

① INITIALLY THE PRODUCT PROPERTIES REQUIRED ARE STRONG TO ENDURE TRANSPORT, CORROSION RESISTANT DUE TO ISOLATING THE PRODUCT FROM WATER VAPOUR AND THIS INCLUDES PREVENTING THE ESCAPE OF AIR (AND THE INGRESS) WITH THE PRODUCT REQUIRING ISOLATION FROM THE ATMOSPHERE THE PRODUCT MUST WITHSTAND INTERNAL + EXTERNAL PRESSURE SO TENSILE STRENGTH WILL NEED TO BE A CONSIDERATION THE MATERIAL WILL ALSO BE REQUIRED TO BE HARD WEARING FOR THE LABEL TO STAY VIBRANT + READABLE. PAINT OR COATINGS MUST BE ABLE TO BE APPLIED AND THE MATERIAL MUST BE LOW COST TO MASS PRODUCE. AN ADDITION TO THIS WILL ALSO BE THE ABILITY TO WITHSTAND TEMPERATURE CHANGES SUCH AS AIR TRANSPORT (COLD IN A CARGO HOLD) AND WARMER DURING SUMMER.

TWO POTENTIAL CHOICES COULD BE PLASTICS, CARDBOARD, TETRA PAK. EACH OF THESE MATERIALS COULD BE SUITABLE BUT HAVE DIFFERENT MANUFACTURING PROCESSES. PLASTIC CAN BE EXTRUDED WITH HEAT, CARDBOARD IS MACHINE FOLDED AS WELL AS TETRA PAK. ALL THREE OF THESE PRODUCTS MUST BE COATED WITH A METALLIC OR WAX/OIL BASED PRODUCT TO KEEP THE PRODUCT FRESH. THIS COMBINATION OF PRODUCT INCREASES COST AND CAN ALSO DECREASE RECYCLABILITY AS THE MATERIALS ARE DIFFICULT TO ~~SEPARATE~~ SEPARATE.

CARDBOARDS ^{HAVE} ~~ARE~~ A FAR HIGHER RECYCLABILITY AND HAVE A LOWER IMPACT ON THE ENVIRONMENT. CARDBOARDS CAN BE DESIGNED IN SUCH A WAY THAT THEY CAN BE STRUCTURALLY SOUND (SARAL TURE) TO TRAVEL INDEPENDENTLY, REDUCING THE NEED FOR EXTERNAL PACKING, UNLIKE PLASTIC.

WHEN IT COMES TO LABELLING OF THE PRODUCT BOTH CARDBOARD/TETRA PAK AND PLASTIC CAN BE EASILY PAINTED/COATED REMOVING THE NEED FOR EXTRA LABELS.

	PLASTIC	CARDBOARD/TETRA PAK
PROS	• CHEAP TO MASS PRODUCE	→
	• EASY TO LABEL	→
	• HIGHER STRENGTH / WEIGHT	• BETTER FOR ENVIRONMENT
	• CAN BE AIRTIGHT	• RECYCLABLE
CONS	• BAD FOR ENVIRONMENT	• STRONG
	• NO RECYCLABILITY AFTER COMBINING WITH METALS	• POOR RESISTANCE TO WATER IF UNTREATED.
	• NEED EXTRA PACKAGING -ING TO TRANSPORT	• STRENGTH COMES AT A COST TO WEIGHT.
		• REQUIRES A LID
		• DIFFICULT TO MAKE AIR TIGHT.

OVERALL MY CHOICE WOULD BE FOR CARDBOARD AS THE ORIGINAL BRIEF WAS HEAVILY LAID TOWARDS THE ENVIRONMENTAL IMPACT. CARDBOARD DOES REQUIRE WOOD HOWEVER IT CAN BE RECYCLED, UNLIKE LAYERED PLASTIC. CARDBOARD IS EASILY MANUFACTURED IN A NUMBER OF SIZES AND SHAPES AND HAS A GOOD STRENGTH/WEIGHT RATIO. CARDBOARD IS CONSIDERED CHEAP TO PRODUCE COMPARED TO PLASTIC AND IS EASILY COATED TO PRODUCE AN ADVERTISEMENT. A COATED CARDBOARD CAN ALSO HOLD FRESHNESS (FOIL LINED) AND PROTECT THE PRODUCT WELL.

② METALLIC BONDING HAS REASONABLE STABILITY AND STRENGTH. THE METALLIC BOND IS THE FORCE OF ATTRACTION BETWEEN THE FREE MOVING ELECTRONS AND POSITIVE METAL IONS.



NEGATIVELY
CHARGED
IONS

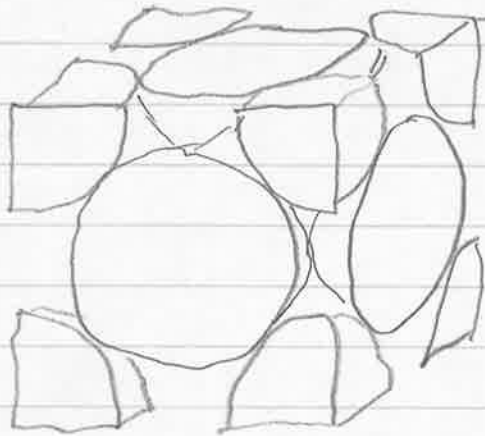


POSITIVELY CHARGED
IONS

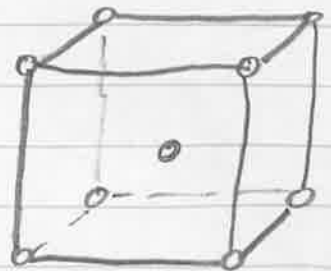
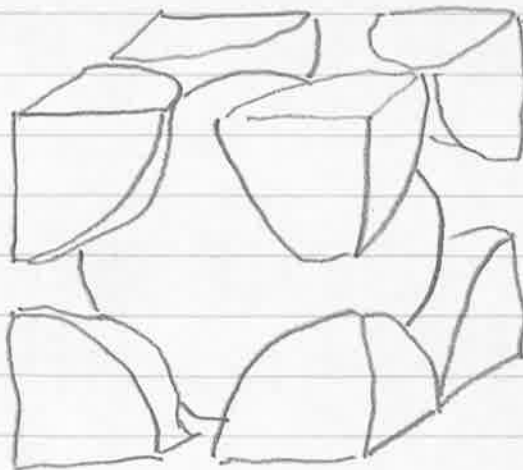
A METAL WITH A VALENCY OF 2 RATHER THAN 1 IS STRONGER BECAUSE THERE ARE MORE ELECTRONS IN THE OUTER SHELL WHICH INCREASES THE ELECTROSTATIC ATTRACTION.

(b) FCC

FCC HAS A TOTAL OF 4 ATOMS PER ^{UNIT CELL} ~~STRUCTURE~~ AND THE PACKING RATIO IS 0.74 $\therefore$ 74%. TO WORK THIS OUT THE FORMULA $x = \sqrt{8} R$ SHOULD BE USED. THIS PACKING STRUCTURE IS THEORETICALLY AS TIGHT AS POSSIBLE

BCC

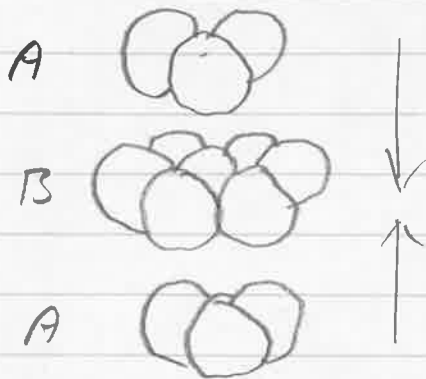
BCC HAS A TOTAL OF TWO ATOMS PER ^{UNIT CELL} ~~STRUCTURE~~ AND HAS A 68% $\therefore$ 0.68 PACKING RATIO. THIS CAN BE WORKED OUT BY THE FORMULA $x = \frac{4}{\sqrt{3}} R$.



HCP

HCP HAS A TOTAL OF 6 ATOMS PER UNIT CELL. ~~AND THIS CAN BE WORKED OUT AS $x = \frac{3\sqrt{3}a^2c}{2}$~~ THE PACKING RATIO IS

74% AND CAN BE WORKED OUT BY USING THE FORMULA $x = \frac{3\sqrt{3}a^2c}{2}$.



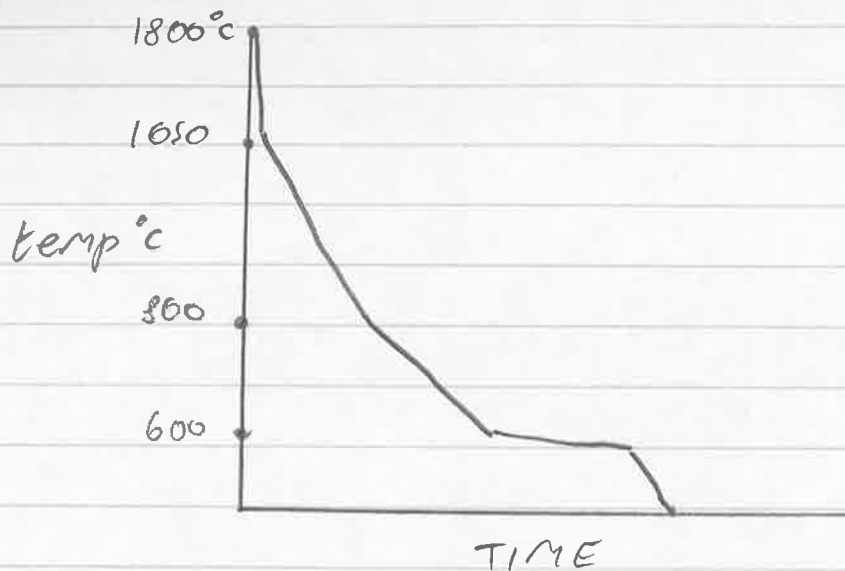
- ③ HCP = 74% $\therefore 0.74$
 BCC = 68% $\therefore 0.68$
 FCC = 74% $\therefore 0.74$

- ④ BASED THAT THE CHART STATES % NI (TO AVOID CONFUSION LIKE IN THE LECTURE) THE MIXTURE IS A LIQUID

THE MIXTURE STARTS AS A LIQUID AND COOLS TO 1650°C WHERE THE CRYSTALS OF β TITANIUM START TO FORM (IT IS DIFFICULT TO TELL FROM GRAPH QUALITY BUT THIS MAY BE $\beta + L$). AS THE ~~LIQUID~~ MIXTURE COOLS IT CONTINUES TO LOSE ENERGY AND AT 800°C THE MIXTURE IS β TITANIUM. THIS IS A BCC CRYSTAL STAGE. AS IT IS COOLED FURTHER TO 800°C THE

MATERIAL BECOMES α TITANIUM AND FREEZES IN A HCP STRUCTURE

②



ENERGY RELEASES AT CHANGE SO COOLS SLOWER

③a) WE REQUIRE HIGH STIFFNESS + LOW DENSITY

COMPOSITES, METALS, ALLOYS, CERAMICS AND POSSIBLY UPPER WOODS.

FOLLOWING THE Y_m VS DENSITY LINES, THESE MATERIALS SIT ON OR NEAR THE LINE.

④ I WOULD CONSIDER COMPOSITES, METALS AND ALLOYS. METALS AND ALLOYS CAN BE EASILY MACHINED AND PROCESSED BUT DO HAVE A SLIGHTLY HIGHER DENSITY. COMPOSITES ARE EXTREMELY LIGHT + STRONG BUT A COMBINATION APPROACH WOULD BE NEEDED AS COMPOSITES CANNOT BE MACHINED.

THE ONLY ISSUE IS WITH NON COATED METALS WHICH OFFER LITTLE CORROSION RESISTANCE.

I WOULD NOT CONSIDER WOOD OR CERAMICS AS YOU CANNOT MACHINE ~~WOOD~~ CERAMICS AND THEY ARE EXTREMELY BRITTLE AND WOOD CAN DEGRADE / ROT AND DOES NOT REACT WELL WITH HEAT (WARPING ETC). WOOD IS ALSO FLAMMABLE.

© TYPICALLY CARBON FIBRE IS VERY LABOUR INTENSIVE TO PRODUCE AND IS USUALLY MADE AS A MONOCOQUE CHASSIS. THE PROBLEM WITH THIS IS THAT IF ANY DAMAGE OCCURS THEN THE WHOLE CHASSIS MUST BE REPLACED. HOWEVER THEY ARE VERY LIGHT. CARBON FIBRE CAN ALSO BE TOO STIFF AND NOT ALLOW FOR ANY 'GIVE' IN THE CAR. THIS COULD ALSO BE A POSITIVE THOUGHT. STEEL SPACE FRAMES ARE EASY TO MAKE AND ALLOW A DEGREE OF FLEXIBILITY. THEY ARE HOWEVER MORE HEAVY AND CORRODE. A POSITIVE THOUGHT IS THAT REPAIRS CAN BE CARRIED OUT TO INDIVIDUAL SECTIONS.

d) WHEN WELDING HAPPENS A FILLER MATERIAL IS MELTED INTO THE CAVITY TO JOIN THE TWO METALS. DURING THIS PROCESS

THE HEAT TRANSFERS INTO THE PARENT MATERIAL IN WHAT IS CALLED THE HEAT AFFECTED ZONE. IN THIS AREA THE MATERIAL PROPERTIES PRACTICALLY CHANGE AND ~~PARENT~~ MATERIAL GRAINS ALIEN TO THE FILLER METAL. ~~TO~~ THE GRAINS SOLIDIFY TO THE UNMELTED BASE MATERIAL CAUSING A FUSION OF MATERIAL.

IF WELDING IS NOT CONTROLLED CORRECTLY THEN THE METAL CAN BECOME BRITTLE AND FATIGUE STRENGTH LOST DUE TO COOLING TOO QUICK THAT CAUSES SMALLER CRYSTALS TO FORM.

BRAZING IS CONSIDERED HIGHER QUALITY BECAUSE IT CAN OFFER STRENGTH EQUAL OR BETTER THAN THE BASE METAL. BRAZED JOINTS ARE FAR MORE DUCTILE. BRAZING ALSO CAN HOLD PRECISION TOLERANCES THROUGH THE PROCESS. BRAZING IS ALSO CARRIED OUT AT A LOWER TEMPERATURE SO THE MATERIAL IS NOT AS SIGNIFICANTLY AFFECTED.

② ANOTHER OPTION IS BONDING MATERIALS, AND RIVETING / FASTENING.

BONDING IS THE JOINING USING A CHEMICAL COMPOUND. THESE COMPOUNDS ARE EASY

TO ADJUST FOR DIFFERENT APPLICATIONS. SURFACE PREP MUST BE FOLLOWED.

PROS

- IMPROVED STIFFNESS
- DAMPS VIBRATION
- GOOD FATIGUE STRENGTH
- SMOOTH CONTOURS

CONS

- SURFACE MUST BE CLEAN
- RIGID PROCESS CONTROL
- H+S CONSIDERATIONS
- FIXTURES/JIGS REQUIRED

FASTENERS CAN BE USED ALSO SUCH AS RIVETS, BOLTS, SCREWS.

PROS

- CORROSION RESISTANT(SS)
- LOW MAINTENANCE
- DURABILITY
- FATIGUE STRENGTH.

CONS

- MUST BE FASTENED CORRECTLY
- MORE EXPENSIVE
- CAN WORK LOOSE

④ THE CYLINDER MUST HOLD UP AGAINST A UNIFORMED PRESSURE EXERTING ON THE INTERNAL + EXTERNAL AREAS OF THE TANK. THE TANK MUST HAVE CORROSION RESISTANCE MUST BE ATTACHED TO A HARNESS, MUST BE ABLE TO BE WORKED AND MACHINED. SHOULD HAVE A HIGH UTS + YIELD STRENGTH. POSSIBLY REQUIRED TO BE COATED TO PROVIDE SALT WATER RESISTANCE.

⑤ 6062 T6 AL

SLIGHTLY HIGHER THAN AVERAGE YIELD STRENGTH. AND RELATIVELY LIGHT. EXPENSIVE TO PURCHASE BUT HAS GOOD CORROSION RESISTANCE

STEEL ALLOY - HOT ROLLED

AVERAGE YS BUT IS VERY HEAVY. GOOD CORROSION RESISTANCE AND MACHINING / FORMABILITY

STAINLESS STEEL 304

HEAVY TO CARRY BUT CORROSION RESISTANT. DIFFICULT TO MACHINE AND WELD / JOIN.

CARBON FIBRE

EXTREMELY STRONG + LIGHT BUT VERY BRITTLE. WOULD NOT DEAL WELL WITH PERPENDICULAR FORCES. ALSO EXTREMELY EXPENSIVE.

I WOULD CHOOSE ALUMINIUM AS IT IS LIGHT, STRONG, GOOD CORROSION RESISTANCE AND CAN BE MACHINED. FOR THE PURPOSE OF A LIFE SAVING DEVICE THE HIGHER COST WOULD BE APPROPRIATE

$$c) \quad \sigma = \frac{Pd}{4t}$$

$$t = \frac{2 \times Pd}{\sigma_{yield}}$$

THE DESIGN RULE APPLIED HAS TAKEN INTO ACCOUNT A 2 TO 1 SAFETY FACTOR AS WE HAVE DOUBLED ~~THE WALL THICKNESS~~ ~~THE PRESS~~ THE PRESSURE THEORETICALLY. THIS ALLOWS US TO KEEP THE USER SAFE

$$d) i) \quad t = \frac{2 P d}{\sigma_{yield}}$$

$$t = \frac{2 \times (20 \times 10^6) \times 0.6}{214 \times 10^6}$$

$$t = \frac{24000000}{214 \times 10^6}$$

$$t = 112.149 \times 10^{-3} \therefore 112.149 \text{ mm}$$

d) ii)

$$VOL = L \times A$$

$$VOL = 0.6 \times 7.853 \times 10^{-5}$$

$$VOL = 4.7118 \times 10^{-5}$$

$$A = \pi r^2 = \pi \times 0.004^2$$

$$A = 7.853 \times 10^{-5}$$

$$A = 7.85 \times 10^{-5}$$

$$VOL = 0.6 \times 7.85 \times 10^{-5}$$

$$V = \underline{4.71 \times 10^{-5}}$$

$$MASS = V \times D$$

$$MASS = 4.71 \times 10^{-5} \times 2700$$

$$MASS = 12.717 \text{ kg} + 2 \text{ kg} = 14.717 \text{ kg}$$

$\uparrow$
 CAPS