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Section B

Question 2

- a) what makes up an atom?
- Nucleus (protons and Neutrons) and Electrons.
 - The valency of an atom can be calculated by how many hydrogen atoms it can bond with.
 - If the atom has a complete outer shell, It is balanced and tends to be chemically inert.
- b) BCCD so, ... $a = 2\sqrt{2}R \rightarrow 2\sqrt{2 \times 0.1241} = 0.996 \text{ nm}$
- c) Point defects vacancies - Missing atoms when the lattice forms leaves vacancies in the structure, allowing distortion of surrounding atoms
- Line defects dislocations - Dislocations allow layers of the lattice to 'slip' relative to their adjacent layers.
- As the areas move, bonds between atoms break, with new bonds forming once the slip motion is completed.
 - This slip effect produces a permanent plastic deformation of the structure.
- Area defects grain boundary - Grain boundaries are the boundaries between the crystals in a material. Bonding structure changes.
- orientation of crystal will be different.
 - Grain boundaries can help impede dislocations.

Advantages of casting

- 1) Casting can produce very complex geometry parts with internal ~~voids~~ cavities.
- It can be used to make small (few hundred grams) to very large size part (thousand of kilograms).
 - Any intricate shape can be produced.
 - Any material can be cast ferrous and non-ferrous.

Disadvantages of casting

- Dimensional accuracy: Because of shrinkage in the casting, the dimension be at risk.
- Low strength: due to high porosity compared to a machined part.
- Post-processing: It requires secondary machining operations in order to improve the surface finish.

Advantages of forging

- Parts manufactured by forging are stronger
- It offers high ductility.
- It is more reliable and less costly.
- It offers better response to heat treatment
- It refines structure of metal.

Disadvantage of forging

- Capital cost is more
- It is limited to simple shapes
- Very high man and material safety procedures need to be followed.
- In hot forging it is difficult to perform secondary operations.

Question 3

$$i) A_n s = E_f = 200 \text{ GPa} \rightarrow 200 \times 10^9 \text{ Pa}$$

$$E_m = 3.2 \text{ GPa} \rightarrow 3.2 \times 10^9 \text{ Pa}$$

$$A_w = 100 \text{ cm} \xrightarrow{\text{to metres}} 1.0 \text{ m}$$

$$A_H = 2 \text{ cm} \rightarrow 0.02 \text{ m}$$

$$V_f = 55\% \rightarrow 0.55$$

$$\text{which means } V_m \text{ is } 45\% \rightarrow 0.45 = (1 - 0.55)$$

$$A_c = 1 \times 0.02 = 0.02 \text{ m}^2$$

$$A_f = A_m = 0.02 \times 0.5 = 0.01 \text{ m}^2$$

$$E_c A_c = E_m A_m + E_f A_f$$

$$0.02 E_c = ((3.2 \times 10^9) \times 0.1) + ((200 \times 10^9) \times 0.1)$$

$$0.02 E_c = \underline{20320 \times 10^6}$$

$$E_c = \frac{20320 \times 10^6}{0.02} = \underline{1016 \times 10^9}$$

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m} \rightarrow \frac{F_f}{F_m} = \frac{(200 \times 10^9) \times 0.55}{(3.2 \times 10^9) \times 0.45} = \underline{64.33}$$

$$\frac{F_f}{F_m} = 64.33 \rightarrow F_f = 64.33 F_m$$

$$F_c = 30 \text{ MPa} \rightarrow 30 \times 10^6 \text{ Pa}$$

$$F_c = F_f + F_m$$

$$30 \times 10^6 = 64.33 + F_m$$

$$30 \times 10^6 = 65.33 F_m$$

$$F_m = \frac{30 \times 10^6}{65.33} = \underline{459.2 \text{ kN}} \quad \text{or} \quad \underline{459.2 \times 10^3 \text{ N}}$$

$$F_f = 64.33$$

$$= 64.33 \times (459.2 \times 10^3) = \underline{29.54 \text{ MN}} \quad \text{or} \quad \underline{29.54 \times 10^6 \text{ N}}$$

$$iii) E = \frac{\sigma}{\epsilon}$$

$$E_m = \frac{\sigma_m}{\epsilon_m}$$

$$E_F = \frac{\sigma_F}{\epsilon_F}$$

$$\epsilon_m = \frac{\sigma_m}{E_m}$$

$$\epsilon_F = \frac{\sigma_F}{E_F}$$

$$\epsilon_m = \frac{459.2 \times 10^3 \text{ N}}{3.2 \times 10^9 \text{ Pa}}$$

$$\epsilon_F = \frac{29.54 \times 10^6 \text{ N}}{200 \times 10^9 \text{ Pa}}$$

$$\epsilon_m = \underline{1.435 \times 10^{-4} \text{ mm/mm}} \quad \epsilon_F = \underline{1.477 \times 10^{-4} \text{ mm/mm}}$$

Ans:

$$b) \begin{aligned} D &= 0.02 \text{ m} \\ h &= 0.001 \text{ m} \\ r &= 0.0005 \text{ m} \\ P &= 65 \times 10^6 \text{ Pa} \end{aligned}$$

$$\frac{h}{r} = \frac{0.001}{0.0005} = \underline{2}$$

$$\sqrt{\frac{h}{r}} = \sqrt{2} = 1.41$$

$$\frac{h}{D} = \frac{0.001}{0.02} = \underline{0.05}$$

$$C_1 = 0.721 + (2.394 \times 1.41) - (0.127 \times 2)$$

$$C_1 = \underline{3.843}$$

$$C_2 = 1.978 - (11.489 \times 1.41) + (2.211 \times 2)$$

$$C_2 = \underline{-9.799}$$

$$C_3 = -4.413 + (18.751 \times 1.41) - (4.596 \times 2)$$

$$C_3 = \underline{12.83}$$

$$C_4 = 2.714 - (9.655 \times 1.41) + (2.512 \times 2)$$

$$C_4 = \underline{-5.88}$$

$$k_t = C_1 + C_2 \left(\frac{h}{D} \right) + C_3 \left(\frac{h}{D} \right)^2 + C_4 \left(\frac{h}{D} \right)^3$$

$$k_t = 3.843 + (-9.799 \times 0.05) + (12.83 \times 0.05^2) + (-5.88 \times 0.05^3)$$

$$k_t = \underline{\underline{2.65}}$$

$$\begin{aligned} \sigma_{\max} &= P k_t \\ &= (65 \times 10^6 \text{ Pa}) \times 2.65 \\ &= \underline{\underline{172.25 \times 10^6 \text{ Pa}}} \quad \text{or} \quad \underline{\underline{172.25 \text{ MPa}}} \end{aligned}$$

Question 4

a) • Electroplating

- It is a process by which a metal:
 - is coated with a thin layer of another metal
 - using electrolysis. In this way the new metal coating protects the metal.

• Galvanization

- This process involves coating iron with a thin layer of zinc. It is generally done by dipping iron in molten zinc. The zinc layer coating thus protects the iron from corrosion.

• Painting and greasing

- Providing a layer of paint or grease on the metal can prevent the exposure of the metal with the external environment thereby preventing corrosion.

• Using corrosion inhibitor

- corrosion inhibitors are chemicals which when added to the corrosion environment has the ability to cut down the rate of corrosion.

b). Use stronger, more capable materials

- select materials with high fracture toughness and slow crack growth.
- consider material that are suitable for the major challenge of the working environments, such as corrosion resistance, better/worse heat conductivity.
- Reduce the margin of errors in assembly and manufacture
 - specify tighter requirement when possible.
 - works done in controlled an environment is usually better than in the field.

SECTION A

1. Ans = a. • Hydrogen
• Ammonia

- In a hydrogen economy, hydrogen would be used in place of the fossil fuels that currently provide four-fifths of the world's energy supply and emit the bulk of global greenhouse gas emissions. This could aid climate goals because hydrogen only emits water when burned and be made without releasing CO_2 .

- Ammonia is commonly produced by reacting methane with steam to produce hydrogen, and then reacting this with ~~large~~ Nitrogen from the air using what
 → turn