ADVANCED MANUFACTURING PROCESSES AND TECHNOLOGY 1

22WSC600

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

ADVANCED MANUFACTURING PROCESSES AND TECHNOLOGY 1

(22WSC600)

January 2023 2 Hours

Answer **ALL FOUR** questions.

Any University-approved calculator is permitted.

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1. A drink company produces six differently flavoured drinks filled in clear plastic bottles of the same shape and size with identical bottle caps. Each flavour is packaged in cases of 30. This company also produces customised cases of drinks containing 30 bottles of two to six different flavours. Different flavours are identified by the colour of the liquids and the labels on the bottles. Currently, one operator receives the customised orders on paper and manually picks the drinks from six different pallets and locates them on a customised pallet (see Figure Q1), before being wrapped by plastic film and labelled (done by a machine and is not part of this question). A random visual counting occurs by another operator for around 25% of all customised pallets before the wrapping process to ensure each pallet has the correct number of bottles from each flavour, as ordered by the customer. However, the demand for customised orders is increasing and one operator cannot deliver the required number in a shift.

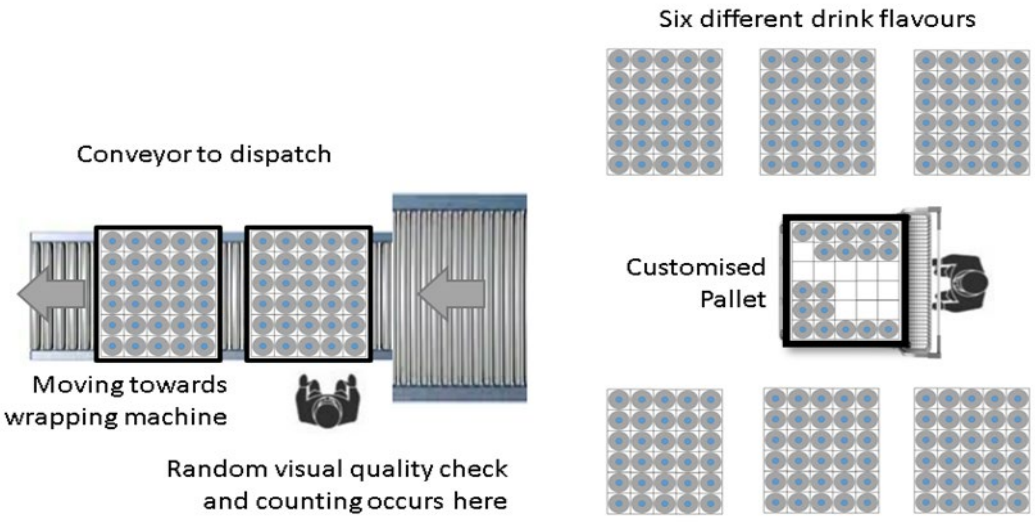

Figure Q1

a) Propose how the process of making customised pallets can be automated to increase productivity and volume without a need for operator intervention. Explain the technologies and equipment that need to be used to support receiving orders, picking up and placing the bottles and identifying the locations, types, and the number of the bottles. You can modify the layout of the pallets in your proposed design, but the conveyor location has to remain unchanged. Draw diagrams if necessary. Note, ignore the plastic wrapping and labelling process as they are already automated. [10 marks]

b) Explain how the visual counting of the bottles by the quality control operator for each customised order can be automated. Suggest the technologies and equipment required for this process. Also, discuss whether counting the bottle in every single pallet is necessary. [4 marks]

c) Discuss what technical business factors in such companies ought to be considered before making a decision on automating an operation similar to the one described above. Explain under which circumstances such automation systems can be financially viable. [6 marks]

2. A facility produces protective filters for ultra-high vacuum pumps as shown in Figure Q2. The filters are produced from dished stainless-steel discs of 0.6 mm thickness and 100 mm diameter. The radius of the curvature of the discs is 280 mm. In total 29,960 evenly spaced holes are required to cover a circle area of radius 39.20 mm in the middle of the blank. Each hole should be 100 ± 5 μm and drilled perpendicular to the surface. The separation between each hole is also 100 ± 5 μm. The rate of production required is five parts per eight-hour shift.

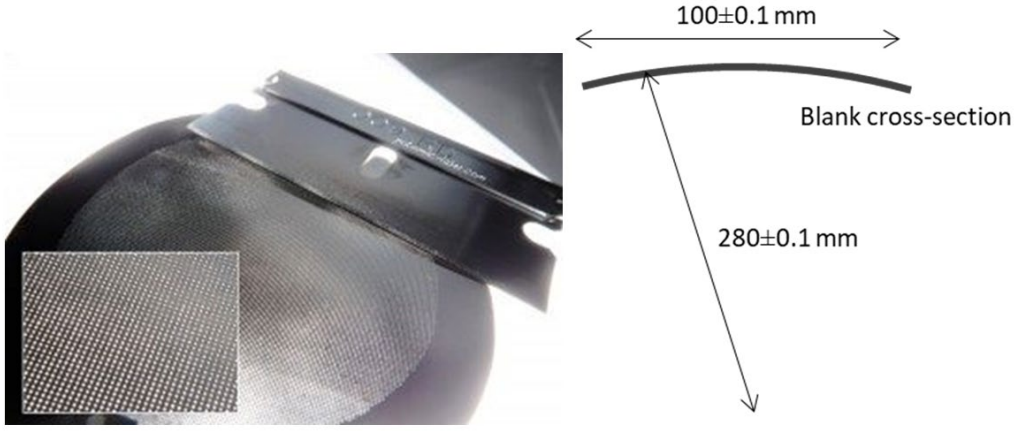

Figure Q2

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, the 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. Create a new document from this template. This happens by default if you double click the template file. [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. The various styles should then appear in your ribbon. These styles will only apply to documents created from this template and should have no effect on any other files you may have open. [10 marks]

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

Density, 8,030 kg m-3

Vaporisation temperature, 2,870°C

Specific heat capacity, 502 J kg-1 K-1

Latent heat of fusion, 285 kJ kg-1

Latent heat of vaporisation, 6,500 kJ kg-1.

3. Safety controls are extremely important when designing and operating laser processing systems

a) Identify a range of mechanisms that can be put in place to convert a class 4 laser product into a class 1 system. [4 marks]

b) Explain why polycarbonate is a suitable shield against stray laser emissions for CO_2 lasers, but not for Nd:YAG lasers. [2 marks]

c) Identify two common hazards associated with using high-power lasers for materials processing that do not involve injury from the laser beam and explain how these can be reduced. [4 marks]

4. Describe the following in the context of automation technologies:

a) Proximity sensors used in industrial automation systems. Explain three different types with one industrial example for each type. [6 marks]

b) Vision-guided robotic system. Describe its advantage and provide one industrial example [4 marks]

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