L-3/T-2/MME Date : 28/03/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

Sub : **MME 343** (Surface Engineering of Materials)

Full Marks : 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) What is meant by 'CASS'? Which quality of coating and how the quality are judged by CASS? **(7)**

   (b) Suppose you have to protect a cylindrical vessel from degradation by corrosion and wear. You have two options.

   Option A: You can use austenitic stainless steel which requires only installation cost (including material) of Tk. 2,70,000. **(20)**

   Option B: You can use mild steel with rubber lining which requires Tk. 1,18,000 for mild steel, Tk. 32,000 for rubber lining and Tk. 50,000 for renewal of lining. As a materials engineer, establish the criterion to decide which option you will prefer for annual, 2 yearly and 3 yearly renewal of rubber lining in Option B. How will other factors influence the selection criterion?

   (c) With schematic diagram show that few milliseconds may be needed to initiate relative motion. **(8)**

2. (a) Develop an equation to express the ploughing component of the co-efficient of friction for a conical shaped wear particle with semi-apex angle α pressed into a softer body. **(15)**

   (b) 'Transition of friction may occur in four different patterns.' – Interpret the patterns with necessary diagrams. Mention and explain the material interfacial conditions applicable to each pattern. **(20)**

3. (a) How does rest time affect static friction? What is its importance on industrial applications? **(10)**

   (b) A hard ball is sliding against a soft and flat surface at 2 different loads. At one load, co-efficient of friction is 0.20 and the groove width is 0.5 mm and at another load, co-efficient of friction is 0.25 and groove width is 1 mm. Calculate radius of the ball and adhesive component of the co-efficient of friction. Assume that the dominant sources of friction are adhesion and ploughing and these are additive. **(13)**

   (c) 'Wear resistance of pure metals is proportional to their hardness but is more complex for alloys' – Justify with necessary diagram and examples. **(12)**

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4. (a) Analyse, with suitable diagrams, the various modes of abrasive wear process as a result of plastic deformation. **(20)**

(b) A hard steel surface considering of an array of conical asperities of an average attack angle of 30° slides on an soft Pb surface (Hardness = 75 MPa) under a load of 10 N. Calculate the volume of Pb displaced in unit slide distance. For another case, the volume of Pb material removed is 10^{-6} m^3 for a sliding distance of 1 km, calculate the wear coefficient of Pb. **(10)**

(c) Prove that transfer of material occurs from one surface to another in adhesive type of wear. **(5)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) Why does corrosion provide a major source of failure in metallic materials? **(10)**

(b) Design a coating deposition system suitable for protecting gas turbine from high temperature corrosion. **(25)**

6. (a) Compare and contrast physical vapour deposition with chemical vapour deposition. **(18)**

(b) How does electroless plating overcome the difficulties that are associated with electroplating. **(10)**

(c) A current of 15 A was passed through a $CuSO_4$ solution for 10 min. The area of the work in the tank was 1500 cm^2. What is the average thickness of Cu deposit? **(7)**

7. (a) With appropriate mathematical relationship along with necessary examples, show that complex plating bath is required for quality deposition. **(20)**

(b) Electrical double layer formation is important for electroplating – explain. **(9)**

(c) Mention the usefulness of laser surface alloying over laser surface melting. **(6)**

8. (a) Differentiate between regular co-deposition and anomalous co-deposition. **(10)**

(b) Briefly describe how current density and pH of plating bath effect electro deposition of alloys. **(15)**

(c) For plating a continuous strip of 0.9 m wide with Sn containing acid solution (valence change 2), the desired strip speed is 500 m/min, current efficiency is 100% and the thickness of Sn is to be 0.5 μm (each side) at a current density of 5000 A/m^2. How long must the plating tank be, assuming that the strip passes straight through the tank with no return bends? (ρ_{Sn} = 7.31 g/cc and A_{Sn} = 118.7). **(10)**

L-3/T-2/MME **Date: 22/03/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **MME 345** (Foundry Engineering)

Full Marks: 280 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** from the rest.

1. Determine the dimensions of a cylindrical feeder (H = 0.5D) attached on top of an aluminium plate casting having dimensions of 25 cm × 12.5 cm × 5 cm by **($46\frac{2}{3}$)**

   (a) Using Caine's relationship, where the constants a = 0.1, b = 0.03 and c = 0.5

   (b) Using Bishop's shape factor method (Graph provided).

   (c) Assuming that the volumetric shrinkage of solidification is 7% for aluminium and that the volume of feeder is 3 times that by the shrinkage consideration alone. Assume reasonable value for any missing data (if any).

2. Ductile iron plate of length 750 mm, width 400 mm, and thickness 75 mm with a composition of C 3.5% Si 2.40% and P 0.08% is to be cast using greensand system with a pouring temperature of 1250 °C. Design a suitable gating system for the casting. Use pouring Time, $t = 0.65\sqrt{W}$ seconds, where W is the weight (in lbs) of the liquid metal to be poured. Indicate clearly all the assumptions you need to make to solve this design problem. Important data: Density of ductile iron = 7.10 g/cc, Volume coefficient of thermal expansion = 1.0%. Assume reasonable value for any missing data (if any). **($46\frac{2}{3}$)**

3. (a) Deduce an expression relating solidification time of a casting with its modulus, with clearly mentioning all assumptions you made. Indicate the advantages and limitations of the expression. **(30)**

   (b) Between macro- and micro-defects, which one is more detrimental in reducing tensile strength and ductility of cast product? Explain your reasonings. Why don't these defects affect yield strength of castings? **($16\frac{2}{3}$)**

Contd P/2

MME 345

4. (a) Why do you prefer fine-grained equiaxed structure in castings and ingots? Explain how an ingot structure consisting entirely of fine-grained equiaxed crystals can be developed. **(16)**

(b) Explain why dendrite arm spacing of casting is more useful in determining casting properties compared to its grain size. **(10)**

(c) What is hot tear? Analyse the mechanism by which this defect is formed. What types of alloys are prone to this defect? Explain some design methods by which you could eliminate this defect. **($20\frac{2}{3}$)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. a) An industry needs to produce 2500 castings per day. As a foundry engineer suggest an appropriate casting process for the industry. Critically compare among sand casting, investment casting and pressure die casting in terms of cycle time, flexibility, quality, materials utilization and operating cost. **($25\frac{2}{3}$)**

(b) How is bonding developed in green sand aggregates during molding? **(16)**

(c) There are different types of sand used in sand molding systems. What type of sand you will choose to produce a cast product with good dimensional accuracy. **(5)**

6. (a) Explain the causes and remedies of the molding defects. **($10\frac{2}{3}$)**

(b) How will you control the molding sand aggregate to obtain optimum molding properties? A foundry received an order of 15,000 pieces of grey iron cylindrical shape casting (L-50 mm, D_0-250 mm and D_i-200 mm). It was decided to produce a master pattern made of aluminium from which steel working patterns were to be cast and machined. Using necessary allowances, determine the dimensions of the master pattern and its core prints. **(22)**

(c) Density (g/cm^3): Grey iron = 7.2; Steel = 7.8; Al = 2.7; Core sand = 1.6
Compressive strength (kg/cm^2): Core sand = 2.0; Factor of safety = 5
Contraction (mm/mm): Grey iron = 8/1000; Steel = 16/1000; Al = 12/1000. **(14)**

7. (a) What type of cast iron you will choose for grinding media and why? How will you produce that type of cast iron? **(15)**

Contd P/2

MME 345

Contd... Q. No. 7

(b) Even if iron of the correct chemical analysis is made in the melting furnace, castings having the desired graphite structure will not be produced without the addition of inoculants. -Explain. **($15\frac{2}{3}$)**

(c) The more spherical shape of graphite phase, the matrix of ductile iron has the greatest effect on properties. Which factor does play the most important role to make spherical shape graphite in ductile iron during solidification? Compare between the graphitization behavior of grey cast iron and nodular cast iron. **(16)**

8. (a) Why is austempered ductile iron (ADI) comparable with wrought steel and how will you obtain ADI? **($15\frac{2}{3}$)**

(b) Explain the points that must be considered during sand moulding and core making for steel castings. **(15)**

(c) Explain how the structure of aluminum foundry alloys is modified and what special attention should be taken during melting and molding of these alloys. **(16)**

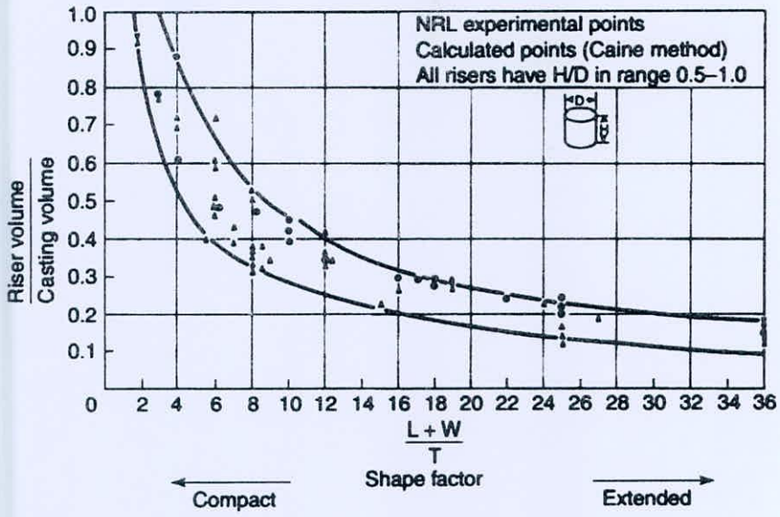


Figure 1 for Q.#1

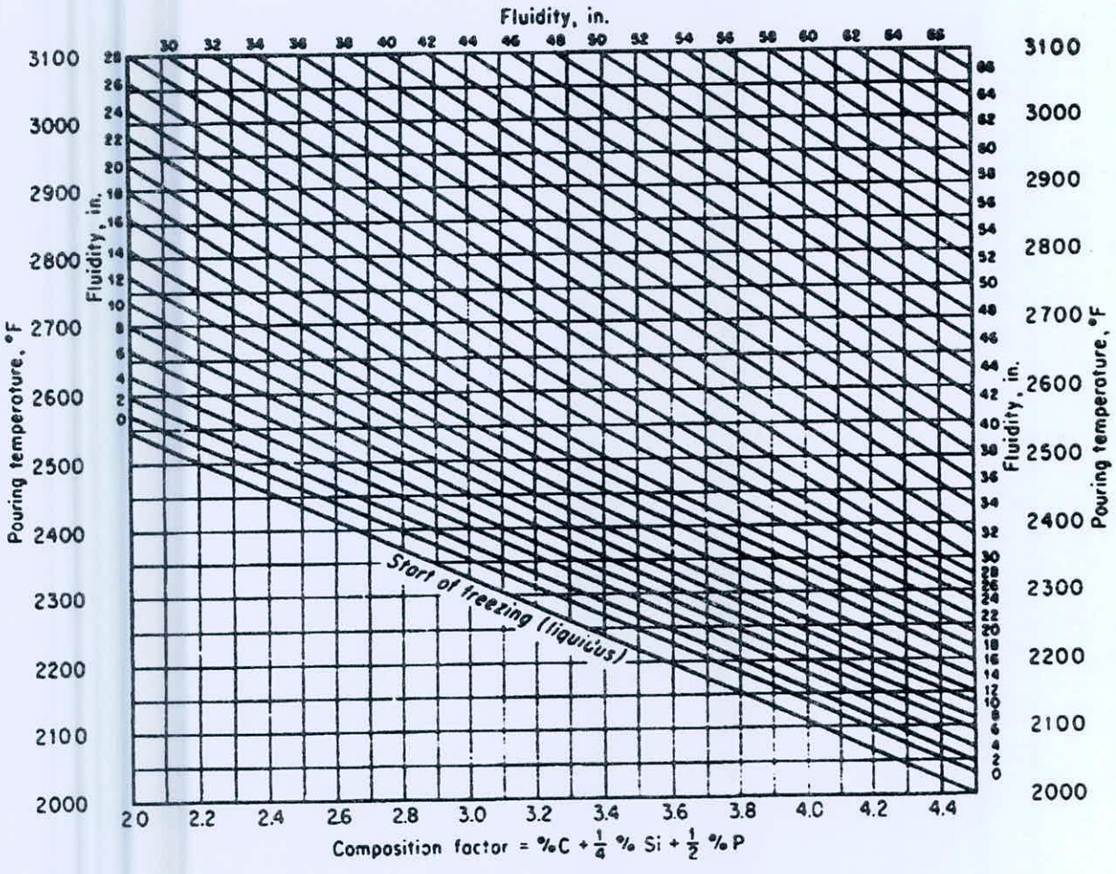


Figure 2 for Q.#2

L-3/T-2/MME **Date: 10/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **MME 347** (Metal Joining Technology)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **EIGHT** questions in this section. Answer any **SIX** questions.

1. (a) How does TIG welding arc shape depend on electromagnetic force or Lorentz force and shape of the tip of electrode? Assess your answer with plots of current densities and Lorentz force. The material was plain carbon steel, and was groove welded. **(12)**

   (b) There are five driving forces for fluid flow in the weld pool of a MIG welded aluminium alloy. It was V-welded 15 mm thick plate. The driving forces are assumed to be **(5 1/2)**

   - buoyancy force,
   - Lorentz force,
   - shear stress induced by the surface tension gradient at the weld pool surface,
   - shear stress acting on the pool surface by the arc plasma, and
   - arc pressure.

   Now, identify from these five forces, which one would have most significant effect on producing deep weld. Support your choice with schematics of weld pools and gradient profiles.

2. (a) Consider yourself as a materials engineer. While working in a research project for automation of TIG and MIG welding processes, you encountered different types of metallographic micrographs (Figures 1 and 2) of TIG welded aluminium alloys. Welding speeds are given in the figure captions. In these four micrographs, the development of grains is different. Formulate your opinion for having different shapes and types of grains in these micrographs. **(12)**

   (b) Draw the microstructures around the weld pool boundary for a 2219 aluminium (essentially Al-6.3% Cu) alloy welded by MIG welding. Weld pool was quenched with ice water during MIG. For your convenience, phase diagram, thermal cycles, and macrostructure of solid plus liquid around weld pool are given in Figure 3. You will draw microstructure only for points 1 and 2, as indicated by the square boxes marked 1 and 2, in the figure. Label the microstructure with clear divisions of different zones. **(5 1/2)**

Contd P/2

MME 347

3. Five mechanisms of liquation in PMZ of an aluminium weld is shown in Figure 4. Consider A_xB_y reacting with matrix mechanism. Further consider, the phase diagram shown in Figure 4a is similar to the Al-rich side of the Al-Cu phase diagram. Here, A_xB_y is intermetallic compound, such as Al_2Cu in the case of Al-Cu alloys. Your alloy is C_2 ($C_2 > C_{SM}$). Draw microstructures of before and after welding conditions for temperature $T < T_E$, $T = T_E$ and $T > T_E$. Support your drawings with possible explanations. **(17 ½)**

4. (a) Figure 5 shows a schematic of liquation cracking in the PMZ of a full-penetration aluminium weld. How does this crack evolve in the base metal? Build your ideas for the formation of this liquation crack. **(5 ½)**

   (b) During solidification of an austenitic stainless-steel weld, how can you achieve these different ferrite structures: interdendritic; vermicular; and lath. You should include impacts of chromium and nickel contents in your critical assessment. Draw relevant ferrite structures. **(12)**

5. Draw a schematic showing the effects of the followings on the development of weld metal (steel) microstructure, having different types of ferrites (Widmanstätten/acicular) and bainite: **(17 ½)**

   (i) the weld metal composition,
   (ii) the cooling time,
   (iii) the weld metal oxygen content, and
   (iv) the austenite grain size

   Now, build a vital and convincing discussion associated with CCT curves for these factors.

6. Figure 6 shows HAZ microstructures of a 1018 steel, welded by TIG method at four different locations. Relevant phase diagram is also given. Microstructures of HAZ are significantly different from the base metal microstructure. Judge the development of such different microstructures. **(17 ½)**

7. (a) Why should we limit the heat input and the preheating of the workpiece when welding quenched-and-tempered alloy steels? **(7 ½)**

   (b) Why do we need a martensitic structure in HAZ (for a carbon steel weld) and hydrogen in weld pool to be susceptible for hydrogen cracking? **(10)**

Contd P/3

MME 347

8. How can we achieve epitaxial growth and non-epitaxial growth (or nucleation) after solidification of a weld pool? Design a welding processes and materials for obtaining these two different microstructures. **(17 ½)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

9. (a) Draw the diagram of desired welds from the weld symbols shown in Fig. 7. **(18)**

(b) 'In the spectrum of joining processes, brazing and soldering lie between fusion welding and solid-state welding. Despite these similarities, brazing and soldering are generally considered to be distinct from welding'. Justify with explanation and examples how brazing and soldering resemble to and differ-from welding. **(17)**

10. (a) With necessary diagram, compare the three major types of fusion welding processes to establish the assertion 'heat input to the workpiece required for welding decreases as the power density of heat source increases'. Also mention the advantages of increasing power density of the heat source. **(15)**

(b) Why does resistance welding produce higher yield for steel than for copper? **(5)**

(c) As an engineer of Bangladesh Railway, suggest a suitable welding methods of joining heavy section steel structures of railroad. Describe the operational steps to join railroads. What are the advantages and disadvantages of the welding method? **(15)**

11. (a) Which current mode would you choose for welding thin sheets of aluminium in GTAW process? Justify your answer. Compare the mode with other usable modes in terms of oxide cleaning action, heat balance in the arc and electrode capacity. **(20)**

(b) 'Laser beam welding has replaced resistance welding in can making industry'. – Prove with advantages of laser beam over resistance welding. **(8)**

(c) According to AWS electrode classification which information is obtained from the electrode type 'E7018-1H4R'. **(7)**

12. Draw the schematics of following weld defects, mention causes of their formation and suggest preventive measures to avoid them. **(18)**

i) Transverse weld metal crack

ii) Hot crack

iii) Lack of fusion

(b) Show and discuss the gradual change of microstructure and hence the properties of a carbon steel from base metal to the fusion zone in the as-welded condition. **(17)**

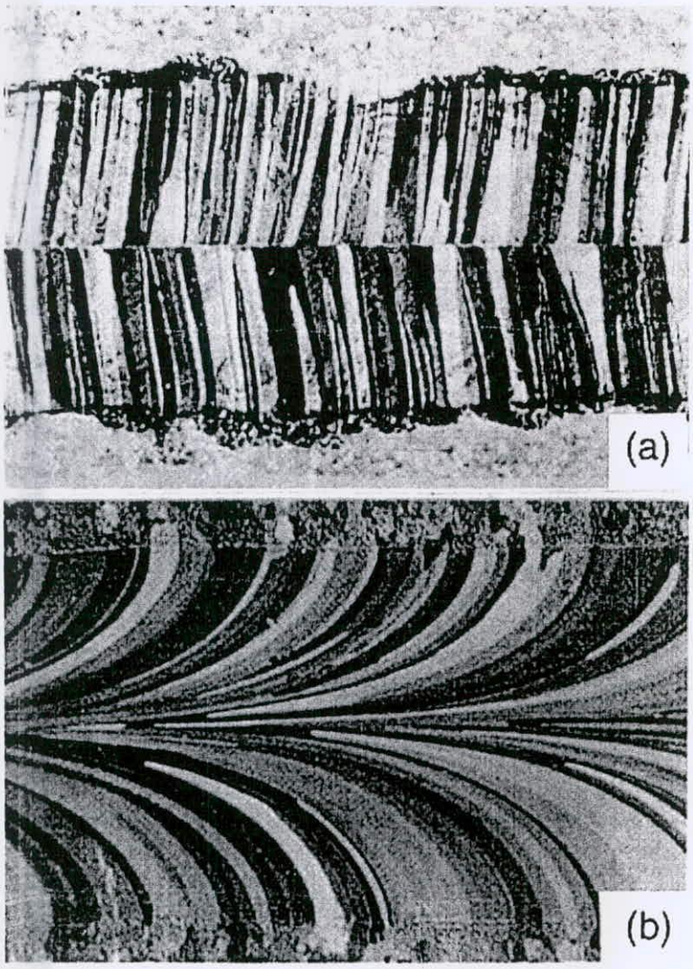


Figure 1 for Question No. 2(a)

Gas–tungsten arc welds of 99.96% aluminium: (a) 1000mm/min welding speed; (b) 250mm/min welding speed.

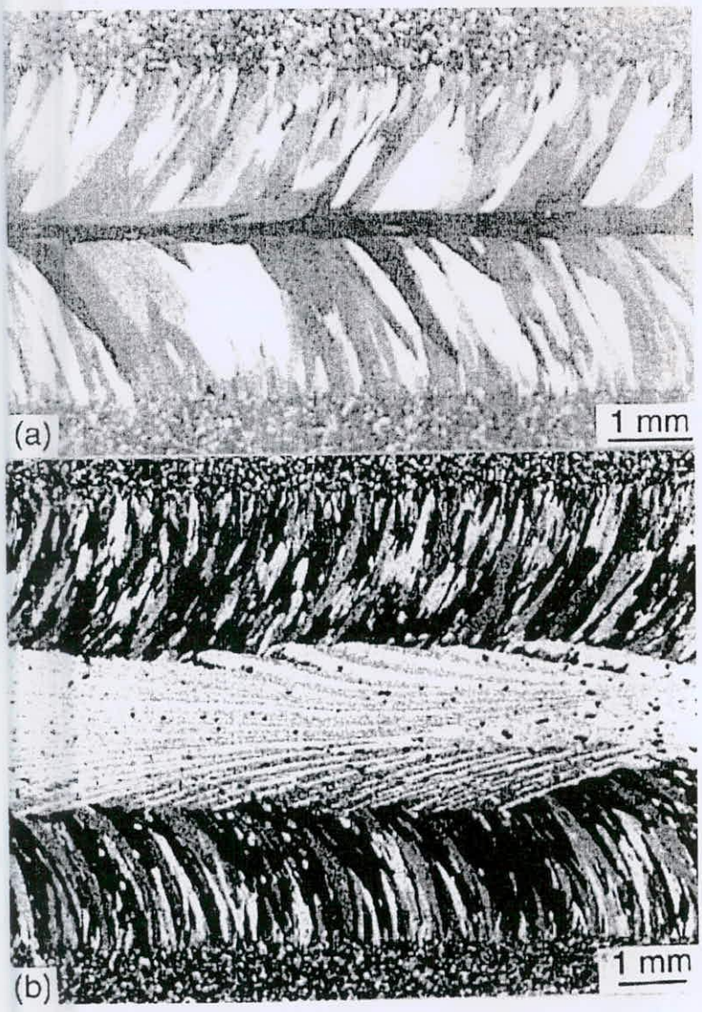


Figure 2 for Question No. 2(a)

Gas–tungsten arc welds of (a) 1100 aluminium at 12.7mm/s welding speed; (b) 2014 aluminium at 3.6mm/s welding speed.

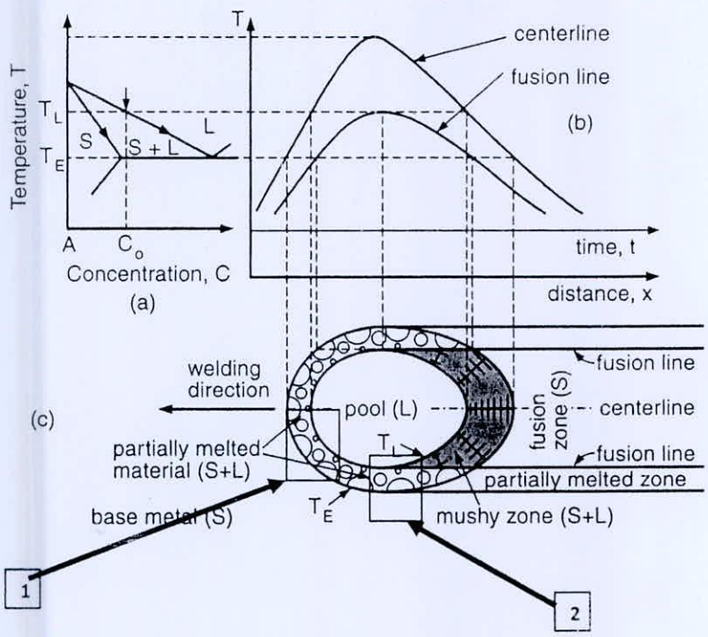
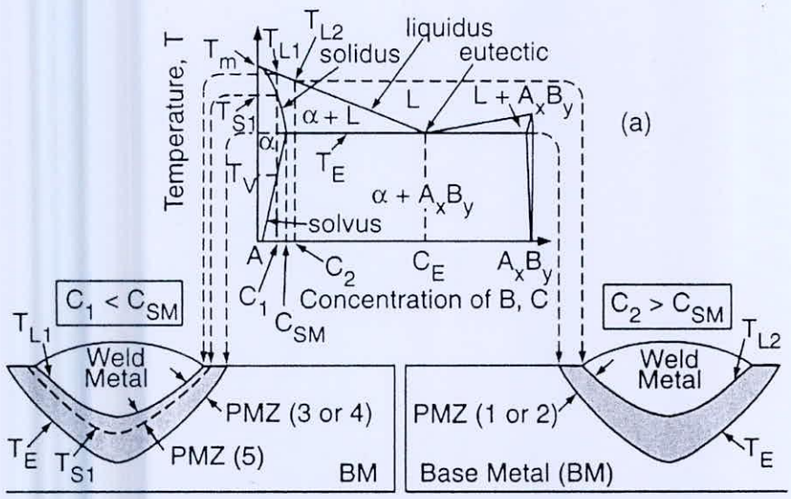


Figure 3 for Question No. 2 (b)

Microstructure around the weld pool boundary: (a) phase diagram; (b) thermal cycles; (c) microstructure of solid plus liquid around weld pool.



3. Residual A_xB_y reacting with matrix: (constitutional liquation)
   $A_xB_y + \alpha \rightarrow L$ at T_E
   if A_xB_y still present at T_E

4. Melting of residual eutectic:
   eutetic(S) → eutectic(L) at T_E
   if eutectic still present at T_E

5. Melting of matrix:
   $\alpha \rightarrow L$ at T_{S1}
   if no A_xB_y or eutectic present at T_E

(c)

1. A_xB_y reacting with matrix:
   $A_xB_y + \alpha \rightarrow L$ at T_E
   A_xB_y always present at T_E regardless of heating rate

2. Melting of eutectic:
   eutectic(S) → eutectic(L) at T_E
   eutectic always present at T_E regardless of heating rate

(b)

Figure 4 for Question No. 3

Five mechanisms for liquation in PMZ of aluminium alloys: (a) phase diagram; (b) two mechanisms for an alloy beyond the solid solubility limit (CSM); (c) three mechanisms for an alloy within the solid solubility limit.

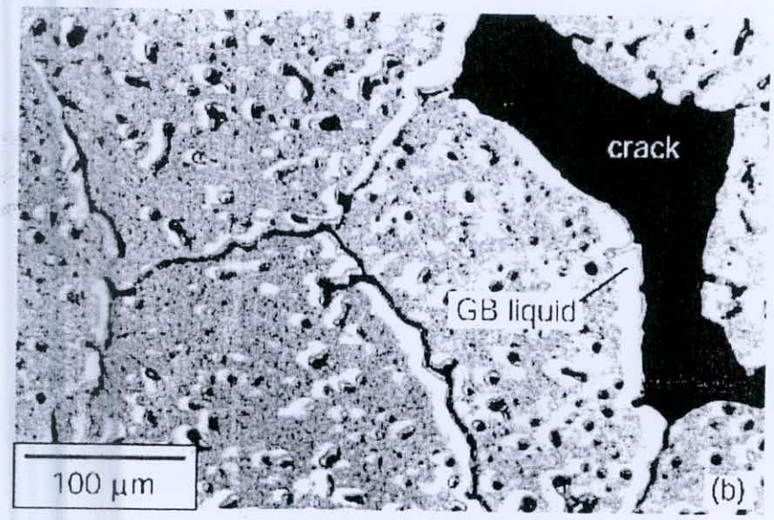


Figure 5 for Question No. 4

Formation of PMZ cracking in a full-penetration weld: PMZ cracking in 6061 aluminium

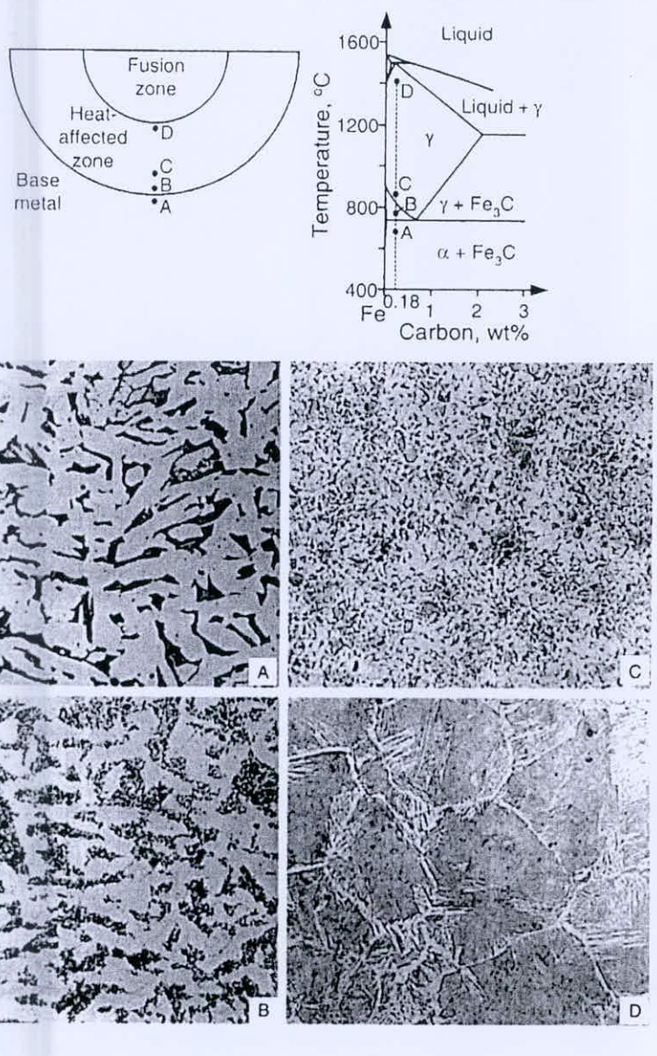
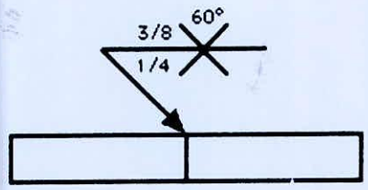
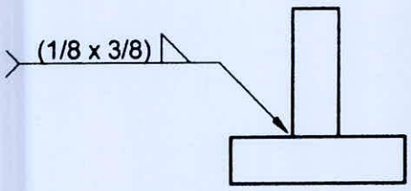


Figure 6 for Question No. 6

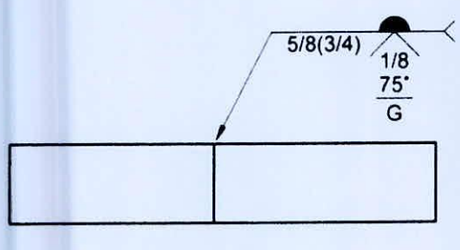
HAZ microstructure of a gas–tungsten arc weld of 1018 steel (magnification ×200)



(i)



(ii)



(iii)

7

Fig.1 for Question No. 5(a)

L-3/T-2/MME **Date: 18/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **MME 365** (Ceramic and Glass Engineering)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Discuss the impact of various types of bonding on the properties of ceramic materials. **(10)**

   (b) 'The MO/SiO_2 ratio directly influences the structure of silicates' – do you agree with the statement? Justify you answer. **(15)**

   (c) With neat sketch, compare and contrast the crystal structures of Al_2O_3 and SiC. **(10)**

2. (a) Amount of void in a ceramic body depends on size ratio and relative amount of fine and coarse particles' – Justify the assertion with necessary diagram. **(12)**

   (b) Based on the functional requirements, classify and mention the purpose of the basic raw materials needed for synthesis of ceramic materials. **(13)**

   (c) Explain how particle size and particle surface impart strong influence on the quality of slip castings. **(10)**

3. (a) Explain why the rate of drying falls sharply after constant rate period. **(12)**

   (b) What derives solid state sintering? Explain the effects of various factors on the sintering rate of a solid state sintering. **(5+10=15)**

   (c) 'Reactive liquid phase sintering is referred to as transient liquid sintering' – explain the assertion. **(08)**

4. (a) Demonstrate different stages of deformation observed during particle compacting for synthesis of ceramic materials. **(15)**

   (b) Suppose you have to select a shaping method, either isostatic pressing or extrusion, for mass production of heat exchanger tubes. Which process do you think will be preferable for the task? Justify your answer with proper reasoning. **(20)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) Briefly discuss the various mechanism for permanent stress development in glass during processing. **(12)**

Contd P/2

MME 365

Contd... Q. No. 5

(b) Suggest the possible schedules for commercial annealing of soda-lime-silica glass sheet of 0.6 cm thickness coming out from rolling process. Also calculate the total time for the completion of the annealing process. The glassware is cooled from one side only. Given thermal expansion coefficient is $90 \times 10^{-7}/°C$, annealing point and strain point are at 550 °C and 500 °C respectively. **(17)**

(c) Identify the significance of critical cooling rate in glass formation. **(6)**

6. (a) Analyze the different processing steps in a glass-melter to generate a perfectly uniform glass melt. **(22)**

(b) Explain the role of CaO and Al_2O_3 in designing soda lime silicate glass. **(13)**

7. (a) What are the challenges in making fully tempered glass with thermal tempering and explain how it is overcome in chemical strengthening technique. **(15)**

(b) Schematically discuss the crack propagation behavior in ceramic materials during tension and compression loading. **(12)**

(c) Illustrate the mechanism by which spiny structure of $(CaO)_3(SiO_2)_2(H_2O)_3$ grows during the hardening reaction of Portland cement. **(8)**

8. (a) Discuss how different process parameters control the quality of diffusion bonded component comprised of a metal plate and a ceramic one. **(20)**

(b) During selection of glazing materials for joining ceramic with metallic part, discuss the physical factors you need to consider. **(15)**

L-3/T-2/MME **Date: 02/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **HUM 305** (Economics of Development and Planning)

Full Marks: 140 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** from the rest.

1. (a) Why is a strict economic definition of development inadequate? What do you understand by economic development? Can you give hypothetical or real examples of situations in which a counter may be development economically but may still be underdeveloped? **(15)**

   (b) How does the concept of "capabilities to function" help us gain insight into development goals and achievements? **(8.33)**

2. (a) Explain how New Human Development Index (NHDI) is calculated. **(15)**

   (b) Do you think that there is a strong relationship between health, labor productivity, and income levels? Explain. **(8.33)**

3. (a) Explain different stages of project evaluation. **(15)**

   (b) Define Net Present Value (NPV), Benefits to Cost Ratio (BCR) and Internal Rate of Return (IRR). How do you interpret the following values of NPV, BCR and IRR of a Development project? **(8.33)**

   NPV (Lakh taka): 975,881.20

   BCR : 1.647

   IRR : 36.67%

4. (a) Given the diversity of developing countries, do you think that there could ever be a single, unified theory of development? Explain. **(15)**

   (b) In what ways do developing countries depend on rich countries? In what ways is the opposite true? **(8.33)**

Contd P/2

HUM 305

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) What is the relationship between a Lorenz curve and a Gini coefficient? **(10)**

(b) Give two examples of how Lorenz curves and Gini coefficients can be used as summary measures of equality and inequality in a nation's distribution of income. **(13.33)**

6. (a) What is meant by tied aid? **(5.33)**

(b) Most nations have increasingly shifted from grants to loans and from untied to tied loans and grants. What are the major disadvantages of tied aid, especially when this aid comes in the form of interest–bearing loans? **(18)**

7. (a) Explain the prospects of industrialization in Bangladesh. **(13)**

(b) What are the challenges of industrialization in Bangladesh? **(10.33)**

8. (a) Do you think that Bangladesh can reach Sustainable Development Goals (SDGs) by 2030? Explain. **(10)**

(b) Do you think that construction of the "Metro Rail" and "Padma Bridge" will help Bangladesh achieve Sustainable Development Goals (SDGs)? If yes, which goals and how? Explain. **(13.33)**
