

ACHA 6012 Automotive materials & Sustainability
Nathan Myer 1801800 13/5/2022 Page 1

1) a) Ethanol:

more reqs via efficiency

- bioethanol from plants (corn, wheat)
 - ~~uses excess animal feed?~~
 - ↳ produces animal feed byproduct (the engineer.co.uk, 350kton/year)
 - ↳ doesn't require expensive drilling
- recovered ethanol from CO₂
 - ↳ science alert 2016: catalyst breaks down atmospheric CO₂ to usable fuel - making fuel from pollution

Hydrogen:

decrease emissions, increase efficiency

- only possible emissions are water & NO_x (if burned)
- faster burn + higher temperature = higher pressure = better efficiency

b) Ethanol:

- already partially mixed in fuels
- lower energy density, need larger tanks
- unexpected outcomes: land loss to farming, food shortage? (local area only)

★ as in Brazil, can be pumped just like petrol - little apparent change to the end user

ACHA 6012 materials & sustainability
Nathan Myer 1801800 13/5/2022 Page 2

1) b) contd Hydrogen:

- Safety Worries? - Public may not be reassured by storage safety measures
- Refuelling: may be more complicated, require training?
- if stored in metal hydride - **WEIGHT INCREASE** of vehicles significant
- bigger tanks, less range
- **COST** - storage more complicated, manufacture via electrolysis expensive, these costs may get transferred to user

c) Ethanol:

- Brazil as model:

- ↳ build ethanol plants
- ↳ change/subsidize certain crops (corn, sugarcane)
- ↳ can use existing petrol distribution infrastructure (with some modifications to tanks & pumps)

ACHA 6012 materials & sustainability
Nathan Myer 1801800 13/5/2022 Page 3

1) c) cont'd Ethanol

- from CO_2
 - ↳ big construction - need to make capture devices
 - ↳ expensive catalyst materials
 - ↳ Wildlife (birds?) impact study needed

Hydrogen

- need Storage & Transport
infrastructure & safety standards
 - ↳ compressed & cooled tanks?
 - ↳ metal hydrides?
 - ↳ how to keep it from escaping confinement over time?
- "Green Hydrogen" from solar & wind not well
 - ↳ requires new power plants (dedicated plants?), construction of on-site production plants
 - ↳ note - electrolysis seawater makes chlorine gas - safety concern
- pumps - pressurized hoses?
changing tanks on the vehicles?
massive pump station overhaul needed

ACHA 6012 materials & sustainability
 Nathan Myer 1801800 13/5/2022 page 4

2) a) Ionic bonding is when one atom donates electron(s) to another atom - the resultant atoms have complete-as-possible outer electron shells, but because the # of protons & electrons no longer matches, they also have a positive or negative charge

Covalent bonding sees atoms sharing an electron, as in H_2 or N_2 .
 outer shells are as complete-as-possible, but the electron isn't permanently transferred

In metallic bonding, not unlike a composite structure, free electrons (the "matrix") move about a lattice of positively charged atomic nuclei (the "dispersed phase"). Any number of atoms may be a part of the lattice.

$$b) \quad 4/\text{cell} \rightarrow \text{FCC} \rightarrow a = 2\sqrt{2}R$$

$$\begin{aligned} 0.362 &= 2\sqrt{2}R \\ R &= \frac{0.362}{2\sqrt{2}} = \boxed{0.128 \text{ nm}} \end{aligned}$$

ACHA 6012 materials & sustainability
Nathan Myer 1801800 13/5/2022 Page 5

2) c) • Point defects:

- Vacancy - an atom is missing

 - ↳ warps nearby structure in around it

 - ↳ may encourage voids during creep?

- Self-interstitial - an "extra" atom is wedged between spots in the matrix

 - ↳ warps nearby structure out around it

- Substitution - a different element atom takes a spot in the matrix

 - ↳ material purity decreases

 - ↳ may have unwanted effects on material property

• Line defect: dislocation

- part of the matrix slides -

- as in shear - across another

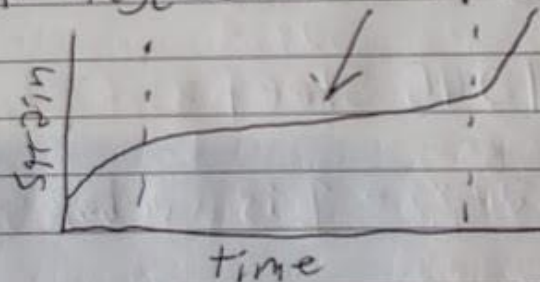
- The mechanism (one of them) behind plastic deformation

- can allow cracks/voids to form

ACHA 6012 materials & sustainability Page 6
Nathan Myer 1801800 13/5/2022

- 2) c) contd. • Area defect: grain boundary
- where one crystal meets another
 - because lattice structure is interrupted, it's easy for impurities to gather / infiltrate here
 - can stop movement of dislocations
 - can provide easy avenue for fracture (brittle fracture)

d) Creep stage 2 is here:



This stage is characterized by dislocation movement - dislocations settle at grain boundaries & triple points, eventually causing cavitation in the 3rd stage

ACHA 6012 materials & sustainability
Nathan Myer 1801800 13/5/2022

page 7

4) 2) i] Aluminum 7xxx - alloyed primarily with Zinc

- Strong and can be heat treated for further strength

- but BRITTLE - susceptible to fracture

"aircraft aluminum" - use it as the skin where hardness is needed but as a structural member, it will need reinforcement. As it's brittle, avoid areas with high strain (as in wing structure).

ii] 1045 Steel

① - alloys - 1 is carbon steel

② - surface finishing

④5 - carbon content - this one is 0.45% carbon (by weight); it's a medium carbon steel, midpoint between strength and ductility.

ACHA6012 materials & sustainability
Nathan myer 1801800 13/5/2022 page 8

4) 6) Composite classes:

- particle reinforcement
- fiber reinforcement
- structural composite

• particle

- "large" particles sit within matrix
- "small" particles intimately bond with matrix
- such as concrete (large),
sintered aluminum powder (small)
- increase stiffness by restricting
dislocation movement

• Fiber

- Fiberglass & carbon fiber!
- Very high strength for weight
(along filament direction)
- commonly seen in racing & high
performance parts
- extremely competent with tensile
loads

ACHA 6012 materials & sustainability
Nathan Myer 1801800 13/5/2022

page 9

4) b) cont'd • Structural

- not different materials, but different structures

- cardboard, aluminum honeycomb
- lightweight
- outside skin carries in-plane loads
- core structure resists bending
- can also be laminated composites like plywood & CF layering
- very good as containers, body panels

c) A) $300 \text{ mm}^2 = .0003 \text{ m}^2$

Vol $.45$

f_{ib} 65 GPa

mat 3.2 GPa

$P = 30 \text{ MPa}$

$.0003 \cdot 30 \text{ e}6 = F_{fib} + F_{mat}$

$\frac{F_{fib}}{F_{mat}} = \frac{65 \text{ e}9 (.45)}{3.2 \text{ e}9 (.55)}$

$\frac{F_{fib}}{F_{mat}} = 16.619$

Force fiber: 8489.2 N

Force matrix: 510.8 N

$\frac{F_{fib}}{F_{mat}} = 16.619$

$F_{fib} = F_{mat} (16.619)$

$.0003 \cdot 30 \text{ e}6 = F_{mat} (16.619) + F_{mat}$

$F_{mat} (16.619 + 1)$

$F_{mat} = \frac{9000}{17.619} = 510.8 \text{ N}$

$9000 = F_{fib} + 510.8$

$F_{fib} = 8489.2 \text{ N}$