# The Effect of Carry – Over on Regenerator Refractories: A Test Method for Selection

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The selection of glass furnace refractories is vital for the quality of glass and for the length of campaign. In a glass furnace initially, a good proportion of the total investment is made up of refractories. Therefore, the quality of the refractories to be used must be assured right from the begining by all means available. As a rough approximation, the cost of refractories used in the melter and the regenerators in glass furnaces (float and container) is about 45 % and 55 %; while the total weight of refractories involved is 25 % and 75 % respectively.

Very frequently, in glass furnaces, cases leading to cold repair originate from regenerator problems. Therefore, special measures have to be taken for the best choice of refractories. In this study, a test method has been designed to investigate the effect of various combinations of batch components on candidate regenerator refractories.

The gas fired test furnace designed had sufficient volume to accommodate normal size bricks. To simulate carry over phenomenon the batch components were injected on to the path of flames at the rate of 10 gr per hour. The test was carried out at a temperature of 1450ºC.

The bricks were investigated using different microscopes, x-ray diffraction and microanalysis methods. The alteration of the hot face and the penetration have been measured.

The effect of fine grained cullet on the corrosion of refractories, in this case basic materials, was found to be remarkable. The fine proportion of sand which is the major component of batch has also a significant contribution. The carry over of soda ash also has some back ground contribution.

It appears that a control on the grain size of cullet may pay for the long run as related to the campaign of the furnace, however the sand grain size must also be considered.

## Introduction

A glass furnace behaves like as "reactor" in chemical plants or systems; where all the reactions occur. High temperature conditions are the characteristic of glass production. Added to this, there is a highly corrosive environment that prevails all through the campaign. Therefore, materials used for the lining (refractories) of the furnace need special care and must be of high quality to withstand the conditions. This prerequisite means high responsibility and high cost, right at the begining of the investment. All parts of the furnace deserve the same attention.

In this study, emphasis will be given to the refractories of the regenerators. As a guideline, the cost of the melter refractories and those of the regenerators are 45 % and 55 %; whereas the quantity (weight) involved is 25% and 75 % respectively. Therefore, it is not a wrong statament to say that regenerator refractories are no less important under any circumstances than the melter refractories. It is therefore evident, that the quality of the regenerator refractories to be used must be assured right from the begining by all means available. Very frequently, in glass furnaces, cases leading to partially hot or cold repairs originate from regenerator problems.

**Regenerator Problems**

The refractories of the regenerators are subjected to thermal, chemical and mechanical influences all through the campaign. The temperature of the checkers varies from 600ºC at bottom to about 1500ºC at the top. Therefore the degree and nature of reactions which take place are highly variable at any location. All possible developments are indicated in Figure1 most of which are concurrent. In practice, the regenarators are under the ınfluence of two negative developments:

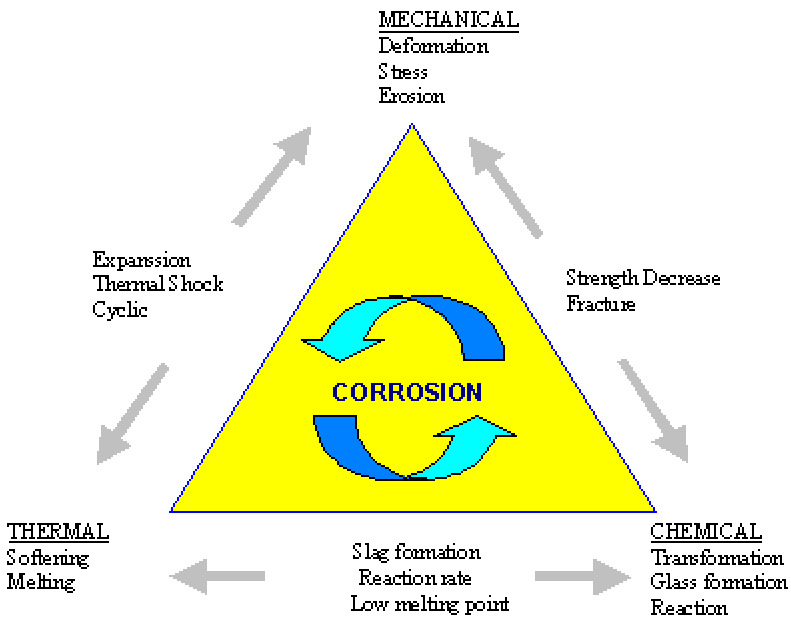


Figure 1. The influences of thermal, mechanical and chemical parameters on regererator refractories.

- The trasport of solid particles of batch origin via the combustion gases (carry-over).

In this case the grain size of the batch components, the moisture content of the batch, the velocity of gases and the flame geometry are important. As an overall result thermal, chemical and mechanical developments can take place.

- The transport of gases originating from the evaporation of the glass and gases from the reaction of batch components.

Temperature is dominantly critical as it may lead to slag formation, softening of the original material, transformation of refractory leading to scaling etc. Condensation of gases in different parts of the regenerators is also largely temperature dependent, eg. the sulfate condensation zone below 1000ºC.

Some refractory components are unstable under the effect of batch components. The classical example is magnesite (MgO) and sand ($SiO_2$). Magnesite is converted to forsterite ($Mg_2SiO_4$) under suitable temperature conditions (Figure 2).

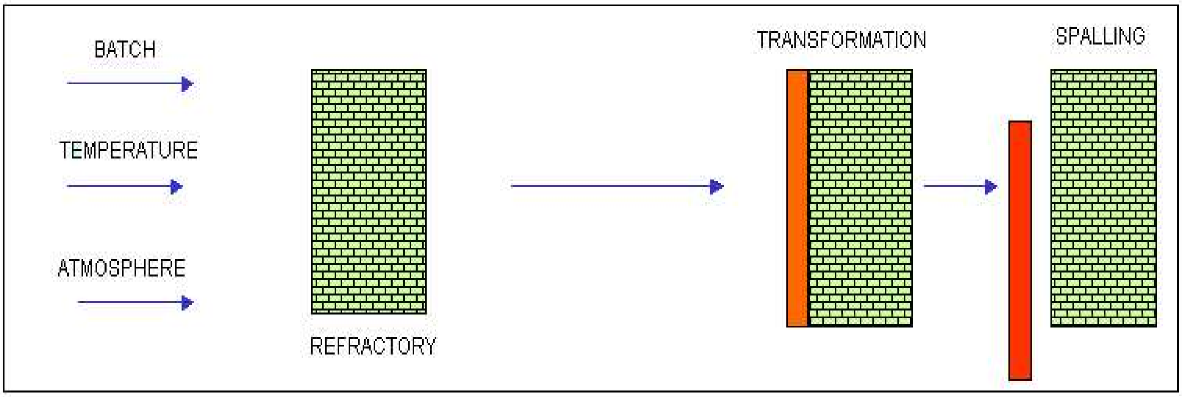


Figure 2. The effect of carry-over of sand (batch) on magnesite bricks, resulting in spalling.

In order to choose the best refractory to withstand the totally unavoidable carry-over conditions a test that simulates the phenomenon has been designed.

**Test For Carry-Over Simulation**

It is important to establish the extent of carry-over on regenerator refractories and the behaviour of refractories to this phenomenon. A test furnace with sufficient volume to accommodate reasonable size of bricks has been construsted. The burner was positioned directly opposite the bricks to be tested and the batch was injected on the path of the flame so that maximum impingement was realized (Figure 3).

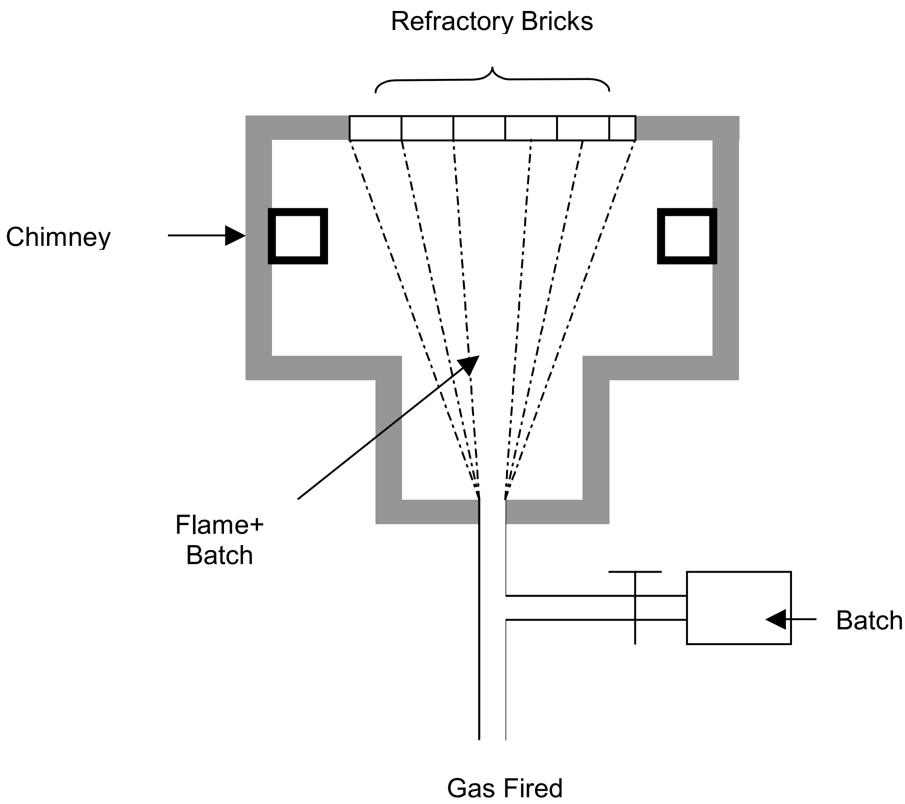


Figure 3. Test furnace used in this study

It took a good deal of effort to decide a suitable amount of batch feeding rate. 10 gr per hour was found to be sufficient. Having installed the combination of refractories a temperature of 1450ºC was attained. Batch feeding was started at this temperature and a runing period of 8 hours was fulfilled.

The selection of individual batch components or suitable combinations with pre-determined proportions and grain sizes were carefully ascertained. At the end of the experiments the refractories were subjected to thorough investigation by using microscopes, XRD and electronmicroprobe techniques. The degree of transformation of the brick sample from the hot face and the extent of penetration was found to be eritically related to the type of batch charged (carried over). The observations made are highly significant and conclusive. This is in a way a semi-quantitative display of carry over phenonenon frequently used in glass literature.

No doubt there may be several combination of corrosive mixtures; for the purpose of this study, 6 different mixtures have been prepared. This set up will help to decide which refractory material is likely to be chosen for the particullar location under investigation.
The batch compositions, the grain size characteristics, with special reference to 100µm, and the corresponding penetration caused on the refractory under study, in this case magnesite are all displayed in Figure 4.

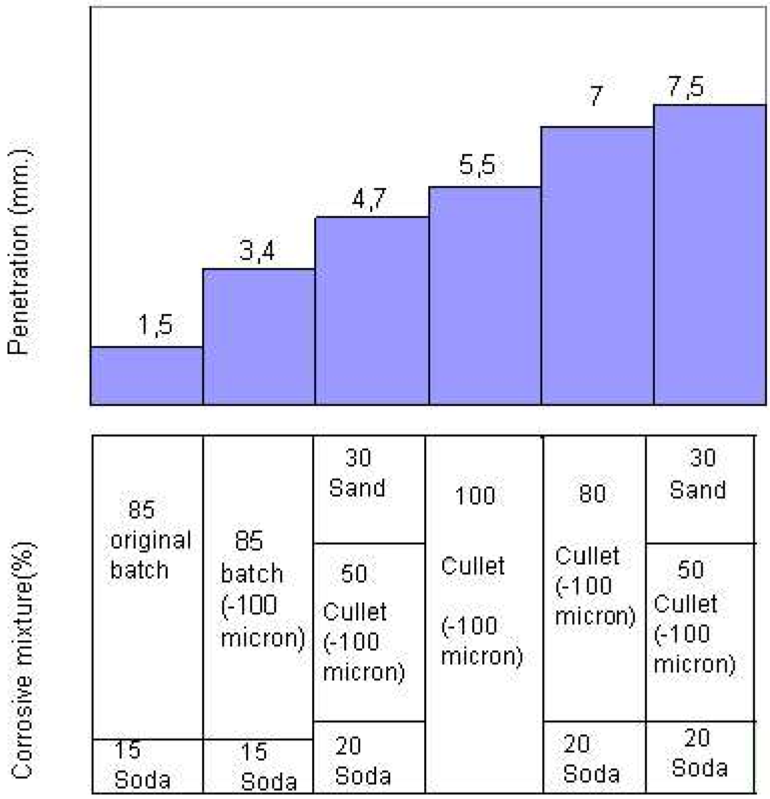


Figure 4. The effect of corrosive mixture on refractory deterioration indicated as penetration.

**Conclusions**

The following conclusions have been derived in this study:

- On individual basis, cullet was found to be the most corrosive agent among the particulate matter carried over to the regenerator. The influence is very remarkable if the grain size is less than 100µm. For practical reasons, during operation every effort should be made to eliminate the fine portion of cullet.

  Extra care should also be taken during heating up of furnaces where only cullet is charged. The fine fraction should be seived. It is the authors proposal that, the minimum size for cullet should not be less than 500µm.

- There is also some contribution to the corrosion of refractory, by the -100µm fraction of the batch. This is much less than the contribution of cullet.

- In this study, container batch without cullet was used. The authors propose that, by eliminating fine cullet and paying enough attention to the fine proportion of the batch an important measure will have been taken to lengthen the campaign of the furnace, and of course improve the quality of glass by reducing retractory corrosion, both in the melter and regenerator.