Chapter 24

Applications in glass manufacture

Glass consists of silica (sand), soda and lime, with small amounts of such chemical constituents as potash, lead oxide and boric oxide added to produce specific qualities in the finished product, for example to render it clear, colored or frosted. The ingredients have remained unchanged for centuries though the methods of production have changed considerably.

Outline of glass manufacturing process

Glass is made by fusing the materials at a high temperature and allowing them to mix together as they become molten. The result is a viscous mass of material which displays all the properties of a solid though it is technically a liquid in the supercooled phase. Very old glass windows in churches and similar buildings can be seen to be thicker at the base than at the top indicating that the material is still capable of flow under gravity, albeit at a very slow rate. The final product of the fusion process depends very much on the mix used. For example if glass is made simply by fusing sand, the result will be a rather crystalline form which will be very brittle. Adding soda and limestone improves the situation: chemically these additions reduce the melting point of the mixture from about 1700 degrees Centigrade to around 850 degrees, and improve the properties of the final product. The modern way of making sheet glass is the so-called ‘float’ process, introduced in 1959. Previously the fused mass of silica and additives had to be cast, rolled and finally polished to remove any distortions in the final surface. Somewhat surprisingly the float process did not evolve from previous experience but was based on entirely new technology. It changed the industry almost overnight.

The grinding and polishing of plate glass made by earlier methods resulted in up to 20% wastage and produced high capital and labor costs. In the float process, a wide ribbon of molten glass, anything up to about twelve feet in width, flows out of the furnace and floats on a bath of molten tin. The environment is controlled closely to permit any irregularities to melt out and allow the glass to assume the contours of the molten tin bed. This being flat, the glass settles into a completely
flat sheet of even thickness if the ambient conditions are such as to allow the mass of material to cool slowly and form its natural shape under gravity. As the continuous glass sheet proceeds across the molten tin bed, it eventually becomes rigid enough to be picked up and run through rollers to anneal it without damaging the surfaces. The resultant product has a uniform thickness and needs no further finishing. There is, of course, a relationship between the density of the glass, the density of the tin and the rate of cooling which will determine the thickness to which the ribbon of molten glass will settle at as it cools. Fortunately this works out, in practice, as about one quarter of an inch, and this is the thickness which meets the demand of almost half the market for glass today. However technical improvements based on impeding or speeding up the flow of the ribbon have made possible the production of thinner and thicker glass sheets using the same float process. A thickness range of one tenth of an inch to no less than one inch is now possible with modern techniques and machinery.

Glass today comes in several forms. Plain glass is used for windows and mirrors, the larger units being of the thicker or plate glass forms. Patterned glass for decorative purposes is made by passing the sheet through suitably imprinted rollers while still in the semi-molten stage. Optical glass, used for lenses and prisms is specially chosen to be homogeneous throughout and free from discoloration. Safety glass, most important in automobile applications, is made from annealed glass which is subjected to further processes to toughen it and to produce properties which will cause it to shatter in small rounded bead-like particles when it finally breaks. Heat-resistant glass is made from a mix chosen to have a very low coefficient of expansion to minimize stresses in the glass when subjected to extreme temperature changes.

Generally speaking glass is a most difficult material to handle. It tends to be fragile, and sheets of glass will shatter if stressed, the resultant pieces being sharp and dangerous to handle. Serious accidents from glass making and handling are legion, yet the product is in widespread use in the home, the car and in the factory and office. Working glass is a craft. Glass blowers shape molten glass by blowing it, sometimes using molds. Flat sheets of glass are regularly cut to shape and edge-ground to meet a variety of needs, and the techniques involved, although they may look easy, demand a great deal of experience and the confidence which comes from regularly handling the material. Transporting and handling glass, particularly in large flat sheets is somewhat hazardous. Is there, then, any role for a robot to play in such a difficult arena? In certain applications, the answer is very much in the affirmative. It is of interest to discuss some of these applications which are typical of what can be achieved. Others will undoubtedly follow as experience is gained in the field as a whole.