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Materials Exams.

Question 1

A shaft of a vehicle motor is going to be put under a great amount of torque and torsional stress during its life cycle. The motor and shaft in question is told to be put under a varied torque; this suggests that the shaft of the motor will also be put under varying loads.

When considering the material to be used it is important to consider the key properties of the material relevant to the usage; for our motor shaft we must consider the torsional strength and the materials ability to resist a twisting load or torque, also the tensile strength of the material must be considered due to the cyclic loading of the shaft.

A good material to use would be a steel, however, this is based on the material being manufactured correctly before machining. Most motor manufacturers use SAE 1045 cold rolled steel as it generally is more machinable than hot rolled steel and less molten material can be used as there is more control of the outer $\varnothing$ of the component. This Carbon steel is suitable for roughly a 500 HP electric motor so would more than likely be suitable however, other materials such as chrome molybdenum steel and resulfurized steel could

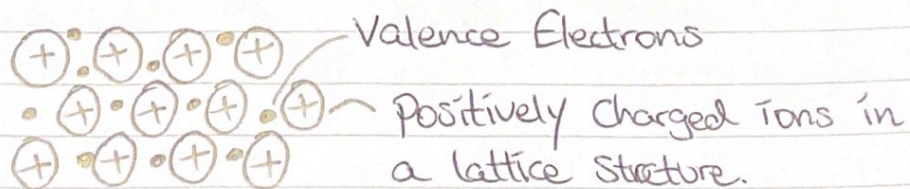
Tummy Game

be used as they are heavier duty, this would of course affect ~~over~~ the 'light as possible' characteristic.

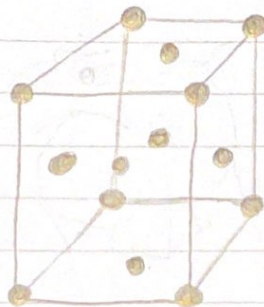
for machining a CNC Lathe would be the ideal equipment as with the correct tooling it could carry out the necessary operations from start to finish.

Question 2

- a) Metallic bonding is the movement of valence electrons which become attracted to and ~~bind~~ ~~to~~ attach to positively charged ions to form bonds. Metals generally have 1 or 2 valence electrons in their outer shell, these electrons possess the highest amount of energy in the atom meaning the more of these electrons that can ~~can~~ form collectively in a pool, the stronger the metallic bond will be, this is why the bonds in some metals are stronger than others.



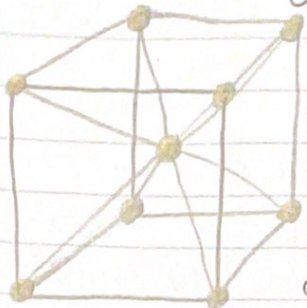
b)



FCC

A face-centered cubic cell structure consists of atoms arranged in a cubic structure where each corner of the cube has a fraction ...

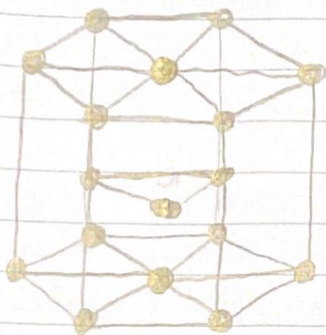
of an atom then an additional 6 full atoms at the center of each cube face.



BCC

A Body-Centered cubic cell structure is a cube with an atom on each corner and an atom in the cubes center. It is

One of the most common structures for metals.



HCP

Hexagonal close packed cell structure has 1 atom per lattice point and 3 inside the prism. HCP is one of the most stable crystal structures and has the highest packing density.

c) Packing Ratio:

$$\frac{\frac{16\pi}{3} r^3}{\sqrt{8}^3 \times r^3} = \frac{\frac{16\pi}{3}}{\sqrt{8}^3} = 0.74$$

d) 10% tin @ 400°C = Liquid.

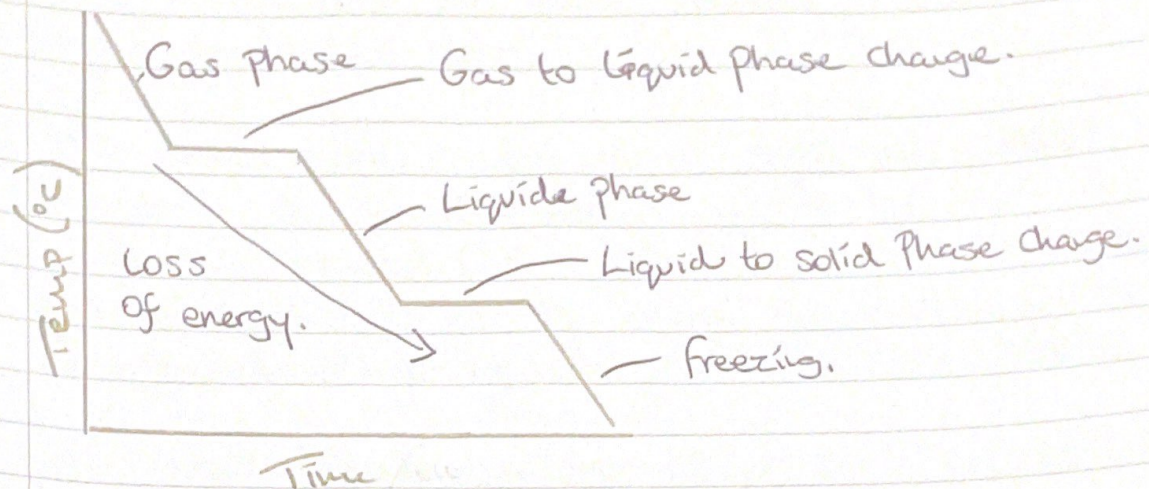
" 250°C = Solid Lead

" 180°C = Solid Lead

" 50°C = Solid Lead + Solid Tin.

% tin for the alloy with lowest melting point: 61.9%

e) Cooling Curve



Question 3

- a) As we are designing for stiffness against material density, & the best class of material to look at ~~is~~ are the composites; ~~exactly~~ in particular the Carbon Fiber Reinforced Plastic, as the stiffness to weight ratio is very good compared to other materials in relatively the same density bracket such as the magnesium alloys. Another good choice would be some of the technical ceramics at the lower end of the density scale as they have an even better stiffness ratio, however they are slightly more dense than the CFRP and can also be costly to manufacture for the application.
- b) For practical reasons some material classes should be discarded, all of the foams, natural materials, elastomers, polymers and metals can be discarded due to a poor stiffness to weight ratio for the intended application; if the budget was very low

for the intended project some compromises could be made with the density, however, this would affect the overall result.

- c) The carbon fibre chassis will be stiffer and lighter, increasing the intended performance of the car's suspension, however, Carbon fibre tends to be more expensive due to its high energy consumption during manufacture, reinforcing each fiber with carbon atoms.

The steel frame can still deliver good figures on the strength and stiffness fronts but it is still roughly half as stiff and a fifth as strong, whilst as being more dense so increasing the net weight of the race car.

- d) During the welding process, the base metal, which is the metal being joined by the weld, can be affected by altering the properties in the heat affected zone. The strength of the material is greatly altered by welding, if the weld is made with too little heat it will not penetrate properly whereas too much will destroy the grain structure of the metal.

Brazing is often deemed a higher quality process for joining metals as long as the filler material is metallurgically compatible with the material and melts at a lower temperature, brazing can create strong joints with barely any alteration to the base metal's properties and grain structure.

- e) Another method to join the frame would be to use a fastening technique such as riveting, this

Method may not be strong enough for the intended use. The last method to join this frame would be to use a type of adhesive bonding which could be possible as adhesive bonding is even used in the aerospace industry today, but would be expensive.

Question 4

- a) The material used for the cylinder must be able to withstand the pressure rating for the intended use, (30 MPa), it must be corrosion resistant as it is going to predominantly be under water, it must be resistant to external damage such as puncture. The material must also be easy to manufacture, keeping the price down for the consumer.
- b) The aluminium is a good choice as it has high yield strength and a low density, allowing the diver to not be weighed down; it is also resistant to corrosion, but may be more susceptible to damage than a steel.

The steel alloy has a sufficient yield strength but a higher density which may act as a counter buoyant. Possibly good for diving dependant on whether it is too dense or not, however, it would be very susceptible to rust damage and wouldn't last long.

The stainless would be very similar to the alloy, although harder to manufacture.

The Carbon fibre would be good as the yield strength is high, however, the manufacturing cost would also be very high.

c)

d) $\sigma = \frac{Pd}{4t}$ $\sigma = \frac{30 \times 10^6 \times 100}{4t}$

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* Ran out of time *