Effect of Colour Bearing Impurities of Alumina on Fused Cast Refractories

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Abstract

Universally, glass manufacturer prefers impurity-free glass tank furnaces in order to produce transparent glasses for pharmaceutical and high-end applications. The lining of the glass tank furnaces is normally made with superior quality of refractories. Therefore, alumina should be free from any colour-bearing impurity, in order to make a high purity fused cast refractory. During the molten glass making, in glass tank furnaces, corrosion of refractory lining happens because of chemical attack of slags at elevated temperatures. Subsequently, heavy element impurities in the oxide (i.e., alumina, used as a prime raw material for fusion cast refractory) are leached out from the lining of the furnaces and diffused into the structures of molten glass at elevated temperatures. Impurities such as Co, Ni, Ti, Cr, etc. present in alumina are mainly responsible for different types of visual colour of pharmaceutical and high-end glass, made in glass tank furnaces.

In the present study, this coloration issue of glass tank furnace refractories is addressed by identifying the route cause analysis of the coloration in the alumina. ICP-MS was used to analyze the trace level impurities of the alumina and required process changes were done to produce / generate the desired quality of alumina for such type of fused cast refractory application, in order to produce highly transparent glass, suited to the required application.

Keywords: Fusion, Colourless, Heavy metal, leaching, Refractory

1. Introduction

Glass has been produced for thousands of years dating from as early as 7000 B.C. [1] for its unique chemical, optical, electrical, and thermal properties. Hence, to meet the requirement of modern applications, glass must be transparent and have no adverse effect of any colour. It is also used in variety of applications like packaging required for jar food, bottles for drink, vials for cosmetics and pharmaceuticals, reinforcement structure for five stars building and construction, interior design and furniture, medical technology, biotechnology, life science engineering etc. In order to achieve these advanced properties, glass industry needs high value super refractory product for the lining of glass melting furnaces or glass tank furnaces. Fused cast Alumina – Zirconia – Silica (AZS) refractory [2] is most widely used for glass melting furnaces. Figure 1 shows a typical lining of AZS in glass tank furnaces and Figure 2 shows the flow of glass during the operation of furnaces. Generally, a melting furnace is used to manufacture the fusion cast AZS refractory, where pure zirconia, silica and fusion grade alumina are used as raw materials.

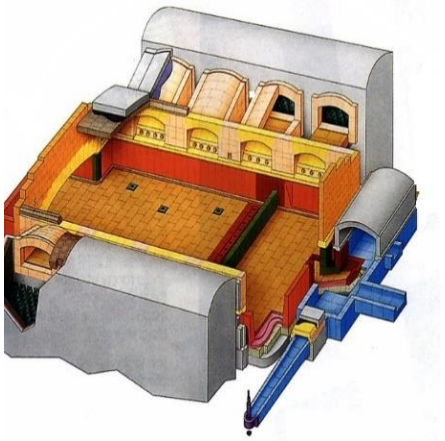

Figure 1. Glass tank furnaces [3], Figure 2. Inside of glass tank furnaces [4].

Alumina [5], Zirconia and Silica melt inside the furnace in developing homogenous compositional chemistry over the entire fused cast refractory material after solidification of molten liquid. The demand for melt cast AZS refractory is increasing day by day in the glass industry due to its property of highly corrosive resistance at high temperature. AZS refractory generally contains 25-30% glass phase (by volume). This glassy phase presents a disadvantage to AZS at service temperature for corrosion and simultaneously with the impurity oxides present in the alumina (which is used as the raw material of the fusion cast AZS refractory) leached out into the molten glass and creates non required colours. The impurity oxides present in alumina, such as Fe, Co, Cr, Ti, etc. [6], are responsible for different types of visual appearance upon the surface of pharmaceutical or any other high-end glasses. Hence there is a need to eliminate or reduce the oxides of impurities present in alumina to improve the quality of the high-end glasses in order to adapt them to modern applications.

Normally, the aluminum tri-hydrate (ATH) is used as the feed material for producing fusion grade alumina. A major volume of ATH is produced through Bayer process (Figure 3) with the use of bauxite as the raw material, which is a natural material deposited over the earth surface over a very long period of times.

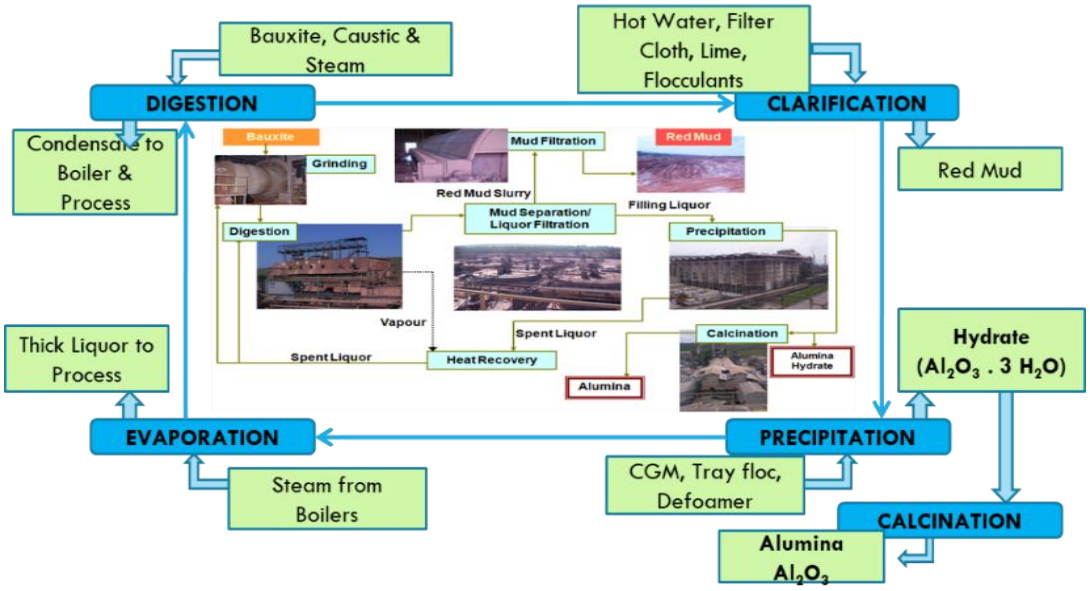

Figure 3. General process flow diagram.

5. Conclusion

The process developed for producing low impurity alumina, having low level of Fe, Co, Cr, Ti, etc. compared to as calcined alumina of Bayer process is very much suitable for producing a good quality fused cast refractory.

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