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Automotive materials and sustainability

ACHA6012

~~22/05~~ 13/05/22

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- a) Biobutanol energy density is close to gasoline therefore it can be easily converted to petrol cars. The refinement process ~~is~~ also produces less greenhouse gases. When burnt biobutanol generates only carbon dioxide ~~and~~ therefore helping cars meet ~~a~~ more ~~str~~ strict emissions standards.

~~Ethanol~~

~~DME produces~~

- Dimethyl Ether, Sulphur free and metal free emissions, ~~D~~ DME contains no heavy metals and only a trace of sulphur. ~~3~~ It produces no soot or particulate emissions, due to lower burn temperatures there is a reduction in NO_x when compared to diesel fuel.

- b) DME has poor lubricity properties therefore fuel system components may need to be replaced more often ~~as~~ an example of this is fuel injectors. DME has a low calorific value, to achieve ~~similar~~ the same power output as ~~a~~ diesel more fuel will need to be used. ~~2~~ This means that a bigger fuel tank will be needed, more fuel stops and may cost the user more as they will need to buy more fuel. May also run forced induction at extra cost.

Biobutanol as this is an alcoholic based fuel it can cause corrosion on the fuel system components such as rubber fuel line deterioration. Biobutanol can be used in ~~a~~ regular ~~to~~ road vehicles with no modifications making it a cheap alternative.

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c)

Biobutanol is less corrosive than other fuels such as ethanol therefore it can be transported using the existing gasoline pipeline. However biobutanol production uses conventional biomass this ~~may~~ used in ~~agriculture~~ agriculture therefore it may cause issues with the nutritional needs of the population as it will take up land for growing food. More land will need to be used for the production of fuels

Q2

a) Ionic bonding is when atoms transfer electrons between each other. Atoms need complete outer shells to be balanced.

Covalent bonding is where atoms are sharing electrons but not permanently. This happens with atoms close to each other on the periodic table. For ionic bonding a donor and receiver atom is required to distribute electrons between them, this differs to covalent bonding as they share the electrons. Metallic bonds instead of directly sharing electrons they shed electrons from their outer shell. This creates positively charged ions and a group of free electrons.

The valency of an atom means how many hydrogen atoms it can bond with if 3 hydrogen atoms can be added ~~to~~ the atom has a valency of 3.

b) Atomic radius of copper

Face Centred cubic dimension

$$a = 0.362 \text{ nm} \times 10^9$$

$$= 3.62 \times 10^{-10}$$

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

$$R = \frac{a}{2} \times \frac{1}{\sqrt{2}}$$

~~$$R = \frac{3.62 \times 10^{-10}}{2} \times \frac{1}{\sqrt{2}} = 1.279 \times 10^{-10} \text{ m}$$~~

$$\frac{3.62 \times 10^{-10}}{2 \times \sqrt{2}} = 1.279 \times 10^{-10} \text{ m}$$

c) Point defects, missing atoms when the lattice forms causes vacancies in the structure allowing distortion of the surrounding atoms, this happens naturally and can't be avoided, the amount of vacancies depends on temperature. Self-interstitial defects occur when an atom has become positioned between the lattice structure causing the structure to deform around the atom. Substitutional defects occur when the original atom in the lattice site of the a crystalline structure is replaced by a different type of atom. This atom will only occupy the ^{lattice site} position in the structure and not the interstitial position.

Line defects are caused by dislocation in the lattice, which are a defect in the structure. Dislocations allow layers of the lattice to move relative to their adjacent layers. As areas move the bonds between atoms break, with new bonds forming once the slip is completed. The slip produces permanent plastic deformation of the structure.

~~Area defects or grain boundaries are also a defect in the structure~~ Area defects are caused by grain boundaries which disrupt the crystalline structure. Grain boundaries are the boundaries between the crystals in a material - Bonding structure changes. Orientation of crystals is changed.

d) Refractory metals can be added to the base materials, refractory metals have good thermal degradation properties, this makes them ~~good~~ excellent at reducing the onset of creep. They create stronger grain boundaries as well as diffusing into the main material. ~~Single~~ Change the grain size. Single crystal structures are better as they don't have grain boundaries. Fine grain sizes also reduce the rate of creep.

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a)

- i) Zinc is the main alloying element. It is least treatable for increased strength. The alloy will become brittle therefore will not be used alone

ii)

- ii) First digit is 0 carbon steel
the third and fourth digits show the percentage of carbon

b) Particle - Reinforced

- the particles are harder and stiffer than the matrix material.
- Particles are of macro or nano scale. Improvement of mechanical behaviour depends on interface bonding. Large particle composites are not dimensionally large but the interaction with the matrix is not on an atomic level. Smaller particles bond on an atomic level and are roughly 0.01-0.1 microns. This restricts plastic deformation. Concrete is a large particle composite, the volume ~~of~~ fraction of the particle and matrix determines the mechanical properties of the composite

Fibre reinforced

Fibreglass and carbon fibre are commonly used. They are high in strength and stiffer and low weight, often used in vehicle part manufacturing. Fibres can be aligned differently within the matrix to produce different material properties. Aligned fibres are effective along fibre direction. The fibres are often brittle, failing with minimum plastic deformation. Matrix materials are often ductile, acting in a

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plastic manner. Fibre reinforced composites will share aspects of both.

- Structural composites are made up of both composite and homogeneous materials. Combined, these create a material with the properties of both. The composite properties are not only dependent on the material properties of the component materials, but the geometric construction of the composite plays a large part. Sandwich panel composites consist of faces and cores. The faces are made from a strong material often aluminium. The core is made from a less dense material such as foam or Nomex. Cores resist deformation perpendicular to the face of the panel.

c)

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m}$$

$$\frac{65 \times 0.45}{32 \times}$$