MANUFACTURING ENGINEERING TRIPOS PART II

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Wednesday 23 April 2003 9 to 12

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Paper 1

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

*All questions carry the same number of marks.*

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

**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**

1 (a) Describe the important features of the Cosworth casting process which distinguish it from conventional sand casting. For what applications is it particularly suited?

For each of the following, explain how the Cosworth process permits improvement, and explain why these improvements are desirable.

(i) Dimensional accuracy of casting.

(ii) Reduction in oxide defects.

(iii) Reduction in porosity.

(iv) Reduction in internal stresses. [10]

(b) You have been asked to advise a company on a plan for the establishment of a casting plant using a novel process which will compete directly with the Cosworth process.

(i) What would be the key operational issues you would need to consider in assessing this plan?

(ii) If the plan were approved, what factors would you use to determine the location of the plant, and how would they influence the selection? [15]

2. (a) Joining processes apply to a wide range of materials and uses. Consider the following applications.

– Joining lead foil onto stainless steel plate.
– Joining aluminium alloy ribs to thin aluminium alloy sheet.
– Joining two sections of polyethylene pipeline.

(cont.

For each application:

(i) Briefly describe the joining method you would advise;

(ii) Explain the reasons for your choice;

(iii) Discuss what problems might be encountered in achieving acceptable quality joints in practice;

(iv) Indicate one possible use of this application. [15]

(b) Surface coatings are used on a range of materials. Consider the case of a steel framed, airport baggage trolley that is expected to be used in both indoor and outdoor conditions under a range of loads.

(i) Explain why a surface coating is required, the nature of the coating and how it might be applied.

(ii) What are the problems associated with ensuring coating integrity?

(iii) Suggest, with reasons, another application which uses the same type of coating. [10]

3 (a) As a manufacturer of laptop computers, your products have recently been performing poorly in the marketplace due to increasing competitive activity and pressure on price. Describe how value analysis could be used to improve your product's performance. [5]

(b) Figure 1 shows an exploded view of the main sub-assemblies of a typical laptop computer. The total production cost is £320 and the cost of each of the sub-assemblies is summarised below:

- Assembly 1: Main board – cost £100
- Assembly 2: Chassis – cost £20
- Assembly 3: Disc drive – cost £30
- Assembly 4: Battery – cost £50
- Assembly 5: Hard drive – cost £20
- Assembly 6: Upper casing – cost £20
- Assembly 7: Standard keyboard – cost £10
- Assembly 8: Low resolution screen – cost £40
- Final integration: £30

Carry out a value analysis for the laptop, aiming for no more than 8 functions. Explain your decisions, commenting on practical difficulties in carrying out this analysis. [10]

(c) Choose the 5 key functions and using the emphasis curve method, assign scores on a scale of 1 to 10 to indicate their relative importance. [5]

(d) Comment on opportunities for improving the value of the laptop computer for Customers.

[5]

(cont.

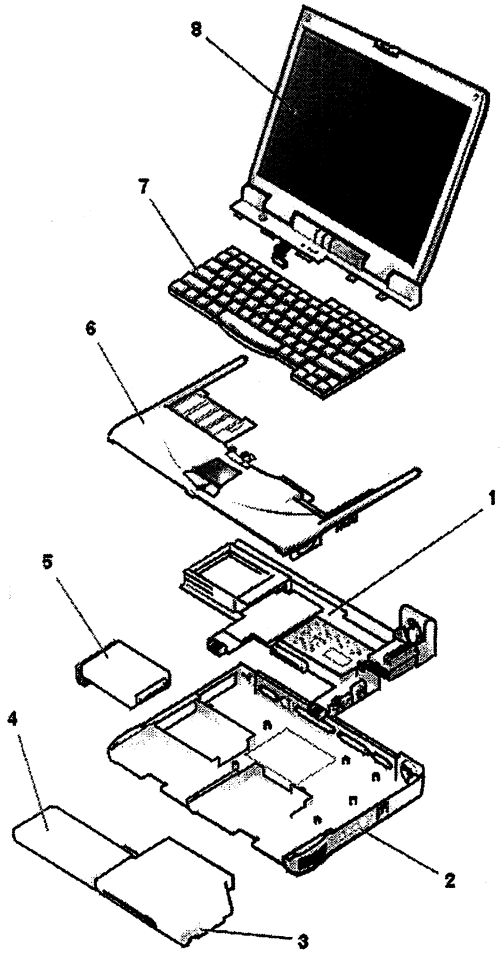


Fig. 1

4 (a) In the context of the electronics industry, explain what is meant by Moore's Law. [5]

(b) (i) Describe the impact that this law has had on the electronics industry over the last 20 years.

(ii) Comment particularly on the impact of Moore's Law on the evolution of

- electronic components
- electronic products
- assembly processes [15]

(c) Discuss the possible limits to the extrapolation of the effects of the law, and the consequences for electronic products. [5]

5 Response maintenance and total productive maintenance represent two quite different approaches to ensuring minimum downtime on production machinery.

(a) Define what is meant by the two approaches, describing key activities associated with each. [8]

(b) Make an assessment of the positive and negative aspects of each approach using examples where appropriate to illustrate your assessment. [7]

(c) You are responsible for the development of an asset management strategy for a margarine production plant which consists of a number of oil and fat refining operations, a blending stage, a (tub) filling/packing stage and a palletising operation.

For the refining stage and the (tub) filling/packing stage only:

(cont.

(i) State the type of equipment and processes you would be expecting to maintain in this stage and identify characteristics that might be important for the maintenance of this operation.

(ii) Specify an appropriate maintenance approach for the stage and justify this selection. [10]

6 (a) Describe the five "levels" of a process automation hierarchy ensuring that you outline:

(i) the function of each level and its interconnection to other levels;

(ii) the timeframes associated with decisions and actions at each level (seconds, minutes, hours, shifts etc);

(iii) the typical information flowing between the different levels. [8]

(b) What is the role of standards in factory automation? [5]

(c) Provide examples of three standards relevant to the automation of operations of a fast moving consumer goods (FMCG) plant, and for each case:

(i) describe the standard and the reason for its development:

(ii) provide an example of the way it is used in an FMCG plant;

(iii) indicate the different level of the automation hierarchy to which it is relevant. [12]

7 (a) Pneumatic circuits provide a means of deploying control sequencing logic in many industrial applications.

(i) Why are pneumatic systems used to provide the control logic in some industrial operations?

(ii) Using a sketch or otherwise, outline the function and use of the following elements in a pneumatic circuit:

- AND;
- a latch;
- speed regulator [8]

b) You are required to automate a drilling operation illustrated in Figure 2.

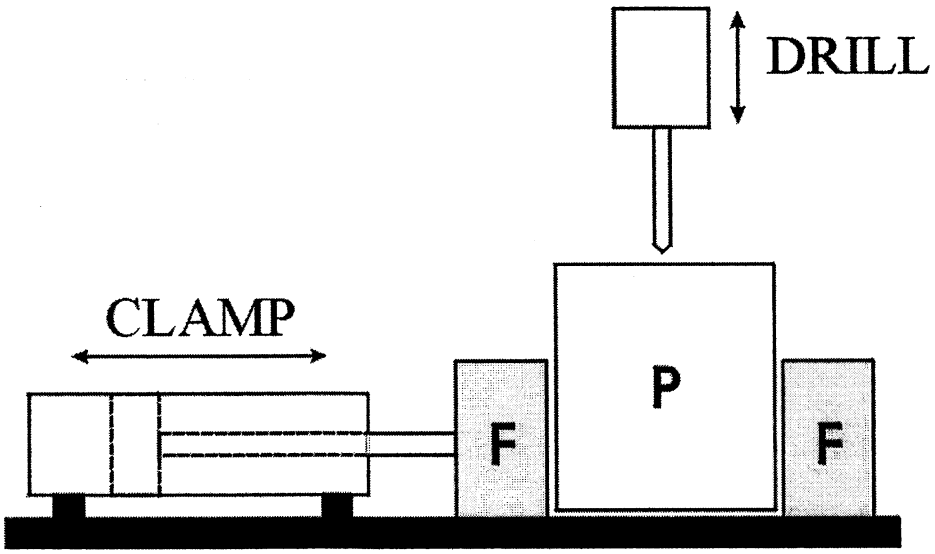


Fig. 2

The required operation sequence is as follows:

- Part P is manually placed in the clamping fixture F.
- P is clamped by pressing a manual push button. (The clamp must only operate if P is present.)

(cont.

- When P is clamped, the drill descends and drills a hole.
- When the drill reaches a pre-set depth, the drill retracts.
- When the drill is fully retracted, the fixture is unclamped by pressing a manual push button.
- The part is manually removed.

Note: The downward travel of the drill must be adjustable, reaction should be rapid. You can assume that both clamp and unclamp buttons cannot be pressed simultaneously.

(i) Design a solution using pneumatics. Your solution should include a pneumatic circuit diagram and the rationale for the design.

(ii) Provide an operating description of the circuit. [17]

8 The diagram in Figure 3 is a schematic for the manufacture and assembly of a product. Two components, A and B, are assembled to make the final product. Component A requires two operations, A1 and A2. Operation A1 is carried out on resource $\alpha$ and Operation A2 is carried out on resource $\beta$. Component B also requires two operations, denoted B1 and B2. Operation B1 is carried out on resource $\alpha$ and Operation B2 is carried out on resource $\gamma$. One item of Component A is assembled with one item of Component B to obtain the finished product. Final assembly employs resource $\delta$.

The set up times and make times are shown beside each of the activities in the diagram. Today is day 1 and there are no outstanding orders. There is no work in progress in the line but sufficient raw materials are available. The factory works an eight hour day, five day week and no overtime.

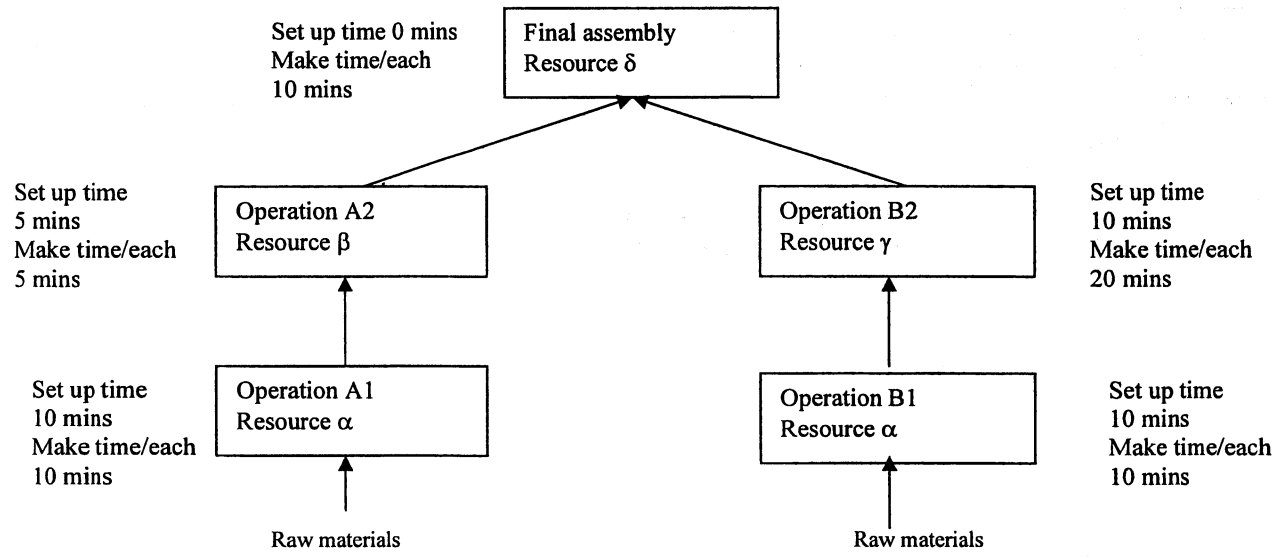


Fig. 3

(a) Which resource is the bottleneck? Explain why. [5]

(b) A customer wants a promise on an order for 100 items, delivered in batches of 10.

(cont.

(i) Assuming that the customer can have the product immediately manufacturing has been completed, i.e. ignoring transport delays, when can he take the first delivery?

(ii) When will the entire order be complete?

(iii) What is the transfer batch from operation B1 to operation B2? [12]

(c) The customer now wants to know if the delivery promise can be improved by taking the entire order as a single delivery.

(i) Can this be achieved for the complete order and/or are there ways in which it makes matters worse?

(ii) If there is an improvement, how big is it?

(iii) Explain the difference by reconciling the delivery time for this promise with that of the previous promise. [8]

**END OF PAPER**