Glass

Glass is, from a thermodynamic point of view, a supercooled liquid Glasses are traditionally described as noncrystalline or amorphous solids. The reason for this description is that glasses do not behave like metals or polymers when they cool from a molten condition. In general, glass is a transparent silica product, which may form an amorphous or crystalline structure, depending on the process used during production.

Glass is a solid material, rigid and hard with a fixed, stable structure, like most solid bodies we encounter. During processing, it is rapidly cooled and, as a result, the glass structure is "frozen" before significant crystallization, giving the glass its unique properties.

Types of Glass

Glass is made up primarily of sand (silicon dioxide, also known as silica, is a common component of sand). Silica or quartz glass is pure silicon dioxide, a very stable material that gives glass its stable and durable nature. Window glass, such as the type that is ordinarily used in houses, is made from a mixture of sand (SiO_2), limestone ($CaCO_3$), and soda ash (Na_2CO_3). A typical glass batch might include 74% silica, 12% soda, 8% lime, and 6% other substances, such as colorizing agents, stabilizers, and other additives that enhance the characteristics of the glass. Early glass workers had a difficult time creating the 2930°F (1611°C) required to melt silica. They found that the addition of soda ash or lime reduced the temperature needed to melt the product to more attainable temperatures.

In addition to providing colorization, metallic oxides helped reduce the tendency of the silica to form solids in the glass. Various types of glasses are made by varying the amount of silica and adding acidic oxides. Colored glasses are made by adding metallic oxides: cobalt oxide is used to produce blue glass, iron oxide produces green-colored glass, and selenium is used to produce red-colored glass, as examples. The ingredients for a glass batch are mixed in dry form and then melted in a special furnace made of heat-resistant brick. The temperature is raised to around (1611°C), where the material becomes a viscous liquid. It is allowed to cool into an orange-hot mass that can be handled and shaped into products.

The general categories of silica glass include soda-lime glass, borosilicate glass, lead oxide glass, aluminosilicate glass, high-content silica glass, fused silica glass, and pyrocerams. Soda-lime glass is the oldest and most prevalent type of glass, accounting for about 90% of manufactured glass. It contains approximately 70% silica, 15% soda (or sodium oxide), and 10% lime (or calcium oxide). It is used in the manufacture of windowpanes, bottles, jars, light bulbs, and other similar items. Soda-lime glass is commonly available in sheets It is produced in many thicknesses and grades, depending on the intended use.

Borosilicate is produced from roughly 80% silica, 13% boron trioxide (B_2O_3), 2% alumina, 4% sodium oxide, and 1% potassium oxide. Borosilicate glass (often sold under the trade name Pyrex) Its properties include low thermal expansion, high chemical stability, and good electrical resistivity.

The lead glasses or lead alkali glasses come in a number of varieties. Optical lead glass is typically made of 58% lead oxide, 35% silica, and 7% potassium oxide (K_2O). This glass has a high refractive index, and it has one of the lowest softening temperatures of all glasses.

In aluminosilicate glass, averages 59% silica, 20% alumina, 9% magnesia (MgO), 6% lime, 5% boron oxide, and 1% sodium oxide. Aluminosilicate glass has a high softening temperature, which enables it to withstand high temperatures. It also has high thermal-shock resistance and high heat resistance. It is often used where chemical resistance is important to the application and is used for combustion tubes, gage glasses, laboratory products, and halogen lamps. It is expensive to produce and difficult to fabricate, which are its main disadvantages..

Pyroceram are polycrystalline glasses that soften above 2000°F (1093°C) and exhibit excellent thermal properties with about the same rigidity as aluminum. Typical compositions used for crystalline glasses include:

(AL_2O_3 - Li_2O – SiO_2), (Al_2O_3 – MgO – SiO_2), (Li_2O – MgO – SiO_2), (Li_2O – SiO_2 – ZnO)

Production

Most industrial glass is produced by continuous melting processes, while batch-type processes are restricted to customized formulations for special purposes. Large-scale production of industrial glasses uses huge melting crucibles with a rectangular shape called glass tanks that are heated from the bottom and sidewalls by natural gas or oil burners; sometimes auxiliary electric heaters immersed in the melt to provide additional heat.

The temperature of the melt can be as high as 1660 °C to ensure the complete melting of alumina-rich raw materials (calcium feldspars); The thick bottom and sidewalls are made from refractory materials, usually mullite bricks, while electro-fused alumina–silica–zirconia bricks are used for the inner layer, which is in direct contact with the melt. The vault or cupola is usually made of silica bricks. The glass tank is divided into two distinct sections called the melting end, where the feed is introduced, and the working or refining end, where the molten glass reaches its working viscosity. The division between the two sections can be either permanent with a refractory barrier or temporary using mobile baffles.

Float glass (annealed glass). In the float glass process, molten glass exiting a melting furnace is poured onto a bath of molten tin metal. The glass floats on the specular surface of the molten tin and levels out as it spreads along the bath, providing a smooth finish on both sides. The glass cools and slowly solidifies as it travels over the molten tin and leaves the tin bath in a continuous ribbon. The glass is then fire-polished. The finished product has near-perfect parallel surfaces. The only drawback of annealed glass is that on mechanical stress it breaks into large and sharp pieces that can cause serious injury. For that reason, building codes worldwide prohibit the use of annealed glass where there is a high risk of breakage and injury.

Tempered glass (toughened glass, safety glass) The hot glass at 600 °C coming from an annealing furnace is placed on a roller table. The glass is then quenched with forced cold air convection. This rapidly cools the glass surface below its annealing point, causing it to harden and contract, while the inner core of the glass remains free to flow for a short time. The final contraction of the inner layer induces compressive stresses in the surface of the glass balanced by tensile stresses in the body of the glass.

This typical pattern of cooling can be observed under polarized light. Tempered glass exhibits typically a mechanical strength six times that of annealed glass, and hence it is also called toughened glass. However, this increased mechanical strength has a drawback. Because of the balanced stresses in the glass, any damage to the glass edges will result in the glass shattering into small pieces, and for that reason it is also called safety glass Moreover, the toughened glass surface is less hard than annealed glass and more prone to scratching.

Laminated glass

laminated glass is produced by the bonding two or more layers of ordinary annealed glass together with a plastic interlayer of polyvinyl butyral which is then heated to around 70 °C and passed through rollers to expel any air pockets and form the initial bond. The plastic interlayer keeps the two sheets of glass tightly bound even when broken, and its high strength prevents the glass from breaking up into large sharp pieces. Multiple laminates and thicker glass increase the strength.

Bulletproof glass panels, made up of thick glass and several interlayers, can be as thick as 50 mm. The plastic interlayer also gives the glass a much higher acoustic insulation rating because of the damping effect.

Uses

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,

– 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)

– Fiber optic cables (phones, TV, computer: to carry information)

– Renewable energy (solar-energy glass, wind turbines)