

Calum McEwan-Franklin
1803213

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Automotive materials & Sustainability exam

13/05/2022

ACHA 6012

Question 1.)

Due to the proposed 2025 Euro VII emission standards, alternative fuels may be considered to meet legislative standards.

2 possible alternative types of fuel could be Biobutanol & Ethanol.

a) Biobutanol will help reach new legislative standards as it is more environmentally friendly compared with fuels refined from oil due to a reduction in greenhouse gases within the refining process. Biobutanol also has a high calorific value & its energy density is close to gasoline making it more suitable for adoption regarding the current fueling infrastructure.

Ethanol also lends itself well as an alternative fuel as burning ethanol produces between 55 to 90% less CO₂ than fossil fuel, with better efficiency. Ethanol can also be produced sustainably from fermentation of biomass, grown specifically or from waste products efficiency at which depends on the quantity of glucose within the substance. However refining processes must adhere to sustainable standards.

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Question 1)

b.)

Biobutanol & ethanol will both have practical implications to the end user.

Biobutanol has a high energy content comparing to gasoline fuels however has a lower energy density, meaning more would be needed to attain similar mileage. This would mean more frequent filling would be needed or larger fuel tanks. However as Biobutanol is insoluble with water, if adopted at a mass level it could be transported in pipelines, being more efficient & a lower cost. Biobutanol also has low vapour pressure & a higher flash point therefore being safer for consumers. Biobutanol also has a higher viscosity than gasoline reducing fuel system & component wear, reducing consumer costs. Biobutanol also offers good solubility & as such enables blends at any ratios with petrol without engine modification & can be used in diesel engines too.

Ethanol also has a lower volumetric energy density comparing to gasoline meaning more will be needed, this will mean consumers need more frequent re-fuels or larger tanks. Ethanol can be produced locally & refined therefore reducing costs to the consumer.

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Ethanol will require engine modifications which will result in an expense for the consumer.

Also, currently the farming machinery used to produce crop production of ethanol are diesel powered limiting the net benefit of its usage.

C.) A key benefit to Biobutanol as an alternative fuel is its compatibility with current engines, meaning mass adoption could be rolled out within the current infrastructure, this is further supported by its high energy density & low flammability meaning feasibility to replace petrol in the current infrastructure is plausible. Its water insolubility allows pipelines to be used for transportation which would need to be implemented into the current infrastructure but afterwards would offer a very efficient system.

As Biobutanol can be produced ~~as~~ through fermentation of glucose rich biomass, production & refinement can be local, this in turn creates jobs & reduces transportation costs which should be passed down to the consumer.

Ethanol would also need to be produced locally to maintain a small carbon footprint, alongside local refineries. Biomass ~~fuel~~ production would also benefit from bio diesel to power agriculture equipment, lowering emissions in each production phase.

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Question 2.)

a.) Ionic bonding is when atoms transfer electrons to each other, Covalent bonding is when atoms share electrons but don't permanently transfer them & Metallic bonding is when metal atoms shed electrons from outer shell freely, creating positive charged ions & a sea of electrons known as delocalised electrons, wherein ions form a tight packed lattice structure & electrons fill the gaps.

The valency of an atom denotes its combining power as the atom has an incomplete outer shell & can therefore bond with other atoms. The Valency of an atom can be measured by how many hydrogen atoms it can bond with.

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Question 2,

B.)

As Copper has 4 atoms per cell unit
it is then a face centred cubic

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

$$a = 0.362 \text{ nm}$$

$\therefore$

$$R = \frac{\left(\frac{a}{2}\right)^2}{2}$$

$$R = \frac{\left(\frac{0.362}{2}\right)^2}{2}$$

$$R = 0.016 \text{ nm}$$

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Question 2.)

C.) point defects at crystalline structures.

- Vacancies, when missing atoms within the lattice allow distortion at the surrounding atoms.
- Self-interstitials, when an atom is positioned between the normal lattice structure atoms.
- Substitutional, when an original atom in the lattice structure is replaced by a different type of atom.

line defects at crystalline structure.

- Dislocations, caused by lattice layers slipping relative to their adjacent layers. breaking original bonds & forming new ones. this produces a permanent plastic deformation at the structure.

Area defects at crystalline structure.

- Grain boundaries create area defects in the crystalline structure. The bonding structure at the crystalline structure changes. Orientation at the crystalline structure changes & as such grain boundaries can act to impede dislocations.

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Question 2.)

d.) The creep failure mechanism that controls the speed of creep in the secondary stage is Dislocation at the crystalline structure. The applied stress will cause the dislocations/defects to move towards the grain boundaries. At the grain boundaries, Dislocations will generally find way to the triple point, the intersect of 3 grain boundaries as this is the weakest point in the structure. This deformation phase is the predictable stage of creep & acts in a linear manner.

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* Question 4.)

a) The main alloying element in the aluminium 7xxx series group is Zinc, the benefit at this is the material is heat treatable for increased strength but at the compromise of becoming brittle.

aii) steel 1045 informs that the steel has the following properties.

1 = the steel type is Carbon

0 = the steel is not resulfurised

45 = the steel has 0.45% carbon content.

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Question 4.)

b.)

The three classification groups of Composites are particle reinforced, fibre reinforced or structural.

Particle reinforced composites have the following properties.

- made with large or dispersion strengthened particles, which differ on the reinforcement/strengthening mechanism. whereby smaller particles form bonds on atomic ~~atom~~ or molecular levels to surrounding matrix restricting plastic deformation, large particles are not dimensionally large but the interaction with matrix material is not on a molecular level. An example of a large particle Composite is concrete.

The volume fraction of particle & matrix determines the mechanical properties of the composite.

Fibre reinforced composites are the most common type of composite & most technologically important composite. They are subclassified by fibre length, with short fibres unable to produce significant improvement in strength.

Fibre orientation also has a contribution to mechanical properties & common orientations are; aligned fibres, Random fibres & woven fibres. each orientation affects different strength properties

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along with differing cost of production.

Structural composites are made up of both structural & homogeneous materials, combined, the material takes properties from both. The composite properties depend on geometric construction as well as the material properties. An example of this is a laminar composite wherein sheets of material are stacked with the direction & orientation of the sheets giving the desired properties.

Another example is a sandwich panel wherein the face material is strong & the core material is less dense but resists deformation perpendicular to the face plane by utilising Honeycomb & Hexagonal Cells.

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Question 4.)

C.)

fibre reinforced composite
longitudinal loading

$$\sigma = 30 \times 10^6 \text{ pa}$$

$$V_f = 0.45\%$$

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

$$V_m = 0.55\%$$

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

$$A = 300 \times 10^{-6} \text{ m}^2$$

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m} \therefore \frac{F_f}{F_m} = \frac{(65 \times 10^9)(0.45)}{(3.2 \times 10^9)(0.55)}$$

$$\frac{F_f}{F_m} = 16.62$$

$$F_c = \sigma A \therefore F_c = (30 \times 10^6)(300 \times 10^{-6})$$

$$F_c = 9000 \text{ N}, F_c = F_f + F_m$$

$\therefore$

$$9000 = 16.62 F_m + F_m \therefore 9000 = 17.62 F_m$$

$\therefore$

$$F_m = \frac{9000}{17.62}, \boxed{F_m = 510.78 \text{ N}}$$

$$\therefore F_f = 9000 - 510.78, \boxed{F_f = 8489.22 \text{ N}}$$