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CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR

MALAYSIA FRANCE INSTITUTE

FINAL EXAMINATION

JANUARY 2014 SESSION

SUBJECT CODE	:	**FTB22203**
SUBJECT TITLE	:	**WELDING METALLURGY 1**
LEVEL	:	**BACHELOR**
DURATION	:	**2 ½ HOURS**
DATE / TIME	:	

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 B, answer TWO (2) questions only.**
6. **Answer all questions in English.**

THERE ARE 4 PRINTED PAGES OF QUESTIONS, AND 1 PAGE OF APPENDIX EXCLUDING THIS PAGE.

SECTION A (Total: 60 marks)

INSTRUCTION: Answer ALL question.

Please use the answer booklet provided.

Question 1

(a) List **TWO (2)** factors directly influence the welding heat flow.

(4 Marks)

(b) Sketch the fusion and heat affected zone (HAZ) for 2D and 3D welding heat flow.

(4 Marks)

(c) In a welding experiment, 40-mm-thick stainless steel plates were joined using Gas Tungsten Arc Welding (GTAW) process. The welding parameter for current and voltage are 220A and 20V, respectively. The heat losses due to the water-cooled copper shoes and by radiation from the surface of the slag pool were 915 and 45 $cal.s^{-1}$, respectively. Calculate the heat source efficiency.

(8 Marks)

A single full penetration weld pass is made on steel using the following parameters.

E = 20 V	ρC = 0.0044 J/mm^3 °C
I = 190 A	h = 5 mm
Travel speed	= 3 mm/s
Efficiency	= 0.8
Room Temperature	= 30°C
Melting Temperature	= 1510°C

(i) Calculate the peak temperatures at distance of 2.0mm from the fusion boundary.

(8 Marks)

(ii) Calculate the width of heat affected zone (HAZ) if the recrystalization temperature is 730ºC.

(6 Marks)

Question 2

The partially melted zone (PMZ) is the area immediately outside the weld metal where liquation can occur during welding.

(a) Sketch the PMZ region for single V butt joint. Indicate clearly the boundary.

(4 Marks)

(b) Discuss the effects of grain size to the partial melting zone (PMZ) cracking.

(6 Marks)

(c) List **TWO (2)** test methods to evaluate the susceptibility of PMZ cracking.

(4 Marks)

(d) Solidification cracking occurs during the terminal stages of solidification. Explain the mechanism of solidification cracking.

(10 Marks)

(e) Discuss the relationship between freezing temperature range and solidification cracking.

(6 Marks)

SECTION B (TOTAL: 40 Marks)

INSTRUCTION: Answer TWO (2) questions only.

Question 1

Heat affected zone (HAZ) is a region where melting not occur but enough to change the microstructure and properties of the materials significantly.

(a) Based on Figure 1, sketch the microstructures and thermal cycles for point 1, 2 and 3.

(10 Marks)

Figure 1: HAZ region in weldment

(b) List **TWO (2)** common problems associated with HAZ.

(4 Marks)

(c) Discuss the effects of peak temperature to grain size in HAZ.

(6 Marks)

Question 2

The properties of weldments depend upon the characteristics of the morphology and microstructures formed in HAZ and fusion zone (FZ).

(a) Discuss how acicular ferrite able to increase the fracture strength of weldment.

(6 Marks)

(b) Explain how Titanium (Ti) able to increase of acicular ferrite volume (%) in FZ.

(4 Marks)

(c) Explain how weld metal oxygen content influences the formation of acicular ferrite.

(6 Marks)

(d) Explain how fine equiaxed grain in fusion zone able to increase the fracture strength of weldment.

(4 Marks)

Question 3

Common morphology occurs in weld solidification structure such as planar, cellular, columnar dendritic and equiaxed dendritic.

(a) Sketch the morphology of cellular and columnar dendritic.

(4 Marks)

(b) Discuss the effect of temperature gradient (G) and growth rate R on the morphology and size of solidification microstructure.

(6 Marks)

(c) Explain the effect of preheating to the size of dendritic. .

(4 Marks)

(d) By apply transverse arc oscillation at low frequencies during arc welding process, is it able to reduce size of subgrain. Explain the effect of reduction size of subgrain to mechanical properties of weldment.

(6 Marks)

END OF QUESTIONS

Appendix 1: Formula

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

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

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

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

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

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

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

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

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

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

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 $(x^2 + y^2 + z^2)^{½}$

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