MANUFACTURING ENGINEERING TRIPOS PART IIA

Monday, 29 April 2013 9 to 10.30

PAPER 2

Module 3P2: OPERATION AND CONTROL OF PRODUCTION MACHINES AND SYSTEMS

Answer not more than ***two*** *questions,* ***one*** *from each of sections* ***A*** *and* ***B.***

Answers to sections ***A*** *and* ***B*** *must appear in two separate booklets.*

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

All questions carry the same number of marks.

There are no attachments.

STATIONERY REQUIREMENTS	SPECIAL REQUIREMENTS
8 page answer booklet x 2	Engineering Data Book
Rough work paper	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

SECTION A

1 (a) Chip formation is part of the process of cutting materials by mechanical means, using tools such as saws, lathes and milling cutters. Describe the basic process of chip formation in an orthogonal cutting operation. [25%]

(b) Describe the four main categories of chips and the conditions under which they are formed. [30%]

(c) In the context of a milling tool explain what is meant by rake angle. Discuss the effects of rake angle on the cutting process, in terms of accuracy, cutting forces, tool life, surface finish and other relevant parameters. [30%]

(d) In turning a steel bar at a given set of machining conditions, the tool life decreases from 80 min to 20 min due to the increase in cutting speed, from 60 m/min to 120 m/min. At what cutting velocity will the life of that tool be 40 min? [15%]

2 (a) Orthogonal cutting requires a balance of forces in order for machining to occur. Draw a force circle diagram to show the relationship between the forces occurring in orthogonal cutting and discuss the nature of the forces involved. [20%]

(b) With appropriate diagrams, show how the use of a cutting fluid can affect the magnitude of the thrust force in orthogonal cutting. [20%]

(c) Derive expressions for the coefficient of friction on the tool chip interface, and the friction angle, in terms of the cutting force and the thrust force. [30%]

(d) In a dry cutting operation using a rake angle of -5^{o}, the cutting force, F_c, and thrust force, F_t, were F_c = 1330 N and F_t = 740 N. When a cutting fluid was used, these forces were F_c = 1200 N and F_t = 710 N. What is the change in the friction angle resulting from the use of a cutting fluid? [30%]

SECTION B

3 (a) Describe the role that the Programmable Logic Controller (PLC) typically plays in automated manufacturing. Include reference to typical decisions for which the PLC is responsible, and to the nature of its interfaces. [20%]

(b) In PLC operations explain the role of:

(i) The PLC scanning sequence;

(ii) an unlatching function;

(iii) timers and counters;

(iv) state machine diagrams. [20%]

(c) A simple product quality inspection and sorting system which separates defective and passable products is shown in Fig 1. The following sensors are used:

SENSOR	ROLE
Power On	[Momentary] Indicator that system powered on
T1	Product In Position sensor on conveyor
T2	Defect detector – Product defective
T3	Defect detector – Product passed
T4	Product detector on Product Expelled Conveyor
T5	Product detector on Product Passed Conveyor
T6-1	Indicator that Product departed from Failed Conveyor
T6-2	Indicator that Product departed from Passed Conveyor

A section of the PLC code used to run the sorting system is given in Fig 2.

(i) Describe the function of each rung in the PLC code in Fig 2 and hence deduce the meaning of each of the internal variables P1 – P5.

(ii) Using these internal variables or otherwise, draw a suitable state machine diagram describing the logic of the sorting system. [60%]

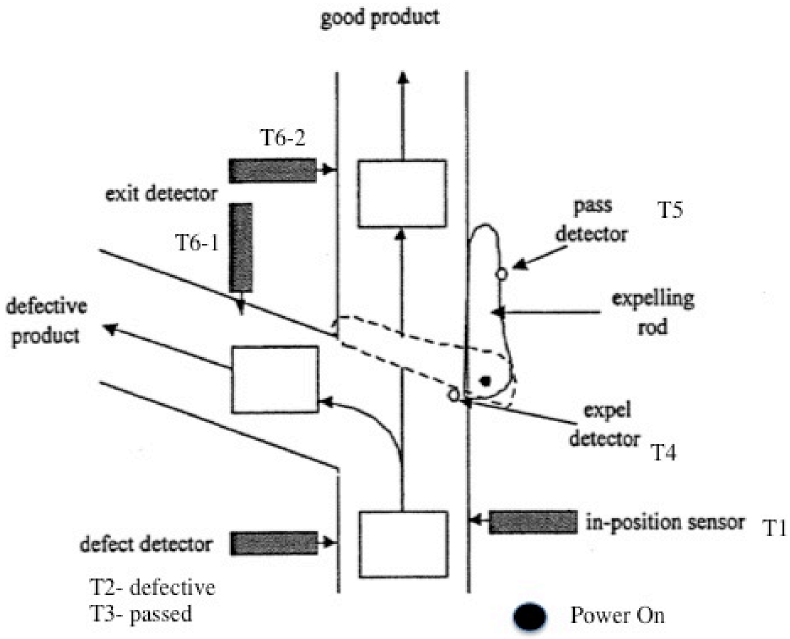

Fig 1: Product Quality Inspection System

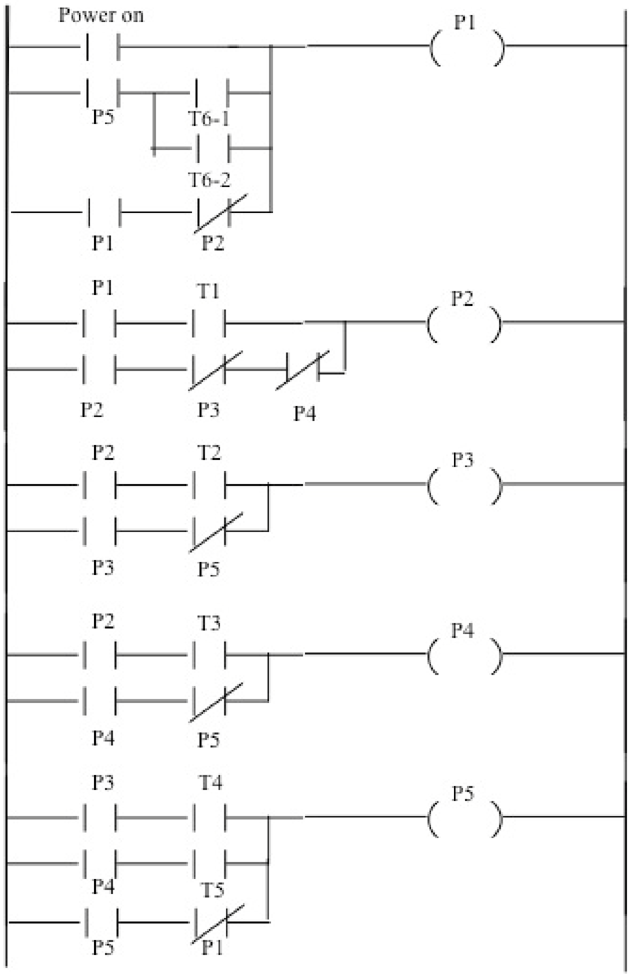

Fig 2: Extract of PLC Code for Defect Detection System

4 (a) Petri Nets are used to graphically describe logic sequences in discrete event operations. Describe, using illustrative examples where appropriate, what is meant in Petri Net design by:

(i) initial marking;

(ii) enabling and firing;

(iii) concurrency. [30%]

(b) A transport line is equipped with a pallet to move two types of parts, part 1 and part 2, from station A to station B, and from station A to station C respectively. The line is driven by an electrical motor and can move forwards or backwards between stations. Micro-switches are installed at each station (denoted sw-a, sw-b, sw-c respectively) to detect when the pallet is in position at each station. Also, a product detector is installed on the pallet to detect the type of the part on the pallet. The system is illustrated in Fig 3.

(i) A Petri Net describing the execution logic for the pallet on the transport line is given in Fig 4. From this Figure and Fig 3 provide a detailed description of the operational logic in the transport line and its interface to the physical operation. [40%]

(ii) The transport line is to be extended so that a pallet can possibly carry both one part 1 and one part 2 at the same time. Describe what additional sensing, logic and actuations would be required to manage this extension. [30%]

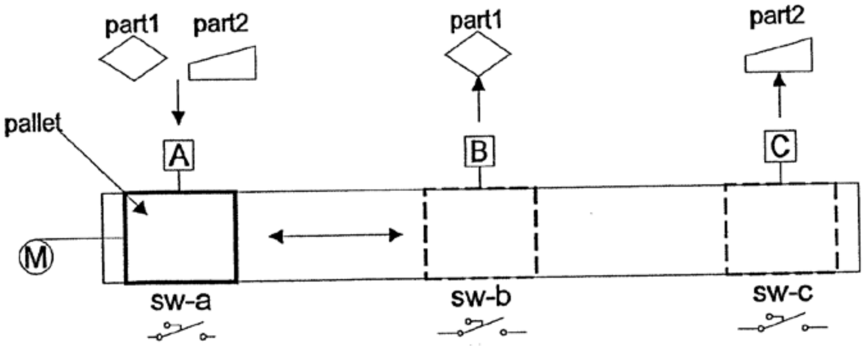

Fig 3: Pallet-based Transport Line

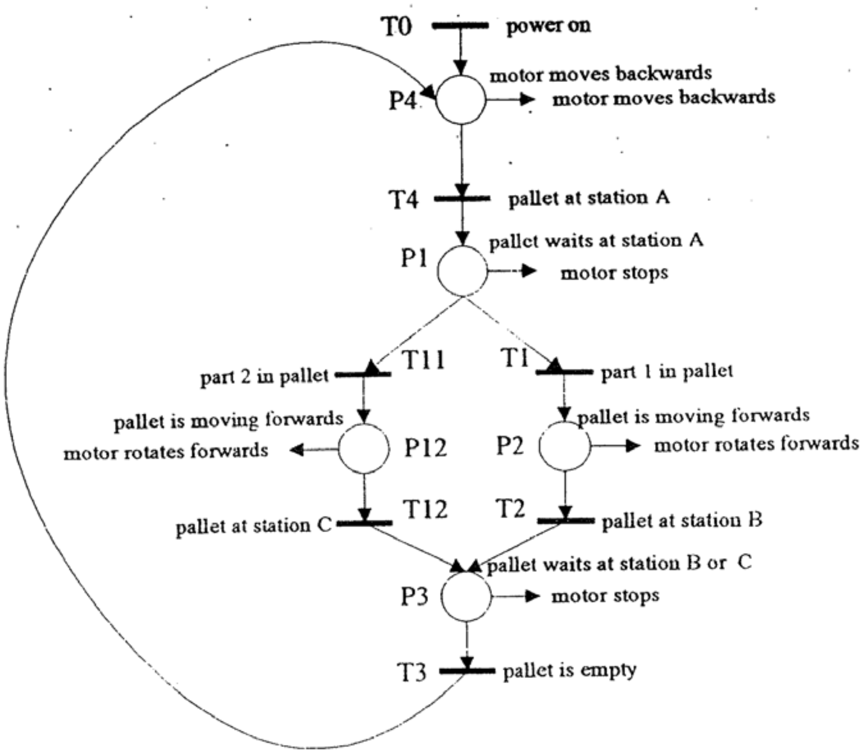

Fig 4: Petri Net for Transport Line Operation

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