MANUFACTURING ENGINEERING TRIPOS PART I

Monday 2 May 2011 9 to 10.30

PAPER 2

Module 3P2: 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.*

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
8 page answer booklet x 2
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

Final version

SECTION A

*Answer **one** question from this section.*

1 (a) Describe the mechanisms involved in chip formation during orthogonal machining operations. [40%]

(b) In machining operations, tool temperatures are low at low cutting speeds and high at high cutting speeds, but low again at even higher cutting speeds. Explain why. [15%]

(c) Describe the types of chips that can be produced during machining operations. What can chip morphology tell you about the machining process? [20%]

(d) In modern manufacturing with computer controlled machine tools, which types of metal chips are undesirable, and why? [15%]

(e) Explain why negative rake angles are generally preferred for ceramic, diamond, and cubic boron nitride tools. [10%]

2 (a) Grinding is a material removal process that involves the use of abrasive cutting tools. Describe the following aspects of the process:

(i) design and operation of a typical grinding wheel;

(ii) the mechanisms of material removal;

(iii) wear of the grinding wheel. [50%]

(b) Centreless grinding is widely used for the finishing of certain geometrical components. Describe the basic operation of centreless grinding and give examples of its application. [30%]

(c) A surface grinding operation is required to finish the profile of the cylindrical steel component between points A and B shown in Fig. 1. Describe the steps you would take to complete the operation and discuss the main process and tool parameters that will influence the final surface finish. [20%]

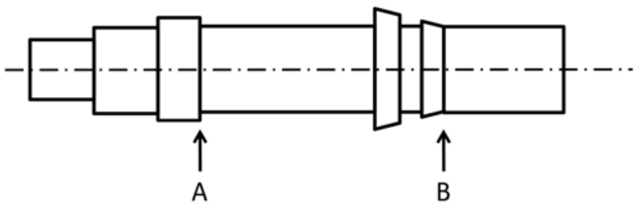

Fig. 1

SECTION B

*Answer **one** question from this section.*

3 (a) Illustrate how XOR, NAND, and NOR logics can be implemented in Ladder Logic Code. Explain each rung of the ladders you generate. [30%]

(b) Using an example, explain how a counter can be implemented in Ladder Logic Code. [20%]

(c) The conveyor belt system shown in Fig. 2 is controlled by a Programmable Logic Controller (PLC). Manufactured parts of varying height and weight move along a conveyor from left to right. The conveyor is started by pressing a momentary push button. The conveyor is divided into two zones: testing and painting. In the testing zone, parts are sensed and classified. A height detector measures the height of each part and classifies it as either tall or short. A weighing device classifies each part as light or heavy. The sensors will therefore classify each part as one of four categories: tall/light; tall/ heavy; short/light; and short/heavy. A switch (LS1) detects when a part passes out of the testing zone. In the painting zone, parts are colour-coded. Three seconds after the part passes out of the testing zone, one of four different spray nozzles is turned on and used to paint a stripe on the part as it passes under the spray stream according to the following colour-code:
Tall/Light: Red; Tall/Heavy: Green; Short/Light: Yellow; Short/Heavy: Blue.
A switch (LS2) detects when a part passes out of the painting zone, after which the conveyor automatically stops.
Generate a Ladder Logic Code for this production operation. Also provide an explanation for each rung of the ladder.

The inputs to the operation are:
- I1: Limit switch LS1 activated
- I2: Limit switch LS2 activated
- I3: Height sensor detects a tall part.
- I4: Weight sensor detects a heavy part.
- I5: Momentary contact push button to start conveyor

The outputs in the operation are:
- O1: Conveyor motor ON
- O2: Activate red paint spray nozzle
- O3: Activate green paint spray nozzle
- O4: Activate yellow paint spray nozzle
- O5: Activate blue paint spray nozzle [50%]

(Cont.

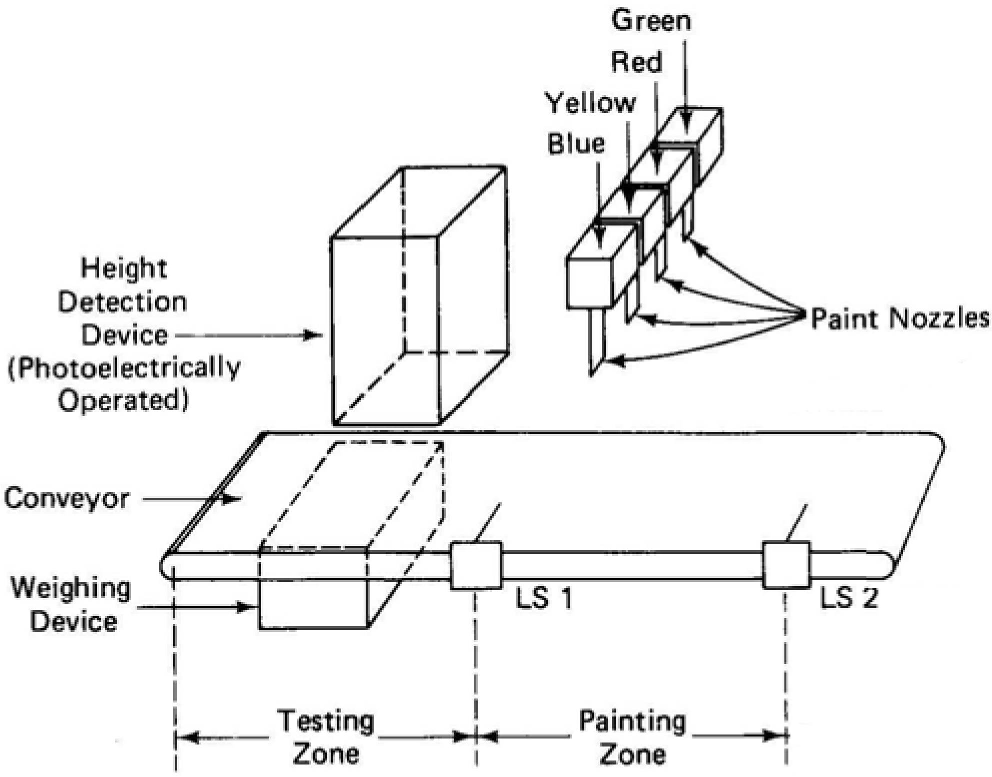
Green
Red
Yellow
Blue
Height
Detection
Device
(Photoelectrically
Operated)
Paint Nozzles
Conveyor
Weighing
Device
LS 1
LS 2
Testing
Zone
Painting
Zone

Fig. 2

4 (a) Discuss how effective maintenance of a machine tool delivers value to a manufacturing plant. [25%]

(b) What monitoring and replacement strategy would you recommend for the following types of equipment? Explain your rationale.

(i) Light bulbs on the ceiling of a production floor

(ii) A motor bearing

(iii) A cutting tool on a CNC machine

(iv) Smoke alarm batteries [25%]

(c) A machine tool experiences a constant average failure rate of 1 failure every 20 days of continuous operation. What is the probability that an operator will be able to complete an operation that takes 5 hours without the tool failing? State any assumptions you make. [20%]

(d) The driving motor used in a machine tool becomes less efficient with usage. This results in an increase in the annual operating cost $c(t)$, which is given by the following equation:

$$c(t)=a+bt$$

where t is the age of the motor in years, and a and b are constants.

If the average cost of replacing the motor is R, derive the expression for the optimal replacement interval that minimises the total cost per year. [30%]

END OF PAPER