Loughborough University

Manufacturing Processes and Automation

24WSP600

Semester 1 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.

Answer **ALL THREE** questions.

All questions carry equal marks.

Use of a calculator is permitted - 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).

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1. Minor surface defects on railway tracks (see Figure Q1) are repaired by identifying the defect location, grinding the surface to remove the defect, welding to restore the track surface, and grinding again to achieve the original track profile. Propose an automated system and necessary equipment that can be mounted on a vehicle moving along railway tracks to perform the following tasks:

a) Identify the location of defects while the vehicle is in motion. Explain how the location can be recorded for follow-up actions. [6 marks]

b) Measure the exact geometry of the defective area. Explain the automation equipment and technologies required for this task. [6 marks]

c) Automate the repair process, including grinding, welding, and final inspection of the repaired area. [8 marks]

Figure Q1

/continued

2. You are working as a manufacturing process engineer in a large company that produces many different components used in gas turbine engines for the aerospace industry. One of your components is a duplex-type fuel nozzle (Figure Q2) and is currently made from several different metallic components which are fabricated into a single final piece using welding and fasteners. The part's major dimensions are 450 x 200 x 150 mm.

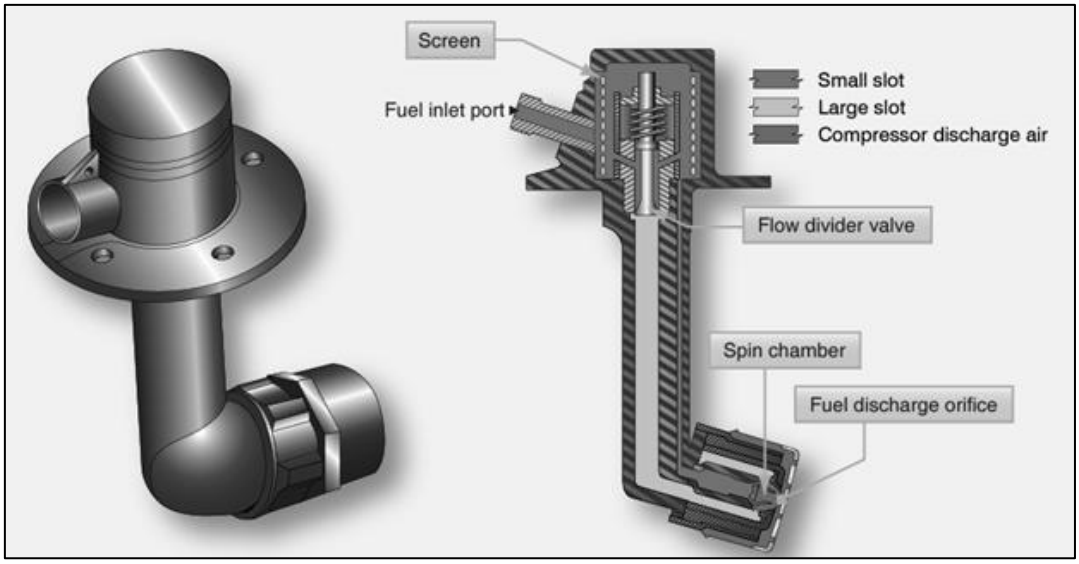

Figure Q2. Duplex-Type Fuel Nozzle (FAA, USA)

a) Describe which factors the company might consider when considering whether to implement additive manufacturing over traditional manufacturing processes to produce this part. What type of additive manufacturing process would you initially suggest would be best for this application? Explain how your suggested process works, using sketches where necessary to support your answer. [10 marks]

b) Compare the benefits and drawbacks of using the additive manufacturing process you have suggested for this application. [10 marks]

3. A faciltiy produces the casings for mobile phones. The earpiece on a particular model of phone requires 12 micro holes of 90 μm diameter to be drilled in a piece of 0.75 mm thick aluminium as shown in Figure Q3. The separation of the holes is 40 μm. The required rate of production is 2,000 parts per hour.

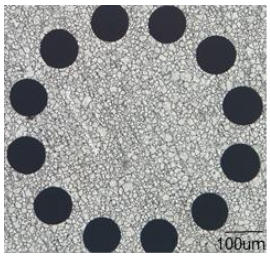

Figure Q3. Drilled hole arrangement

a) Propose a suitable laser drilling system for undertaking this process. In your answer specify the type of laser, the operation mode, the drilling technique, beam manipulation system and identify an appropriate assist gas. You should also consider how the workpiece will move relative to the laser and describe a suitable safety system. In your answer describe any defects that may occur in the final part and how these could be avoided. Justify any decisions that you make. [10 marks]

b) Based on your selected laser system, calculate the required laser power in order to produce the required number of parts in one shift. You do not have to consider the time required for the manipulation of the part into the laser processing area but should consider a suitable time for the movement of the laser or workpiece between holes. Specify a suitable overall efficiency of your chosen system. Justify any decisions that you make. [10 marks]

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

Density, 2,700 kg m^{-3}

Vaporisation temperature, 2,470 °C

Specific heat capacity, 900 J kg^{-1} K^{-1}

Latent heat of fusion, 397 kJ kg^{-1}

Latent heat of vaporisation, 9,429 kJ kg^{-1}.

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