INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

TIME: 3HRS, FULL MARKS: 100, DEPT.: MECHANICAL ENGINEERING

NO OF STUDENTS: 153, END SEMESTER EXAMINATION: NOV 2011

SUB NO: ME31007, SUB NAME: CASTING FORMING WELDING

3RD YR BTECH

Instruction: USE SEPARATE ANSWER SCRIPT FOR EACH PART (TOTAL 3 NOS)

PART-A (CASTING)

C1. (a) A cylindrical sand casting is 0.1 m diameter and 0.5 m length. Another casting of same material is elliptical in cross section with major axis twice minor axis and has same cross section area and length. What is their ratio of solidification time for similar casting condition? [4]

(b) Fig.1 below shows Al-Si phase diagram. How many eutectic points are there in the phase diagram? You are considering making a shape casting from two alloys, one containing 2% Si and the other containing eutectic composition. Show the temperature-time curve (freezing curve) for both the alloy and which alloy composition will be more prone to segregation? [1+4+2=7]

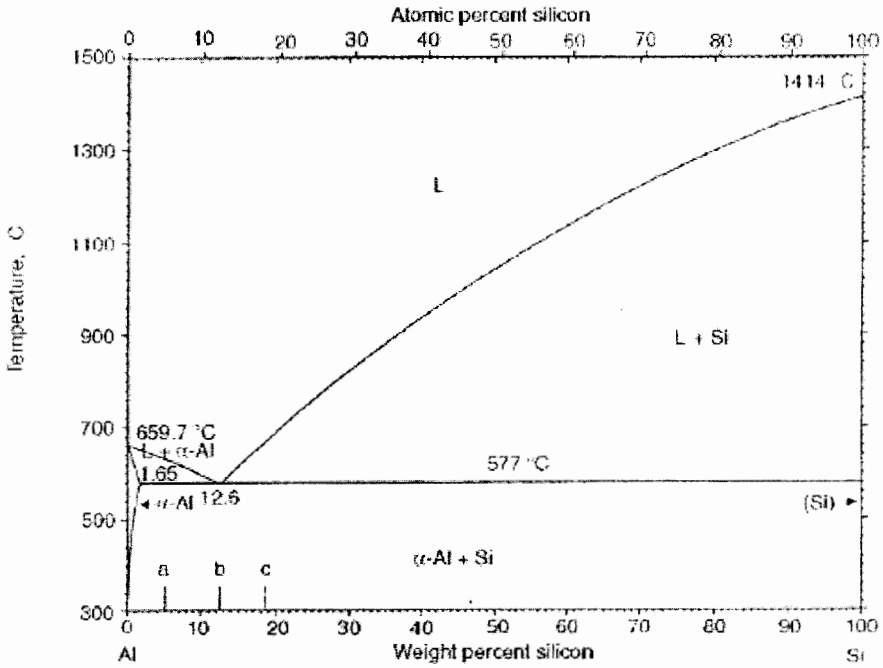


Fig. 1 Al-Si phase diagram.

C2. The maximum equilibrium solubility of hydrogen at a partial pressure of 1 atm in liquid iron is 27 cm3 per 100 gm. This drops to 7 cm3 per 100 gm upon complete solidification. The density of iron (liquid and solid) is 7.9 gm/cm3. Calculate the percentage of gas porosity in an iron casting if the partial pressure of hydrogen in contact with molten iron is 0.1 atm. What hydrogen partial pressure is required to eliminate the gas porosity? [10]

C3. Write only the answers [2*6=12]

(a) Fluidity of Mg and Al alloy was measured by spiral test after heating both the alloys to 100^0 C superheat. Which among the above two will show higher fluidity if their latent heat are 136 and 232.5 cal/dm^3, and specific heat are 0.3 and 0.25 cal/dm^3.^{0}c respectively.

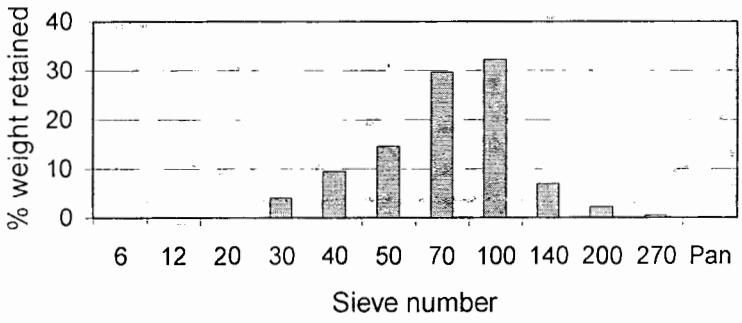
(b) The contact angle (θ) for two fluids "a" and "b" is: for "a" $\theta<90^0$ and for "b" $\theta>90^0$. Which among the above two have better fluidity?

(c) Q. 0.6 % carbon steel has following data for sand and chilled mold casting. Which will be difficult to feed? Start and end of freezing time at the centre line= 24, 48 min (for sand mold) & 8, 10 min (for chill mold). Assume liquid metal starts freezing at the mold wall as soon as it is filled.

(d) A spherical casting of diameter 10 cm has a cylindrical riser 5 cm in diameter and 10 cm high. Will the riser prevent macroporosity?

(e) Sand distribution data obtained from sieve analysis is shown in Fig. 1. What is the screen number of this sand?

Fig. 2 sand distribution



(f) The equilibrium partition coefficients of "O" and "Mn" in iron are 0.03 and 0.77. Which solute element will have lower segregation tendencies?

PART-B (FORMING)

Instruction: Assume any data which is required; but not mentioned in PART-B.

F1. (a). Derive the expression of the forging force of a circular disc in an open-die forging process using flat platens. Use von-Mises' yield criteria and consider only slipping friction condition. [10]

(b). A circular disc of 120 mm diameter and 64 mm height is forged at room temperature between two flat dies to 36 mm height. Determine the die load at the end of compression using slab method analysis. The yield strength of material is given as, $\sigma=15.0(0.01+\varepsilon)^{0.41}$ kgf/mm^2, where ε is the compressive strain, and the coefficient of friction is 0.05. Consider only the slipping friction condition. [5]

F2. (a) Derive the force requirement in a high friction forward extrusion process considering semi-die angle as 45°. Use Slab method. *[Hint: Use the concept of drawing operation with different boundary conditions]* [8]

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(b) Estimate the maximum force required for extruding a cylindrical aluminium billet of 40 mm diameter and 70 mm length to a final diameter of 12 mm. The average tensile yield stress and shear yield stress for aluminium are 180 N/mm^2, and 100 N/mm^2, respectively. Assume, semi-die angle is 45°, and coefficient of friction is 0.15. *[Hint: Maximum force would be at the beginning of the operation]*

[5]

F3. Write short notes on: [5]

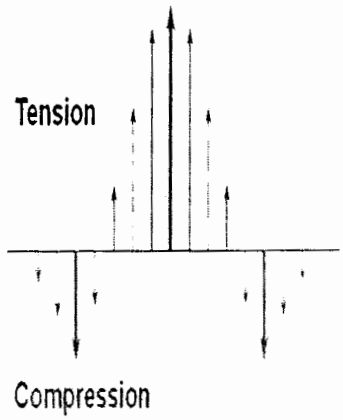
(a) Difference between backward and forward extrusion processes
(b) Steps involved in a powder metallurgy process

PART-C (WELDING)

W1. A continuous fillet weld is to be made with cross sectional area 20 sq.mm. The power source in a particular welding setup is capable of generating 3500 W that can be transferred to the work surface with an efficiency of 70%. The metal to be welded is low carbon steel whose melting point is 1700 K. Melting efficiency of the operation is 60%. Determine the travel speed of the welding operation. Assume any unknown, if necessary. [10]

W2. A welding power source is transferring 3.0 kW to a metal plate. The heat impinges the surface in a circular area with intensities varying inside. The distribution is as follows: 70% of the power is transferred within a circle of diameter 5.0 mm and 90% is transferred within another concentric circle of 12.0 mm diameter. What are the power densities in both the circular areas? [10]

W3. The figure below is the distribution of some important parameter due to arc welding on a plate. Can you identify it and explain in detail what the welding condition was ? [8]



W4. Discuss the use of Helium and Argon as shielding gases for arc welding. Comment about the typical properties of these gases in the context of welding. [5]

1 MARK FOR GOOD HANDWRITING

BEST WISHES FROM THE COURSE INSTRUCTORS