

4b) 3 Groups:

PARTICLE REINFORCED: WHERE THE PARTICULATES ARE HARDER AND STIFFER THAN THE MATRIX MATERIAL. PARTICLES ARE MACRO, MICRO AND NANO SCOPIC SCALE. THE MECHANICAL BEHAVIOUR CAN BE IMPROVED DEPENDING ON INTERFACE BONDING

i) LARGE PARTICLE REINFORCED, WHERE LARGE IS A RELATIVE TERM, AND INTERACTION WITH THE MATRIX IS NOT ON THE ATOMIC LEVEL.

ii) DISPERSION STRENGTHENED HAS MUCH SMALLER PARTICLES FOR REINFORCEMENT, TYPICALLY 0.1-0.01 MICRONS. BONDS ARE FORMED ON MOLECULAR OR ATOMIC LEVELS TO SURROUNDING MATRIX, RESTRICTING PLASTIC DEFORMATION.

CONCRETE IS A COMMON LARGE PARTICLE COMPOSITE, WITH ALUMINIUM OXIDE BEING A DISPERSION STRENGTHENED COMPOSITE.

GREIG WESTERN 1804348
13/5/22
ACHA 6012

10 OF 11

4b FIBRE REINFORCED COMPOSITES:

CARBON FIBRE, Kevlar AND FIBREGLASS ARE WELL KNOWN IN THIS CLASS WITH HIGH SPECIFIC STRENGTH OR STIFFNESS BEING REQUIREMENTS. SPECIFIC STIFFNESS KNOWN AS SPECIFIC MODULUS.

THESE ARE USED IN AIRCRAFT AND MOTORSPORT AS THEY ARE STRONG AND LIGHT BUT EXPENSIVE

STRUCTURAL COMPOSITES:

LAMINATES AND SANDWICH PANELS.

LAMINATES ARE MADE UP OF SHEETS PLACED IN DIFFERENT DIRECTIONS TO MAKE USE OF DIRECTIONAL STIFFNESS OR STRENGTH. SANDWICH PANELS USE FACES OF COMPOSITE OR OTHER MATERIALS ~~AND~~ EITHER SIDE OF A LESS DENSE MATERIAL. ~~THESE ARE NOT~~ HONEY COMB IS OFTEN USED.

GREIG WEBSTER 1804348
13/5/22
ACHA 6012.

PAGE 11 of 11

$$4c) V_f = 0.45 \therefore V_m = 0.55$$

$$A = 300 \text{ mm}^2 = ~~3 \times 10^{-5} \text{ m}^2~~ 3 \times 10^{-4} \text{ m}^2$$

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

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

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

LONGITUDINAL SO ST

$$E_u = E_m V_m + E_f V_f$$

$$= ((3.2 \times 10^9) \times 0.55) + ((65 \times 10^9) \times 0.45)$$

$$= 1.76 \times 10^9 + 29.25 \times 10^9$$

$$= 31.01 \times 10^9 \text{ Pa} = 31.01 \text{ GPa}$$

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

$$= \frac{29.25 \times 10^9}{1.76 \times 10^9} = 16.62 ~~16.62~~ ~~16.62~~ ~~16.62~~$$

$$\therefore F_f = 16.62 F_m$$

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13/5/22
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ACHA 6012

PAGE 6 OF 11

2) POINT DEFECTS HAVE 3 SUBCATEGORIES:

- i) VACANCIES: THESE ARE MISSING ATOMS IN THE LATTICE STRUCTURE ALLOWING ATOMS SURROUNDING THE VACANCY TO DISTORT. THESE OCCUR NATURALLY, CANNOT BE AVOIDED, AND ARE DETERMINED BY TEMPERATURE UP TO MELTING POINT, MEASURED USING THE RATIO OF ~~VACANT~~ VACANT SITES TO FILLED SITES, KNOWN AS EQUILIBRIUM CONCENTRATION.
- ii) SELF INTERSTITIALS: THESE OCCUR WHEN THE LATTICE STRUCTURE IS INTERRUPTED BY AN ATOM POSITIONED BETWEEN THE NORMAL STRUCTURE.
- iii) SUBSTITUTIONAL: THIS IS WHEN A DIFFERENT ATOM TO THE ORIGINAL LATTICE IS INTRODUCED INTO THE STRUCTURE.

LINE DEFECTS ARE CAUSED BY DISLOCATIONS IN THE LATTICE ALLOWING LAYERS TO SLIP RELATIVE TO ADJACENT LAYERS. BONDS ARE BROKEN IN THIS MOVEMENT WITH NEW BONDS FORMED ONCE THE SLIP COMPLETES. PERMANENT ~~IS~~ PLASTIC DEFORMATION IS PRODUCED.

GREIG WESTERN
1804348
13/5/22

PAGE 1 OF 11

MATERIALS AND SUSTAINABILITY
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SECTION A

1. 2 ALTERNATIVE FUELS

HYDROGEN

BIOETHANOL

9) ALSET GLOBAL HAS DEVELOPED A HYBRID HYDROGEN SYSTEM WHICH CAN ~~BE~~ USED TO BLEND PETROL AND HYDROGEN TOGETHER IN ANY PERCENTAGE FROM 0-100%. WITH IT'S WIDE IGNITION RANGE HYDROGEN CAN BE BURNED IN A VERY LEAN MIXTURE ALLOWING UP TO 30% INCREASED EFFICIENCY OVER PETROL. HYDROGEN'S ONLY EMISSION IS WATER.

BIOETHANOL, PRODUCED FROM SUGAR BEET, CAN BE ADDED TO PETROL UP TO 5%. ACCORDING TO BRITISH SUGAR, ~~THE~~ GREEN HOUSE GASSES CAN BE REDUCED BY OVER 70% COMPARED TO PETROL ALONE.

GREIG WESTER 1804348
1804348
13/5/2022
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ACHA 6012

PAGE 2 OF 11

1b) PRACTICALITIES:

HYDROGEN IS VERY DIFFICULT TO STORE DUE TO IT'S DENSITY. NOT ONLY WILL IT SEEP PAST SEALS BUT IT MUST ALSO BE STORED AT VERY HIGH PRESSURES (300 - 450 BAR ACCORDING TO ACSET GLOBAL) TO ACCOUNT FOR IT'S LOW DENSITY. ~~W~~ WITHOUT THE NEED FOR EXCESSIVELY FREQUENT REFUELLING. HYDROGEN ALSO PRODUCES APPROXIMATELY 20% LESS POWER COMPARED TO PETROL WHEN TESTED IN AN ASTON MARTIN.

BIOETHANOL CAN HAVE DETRIMENTAL EFFECTS ON THE FUEL LINES IF NOT DESIGNED FOR THE FUEL. COMPONENTS CAN CORRODE OR BE EATEN AWAY CAUSING EXTRA COST IN REPLACEMENT DUE TO IT'S LOWER SPECIFIC ENERGY CONTENT. ONE MUST ALSO CARRY MORE FUEL FOR THE SAME POWER REQUIREMENTS.

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13/5/22

MATERIALS + SUSTAINABILITY

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1c)

HYDROGEN WILL REQUIRE ENTIRELY NEW INFRASTRUCTURE IN PRESSURE RESISTANT TANKS WITH VERY TIGHT TOLERANCE SEALS. VEHICLES FUEL STORAGE FACILITIES WILL ALSO NEED TO BE CHANGED TO ACCOUNT FOR THE SAME ISSUES, AND MUST BE IN ADDITION TO ANY EXISTING PETROL FUEL SYSTEM, INCREASING WEIGHT. THE TRANSPORT OF HYDROGEN TO FUEL STATIONS MUST ALSO ~~BE~~ BE ADDRESSED, POSSIBLY USING PIPELINES INSTEAD OF TANKERS.

BIOETHANOL WOULD REQUIRE A MASSIVE INCREASE IN THE PRODUCTION OF CROPS TO PRODUCE THE FUEL. THE FUEL, BEING HYGROSCOPIC, ALSO HAS A SHORTER SHELF LIFE THAN PETROL ALONE DUE TO THE INGRESS OF WATER. STORAGE TANKS AND FUEL DISPENSING PIPES MUST ALSO BE RESISTANT TO CORROSION AND RUBBER BEING BROKEN DOWN BY THE FUEL.

SECTION B.

2.

a) IONIC BONDING DESCRIBES THE TRANSFER OF ELECTRONS BETWEEN ATOMS TO ACHIEVE A COMPLETE OUTER SHELL OF A RECEIVER FROM A DONOR. RECEIVERS WILL HAVE A VALENCY NUMBER HIGHER TO THE MAXIMUM CAPACITY OF THE OUTER SHELL.

COVALENT BONDING IS THE SHARING OF ELECTRONS TO TRY TO ACHIEVE A FULL OUTER SHELL. THIS USUALLY HAPPENS IN NON METALS BETWEEN ATOMS OF SAME OR SIMILAR ELEMENTS ON THE PERIODIC TABLE.

METALLIC BONDING REQUIRES METAL ATOMS TO SHED ELECTRONS FROM THEIR OUTER SHELLS LEAVING SURPLUS ELECTRONS, KNOWN AS DELOCALISED ELECTRONS, TO FILL GAPS MADE BY IONS IN THEIR CLOSELY PACKED LATTICE STRUCTURE. THESE IONS ARE POSITIVELY CHARGED DUE TO THE SHED ELECTRONS. THE NUMBER OF ATOMS IN THESE STRUCTURES IS NOT SET, MEANING THE CHEMICAL FORMULA IS LESS IMPORTANT THAN FOR GASSES.

2b) COPPER, 4 ATOMS PER UNIT CELL = FACE CENTRED

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

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

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

$$a = 0.362 \text{ nm} = 3.62 \times 10^{-10} \text{ m}$$

$$\therefore \frac{\left(\frac{3.62 \times 10^{-10}}{2}\right)^2}{2} = R$$

$$\therefore R = 1.638 \times 10^{-20} \text{ m}$$

2c. AREA DEFECTS.

GRAIN BOUNDARIES CREATE AREA DEFECTS IN CRYSTALLINE STRUCTURE. THESE BOUNDARIES IMPEDE DISLOCATIONS AS THEY ARE BETWEEN CRYSTALS IN A MATERIAL, CHANGING THEIR ORIENTATION IN THE STRUCTURE.

d) 3 STAGES OF CREEP:

PRIMARY: MATERIAL DEFORMS ~~TO~~ DUE TO APPLICATION OF LOAD. STRAIN RATE SLOWS DUE TO WORK HARDENING

SECONDARY: THE PREDICTABLE STAGE, DEFORMATION STABILISES TO ACT LINEARLY.

TERTIARY: PRIOR TO FAILURE THE MATERIAL EXPERIENCES RAPID DEFORMATION.

GREGG WESTER 1804348
13/5/22
ACHA 6012

PAGE 8 OF 11

4.

9) i) THE MAIN ALLOYING ELEMENT IN 7XXX ALUMINIUM IS ZINC WHICH IS HEAT TREATABLE FOR INCREASED STRENGTH. HOWEVER, THE ALLOY BECOMES BRITTLE

ii) 1045

1 : FIRST DIGIT TELLS OF STEEL TYPE BETWEEN 1 + 9, IN THIS CASE CARBON STEEL.

0 : MODIFICATIONS TO THE STEEL, IN THIS CASE NONE

45 : CARBON CONCENTRATION WITH 0.45% IN THIS CASE.