



POSTAL BOOK PACKAGE 2026

MECHANICAL ENGINEERING

CONVENTIONAL Practice Sets

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PRODUCTION AND MAINTENANCE ENGINEERING

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Metal Casting

Practice Questions : Level-I

- Q.1** A pressure die casting set-up was testing by injecting water (density 1000 kg/m^3) at pressure of 200 bar. Mould filling time was found to be 0.05 s. Afterwards, the actual casting is made by injecting the liquid metal (density 2000 kg/m^3) at an injection pressure of 400 bar. Neglecting all losses (friction, viscous etc). Determine the approximate mould filling time.

Solution:

Let us injection velocity of liquid V_1 from Bernoulli equation,

$$V_1 = \sqrt{\frac{2p_0}{\rho}} = \sqrt{\frac{2 \times 200 \times 10^5}{1000}} = 200 \text{ m/s}$$

Volume flow rate through unit cross-section,

$$Q_1 = A_1 \times V_1 = 1 \times 200 = 200 \text{ m}^3/\text{s}$$

Volume of liquid flow in 0.05 sec = $Q \times t_{f1} = 200 \times 0.05 = 10 \text{ m}^3$

When liquid metal injected.

The injection velocity of liquid metal (V_2) from Bernoulli equation,

$$V_2 = \sqrt{\frac{2p_2}{\rho}} = \sqrt{\frac{2 \times 400 \times 10^5}{2000}} = 200 \text{ m/s}$$

- Q.2** A cylinder riser is used for casting steel cube of 10 cm side. Its freezing constant for the metal is 0.1, contraction ratio from liquid to solid is 0.03 and same mould material is used around casting and riser. Determine the dimension of the riser (side riser), for the freezing ratio of 1.25.

Solution:

By Caine's method

$$x = \frac{a}{y-b} + c$$

where, a = freezing constant, b = contraction ratio, c = relative freezing rate of riser and casting = 1, if same mould material is used around casting and riser.

$$x = \text{freezing ratio} \left(\frac{(A/V)_c}{(A/V)_r} \right)$$

$$y = \text{volume ratio} (V_r/V_c)$$

Put the values of a , b and c

$$x = \frac{0.1}{y-0.03} + 1$$

At

$$x = 1.25$$

$$1.25 = \frac{0.1}{y - 0.03} + 1$$

$$y = 0.43$$

$$y = \frac{V_r}{V_c} = 0.43$$

For side riser,

$$h = d$$

$$V_r = \frac{\pi}{4} d^2 \times h = \frac{\pi}{4} d^3$$

$$V_c = 1000 \text{ cm}^3$$

$$\frac{\pi}{4} \times \frac{d^3}{1000} = 0.43$$

$$d = 8.180 \text{ cm}$$

Q3 Calculate the time required for filling the mould of a sand casting of dimension 40 mm × 10 mm × 10 mm using top gating with metal flow rate of 25 cm³/min (design should be such that the pressure anywhere in sprue should not be less than atmospheric pressure).

Solution:

$$\text{Time taken for filling mold, } t_f = \frac{V}{A_g v_g}$$

$$A_g v_g = \text{Volumetric flow rate} = 25 \text{ cm}^3/\text{min}$$

$$V = \text{Volume} = \frac{40 \times 10 \times 10}{1000} = 4 \text{ cm}^3$$

$$t_f = \frac{4}{25} \text{ min} = 0.16 \text{ min}$$

Q4 A sand core having volume 2500 cm³ is used in the casting of a cast iron machine part. The density of core sand and cast iron is 1500 kg/m³ and 6000 kg/m³, respectively. What is the net force acting on the core during pouring? (Take acceleration due to gravity, g = 10 m/s²)

Solution:

$$\begin{aligned} \text{Buoyancy force} &= V_{\text{core}}(\rho_m - \rho_c)g \\ &= 2500 \times 10^{-6}(6000 - 1500) \times 10 = 112.5 \text{ N} \end{aligned}$$

Q5 The dimensions of a cylindrical top riser (h/d = 1), to feed steel casting 30 cm × 30 cm × 10 cm are to be determined. Casting is poured horizontally into the mould. Determine the dimension of the riser using modulus method.

Solution:

Using modulus method,

$$m_r = 1.2 m_c$$

$$\text{and for cylindrical top riser, } m_r = \frac{D}{5}$$

∴

$$\begin{aligned} D &= 6 M_c \\ &= 6 \left(\frac{V}{SA} \right)_C = 6 \times \left(\frac{30 \times 30 \times 10}{2(30 \times 30 + 30 \times 10 + 10 \times 30)} \right) = 18 \text{ cm} \end{aligned}$$

Q.6 The dimensions of a steel slab casting is 25 cm × 25 cm × 5 cm. What is the shape factor of the slab according to the Naval Research Laboratory method?

Solution:

According to Naval Research Laboratory method,

$$\text{Shape factor of casting} = \frac{L+W}{t}$$

Where,

L = Length of casting = 25 cm

W = Width of casting = 25 cm

t = Thickness of casting = 5 cm

$$\text{Shape factor} = \frac{25+25}{5} = \frac{50}{5} = 10$$

Q.7 In a sand casting operation, a solid cylinder having a diameter of 10 cm and a height of 5 cm takes four minutes to solidify. What will be the solidification time, if the cylinder height is doubled?

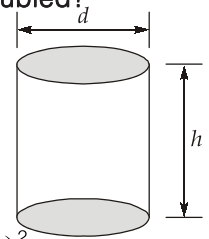
Solution:

$$t_s = k \left(\frac{V}{SA} \right)^2 = k \left(\frac{\frac{\pi}{4} d^2 h}{2 \times \frac{\pi}{4} d^2 + \pi d h} \right)^2 = k \left(\frac{dh}{2d + 4h} \right)^2$$

$$\frac{t_{s,2}}{t_{s,1}} = \left[\frac{d_2 h_2}{2d_2 + 4h_2} \times \frac{2d_1 + 4h_1}{d_1 h_1} \right]^2 = \left(\frac{10 \times 10}{2 \times 10 + 4 \times 10} \times \frac{2 \times 10 + 4 \times 5}{10 \times 5} \right)^2$$

$$t_{s,2} = \frac{16}{9} \times 4$$

$$t_{s,2} = 7.1 \text{ minutes}$$



Q.8 A casting process is performed to make 0.5 m long hollow cylindrical copper pipes having external diameter 0.3 m and wall thickness 20 mm. If the liquid metal shrinkage, solidification shrinkage and solid contraction in terms of volume for the copper are 0.5%, 5% and 8%, respectively. Determine the required amount of molten metal that must be poured into the mould.

Solution:

$$\begin{aligned} \text{Volume to be poured} &= \frac{\text{Final volume}}{(1-0.005)(1-0.05)(1-0.08)} \\ &= \frac{\frac{\pi}{4} (0.3^2 - 0.26^2) \times 0.5}{(1-0.005)(1-0.05)(1-0.08)} \times 10^6 \text{ cm}^3 = 10115.1 \text{ cm}^3 \end{aligned}$$

Q.9 Solidification time of a spherical casting is 15 seconds. Determine the solidification time of a cubical casting of same volume as the spherical casting and casted under identical conditions.

Solution:

$$\frac{4}{3} \pi r^3 = a^3$$

(where, r is the radius of sphere and a is the side of cube)

$$\therefore a = \left(\frac{4}{3} \pi \right)^{1/3} r$$

$$\frac{(t_s)_{\text{cube}}}{(t_s)_{\text{sphere}}} = \frac{\left(\frac{V}{SA}\right)_{\text{cube}}^2}{\left(\frac{V}{SA}\right)_{\text{sphere}}^2} = \frac{(a/6)^2}{(r/3)^2} = \left(\frac{a}{2r}\right)^2 = \left(\frac{\left(\frac{4}{3}\pi\right)^{1/3}}{2}\right)^2 = 0.6496$$

$$(t_s)_{\text{cube}} = 0.6496 \times 15 = 9.74 \text{ seconds}$$

Practice Questions : Level-II

Q.10 What are different methods of casting inspection? Explain each method briefly.

Solution:

Non destructive inspection techniques are necessary for creating a confidence when using a cast product. Some techniques used for testing the various kinds of defects are listed below.

- 1. Visual inspection:** Common defects such as rough surfaces (fused sand), obvious shifts, omission of cores, and surface cracks can be detected by a visual inspection of casting. Cracks may also be detected by hitting the casting with a mallet and listening to the quality of the tone.
- 2. Pressure test:** The pressure test is conducted on a casting to be used as a pressure vessel. In this, first all the flanges and ports are blocked. Then, the casting is filled with water, oil or compressed air. Thereafter, the casting is submerged in a soap solution when any leak will be evident by the bubbles that come out.
- 3. Magnetic particle inspection:** The magnetic particle test is conducted to check for very small voids and cracks at or just below the surface of a casting of a ferromagnetic material. The test involves inducing a magnetic field through the section under inspection. The powdered ferromagnetic material is spread out onto the surface. The presence of voids or cracks in the section results in a change in the permeability of the surface; this, in turn, cause a leakage in the magnetic field. The powdered particles offer a low resistance path to the leakage. Thus, the particles accumulate on the disrupted magnetic field, outlining the boundary of discontinuity.
- 4. Dye penetrant inspection:** The dye-penetrant method is used to detect invisible surface defects in a nonmagnetic casting. The casting is brushed with, sprayed with, or dipped into a dye containing a fluorescent material. The surface to be inspected is then wiped, dried and viewed in darkness. The discontinuities in the surface will then be readily visible.
- 5. Radiographic examination:** The radiographic method is expensive and is used only for subsurface exploration. In this, both X- and γ -ray are used. With γ -rays, more than one film can be exposed simultaneously; however, X-ray pictures are more distinct. Various defects, e.g., voids, nonmetallic inclusions, porosity, cracks and tears can be detected by this method. On the exposed film, the defects, being less dense, appear darker in contrast to the surrounding.
- 6. Ultrasonic inspection:** In the ultrasonic method, an oscillator is used to send an ultrasonic signal through the casting. Such a signal is readily transmitted through a homogeneous medium. However, on encountering a discontinuity, the signal is reflected back. This reflected signal is then detected by an ultrasonic detector. The time interval between sending the signal and receiving its reflection determines the location of the discontinuity. The method is not very suitable for a material with a high damping capacity (e.g., cast iron) because in such a case the signal gets considerably weakened over some distance.

Q.11 What is aspiration effect? Design a sprue for avoiding aspiration to deliver liquid iron at a rate of 20 kg/sec. Neglecting frictional and orifice effects. Take density of molten iron as 7800 kg/m³. The height of pouring basin is 9 cm and height of sprue as 25 cm.

Solution:

Aspiration Effect: When molten metal passes through a passage in sand mould, the gases originated in the sand due to high temperature of metal may mix in metal and cause porous casting. This mixing of generated gases in mould with molten metal is called aspiration effect.