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Q3) a)

Casting is one of the oldest manufacturing processes used. It has been heavily refined over the time.

Casting is when a liquid metal is poured into a mould, which can be made from sand, clay or other suitable material, and then cooled and extracted.

Common automotive parts are cast from aluminium or steel.

Advantages are large, intricate shapes can be used. It has a short production run and quite sustainable if reusable moulds are used.

Disadvantages are that there is poor dimensional control and the moulds leave a poor surface finish, which leads to additional machining required and some material loss.

Forging is another commonly used manufacturing process. Through a combination of heat and pressure a billet is shaped into its desired form. Dies are used to determine the shape and it creates strong final products made from a single piece.

Advantages are that the material grain structure aligns because it's made from a single piece. Because dies are used a high production rate can be achieved as well.

Disadvantages are that high initial costs occur because dies are expensive and wear out so need replacing from time to time. This process is really only viable for large production runs to warrant the upfront cost. Forging is often used for pistons.

Another manufacturing process is extrusion. Material is pushed through a form to extrude the desired shape. This allows for complex shapes to be made and is usually used for structural members, part of the chassis for example. There is no material wastage and very rapid production allowing for high output.

It's not suited for brittle materials though. It also requires low melting point alloys and can leave defects which is no good in structural members.

b)

Stage 3, 4 & 5 2, 3 & 4 in the FMEA are used to calculate the RPN.

Stage 2 is the likelihood of detection (D)

where the likelihood is ranked from 1-10 where 1 is absolute certainty

Stage 3 is the severity number (S)

where severity is ranked 1-10, 10 being the worst

Stage 4 is the probability of occurrence (P)

where the probability is ranked 1-10, 10 where it is unavoidable

RPN is then calculated as follows

$$RPN = D \times S \times P$$

c) $D = 0.01 \text{ m}$

$$h = 1.1 \text{ mm} = 0.0011 \text{ m}$$

$$r = 0.5 \text{ mm} = 0.0005 \text{ m}$$

$E = 55 \text{ Pa}$ Bending

i)

$$\frac{h}{r} = 2.2$$

$$C1 = 0.935 + 1.922 \sqrt{2.2} + 0.004 \times 2.2 = 3.79$$

$$C2 = -0.552 - 5.327 \sqrt{2.2} + 0.086 \times 2.2 = -8.26$$

$$C3 = 0.754 + 62.81 \sqrt{2.2} - 0.129 \times 2.2 = 9.80$$

$$C4 = -0.138 - 2.876 \sqrt{2.2} + 0.031 \times 2.2 = 5.47$$

$$K_t = 3.79 + (-8.26) \left(\frac{2 \times 0.0011}{0.01} \right) + 9.8 \left(\frac{2 \times 0.0011}{0.01} \right)^2 + 5.47 \left(\frac{2 \times 0.0011}{0.01} \right)^3$$

$$K_t = 1.92$$

$$\sigma_{\max} = 1.92 \times \frac{32 \times 55}{\pi (0.01 - 2 \times 0.0011)^3} = 2266627825 \text{ N/m}^2 \quad (2)$$

d) $a = 3.1 \text{ nm} = 0.0031 \text{ m}$

$\sigma = 625 \times 10^6 \text{ Pa}$

$E = 200 \times 10^9 \text{ Pa}$

$G_c = ?$

$$K = 625 \times 10^6 \times \sqrt{\pi \times 0.0031} = 61678783.66$$

$K = K_c$

$$G_c = \frac{K_c^2}{E} = \frac{61678783.66^2}{200 \times 10^9} = 3.08 \times 10^{-4} \text{ Pa m}$$

Q2 a) Covalent bonding is where atoms share electrons but don't permanently transfer them. Usually happens with same elements, very common with non-metals.

Metallic bonding is where metal atoms shed electrons from their outer shell, creating a positively charged sea of delocalized electrons.

The ~~ions~~ form a lattice where the electrons fill the gaps.

The valency of atoms is the measure of how many H_2 atoms it can bond with.

Ionic bonding is where atoms fully transfer atoms to be between each other. So a donor sheds an electron to become balanced, and the which means having a full outer shell, and the receiving atom with a nearly full outer shell takes the electron to complete its shell.

Metals usually are donors whereas receivers tend to be non-metals.

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13/05/22

b) 4 atoms = FCC

$$R = 2$$

$$a = 0.362 \text{ nm} = \cancel{0.000362 \text{ m}} = 0.362 \times 10^{-9}$$

$$R = \frac{a\sqrt{3}}{4} = \frac{0.362 \times 10^{-9} \times \sqrt{3}}{4} = \cancel{1.56 \times 10^{-10} \text{ m}} = 1.58 \times 10^{-10} \text{ m}$$

c) Point defects ~~have~~ can be vacancies, interstitials or substitutional. Line defects ~~can be~~ are dislocations and area defects are problems with the grain boundaries.

Vacancies are missing atoms in the lattice allowing for distortion of surrounding atoms.

Interstitials are when an atom ends up in between the lattice structure, so the exact opposite of a vacancy.

Substitutional defects is when an atom gets substituted for a different one. This is not wanted when needing pure materials. In alloys it is very much wanted.

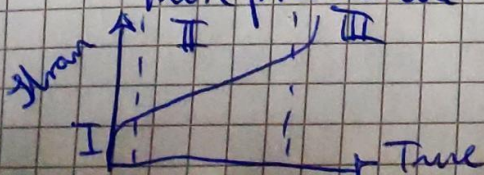
Line defects are where the whole atom lattice accidentally shifts. This leads to atom bonds breaking and reforming.

This is a permanent plastic deformation. Sometimes wanted for for example with work hardening but not always ideal.

Grain boundaries create area defects in the lattice. This means that the bonding structure changes and changes the orientation of the crystal structure.

They can help impede dislocations though.

d) Stage 2 ~~is an ~~elastic~~ deformation~~ ^{is} where material deformation stabilizes and becomes linear, and ~~so~~ so more predictable.



Dislocation movement leads to the predictability

(4)

Q1)

a) LPG could help meet these regulations because it emits 15% less CO_2 than compared to petrol, 30% less CO, and 50% less NO_x than petrol. Bioethanol is also a good choice because it is a second-generation alcoholic fuel. It has a high energy density and can be mixed with gasoline.

b) LPG is already used in about 3% of existing cars, so there's already an existing infrastructure that would need to be expanded. The fueling might have to be standardized globally. The biggest change internally in motors would have to be the vapouriser. It does increase the ignition system maintenance and valve wear because of lower lubricity.

Bioethanol has low flammability so it would have to be mixed still with gasoline. It has a lower corrosiveness though, so that is an advantage over E10 for example. Energy density being similar to gasoline makes it quite suitable for current combustion motors.

Bioethanol being a byproduct of distillation, makes it an infinite resource, as long as people keep drinking alcohol, which certainly is not going to stop anytime soon, especially with students. It is green as well because it reduces greenhouse gas emissions.

c) The American Le Mans series is hedging its bets on bioethanol in its future races. They do that because they claim it is easy to implement in current infrastructure, partly due to its low corrosiveness of elastomers and metals such as hoses and engine components. BP has started heavily investing into crops that can be refined into bioethanol. Those crops BP claim have a negative footprint, due to strong pollutants such as CO_2 . Their blends have proven a good fuel economy and improved drivability.

Bioethanol needs distilleries which already exist due to people drinking alcohol. Farming program is also already established.

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LPG has an already existing infrastructure because it is already used. It only needs standardisation and expansion of already existing infrastructure.