2.3 Glass – Ceramics – Refractories

Glass is an inorganic solid material that is usually transparent or translucent as well as hard, brittle, and impervious to the natural elements. Glass has been made into practical and decorative objects since ancient times, and it is still very important in applications as disparate as building construction, house wares, and telecommunications. It is made by cooling molten ingredients such as silica sand with sufficient rapidity to prevent the formation of visible crystals.

Types of Glass

Annealed Glass

- Annealed glass is a basic product formed from the annealing stage of the float process. The molten glass is allowed to cool slowly in a controlled way until it reaches room temperature, relieving any internal stresses in the glass. Without this controlled slow cooling, glass would crack with relatively little change in temperature or slight mechanical shock. Annealed glass is used as a base product to form more advanced glass types.

Heat Strengthened Glass

- Heat Strengthened Glass is semi tempered or semi toughened glass. The heat strengthening process involves heating annealed glass back up to about 650 to 700 degrees Celsius and then cooling it quickly, although not as fast as with toughened glass. The heat strengthening process increases the mechanical and thermal strength of annealed glass, making it twice as tough as annealed glass. When it breaks the fragments are similar in size to annealed glass, but with a greater likelihood of staying together. This glass is not often used in balustrades or similar structural applications because of its

Tempered or Toughened Glass

- This is the most common type of glass used in balustrades or similar structural applications. Annealed glass is heated to about 700 degrees Celsius by conduction, convection and radiation. The cooling process is accelerated by a uniform and simultaneous blast of air on both surfaces. The different cooling rates between the surface and the inside of the glass produces different physical properties, resulting in compressive stresses in the surface balanced by tensile stresses in the body of the glass. This process makes the glass four to five times stronger and safer than annealed or untreated glass. The counteracting stresses or surface compression gives toughened glass its increased mechanical resistance to breakage, and when it does break, causes it to produce small, regular, typically square fragments rather than long, dangerous shards that are far more likely to lead to injuries.

Laminated Glass

- Any one of the above types of glass can be laminated. The most commonly used finished product is two sheets of toughened glass, laminated together with a 1.52mm thick Polyiynil

Butyral (PVB) interlayer. Laminated glass offers many advantages. Safety and security are the best known of these, so rather than shattering on impact, laminated glass is held together by the interlayer. This reduces the safety hazard associated with shattered glass fragments, as well as, to some degree, the security risks associated with easy penetration.

Glass is used for following

- Packaging (jars for food, bottles for drinks, flacon for cosmetics and pharmaceuticals)
- Tableware (drinking glasses, plate, cups, bowls)
- Housing and buildings (windows, facades, conservatory, insulation, reinforcement structures)
- Interior design and furniture (mirrors, partitions, balustrades, tables, shelves, lighting)
- Appliances and Electronics (oven doors, cook top, TV, computer screens, smartphones)
- Automotive and transport (windscreens, backlights, light weight but reinforced structural components of cars, aircrafts, ships, etc.)
- Medical technology, biotechnology, life science engineering, optical glass
- Radiation protection from X-Rays (radiology) and gamma-rays (nuclear)
- Fibre optic cables (phones, TV, computer: to carry information)
- Renewable energy (solar-energy glass, wind turbines)

Ceramics

A **ceramic** is an inorganic, non-metallic solid mainly based on oxide, nitride, boride, or carbide that are shaped and then fixed at high temperatures. **Ceramic** is hard, brittle, heat-resistant, and corrosion-resistant.

Ceramic is used almost everywhere like in kitchens, cookware, pottery, bricks, pipes, etc.

Many ceramics contain a mixture of ionic and covalent bonds between them. That's why they exist in crystalline, semi-crystalline, and vitreous form.

Properties of Ceramics

1. Ceramics have high hardness.

2. They are brittle and have poor toughness.

3. They have a high melting point.

4. They have poor electrical and thermal conductivity.

5. They have low ductility.

6. They have a high modulus of elasticity.

7. They have high compression strength.

8. They show optical transparency to a variety of wavelengths.

Application of Ceramics

- Silicon carbide and tungsten carbide are technical ceramics that are used in body armor, wear plates for mining, and machine components due to their high abrasion resistance.
- Uranium oxide (UO2) is a ceramic that is used as a nuclear reactor fuel.
- Zirconia is a ceramic that is used to make ceramic knife blades, gems, fuel cells, and oxygen sensors.
- Barium titanate is a ceramic that is used to make heating elements, capacitors, transducers, and data storage elements.
- Stealite is a ceramic that is used as an electrical insulator.

Classification of Ceramics

1. **Classification based on the composition**

Oxide ceramics

- Oxide ceramics contains **oxide fibers** which include a combination of Zirconium dioxide, aluminum trioxide, and titanium dioxide. The oxide fibers help ceramics to withstand oxidation and provide strength and reinforcement.

Non-oxide ceramics

- Non-oxide ceramics offer a great replacement to **oxide ceramics** because oxide ceramics can't be used in extreme environments and can't bear heavy loads.Non-oxide overcomes all these limitations of oxide ceramics because they have high corrosion resistance, hardness, and oxidation resistance. They even don't degrade till **2400 C** temperature.

Fiber-Reinforced Ceramics

- Fiber-reinforced ceramics is also known as **ceramic matrix-fiber composite.** It has increased toughness, high strength, and polycrystalline structure.Due to their ability to resist high temperature and resistance, they are used in heat shield systems like burners, flame holders, and hot gas ducts.

2. Classification based on Applications

Classification of ceramics can be given on how they are used:

Structural Ceramics

- Structure ceramics are **clay-based** (generally) which are pressed into shape according to our need. They have **good insulating properties** which can be altered by changing their density. The denser the ceramic, the lower the insulating properties. Structural ceramics includes bricks, dinner bricks, dinner plates, and statues.

Refractory Ceramics

- Ceramics that can hold their shape and strength at high temperatures are called **refractory ceramics.** That's why they are used in furnaces and kilns. They are made using oxide like silicon dioxide, titanium dioxide, zinc oxide, and many other oxides.

Electrical Ceramics

- Electrical ceramics or **electroceramics** are known for their excellent electrical properties. They have good mechanical, thermal, and electrical properties which make them versatile for use. The conductivity of electrical ceramics increases when the temperature increases. For example Dielectric ceramics, fast ion conductor ceramics, etc.

Magnetic Ceramics

- Magnetic ceramics are oxide materials that show a certain type of permanent magnification **(ferrimagnetism).** Magnetic ceramics are made up of **ferrites** which are crystalline minerals composed of iron oxide combine with some other metal. Magnetic ceramics are used in a variety of places like in transformer, telecommunication, and information recording.

Abrasives Ceramics

- Abrasives ceramics can be natural or synthetic which are used to grind or cut away other softer material. They have high hardness, wear-resistance, and high toughness.

Refractories

A fire brick, firebrick, or refractory is a block of ceramic material used in lining furnaces, kilns, fireboxes, and fireplaces. A refractory brick is built primarily to withstand high temperature, but will also usually have a low thermal conductivity for greater energy efficiency. Fire clay is used for making this type of bricks. This clay can resist high temperature without undergoing any appreciable change in structural properties like melting or softening.

Types of Fire Bricks

There are mainly three varieties of refractory bricks.

1. Acid Refractories
   - Ordinary Fire Bricks
   - Silica Bricks
   - Ganister Bricks
2. Basic Refractories
   - Magnesite Bricks
   - Dolomite Bricks
   - Bauxite Bricks

3. Neutral Refractories
    - Chromite Bricks
    - Carborundum
    - Chrome Magnesite Bricks
    - Spinal Bricks
    - Forsterite Bricks

Some major types of refractory materials

- Fireclay refractories.
- High alumina refractories.
- Silica brick.
- Magnesite refractories.
- Chromite refractories.
- Zirconia refractories.
- Insulating materials, and.
- Monolithic refractories.

This material can resist heat, pressure, and all types of chemical attacks. Still, it retains strength as well as form. Refractories are non-metallic, porous, polycrystalline, inorganic, and heterogeneous. These materials are composed of oxides, carbides, nitrides, etc.

Important properties of refractories include chemical composition, bulk density, apparent porosity, apparent specific gravity and strength at atmospheric temperatures. These properties are frequently among those which are used as 'control points' in the manufacturing and quality control process

In addition to high melting points, refractory metals also offer several additional benefits, such as high corrosion resistance, excellent heat conductivity and electrical conductivity, high hardness at room temperature, low thermal capacity and extreme resistance to deformation

Applications

Refractory metals, and alloys made from them, are used in lighting, tools, lubricants, nuclear reaction control rods, as catalysts, and for their chemical or electrical properties. Because of their high melting point, refractory metal components are never fabricated by casting.