MANUFACTURING ENGINEERING TRIPOS PART IIB

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Wednesday 24 April 2013 9 to 12

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PAPER 1

*Answer not more than **four** questions.*

*Answer **each** question in a separate booklet.*

*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 | SPECIAL REQUIREMENTS |
|---|---|
| 8 page answer booklet x 4 | Engineering Data Book |
| Rough work pad | 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

Final Version

1 (a) Both *closed-die hot forging* and *powder metallurgy* (PM) processing involving uniaxial pressing can be used to make near-net shape metallic discs.

(i) Describe both these processes in detail.

(ii) Explain, giving as many reasons as you can, why one would be chosen over the other for the production of:

- a rotating disc for a gas turbine engine;

- a disc-shaped component for attaching the rear-view mirror to a car windscreen.

(iii) For each of the applications listed in (ii), indicate what material would be used, and any processing steps which would precede or follow the forging or PM processing. [70%]

(b) A disc-shaped component is to be made from a thermoplastic polymer by injection moulding. In initial tests the part was found to deviate significantly from its intended shape. Suggest possible causes for this deviation, methods by which these causes might be investigated, and possible changes to the process which might allow the correct final shape to be achieved. [30%]

2 (a) Discuss the properties of three polymeric materials that are commonly used for storing liquid food products, giving examples in each case. [30%]

(b) Fig 1 shows a schematic of a polymeric drinks bottle to be manufactured in volumes of around one million per year. It will contain a carbonated drinks product. The manufacturer has decided to use PET (Polyethylene terephthalate) for the bottle. Giving reasons, discuss whether this is a suitable choice of material. [15%]

(c) Detail the manufacturing process that you would use to produce the PET bottle. [40%]

(d) Discuss the requirements for the mould tool used in the manufacturing process in part (c), in terms of material and surface finish. [15%]

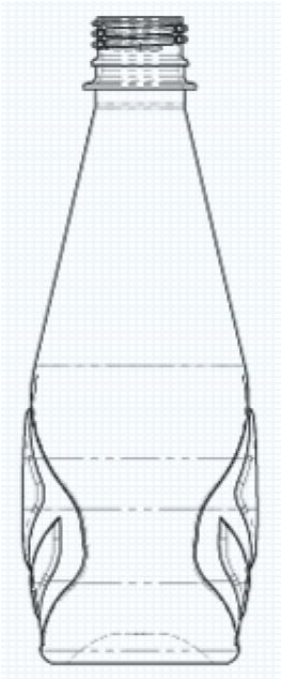

Fig 1 Schematic of a polymeric drinks bottle

3 Polymer-based food packaging is favoured by producers and manufacturers, but its environmental credentials are compromised by the prominence of discarded packaging, both as part of the managed waste stream and as litter.

(a) What are the functions of primary food packaging? What are the particular environmental benefits associated with the use of polymers in food packaging? [30%]

(b) What are the end-of-life options for disposal of polymer food packaging, and what are the environmental consequences of each? Why is recycling feasible for some packaging (e.g. bottles) but not currently economically viable for most primary packaging films? [40%]

(c) Biopolymers are often promoted as an environmentally beneficial solution to primary food packaging. Polylactic acid (PLA) is a biopolymer produced from maize and can biodegrade. Discuss the extent to which use of a biopolymer such as PLA could contribute to the overall environmental impact of food packaging. [30%]

4 Plant maintenance is a key activity in the operation of any process plant. *Response maintenance* describes a particular strategy for plant maintenance in the oil industry.

(a) Describe what is meant by *programmed maintenance* and *response maintenance* and describe how a decision is made as to whether or not programmed maintenance is justified. [30%]

(b) Contrast *standard* and *imperative response maintenance* procedures and describe how a decision is made as to whether or not a maintenance task requires an imperative response. [40%]

(c) The activities, activity predecessors, and estimated durations of a maintenance task for a particular piece of equipment are given in Table 1.

(i) Determine the task duration. Explain your approach.
(ii) Describe the approach you could use to reduce the task duration. [30%]

| Activity | Description | Activity Predecessor | Activity Duration (days) |
|---|---|---|---|
| A | Identify fault and scope activity | - | 0.5 |
| B | Resource spare part | A | 3 |
| C | Check the spare part | B | 0.5 |
| D | Disassemble the equipment | A | 2 |
| E | Record equipment condition data in log | D | 0.25 |
| F | Replace faulty part and reassemble the equipment | C, D | 2 |
| G | Perform final checks and record activity in log | F | 0.5 |

Table 1

5 An automated system for the assembly of electrical light switches is shown in fig 2. The assembly processes are carried out at four independent stations positioned around a high speed, rotary carousel. Each station performs a specific task:

Station 1) Loading plastic face plates to carousel and unloading finished electrical light switch from the carousel.
Station 2) Assembling electrical switch on face plate.
Station 3) Inserting and fastening three screws to the electrical terminals of the switch.
Station 4) Inspecting and testing the finished electrical light switch.

The control systems implemented at each workstation are independent but are co-ordinated by a high level control system used to trigger the motion of the rotary carousel.

(a) Station 3 is equipped with a SCARA Robot, fitted with a Screw Driver end-effector. There is a separate Screw Feeder. Fig. 3 shows the functionality of the Screw Driver end-effector and details of screw pick-up attachment.

Identify the appropriate sensors that should be installed on:

(i) the carousel;

(ii) the robot end-effector; and

(iii) the screw feeder.

Describe the role of each sensor in achieving robust operations. [60%]

(b) Describe two types of tests that are carried out on a newly developed production system and illustrate how each could be used on Station 3. What additional tests would you suggest to ensure effective integration with the rest of the production system. [40%]

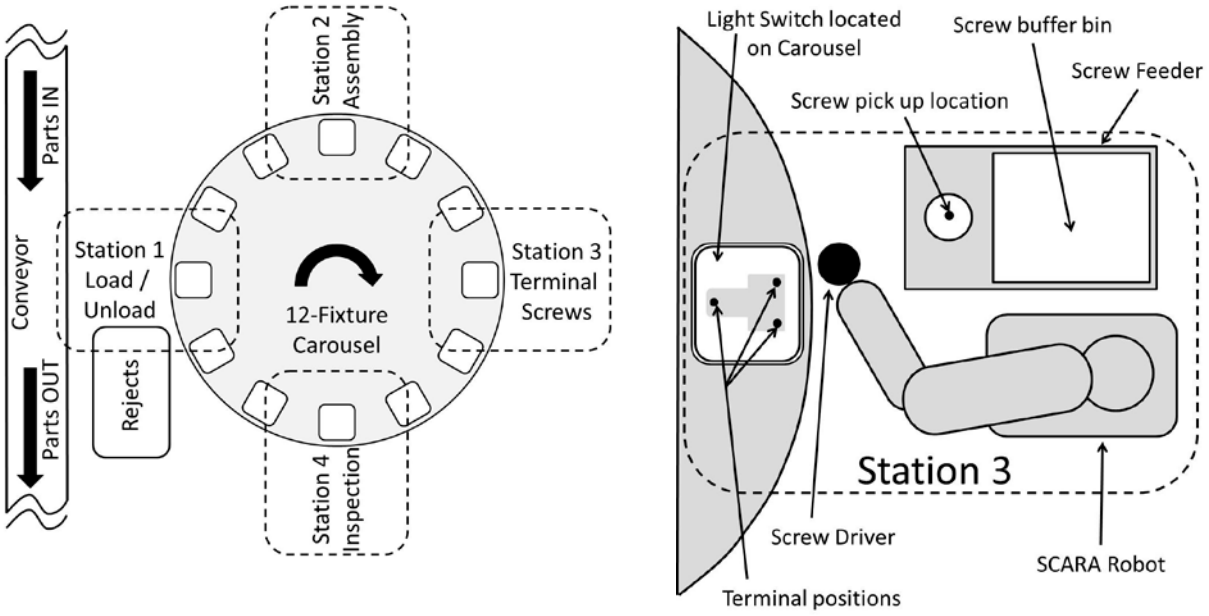


Fig.2 Plan view of production system and close-up of equipment in Station 3.

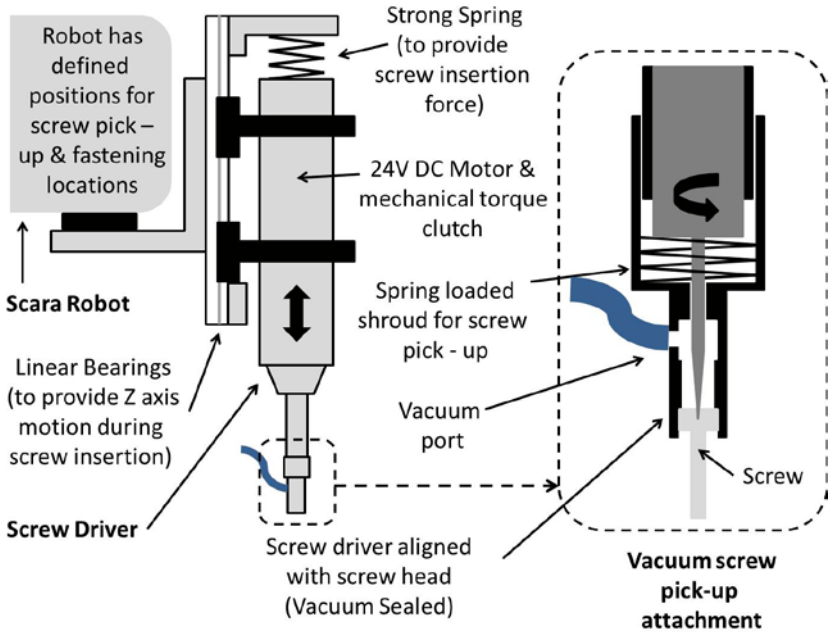


Fig 3 Screw driver end-effector & Cross section view of screw pick-up attachment

6 (a) In the context of an industrial automation project, discuss the purpose of the *functional specification*. [20%]

(b) Identify the main areas that should be covered in the *functional specification*. Discuss what is meant by each area. [30%]

(c) The following extract is from a *functional specification* for a simple robotic assembly operation to attach a cover plate to a housing:

> "The incoming parts will be supplied in a form to be specified by the system vendor. The system will assemble the cover to the main housing from the parts supplied. Perfect alignment should be achieved by a vision system, and the parts bolted together using bolts fed from a bowl feeder. The system will operate efficiently over three shifts with minimal manning. The reject rate will be less than 1%."

Identify the strengths and weaknesses of this specification, and write an improved specification. [50%]

**END OF PAPER**