Version WON/4

MET2
MANUFACTURING ENGINEERING TRIPOS PART IIA

Monday 25 April 2016 9 to 10.30

Paper 2

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

*Answer **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.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS
8 page answer booklet x 2
Rough work pad

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Engineering Data Book

10 minutes reading time is allowed for this paper.

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

SECTION A

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

1 (a) Describe the four main categories of chip formation produced in orthogonal cutting. In each case, list the general machining conditions that lead to their production. [20%]

(b) Describe the main classifications of tool wear and discuss their causes. [20%]

(c) Sketch typical wear/time curves for a cutting tool from the initial point of use to the point of failure. Explain how this data can be used to define the characteristic of a particular cutting tool/component material combination. [20%]

(d) A steel ring shown in Fig.1, of outside diameter 600 mm and internal diameter 200 mm, is being face machined on a vertical CNC lathe. The machine is capable of maintaining a constant cutting velocity and the feed rate is set to 0.25 mm/rev. Using Taylor's empirical tool life relationship, determine the number of components that can be machined per tool for a tool life of 50 min. From initial tests, when V = 50 m/min, tool life T = 60 min, and constant n = 0.3. [40%]

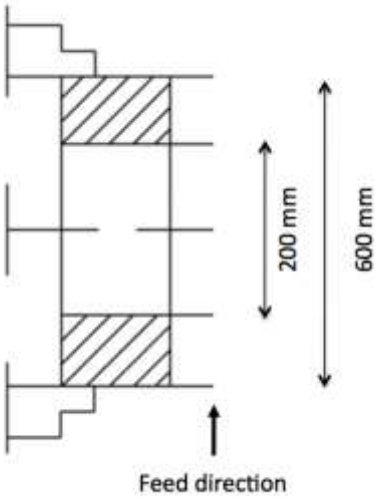

Fig. 1

2 (a) In studying the mechanics of orthogonal metal cutting, Merchant proposed a thin shear-plane cutting model. What assumptions did he base his model on? [10%]

(b) Using Merchant's circle, derive the force equations for friction force F, normal force to the rake face N, shear force on shear plane F_s and normal force to the shear plane F_n as functions of cutting force F_c and thrust Force F_t. [30%]

(c) Orthogonal cutting of steel is carried out with a rake angle of 10 degrees. The cutting speed is 200 mm/min and the chip thickness ratio is 0.31. The thrust force F_t and the cutting force F_c are measured as 1200 N and 650 N respectively. Using this data,

(i) Determine the validity of the shear-angle relationship suggested by Merchant, which is given as

$$f = \frac{p}{4} - \frac{1}{2}(b - a)$$

where ϕ is the shear angle, β is the friction angle, and α is the rake angle. [30%]

(ii) What is the proportion of shear work to the total work done? [15%]

(iii) What is the proportion of friction work to the total work done? [15%]

SECTION B

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

3 (a) Industrial robots have been developed over many years to meet the needs of industrial applications. These developments have been in many areas including robot arm configurations, motion drive systems and on-board software systems.

(i) Discuss and compare the different approaches used for programming robots. [10%]

(ii) For three robot types with different degrees of freedom, discuss the influence that the robot's degrees of freedom will have on potential applications. [20%]

(iii) Why are more flexible, 'human-like' robots becoming more popular in industrial robot developments? [20%]

(b) A consumer electronics company is looking to purchase a robot to carry out packaging at the end of a washing machine production line. The robot is required to lift a 50 kg washing machine off the assembly line and place it into an open cardboard box on the pallet line. This will require a robot to have a reach of three meters and an axis speed of one meter per second. Fig. 2 gives a chart showing the characteristics of different types of robots. Examine the information given in Fig. 2 and determine the best type of robot for this task. Describe why you have chosen this type of robot, listing both the benefits and limitations that you have considered. What other information might you request to assist you in making your decision? [50%]

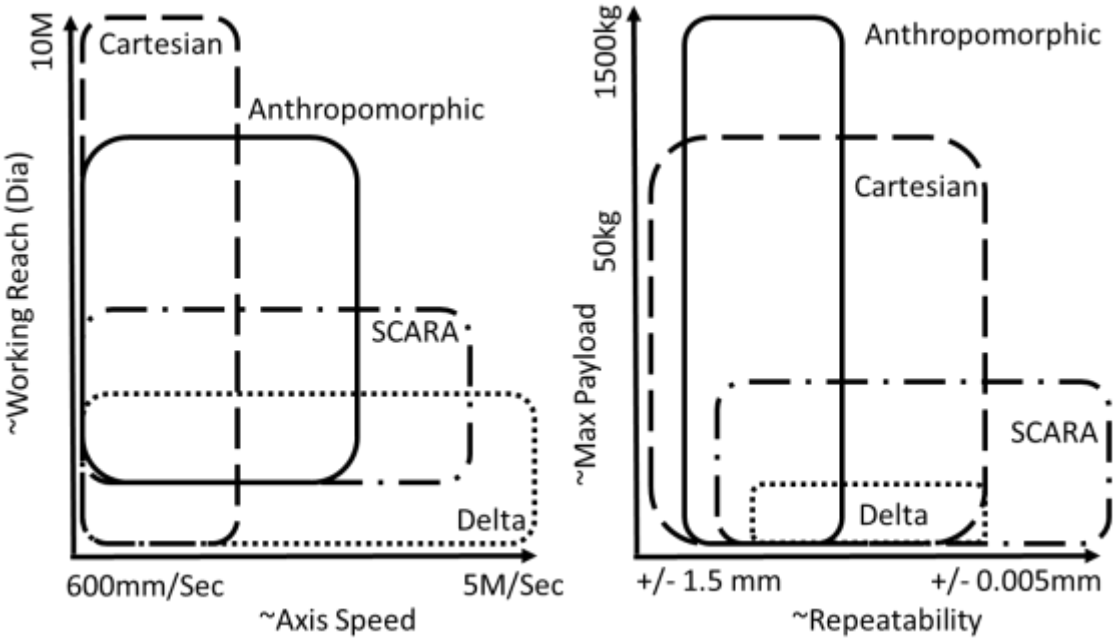
10M
Cartesian
Anthropomorphic
~Working Reach (Dia)
SCARA
Delta
600mm/Sec
5M/Sec
~Axis Speed
1500kg
Anthropomorphic
50kg
Cartesian
~Max Payload
SCARA
Delta
+/- 1.5 mm
+/- 0.005mm
~Repeatability

Fig.2

4 An aircraft manufacturing plant has a semi-automated riveting machine. The machine clamps two aluminium components A and B into position and then rivets the components together. The machine is fitted with a simple robot loader for loading the components. The loading sequence for Components A and B can be specified by an operator. The unload operation is carried out manually after the riveting operation is complete. The control system for the machine is being updated with a Programmable Logic Controller (PLC). The Petri Net for the machine control is given in Fig. 3.

(a) (i) Describe the function of the Petri Net state designated Robot Loader (S2). [20%]

(ii) Show how the Petri Net could be enhanced to ensure that Component A is loaded and clamped in place before Component B is loaded. Clearly describe the changes you are proposing. [20%]

(iii) The Robot Loader is also to be used to unload the riveted part once completed. Show how you would amend the Petri Net in Fig. 3 to allow for this. [10%]

(b) (i) Discuss the factors that need to be considered when converting a Petri Net to Ladder Logic for use in an automated manufacturing operation. [15%]

(ii) Convert the section of the Petri Net shown in Area A into Ladder Logic. [35%]

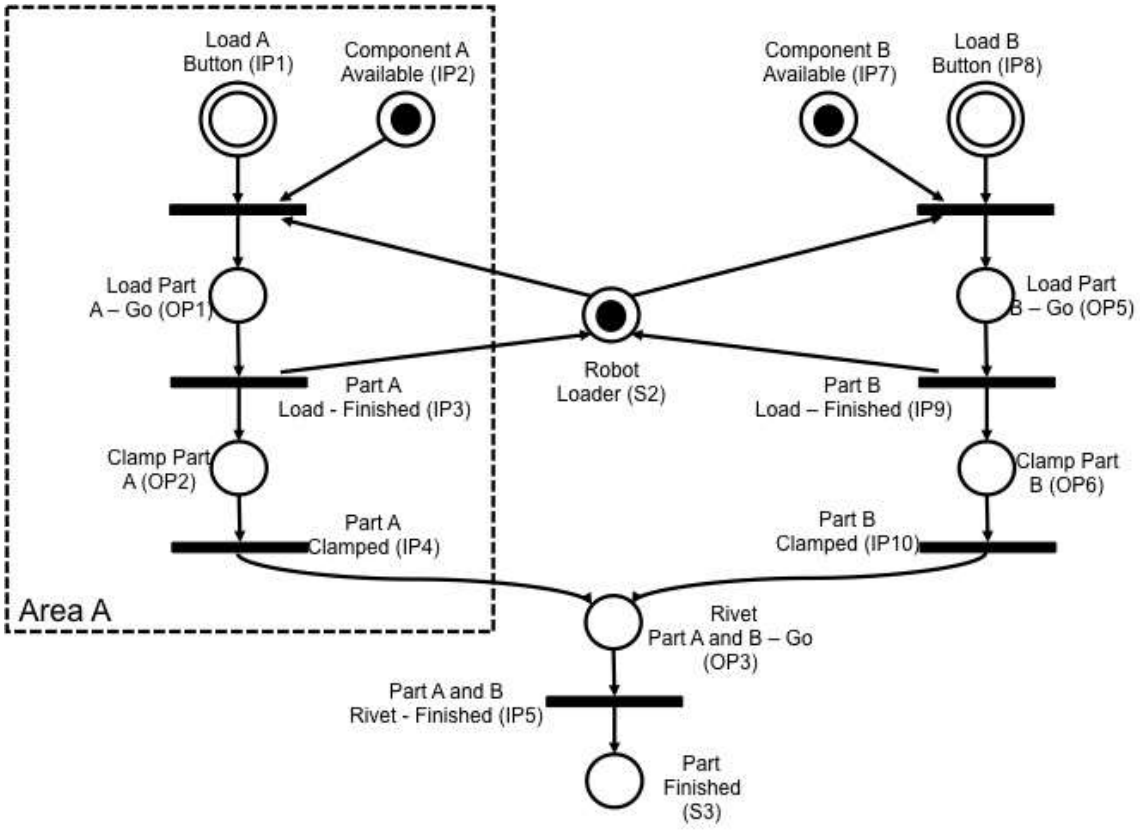

Fig. 3

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