

Ryan Harris

Materials

EoCom-ACMA4000

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Ryan Morris

Question 1.

The Spindle requirements:

- light as possible
- Varying torque - cyclic loading.
- good finish and surface / material choice.
- manufacturing suggestion

- The Spindle firstly needs to be light weight which is a material property and refers to its density as a mechanical property.

The Spindle is also required to withstand Varying torque, better described as cyclic loading. The material property is fatigue strength but the mechanical property is fatigue.

- ~~The~~ The Component looks to be manufactured in a CNC Lathe which I would suggest to be the best approach to the machining of the Spindle. However this component could be coated or even 3D printed. However this part looks to be mass produced, therefore CNC machining will be the best manufacturing method.

In terms of material selection, low density light weight materials to be considered for the spindle include:

Aluminium, Aluminium alloys, Titanium, low density Steels.

The Spindle also needs to have good Fatigue Strength materials considered:

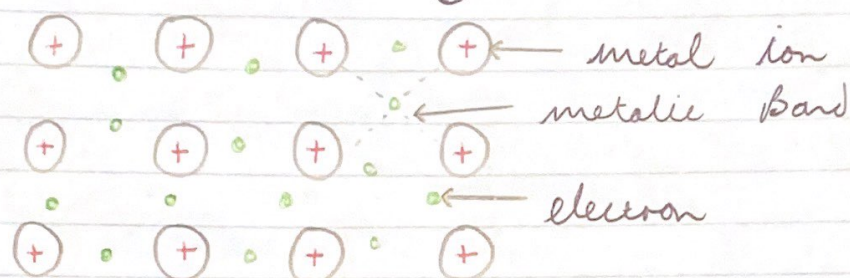
- High Carbon Steel.
- Aluminium alloy.
- Medium Carbon Steel.
- Titanium.

With it's need to withstand cyclic loading as a main priority, aluminium can not be selected, therefore I would suggest a medium carbon steel that is machined via a CNC lathe.

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Question 2:

a) metallic bonding:

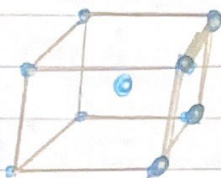


A metallic bond is a crystalline of metallic ions with a sea of electrons.

Valency is combining capacity of an atom. It is number of bonds an atom can form. The higher the number of valence electrons, the stronger the metallic bond and the stronger the metal is.

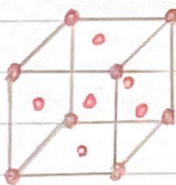
b) Body Centred cubic

A body centred cubic structure consists of atoms arranged in a cube where each corner of the cube shares an atom with one atom positioned in the centre.



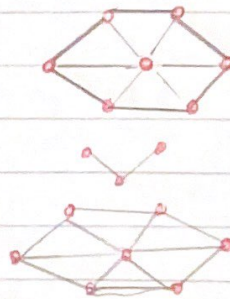
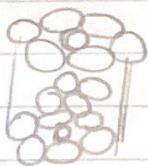
Face centred cubic

Atoms arranged in a cube where each corner of the cube has a fraction of an atom with 6 additional full atoms positioned at the centre of each cube face.



Hexagonal close packed.

HCP refers to layers of spheres packed so that spheres in other layers are not in contact with each other.



c) Packing ratio for FCC

length of side of cell "r"

Use Pythagoras:

$$S^2 + S^2 = (4r)^2$$

$$\therefore 2S^2 = 16r^2, \quad S^2 = 8r^2, \quad S = \sqrt{8} \times r$$

● Cell Volume

$$S \text{ (length of side of cell)} = \sqrt{8} \times r$$
$$\therefore V = S^3 = \sqrt{8}^3 \times r^3$$

Atoms per cell.

$$\text{there are } 8 \times \frac{1}{8} \text{ atoms} + 6 \times \frac{1}{2} \text{ atoms} = 4$$

Volume of atoms:

$$4 \text{ atoms per cell} \therefore 4 \times \frac{4\pi}{3} r^3 = \frac{16\pi}{3} r^3$$

Packing Ratio

Packing ratio vol of atoms / vol of cell.

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

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Question 2d:

10% tin Sn @ 400, 250, 180 and 50°C.

at 400°C the mixture can be described as liquidous, both lead and tin.

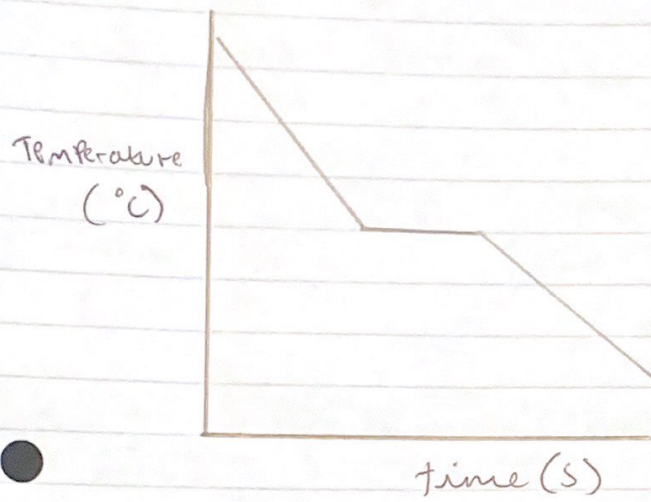
● at 250°C the mixture begins to cool and forms a solid, crystalline structures begin to take shape, it is described as α tin.

At 180°C more grains have formed within the mixture as it has cooled further but is still described as α tin.

● At 50°C the mixture is fully solid of both lead and tin and described as $\alpha + \beta$.

2e) the percentage of tin for the alloy with lowest melting point is 61.9% tin.

Question 2 F.



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Question 3a

The Chassis is required to be stiff with low density to make it lightweight.

From the material selection map it is easy to select Composites, metals and ceramics as the 3 best suited classifications.

- They provide the best stiffness values which is essential for the safety of the racing car. They are not absolutely the lightest materials however.

Composites such as carbon fibre are an excellent choice for racing car chassis. The carbon filaments themselves boast high tensile strength + stiffness when laminated together and are super lightweight for their

- excellent strength. The only downfall is the expense.

Hollow steel frames welded are also a choice for racing cars, however become heavier as the amount of sections increases.

Technical ceramics such as titanium alloy have excellent stiffness to density ratio to be considered for the chassis.

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Question 3b.

Natural materials such as wood, could not be considered due to its low stiffness value, it would not make a safe platform / chassis of a racing car.

- Foams, again very low stiffness value and not practical as a racing car chassis.

Polymers, fairly brittle, not a good suit for the chassis, unable to withstand temperature. Cannot be machined easily to make / join the chassis framework.

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Question 3c.

Carbon fibre has many advantages. It has very low weight, great strength, low thermal expansion co-efficient and a very high degree of mechanical rigidity. It's only downfall is its price. If money was not an issue the a racing car chassis would ideally be made of carbon fibre.

Steel frames have advantages such as adaptability to sudden design changes which is often in the case of racing. They are also easier to inspect for damages. Steel frames are also cost effective and have a faster build time. They are heavy however compared to carbon fibre but a great substitute due to its cost effective nature.

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Question 3d,

The base metal during welding is ~~resisted~~^{the} metal be joined. The welding ~~resists~~^{leads} to change properties of the metal because of the need to melt the metals. After the base metal is welded, the re-crystallisation of the metal massively affects the properties.

- Brazing does not melt the base metals and therefore operates at a much lower temperature limiting the affects on the metals properties.

Question 3e,

Fastening, rivets could be used to join the framework together. Rivets are highly cost effective. Solid steel rivets are very

- durable and corrosion resistant.

Nuts and bolts could also be used. This again is a cost effective method. Allowing for ease of disassembly to allow for better transport

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Question 4a,

A Scuba divers air cylinder needs to be lightweight, low density. the material needs to be corrosion resistant as it will be subjected to Salt Water. Needs to have good yield strength

Question 4b,

● 6062 T6 Aluminium has a low yield strength which is not ideal as it needs to limit plastic deformation it is however lightweight which allows for good transportability.

At 510 MPa and 7.9 g/cm^3 304 Stainless Steel is the most suitable material for the cylinder.

● Question 4c:

Factor of Safety is essential, it is the structural capacity of a system which determines the load carrying capacity beyond the actual load.

This ensures the diver will stay safe