Various ideas and technical foundations for achieving carbon neutral glass melting

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Abstract

With extreme weather occurring on a global scale and large-scale natural disasters increasing, responding to climate change issues, especially reducing greenhouse gas emissions, has become a common issue worldwide. More than 150 countries and regions have announced that they will achieve carbon neutrality by a certain year, such as 2050.
Flat glass is one of the essential materials for humanity. Architectural glass for creating a bright living environment that protects from the rain and wind and lets in natural light. Automotive glass that ensures a clear field of vision even when moving at high speeds. Display glass forms and protects devices that display a variety of information.

In 2018, sheet glass production in Japan was 160 million m2 (1.2 million tons) per year, and CO2 emissions from the sheet glass industry were 1.1 million tons per year. This is equivalent to 0.9% of Japan's total GHG emissions and 4% of industrial CO2 emissions. This picture appears to be similar on a global scale.

The CO2 emissions for each ton of glass produced in a classic regenerative air combustion furnace is approximately 0.5 ton. This includes 0.34 tons from fossil fuel combustion and 0.16 tons from carbonate raw materials. The result of decades of development and operation by our predecessors, these numbers are not to be faulted. However, we have to let go of the sophisticated combustion-based glass production furnaces we inherited from our predecessors. Achieving both carbon neutrality and a sustainable supply of glass products will require a major global challenge over the coming decades. In this lecture, we will introduce this difficulty by giving some concrete examples.

Table 1 summarizes the means to reduce CO2 emitted from glass production. As mentioned above, the CO2 emissions per ton of glass produced in a classic regenerative air combustion furnace are approximately 0.5 tons, of which 0.34 tons come from the combustion of fossil fuels and 0.16 tons from the carbonate raw material.

Methods for reducing CO2 from burning fossil fuels can be categorized into energy saving (reducing the amount of fossil fuel used) and switching from fossil fuels to low-carbon energy sources. Energy saving measures include the introduction of oxy-fuel combustion, the introduction of various types of waste heat recovery equipment, and the reduction of heat loss from the furnace walls by strengthening insulation. These are already viable technologies, but they alone will not produce sufficient CO2 reduction effects. To achieve dramatic CO2 reduction effects, we must switch from fossil fuels to low-carbon energy sources. Alternative

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combustion gases are hydrogen, ammonia, and biogas. Electricity can also be used as a heat source other than combustion. Whether it's electricity, hydrogen, or ammonia, it's important to identify how clean it is. We need a transformation strategy that takes into account the CO2 footprint of available alternative energies by region and by decade.

Raw material-derived CO2 emissions are the result of the thermal decomposition of carbonates such as soda ash, limestone, and dolomite. Soda ash can be derived from both chemical and natural carbonate minerals. Limestone and dolomite are natural carbonate minerals. In the glass melting furnace, CO2 that was originally fixed underground is released into the atmosphere. The highest priority in reducing these emissions is to reduce the amount of raw materials used, i.e. to increase the proportion of recycled cullet. Using cullet collected from construction debris to melt high-quality glass such as float glass is a big challenge, but it has to be done. Glass production using 100% recycled cullet is difficult in terms of market balance, so it is inevitable that mineral raw materials will continue to be consumed. It is possible to use quicklime or calcined dolomite instead of limestone or dolomite. Limestone and dolomite are fired separately in a kiln to transform them into oxides before being put into a glass furnace. Although carbonate minerals emit CO2 into the atmosphere, it should be easier to capture the CO2 emitted by firing them in a kiln alone rather than decomposing them in a glass furnace mixed with combustion gas. Industrially available sources of sodium other than sodium carbonate are sodium chloride or caustic soda. A small amount of sodium chloride may be added to the batch as a fining agent. The use of sodium chloride as the main raw material for soda-lime glass is impractical when considering what to do with the large amounts of chlorine (and probably hydrogen chloride) generated in the furnace. In this lecture, we will examine how to use caustic soda as a raw material for glass and the remaining issues.

The two directions mentioned so far aimed to reduce or eliminate CO2 sources. In addition, it is also necessary to consider capturing CO2 from furnace flue gas, then storing it underground or utilizing it as a valuable resource. The site must either have infrastructure in place to store the captured CO2 underground, or a stable channel to sell the CO2 or its derivatives over the life of the furnace, which exceeds 15 years. In this lecture, as an attempt to clear this difficult condition, we will also consider the idea of local production for local consumption.
Finally, I will introduce some important points from the perspective of industrial R&D involved in the innovation of glass melting processes. We work both to bring new glass products to market and to maintain the sustainable supply of existing glass products. Invention of technology that gives competitiveness to small-volume production of specialty glass. Innovative technology that makes the mass production process of commoditized glass carbon neutral. Both development topics are important to us. Although these may seem to be at opposite ends of the spectrum, the scientific understanding required is common to both types of development.

Keywords: glass melting, glass batch, furnace design, carbon neutral