Influence of the Refractories Chemical Composition Onto Opal Glass Furnace Durability

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Abstract* – *In this paper, study of refractories corrosion processes at a basic production stage of an opal glass were described. Main problem of the glass furnaces for opal glass is unability to use high-zirconia oxide lining because of fragility such refractories, caused by transition of zirconium oxide crystals from monocline crystal system to cubic crystal system. There was found the optimal chemical composition for such purposes, based on Zirconia Aluminum Silicates which may increase the term of service of furnaces.

Key words – opal glass, fluorine, corrosion, refractories, lining, glass production, aluminium zirconia silicates.

I. Introduction

In the modern chemical production many processes are carried out at high temperatures in furnaces of various designs. Rational and trouble-free operation of all enterprise depends on the right choice of the furnace, its calculation and design registration.

By production of glass and products from it the furnace is the main heating and technological unit. Profitability of all enterprise depends on its trouble-free operation. Time of a non-working state (spent for repair) of the furnace sustains for itself the considerable material losses.

Lining is a construction from the high-heat, heat-insulating and acid-resisting materials protecting the reaction chamber from influence of the environmental atmosphere. High-heat lining of a glass furnace is intended for decrease of thermal losses and protection from influence of high temperatures and from contact with a liquid silica glass. As a part of fireproof coverings stratified sponges and products on their basis are used. The lining has to resist to deformation under the influence of a constant and changing thermal load. The internal surface of lining participates in heat exchange processes with a surrounding envaiors. Thus, it participates in two interdependent systems of heat exchange: internal and external. Presence of a liquid phase at glass furnaces increases participation of lining in technological process. The gas phase also actively interacts with lining accelerating its destruction.

II. Formulation of the problem

The period of operation of a glass furnace makes from 10 to 15 years. However everything changes at manufacture of an opal glass [1].

Opal glasses are widely used in the fields of science, industry and commerce in the form of containers for therapeutic and cosmetic creams for deodorant containers, lighting globes, glass filters and other.

Recently, there has been increased demand for lowcost, high-quality, heat-resisting, chemically stable, opal glass containers which can be produced at low cost in large quantities by conventional high-speed glass-forming techniques. Conventional opal glasses have not fulfilled these requirements in that in manufacturing opal glasses by the prior art methods, it is often necessary to rebuild or replace the glassmelting furnace at frequent intervals due to the corrosive nature of the opacifying agents (e.g., fluoride and phosphates) on the furnace refractories. This is expensive, and makes prolonged, continuous operation impractical. Additionally, the batch costs for such opal glasses are often quite high when compared to conventional soda-lime-silica glass batch costs. Another disadvantage associated with opal glass manufacturing is that of high fuel consumption in gas fired furnaces during the melting and refining operation. Fuel costs are high since the molten glass itself is opal, and radiant heat energy tends to be reflected rather than absorbed by the molten glass.

Another disadvantage of known opal glasses is that the degree of opacity is often difficult to control and nonuniformity in the finished article is frequently a problem. This nonuniformity is caused by improper mixing of the opacifying agent in the batch which results in localized uncontrolled development of the opalizing species [2].

Life cycle of the furnace for manufacture of an opal glass makes no more than 2-3 years.

Excess content of fluorine in fusion mixture is the reason. It is known that fluorine – the strong oxidizer and with ease influences with silicate materials. It acts as a unique component in achievement of opal opacity of glass. Into an opal glass fluorine is entered in the form of a component of natural mineral of fluorspar CaF_2.

Fluorine at high temperatures gains character of a supervolatile component which intensively destroys inert, in less aggressive conditions, refractories.

From routine soda-lime silicate glass disappears 1/3 injected into fluorine fusion mixture during melting at achievement 1450 °C in the form of fluorides, HF, and, even more, F_2. It is difficult to define precise selection of the free fluorine as the gas analyzer has to be made from incredibly steady both to the fissile oxidizers, and to high temperatures of material. Complexity of definition of availability of fluorine in the form of gas is also that the free fluorine instantly contacts water vapor, forming gaseous hydrofluoric acid. However at the content of fluorine in fusion mixture over 7 weight percent the amount of the fluorine which remained in fusion mixture aspires to a stationary value of equal about 5 weight percent, counting on the partial fluorine.

Solubility of fluorine in silicate glasses is limited. Usually does not exceed 3 weight percent.

Exess is distinguished in the form of the crystal fluorides giving opacity to glass.

III. Results and Discussion

Aluminium Zirconia Silicates (AZS) refractories can become a solution with kiln lining destruction. AZS represents a technical stone and falls into to zircon refractories. Has the phase structure described by the threefold system ZrO_2 - Al_2O_3 - SiO_2. The mineral structure them is presented: corundum (40-50%), brazilite (10-40%) and silica-alumina glass (13-20%).

The brazilite on a row with zircon is the main source of raw materials for extraction of oxide of zirconium.

It is known that zirconium dioxide has the increased resistance to an acid condition that is necessary property at excess selection from fusion mixture of overactive Fluorine.

Under these conditions, it is considered that the level of defects of refractory origin in special glasses today is still too high. Moreover, in certain cases, notably those of borosilicate and fluoride opal glasses go hand in hand with problems of longevity in furnaces due to insufficient refractory resistance to corrosion. There are considerable differences in the chemical and physico-chemical characteristics associated with the opal glasses. However, these type of glasses is prepared in electric or flame furnaces equipped with fusedcast refractories of the AZS group. The behavior of AZS refractories in contact with these glasses depends on how aggressive they are and on the temperatures involved. But, whatever the nature of glass, the defects generated by the normal corrosion of the refractories consist mainly of an alumina matrix accompanied by a minority of ZrO_2.

Clear oxide of zirconium is almost inert in relation to Fluorine and its derivants even at influence high (more than 1500 °C) temperatures. Nevertheless, an essential shortcoming is the considerable volume heat set that leads to destruction of the arch of the furnace. At gradual temperature increase material linearly extends, but at achievement of temperature of 1000 - 1200 °C volume sharply decreases to a state less than initial, which is shown on Fig. 1. It is bound to the fact that in this interval there is a transition of crystals of oxide of zirconium from monocline crystal system to cubic crystal system. Changes of volume reach 3-4% of initial.

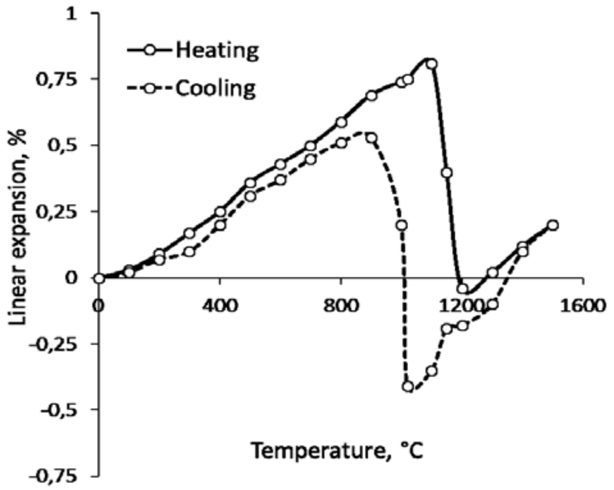

Fig. 1. Linear expansion curves (94% ZrO_2)

For avoiding of this effect it is necessary to regulate amount of oxide of zirconium as a part of high-heat material. The optimum amount of this oxide makes 38-42% of the common structure. At this ratio high resistance to a severe atmosphere remains and destructive action of decrease of volume is avoided.

However, the received firmness is not enough to protect kiln lining from harmful influence of the emitted fluorine.

Use of a refractory by component structure will be the constructive decision: Al_2O_3- 3.0%, ZrO_2- 82.0%, SiO_2- 13.4%, Na_2O-1.4%, Others – 0.2%.

This combination of raw materials will give a material resistance to aggressive environs and which will not give a reduction in linear size and shown at Fig. 2.

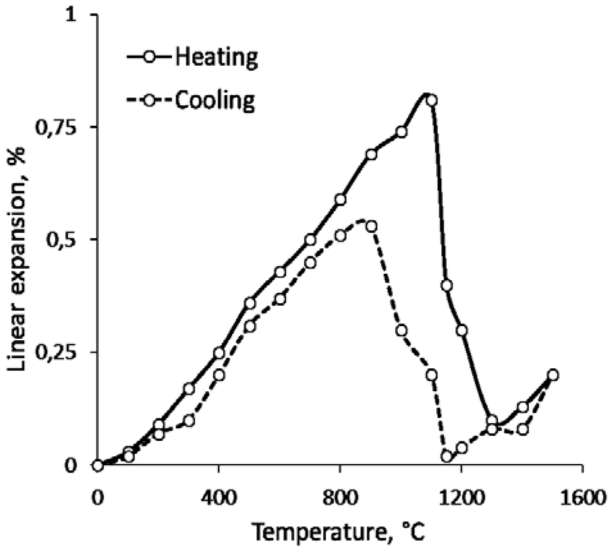

Fig. 2. Linear expansion curves (82% ZrO_2)

This is made up of Zirconia crystals which are mutually interlocked in a conguration giving it an extremely dense structure. Since it consists of a single phase composition, the glass/refractory interface of material is very smooth and no reaction layer is formed. It reveals outstanding resistance to corrosion by glasses such as hard boro-silicate and aluminosilicate.

Conclusion

In this research we characterized complexity of the technology solution of high-heat material selection for furnaces lining for manufacture of an opal glass. It agrees to experimental data, an optimal choice is AZS refractories with the content of zirconium oxide of 82% because of high-stability to the fluoride. This material maintains a severe atmosphere and the field of high temperatures, at the same time not considerably changing in sizes.

References

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