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Automotive Materials and Sustainability

ACHA6012

Ten Pages

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3rd Year Exam

SECTION A

1

A) Two fuels being used are Hydrogen & Bio-Ethanol.

Hydrogen has the potential to reduce emissions by 50-80 percent, which would sit well within the Euro 7 regulations. Can achieve this due to its wide ignition range, which will allow for a very lean combustion. As well as this, Hydrogen burns at a much faster rate than Gasoline. The faster burn rate will result in a much more efficient combustion, which for Hydrogen is 30% more efficient than Gasoline.

Bio-Ethanol has the ability to reduce emissions also. In the current climate, UK vehicles run with 10% Ethanol in their petrol. The production of Ethanol can be outsourced to the farming sector, where sugar can be fermented & then distilled to produce a pure alcohol solution, where a Bio-Ethanol solution is then extracted. The use of Bio-Ethanol from existing farmland can save up to 70% Greenhouse Gas emissions compared to Gasoline production.

SECTION A

1

- B)
- Hydrogen can be practical for a customer.
 - More ~~effe~~ efficient ~~burn~~ ~~burn~~ combustion will result in the miles per fill rising.
 - Alset Global, ~~Pro~~ using a hydrogen powered Aston Martin Rapide S, found that a vehicle can run for 100-200km on purely Hydrogen, which is much further than a Toyota Prius
 - Longer gaps between fuel stops can result in fewer fuel stops, which will in turn result in ~~cheaper~~ ^{better} fuel economy for the vehicle. This makes hydrogen running ~~more~~ cheaper for the consumer.
 - Bio-Ethanol can be grown anywhere, making it highly practical.
 - The use of wasted food, leftover ~~from~~ during the farming process can be used to produce the Bio-Ethanol
 - However, ~~need the~~ to create the Bio-Ethanol, a large amount of sugar is required.
 - British sugar for Bio-Ethanol states that in order to create 55,000 tonnes of Bio-Ethanol, 110,000 tonnes of sugar is needed.
 - Using this much for Bio-Ethanol could have a large impact on food production

SECTION A

1

- c)
- Hydrogen will need lots of infrastructure
 - New pumps will need to be fitted to every fuel station for Hydrogen vehicles
 - This will be an expensive & lengthy process
 - In order to maximise the combustion properties of Hydrogen, extensive engine research will need to be conducted
 - The high burn rate of Hydrogen fuel can damage the engine block if not properly designed to withstand the higher combustion forces
 - Alset Global suggest that to achieve the 30% more efficient burn, different injection & fuel control processes will need to be ~~developed~~ developed
 - BioEthanol will need large amounts of farmland developed
 - Can be ~~an~~ unethical as destroying landscape

SECTION B

2

- A)
- Ionic bonding is where atoms transfer electrons between them in order to achieve a full outer shell.
 - This will involve a donor & receiver, where the donor will lose an electron & become positively charged & the receiver atom will gain an electron & become negatively charged
 - Covalent bonding is where atoms share electrons but don't permanently transfer them.
 - Covalent bonding is rare for metals whereas ionic bonds typically happen between metals & non metals
 - Metallic bonding is where metal atoms shed electrons from their outer shell freely.
 - Creates a sea of delocalised electrons within a lattice of positively charged ions
 - Metallic bonding can only happen to metal atoms
 - Valency is the measure of how many Hydrogen atoms an atom can bond with

SECTION B

2

$$B) a = 0.362 \text{ nm} = 0.362 \times 10^{-9} \text{ m}$$

FACE CENTRED

$$a = 2\sqrt{2} R$$

$$R = \frac{a}{2\sqrt{2}} = \boxed{0.128 \text{ nm}}$$

C) POINT

Vacancy: Structure is missing atoms when the lattice forms, leaving ~~vacancies~~ ^{vacancies} vacancies in the structure. At these points, the ~~at~~ surrounding atoms can distort.

Self-Interstitial: Atom has become positioned between the typical lattice structure atoms. A weakness in the structure is created at these points

SECTION B

2

C (Cont) Substitutional: Original atom in the lattice site of the structure is replaced by a different atom

LINE

Dislocation: Allows ~~for~~ layers of the structure to slip relative to the adjacent layers.

As the layers slip, atomic bonds break & reform, causing a permanent plastic deformation of the structure.

AREA

Grain Boundaries: They are boundaries between the ~~ex~~ crystals in the material. A Grain boundary can impede the dislocation of a structure

SECTION B

2

D) The dislocation movement controls the creep speed. Dislocations will move towards grain boundaries as the structure settles.

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A

i) Zinc is the main alloy. Metal can be heat treated for improved strength. However, the addition of Zinc can make the material brittle.

ii) 1 = Carbon additive
45 = Percentage of Carbon added

B) PARTICLE REINFORCED

- Particulates are harder & stiffer than the matrix
- Depending on particulate size, mechanical behaviour is improved
- Best option for effectiveness will be small, evenly distributed particles
- Example is Concrete, where sand is the particulate

SECTION B

4

B Cont) FIBRE REINFORCED

- Fibres set within matrix
- Typically Carbon Fibre or Fibreglass
- Can provide high strength/stiffness characteristics with minimal weight
- This is due to the low density fibre used
- Strength characteristics of composite can be influenced by the orientation of the fibres
- Aligned fibres provide longitudinal load transfer capabilities
- Random fibres are cheaper but don't provide anywhere near the load transfer capabilities of aligned fibres.
- Woven fibres provide high strength multi-directional load transfer capabilities

STRUCTURAL

- Composites that are made of both composite & homogenous materials
- Combination of materials will obtain properties from both
- Comprised of Faces & Cores
- Faces made from strong material, which will absorb most of the in-plane loading

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B (Cont)

- Cores made of less dense materials that resist the perpendicular deformation
- Typical core is a honeycomb structure

C)

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

$$V_f = 0.45$$

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

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

$$A = 300 \text{ mm} = 300 \times 10^{-3} \text{ m}^2$$

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

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m} \quad \therefore F_c \neq E_c V_c$$

~~$$F_f = E_f V_f$$~~

~~$$F_f = (65 \times 10^9) \times 0.45$$

~~$$= 2.93 \times 10^{10} \text{ N}$$~~~~

4

C Cont) ~~F_m~~

$$\cancel{F_m} \quad \cancel{E_m V_m} \quad F_c = \text{Stress} \times \text{Area}$$

$$F_c = (30 \times 10^6) \times (300 \times 10^{-3})$$

$$= 9 \times 10^6 \text{ N}$$

$$F_c = F_m + F_f$$

$$9 \times 10^6 = F_m + F_f$$

$$F_f = E_f V_f$$

$$= (65 \times 10^9) \times (0.45 \times 10^{-3})$$

$$= \underline{29.25 \times 10^6 \text{ N}}$$

$$F_c = F_f + F_m$$

$$F_m = F_c - F_f$$

$$= (9 \times 10^6) - (29.25 \times 10^6)$$

=

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✓ ✓