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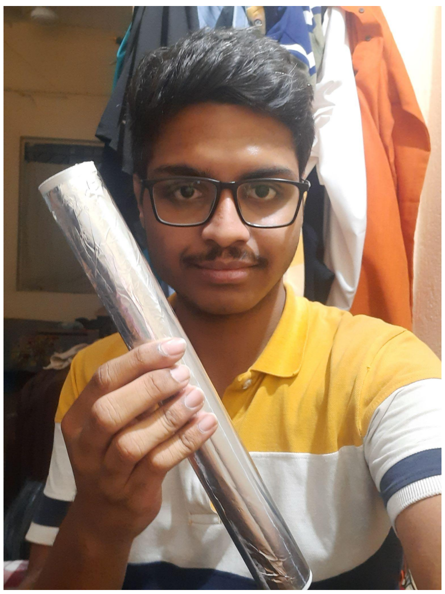
Course - Materials Engineering
Date - 4/11/2022

Materials Engineering Assignment

Aluminium (Metal):

a) Image -



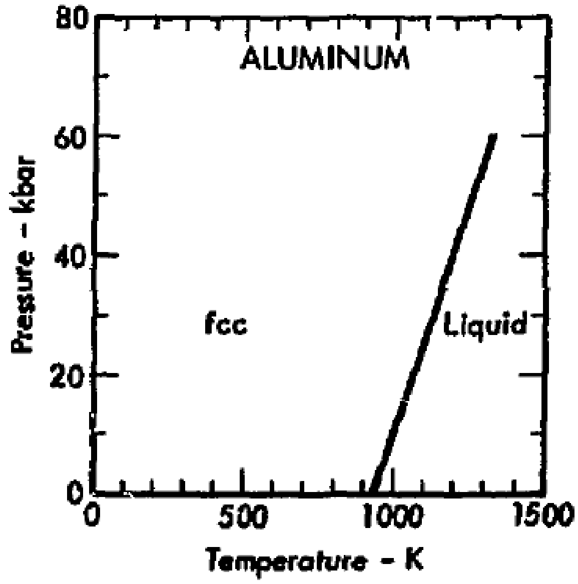
b) Description about the object -

Aluminium foil is aluminium prepared in thin metal leaves with a thickness less than 0.2 mm (7.9 mils). Standard household foil is typically 0.016 mm (0.63 mils) thick, and heavy duty household foil is typically 0.024 mm (0.94 mils). The foil is pliable, and can be readily bent or wrapped around objects. Thin foils are fragile and are sometimes laminated with other materials such as plastics or paper to make them stronger and more useful.

c) Materials Details -

1. *Possible Composition -*
   Aluminium foil is 98.5% aluminium with the balance primarily from iron and silicon to give strength and puncture resistance.
2. *Crystal Structure -*
   At room temperature Aluminium has the face-centred-cubic crystal structure with a basis of one Ni atom.

3. *Phase Diagram -*



d) Processing Details -

The pure form of aluminium does not naturally occur in nature, so remained largely unknown until as recently as 200 years ago. Resting aluminium using electricity was first developed in 1886 and is still used to this day.

The aluminium production process starts with the mining of bauxites, an aluminium rich mineral in the form of aluminium hydroxide. About 90% of global bauxite supply is found in tropical areas.

Bauxite is crushed, dried and ground in special mills where it is mixed with a small amount of water, this process produces a thick paste that is collected in special containers and heated with steam to remove most of the silicon present in bauxites.

At an aluminium smelter, alumni is poured into a special reduction cell with molten cryolite at 950 degree celsius. Electric currents are then induced in the mixture at 400 kA or above; this current breaks the bond between the aluminium and oxygen atoms resulting in liquid aluminium settling at the bottom of the reduction cell.

Primary aluminium is cast into ingots and shipped to customers or used in the production of aluminium for various purposes.

e) Mechanical Properties -

Properties	*Metric*
Elasticity in Tension	10000 ksi

Tensile strength ultimate	13,000 Psi
Yield strength	5,000 Psi
Shear Strength	9000 Psi

Stainless Steel (Alloy):

a) Image -

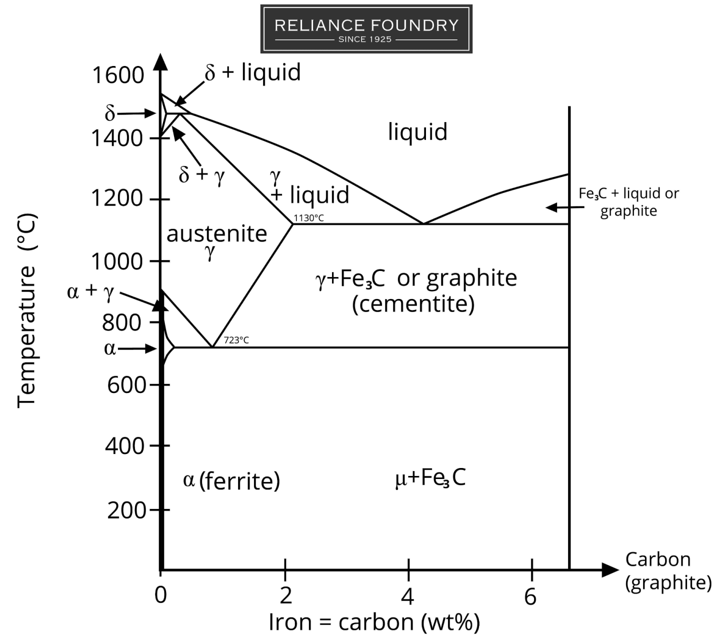
b) Description about the object -

A bowl is a typically round dish or container generally used for preparing, serving, or consuming food. The interior of a bowl is characteristically shaped like a spherical cap, with the edges and the bottom forming a seamless curve. This makes bowls especially suited for holding liquids and loose food, as the contents of the bowl are naturally concentrated in its centre by the force of gravity.

c) Materials Details -

1. *Possible Composition -*
   Stainless steels are steels containing at least 10.5% chromium, less than 1.2% carbon and other alloying elements.
2. *Crystal Structure -*
   Austenitic stainless steels have a face-centred cubic (FCC) crystal structure
3. *Phase Diagram -*

Iron-Carbon Phase Diagram



d) Processing Details -

- *Melting the Raw Materials:* Raw materials are melted in an electric furnace and heated to their melting point. This process can take anywhere between 8 and 12 hours.
- *Removal of Carbon:* The molten material is placed into a vacuum oxygen decarburization (VOD) or argon oxygen decarburization (AOD) system to remove excess carbon.
- *Tuning or Stirring:* To help fine-tune the quality of the final product, the molten steel may be stirred to help distribute and/or remove specific stainless steel components from the mixture and ensure uniform quality.
- *Forming the Metal:* As the stainless steel begins to cool, it is put through a variety of forming processes—starting with hot rolling while the steel is still above its crystallisation temperature.
- *Heat Treatment/Annealing:* To relieve internal stresses and alter the stainless steel's mechanical properties, it may be annealed (heated and cooled under controlled conditions).
- *Cutting and Shaping:* After the annealing process, stainless steel is put through a variety of cutting and shaping processes to create an ideal final product for the application.
- *Applying Surface Finishes:* The stainless steel manufacturer may apply different surface finishes to their stainless steel billets, blooms, or wires before shipping them to other manufacturers. Most common surface finish is simply grinding down the surface to remove impurities and make it smoother.

e) Mechanical Properties -

Properties	Metric
Tensile Strength	500 - 700 (MPa)
Proof Stress	190 (MPa)
Elongation A50 mm	45 Min %
Hardness Brinell	215 Max HB

****For 304 stainless steel alloys - bar and section up to 160 mm diameter / thickness*

Glass (Ceramic):

a) Image -

b) Description about the object -

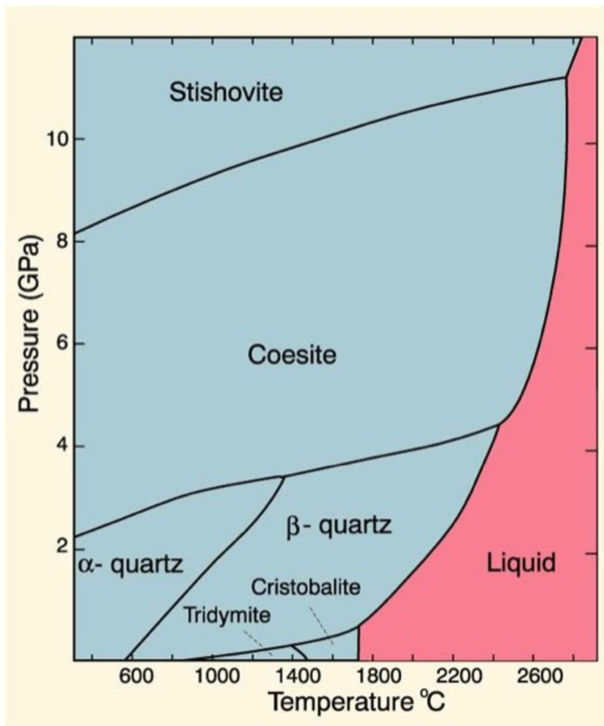
A window is an opening in a wall, door, roof, or vehicle that allows the exchange of light and may also allow the passage of sound and sometimes air. The window shown in the picture above is made of glass which is a transparent material. Transparency of the glass ensures passage of proper sunlight during the day.

c) Materials Details -

1. *Possible Composition -*

Glasses are made from three main materials—sand (silicon dioxide, or SiO2), limestone (calcium carbonate, or CaCO3), and sodium carbonate (Na2CO3).

2. *Crystal Structure -*
   Glasses do not exhibit the ordered crystalline structure of most other ceramics but instead have a highly disordered amorphous structure.
3. *Phase Diagram -*
   Phase Diagram of SiO_2



d) Processing Details -

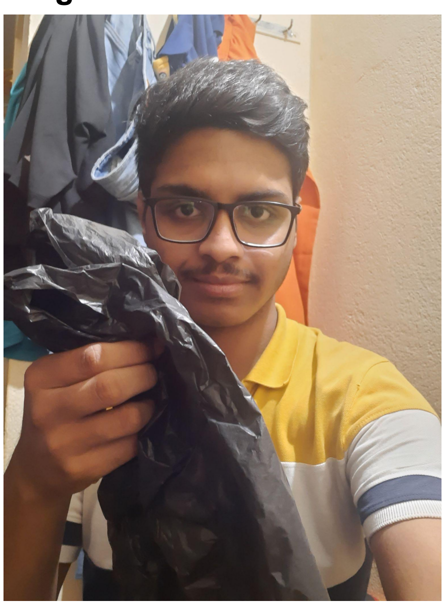
The main components, comprising silica sand, calcium oxide, soda & magnesium are weighed and mixed into batches to which recycled glass (cullet) is added. The use of 'cullet' reduces the consumption of energy. The materials are tested and stored for mixing later under computerised control. The superior clarity offered by Saint-Gobain Clear Glass. The batched raw materials pass from a mixing silo to a five-chambered furnace where they become molten. Temperatures in the furnace reach up to 1600°C. The molten glass is then "floated" onto a bath of molten tin at a temperature of about 1000°C. It forms a "ribbon" which is normally between 5 and 6 mm. By suitably drawing the glass through a complex process involving top roll machines, ribbon thickness in the range of 1.9mm to 19mm can be achieved. The glass, which is highly viscous, and the tin, which is very fluid, do not mix and the contact surface between these two materials is perfectly flat, giving the term "flat" glass to the final product. On leaving the bath of molten tin, the glass - now at a temperature of 600°C - has cooled down sufficiently to pass to an annealing chamber called a lehr. The glass is now hard enough to pass over rollers and is annealed, which modifies the internal stresses, enabling it to be cut and worked in a predictable way and ensuring flatness of the glass. As both surfaces are fire finished, they need no grinding or polishing. After cooling, the glass undergoes rigorous quality checks. It is then cut into sheets of sizes varying up to a maximum of 6000mm x 3660 mm which are, in turn, automatically stacked, stored and ready for transport.

e) **Mechanical Properties -**

Properties	*Metric*
Density	2.6 kg per m^2 per mm of thickness
Compressive strength	1000 MPa
Tensile strength	40 MPa (Annealed), 120 to 200 MPa (toughened glass)
Young's modulus	70 GPa

Polythene (Plastic):

a) **Image -**

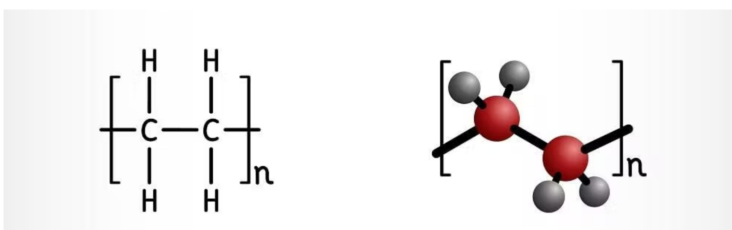


b) **Description about the object -**

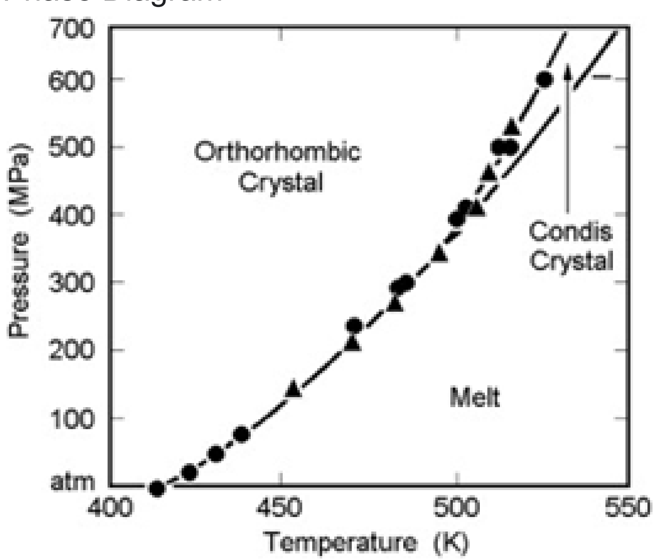
A polythene bag is a bag made of thin plastic, especially one used to store or protect food or household articles. A plastic bag can take the shape of any object so it is best fit for carrying different types of items.

c) Materials Details -

1. *Possible Composition -*
   Polyethylene is primarily made up of the monomer ethylene. Ethylene is a chemical compound with the formula C_2H_4. It is a gaseous hydrocarbon which can be generated by ethane cracking
2. *Crystal Structure -*
   Polyethylene is a partially crystalline solid whose properties are highly dependent on the relative content of the crystalline phase and amorphous phase, i.e., crystallinity. The orthorhombic unit cell, identical with the crystal structure of straight-chain alkanes, is the most stable crystal structure.
   Plastics always consist of large molecules called polymers. Polymers, in turn, consist of many identical small particles that are strung together like a chain. We call these individual small particles monomers. The length of these polymer chains determines the properties of plastic.



3. Phase Diagram -



d) **Processing Details -**
Polyethylene starts with naphtha, or petroleum, which is extracted from crude oil and heated to release ethylene, which forms branch-like structures to become polyethylene. Polyethylene exists in many different branch structures. As explained on Plastics Europe, the Association of Plastics Manufacturers website, different characteristics such as stiffness or elasticity can be imparted to the polyethylene during production, depending on the density of the material and its liquidity in melted form. The density and liquidity also largely depend on the amount of pressure applied during production. Producing polyethylene at low pressure forms straight, robust and tightly packed branches. The result is dense polyethylene with a firm and stiff structure. Manufacturing polyethylene at high pressure causes the particles to form a crisscross of branches and side branches, resulting in a lighter, more elastic material.

e) **Mechanical Properties -**

Properties	Metric
Tensile Strength, Yield at 23 C	*7.0 - 16 MPa*
Tensile Strength, Break at 23 C	*32 - 60 MPa*
Elongation, Yield	*200 - 750 %*
Elongation, Break	*450 - 810 %*

Wood (Composite):

a) **Image -**

b) Description about the object -

This is a picture of a Study Table made up of plywood. Wood is a porous and fibrous structural tissue found in the stems and roots of trees and other woody plants. It is an organic material – a natural composite of cellulose fibres that are strong in tension and embedded in a matrix of lignin that resists compression. The item under consideration is a wooden plywood board of dimensions 175 cm X 80 cm X 2 cm.

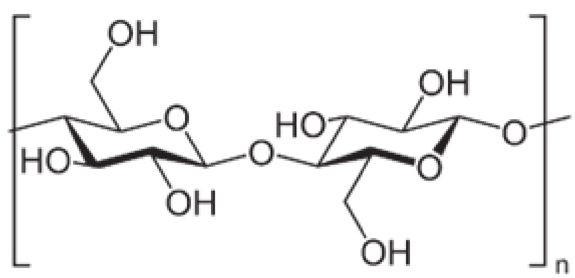
c) Materials Details -

1. *Possible Composition -*
    - Cellulose: Cellulose is a polymer ($C_6H_{10}O_5$) that can crystallise to form very strong fibres. Cellulose is the primary strengthening material in wood.
    - Lignin: Lignin is also a polymer but is typically in an amorphous form. The lignin acts as the matrix or binder for the cellulose.
    - Hemicellulose: Hemicellulose is a partly crystalline polymer that also acts as a matrix or binder.
    - Water
    - Extractives: Extractives are the organic impurities that are responsible for the wood's colour, smell, and, in some cases, resistance to rot, fungus, and insects.
2. *Crystal Structure -*

    No crystal structure available.

    Internal Structure -

    Cellulose Iβ is arranged in a two-chain monoclinic P21 unit cell with dimensions a = 7.78 Å, b = 8.2 Å, and c (length axis) = 10.38 Å and angles α = β = 90°, and γ = 96.5°.

    Cellulose

3. Phase Diagram -

    Wood is complex in its chemical state as it contains components of both liquid and solid form. Also, when you burn wood many chemical reactions take place, primarily the conversion of its carbon content to coke as well as production of CO_2, remember that it both goes in smoke and stays behind as ash, this is not a conventional phase transition as there is no clear phase change, it is much more of a chemical reaction with products in different state.

d) **Processing Details -**

The first step is to select a good log from selected tree wood based on the type of plywood to be manufactured. This log is referred to as a peeler. Peeler is straight and has a good diameter because it is expected to have a large number of layers. The large blade is used in the sawmill to process thin layers and make veneer sheets. To achieve the best results, the log is kept horizontally under the blade. The blade is continuously pressed, and several layers are cut into pieces. The sheets are then heated to remove any remaining water content. Before proceeding, a thorough dehydration of the sheets is confirmed. After drying the sheets those are glued together maintaining the system of a different type of plywood. In this step, caution is maintained to get the best result. After patching and grading this glueing takes place. urea formaldehyde and phenol formaldehyde are used for glueing. And Furmecyclox is used for fungal resistance quality. The glued plywood primary sheets are sent for baking and pressing at required temperature and pressure. The minimum temperature is 140 degrees Celsius and pressure is 1.9 MPa.

e) **Mechanical Properties -**

Properties	*Metric*
Hardness, Wood Indentation	2400 N
Ultimate Tensile Strength	2.00 MPa
Compressive Strength	4.14 MPa (Perpendicular to Grain)
Shear Strength	7.38 MPa (Parallel to Grain)