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Effective melting for glass forming

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Glass plays an increasingly important role in the sector of green energy generation and saving in 21st century, on one hand. But on the other hand the production of glass would cause severe impact on the environment if we cannot dramatically reduce the energy consumption for glass production. In recent years, much effort has been made in glass industry to save energy and reduce waste gas emission. However, despite considerable progress there is still great potentiality to further reduce energy consumption of glass production by innovating glass technology, e.g., by optimizing glass melting and forming processes. Therefore we have done some work related to reduction of energy consumption of glass production. The work is done by seeking and defining the optimum glass forming temperature and viscosity, at which the energy consumption can be kept at the lowest level, but without lowering the quality of final products. In other words, we attempted to save energy by performing effective melting before glass forming. Effective melting here refers not necessarily to ‘sufficiently high’ temperature melting, but to ‘appropriately low’ temperature melting as long as glass forming can be effectively conducted, and the quality of glass fulfills the requirement of the targeted applications. Here, we demonstrate the importance of effective melting for energy saving in glass industry through the following four case studies.

First, we have examined the conventional view about the optimum temperature window for fiberizing glass. For instance, E glass fibers are normally spun at 20~50 °C above liquidus temperature (T_{liq}) in a viscosity range of 50~200 Pa s. However, this fiberizing condition is not necessarily suitable for other types of fiberizing processes. In some circumstances the fibers could be spun well below T_{liq} , and thus unnecessary energy consumption could be avoided. To find the optimum fiber spinning window, we have established the correlations among melt viscosity, fiberizing output, and liquid stability range (i.e., supercooled melt region below T_{liq}) during fiberizing. Bases on these correlations we can design an optimum glass fiberizing processes, and thereby save an appreciable amount of melting energy.

Second, we have proposed the optimum temperature and viscosity window for producing foam glasses with high insulation ability and without unnecessary energy consumption. The foam glass is produced from waste cullet with various chemical compositions. Because of the diversity of cullet compositions, we have found that it is crucial to control the foaming viscosity (instead of foaming temperature) of glass melts for attaining high quality foam glass and stable foaming processes. In order to lower energy consumption the foaming temperature should be kept at the lowest level as long as the optimum foaming viscosity allows for producing high quality foam glasses. An optimized foaming process can result in saving a large amount of energy. This work contributes to energy saving through the following

factors: 1) use of recycled glass cullet; 2) optimal control over melt viscosity during foaming process; 3) high insulation capability of foam glasses.

Third, we have developed suitable glass compositions and therefrom produce glass particles used as supplement cementitious materials of the cement. Such particles have a striking synergy effect on the cement performances, i.e., both pozzolanicity and compressive strength are enhanced when they are mixed with calcium carbonate in the ratio of 2:1. Another important advantage of the optimized glass compositions is that rather low melting temperature is required to make glass particles, and hence, the energy consumption can be greatly lowered. This is due to the fact that not only the viscosity at T_{liq} is reduced, but also melt homogenization and refining procedures can be skipped compared to normal commercial glass production.

Fourth, we have found an energy effective method for producing opal glasses and functional nanocrystal glasses. This new method is based on the control of phase separation and nanocrystal formation in the melts by varying cooling rate. Consequently, the transparency and functionalities can be tailored by varying cooling rate. The new method saves much more energy compared to the traditional method, viz. the reheating and isothermal treatment protocol.

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