ENGINEERING TRIPOS PART IIA
MANUFACTURING ENGINEERING TRIPOS PART I

Tuesday 1 May 2007 9 to 10.30

ENGINEERING TRIPOS PART IIA: Module 3C1
MANUFACTURING ENGINEERING TRIPOS PART I: Paper P4A

MATERIALS PROCESSING AND DESIGN

Answer not more than ***three*** *questions.*

All questions carry the same number of marks.

The ***approximate*** *percentage of marks allocated to each part of a question is indicated in the right margin.*

There are no attachments.

STATIONERY REQUIREMENTS
Engineering Tripos:
Single-sided script paper

Manufacturing Engineering Tripos:
20 page booklet, rough work pad

SPECIAL REQUIREMENTS
Engineering Data Book
CUED approved calculator allowed

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

Version 2

1 A part is to be sand-cast using aluminium-12% silicon alloy. The required shape is shown in Figure 1. The thickness at B is 10mm; the width of the part is 50mm. The initial design suggests that metal will be poured in through feeders situated at both ends.

(a) Outline how the mould will be made, explaining the significance of the features you describe. [15%]

(b) Indicate where macroscopic casting defects may be expected to occur in the part. In each case, describe why the defect has formed. Suggest changes to the feeding geometry (number of feeders, position) which might improve the quality of the casting, explaining your reasoning. [45%]

(c) Describe the origin of the defects you would expect to find on a microscopic scale within the casting. [10%]

(d) What differences in the nature and distribution of macroscopic and microscopic defects would you expect to find if the casting were made from aluminium-20% silicon? [10%]

(e) Regions of the aluminium-12% silicon casting which are free from macroscopic defects are removed for tensile testing. The failure strengths of samples taken from the centres of regions A and B are found to be different. Why should this be so? Explain two methods by which the strength of the material in both regions could be improved. [20%]

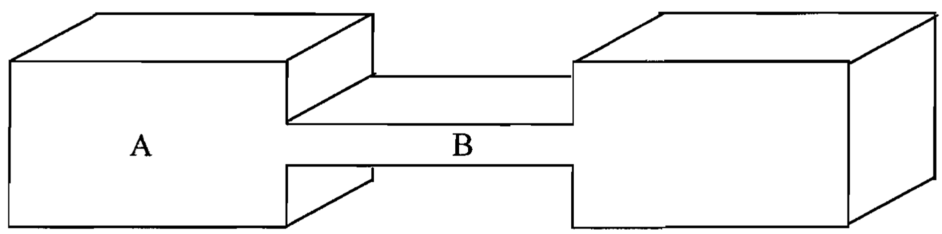

Figure 1.

2 (a) A large telescope mirror (1 m diameter and 50 mm thick, with stiffening ribs on the back surface) for use in a satellite is made from silicon carbide by the following process steps. Ceramic powder is mixed with a small amount of polymer binder and uniaxially pressed in a die. The component is then encapsulated in a polymer film and cold isostatically pressed. The polymer film is removed, the component is green machined to form the optical surface and the stiffening ribs, and then sintered at atmospheric pressure. Chemical vapour deposition (CVD) is then used to form a thin (0.5 mm) layer of silicon carbide on the mirror surface, which is finally polished.

(i) Describe the processes of *uniaxial pressing*, *cold isostatic pressing*, *green machining* and *chemical vapour deposition.* Indicate the changes which result from each process, explaining why each step is necessary and why this sequence is appropriate. [30%]

(ii) What advantages or disadvantages might ceramic powder injection moulding offer as one of the process steps? [10%]

(b) Suggest one process which would be appropriate for each of the following applications. In each case briefly describe the process and indicate why it would be suitable.

(i) Joining a tubular steel drive shaft to a solid cylindrical steel hub for an automotive application;

(ii) Joining the seam down the cylindrical wall of a tin-coated steel can for containing food;

(iii) Cladding both sides of a sheet of aluminium-copper alloy with pure aluminium, for use in an aircraft wing;

(iv) Joining two thin sheets of steel in car body manufacture. [60%]

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3 (a) (i) Summarise a simple classification of component shape for the purposes of selecting a shaping process. Explain why shape is a discriminating attribute to use in selection. [15%]

(ii) For selection of a joining process, the joint geometry is an important characteristic that may be used to eliminate unsuitable processes. Sketch the three main joint geometries, and comment on considerations that may influence the choice of process for a given geometry. Summarise three secondary requirements to consider in selecting a joining process. [25%]

(iii) Discuss the competition between casting, forging and powder processing for manufacture of metallic components, with reference to the main attributes used for selection of shaping processes. Identify where any one of these process classes appears to offer a particular advantage. [20%]

(b) The manufacture of articles from polymer-matrix composite materials reinforced with continuous fibres presents particular problems when section changes or joints are required. Explain why this is so, and what can be done to reduce the problem. Discuss to what extent the same problems will be encountered when manufacturing with short-fibre composites. [40%]

4 For each of the situations below, describe the likely origin of the problem and suggest possible changes in alloy, process operation or component design to improve the outcome.

(a) Very early fatigue failure of a forged component from a point where the section changes abruptly; [20%]

(b) Excessive earing in the cupping stage of can-making leading to frequent machine jamming during subsequent deep drawing; [20%]

(c) Poor surface finish in extrusion of a complex aluminium profile; [20%]

(d) Peak hardness 25% below the target value following age hardening of an extruded heat-treatable aluminium alloy; [20%]

(e) Very low ductility accompanied by grain boundary fracture during forging of a steel component made from recycled feedstock. [20%]

END OF PAPER