MADE EASY PUBLICATIONS

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MECHANICAL ENGINEERING

CONVENTIONAL Practice Sets

CONTENTS

PRODUCTION AND MAINTENANCE ENGINEERING

1

CHAPTER

Production and Maintenance Engineering

Metal Casting

Practice Questions : Level-I

Q.1 Gray cast iron blocks 200 × 100 × 10 mm are to be cast in sand moulds. Shrinkage allowance has pattern making is 1%. Determine the ratio of the volume of the pattern to that of the casting will be.

Solution:

For Gray cast iron, there is a possible of expansion of the material in liquid and solidification states. But in solid state, there is contraction of material due to this size of casting will be decreased.

$$\therefore \quad \frac{\text{Volume of pattern } (V_p)}{\text{Volume of casting } (V_c)} = \frac{202 \times 101 \times 10.1}{200 \times 100 \times 10} = 1.03$$

Q.2 A casting of size 100 mm × 100 mm × 50 mm is required. Assume volume shrinkage of casting as 2.6%. If the height of the riser is 80 mm and riser volume desired is 4 times the shrinkage in casting, what is the appropriate riser diameter in mm?

Solution:

$$\text{Shrinkage volume of casting} = \frac{2.6}{100} \times 100 \times 100 \times 50 = 13000 \text{ mm}^3$$

Volume of riser should be 4 times of shrinkage volume of casting

$$V_r = 4 \times 13000 = 52000 \text{ mm}^3$$

$$V_r = \frac{\pi}{4} d^2 h = 52000 \qquad [\because h = 80 \text{ mm}]$$

or $$d^2 = \frac{52000 \times 4}{\pi \times 80}$$

or $$d = 28.76 \text{ mm}$$

Q.3 Gray cast iron blocks of size 100 mm × 50 mm × 10 mm with a central spherical cavity of diameter 4 mm are sand cast. The shrinkage allowance for the pattern is 3%. Determine the ratio of the volume of the pattern to volume of the casting.

Solution:

Ratio of volume of pattern to casting

$$= \frac{[(1.03 \times 100) \times (1.03 \times 50) \times (1.03 \times 10)] - \frac{4}{3}\pi(2.06)^3}{(100 \times 50 \times 10) - \frac{4}{3}\pi(2)^3} = 1.09$$

Q.4 In sand casting of hollow part of lead, a cylindrical core of diameter 120 mm and height 180 mm is placed inside the mould cavity. The densities of core material and lead are 1600 kg/m^3 and 11300 kg/m^3 respectively. Determine the net force that tends to lift the core during pouring of molten metal.

Solution:

Net force acting on core = $(\rho - \sigma)gV$

where $V = \frac{\pi}{4} \times 120^2 \times 180 = 2035752 \text{ mm}^3 = 2.035 \times 10^{-3} \text{ m}^3$

$\therefore$ Net force = $(11300 - 1600) \times 9.81 \times 2.035 \times 10^{-3} =$ **193.71 N**

Q.5 Determine the shape factor for a casting in the form of an annular cylinder of outside diameter 30 cm, inside diameter 20 cm and height 30 cm (correction factor $k = 1.0$).

Solution:

$$\text{Shape factor, } Z = \frac{\text{Length + width}}{\text{Thickness}} = \frac{L + w}{t}$$

In case of annular cylinder, $L = 30$ cm

$$w = \pi D_{mean} = \pi\left(\frac{30+20}{2}\right) = 78.53 \text{ cm}$$

$$t = \frac{30-20}{2} = 5 \text{ cm}$$

$$Z = \frac{30+78.53}{5} = 21.70$$

Q.6 A cylindrical job with diameter of 200 mm and height of 100 mm is to be cast using modulus method of riser design. Assume that the bottom surface of cylindrical riser does not contribute as cooling surface. If the diameter of the riser is equal to its height, then determine the height of the riser.

Solution:

According to modulus method,

$$M_R = 1.2\, M_C$$

$$M_R = \left(\frac{V}{A}\right)_R = \left[\frac{\frac{\pi}{4} d^2 h}{\frac{\pi}{4} d^2 + \pi d h}\right]$$

If $h = d$

$$M_R = \frac{d}{5}$$

Now, $M_R = 1.2\, M_C$

$$\left(\frac{d}{6}\right) = 1.2 \times \left[\frac{\frac{\pi}{4} \times 200^2 \times 100}{2 \times \frac{\pi}{4} \times 200^2 + \pi \times 200 \times 100}\right]$$

$$d = 6 \times 25 = 150 \text{ mm}$$

$\because$ For riser, $d = h =$ **150 mm**

Q.7 The dimensions of a cylindrical side riser (height = diameter) for a 25 cm × 15 cm × 5 cm steel casting are to be determined. For the tabulated shape factor values given below, find the diameter of the riser.

Shape Factor	2	4	6	8	10	12
Riser volume/Casting volume	1.0	0.70	0.55	0.50	0.40	0.35

Production and Maintenance Engineering

7 CHAPTER Non-Traditional Machining Methods

Practice Questions : Level-I

Q.1 A researcher conducts electrochemical machining (ECM) on a binary alloy (density 6000 kg/m^3) of Aluminium (Atomic weight = 27, valency = 3) and metal *A* (atomic weight 42, valency 3). Faraday's constant = 96500 coulomb/mole. The volumetric material removal rate of the alloy is 80 mm^3/s at a current of 3600 A. What is the percentage of the metal *A* in the alloy?

Solution:

Let the chemical equivalent of alloy be *e*.

The MRR in ECM process can be represented by

$$\text{MRR} = \frac{eI}{FP}$$

$$80 = \frac{e \times 3600}{96500 \times 6000 \times 10^{-6}}$$

$$e = 12.867$$

Now,

$$\frac{1}{e} = \frac{3}{42} \times \left(\frac{x}{100}\right) + \left(\frac{100 - x}{100}\right) \times \frac{3}{27}$$

On solving

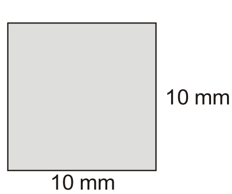
$$x = 84.15\%$$

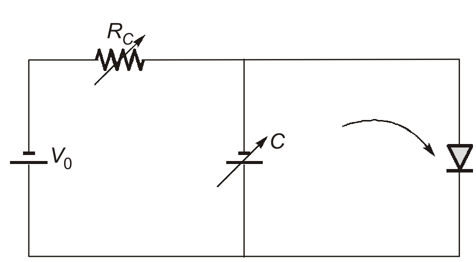
Q.2 During an electric discharge drilling of a 10 mm square hole in a low carbon steel plate of 6 mm thickness, brass tool and kerosene are used. The resistance and capacitance in the relaxation circuit are 50 Ω and 10 μF, respectively. The supply voltage is 200 V and the gap is maintained at such a value that the discharge (sparking) takes place at 150 V. Estimate the time required to complete the drilling operation. Approximate relationship between material removal rate (Q) and power (W) for steel material is given by:

$$Q \approx 27.4\ W^{1.54}$$

Solution:

Square hole of 100 mm × 10 mm thickness of plate = 6 mm, Resistance = 50 Ω, Capacitance = 10 μF, V_s = 200 V, V_d = 150 V, Q = 27.4 W$^{1.54}$





Find: Time for complete drilling operation

$$MR = 10 \times 10 \times 6\,(10^{-3})^3 = 600 \times 10^{-3}$$

$$\frac{R}{t_C + t_D} = Q$$

$$\frac{600 \times 10^{-5}}{t_C + t_D} = 27.4\,W^{1.54}$$

Now, Total time, $T = t_C + t_D = 27.4 \times \left(\frac{V^2}{R}\right)^{1.54}$

$V = 150$ V, $R = 50\ \Omega$

On solving, we get, $T = 1.797 \times 10^{-12}$ s

Q.3 **During an electric discharge drilling of a 10 mm square hole in a low carbon steel plate of 5 mm thickness, brass tool and kerosene are used. The resistance and capacitance in the relaxation circuit are 50 Ω and 10 μF, respectively. The supply voltage is 200 Volts and the gap is maintained at such a value that the discharge (sparking) takes place at 150 Volts. Estimate the time required to complete the drilling operation.**

Solution:

Given that:

Thickness of plate, $w = 5$ mm; Resistance, $R = 50\ \Omega$; Capacitance, $C = 10\ \mu$F; Supply voltage, $V_o = 200$ volts

Voltage across the gap at any time, $t_o = V$; Discharge (sparking) voltage, $V_d = 150$ Volts.

Material removal rate, MRR = Q mm^3/min

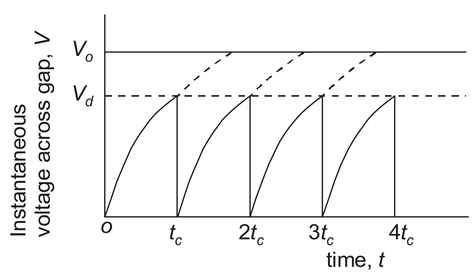
Power input = W

The amount of energy released per spark,

$$E = \frac{1}{2}CV_d^2 = \frac{1}{2}(10 \times 10^{-6}) \times (150)^2 = 0.1125\text{ J} = 0.113\text{ J}$$

$$\text{Cycle time, } t_c = RC\log_e\left(\frac{V_0}{V_o - V_d}\right) = 50 \times 10 \times 10^{-6}\log_e\left(\frac{200}{200-150}\right)$$

$$= 50 \times 10^{-5} \times 1.39 = 7 \times 10^{-4}\text{ s}$$



Average power input, $W = \dfrac{\text{Amount of energy released per spark (E)}}{\text{Cycle time } (t_c)}$

$$= \frac{0.113}{7 \times 10^{-4}} \times 10^{-3}\text{ kW} = 0.16\text{ kW}$$

The material removal rate (MRR), $Q = 27.4(\text{kW})^{1.54} = 27.4(0.16)^{1.54} = 1.63$ mm^3/min.

Total amount of material to be removed = 10 × 10 × 5 = 500 mm^3

Time required to complete the drilling operation = $\dfrac{\text{Total amount of material to be removed}}{\text{Material removal rate}}$

$$= \left(\frac{500}{1.63}\right) = 306.74\text{ min.}$$

Time required to complete drilling = 306.74 min.