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## Internal Assesment Test - I

| Sub: | Metal Casting, Forming and Joining | | | | | | | Code: | 21ME32 |
|---|---|---|---|---|---|---|---|---|---|
| Date: | 01/12/2022 | Duration: | 90 mins | Max Marks: | 50 | Sem: | III | Branch: | MECH 17 scheme |

Answer Any FIVE full Questions

| | | Marks | OBE CO | OBE RBT |
|---|---|---|---|---|
| 1 | Explain with the neat sketch different pattern allowance | [10] | CO3 | L2 |
| 2 | Explain with the neat sketch steps involved in sand casting process | [10] | CO1 | L2 |
| 3 | Explain with the neat sketch $CO_2$ moulding methods | [10] | CO1 | L2 |
| 4 | Explain with the neat sketch investment moulding methods | [10] | CO1 | L2 |
| 5 | Explain with the neat sketch construction and working of electric arc furnace | [10] | CO2 | L2 |
| 6 | Explain with the neat sketch construction and working of CUPOLA furnace | [10] | CO2 | L2 |

**CI** **CCI** **HOD**


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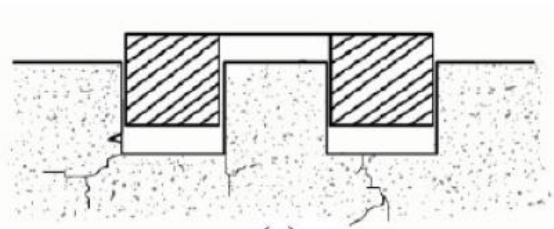
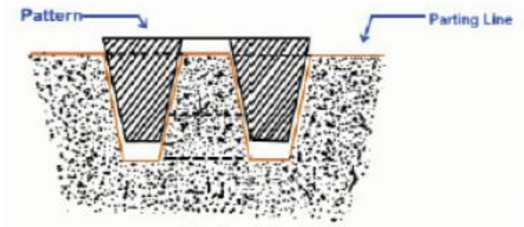
**Q1) SHRINKAGE OR CONTRACTION ALLOWANCE**

In casting process solidification of the molten metal takes place. All the metals or alloys undergo decrease in volume during solidification. This change in volume is known as **shrinkage**. Shrinkage of molten metal takes place in three stages. First stage, period in which temperature falls from the pouring temperature to the liquids temperature called ***Liquid contraction***. Second stage, period in temperature falls from liquids temperature to solidus temperature called ***Solidifying contraction***. Third stage, period from solidus temperature to the temperature reaches to room condition called ***Solid contraction***. The contraction of metal during first and second stage is taken care of by providing proper gating and risering. But contraction of metal at third stage is taken care by providing positive shrinkage allowance to the pattern. ***"Shrinkage allowance is an allowance added to the pattern, to compensate for the metal shrinkage that takes place while the metal solidifies"***

**DRAFT ALLOWANCE**

Draft is meant the taper provided by the pattern maker on all vertical surfaces of the pattern so that pattern can be removed from the sand without tearing away the sides of the sand mold. Figure (a). shows a pattern without draft allowance being removed from the pattern. In this case, till the pattern is completely lifted out, its sides will remain in contact with the walls of the mold, thus tending to break it. Figure (b). is an illustration of a pattern with proper draft allowance. Here, the moment pattern lifting commences, all of its surfaces are well away from the sand surface. Draft allowance varies with the complexity of the sand job. But in general inner surface details of the pattern require higher draft than outer surfaces. The amount of taper varies from 0.50 to 1.50. It may be reduced to less than 0.50 for larger castings. The wooden pattern required more taper than metal patterns because of the greater fractional resistance.


(a)



(b)

**MACHINING ALLOWANCE**

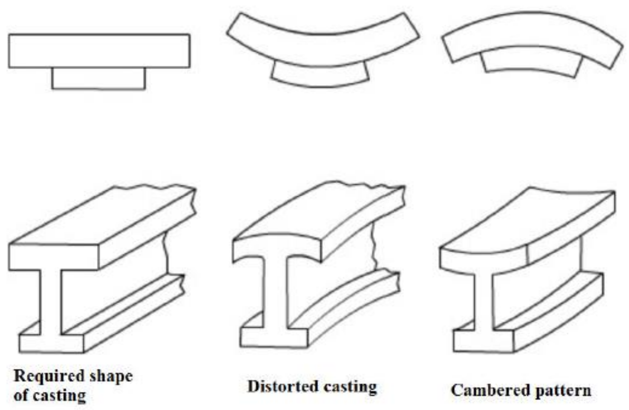
For good surface finish, machining of casting is required. The dimensions gets reduces after machining. Hence the size of the pattern is made larger than the required. For machining extra metals are needed. This extra metal is called machining allowance. This allowance is given in addition to shrinkage allowance. The amount of this allowance varies from 1.6 to 12.5 mm which depends upon the following

1. Type of casting metal
2. Size and shape of casting
3. Method of casting used
4. Method of machining employed

**DISTORTION ALLOWANCE**

Sometimes castings get distorted, during solidification, due to their typical shape. For example, if the casting has the form of the letter U, V, T, or L etc. It will tend to contract at the closed end causing the vertical legs to look slightly inclined outward. This can be prevented by making the legs of the U, V, T, or L shaped pattern converge slightly (inward) so that the casting after distortion will have its sides vertical. The distortion in casting may occur due to internal stresses. These internal stresses are caused on account of unequal cooling of different section of the casting and hindered contraction. Measure taken to prevent the distortion in casting includes:

• Modification of casting design
• Providing sufficient machining allowance to cover the distortion affect
• Providing suitable allowance on the pattern, called camber or distortion allowance (inverse reflection)




**RAPPING OR SHAKING ALLOWANCE**

To remove the pattern from the mould cavity, pattern is rapped with the help of draw spike so that they can be detached from the mould. But due to excessive rapping the size of the cavity in mould gets enlarged. Therefore the size of the pattern is made smaller than the casting, which is known as rapping allowance. In small and medium size casting, this allowance can be neglected. But in larger casting this allowance is considered by making the part slightly smaller than required size. This is negative allowance.

## Q2) STEPS INVOLVED IN CASTING

1. ***Mould sand preparation:*** Mould sand mixture is prepared by using base sand, binder, water and other ingredients and this mixture is used to prepare mould cavity with the help of pattern.
2. **Pattern making.** It is the duplicate copy of the object to be cast and is made up of wood, metal, wax or other materials with the help of special tools. During solidification, the molten metal undergoes reduction in volume thus the size of the pattern is made larger than the product. Patterns are required to make moulds. The mould is made by packing molding sand around the pattern.
3. ***Preparation of mould:*** Mould is produced by ramming sand mixture around a pattern placed in a support or flask, for easy removal of pattern the mould is made into two parts. • In horizontal moulding, top half box in called the cope and bottom half box is called the drag. • In vertical moulding, the leading half box is called the swing and the back half box is called the ram. When the pattern is removed from the moulding box by leaving the imprints called cavity and creating the gating/feeding system to direct the molten metal into the mould cavity.
4. ***Core preparation:*** If the casting is to be hollow, additional patterns called as core that are placed in the mould cavity to form the interior surfaces and sometimes the external surfaces as well of the casting. The shape of the core corresponds to the shape of the hollow required.
5. ***Melting and pouring:*** Metal is melted in the melting furnace. The molten metal is poured into the mould cavity and allowed to solidify. The solidification process allows the product to gain the desired properties and strength. The shrinkage in casting is controlled by the riser and proper design of the mould. The solidified metal is removed from the cavity by destroying the mould.
6. ***Cleaning:*** Includes all the operations required to remove the **gates** and **risers** that constitute the gating/feeding system and to remove the adhering sand, scale, parting fins, and other foreign material that must be removed before the casting is ready for shipment or other processing.
***7. Inspection & Testing*** • Inspection follows, to check for defects in the casting as well as tonsure that the casting has the dimensions specified on the drawing and/or specifications. • Inspection for internal defects may be quite involved, depending on the quality specified for the casting.

**Advantages**

1. Cheapest method of fabrication.
2. Large size objects can be produced easily.
3. The objects with complex and intricate shapes, which cannot be produced by other method of production, can usually be cast.
4. Castings with wide range of properties can be produced by adding various alloying elements.
5. All metals and alloys can be cast and also some plastics.
6. Required dimensional accuracy can be achieved by selecting proper type of moulding and casting process.

7. Suitable for batch production and also for mass production system.

**Dis-Advantages**
1. Time required for process, making casting is quite long.
2. It requires high energy to melt the metal.
3. The working conditions in foundries are quite bad due to dust, heat, fumes, slag, etc.
4. Metal casting is highly labor intensive than other process.
5. Lesser productivity than other processes.

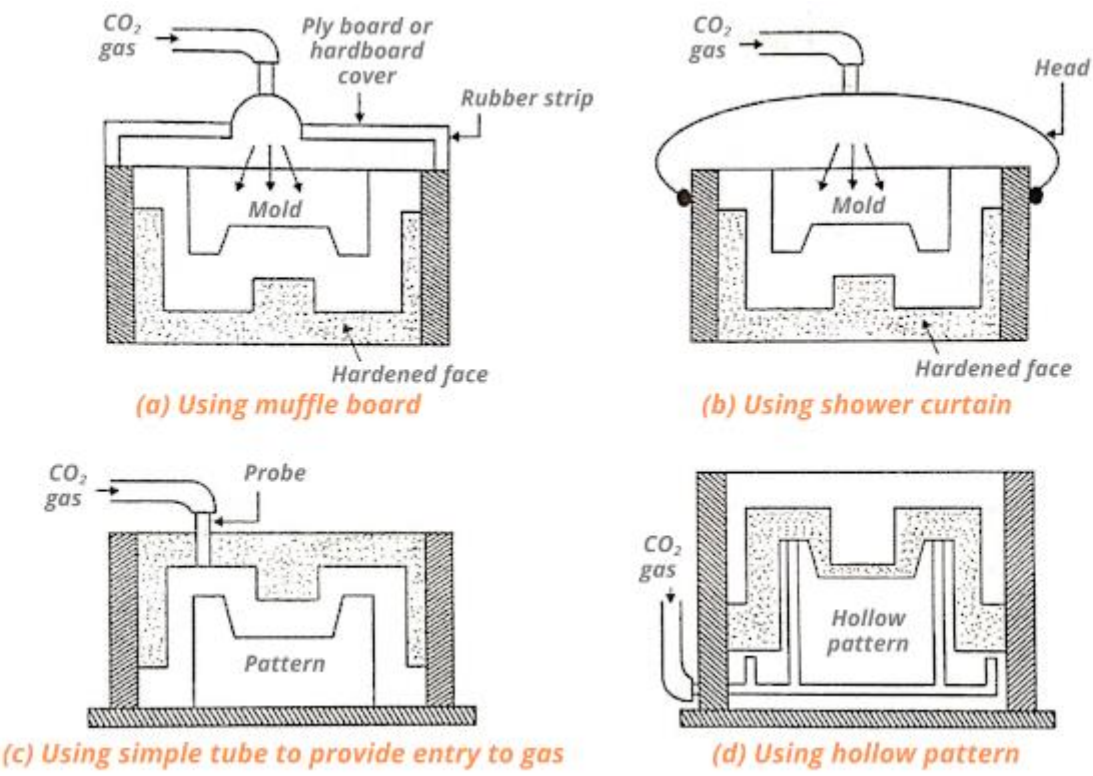
## Q3) $CO_2$ molding process

Working Principle The highly flowable mixture of pure dry silica sand and sodium silicate binder is rammed or blown into the mould or core box. Carbon –dioxide gas at a pressure of about 1.5 bar is diffused through the mixture (of sand and sodium silicate) to initiate the hardening reaction which takes from a few seconds to a few minutes depending upon the size of core or mould.Passage of carbon-dioxide through the sand containing sodium silicate produces carbonic acid in the aqueous solution, this causes a rise in the SiO2- Na2O ratio and the formation of a colloidal silica gel which hardens and forms a bond between the sand grains. The reaction is represented by the following equation.

NaSiO3 + CO2 ---------◊ NaCO3 + SiO2
(Sodium Silicate) (Silica Gel)

**Operation**

This sand is mixed with 3 to 5 % sodium silicate liquid base binder in Muller for 3 to 4 minutes. Additives such as coal powder, wood flour sea coal, and dextrin may be added to b improve its properties. Aluminium oxide Kaolin clay may also added to the sand. Patterns used in this method may be coated with Zinc of 0.05 mm to 0.13 mm and then spraying a layer of aluminium or brass of about 0.25 mm thickness for good surface finish and good results.




(a) Using muffle board
(b) Using shower curtain
(c) Using simple tube to provide entry to gas
(d) Using hollow pattern

**Advantages**
• Operation is speedy since we can use the mould and cores immediately after processing.
• Heavy and rush orders
• Floor space requirement is less
• Semi skilled labor may be used.

**Disadvantages**: Difficult in reusing the moulding sand.

## Q4) INVESTMENT MOULDING

This process is also known as **low wax process** or **precision casting**. In this process a disposal type of pattern is used like wax pattern which subsequently melted from the mould, leaving a cavity having all the details of the original pattern. In this process, refractory sand slurry is prepared by using -325 mesh **silica flour** with a binder **ethyl silicate** or **colloidal silica** etc., **accelerator (HCL)** and **water**.

**Steps involved in process**

1. ***Pattern making*****:** The investment casting process begins with the production of wax pattern of the desired casting. Pattern is prepared by injecting molten wax into the metallic mould and allows cooling for some time as shown in **Fig a.** After solidification the wax takes the shape of the cavity. Metallic mould gives a smooth surface finish and long life.

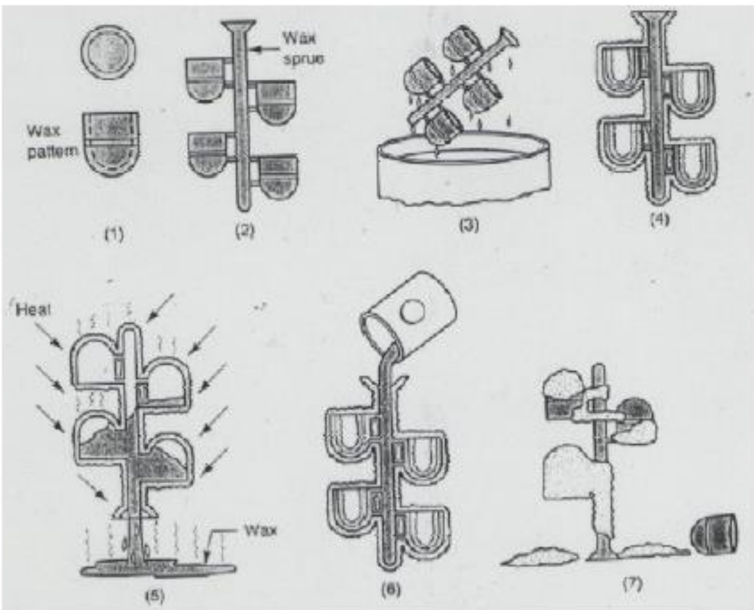
2. ***Assemble the wax patterns:*** Depending on the application multiple wax patterns may be created and then assembled into one complex pattern so that they can all be cast at once. These multiple patterns are attached to a common wax sprue, and gating system which forms the **cluster** or **tree** of patterns as shown in **Fig b.**

3. ***Investment*****:** The ceramic mould, known as the *investment*, is produced by three repeating steps: coating, stuccoing, and hardening. I. The first step involves dipping the cluster of patterns into slurry of fine refractory material and then letting any excess drain off, so a uniform surface is produced. This fine material is used first to give a smooth surface finish and reproduce fine details. II. In the second step, the cluster is *stuccoed* with a coarse ceramic particle, by dipping it into a fluidized bed, placing it in a rainfall-sander, or by applying by hand. III. Finally, the coating is allowed to harden. These steps are repeated (6-8 times) until enough layers (5-15 mm thickness) must be formed to build a shell strong enough to with stand subsequent operations as shown in **Fig c.**

4. ***Dewaxing*****:** The investment is then allowed to completely dry, which can take 16 to 48 hours. Drying can be enhanced by applying a vacuum or minimizing the environmental humidity. The coated wax assembly is inverted and the shell is heated around 10000C to 12000C to remove wax as well as to improve the strength of shell as shown in **Fig d.** The collected wax is then reused.

5. **Mould preparation:** The prepared investment mould shell is placed in a flask and the backing sand material is rammed around the shell to give support in a flask. Now the mould is completely ready to receive the molten metal.

6. ***Pouring:*** The molten metal is poured into the shell through a funnel- shaped pour cup and flows down by gravity, through the gates and into the part cavities as shown in **Fig e.** As the metal cools, the parts, gates, sprue and pouring cup become one solid casting. After the casting has cooled, the ceramic shell is broken off and the parts are cut from the sprue.

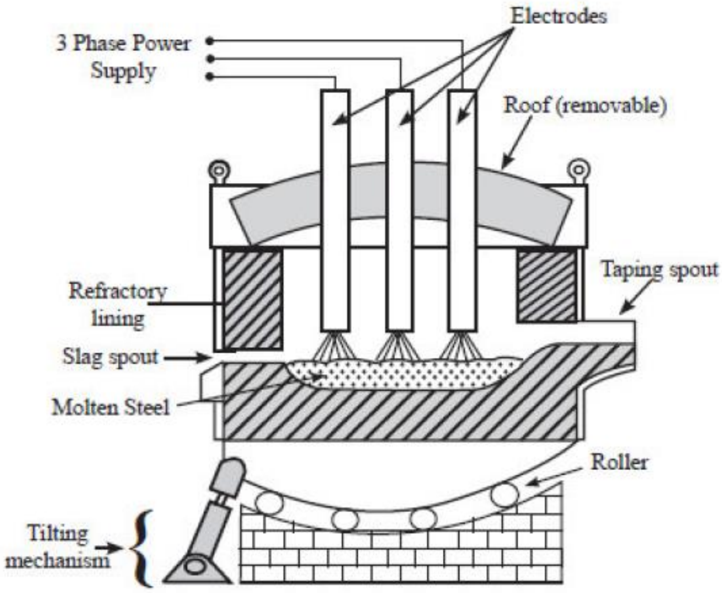



## Q5) DIRECT ARC ELECTRIC FURNACE

**Construction**

1. This furnace consists of a cylindrical shell with hemispherical bottom made of thick mild steel shell. The furnace shell is lined in the side, bottom and roof with refractory bricks to protect it from internal heat.

2. The base is mounted on rollers to enable tilting of the furnace forward for pouring molten metal into ladle through pouring spout and can also tilt backward to remove slag through charging door.
3. The roof is a dished dome made of steel shell lined inside with refractory bricks, which can be opened to charge the raw materials into the furnace.
4. The roof is provided with three holes, through which non-consumable graphite electrodes are inserted into the furnace and these electrodes which in turn are connected to the 3-phase power supply.
5. The charging door is provided in the front side for observation, minor charging, slagging etc., while a pouring spout is provided on the opposite side to remove molten metal.




**Working**

6. The furnace is charged with raw materials through the charging door. The electrodes are lowered down and fixed at proper position.
7. The arc is produced, when the tip of the electrodes are struck with the charge metal, on supplying necessary current.
8. The suitable gap is maintained between electrodes and charge metals by regulating the movement of the electrodes so that stabilised arc is maintained between them.
9. The heat is generated by resistance offered by the charge metals to the flow of current. The arcing temperature is of about 3000 $^0$C, thus sufficient heat can be generated.
10. The metal below the electrodes starts melting; gradually it melts remaining metal in the furnace. As the charge starts melting, the flux reacts to form slag containing all the impurities. Once the metal reaches the required pouring temperature, the arc is disconnected by raising the electrodes.
11. Slag is removed through the charging door by tilting the furnace backward and also clean molten metal is removed through spout by tilting it forward.

## Q6) CUPOLA FURNACE:

Cupola furnaces are tall, cylindrical furnaces used to melt iron and ferrous alloys in foundry operations. A schematic diagram of a cupola is shown below. This diagram of a cupola illustrates the furnace’s cylindrical shaft lined with refractory and the alternating layers of coke and metal scrap. The molten metal flows out of a spout at the bottom of the cupola.

**Operation**

1. **Preparation:** The slag and waste from previous melting is cleaned. The bottom doors are closed. A sand bottom is prepared sloping towards tap spout. The height of sand bed is to be about 200 mm. a tap spout is formed and lined with clay. A slag hole is prepared. The cupola is dried thoroughly.

2. **Firing:** Oiled waste and wooden pieces are placed at the bottom and fire is started. Now air is supplied into the furnace. When the wood starts burning, coke is charged in several portions. When the coke burns, more coke is added up to the tuyere level. The blast is turned off. Again coke is added upto the level of bed charge. When the coke bed burns for half an hour, the charging is done.

3. **Charging:** Alternative layers of coke, flux and iron metal is charged through the charging door. The metal to coke ratio by weight is about 8:1 is maintained. The commonly used flux is limestone and is added upto 25-50% by weight of the coke charged.
4. **Melting:** After charging the cupola with alternative layer of coke, flux and metal, the charge is allowed to preheat of about 30-45 minutes and preheating of charge takes place by heat from the burnt coke, which is supplied during firing stage.

Once the coke becomes hot, it melts the metal charge. The tap spout is kept closed by a plug. The liquid metal falls down and the coke floats up on top of it. The flux also melts and reacts with the impurities of the molten metal forming a slag over a liquid metal.