DIGITAL EDUCATION
MARTCOST

MECHANICAL ENGINEERING

Material Science & Production Engineering

Hand Notes For GATE, IES, PSUs & Competitive Exam

Hand Notes

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6|8|11
Saturday

PRODUCTION

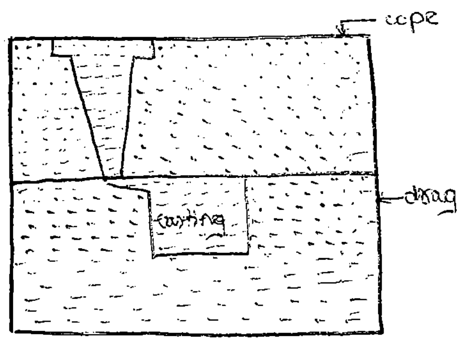
120 hrs

Marks :- 27 to 30.

CASTING

ref:- principles of metal casting by Kofts and Ru33enthal.
work shop technology by Hajra Choudari.

Casting is a process in which the liquid molten metal is poured into the casting cavity, allow it to solidify and after solidification; the casting can be taken out by breaking the mould.



we pour the liquid molten metal to the casting cavity.

Steps

1. Pattern making
2. Mould and core making
3. Pouring and solidification
4. Fettling
5. Inspection

Pattern making

Replica of the casting to be produced is the pattern.

Replica means that shape of the pattern remain same as the shape of the casting to be produced but the dimensions of the pattern is different from the casting.

pattern size = Casting size ± Allowances

Allowances :-

5 diff types of allowances

1. Shrinkage allowance } These two have greater significance in change in size.
2. machining allowance
3. Draft allowance
4. Shake allowance
5. Distortion allowance

(1) Shrinkage allowance :-

The metals are poured at the pouring temperature

Pouring temp = Melting Point + 150-200°C

→ degree of superheat (150-200°C)

* Always the pouring temperature must be greater than M.P

To avoid the solidification of the molten metal in the passages
[It make use of sensible heat than the latent heat ; thus no phase change occurs]

$$PT_{(L)} \xrightarrow[\text{sensible heat (1)}]{\text{cool}} FT_{(L)} \xrightarrow[\text{latent heat (2)}]{\text{cool}} FT_{(S)} \xrightarrow[\text{sensible heat (3)}]{\text{cool}} RT_{(S)}$$

RT - room temp
FT - freezing temp

3 stages involved in so cooling.

* In all the 3 stages of cooling ; the shrinkage of material will be taking place.
whatever shrinkage taking place in the 1st and 2nd stage is named as liquid shrinkage and whatever shrinkage taking place in 3rd stage is named as solid shrinkage.

The liquid shrinkages are compensated by the riser and solid shrinkage by providing shrinkage allowance on the pattern.

Shrinkage allowance is the allowance provided in pattern for compensating solid shrinkage taking place during casting of the material from freezing temperature as a solid to the room temperature.

Aluminium has the highest liquid shrinkage [6%]

Because the liquids are measured as a form of volume, liquid shrinkages can be specified as a % by volume.

Because the solids are measurable as dimensions, the solid shrinkage will always be specified as a % over dimension.

When a material is heated it expands by

$$\delta L = L \alpha \Delta T$$
$$= L \alpha (T_F - T_r)$$

L - dimension
α - coeff of thermal expansion
ΔT - change in temp.
FT - fr. temp
RT - room t.

This much will shrink. So this is the shrinkage allowance

$$\boxed{\text{Shrinkage allowance} = L \alpha (T_F - T_r)}$$

It mainly depends of α

strictly speaking S.A should be calculated by this formula but due to unavailability of all

Brass - is having highest solid shrinkage and thus highest shrinka allowance [$\alpha = 23\ \mu m/m^\circ C$]

Admirality metal - It is having slightly higher $\alpha = 23.5\ \mu m/m^\circ C$

Invar, Platinum-iridium alloy - α = 'almost 0'.

Invar - $\alpha = 0.0000096$

For casting of these 2 metals No shrinkage allowance is provid

Grey cast Iron, Ice - $|\alpha = -Ve|$

on cooling it expands and contracts on heating.

Taking all shrinkage together is the total shrinkage

Steel - liquid and solid shrinkage taken together would be highest in steel.

* largest riser needed - Aluminium
* largest cast volume - brass
* casting = 200 × 100 × 50, SA = 1%] Grey cast iron.

? $\dfrac{\text{Vol of Patt}}{\text{vol of casting}} = \dfrac{(.99)^3\,[200 \times 100 \times 50]}{[200 \times 100 \times 50]} = (.99)^3 = .97$ —— since -Ve allowance volume should be reduced.

99%

$200\ \frac{99}{100}$

$99\{2 \times 1 \times \frac{1}{2}\}$

$\frac{99}{2}$

② Machining allowance

The excess material provided on the pattern which will be removed by machining of the casting after the casting process is completed.

It's be provided due to

① As it is the casted components, will have poor surface finish, but most of the engineering components require good or excellent surface finish which is possible by machining. ∴ for machin the component excess materials should be provided.

② To accomodate variation in shrinkages taking place due to the variation of room temperature.

$$SA = L\,\alpha\,(T_f - T_r)$$

machining allowance is provided on x mm/side.

eg:- Cylinder D = 20 mm, L = 300 mm

SA = 2 in 100 = $\frac{2}{100}$ or 2:100

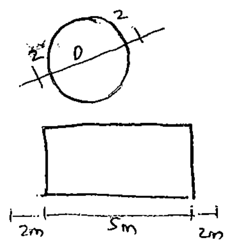
∴ MA = 2 mm/side

w.t is the dimensions of pattern provided by SA + MA

$$D = 200 + \frac{2}{100} \times 200 = 204$$

$$L = 500 + \frac{2}{100} \times 500 = 510$$

dimensions with SA + MA



$$D = 204 + 2 + 2 = 208$$

$$L = 510 + 2 + 2 = 514$$

OR

better:- dimension of pattern size with MA

$$D = 200 + 2 + 2 = 204$$

$$L = 500 + 2 + 2 = 504$$

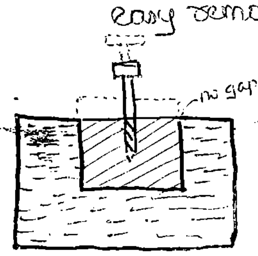
PS with MA + SA

$$D = 204 + \frac{2}{100} \times 204 = 208.08$$

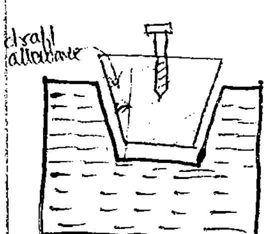
$$L = 504 + \frac{2}{100} \times 504 = 514.08$$

(3) Draft allowance

Making the vertical surfaces of the pattern into inclined surfaces for easy removal of the pattern from the mould.



* always the removal of pattern should be with human hand. No machineries should be engaged.
So if a small shake to our hand — disruption occurs

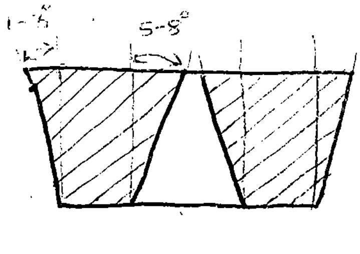


with out providing draft allowance — until the last point of the pattern comes out from the mould, there is a contact b/w the pattern and the mould and any shaking or vibration taken place to the hand make causes to damage the mould walls.

with the provision of draft allowance; as soon as a small amount of pattern is lifted from the mould, immediately the clearance or gap is existing b/w the pattern and the mould. ∴ the pattern can be removed easily without any damages to the mould walls.
∴ the

for external draft surfaces the draft allowances is 1–3°

for internal surfaces the draft allowances = 5–8°



NOTE :- In casting process ; if pattern is made by using the materials like wax, mercury (frozen), and polystyrene as a pattern ; then no draft allowance is to be provided.

mercury at room temp ⇒ liquid / melting point of Hg is $-39°C$.
Thus mercury when cooled to -70 to $-80°C$; perfect solid Hg is obtained. Then mould is made and when kept in room temp. it changes to liquid. so easily removed.

In case of wax when the molten metal is poured ; it's removed in liquid state.

Polystyrene not polystrene (thermosetting plastic) — it can't be converted to liquid

↳ (thermo plastic) — it's been used.

without removing pattern metal is removed.

M.P of polystyrene — 170–200°C and vapourization temp is 250

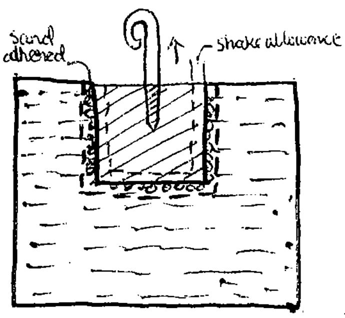
The pouring temp would be above it and with in no time the polystyrine is vapourized and escaped by the porousity property of moulding sand. Also it's escaped through risers.

application → Very large sized casting like machine tool beds.

disadvantages → Not reusable

* large sized pattern could not be removed by human hand ⇒ so here no need of removal of pattern.

④ Shake allowance :-



During removal of the pattern from the mould, whatever the moulding sand which has adhered to the pattern also gets removed and it damages the mould walls.

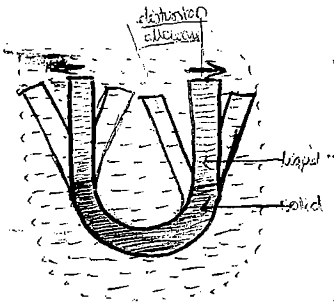
To avoid this, before removal of the pattern from the mould, the pattern will be shaked so that the adhered moulding sand will be separated and no damages would take place to the mould.

But during shaking of the pattern the size of the cavity produced will become greater than the size of the pattern ; which increases the size of the casting.

To maintain the size of the casting as required, originally the pattern size has to be reduced by an amount equal to shake allowance.

The amount of the shake allowance depends on the mold making person.
If the pattern is made of wax or Hg or polystyrene as the, no shake allowance is provided.

(5) Distortion allowance



It's not required on all the castings but it's required to provide only during the casting of U or V shaped castings to be produced

During casting of U or V shaped castings, because of the differential shrinkage; the vertical legs of U may get bent outwards and produces inclined legs of U

To get vertical legs of U in the original pattern; the legs would be bent inwards so that during casting these legs would be bent outward and produces vertical legs of U.

The amount of bending legs inward is called **distortion allowance**.

The amount of distortion allowance depends on $\boxed{\frac{L}{t}}$ ratio where L - length of the leg and t - thickness of leg.

Pattern materials

Properties

1. Low or minimum moisture absorption.
   If moisture absorption takesplace - pattern increases size → cavity increases → casting size increase
2. Low dencity - for easy handling (placing and removal)
3. Good or excellent surface finish
4. Easiness in fabrication.
5. Cheap

Materials

1. **Wood** :-

light weight, low dencity, ... all the properties req for pattern is present (0.4 - .8g/cc) except moisture absorbtion.

whichever wood having low moisture absorbtion; the corresponding wood can be taken as pattern materials.

eg:- Teak wood, mahagony.

2. **Metal** :-

would have a problem of difficulty in manufacturing and dencity would be high.

Out of all metals lowest δ is possessed by Al (2.7g/cc) but it has dencity almost 5 to 8 times higher than the dencity of ~~too~~ wood.