

## **Exam Production of Aerospace Systems**

Code: AE 3321-II - **Closed Book Exam**

Date: Monday September 7, 2015, 19.00-22.00; Lecture room J, AE  
15 Multiple Choice questions and 4 Open questions

**Read carefully - write in clear script – give concise answers**  
**Text of the reader & slides is leading**

### **Multiple Choice Questions**

(1 alternative per question – 3 points per MC question)

#### **Question 1. Rubber forming**

Which of the following statements about rubber forming of metal sheets is true (one answer)?

- a) The rubber forming process has many variables like the pressure, the lubrication, the working temperature
- b) Rubber forming is ideal for so-called flanged parts: flat web plates with curved flanges at the periphery
- c) Rubber forming is ideal for so-called deep drawing shapes; the height/diameter ratio can easily exceed 1.5
- d) The biggest disadvantage is the long production time per part which cannot be overcome by any measure.

#### **Question 2. Heat treatment**

A heat treatment may have the following impact on metal sheet:

- a) The yield stress is decreased and the ductility is reduced
- b) The ductility is increased and the formability is reduced
- c) The sheet shows warpage (distortions) and becomes more brittle
- d) The yield stress is reduced and the stiffness is increased.

Which one of these alternatives is true?

#### **Question 3 Explosive forming**

Explosive forming is a process which:

- a) Is able to form large and thick walled shells
- b) Can be performed at any metal work shop
- c) Requires certified people and dedicated tooling
- d) Is applicable up to small size (O(100)) product series

Which answer is false?

#### **Question 4. Nesting**

“Nesting” during cutting operations can be related to:

- a) The concept of Lean Manufacturing
- b) The concept of “burr-less” cutting
- c) The idea of universal tooling
- d) None of the above alternatives is true

#### **Question 5 Forming principles**

There are multiple forming principles. Which of the following statements is false?

- a) Plastic deformation is based on movements of small defects in the crystal lattice, so-called dislocations.
- b) Plastic deformation and superplastic deformations are based on the same principle, although the temperature is different

- c) Thermoplastic composites with continuous fibres can be deformed into 3D shapes by intra-ply and inter-ply shear deformations
- d) The deformation of thermoplastic composites with short fibres is dominated by the flow of the polymer

### Question 6 Machining processes

Which of the following processes is a separation process and not a machining process?

- a) Punching
- b) Water jet cutting
- c) Drilling
- d) Laser cutting

### Question 7 Adhesive bonding (process)

Which of the following statements is false?

- a) In the adhesive bonding process the surface pretreatment is very important
- b) An adhesive bond should be designed to transfer shear forces, not tensile forces
- c) In the adhesive bonding process the curing process is the most critical step
- d) The different layers in an adhesive bond act like a chain: the weakest link determines its' strength

### Question 8. Extrusion

One of the bulk forming processes is Extrusion. Usually extrusion is performed at elevated temperatures. Why?

- a) To improve the straightness of the profiles
- b) To have a better formability
- c) To reduce the extrusion force
- d) To form and heat treat the material simultaneously

Which answer is the best?

### Question 9. Vacuum Infusion & RTM

What are the similarities between Vacuum Injection (VI) and Resin Transfer Moulding (RTM)? Which argument is false?

- a) Both processes apply pressure differences during the resin injection process
- b) For both the injection process depends on the fibre architecture and fibre volume content
- c) For both the maximum applicable product sizes (length, thickness, etc.) are the same
- d) The curing process for both methods is the same

### Question 10 Batches

Which of the following statements about batch production is true?

- a) The batch size is always the same for a specific part
- b) Batches are used in part manufacture as well as in line production
- c) The larger the batches, the larger the required storage space
- d) The batch size is related to the delivery interval only

### Question 11 Different joining techniques

There are a number of different joining techniques. Which statement is correct?

- a) Adhesive bonding and welding are capable of providing air- and liquid tight joints
- b) Stress concentrations are much less in adhesively bonded and bolted joints

- c) Fusion welding cannot join different metals, but it can join different alloys of the same metal
- d) Both riveting and bolting are used for joints loaded in tension

**Question 12 Solid and Hi-Lock rivets**

Replacing a solid rivet (aluminium) by a hi-lock rivet (titanium),

- a) Increases the bearing strength of the joint and may result in a reduced rivet pitch
- b) Increases the shear strength of the rivet and may result in a reduced rivet pitch
- c) Increases the bearing strength of the joint and may allow for increasing the rivet pitch
- d) Increases the shear strength of the rivet and may allow for increasing the rivet pitch

Select the correct answer.

**Question 13 Divisions**

The following statements are about manufacturing and mounting divisions. Which is false?

- a) Manufacturing divisions result from structural breakdown and facilitate the work share
- b) Manufacturing divisions manufacture parts, mounting divisions assemble the parts
- c) Separations in the structure to facilitate assembly are called manufacturing divisions
- d) Divisions that are aiming at an easy operation of aircraft are called mounting divisions

**Question 14 Quality**

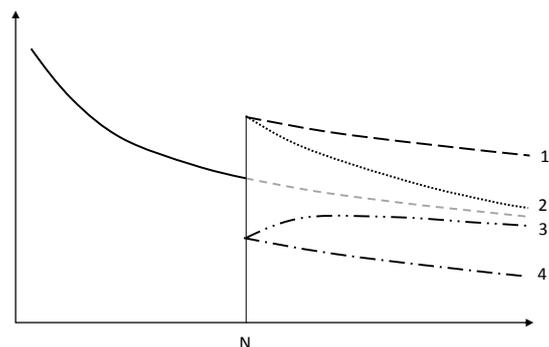
“All the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that an entity will fulfil requirements for quality” is the definition of:

- a. Quality planning
- b. Quality control
- c. Quality policy
- d. None of the above

**Question 15 Learning curve**

When a modification is implemented in the assembly of aircraft number N, the learning curve changes according to line (see figure):

- a. Line 1
- b. Line 2
- c. Line 3
- d. Line 4



## Open Questions

(4 points each sub-question)

### **Question 16 – Liquid phase processing**

- a) Both metals and polymers can be processed in a (nearly) liquid phase. Describe briefly the material characteristics during such processes.
- b) Some processes require also the application of pressure. For what materials or situations do we need pressure? Explain your answer.
- c) Injection moulding processes may induce so-called “knitlines”? Explain what these are, how they occur and what the consequences might be for the part’s performance.
- d) What tooling materials are needed for liquid processing of high temperature metal alloys? Explain your answer.

### **Question 17 – Resin infusion processes**

For the manufacture of composite parts one could use resin infusion processes like Vacuum Infusion (VI) or Resin Transfer Moulding (RTM).

- a) What process would you select when part accuracy is important? Explain your answer.
- b) Resin infusion processes are not applied for thermoplastic resins. Why not? Explain your answer referring to the microstructure of thermoplastic polymers.
- c) Name and explain at least three parameters which influence the flow front velocity during a resin infusion process.
- d) In fusion processes we first shape the fibres before impregnation. Describe briefly a process which impregnates the fibres before shaping them in a mould.

### **Question 18 Adhesive bonding**

Adhesive bonding is one of the joining methods used in the aerospace industry.

- a) Mention at least 2 advantages and 2 disadvantages of adhesive bonding.
- b) The quality of adhesive bonding is highly dependent on the pretreatment of the adherents (parts to be bonded). What makes the pretreatments often so elaborate? Explain your answer.
- c) The adhesive bonded joints transfer the loads by shear stresses. The highest stresses occur at the edges of the bond. Explain this.

### **Question 19 - Assembly of aircraft.**

- a) Mention four different reasons why an aircraft has to be assembled.
- b) The structural breakdown of an aircraft results in manufacturing and mounting divisions. Mention at least 2 structural features which are ideal to create a manufacturing or mounting division.
- c) “Assembly adds weight to an aircraft”. Which features (2) in the joint contribute to the weight increase?

Success