CLASS TEST

S.No. : 01JP_ME_06082024

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MECHANICAL ENGINEERING

Casting and Welding

Duration : 1:00 hr. **Maximum Marks : 50**

Read the following instructions carefully

1. This question paper contains **25** objective questions. **Q.1-25 carry two** marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (ORS) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be NEGATIVE marking. For each wrong answer 1/3rd of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the ORS.
6. Using HB pencil, darken the appropriate bubble under each digit of your registration number.
7. No charts or tables will be provided in the examination hall.
8. Use the blank pages given for rough work.
9. Choose the Closest numerical answer among the choices given.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.1 Given below are some elements of a gating system used in casting:
1. Strainer
2. Splash core
3. Skim bob

Which of the above elements directly or indirectly prevents impurities in casting?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

Q.2 The power developed in an Arc Welding operation = 3000 W. This is transferred to the work surface with a heat transfer factor = 0.80. The metal to be welded is aluminum whose melting point is 820 K Assume the melting factor = 0.40. A fillet weld is to be made with a cross-sectional area 20.0 mm^2. And the unit energy required to melt the metal is 26 J/mm^3, the travel speed at which the welding operation can be accomplished is
(a) 2.31 mm/s (b) 4.61 mm/s
(c) 1.85 mm/s (d) 18.03 mm/s

Q.3 A cuboidal mould having dimensions 100 mm × 90 mm × 20 mm is filled with molten metal through a gate with height 'h' and cross-sectional area A, the mould filling time is t_1. The height is now quadrupled and the cross-sectional area is halved. The corresponding filling time is t_2. The ratio t_2/t_1 is
(a) 0.25 (b) 0.50
(c) 2 (d) 1

Q.4 Consider the following statements regarding the effect of increase in the percentage of the water content on moulding sand properties :
1. The compressive strength, first increases and then decreases.
2. The permeability, first increases and then decreases.
3. The flowability, first decreases and then increases.

Which of the following statements are correct?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.5 A welding current of 50 A is supplied at a welding speed of 100 mm/min at a voltage supply of 10 V. If the area of the weld bead is 100 mm^2 then total heat input would be
(a) 0.3 J/mm (b) 3 J/mm
(c) 30 J/mm (d) 300 J/mm

Q.6 A cube of side 'a' and a sphere of diameter 'a' made up of the same material are being cast. The ratio of the solidification time of the cube to that of the sphere is
(a) 1 : 4 (b) 1 : 2
(c) 9 : 16 (d) 1 : 1

Q.7 In arc welding of a butt joint, the welding speed is to be selected such that highest cooling rate is achieved. Melting efficiency and heat transfer efficiency are 0.5 and 0.7 respectively. The area of the weld cross-section is 5 mm^2 and the unit energy required to melt the metal is 10 J/mm^3. If the welding power is 2 kW, the welding speed is closest to
(a) 4 mm/s (b) 14 mm/s
(c) 24 mm/s (d) 34 mm/s

Q.8 Match **List-I** (Welding process) with **List-II** (Applications) and select the correct answer using the codes given below the lists:

	List-I		List-II
A.	Ultrasonic welding	**1.**	Fabrication of composite laminations
B.	Friction welding	**2.**	Joining of armature windings
C.	Forge welding	**3.**	Drill bit, axle and hub
D.	Diffusion welding	**4.**	Agricultural applications

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	3	2	4
(c)	2	3	4	1
(d)	2	4	3	1

Q.9 Consider the following statements regarding investment casting:
1. Pattern is produced by wax.
2. The process is carried out in vacuum.
3. Complex shape of the objects with low melting point materials are produced.

Which of the above statements are correct?
(a) 1 and 2
(b) 2 and 3
(c) 1 and 3
(d) 1, 2 and 3

Q.10 The problem of arc blow while welding will increase when
(a) Intensity of current is reduced
(b) Shorter arc length is used
(c) Using DC welding in place of AC welding
(d) Placing more than one ground lead from base metal

Q.11 A welding operation is being performed with voltage 30 V and current = 120 A. The cross-sectional area of the weld bead is 20 mm^2. The workpiece and filler are of titanium for which the specific energy of melting is 19 J/mm^3. Assuming a thermal efficiency of the welding process 70%, the welding speed is
(a) 13.53 mm/s (b) 6.63 mm/s
(c) 7.39 mm/s (d) 15.08 mm/s

Q.12 In a *DC* arc welding operation, the voltage arc length characteristic was obtained as $V_{arc} = 20 + 4l$, where the arc length l was varied between 5 mm and 7 mm. Here V_{arc} denotes the arc voltage in Volts. The arc current was varied from 400 A to 500 A. Assuming linear power source characteristic, the open circuit voltage is
(a) 40 V (b) 48 V
(c) 80 V (d) 100 V

Q.13 The dimensions of cylinder side riser (height = diameter) for a 35 cm × 20 cm × 10 cm steel casting are to be determined. For the tabulated shape factor values given below. Diameter of the riser is

Shape factor	3	3.5	4	4.5	5	5.5	6.0
Riser volume / Casting volume	1.0	0.7	0.55	0.5	0.40	0.35	0.25

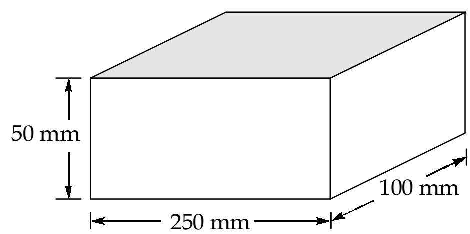
(a) 14.61 cm (b) 15.28 cm
(c) 13.06 cm (d) 16.46 cm

Q.14 A mold sprue is 20 cm long, and the cross-sectional area at its base is 2.5 cm^2. The sprue feeds a horizontal runner leading into a mold cavity whose volume is 1560 cm^3. The time required to fill the mold cavity is
(a) 19.69 s (b) 7.87 s
(c) 3.15 s (d) 4.46 s

Q.15 A solid cylinder of diameter *D* and height equal to *D* and a solid cube of side *L* unit are being sand cast by using the same material. Assuming there is no superheat in both the cases, the ratio of solidification time of the cube to the solidification time of the cylinder is
(a) $\left(\frac{L}{D}\right)^2$ (b) $\left(\frac{2L}{D}\right)^2$
(c) $\left(\frac{2D}{L}\right)^2$ (d) $\left(\frac{D}{L}\right)^2$

Q.16 A spherical riser with diameter 2 cm is used for a sand casting process. The mould of cuboidal shape with length L, width W and height H related as L = 2W = 4H. If the total solidification time of casting is 50% of the solidification time of riser, then length *L* is
(a) 3 cm (b) 2 cm
(c) 2.5 cm (d) 3.3 cm

Q.17 The figure below shows the final product which is to be casted keeping the pattern solely in drag portion with shaded surface along the parting line. The metal for casting gray cast iron. The volume of material required for pattern, considering a shrinkage allowance of 10 mm per m and shake allowance of 1 mm per edge of pattern is



(a) 26.8×10^{-4} m^3
(b) 12.52×10^{-4} m^3
(c) 12.45×10^{-4} m^3
(d) 13.24×10^{-4} m^3

Q.18 A shielded metal arc welding process is to be done on a steel workpiece with 30 V power supply. If a weld with triangular cross-section having leg length and height both as 10 mm is to be produced, then the current that will be needed for a welding speed of 10 mm/s is
[Assume, thermal efficiency as 80% and specific energy needed to melt the steel electrode as 10.5 J/mm^3.]
(a) 175 A (b) 218.75 A
(c) 140 A (d) 228.57 A

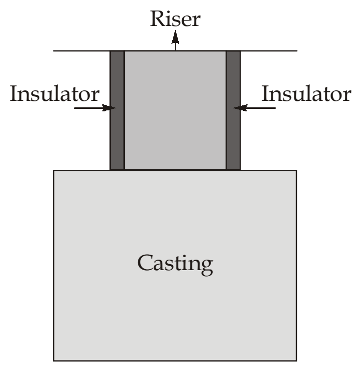
Q.19 For casting a cylindrical aluminium bloom having a length of 1000 mm and diameter of 750 mm, the approximate solidification time (in minutes) estimated using Chvorinov's rule is [The mould constant is 2 s/mm^2]
(a) 45 (b) 37
(c) 620 (d) 440

Q.20 A direct current welding machine has the characteristics $5V + I = 250$, where V is the voltage and I is the current in ampere. At the maximum arc power, the current through the electrode is
(a) 25 ampere (b) 75 ampere
(c) 125 ampere (d) 250 ampere

Q.21 A low carbon steel plates is to be welded by the manual metal arc welding process using a linear V-I characteristics DC power source.

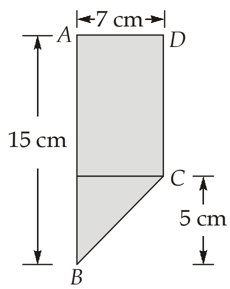
The following data are available:
OCV of power source = 62 V; SSC = 130 A;
Arc length = 4 mm;
Traverse speed of welding = 150 cm/min;
Efficiency of heat impact = 85%;
Voltage is given as $V = 20 + 1.5$ L, where V is in volts and L is in mm;
The heat input into work piece will be
(a) 1668 W (b) 1963 W
(c) 3978 W (d) 4681 W

Q.22 A 10 cm high cylindrical riser is positioned on top of a 10 cm × 10 cm × 10 cm cube casting as shown in figure. The riser extends from the top face of the cube through to the surface of the mould as illustrated. Assume no heat is lost through the top of the riser to the atmosphere. An insulation is placed around the riser which effectively doubles the cooling time. The minimum diameter of the cylindrical riser required to prevent macroporosity (Solidification shrinkage) is



(a) 5.8 cm (b) 4.8 cm
(c) 8.0 cm (d) 4.0 cm

Q.23 A sweep piece pattern is used during casting of cast iron in sand mould. The sweep is pinned about AB. Neglecting the amount of molten metal required for gating and riser. The size of the cavity is



(a) 1796 cm^3
(b) 2565 cm^3
(c) 2309 cm^3
(d) 2053 cm^3

Q.24 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. Using modulus method, the diameter of the riser is

(a) 18 cm (b) 17 cm
(c) 16 cm (d) 15 cm

Q.25 Resistance welding is used to make lap joint with a current of 15000 A for 0.5 s. Joint is assumed to be in cylindrical shape of diameter 4 mm and height of 1.5 mm. The effective resistance of joint is 100 μΩ. The density of metal is 7.8 g/cm^3. The heat lost to the surrounding if heat required to melt sheet is 1795 kJ/kg is

(a) 0.263 kJ (b) 11.250 kJ
(c) 11.513 kJ (d) 10.986 kJ

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CASTING and WELDING

MECHANICAL ENGINEERING

Date of Test : 06/08/2024

ANSWER KEY

1.	(d)	6.	(d)	11.	(b)	16.	(d)	21.	(a)
2.	(c)	7.	(b)	12.	(c)	17.	(b)	22.	(b)
3.	(d)	8.	(c)	13.	(a)	18.	(b)	23.	(a)
4.	(d)	9.	(a)	14.	(c)	19.	(c)	24.	(a)
5.	(d)	10.	(c)	15.	(a)	20.	(c)	25.	(d)

DETAILED EXPLANATIONS

1. **(d)**

Strainer : It is a ceramic coated screen with many holes in sprue which removes dross.
Splash core : It reduces eroding force of liquid metal thus preventing mould erosion.
Skim bob : It prevents heavier and lighter impurities from reaching mould cavity.

2. **(c)**

Power input × η_{melt} × $\eta_{transfer}$ = Energy required

$$3000\,\text{J/sec} \times 0.80 \times 0.4 = 26\,\text{J/mm}^3 \times 20 \times v$$

$$\text{Weld speed, } v = 1.846 \text{ mm/s} \simeq 1.85 \text{ mm/s}$$

3. **(d)**

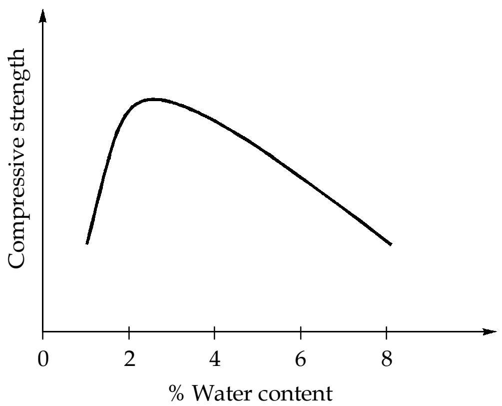
$$t_1 = \frac{V}{\left(A \times \sqrt{2gh}\right)}$$

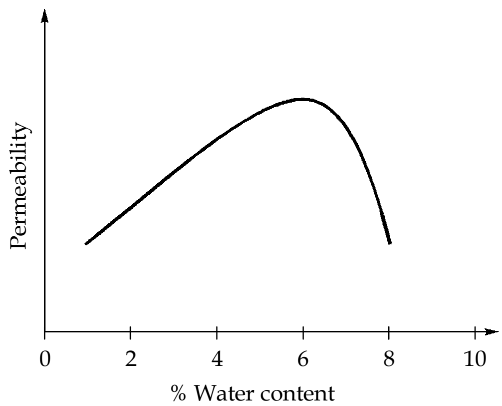
Now, for t_2 we have $h_2 = 4h$, $A_2 = \dfrac{A}{2}$

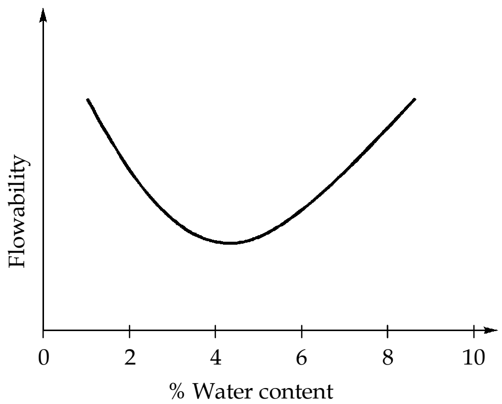
$$t_2 = \frac{V}{\left[\left(\frac{A}{2}\right) \times \sqrt{2g \times 4h}\right]}$$

So, $$\frac{t_2}{t_1} = 1$$

4. **(d)**







5. (d)

Given : $I = 50$ A, $V = 10$ V, $v = 100$ mm/min

$$\text{Heat input} = \frac{VI}{v} = \frac{10\times50\times60}{100} = 300 \text{ J/mm}$$

6. (d)

According to Chvorinov's rule,

$$t_s \propto \left(\frac{\text{Volume}}{\text{Surface area}}\right)^2$$

$$\Rightarrow \quad t_s \propto \left(\frac{V}{A}\right)^2$$

$$\therefore \quad \left(\frac{V}{A}\right)_{cube} = \left(\frac{a}{6}\right)$$

$$\left(\frac{V}{A}\right)_{sphere} = \left(\frac{a/2}{3}\right) = \left(\frac{a}{6}\right)$$

$$\therefore \quad \frac{(t_s)_{cube}}{(t_s)_{sphere}} = \frac{(a/6)^2}{(a/6)^2} = 1:1$$

7. (b)

Volume of weld = 5V mm^3/s; V = Velocity of welding

Energy required = 10 × 5V = 50V J/s

Now, $(2\times10^3)\times0.5\times0.7 = 50V$

$\Rightarrow$ $V = 14$ mm/s

8. (c)

9. (a)

In investment casting, complex shape of the objects with high melting point materials are produced.

10. (c)

AC welding should be used in place of DC to nullify effect of magnetic field which ultimately reduces arc blow.

11. (b)

Energy required for the weld operation = Specific energy × Area of weld bead

$= 19 \text{ J/mm}^3 \times 20 \text{ mm}^2$

$= 380$ J/mm

Energy supplied $= VI$

$= 120 \times 30$

$= 3600$ J/s

$$\eta_{th} = \frac{\text{Energy required}}{\text{Energy supplied}}$$

$$0.70 = \frac{380 \times v}{3600}$$

$\Rightarrow$ Weld speed = 6.6315 mm/s

12. (c)

$$V_{arc} = 20 + 4l$$

for l = 5 mm, V_{arc} = 40 V

for l = 7 mm, V_{arc} = 48 V

$$V = V_O - \frac{V_O}{I_S} I$$

$$40 = V_O - \frac{V_O}{I_S} \times 500 \quad \text{...(i)}$$

$$48 = V_O - \frac{V_O}{I_S} \times 400 \quad \text{..(ii)}$$

From equation (i) and (ii),

$$-8 = \frac{V_O}{I_S}(400 - 500)$$

$$\frac{V_O}{I_S} = \frac{8}{100}$$

$$40 = V_O - \frac{8}{100} \times 500$$

$$V_O = 80 \text{ Volt}$$

13. (a)

$$Z = \frac{L + W}{t}$$

Z = Shape factor, L = Length, w = Width, t = Thickness

$$Z = \frac{35 + 20}{10} = 5.5$$

$$\frac{\text{Riser volume}}{\text{Casting volume}} = 0.35$$

$$\frac{\frac{\pi d^2}{4} \times h}{35 \times 20 \times 10} = 0.35$$

$$\frac{\pi d^3}{4} = 0.35 \times 35 \times 20 \times 10$$

$$d = 14.61 \text{ cm}$$

14. (c)

$$h = 20 \text{ cm}$$

$$A_{base} = 2.5 \text{ cm}^2$$

$$\text{Volume} = 1560 \text{ cm}^3$$

The velocity of the molten metal at the base,

$$v = \sqrt{2 \times 981 \times 20} = 198.1 \text{ cm/s}$$

Volumetric of flow rate, $Q = A_{base} \times v$

$= 2.5 \times 198.1 = 495.227 \text{ cm}^3/\text{s}$

Time required to fill the mold cavity,

$$t = \frac{\text{Volume}}{Q}$$

$$= \frac{1560}{495.227} = 3.15 \text{ sec}$$

15. (a)

$$\text{Solidification time, } t = k\left(\frac{V}{A}\right)^2$$

$$\text{For cube, } V = L^3,\ A = 6L^2$$

$$t_{cube} = k\left(\frac{L}{6}\right)^2$$

$$\text{For cylinder, } V = \frac{\pi}{4}D^3$$

$$A = 2\times\frac{\pi}{4}D^2 + \pi D^2 = \frac{3\pi D^2}{2}$$

$$t_{cylinder} = k\left(\frac{D}{6}\right)^2$$

$$\text{Ratio of solidification time, } \frac{t_{cube}}{t_{cylinder}} = \left(\frac{L}{D}\right)^2$$

16. (d)

Given, $t_{casting} = 50\%$ of t_{riser}

Using Chvorinov's rule,

$$k\left(\frac{V_c}{A_c}\right)^2 = \frac{1}{2}k\left(\frac{V_r}{A_r}\right)^2$$

$$\left(\frac{V_c}{A_c}\right)^2 = \frac{1}{2}\left(\frac{\frac{4}{3}\pi r^3}{4\pi r^2}\right)^2 = \frac{1}{2}\left(\frac{r}{3}\right)^2$$

$$\left(\frac{V_c}{A_c}\right)^2 = \frac{1}{2}\left(\frac{d}{6}\right)^2 = \frac{1}{2}\left(\frac{2}{6}\right)^2$$

$$\left(\frac{V_c}{A_c}\right)^2 = \frac{1}{18} \quad \text{...(i)}$$

For casting L = 2W = 4H

$$\Rightarrow \quad W = \frac{L}{2} \text{ and } H = \frac{L}{4}$$

Thus,
$$\frac{V_c}{A_c} = \frac{(L)\left(\frac{L}{2}\right)\left(\frac{L}{4}\right)}{2\left((L)\left(\frac{L}{2}\right)+\left(\frac{L}{2}\right)\left(\frac{L}{4}\right)+\left(\frac{L}{4}\right)(L)\right)}$$

$$\frac{V_c}{A_c} = \frac{\frac{L^3}{8}}{2\left(\frac{L^2}{2}+\frac{L^2}{8}+\frac{L^2}{4}\right)} = \frac{\frac{L^3}{8}}{\frac{7L^2}{4}} = \frac{L}{7(2)} = \frac{L}{14}$$

From equation (i), $\left(\frac{L}{14}\right)^2 = \frac{1}{18}$

$$L^2 = \frac{14^2}{18}$$

$\Rightarrow$ $$L = \frac{14}{\sqrt{18}} = 3.3 \text{ cm}$$

17. (b)

For gray cast iron, the shrinkage allowance is positive like all other metals. It expands only during solidification and not in solid state.

Thus, pattern dimensions after considering shrinkage allowance are:

$$l = 250+\left(\frac{10}{1000}\times 250\right) = 252.5 \text{ mm}$$

$$W = 100+\left(\frac{10}{1000}\times 100\right) = 101 \text{ mm}$$

$$t = 50+\left(\frac{10}{1000}\times 50\right) = 50.5 \text{ mm}$$

Now, shake allowance is a negative allowance and is given only on the dimensions parallel to the parting line.

Therefore, dimensions after shake allowance,

$\therefore$
$$l = 252.5 - 2 = 250.5 \text{ mm}$$
$$W = 101 - 2 = 99 \text{ mm}$$
$$t = 50.5 \text{ mm}$$

Thus, volume of pattern $= l \times w \times t$
$= 250.5 \times 99 \times 50.5$
$= 1252374.75 \text{ mm}^3$
$= 12.52 \times 10^{-4} \text{ m}^3$

18. (b)

Area to be welded, $A = \frac{1}{2}bh = \frac{1}{2}\times 10\times 10 = 50 \text{ mm}^2$

Now, thermal efficiency,

$$\eta_{th} = \frac{\text{Energy required for melting}}{\text{Energy supplied by power source}}$$

$$= \frac{u \times A \times v}{VI}$$

where, u = specific energy, v = welding speed

$$\therefore \quad I = \frac{u \times A \times v}{V \times \eta_{th}} = \frac{10.5 \times 50 \times 10}{30 \times 0.8} = 218.75\,A$$

19. (c)

Given: L = 1000 mm, d = 750 mm, k = 2 s/mm^2,

$$\text{Solidification time (t)} = k\left(\frac{V}{A}\right)^2$$

$$\left(\frac{V}{A}\right)_{\text{cylinder}} = \frac{\frac{\pi}{4}D^2L}{2 \times \frac{\pi}{4}D^2 + \pi DL} = \frac{D^2L}{2D^2 + 4DL}$$

$$= \frac{(750)^2 \times 1000}{2(750)^2 + 4 \times 750 \times 1000} = 136.36 \text{ mm}$$

Now the solidification time,

$$t = k\left(\frac{V}{A}\right)^2 = 2 \times (136.36)^2$$

$$= 37188.1 \text{ s} = 619.8 \text{ min} \simeq 620 \text{ minutes}$$

20. (c)

$$\text{Power, } P = \text{VI}$$

$$5V + I = 250$$

$$V = \frac{1}{5}(250 - I)$$

$$P = \frac{1}{5}(250I - I^2)$$

For maximum arc power,

$$\frac{dP}{dI} = 0$$

$$250 - 2I = 0$$

$$\therefore \quad I = 125\text{A}$$

21. (a)

$$V = OCV - \frac{OCV}{SSC}I$$

$$V = 62 - \frac{62}{130}I$$

$$V = 20 + 1.5\text{ L} = 20 + 1.5 \times 4 = 26 \text{ V}$$

For L = 4 mm,

$$26 = 62 - \frac{62}{130}I$$

$$\Rightarrow \quad I = 75.5 \text{ A}$$

$$\text{Power consumed} = V \times I$$

$$P = 75.5 \times 26 = 1963 \text{ W}$$

$$\text{Heat input into work-piece} = 0.85 \times 1963 = 1668.25 \text{ W} \simeq 1668 \text{ W}$$

22. (b)

$$\text{Solidification time for riser when uninsulated} = k\left(\frac{V}{A}\right)^2 = k\left[\frac{\pi}{4}\frac{d^2h}{\pi dh}\right]^2 = \frac{kd^2}{16}$$

Solidification time doubles when insulation is used,

$$(t_s) = 2(t_s)_{\text{riser without insulation}}$$

$$= 2\frac{kd^2}{16} = \frac{kd^2}{8}$$

To prevent macroporosity or solidification shrinkage

$$(t_s)_{\text{riser}} = (t_s)_{\text{casting}}$$

$$\Rightarrow \quad \frac{kd^2}{8} > k\left(\frac{a^3}{6a^2}\right)^2$$

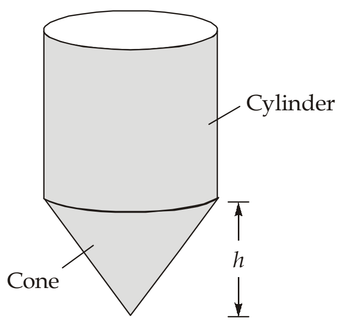
$$\Rightarrow \quad \frac{d^2}{8} > \frac{a^2}{36}$$

$$\Rightarrow \quad d^2 > \frac{8a^2}{36} = \frac{8 \times 10^2}{36}$$

$$d > 4.714$$

$$d_{\min} \approx 4.8 \text{ cm}$$

23. (a)



$$\text{Size of casting} = \text{Volume of cone + volume of cylinder}$$

$$= \frac{\pi r^2 h}{3} + \pi r^2 (15 - h)$$

$$= \frac{\pi \times 7^2 \times 5}{3} + \pi \times 7^2 \times 10 = 1795.944 \text{ cm}^3 \simeq 1796 \text{ cm}^3$$

24. (a)

Using modulus method,

$$m_r = 1.2\, m_c$$

and for cylindrical top riser, $m_r = \dfrac{V}{A} = \dfrac{\frac{\pi}{4}D^2}{\pi D^2 + \frac{\pi}{4}D^2} = \dfrac{D}{5}$

$\therefore \quad D = 6\, M_c$

$$= 6\left(\frac{V}{A}\right)_C = 6\times\left(\frac{30\times30\times10}{2(30\times30+30\times10+10\times30)}\right) = 18 \text{ cm}$$

25. (d)

Heat required to melt, $Q_R = \dfrac{\pi}{4}\times d^2\times h\times\rho\times u$

$$Q_R = \frac{\pi}{4}\times 4^2\times 1.5\times 0.0078\times 1795$$

$$= 263.912 \text{ J}$$

Heat supplied to weld, $Q_S = I^2Rt$

$$Q_S = (15000)^2 \times (100 \times 10^{-6}) \times 0.5$$

$$= 11250 \text{ J}$$

Heat lost to the surrounding, $Q_{\text{lost}} = Q_S - Q_R$

$$Q_{\text{lost}} = 11250 - 263.912$$

$$= 10986.08 \text{ J} = 10.986 \text{ kJ}$$

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