Collage of Engineering

Materials Department

Third Class

Lecture (6-a)

GLASS

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4.4 Heat treatment of glass

5-4-1 annealing of glass

Glass products sometimes have induced residual stress unlike metal products if cooling is not done at a sufficiently low rate. In order to release the internal stresses the temperature of glass melt is held steady over a long period time. This process is known as *annealing*.

Annealing is a process of controlled cooling and heating of a material to remove residual stresses. The process may be carried out in a thermally insulated chamber known as a *lehr*.

Glass contracts as it cools down because of its low thermal conductivity. Moreover, when there is large amount of stress developed inside the glass, it will break automatically to

relieve the stress. Therefore slowing down the cooling rate will enable less temperature difference throughout the bulk of material and that will cause less stress. Temperature variation may cause crack or shatter of glass in the absence of annealing process.

Annealing removes thermal stresses from the glass caused by quenching process and hence increase the overall strength.

The annealing process is shown in Figure 12. In annealing process, the glass is heated until the temperature reaches a stress-relief point, i.e. annealing temperature (also known as *annealing point*) at a viscosity (η) of 10^{13} Poise.

At the annealing temperature, the glass is still in a hard state but at the same time it is soft enough to relieve thermal stresses. The glass is then allowed to remain at the annealing

point for some period of time until the temperature is even throughout. The soaking time depends upon the size, thickness and type of the glass. The glass is then cooled to a temperature below the strain point ($\eta=10^{14.5}$ Poise) at a predetermined rate. Subsequently, the temperature can be dropped to ambient temperature at a rate limited by thermal conductivity, heat capacity and thermal expansion coefficient and thickness of the glass. Annealing time may range from a few minutes to few months. For example, at the strain point annealing, time is few hours, while at the stress relief point, stresses relax within several minutes. Stresses that are still present below the strain point are not possible to remove and are permanently present in the glass.

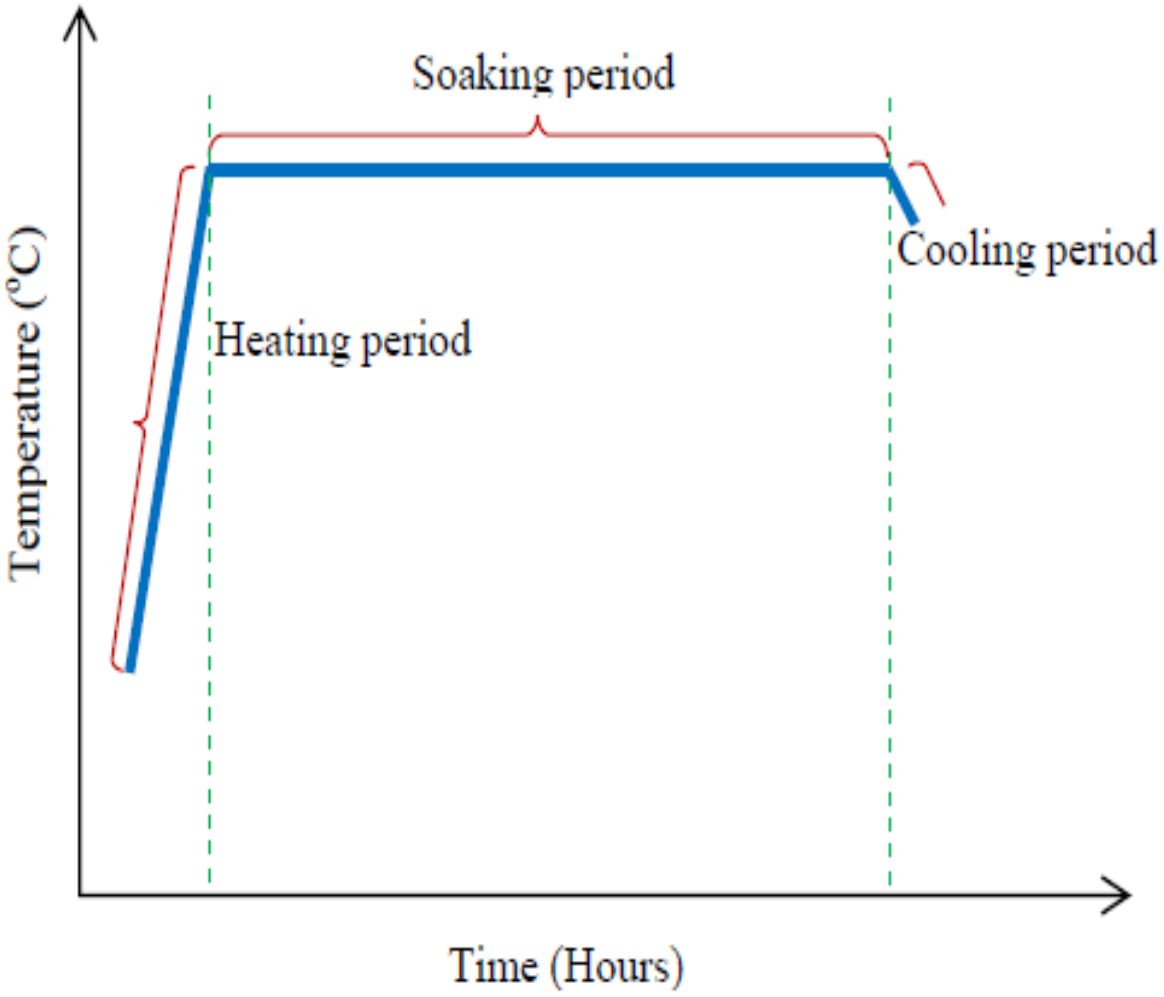

Figure 12: A general annealing curve for common glasses