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CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR

MALAYSIA FRANCE INSTITUTE

FINAL EXAMINATION

SEPTEMBER 2014 SESSION

SUBJECT CODE	:	**FTB22203**
SUBJECT TITLE	:	**WELDING METALLURGY 1**
LEVEL	:	**BACHELOR**
DURATION	:	**2.00 PM – 4.30 PM (2.5 HOURS)**
DATE / TIME	:	**4 JANUARY 2015**

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.

SECTION A

INSTRUCTION: Answer ALL question.

Question 1

(a) State **TWO (2)** examples for welding process that included in heat source of focus.

(4 Marks)

(b) Sketch the penetration made by GTAW with DC electrode negative and positive.

(4 Marks)

(c) For a single complete joint penetration weld pass is made on high strength low alloy steel (HSLA) using the following conditions:

E = 20 V	$\rho C = 0.0047$ J/mm^3
I = 120 A	h = 25 mm
U = 15 cm/minute	$\eta = 0.80$
$T_o = 28°C$	$T_m = 1510°C$

(i) Calculate the net heat input (H_{net}).

(4 Marks)

(ii) Calculate the cooling rate at 800°C along the *x* axis.

(8 Marks)

(iii) If recrystallization temperature is 725ºC and preheating temperature apply for the weld specimen is 150°C. Predict the width of HAZ.

(10 Marks)

Question 2

(a) Cracks can occur in weldment when internal stress exceed the ultimate strength of base metal or weld metal. Commonly, it can be classified as hot or cold cracking.

(i) State **TWO (2)** methods to determine the susceptibility of solidification cracking.

(4 Marks)

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

(6 Marks)

(iii) Explain how primary solidification phase influence the solidification cracking in austenitic stainless steels.

(6 marks)

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

(i) Discuss the effect of grain size to the partial melting zone (PMZ) cracking.

(6 Marks)

(ii) Briefly explain the mechanism of liquation cracking in PMZ.

(8 Marks)

SECTION B

INSTRUCTION: Answer TWO (2) questions only.

Question 1

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

(a) Based on Figure 1, sketch the microstructures for point 2, 3 and 4.

(6 Marks)

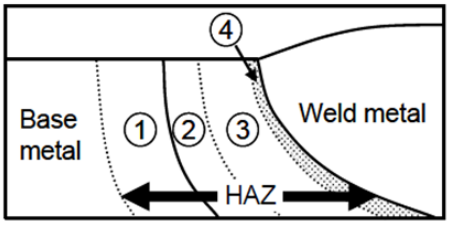

Figure 1: HAZ region in weldment

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

(4 Marks)

(c) Discuss the effect of heat input to the size and location of HAZ.

(6 Marks)

(d) How to minima the effect of low toughness in HAZ for carbon steel.

(4 Marks)

Question 2

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

(a) State **THREE (3)** factors affecting microstructure form in fusion zone.

(6 Marks)

(b) Sketh the side plate ferrite and acicular ferrite structure.

(4 Marks)

(c) Discussion how acicular ferrite structure able to increase fracture strength of weldment.

(6 Marks)

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

(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 heat input to the size of dendritic.

(4 Marks)

(d) Explain the effect of reduction size of subgrain to mechanical properties of weldment.

(6 Marks)

END OF QUESTION

Appendix 1: Formula

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

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

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

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

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

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

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

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

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

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

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