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CONFIDENTIAL

SET B

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2010 SESSION

SUBJECT CODE	:	FTB 22202
SUBJECT TITLE	:	WELDING METALLURGY 1
LEVEL	:	BACHELOR
TIME / DURATION	:	12.30pm – 3.00pm (2.5 HOURS)
DATE	:	28 APRIL 2010

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. This question paper consists of TWO (2) sections. Section A and B. Answer ALL questions in section A. For Section C answer THREE (3) questions only.
6. Answer ALL questions in English.

THERE ARE 3 PRINTED PAGES OF QUESTIONS AND 1 PAGE OF APPENDIX, EXCLUDING THIS PAGE.

SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.
Please use the answer booklet provided.

Question 1

Give your opinion about the main issues in studying heat flow during welding.

(6 Marks)

Question 2

The equilibrium freezing range of 5058 aluminum alloy is about 50ºC. Suppose the welding speed is 3 mms^{-1} and the diffusion coefficient DL is 2.2×10^{-5} cm^2s^{-1}.

(a) Calculate the minimum temperature gradient required for planar solidification at the weld center line.

(5 Marks)

(b) What is the corresponding cooling rate? Can this level of cooling rate be achieved in arc welding?

(5 Marks)

Question 3

Give **TWO (2)** types of testing methods to determine the Partial Melted Zone (PMZ) cracking susceptibility.

(4 Marks)

Question 4

(a) Define the Heat Affected Zone (HAZ) for steels.

(4 Marks)

(b) Sketch and labels the Heat Affected Zone (HAZ) for steels

(6 Marks)

Question 5

Discuss the competitive growth in bulk fusion zone.

(10 Marks)

SECTION B (Total: 60 marks)

INSTRUCTION: Answer THREE (3) questions only.
Please use the answer booklet provided.

Question 1

(a) Calculate the cooling rate at 850°C along the x axis of a wide thick austenitic steel plate using GMAW process at welding speed 8 cm.min^{-1} with a welding current and voltage of 140 Ampere and 25 Volts respectively. Assume 75% arc efficiency, thermal conductivity of steel is 25 Wm^{-1}°C^{-1} and welding, melting point 1500°C and the room temperature as 25°C.

(10 Marks)

(b) Large aluminum sheets 120 mm thick are butt welded using Gas Tungsten Arc Welding (GTAW) with alternating current. The current, voltage, and welding speed are 120 Ampere, 20 Volts, and 3mms^{-1}, respectively. Calculate the peak temperatures at distance of 2.5 mm from the fusion boundary. Assume 60% arc efficiency, α = 8.5 x 10^{-5} m^{2}s^{-1}, ρC = 2.7 x 10^6 Jm^{-3}K^{-1}, k = 229 Jm^{-1}s^{-1}K^{-1} and melting point = 933K.

(10 Marks)

Question 2

Solidification cracking in aluminum alloys mostly influence by metallurgical and mechanical factors.

(a) Name **TWO (2)** mechanical factors that influence solidification cracking.

(4 Marks)

(b) Discuss the effects of solidification temperature range to solidification cracking.

(8 Marks)

(c) Explain why fine equiaxed grains are often less susceptible to solidification cracking than columnar grain.

(8 Marks)

Question 3

There are several problem associated with partially melted zone (PMZ) such as liquidation cracking, loss of ductility and hydrogen cracking.

(a) Explain the mechanism of liquidation cracking in PMZ.

(6 Marks)

(b) Discuss why aluminum alloys is more susceptible to liquidation cracking than iron base alloys.

(10 Marks)

(c) State **FOUR (4)** remedies for problems associated with the PMZ.

(4 Marks)

Question 4

Weld microstructures developed during welding in Weld Metal and Heat Affected Zone (HAZ) play an important role to the mechanical properties of weldment.

a) Explain how cooling rate and alloying elements influence the weld microstructure.

(10 Marks)

b) Explain by the aid of sketches why there are variations in microstructures in HAZ region.

(6 Marks)

c) Give **TWO (2)** problems commonly associated with HAZ region in carbon steel.

(4 Marks)

END OF QUESTION

Appendix 1: Formula

$$Q = \eta EI \qquad H_{net} = \frac{Q}{U}$$

$$\int_0^{\infty} WC(T_{out} - T_{in})dt = \eta \mathrm{EIt}_{weld}$$

$$\left.\frac{\partial T}{\partial t}\right|_x = \left.\frac{\partial T}{\partial x}\right|_t \bullet \left.\frac{\partial x}{\partial t}\right|_T = 2\pi k_s U \frac{(T - T_o)^2}{Q}$$

$$\frac{2\pi(T - T_o)k_s g}{Q} = \exp\left(\frac{Ux}{2\alpha_s}\right) K_o\left(\frac{Ur}{2\alpha_s}\right)$$

$$\frac{2\pi(T - T_o)k_s R}{Q} = \exp\frac{-U(R - x)}{2\alpha_s}$$

$$Cooling\ rate = 2\pi k\rho C\left(\frac{h}{H_{net}}\right)^2 (T_c - T_o)^3$$

$$\text{Cooling Rate} = \frac{2\pi k_s (T_c - T_o)^2}{H_{net}}$$

$$\frac{1}{T_p - T_o} = \frac{\sqrt{2\pi e}\,\rho Chy}{H_{net}} + \frac{1}{T_m - T_o}$$

$$D = \frac{dU}{2\alpha}$$

$$n = \frac{QU}{4\pi\alpha^2 \rho C (T_m - T_o)}$$

Definition of symbols

Q = Energy

E = Voltage

I = Current

η = efficiency

H_{net} = Net energy input

T = temperature

t = time

C = specific heat of water

W = mass flow rate of water

k_s = Thermal conductivity of solid

g = Thickness of the workpiece

U = welding speed

α_s = Thermal diffusivity of solid

K_o = modified Bessel function of the second kind and zero order.

ρC = Volume Thermal capacity

k = Thermal conductivity

T_c = Temperature at which the cooling rate to be calculated, °C

T_o = initial plate temperature

r = radial distance from origin $(x^2 + y^2 + z^2)^{1/2}$

h = thickness for the base metal

e = constant value (2.718)

G = Temperature gradient

R = Growth rate

D_L = diffusivity of the solute in the liquid

ΔT = equilibrium freezing range

d = weld penetration

n = dimensionless operating parameter