Advancing Consumable Refractories

➤A new consumable refractory has been developed to reduce costs and increase production for container glass manufacturers.

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All of us can remember when everyday items such as ketchup, mayonnaise and beer were found solely in glass containers. Now these products are packaged not only in glass, but also in plastic and aluminum. The glass container industry has responded to this competition by producing its goods as economically as possible, and one way of addressing that goal is to minimize manufacturing costs.

The manufacture of a glass bottle starts with feeding ingredients such as silica, soda and cullet (recycled glass) into a melter (see Figure 1) and fusing them at an average temperature of 2800°F. The glass leaves the melter through a distribution system and eventually arrives at a gob feeder, where it is formed into cylindrical "gobs" that then slide down troughs into molds where they are shaped and blown into bottles. A bottle-making machine can contain 10 or more molds and manufacture at rates exceeding 400 bottles/minute.

The Role of the Feeder

A melter can support two or more feeders, with each feeder providing glass for a single bottle-making machine. The feeder consists of several carefully designed cast refractory shapes (see Figure 2), which are known as *consumable refractories* since their lifespans are relatively short as a result of chemical corrosion and mechanical abrasion. These refractories must be of the highest quality at this stage of the process to ensure uniformity and consistency in the final product; any flaws that arise from refractory defects will result in lost production.

A feeder assembly consists of four main parts. The orifice ring is a disk-shaped refractory located at the bottom, and it contains one to four cylindrical holes through which the glass is dispensed and shaped into gobs. With glass flowing over and through the ring, it is subjected to rapid wear and therefore must be replaced relatively frequently. The spout contains the glass above the orifice ring and has a service life of about one year.

The feeder tube is located just above the orifice ring, thereby creating a gap through which glass flows at a controlled rate. The feeder tube rotates at a rate set by the glass manufacturer, and this movement thermally homogenizes the glass. Suspended in the center of the feeder tube are one to four ceramic plungers (one for each hole in the orifice ring). The plungers oscillate vertically and force precisely measured amounts of glass through the orifice ring. The oscillation rate can be quite rapid; plungers serving a 400 bottle per minute machine using a 3-hole orifice ring will rise and lower at nearly 135 cycles per minute.

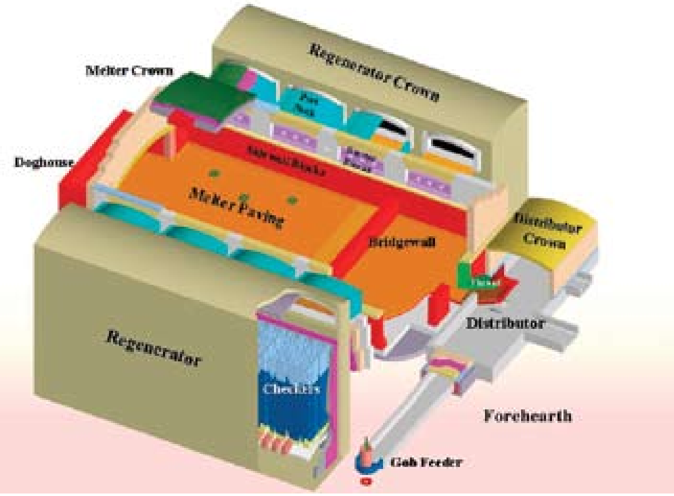

Figure 1. In a glass melting furnace, ingredients are added through the doghouse and glass exits at the gob feeder.

Consumable refractories for the feeder are expensive, but not in the same way as raw materials or labor costs. The high cost of consumable refractories is a result of the time required to replace worn refractory parts, which can result in thousands of dollars in lost production time. Despite their cost to bottle-making manufacturers, consumable refractories have not been improved for at least 25 years.

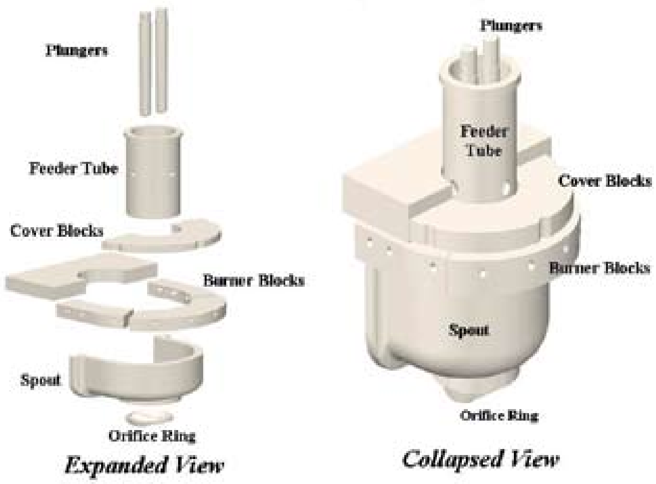

Figure 2. Feeder refractory assembly.

A New Development

Numerous refractory products are manufactured for the glass industry with zirconia contents ranging from 20 to 50%. Certain refractory materials,* which contain nearly 30% ZrO_2, are offered for applications that require high glass corrosion resistance. The refractory is made using zircon ($ZrO_2 \cdot SiO_2$) and high-purity aluminosilicate materials. Mixes are cast into a mold using ethyl silicate as a binder, which allows the shapes to set rapidly and allows the molds to be used more efficiently. The demolded shapes are then dried, fired well above their expected service temperature, and packed for shipment to the customer.

> When tested in customer facilities, the results of expendables made with the new composition have shown performance improvements of 35 to 60%.

These materials are widely accepted by the glass industry and provide superior performance in many applications. However, improved glass corrosion resistance was needed for feeder expendables, and R&D efforts have sought to develop a new product that would be superior to anything on the market.

The development required a twofold approach. First, the amount of ethyl silicate added to the mix needed to be minimized to achieve higher density and lower porosity. However, reducing the ethyl silicate amount leads to increased mix viscosity. This, in turn, increases the chances of air entrapment during casting, which can lead to macroporosity (porosity that can be seen by the naked eye). Adding liquid to increase fluidity allows air bubbles to rise to the surface more easily during the casting process, but it also decreases density and increases the fine porosity, translating to reduced glass corrosion resistance. The trick then is to minimize liquid demand while achieving sufficient fluidity to release air bubbles.

Table 1. Comparison of the properties of the previous and new glass consumable refractories.

	PRODUCT	
Physical Properties	**Previous**	**New**
Bulk density, lb/ft³	182	191
Apparent porosity, %	20	18
Material Chemistry (%)		
Al_2O_3	55.4	53.4
$ZrO_2 + HfO_2$	28.8	30.0
SiO_2	15.3	16.1

The second approach involved the modification of the mix. To minimize risk to the customer, the goal was to keep not only the same overall chemistry as the original shapes, but also retain the same chemistries within the matrix and coarse aggregate portions of the refractory body. These objectives were achieved, but required substantial raw material adjustments. In combination with the ethyl silicate work, the raw material changes allowed for a more fluid mix, and, as a result, almost no macroporosity.

Demonstrative Benefits

Table 1 illustrates the properties of the new refractory material** in comparison to the previous product. The enhancements in density and porosity appear to be insignificant; however, the finished product provided a quantum leap forward in glass corrosion resistance and significantly increased wear life.

When tested in customer facilities, the results of expendables made with the new composition have shown performance improvements of 35 to 60%. Achieved benefits include increased service life, more consistent gob weights and better temperature uniformity. The consumable refractories' advancements have translated into improved manufacturing efficiencies—it is now possible for glass bottle manufacturers to reduce the annual losses normally incurred during replacement of feeder refractories by up to 50%. Work continues with many container operations to demonstrate the benefits of cast shapes made with the new refractory material, and the trials are showing reduced down times and improved production efficiencies. ⊕

For more information regarding cast shapes and other refractory materials for the glass industry, contact Gary Stark at MINTEQ International, Inc., 395 Grove City Rd., Slippery Rock, PA 16057; (800) 245-1929; e-mail Gary.Stark@minteq.com; or visit www.minteq.com.

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*such as shapes made with the ZEDPAVE-CF™ refractory material, manufactured by MINTEQ International, Slippery Rock, Pa.

**ENDURATEQ® shapes, developed by MINTEQ International.