Loughborough University

MANUFACTURING PROCESSES AND AUTOMATION

22WSP600

Semester 1 2022 In-Person Exam paper

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **2 hours**.

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

You may use a calculator for this exam. It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are **not** allowed).

Loughborough University

MANUFACTURING PROCESSES AND AUTOMATION

(22WSP600)

January 2023 2 Hours

Answer **ALL THREE** questions.

Any University-approved calculator is permitted.

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1. Consider the aluminium gasket in Figure 1. This part arrives at an assembly station in a box containing a quantity of 100 gaskets placed neatly on top of each other. The location of the box is fairly accurate with a 2 mm tolerance in each direction and is within the reach of a robot on this station. The robot picks one gasket up at a time from the box and locates it on a flat surface of an engine block with five screws projected from its surface. Screws on the component tightly match the holes on the gaskets, and the position of the engine block on the assembly table is accurate and known to the robot.

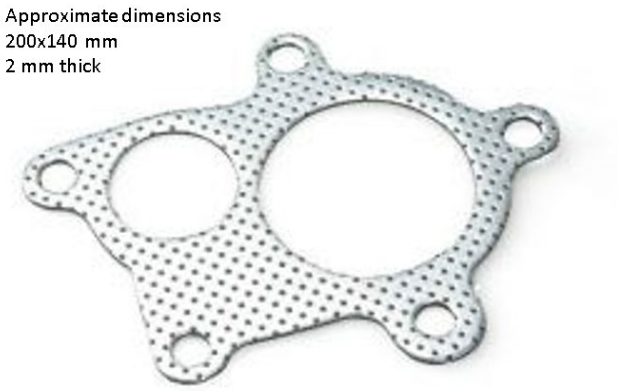

Figure 1. Gasket for assembly.

a) Suggest an automation system and the necessary technologies and equipment to pick up each gasket from the box and locate it on the engine block. You may draw diagrams if necessary. [12 marks]

b) How can your proposed system check if there are no gaskets remaining in the box? [2 marks]

c) In the context of the cost of automation for this process, discuss how one can decide whether automation is a financially viable solution for such an assembly operation. [6 marks]

2. A facility produces spiral-welded steel pipes, as shown in figure 2. The steel is 1.2 mm thick, the diameter of the pipe is 150 mm, and the length of the welded sections of pipe are 6.5 m. The pipe sections are to be welded using a fibre laser using a nitrogen shield gas. The weld is autogenous and does not require any additional filler material.

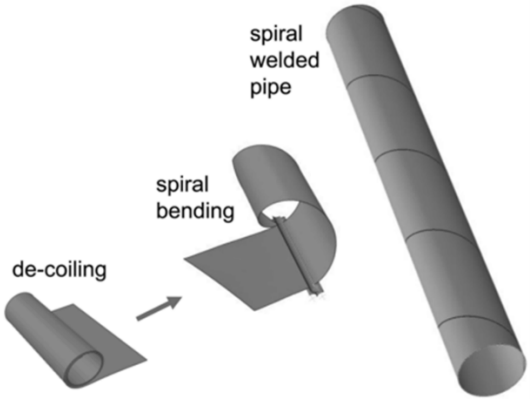

Figure 2. Formation of spiral welded pipes

a) For the given welding process, briefly describe how the system might be automated to allow the laser to move relative to the work piece. In your description, explain how this might lead to a number of defects in the final part. [5 marks]

b) Identify five origins of energy inefficiency in the described welding process, and for each inefficiency explain a method for reducing the extent of those energy losses. [5 marks]

c) Using the equation for autogenous welding:

$$\eta P = aV\rho\left(C_p \Delta T + L_f\right)$$

where a is the cross sectional area of the weld and all other nomenclature in the equation has its usual meaning, calculate the required operating power of the laser system given that each section of pipe needs to be welded in 6 minutes. Assume that for the laser system that the resulting cross section of the weld (as shown in figure 3) is 5.8 mm^2, and that length of the welded seam is 32.4 m for each part. In your calculation use a suitable value for the compound energy losses experienced in the system. You should assume that, for this process, no material is vaporised. Show your working.

[10 marks]

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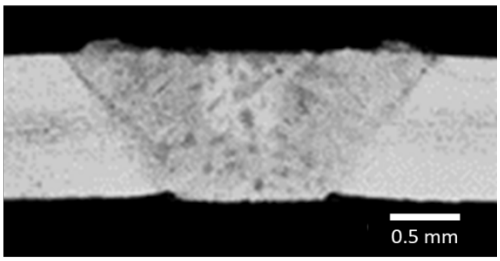

Figure 3. Cross section of weld seam.

For your calculation, you will require the following material properties for steel:

Density, 8,050 kg m^{-3}

Melting point, 1,370 °C

Specific heat capacity, 420 J kg^{-1} K^{-1}

Latent heat of fusion, 247 kJ kg^{-1}.

3. In the context of CNC machining:

a) Write an NC program to manufacture the thin slot, the holes and the pocket shown in Figure 4 using a suitable cutting tool for each feature. In your answer you should summarise the actions of each program block in writing. The machining strategy and the resultant program should require the least number of blocks possible.

You should assume that the outer geometry of the workpiece has already been produced to size.

State any further assumptions you have made when deriving your program. [12 marks]

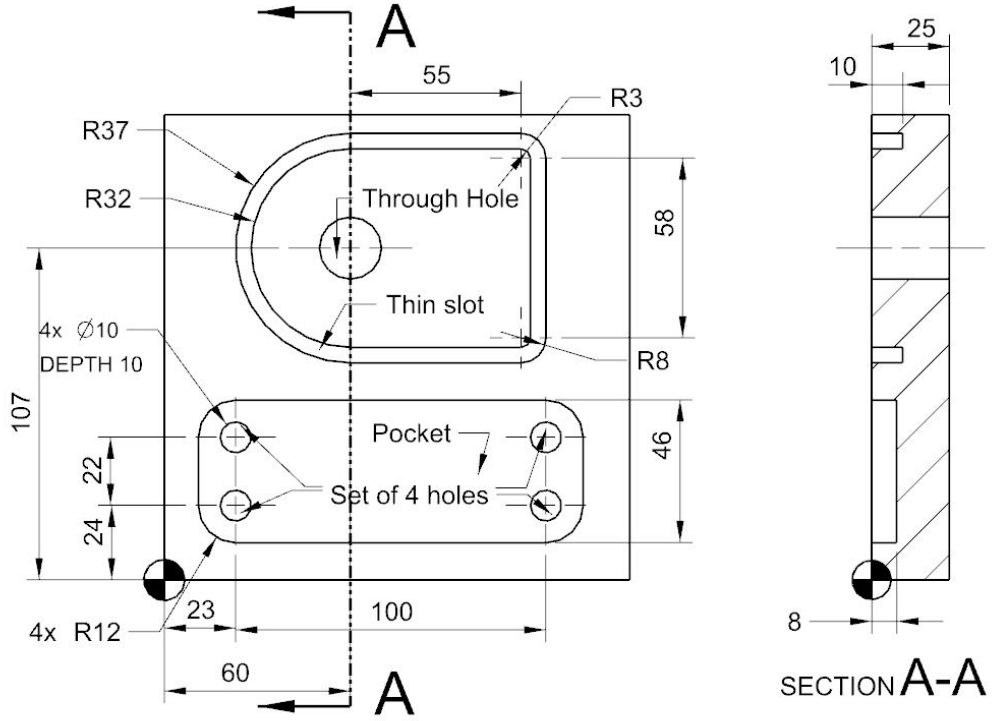

Figure 4. Diagram of part to be produced

b) What are the systems and sets of components that control and affect the CNC machine accuracy and repeatability? [5 marks]

c) Explain, with the aid of an example, the two methods used to program a cutting tool to perform a circular interpolation. [3 marks]

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