fluxes, and the rosin-based fluxes. These are available as liquids, powders, pastes, solid and in flux-cored wires. Soldering fluxes may also be toxic and corrosive and require post-cleaning operations. Filler materials include combinations of tin-lead, tin-silver-lead, tin-zinc, silver-copper-zinc and zinc-aluminum alloys. Again, as with brazing filler metals, solders are supplied as wires, foil, sheets, pastes, preforms, or as bars and ingots.

Ane.6 Sintering is a heat treatment applied to a powder compact in order to impart strength and integrity. The temperature used for sintering is below the melting point of the major constituent of the Powder Metallurgy material.

After compaction, neighbouring powder particles are held together by cold welds, which give the compact sufficient "green strength" to be handled. At sintering temperature, diffusion processes cause necks to form and grow at these contact points.



The three stages of solid state sintering: left: initial stage, centre: intermediate stage, right: final stage (Courtesy EPMA)

There are two necessary precursors before this "solid state sintering" mechanism can take place:-

- Removal of the pressing lubricant by evaporation and burning of the vapours
- Reduction of the surface oxides from the powder particles in the compact.

These steps and the sintering process itself are generally achieved in a single, continuous furnace by judicious choice and zoning of the furnace atmosphere and by using an appropriate temperature profile throughout the furnace.

Sinter hardening

Sintering furnaces are available that can apply accelerated cooling rates in the cooling zone and material grades have been developed that can transform to martensitic microstructures at these cooling rates. This process, together with a subsequent tempering treatment, is known as sintering hardening, a process that has emerged, in recent years, has a leading means of enhancing sintered strength.

Liquid Phase Sintering

Transient liquid phase sintering

In a compact that contains only iron powder particles, the solid state sintering process would generate some shrinkage of the compact as the sintering necks grow. However, a common practice with ferrous PM materials is to make an addition of fine copper powder to create a transient liquid phase during sintering.

At sintering temperature, the copper melts and then diffuses into the iron powder particles creating swelling. By careful selection of copper content, it is possible to balance this swelling against the natural shrinkage of the iron powder skeleton and provide a material that does not change in dimensions at all during sintering. The copper addition also provides a useful solid solution strengthening effect.

Permanent liquid phase sintering

For certain materials, such as cemented carbides or hardmetals, a sintering mechanism involving the generation of a permanent liquid phase is applied. This type of liquid phase sintering involves the use of an additive to the powder, which will melt before the matrix phase and which will often create a so-called binder phase. The process has three stages:

- **Rearrangement**
  As the liquid melts, capillary action will pull the liquid into pores and also cause grains to rearrange into a more favourable packing arrangement

- **Solution-precipitation**
  In areas where capillary pressures are high, atoms will preferentially go into solution and then precipitate in areas of lower chemical potential where particles are not close or in contact. This is called contact flattening and densifies the system in a way similar to grain boundary diffusion in solid state sintering. Ostwald ripening will also occur where smaller particles will go into solution preferentially and precipitate on larger particles leading to densification.

- **Final densification**
  Densification of the solid skeletal network, liquid movement from efficiently packed regions into pores. For permanent liquid phase sintering to be practical, the major phase should be at least slightly soluble in the liquid phase and the “binder” additive should melt before any major sintering of the solid particulate network occurs, otherwise rearrangement of grains will not occur.