

Approaching to Fuel Save and Quality Improvement for Container and Tableware Glass Melting Furnace

(The 39th AFGM, Cebu Philippines)

Masami Kitano

AGC Ceramics Co., Ltd. Glass Engineering Division, Osaka, Japan

Introduction

To meet a pressing need of cost reduction in the glass industry in these days, performance improvement of the melting furnace is an inevitable agenda. Despite its long history of glass production since ancient times, it is not easy to find the right answer even in the modern times due to the multi-causal factors in the high temperature operation.

AGC Ceramics Co., Ltd (AGCC for short) have been working on such issue as a refractory specialist since 1916 as well as proven engineering services since 1976 (100 years and 40 years anniversary respectively by next year).

Today, we address it in terms of improving fuel efficiency and glass quality with not only scientific approach in the laboratory but also practical result at the factory site.

1. Abstract

Firstly, we speak on energy saving. In the actual record, AGCC's concept which consists of Hyper-RegeneratorTM and Thermotect-WallTM can attain 10% to 15% energy saving as compared with a conventional design. One of the epochs in 2015 is AGCC's technology got certified by Japanese environment ministry and one Japanese customer is receiving a governmental subsidy to their coming project. Hence, AGCC's concept is appreciated by the almost all customers and applied for their projects nowadays.

Secondly, we approach one of the intractable quality issues, so-called cat-scratch. We validate a modeling theory about the significant corrosion behavior of the fused cast AZS refractory at high temperature as the actual phenomena in the furnace operations. If temperature of the refractory increases 50 degrees C at the certain high level, the corrosion speed increases double. This tells us there is a lot of cat-scratch in the early stage of the furnace life because of air cooling is not so effective due to the thickness of refractory itself. AGCC have analyzed the defects in detail and understood the each characteristic and tendency, and have been proposing a counter measure to minimize cat-scratch.

2. Energy saving concept

2-1 Hyper-RegeneratorTM

The main concept of Hyper-RegeneratorTM is the double-pass chamber for the checker package. (Fig.1) To put it simply, a longer passage is logically better for the heat exchange however to maintain the flow velocity per air/gas volume and utmost utilization of checker package are the tough subjects.

One of the important issues of the double pass is to prevent the gas/air flow separation and make it a synchronized route. (Fig.2)

One of the troubled cases of regenerator is checker clogging. AGCC set up the condensation temperature of Na₂SO₄ near by rider arch in Hyper-RegeneratorTM in order to drop it off easily to the flue area. (Fig.3)

There are such key factors in order to obtain a proper function from a double pass regenerator. AGCC have made several improvements for 40 years and now provide the 4th generation of Hyper-RegeneratorTM with confidence.

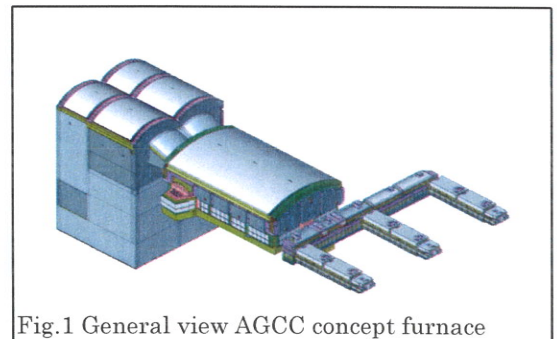


Fig.1 General view AGCC concept furnace

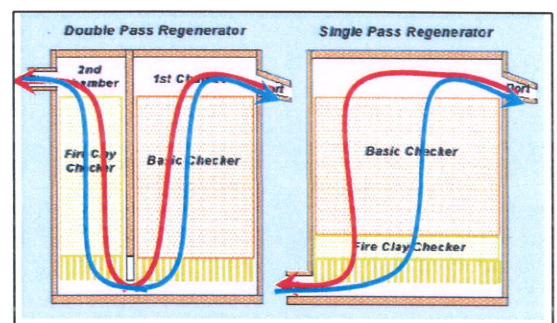


Fig.2 Air / Gas flow route

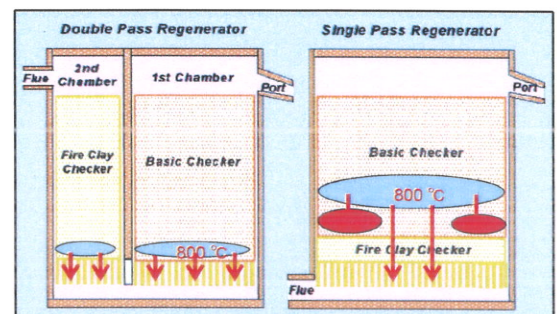


Fig.3 Checker clogging maintenance

2-2 Thermotect-Wall™

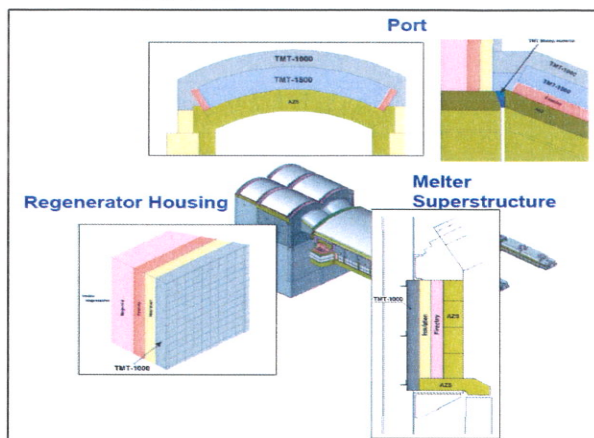


Fig. 4 General Idea of Thermotect™ to glass furnace

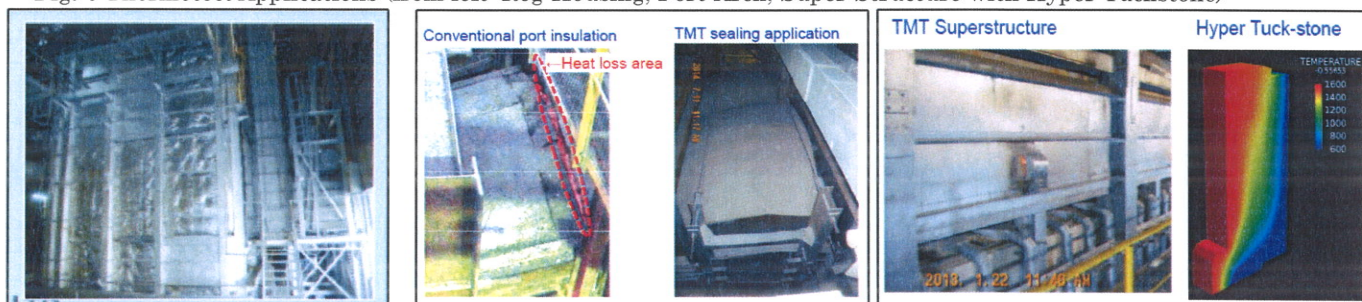
AGCC developed TMT by the internal raw material technologies.

Thetmotect-wall™ consists of the newly-developed insulation material by the trade name of Thermotect™ (TMT for short). TMT is high thermal insulating monolithic material and exercise the same performance as ceramic fiber and therefore this monolithic is usable at high temperature up to 1,600 degree C with excellent volume stability. The advantages of TMT as compared to ceramic fiber are durability for long-term operation, joint-less configuration and human body-friendly since it does not contain RCF (Refractory Ceramic Fiber) which is identified by WHO as a possible human carcinogen.



Fig. 5 Installation (trowel, cast)

Fig. 6 Thermotect Applications (from left: Reg-Housing, Port-Arch, Super-Structure with Hyper-Tuckstone)



2-3 Integrated Concepts

AGCC also integrate the other devices, ex. Middle pressure burners, to the concept furnace and attain probably the best fuel efficiency furnace in the world.

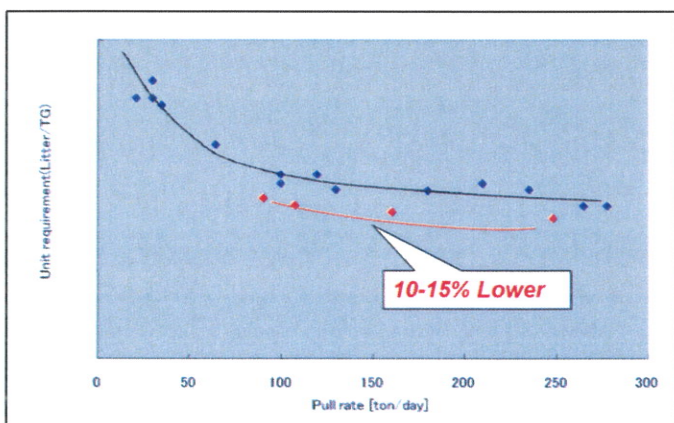


Chart 1 : Fuel Consumption

Fuel consumptions at the furnaces supplied by AGCC. The red dots are furnaces which are furnished with the 4G Hyper Regenerator and Thermotect-Wall.

3. Glass Quality Improvement

3-1. Risk of Glass Load Olympic

There is a tendency toward high load as a high melting performance, (so-called Glass Load Olympic), however high road generate an adverse impact on refractories due to high temperature.

A well-known case (because of visual trouble) is high melting temp. over 1600 degree C may damage Silica crown.

AGCC consider better not participate in the Glass Load Olympic as a refractory specialist, since there are indirect impacts on the furnace performance, i.e. glass quality and campaign life, in terms of a distinctive corrosion behavior of the fused cast refractories under the high temperature condition.

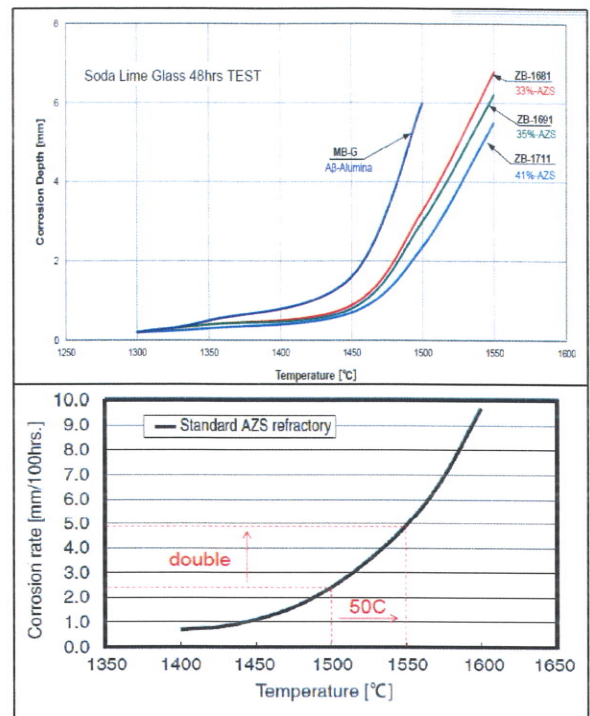
3-2. Corrosion behaviors of fused cast refractory

Chart 3 shows the relationship between temperature and corrosion speed of each fused cast refractory with soda-lime glass, 48 hours. Chart 4 focuses on fused cast AZS and extends up to 100 hours by TC 11 method. Based on these charts, we see if temperature increases 50 degree C at such a high atmosphere, the corrosion speeds become more than double.

We can see the corrosion phenomena of sidewall at Chart 5. This chart shows the simulation result and actual phenomena. The vertical axis shows thickness of the samples (250mm) and the horizontal axis shows time (month). Each line indicates the corrosion depth per the passage of time. We see the corrosion progress is very rapid at the initial stage. For instance, if operation temperature is 1600 degree C, more than 200 mm of fused cast AZS wipe out within 12 months (1 year).

Once the thickness become thinner, the progress become slower due to the cooling effect, i.e. the boundary temperature between the molten glass and refractory become lower. (Fig.7). That is the reason why the lines become shallow as time goes on.

These corrosion phenomena affects to the furnace life and glass quality caused by contaminating of ZrO_2 . You may have an experience of major problem of cat-scratch at the initial stage of the furnace life and become relatively milder symptoms with time.



Fused-cast corroded depths per temperature variation
Chart 3 (above): 48 hours of AZS / Alumina
Chart 4 (below): 100 hours of AZS

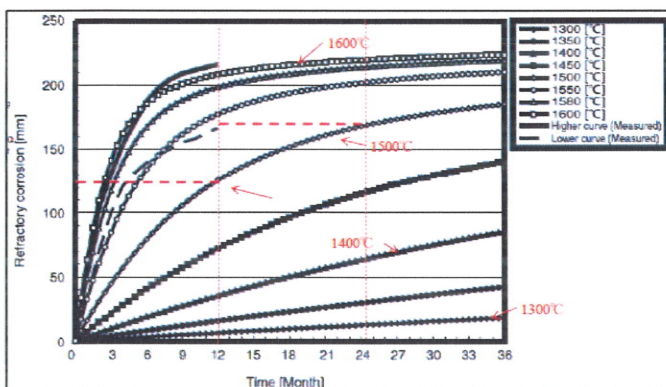


Chart 5 : Sidewall investigation

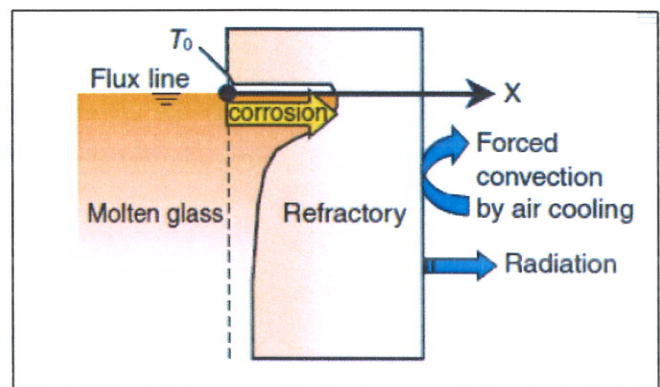


Fig 7: Corrosion mechanism of Sidewall

3-3. Cat-scratch

AGCC collect and analyze the cat-scratch in detail. ZrO_2 type generates mainly from AZS refractory in Melter. Ordinary, the mark is not so strong and multiple knots. The diffusion speed is slow. Al_2O_3 type generates mainly from Alumina refractory in Working-end and Forehearth. Ordinary, the mark is strong and single knot. The diffusion speed is fast. Sometime, there is a mixed type. Al_2O_3 is hidden behind ZrO_2 (Fig. 9)

Fig.9 Chemical analysis

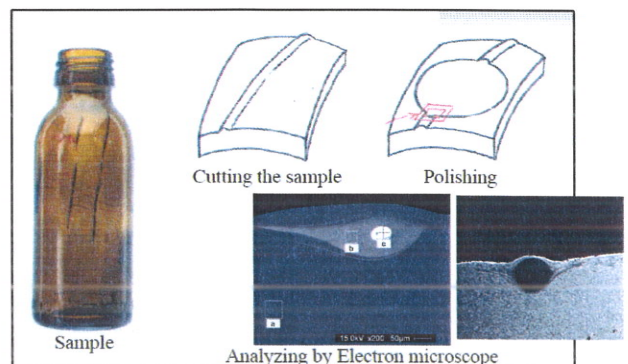
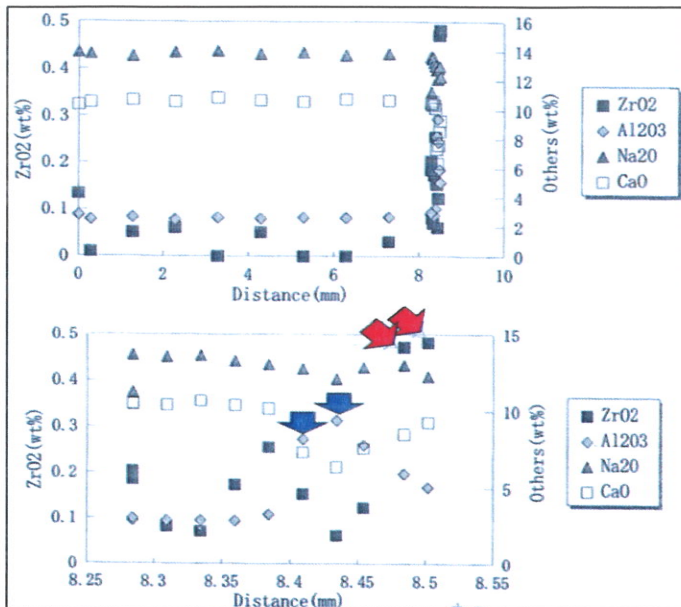
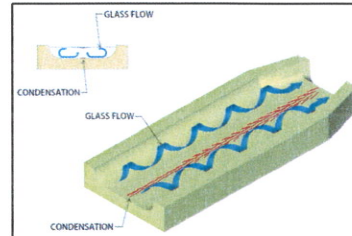


Fig. 8 Cat-Scratch analysis



Then, such a dense material flows condensed at the center of Forehearth. Unfortunately, Cat-scratch is unavoidable symptom however it can be reduced the occurrence by

- (1) optimize the temperature,
- (2) good design, reduce stagnant
- (3) refractory selection.



As a supportive care, AGCC recommend to mix the condensation by stirrer.

4. Conclusion

A fundamental knowledge is important for the glass furnace performance. A good concept, for structure, material selection and innovative application, conduces to a good performance of energy saving and glass quality.

AGCC make every possible effort to the glass industry, with proven refractory materials for 100 years and proven engineering service for 40 years. Each one of the Hyper-RegeneratorTM, and Thermotect-WallTM, is just a good example of the grand sum of AGCC activities.