



**FACULTY OF ENGINEERING AND THE ENVIRONMENT
DEPARTMENT OF METALLURGICAL ENGINEERING
PRODUCTION METALLURGY**

EMG 5204

Final Examination Paper

APRIL 2025

Time Allowed: 3 hours

Total Marks: 100

Examiner: C MAZEMO

INSTRUCTIONS

1. Answer ALL questions in **Section A** and any TWO from **Section B**
2. Each question carries **20 marks**.
3. Where a question contains subdivisions, the mark value of each subdivision is shown in brackets.
4. Illustrate your answer, where appropriate, with clearly labeled diagrams.
5. Started each question on a new page.
6. This paper comprises of 4 printed pages

Additional requirements:

Calculator

SECTION A

ANSWER ALL QUESTION IN THIS SECTION

Question A1

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. (7 Marks)



- a.
- b. Figure 1: HAZ region in weldment

- b) List **TWO (2)** common problems associated with HAZ. (3 Marks)
- c) Discuss the effects of peak temperature to grain size in HAZ. (6 Marks)
- d) List **TWO (2)** factors directly influence the welding heat flow. (4 Marks)

Question A2

- a) Three metal pieces being cast by the students at University X have the same volume, but different shapes. One is a sphere, one a cube, and the other a cylinder with its height equal to its diameter. Which piece will solidify the fastest, and which one the slowest? Briefly explain why. Assume that $n = 2$ and the volume is a unity. [8 Marks]
- b) Pure aluminium is poured into a sand mold. The metal level in the pouring basin is 200mm above the metal level in the mold, and the runner is circular with a 7.5mm diameter.
- Calculate the velocity and rate of the flow of the metal into the mold.
 - Is the flow turbulent or laminar? [4 Marks]

- c) A cylinder with a diameter of 40mm and height of 80mm solidifies in 3mins in a sand-casting operation.
- Find the solidification time if the cylinder height is doubled.
 - Calculate the time if the diameter is doubled. **[4 Marks]**
- d) Explain the significance of Reynolds number during metal casting. **[4 Marks]**

Question A3

Describe the various concepts and methods of compaction and sintering in powder metallurgy. Discuss the different techniques employed in each process and how they impact the final properties of the manufactured components. **[20 marks]**

SECTION B

ANSWER ANY TWO QUESTION

Question 4

- a) Explain the advantages and limitations of permanent mold casting process. **[6 Marks]**

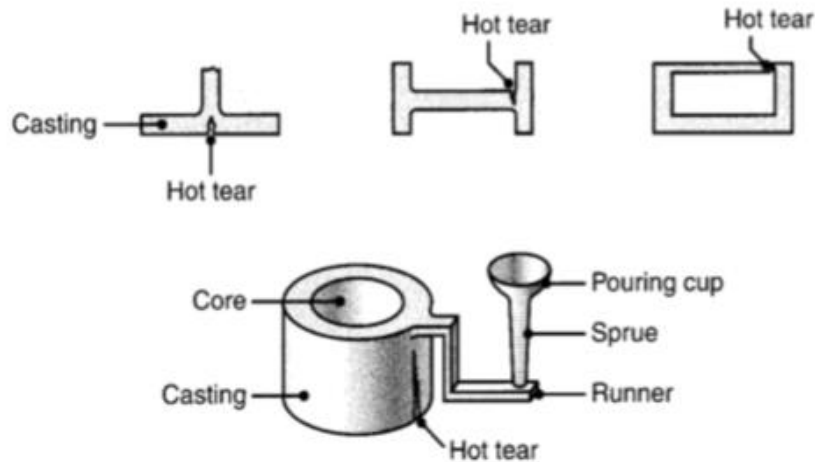


Figure 1 : Casting defects

- b) Describe how the defects in Figure 1.1 were formed. **[4 Marks]**
- c) Explain why a casting may have to be subjected to various heat treatments. **[4 Marks]**
- d) One method of relieving stress concentrations in a part is to apply a small, uniform plastic deformation to it. Briefly explain your concerns and recommendations if such an approach is suggested for a casting. **[6 marks]**

Question 5

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. **(2 Marks)**
- d) Solidification cracking occurs during the terminal stages of solidification. Explain the mechanism of solidification cracking. **(8 Marks)**

Question 6

- a) Compare and contrast the different methods of powder production by atomization. **[10 marks]**
- b) What are the key reasons for blending in powder metallurgy, and how do certain factors influence the properties and the performance of the final product? **[5 marks]**
- c) What are some metals that are challenging to fabricate using conventional methods, and how does powder metallurgy enable the shaping of these materials? **[5 marks]**