

# Manufacturing system course work

Engineering



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## **Manufacturing system/ course work**

a) Explain why rapid prototyping techniques can be usefully applied in the product design process leading to the manufacture of new products.

[5 marks]

Solution

Rapid prototyping can be used in the design and processing of products leading to the manufacture of new products because it allows the increase of the capability of visualization during the early stages of product design through the use of rapid physical models. Rapid prototyping also allows the detection of design flaws before the product is finally manufactured. The use of rapid prototyping also allows rapid creation of tools for the manufacture of physical prototypes. This allows for the saving of the time spent and cost incurred on the production of new products. Rapid prototyping also allows the customization of various products.

(b)

When designing a manufacturing system for a new product, a company has to decide between conventional manufacturing techniques with £12k tooling costs and £3 molding cost per part or rapid manufacturing with £400 computing costs and £23 fused deposition modeling cost per part. Make a sketch showing the relationship of these costs, calculate the break even quantity, BEQ, and recommend a production strategy for a quantity of 350.

[10 marks]

Solution

Fixed costs (FC) =  $400 + 23 \times 350 = £8450$

Sales price per unit (P) = £24. 14

Variable cost per unit (VC) =£23

The best strategy in this case is the rapid manufacturing with £400 computing costs and £23 fused deposition modeling cost per part.

(c)

Use a simple sketch of each process to compare and contrast the compression moulding and injection molding of polymers.

[5 marks]

Solution

a. The compression molding of polymers

a) This process is primarily dependent on: The amount of materials, the heating time, the force that is applied on the mold and the cooling time.

b) It has a low initial cost of set up

c) It is quick to set up

d) It is capable of handling large parts that are beyond the capacity of extrusion techniques

e) It allows molding of intricate parts

f) It allows good finishing on the surfaces

g) It produces fewer knit lines

h) Speed of production is not up to the molding standards

i) It is limited to flat and moderately curved parts that have no undercuts

b. Injection molding of polymers.

a) This process has issues with incomplete fillings, surface imperfections, burned parts and warped parts.

b) The process incurs low costs in mass production

c) It has a high precision

d) This process has geometrics that are only limited to the manufacturability

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of the mold.

e) This process incurs a high cost of setting up.

(d)

A flat plate 600mm x 400mm is to be compression molded. If the required molding pressure is 30MN per m<sup>2</sup>, calculate the press force required. If the press has two rams each of 300mm diameter, calculate the required pressure setting in Bar for the press hydraulic system relief valve.

[5 marks]

Solution

2.

(a)

Identify the five standard flow diagram symbols that can be used in the initial design and analysis of manufacturing systems. Use the symbols to produce a labeled, outline flow process chart for the manufacture of a pencil sharpener having either a plastic or metal body.

[10 marks]

Solution

The flowchart for the manufacture of a pencil sharpener

(b)

With reference to the International Rectifier Ltd MOSFET electronics manufacturing study, make a simple labeled sketch to explain how the three important functions of packaging an electronic component can be achieved. Include notes on three materials and three processes essential to the current global electronics manufacturing industry.

[15 marks]

Solution

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1. The three technologies used in the packaging of electronic components include: Silicon wafer: This involves the testing of pads before they are packaged. The pad is tested and the time it takes to perform determined. Wafers are normally laminated on a tape on the back and then deionization is performed on the silicon wafer.
2. Wire bonding: Either aluminum or copper wires are used in bonding. This depends on the type of application. The wire is passed through an ultrasonic capillary and through a proper combination of temperatures and energy, a wire bond is formed.
3. Molding and solder plating: This process encapsulates the whole wire bond against exposure to contamination and other physical damages.

The materials used in packaging include:

- a) Metals: This includes metals such as copper, aluminum, molybdenum and tungsten.
- b) Ceramics: This includes aluminum oxide substrate that is modified with barium oxide and silicon oxide.
- c) Polymers: This includes polymers such as epoxies, silica filled anhydride filled with resin and polyimide dielectric.

3.

(a) Give an example of A0, A4 and A10 manufacturing systems as defined by the Automation Classification Index and identify typical products that may be produced in each of them, either from a historical, contemporary or futuristic context.

[5 marks]

Solution

i. A0 manufacturing systems-Tailor made clothes

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ii. A4 manufacturing systems- Mail sorting line

iii. A10 manufacturing systems-CAD/CAM system

(b) A vertical machining center has three axes of motion and the manufacturer's sales catalogue includes the following specification information:

Repeatability +/- 0.0025 mm Drive motor 1.8 degree steps

Define the three axes using the Right Hand Rule and propose an assembly of machine elements that would achieve the repeatability shown above for one axis of motion in open loop control. Use a sketch to explain your design and show calculations throughout the chain of motion.

[8 marks]

Solution

There are basically three axes that exist in such a system which include:

- a) The X axis: This is the primary feed axis
- b) Y axis: It is aligned horizontal to the table
- c) Z axis: It is aligned away from the work piece/ spindle axis

The sketch below is a proposed design of the above:

The design above has an origin set inside the machine's grid system. The part of origin is established using a process known as work shift. Though work shifting, the parts of the design can be relocated depending on the axis of interest.

Given that:

$$F = 14, df = 3.217 \text{ and } P = 0.016.$$

$$r = S^2_A / (S^2 + S^2_A)$$

$$S^2_A = (MSA - MSW) / n_0$$

And  $n_0$  is the weighted average number of observation per group

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so  $n_0 = 2$

$$N_0 = [1/(a-1)] * [\text{SUM}(n_i) - (\text{SUM}(n_i^2)/\text{SUM}(n_i))]$$

$$S_2 = \text{MSW} = 0.257$$

$$S_{2A} = (\text{MSA} - \text{MSW})/n_0 = (0.828 - 0.257)/2 = 0.2855$$

$$r = S_{2A}/(S_2 + S_{2A}) = 0.2855/(0.257 + 0.2855) = 0.526$$

(c) Use a simple sketch to explain how the three main elements of a system for closed loop axis control would be related.

[4 marks]

Solution

The three main elements of the system include:

- a) Controller: These are the ceilings and parameters set for the operation of the system.
- b) Process: This involves the actual methods of processing that are unique in the system
- c) Measurement: This is the feedback signal that gives signal to the process.
- (d) A version of the machine is available fitted with linear optical gratings.

Explain how this option would differ from rotary encoders. If the gratings were of imperial pitch 1/2500 inch, and fitted with a x4 multiplier reading head, calculate the repeatability of the machine in mm based on using grating positional information.

[8 marks]

Solution

Diffraction gratings are normally used in the dispersion of light. This means to spatially separate light that has different wavelengths. They have been used as a replacement for prisms in most fields of spectral analysis. On the other hand rotary encoder normally operates by measuring the number of

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rotations, the rotational angle, and the rotational position and translates this to either a digital or analogue signal.

Given that:

$$F = 4 \text{ and } P = 0.01016$$

$$r = S^2_A / (S^2 + S^2_A)$$

$$S^2_A = (MSA - MSW) / n_0$$

$$\text{So } n_0 = 4$$

$$S^2 = MSW = 0.176$$

$$S^2_A = (MSA - MSW) / n_0 = (0.564 - 0.176) / 4 = 0.097$$

$$r = S^2_A / (S^2 + S^2_A) = 0.097 / (0.176 + 0.564) = 0.131$$

References

Mandel, J. , Repeatability and Reproducibility for Pass/Fail Data, Journal of Testing and Evaluation, JTEVA, Vol. 25, No. 2, March, pp. 151-153 (2007)., 1995.