

## PAGE 1 OF 10

- ①. MUST BE ISOLATED FROM ATMOSPHERIC WATER VAPOR
- MUST HAVE EYE CATCHING DESIGNS.
  - TIGHT PROOF MATERIALS
  - APPEAL TO OUTDOOR PEOPLE WHO CARE FOR ENVIRONMENT

## REQUIREMENTS:

- MUST KEEP OUT WATER VAPOR FROM ATMOSPHERE
  - MUST BE CHEAP TO PRODUCE
  - MUST BE ENVIRONMENTALLY FRIENDLY
  - MUST HAVE EYE CATCHING DESIGNS
- } MOST IMPORTANT  
TO LEAST IMPORTANT.

## POSSIBLE MATERIALS:

## PLASTIC:

## PROS:

- CHEAP
- RECYCLABLE
- WILL KEEP OUT WATER VAPOR
- EASY TO FORM/MOULDABLE
- STRONG AND LIGHTWEIGHT

## CONS:

- CAN BE HARMFUL TO THE ENVIRONMENT IF NOT CORRECTLY DISPOSED OF.

## CARDBOARD:

## PROS:

- CHEAP
- RECYCLABLE
- CAN BE SHAPED/MOULDABLE
- NOT SO HARMFUL TO ENVIRONMENT
- LIGHTWEIGHT

## CONS:

- NOT AS STRONG AS PLASTIC
- NOT SO GOOD FOR KEEPING OUT MOISTURE.
- CAN'T BE AS EASILY FORMED AS PLASTIC.

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PAGE 2 OF 10

PLASTIC CAN BE MORE HARMFUL TO <sup>THE</sup> ENVIRONMENT THAN CARDBOARD. HOWEVER WITH NEW ADVANCES IN TECHNOLOGY, WE ARE ABLE TO RECYCLE MOST OF THE PLASTIC WE PRODUCE. PROFITS WILL / COULD BE IMPACTED WITH THE USE OF PLASTIC DUE TO MORE EXPENSIVE MANUFACTURING COSTS AND HIGHER MATERIAL PRICES ETC. YOU WILL HOWEVER SAVE MONEY ON PRODUCE COSTS AS THE PLASTIC WILL KEEP THE SNAIL ~~MOIST~~ WATER VAPOR FROST FOR LONGER, THEREFORE INCREASING SHELF LIFE OF PRODUCE.

I FEEL PLASTIC WOULD BE THE OBVIOUS CHOICE AS THE PROS FAR OUTWEIGH THE CONS.

PAGE 3 OF 10

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- ① METALS WITH 2 VALENCE ELECTRONS ARE GENERALLY STRONGER THAN METALS WITH 1 BECAUSE OF THE EXTRA ELECTRONS ON THE OUTER SHELL. THIS MEANS THE ELECTROSTATIC ATTRACTION BETWEEN MOLECULES ARE STRONGER. SOME EXAMPLES OF 1 VALENCE AND 2 VALENCE METALS ARE AS FOLLOWS:

(1 VALENCE ELECTRON)

ALKALI METALS:

- LITHIUM (Li)
- SODIUM (Na)
- POTASSIUM (K)

(2 VALENCE ELECTRONS)

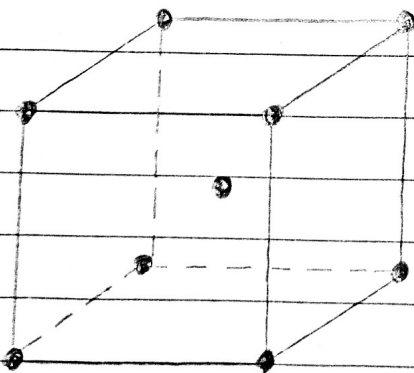
ALKALINE EARTH METALS:

- MAGNESIUM (Mg)
- CALCIUM (Ca)
- RADIUM (Ra)

METALS WITH 2 VALENCE ELECTRONS ALSO HAVE A HIGHER MELTING POINT.

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BCC (BODY CENTERED CUBIC)

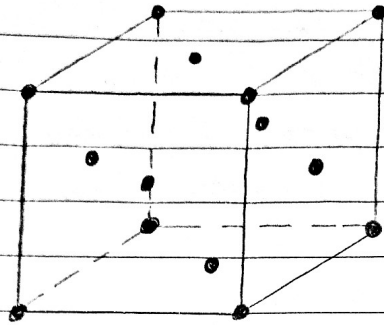
PACKING RATIO = 0.68

- ATOMS ARRANGED IN A CUBE WHERE EACH CORNER SHARES AN ATOM WITH ONE IN THE CENTRE.

PAGE 4 OF 10

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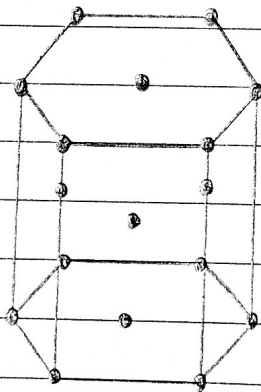


FCC (FACE CENTERED CUBIC)

PACKING RATIO = 0.78

- EACH CORNER HAS A FRACTION OF AN ATOM WITH 6 ADDITIONAL FULL ATOMS AT THE CENTRE OF EACH FACE. EACH CORNER ATOM REPRESENTS  $\frac{1}{8}$  OF AN ATOM.

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HCP (HEXAGONAL CLOSED PACK)

PACKING RATIO = 0.74

- LAYERS OF SPHERES PACKED SO ALTERNATING LAYER OVERLAP ONE ANOTHER. IT IS A SLIP SYSTEM, WHICH IS A CLOSED-PACKED STRUCTURE.

- ③ BCC (BODY CENTERED CUBIC) - PACKING RATIO = 0.68      68%
- FCC (FACE CENTERED CUBIC) - PACKING RATIO = 0.78      78%
- HCP (HEXAGONAL CLOSED PACK) - PACKING RATIO = 0.74      74%

(SOME RESEARCH SUGGESTS FCC IS 0.74, HOWEVER MAJORITY SAY 0.78).

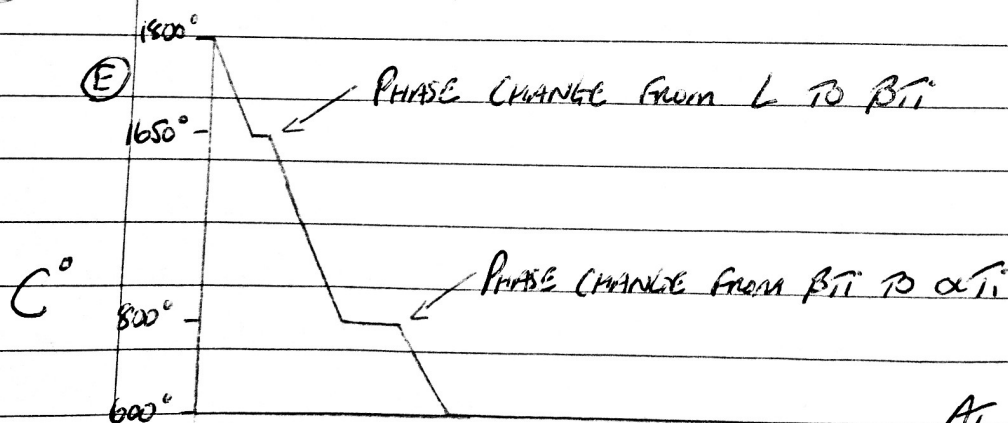
PAGE 5 OF 10

① 97% TITANIUM

3% NICKEL

HEATED TO 1800°C

① MIXTURE WILL BE PURELY LIQUID AT 1800°C

② ~~MIXTURE AT 1650°C THE MIXTURE WILL BE PURELY A LIQUID ALLOY~~③ ~~MIXTURE AT 800°C~~② MIXTURE AT 1650°C IS  $\beta$  TITANIUM MIXED WITH LIQUID③ AT 800°C WE HAVE  $\beta$  TITANIUM AND LIQUID (MELT) AND IS IN A LIQUID STATE. JUST BEFORE THE NEXT PHASE CHANGE.④ AT 600°C IT BECOMES PURE  $\alpha$  TITANIUM (HCP)

AT 600°C IT IS PURELY  $\alpha$ Ti  
(TITANIUM WITH AN HEXAGONAL  
CLOSED PACKED CRYSTAL STRUCTURE)

③ MAXIMISE STRENGTH/DENSITY WHILE KEEPING CHASSIS STRONG

④ AL ALLOYS CFRP (CARBON FIBRE REINFORCED PLASTIC) - COMPOSITES

TI ALLOYS - METALS

WC - TUNGSTEN CARBIDE - TECHNICAL CERAMICS

$Al_2O_3$  - ALUMINIUM ALLOY - TECHNICAL CERAMICS

THESE CLASSES HAVE BEEN CHOSEN DUE TO THEIR LIGHT WEIGHT AND HIGH STRENGTH, THEY ARE MATERIALS READILY AVAILABLE.

⑤ TECHNICAL CERAMICS WOULD BE REMOVED FROM THE LIST ON FURTHER RESEARCH, DUE TO THEM NOT HAVING THE REQUIRED STRENGTH FOR THE TASK.

COMPOSITES WOULD ALSO NEED TO BE REMOVED, FOR THE SAME REASONS AS THE TECHNICAL CERAMICS.

THE ABOVE MATERIALS LOOKED VIABLE ON INITIAL THOUGHTS, HOWEVER WERE FOUND TO BE UNREASONABLE AND IMPRACTICABLE <sup>AFTER</sup> FURTHER THOUGHT. THIS PROCESS IS FUNDAMENTAL TO FINDING MATERIALS FOR USE.

⑥ CARBON FIBRE WOULD BE A GREAT CHOICE, DUE TO ITS LIGHTWEIGHT AND THE FACT IT CAN WITHSTAND HIGH ENERGY FORCES. IT HAS MORE STRENGTH THAN METAL AND IN GENERAL ACHIEVES HIGHER LEVELS OF PERFORMANCE COMPARED TO ITS STEEL COUNTERPARTS.

• STEEL IS A FAR CHEAPER <sup>OPTION</sup> ~~STEEL~~, HOWEVER SOME THINGS MUST BE SACRIFICED AS DISCUSSED ABOVE. IT IS EASIER TO REPAIR THAN CARBON FIBRE AND ALTHOUGH FAR CHEAPER, WOULD

• WE DO HOWEVER SEE THAT MONEY IS NO ISSUE FOR THE CUSTOMER ON THIS OCCASION, SO CARBON FIBRE WOULD STILL BE THE RECOMMENDED MATERIAL OF CHOICE.

PAGE 7 OF 10

① BRAZING IS DEEMED A HIGHER QUALITY OPTION FOR A NUMBER OF REASONS, SOME OF THOSE REASONS ARE AS FOLLOWS:

- EASIER TO JOIN TWO DISSIMILAR METALS TOGETHER.
- CREATES STRONGER JOINTS
- BARELY ALTERS BASE METALS PROPERTIES
- LEAVES A NICE FINISH

BRAZING VS WELDING THE NAME SAME MATERIAL ALSO DIFFERS. YOU REQUIRE A LOWER TEMPERATURE TO BRAZE THAN YOU WOULD WITH WELDING. ( $620^{\circ}\text{C}$  -  $870^{\circ}\text{C}$ ) AND BASE METALS ARE NEVER MELTED DURING THE BRAZING PROCESS.

WELDING GENERALLY REQUIRES MUCH MORE HEAT GENERALLY RESULTING IN TEMPORARILY MELTING THE BASE METAL, AND THEREFORE CHANGING THE MATERIAL PROPERTIES THIS CAN WEAKEN STEEL AND REDUCE HARDNESS AND STRENGTH.

② TWO OTHER OPTIONS FOR JOINING COMPONENTS COULD BE A MECHANICAL FASTENER, NUT AND BOLT ETC. THIS IS THE CHEAPEST AND EASIEST WAY, HOWEVER IS NOT ALWAYS AN OPTION.

GLUING IS ANOTHER OPTION, IT MAY NOT BE AS STRONG AS WELDING OR MECHANICAL FASTENING BUT WILL MEAN HAVING SOMETHING WATERTIGHT WHICH WELDING CAN DO, BUT CORROSION IS INEVITABLE.

PAGE 8 OF 10

④ 20 MPa

EXTERNAL LENGTH = 600mm

EXTERNAL DIAMETER = 100mm

① THE MATERIAL USED IN THE AIR CYLINDER MUST BE ABLE TO WITHSTAND THE PRESSURE OF THE AIR GAS INSIDE, WHICH WHILE BEING ABLE TO MAINTAIN IT UNDER WATER. IT MUST BE AS CORROSION RESISTANT AS POSSIBLE AS IT WILL BE USED UNDERWATER. IT SHOULD BE HARD ENOUGH TO BUMP INTO ROCKS ETC. AND IDEALLY WOULD BE ABLE TO HAVE REPAIR WORK DONE TO IT IF REQUIRED, BARPING, WELDING ETC.

- TOUGHNESS
- CORROSION RESISTANT
- ABLE TO HANDLE HIGH PRESSURE
- ALLOW FOR WORK TO BE DONE.
- LIGHTWEIGHT WHEN OUT OF WATER.

②

- 6062 TO ALUMINIUM - IT HAS A GOOD YIELD STRENGTH, WHICH CAN HANDLE 11 TIMES THE PRESSURE REQUIRED. IT HAS A LOW DENSITY SO WILL BE EASY TO LIFT OUT OF THE WATER AND MEAN EASY TO TRANSPORT. IT IS USED ON AIRCRAFT FUSELAGES SO IS KNOWN TO WORK WELL WITH EXPANSION / CONTRACTION AND ALUMINIUM IS CORROSION RESISTANT IN NORMAL ATMOSPHERE.

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PAGE 9 OF 10

- STEEL A1020 - HOT ROLLED - LOWER YIELD STRENGTH ~~ALWAYS~~ BUT STILL WITHIN RANGE. HIGHER DENSITY SO HEAVIER TO <sup>CARRY</sup> ~~CARRY~~ ~~LOADING~~ AND NOT CORROSION RESISTANT.
- 304 STAINLESS STEEL - VERY HIGH STRENGTH, STILL HEAVY AND MORE CORROSION RESISTANT THAN 1020 STEEL BUT NOT ALUMINIUM.
- PRE-PREGNATED CARBON FIBRE - VERY HIGH STRENGTH, VERY LIGHTWEIGHT AND REINFORCED FOR STRENGTH AND CORROSION RESISTANCE.

CARBON FIBRE COMPOSITE WOULD BE THE CHOICE AS IT IS BY FAR THE LIGHTEST AND STRONGEST AND CAN LOSE THE BEST WITH MINUSING DUE TO ITS MINIMAL TO NO AMOUNT OF METAL.

③  $\sigma$  - HOOP STRESS

P - PRESSURE

D - DIAMETER

T - WALL THICKNESS

$$\sigma = \frac{PD}{4t}$$

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 $\frac{2PD}{\sigma_{YIELD}}$

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PAGE 10 OF 10

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①

$$t = \frac{2Pd}{\sigma_{YIELD}}$$

$$t =$$

$$① \quad F_{TENS} = 1850 \text{ N/A}$$

$$A_{SHA} = \pi r^2 \times L = \pi \times 0.05^2 \times 0.6 = 94.25 \times 10^{-3} \times 10^{-3} = 7.85 \times 10^{-3}$$

$$\text{LENGTH} = 0.6 \text{ m} / 600 \text{ mm}$$

$$\text{DIAMETER} = 0.1 \text{ m} / 100 \text{ mm}$$

$$P = \frac{F}{A} = \frac{1850}{94.25 \times 10^{-3}} = 19.62 \times 10^3$$

$$② \quad t = \frac{2Pd}{\sigma_{YIELD}} = \frac{2 \times 19.62 \times 10^3 \times 0.1}{1850} = 2.12 \text{ mm} \quad 8.48 \text{ mm}$$

$$③ \quad T = \frac{2Pd}{\sigma_{YIELD}} = \frac{2 \times 19.62 \times 10^3 \times 0.1}{1850} = 2.12 \text{ mm} \quad 8.48 \text{ mm}$$

$$④ \quad m = D \times V \quad m = 1.74 \times 4.71 \times 10^{-3} = 8.199 \times 10^{-3} \text{ kg}$$

$$8.199 + 2 = 10.199 \text{ kg}$$