Questions

10.1 Sand casting is which of the following types: (a) expendable mold or (b) permanent mold?
Answer. (a).

10.2 The upper half of a sand casting mold is called which of the following: (a) cope or (b) drag?
Answer. (a).

10.3 In casting, a flask is which one of the following: (a) beverage bottle for foundrymen, (b) box which holds the cope and drag, (c) container for holding liquid metal, or (d) metal which extrudes between the mold halves?
Answer. (b).

10.4 In foundry work, a runner is which one of the following: (a) channel in the mold leading from the downsprue to the main mold cavity, (b) foundryman who moves the molten metal to the mold, or (c) vertical channel into which molten metal is poured into the mold?
Answer. (a).

10.5 Turbulence during pouring of the molten metal is undesirable for which of the following reasons (two best answers): (a) it causes discoloration of the mold surfaces, (b) it dissolves the binder used to hold together the sand mold, (c) it increases erosion of the mold surfaces, (d) it increases the formation of metallic oxides that can become entrapped during solidification, (e) it increases the mold filling time, and (f) it increases total solidification time?
Answer: (c) and (d).

10.9 A riser in casting is described by which of the following (three correct answers): (a) an insert in the casting that inhibits buoyancy of the core, (b) gating system in which the sprue feeds directly into the cavity, (c) metal that is not part of the casting, (d) source of molten metal to feed the casting and compensate for shrinkage during solidification, and (e) waste metal that is usually recycled?
Answer. (c), (d), and (e).

10.10 In a sand casting mold, the \( V/A \) ratio of the riser should be (a) equal to, (b) greater than, or (c) smaller than the \( V/A \) ratio of the casting itself?
Answer. (b).

11.1 Name the two basic categories of casting processes?
Answer. The two categories are: (1) expendable mold processes, and (2) permanent mold processes.

11.2 In sand casting, the volumetric size of the pattern is (a) bigger than, (b) the same size as, or (c) smaller than the cast part?
Answer. (a).

11.4 For which one of the following reasons is a green mold named: (a) green is the color of the mold, (b) moisture is contained in the mold, (c) mold is cured, or (d) mold is dry?
Answer. (b).
11.6 Which of the following casting processes are expendable mold operations (four correct answers): (a) centrifugal casting, (b) die casting, (c) investment casting, (d) low pressure casting, (e) sand casting, (f) shell molding, (g) slush casting, and (h) vacuum molding?
Answer. (c), (e), (f), and (h).

11.10 Which of the following qualifies as a precision casting process (two correct answers): (a) ingot casting, (b) investment casting, (c) plaster mold casting, (d) sand casting, and (e) shell molding?
Answer. (b) and (c).

11.11 Which of the following casting processes are permanent mold operations (three correct answers): (a) centrifugal casting, (b) die casting, (c) expanded polystyrene process, (d) sand casting, (e) shell molding, (f) slush casting, and (g) vacuum molding.
Answer. (a), (b), and (f).

11.12 Which of the following metals would typically be used in die casting (three best answers): (a) aluminum, (b) cast iron, (c) steel, (d) tin, (e) tungsten, and (f) zinc?
Answer. (a), (d), and (f).

11.13 Which of the following are advantages of die casting over sand casting (four best answers): (a) better surface finish, (b) closer tolerances, (c) higher melting temperature metals, (d) higher production rates, (e) larger parts can be cast, and (f) mold can be reused?
Answer. (a), (b), (d), and (f).

Problems

6.3 Using the lead-tin phase diagram in Figure 6.3, determine the liquid and solid phase compositions for a nominal composition of 40% Sn and 60% Pb at 204°C (400°F).

Solution: From Fig 6.3, the compositions are observed as follows:
Liquid phase composition = 56% Sn - 44% Pb.
α phase composition = 18% Sn - 82% Pb.

NOTE TO GRADER: Please realize that these values are taken from a graph so some leniency warranted.

6.4 For the preceding problem, use the inverse lever rule to determine the proportions of liquid and solid phases present in the alloy.

Solution: From Fig 6.3, measured values of CL and CS are: CL = 10.5 mm, CS = 15 mm.
Liquid phase proportion = 15/(15 + 10.5) = 15/25.5 = 0.59
α phase proportion = 10.5/25.5 = 0.41
10.1 A disk 40 cm in diameter and 5 cm thick is to be cast of pure aluminum in an open mold casting operation. The melting temperature of aluminum = 660°C and the pouring temperature will be 800°C. Assume that the amount of aluminum heated will be 5% more than what is needed to fill the mold cavity. Compute the amount of heat that must be added to the metal to heat it to the pouring temperature, starting from a room temperature of 25°C. The heat of fusion of aluminum = 389.3 J/g. Other properties can be obtained from Tables 4.1 and 4.2 in the text. Assume the specific heat has the same value for solid and molten aluminum.

**Solution:** Volume \( V = \pi D^2 h/4 = \pi (40)^2 (5)/4 = 6283.2 \text{ cm}^3 \)

Volume of aluminum to be heated = 6283.2(1.05) = 6597.3 cm\(^3\)

From Table 4.1 and 4.2, density \( \rho = 2.70 \text{ g/cm}^3 \) and specific heat \( C = 0.21 \text{ Cal/g}^\circ\text{C} = 0.88 \text{ J/g}^\circ\text{C} \)

Heat required = \( 2.70(6597.3)\{0.88(660-25) + 389.3 + 0.88(800-660)\} \)

= 17,812.71 \{558.8 + 389.3 + 123.2\} = 19,082,756 J

10.7 Molten metal can be poured into the pouring cup of a sand mold at a steady rate of 1000 cm\(^3\)/s. The molten metal overflows the pouring cup and flows into the downsprue. The cross-section of the sprue is round, with a diameter at the top = 3.4 cm. If the sprue is 25 cm long, determine the proper diameter at its base so as to maintain the same volume flow rate.

**Solution:** Velocity at base \( v = (2gh)^{0.5} = (2 \times 981 \times 25)^{0.5} = 221.5 \text{ cm/s} \)

Assuming volumetric continuity, area at base \( A = (1000 \text{ cm}^3/s)/(221.5 \text{ cm/s}) = 4.51 \text{ cm}^2 \)

Area of sprue \( A = \pi D^2 /4; \) rearranging, \( D^2 = 4A/\pi = 4(4.51)/\pi = 5.74 \text{ cm}^2 \)

\[ D = 2.39 \text{ cm} \]

10.21 The total solidification times of three casting shapes are to be compared: (1) a sphere, (2) a cylinder, in which the length-to-diameter ratio = 1.0, and (3) a cube. For all three geometries, the volume = 1000 cm\(^3\). The same casting alloy is used in the three cases. (a) Determine the relative solidification times for each geometry. (b) Based on the results of part (a), which geometric element would make the best riser? (c) If the mold constant = 3.5 min/cm\(^2\) in Chvorinov's Rule, compute the total solidification time for each casting.

**Solution:** For ease of computation, make the substitution 10 cm = 1 decimeter (1 dm). Thus 1000 cm\(^3\) = 1.0 dm\(^3\).

(1) Sphere volume \( V = \pi D^3 /6 = 1.0 \text{ dm}^3 \). \( D = 6/\pi = 1.910 \text{ dm} \). \( D = (1.910)^{0.333} = 1.241 \text{ dm} \)

Sphere area \( A = \pi D^2 = \pi(1.241) = 4.836 \text{ dm} \)

\( V/A = 1.0/4.836 = 0.2067 \text{ dm} \)

Chvorinov’s Rule \( T_{TS} = (0.2067)^2 C_m = 0.0428 C_m \)

(2) Cylinder volume \( V = \pi D^2 H/4 = \pi D^3 /4 = 1.0 \text{ dm}^3 \). \( D = 4/\pi = 1.273 \text{ dm} \)
Therefore, $D = H = (1.273)^{0.333} = 1.084$ dm

Cylinder area $A = 2\pi D^2/4 + \pi DL = 2\pi (1.084)^2/4 + \pi (1.084)(1.084) = 5.536$ dm$^2$

$V/A = 1.0/5.536 = 0.1806$ dm

Chvorinov’s Rule $T_{TS} = (0.1806)^2 C_m = 0.0326 C_m$

(3) Cube: $V = L^3 = 1.0$ dm$^3$, $L = 1.0$ dm

Cube area = $6L^2 = 6(1)^2 = 6.0$ dm$^2$

$V/A = 1.0/6.0 = 0.1667$ dm

Chvorinov’s Rule $T_{TS} = (0.1667)^2 C_m = 0.0278 C_m$

(b) Sphere would be the best riser, since V/A ratio is greatest.

(c) Given that $C_m = 3.5$ min/cm$^2 = 350$ min/dm$^2$

Sphere: $T_{TS} = 0.0428(350) = 14.98$ min

Cylinder: $T_{TS} = 0.0326(350) = 11.41$ min

Cube: $T_{TS} = 0.02778(350) = 9.72$ min

10.24 A cylindrical riser is to be designed for a sand casting mold. The length of the cylinder is to be 1.25 times its diameter. The casting is a square plate, each side = 10 in and thickness = 0.75 inch. If the metal is cast iron, and the mold constant = 16.0 min/in$^2$ in Chvorinov’s Rule, determine the dimensions of the riser so that it will take 30% longer for the riser to solidify.

**Solution:** Casting volume $V = tL^2 = 0.75(10.0)^2 = 75$ in$^3$

Casting area $A = 2L^2 + 4Lt = 2(10.0)^2 + 4(10.0)(0.75) = 230.0$ in$^2$

$V/A = 75/230 = 0.3261$

Casting $T_{TS} = 16(0.3261)^2 = 1.70$ min

Riser $T_{TS} = 1.30(1.70) = 2.21$ min

Riser volume $V = \pi D^2 H/4 = 0.25\pi D^2 (1.25D) = 0.3125\pi D^3$

Riser area $A = 2\pi D^2/4 + \pi DH = 0.5\pi D^2 + 1.25\pi D^2 = 1.75\pi D^2$

$V/A = 0.3125\pi D^3 / 1.75\pi D^2 = 0.1786D$

Riser $T_{TS} = 16.0(0.1786D)^2 = 16.0(0.03189)D^2 = 0.5102D^2 = 2.21$ min

$D^2 = 2.21/0.5102 = 4.3316$

$D = (4.3316)^{0.5} = 2.081$ in

$H = 1.25(2.081) = 2.602$ in.