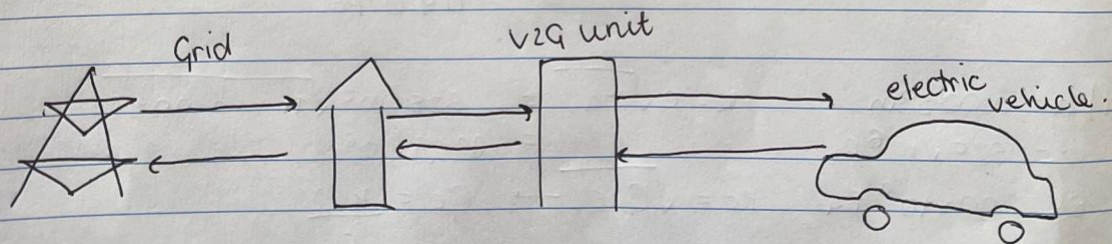


Section A.

1. a) $\frac{1}{2}$ kg of hydrogen $\rightarrow$ more efficient than conventional internal combustion. No carbon emissions from exhaust
 2. 7g of carbon dioxide per km instead of 20.9g
- EV $\rightarrow$ fits the regulations and already widely used.

b) electric vehicle charging is already been made readily available, however the time difference of charging and filling up with petrol may be impractical for some users. Improved environment, potential increase in health. much cheaper than petrol. Different types of chargers may also be an issue. CHADEMO is becoming the main type due to V2G, however, many other chargers are still being used.

c) Vehicle 2 grid could be set in place to help electric vehicles to be environmentally and economically successful. This allows electric vehicle batteries to store energy and discharge it back to the electricity network when it's most needed. In 2011 in the Tohoku earthquake and tsunami, Nissan sent 66 Nissan Leafs which acted as the primary power supply for almost 2 weeks.



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Section B.

3.0 3 c) A notch in a circular shaft.

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

$$h = 0.0018 \text{ m}$$

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

$$P = 55 \text{ Pa}$$

$$1) \frac{h}{r} = \frac{0.0018}{0.0005} \quad \sqrt{\frac{h}{r}} = \sqrt{3.6} = 1.8974$$

$$C1 = 0.935 + (9.22 \times 1.8974) + (0.004 \times 1.8974) = 4.5894$$

$$C2 = -0.552 - (5.327 \times 1.8974) + (0.086 \times 1.8974) = -10.4963$$

$$C3 = 0.754 + (6.281 \times 1.8974) + (0.121 \times 1.8974) = 12.4419$$

$$C4 = -0.138 - (2.876 \times 1.8974) + (0.031 \times 1.8974) = -5.5361$$

$$b) \left(\frac{2h}{D} \right) = \left(\frac{2 \times 0.0018}{0.01} \right) = 0.36$$

$$Kt = C1 + C2 \left(\frac{2h}{D} \right) + C3 \left(\frac{2h}{D} \right)^2 + C4 \left(\frac{2h}{D} \right)^3$$

$$Kt = 4.5894 + (-10.4963 \times 0.36) + (12.4419 \times 0.36^2) + (-5.5361 \times 0.36^3)$$
$$= 2.1469$$

$$ii) \sigma_{max} = Kt \sigma = P Kt = 55 \times 2.1469 = 119.07 \text{ Pa}$$

$$d) a = 0.0038 \text{ m} \quad k = \sigma \sqrt{\pi a} = 625 \times 10^6 \sqrt{\pi \times 0.0038}$$

$$\sigma = 625 \times 10^6 \text{ Pa} = 68.29 \times 10^6$$

$$E = 200 \times 10^9 \text{ Pa} \quad Kc = \sqrt{GcE} \rightarrow Gc = \frac{Kc^2}{E}$$

$$R = (68.29 \times 10^6)^2 \div 200 \times 10^9 = 23316.508 \text{ kPa m}$$

th 55 Pa.

3. a)

b) FMEA:

reducing repair costs:

identify potential failure to prevent maintenance
correct identification of failures so components
can be designed to last longer.

Safety:

identify and eliminate potential failure points
in the design.

identifying causes of in service failures and rectify
issue.

monitoring:

designing the systems that allow thorough monitoring
of design and process.

create a way to assess service components to meet
design expectation / safety requirements.

RPN is calculated by rating the following out of
10: severity S , probability of occurrence P , probability of detection D .
the risk is calculated by multiplying them together
 $S \times P \times D$.

4 a) i Zinc

benefits $\rightarrow$ highest strength, heat treatablelimitation $\rightarrow$ corrosion resistance is not good due to the addition of zinc.ii - first $\rightarrow$ primary alloying elementthird $\rightarrow$ specific alloy elementfourth $\rightarrow$ minimum aluminium content.b) partially reinforced ~~fibres~~

3 structures aligned fibres, random fibres and woven fibres. Aligned fibres are longer than critical fibre length, therefore highly effective in fibre direction. The entire load transferred from matrix to fibre longitudinally. Random fibres aren't as strong, but are easier to make and much cheaper, also isotropic. Woven fibres composite isotropic to loading, much stronger than random fibres but are expensive. ~~partially reinforced~~ harder and stiffer than the matrix material.

- particles are of macro, micro or nano scale.

- improvement of mechanical behaviour.

2 groups: large particle or dispersion strengthened
large particle:

- interaction with the matrix material is at atomic level.

dispersion strengthened:

- 0.01 - 0.1 microns.

- bonds on atomic / molecular levels surrounding matrix

used for fibreglass and carbon fibre

~~aligned fibres, random and woven~~

used for tyre rubber, cemented carbide and spheroidite steel

4.6 continued

fibre reinforced:

used for fibreglass and carbon fibre.

high strength.

specific strength

specific modulus

aligned fibres $\rightarrow$ highly effective along fibre direction.

random fibres $\rightarrow$ isotropic, not strong, cheap and easy to produce.

woven fibres $\rightarrow$ isotropic to loading, much higher strength.

structural:

made from composite and homogeneous material.

multiply carbon fibre and aluminium honeycomb laminar composites.

• sheets of material

• direction and orientation of the sheets is changed for desirable material properties.

• carbon fibre is generally processed this way.

sandwich panel:

faces: strong material eg carbon fibre, aluminium or plywood. the face absorbs the load.

cores: less dense material eg foam, aluminium or nomex. resists deformation perpendicular to the face to resist bending.

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4c) F_j and F_m

$$v_j = 0.45$$

$$v_m = 0.55$$

$$E_j = 65 \times 10^9 \text{ Pa}$$

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

$$\sigma = 30 \times 10^6 \text{ Pa} \rightarrow \sigma_m = 15 \times 10^6 \text{ Pa} \quad \sigma_j = 15 \times 10^6 \text{ Pa}$$

$$E A A_c = E A A_m + E A A_j$$

$$E = 3.2 \times 10^9 +$$

$$E A A_c = E A A_m + E A A_j$$

$$\frac{F_j}{F_m} = \frac{E_j v_j}{E_m v_m} = \frac{65 \times 10^9 \times 0.45}{3.2 \times 10^9 \times 0.55} = 16.6193 \text{ N}$$

$$F_c = F_j + F_m$$