MID-SEMESTER EXAMINATION: SEPTEMBER 2016

DEPARTMENT OF MECHANICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

SUB NO: ME31007	SUB NAME: CASTING FORMING AND WELDING	
TIME: 2 HRS	FULL MARKS: 100	NO OF STUDENTS: 181

Instructions:

Assume any data, if required BUT NOT mentioned in the question. Clearly mention your assumption

	Part A (Casting, 33 marks)	
C1.	The ***K***, ***n*** and ***m*** values for a cast metal are 1140 MPa, 0.35 and 0.01 respectively. A tensile test piece from this metal has initial width, thickness and gauge length of 12.5 mm, 0.45 mm and 50 mm respectively. Determine the increase in load when extension is 10% and the extension rate of gauge length is increased from 0.5 to 50 mm/min. (Note that the material follow power law i.e. $\boldsymbol{\sigma = K.\varepsilon^n.\dot{\varepsilon}^m}$).	11
C2.	Selection of parting line and draw direction is very critical while designing a pattern for a casting. In this context, answer the following questions. (i) What is parting line? (ii) What are the characteristics of parting line (mention at least four)? (iii) How to select parting line (explain briefly with a schematic diagram)?	2+4+5
C3.	Why is under-cooling required for solidification during casting? Suppose that liquid copper is under-cooled until homogeneous nucleation occurs. Calculate (a) the critical radius of nucleus required, and (b) the number of copper atoms in the nucleus. Assume that the lattice parameter of the solid FCC copper is 0.3615 nm, freezing temperature is 1085^0C, latent heat of solidification is 1628 J/cm^3, surface energy 177×10^{-7} J/cm^2 and typical under-cooling for homogeneous nucleation is 236^0C.	2+4+5

	Part B (Forming, 34 marks)	
F1.(a)	Derive the deviatoric stress invariants of a body undergoing plastic deformation having 3D system.	10
(b)	From the above, find out the value of the hydrostatic stress of a deviatoric stress tensor.	3
(c)	A body, undergoing plastic deformation, has a total stress system as:	6

	$$\sigma\ (MPa) = \begin{pmatrix} 50 & 30 & 20 \\ 30 & -20 & -10 \\ 20 & -10 & 10 \end{pmatrix}$$ Find out the deviatoric stress matrix.	
F2.(a)	Find out a relation between true-stress and engineering stress.	3
(b)	A tensile specimen with a 12 mm initial diameter and 50 mm gage length reaches maximum load at 90 kN and fractures at 70 kN. The minimum initial diameter at fracture is 10 mm. Determine ultimate tensile stress, true fracture stress and true-strain at fracture.	4
F3.(a)	Draw the HCP crystal structure, and find out the packing factor.	2+3
(b)	Draw a true-stress strain curve of a ductile material. Show the elastic recovery after withdrawal of the load/stress which is applied beyond the yield point.	1+2

	Part C (Welding, 33 marks)	
W1.	Briefly explain the desired characteristics of a DC power source to compensate the arc length variations so as to achieve a uniform metal deposition rate in a typical arc welding process.	10
W2.	Discuss the features of "Bridging" (Short-circuiting) metal transfer mode in arc welding. Explain with the help of I-V (current-voltage) traces.	8
W3.	A single full penetration weld pass is made on 5 mm steel plates. The welding speed is 5 mm/s. The welding voltage and current is respectively given as 20 V and 200 A. The sample temperature at ambient condition is 25 °C and its melting point is given as 1510 °C. Assume an arc efficiency of 90 %. Given, ρC = 0.0044 J/mm^3.K (i) Calculate the peak temperature at a distance of 2.0 mm from the weld fusion boundary (ii) Find the width of recrystallization zone if the recrystallization temperature is 730° C (iii) Find the influence on the width of recrystallization zone if a preheated sample is used (Assume preheat temp =200° C) *[Assume any data required, if not given. Given, symbols with usual meaning,* $$\frac{1}{T_p - T_0} = \frac{(2\pi e)^{0.5}\,\rho C h y}{H_{net}} + \frac{1}{T_m - T_0}$$ *Assumptions based on Rosenthal's solution for heat transfer equations could be made.]*	5+5+5

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