

### **Multiple Choice Questions**

- 1      A  
A larger burr is created when the material is softer (ductility increase) and when the gap the is larger – so increase + increase (all other alternatives incorrect)
- 2      C  
Shearing (A and B) and punching (D) are no chip-removing processes
- 3      B  
A = true; all kind of food stock (fish e.g) and materials are cut by WJC  
B= false; abrasive is primarily used for the hardness of the material  
C = self explaining  
D = laminates may delaminate, therefore more difficult
- 4      C  
A – die castings can be as/more complex as sand castings (more complex = higher costs)  
B - Metal casting don't need pressure to fill the mould  
C – To obtain the right product (dimensions) the designer need to take these features into account  
D – right order is: sand casting – investment casting – die casting (non-reusable die – semi-reusable die – reusable die)
- 5      A  
A - biggest threat for such castings: pores/cavities and cracking due to residual stresses  
B – warping depends a lot on the shape of the product (ribbed products hardly warps)  
C – Cooling time is related to material and largest thickness; not to thickness variations  
D – removal depends on e.g. draft angles & tool concept, not on thickness variations
- 6      B  
A – is called a flash  
B – correct  
C – No, a knit line can also happen within the same polymer (more than one polymer in a product is not so common – different injection temperatures)  
D – In injection moulding the (short) fibres flow with the resin
- 7      D  
A – is used to select the right manufacturing process  
B – see A  
C – in this row “price” is not a product feature (determined once the product is made)  
D – correct answer
- 8      B

I this statement is true. The pace of the (sub)assembly lines is derived from the delivery interval (= e.g. # AC/month).

II This statement is not true. Structural breakdown can be seen in the assembly area of the factory but NOT in the part manufacturing shops

- 9 B  
A – is the other way around: composites require higher tolerances due to lack of ductility  
B – true, you can make lightweight structures with heavy materials, due to cleverly designed structures!  
C – No, the transition is still going on, but it starts in the 1960s/1970s  
D – The opposite. Simulation of metal technology has reached a high maturity level, whereas the composites (also due to their complexity) are not that far developed
- 10 D  
Stiffness is the most important feature because it dictates the accuracy of the assembly
- 11 B  
A – welding stresses can be relieved by heat treatments  
B – significant changes in microstructure has also large impact on properties (decrease)  
C – thin sheets is not a real obstacle, though not easy  
D – on the contrary – Aerospace would like to use welding because of low costs
- 12 A  
Then the bearing stress, the shear-out stress and the rivet shear stress are reduced by about 50%, but the net section stress remains at the same level. Therefore,  
A – is correct (thereby alleviating the net section stress a little)  
B – if changed, the rivets can become smaller  
C – No, net section is still the same  
D – No, is reduced by about 50%, because the load per rivet is reduced by about 50%
- 13 A  
A – solidifying of thermosets by curing/crosslinking; thermoplastics by cooling down  
B – not for thermoplastics; infusion for thermoplastics is not feasible (high viscosity)  
C – No, infusion processes are not feasible for thermoplastic composites  
D – After curing, thermoset cannot be reshaped anymore
- 14 B  
A – no, although often more partners are needed; more complex organisation  
B – true, financial risk become really high and should be divided over multiple partners (see Boeing)  
C – no, on the contrary – see Airbus  
D – no, number of incidents has decreased significantly in the last decades
- 15 C

In-situ infusion speed means the infusion speed at a certain spot in the product. This is influenced by the fibre architecture (A + B), the viscosity (Incl. D), and the local pressure difference. The spot does not “know” how big the part is (C).

16 E

One of the big challenges for composite technology is to find a method to measure (the properties of) incomplete cure. None of the current methods are capable of this.

### ***Open Questions***

- 17a. Tape laying is a mechanical (not manual!) lay-up technique, using continuous tapes (few cm wide), usually UD material, and orient the tapes in preferred directions. Tape next to tape, layer after layer the product is made. The large potential of this process is the option of automation.
- 17b. Autoclave (= pressure vessel) curing is accelerating the chemical cure of the thermoset polymer by increased temperature T. At same time vacuum is applied to remove air; and the pressure p is used to consolidate the material (compaction). Key parameters: T, p, t (time).
- 17c. RTM is a closed mould principle. Tolerances of the product stems from the tolerances of the two matching dies. Lay-up followed by Autoclave curing uses only one die; the second “die halve” is a foil, not so accurate. (Note: for RTM the dry fibres are usually placed by hand).
- 18a. Product focused: Quality Control of the finished part only; Process focused Quality Control is also performed on the product at (multiple) intermediate production steps.
- 18b. Quality Control activities: Quality Control upon reception of the materials (intake); monitoring the fibre orientations during lay-up; monitoring correct sequence of the ply build-up; parameter control during curing in Oven or Autoclave (p, T, t); dimensional inspections after product is finished; NDT for delaminations, etc.
- 18c. Authorities sets the rules the manufacturer has to comply with; Authorities have audits to check this, and in the end they approve (certify). Note that the rules are very high level rules about methodology, organisation, etc.
- 19a. Philosophy – a fundamental attitude and way of working. Although there are general objectives, there are no fixed targets. The ultimate goal can never be achieved.
- 19b. Yes, to some extent. LM will reduce/eliminate activities that do not contribute to value. Is also relevant for reducing energy and (a.o. material) resources. But, the goals for both concepts are different, so it does not match under all circumstances!!
- 19c. LM can be applied in administrative environments too. View the administration as a production environment for processing information (= “product”) and look at transport, stocks, waiting times, etc.
- 20a. True, when loaded in peel the peak stresses will debond the adherents (like peeling off tape)
- 20b. True. Welding except for TP composites is no option (large microstructural changes); riveted/bolted joints create holes which induce significant stress concentrations. And composites doesn't have the ductility to level off these high stress peaks.
- 20c. True. When extending the overlap length, only the less efficient centre becomes larger;

the peak stresses at the edges are hardly effected.

20d. Yes, in case of more than 2 rows. If the number of rows is 4 or 5 than definitely the same effect as a bath tub is visible. (Note: this sub-question has been removed from the grading)