

Exam Production of Aerospace Systems

Code: AE 3321-II - Closed Book Exam

Date: Monday, April 14, 14.00-17.00

3 Open questions and 20 Multiple Choice questions

Read carefully - write in clear script – give concise answers

Multiple Choice Questions

(1 alternative per question)

Question 1.

What statement related to the product flow in an aircraft factory is correct?

- a) The factory is one large assembly line with small workshops and warehouses in between
- b) Ideally the floor plan of a factory resembles the product flow chart
- c) The product flow increases with increasing working experience of the labourers
- d) The product flow in the assembly line is dictated by the delivery interval or fractions of it

Question 2.

What is meant with an “80%” learning curve?

- a) The working hours for Aircraft serial number 2N is 80% of the hours needed for serial number N
- b) The throughput time for Aircraft serial number 100 is 80% of the time required for serial number 50
- c) The delivery interval for Aircraft serial number 2N is 80% of the delivery interval for serial number N
- d) The working hours for Aircraft serial number N is 80% of the hours needed for serial number 2N

Question 3

Which of the following statements about sustainability and durability is true?

- a) The concepts of sustainability and durability are identical
- b) A Life Cycle Analysis is a tool for the evaluation of sustainability
- c) A Life Cycle Analysis is a tool for the evaluation of durability
- d) None of the above alternatives is true

Question 4

Two gunmen fired five shots each (see figure 1). Which answer (about repeatability and predictability) is correct?

- a) The results of gunman 1 are predictable and repeatable
- b) The results of gunman 1 are repeatable, but not predictable
- c) The results of gunman 2 are not predictable and not repeatable
- d) The results of gunman 2 are repeatable but not predictable.

Question 5

What is the best definition for the entity “waste” as used in Lean Manufacturing?

- a) Waste is all materials, scrap and leftovers that have to be removed after production
- b) Waste is all activities that support the production but does not add anything to the product
- c) Waste is all activities that do not contribute to the value of the product
- d) Waste is all activities that are not favoured by the shareholders of the company

Question 6

Currently, there are several typical drivers for the automation of composite manufacturing processes.

What answer does not provide typical drivers?

- a) Improved accuracy and a higher product quality
- b) Higher profits for the shareholders and cheap labour

- c) Reduced through-put time and better reproducibility
- d) Higher production volume and more efficient use of equipment

Question 7

Which of the following statements about Non Destructive Testing is false?

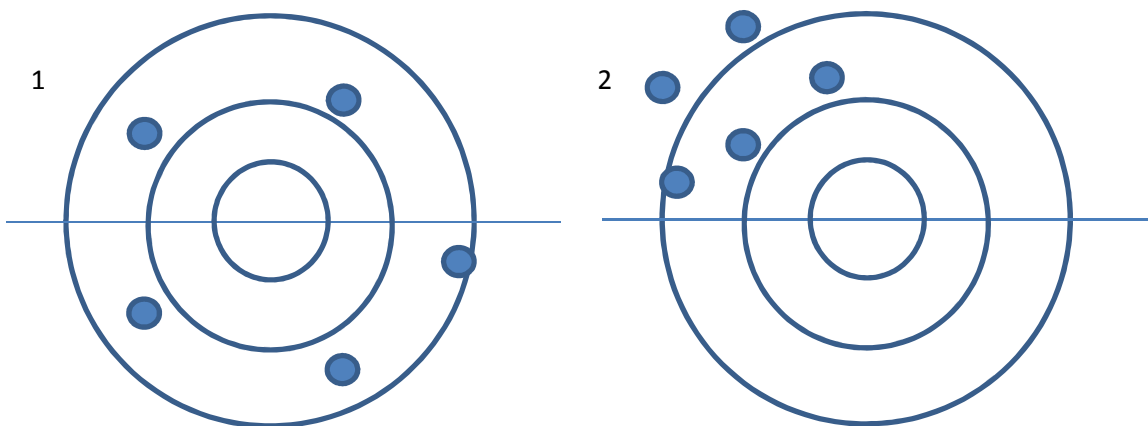
- a) NDT techniques are used for flaw detection during manufacturing and operation of the aircraft
- b) Some NDT techniques are capable of detecting flaws inside the material, others to detect flaws at the surface
- c) Ultrasonic testing is used for the detection of porosity and surface cracks in composites
- d) The X-ray technique is based on detecting differences in density and is therefore able to detect thickness differences

Question 8.

The following statements are about Non Destructive Testing of structures:

- I. In general, visual inspection is more appropriate for metal structures than for composite structures
 - II. Metal and composite structures encounter the same type of flaws during operation and therefore the same NDT techniques can be used
- a) Both statements are true.
 - b) Statement I is true but statement II is false
 - c) Statement I is false, but statement II is true
 - d) Both statements are false.

Figure 1



Question 9.

When we look at metals and composites, the following statements are made. Which statement is false?

- a) One way to compare metals and composites is by specific properties
- b) Composites have better specific properties than metal alloys mainly because of their density
- c) The current material transition from metals to composites is easier than the material transition in the 1930s
- d) The trinity philosophy states that changing materials, also requires changes in design and manufacturing

Question 10

For proper shearing of metals the following measures are to be taken

- a) The process needs ample cutting fluids for reducing tool wear and chip removal
- b) The clearance between cutting knife and work table should be within a specific range (not too small/not too large)
- c) The cutting knives should have an shear angle with respect to the work piece material
- d) Shearing is not an appropriate process for the nesting of products

Which is the incorrect measure?

Question 11

For chip-removal processes like drilling, the following statements can be made. Which one is true?

- a) The drill bits are often hardened (by coatings or else) to increase the tool life.
- b) Wear is absent in a non-contact chip-removal process like water-jet cutting
- c) The tool wear is reduced significantly by air cooling through tiny channels in the drill bit
- d) The edges of most tool bits of machining processes have a negative rake angle

Question 12

Which of the following statements about injection moulding is true?

- a) In injection moulding of metals, high pressure is applied to overcome the high viscosity of molten metals
- b) With multiple injection points in injection moulding, knit lines will occur
- c) Injection moulding machines of thermoplastic polymers use plungers instead of screws
- d) Thermoplastic polymers can be reinforced with long fibres ($\approx 5-10$ cm) before injection moulding

Question 13

Which of the following statements about manufacturing with thermoplastic composites is correct?

- a) Thermoplastic composites need high temperatures to obtain a high viscosity during manufacturing
- b) Thermoplastic composites can be processed much faster than thermoset composites
- c) After curing of thermoplastic composites, further processing is not permitted
- d) Thermoplastic and thermoset composites can be manufactured with the same processes.

Question 14

In resin injection processes the injection time is influenced by the following parameters:

- a) Fibre volume fraction
- b) Mould material
- c) Resin viscosity
- d) Process temperature
- e) Pressure differences

Which parameter is not correct?

Question 15

In what ways can the rigid/flexible assembly concept be applied in aircraft assembly? Which alternative is not correct?

- a) Joining of the skin to a fuselage frame
- b) Drilling holes in both components to the right dimensions before assembly
- c) Joining a double curved panel to a single curved panel
- d) Joining the leading edge of the wing to the wing box

Question 16

Preloading of a bolt is based on:

- a) The reduction of the maximum stress in the bolt
- b) The increase of the minimum stress in the bolt
- c) The reduction of the stress amplitude of the fatigue loading
- d) None of the above alternatives is correct

Question 17

Which of the following statements is true?

- a) Adhesive bonding for thick adherents requires thicker bond lines
- b) Adhesive bonding for assembly is possible in case of out-of-autoclave curing (e.g. in an oven)
- c) Welding of dissimilar materials is limited by the melting points of the materials
- d) Welding of metals and thermoplastics is performed using the same methods

Question 18

What is the origin of the “bath tub curve”-like stress distribution in a bonded joint?

- a) The bath-tub-shape is created by the flexibility of the adhesive
- b) The differences in deformations in adherents opposite of the bond line
- c) The stiffness difference between the adhesive and the adherents
- d) The peel stresses that are present at the ends of the bond line

Question 19

A double lap joint has a rivet of 4 mm in diameter, sheet thickness of $t_1=t_3 = 0.6$ mm and $t_2= 1.0$ mm. The load transferred by the rivet is 2500 N. What is the largest bearing stress in the joint?

- a) 312.5 MPa
- b) 520.8 MPa
- c) 625 MPa
- d) 1041.6 MPa

Question 20

The following statements are about comparing integral and assembled substructures:

- I. In general, integral parts are advantageous with respect to weight, but are a disadvantage with respect to Damage Tolerance performance
 - II. Generally, an assembled substructure has disadvantages with respect to logistics, but has an advantage with respect to maintenance and repair
- a) Both statements are true
 - b) Statement I is true but statement II is false
 - c) Statement I is false, but statement II is true
 - d) Both statements are false.

Open Questions

Question 21.

Lean Manufacturing (LM)

- Give a brief description of at least two of the following LM tools: value stream mapping, Just-in-time, load levelling.
- “Not all the waste in a manufacturing process can be eliminated”. Explain this statement and give two examples.

Quality control and Non Destructive Testing (NDT)

- When a composite skin is laminated, vacuum bagged and cured in an autoclave, what quality control activities (mention at least 2) can be performed to guarantee a good quality? Explain your answer.
- In case of bonding two metal sheets, which NDT method would you recommend to check the quality of the bond and why?
- Ultrasonic inspection is often performed submerged in water or using water squirters. Why?

Question 22.

Figure 2 shows a sketch of a thin-walled product component ($\pm 200 \times 350 \times 30$ mm). This product can be made of a metal alloy or of composites.

- Mention at least one manufacturing process for metals which cannot be used for this product and give the reason why not?
- Mention at least one manufacturing process for composites which cannot be used for this product and give the reason why not?
- Which process would you select for this product if it was made of metals and why?
- Which process would you select for this product if it was made of composites and why?
- Would the number of parts make a difference in your choices in c and d? Explain your answer.

PS. Make assumptions when necessary.

Question 23.

Assembly of aircraft

- What is a manufacturing division?
- What joining methods are used for mounting divisions and why?
- Assembly jigs should have specific properties like stiffness and accessibility. Explain how these properties are implemented in an assembly jig.
- Explain the concept of “hole-to-hole”; how does it work and what are the advantages?
- Mention (and describe briefly) at least two differences between the assembly of composite structures and the assembly of metal structures.



Figure 2