PRECAST SAFETY LINING IN BF MAIN TROUGH

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INTRODUCTION

Leader in the iron market in Western Europe, Calders is a significant player in blast furnace operations worldwide.

We have always taken the attitude, that a refractory supplier should be a partner with his client. This partnership involves not only the buying and selling of state-of-the-art products, but also a mutual understanding of the application requirements, an effort to supply the best refractory technology and the sharing of the desire to push back the limits of this technology.

For the casthouse floor, we have developed many products and solutions to respond to all key requirements of our customers in order to:

- To assure total reliability
- To achieve long campaigns
- To reduce the maintenance downtime

In order to improve the reliability and the safety of the main runners, we have developed the concept of a special lining adapted for the main trough, sandwiched between the wear and the safety lining constructed from prefabricated shapes. The shapes are made with a special high strength non-oxidising castable which resists iron and slag contact. The shapes allow the trough more flexibility and provide an additional interface to stop iron penetration.

THE PROBLEM

The refractory lining of a main runner is generally composed of different layers (see Fig 1):

- an insulation layer to avoid the heating up of the metallic shell or of the backlayer concrete
- a safety layer which role is to ensure the security if the wear lining fails
- a wear lining in contact of the hot metal and the slag during the runner campaign.

At the end of the campaign, the wear lining is worn (see Fig 1) and has to be repaired.
After wrecking of the worn areas, the former is placed and new product is cast (see Fig 1). A new campaign can start again.
However, after numerous campaigns, following phenomena are observed:

- the safety lining is in poor conditions; it is cracked vertically and horizontally and for this reason cannot anymore play its role of security.

- the permanent wear lining, which is not replaced at each repair, becomes old, more or less oxidised and is infiltrated by metal. This will lead to a loss of mechanical strength and a loss of corrosion resistance.

As a consequence the back layers of the trough are no more reliable for the hot metal transport (see Fig1 / Ω).

![Figure 1: the Problem](image)

**THE CONCEPT**

We have developed a concept of prefabricated shapes used as safety lining in order to avoid the failure of the backlayers in a main trough.

The idea is to place a layer of precast pieces (see Fig2 / Ω) between the wear lining (see Fig2 / Ω) and the back lining (see Fig2 / Ω).

This layer is composed of a juxtaposition of independent blocks which are dry joined. They are made with a special adapted castable, the CALDE™ CAST LC 70 S20, which shows:

- very high mechanical strengths (even at low temperature)
- very high oxidation resistance
- excellent corrosion resistance
The pieces are dried and preheated in our plant prior to installation.

The concept can be adapted to all types of runners (particularly main troughs but also secondary runners). It can be applied to a new runner but also for existing runners after a general repair (in this case it is not necessary to take the bottom of the runner out).

**RULES OF INSTALLATION**

In order to obtain all the characteristics of this concept, some rules of installation are required:

1. First of all the blocks are completely independent and are dry jointed. No mortar or cement is used to join them or to stick them on the backlayers.

2. In order to obtain a regular and perfect packing without any discontinuity, it is recommended to use baffle joints. The objective is to avoid any risk of fused liquid penetration between 2 pieces when a crack of the wear lining reaches the blocks.
The position of the blocks in the walls has also an important role: they have to ensure the safety of the trough in the most risky areas of the runner (see Figure 3).

- the bottom of the shapes has to be below the bottom of the runner (see Fig3 / 1).
- the hot metal / slag interface has to be in front of the blocks (see Fig3 / 2).
- the top of the blocks should not appear out of the walls, we recommend to bury them in the wear (see Fig3 / 3).

In order to avoid any risk of oxidation of the wear lining from the back, we suggest to use a self-flowing castable or a dry vibrating mix behind the blocks. These materials should be installed once the pieces have been placed (“pouring” of the back layer).

Generally, as the campaign length of a runner is determined by the wear in the beat area, a longer campaign can be achieved by increasing the wear lining in this area. For this reason, the thickness of the blocks are in most cases fixed by the thickness of the wear lining in the impact area of the trough and by the global thickness available in the walls.

Of course, via thermal calculations, it is necessary to determine the quality of the products behind the blocks to avoid too high temperatures on the metallic shell. More, it is absolutely necessary also to ensure that the liquidus limit of the hot metal (1150°C) is situated inside the safety lining and not closer to the shell: this provides an immediate solidification of the liquids whenever they are able to penetrate the lining (via cracks)

For the slag and hot metal outlets, the same pieces can be used as elsewhere in the trough; it is just necessary to cut them in their upper part.

All of these requirements added to the unicity of each runner allow:

- the calculation of the exact positioning of the precast shapes
- the size of the precast pieces
- the installation conditions.

THE PRODUCT

The precast shapes are made with a special adapted castable, the CALDE™ CAST LC 70 S20.

It is a low cement castable, based on brown fused corundum, containing 20% silicon carbide and presenting a very high density.

3 major characteristics can be pointed out:

- The high mechanical strengths of the product ensure a good stability of the backlayer of the main trough and make sure the blocks resist against the successive wrecking.
- The product shows an excellent resistance against oxidation (it contains SiC but it doesn’t contain any carbon avoiding the risk of its oxidation and of the characteristics decrease). The blocks remain chemically stable in time. Consequently, the physical stability is also improved.
- The product shows very good corrosion resistance against slag and hot metal. Despite the lack of any carbon, its high density and SiC content ensure an good
resistance against corrosion. Without carbon, the CALDE™ CAST LC 70 S20
does not offer the corrosion resistance of a classical wear lining product.
However let’s remember the role of the precast shapes is not to be used as a
wear lining but as a safety lining and in this case its corrosion resistance is
more than sufficient.

SOME EXAMPLES

Figure 4 below shows some adaptations of the concept for several various runner
geometries. It shows the prefabricated blocks can be adapted to all types of runners.

Figure 4: Some examples
ADVANTAGES

Lots of advantages exist by the use of the concept of precast pieces as safety lining. Let’s see the most important of them.

- Each runner is unique: however, for each one, it is possible to determine a given geometry of the pieces in order to introduce the concept. The concept can be adapted to all runners, new or old.
- The installation of the blocks in the runner and the filling with the pouring material behind is done quickly and easily (no former, no drying for the blocks).
- The wear lining in front of the precast shapes can be made by all the known methods: castable, zoning of two or more castables, wet ramming, dry ramming, ...
- The quality of the precast pieces is ensured as they are produced in optimal conditions in our own plants.
- The use of dry precast pieces avoids any drying problems during the installation. More, to pour the product behind the blocks, no former is required as the pieces can be used as a mould.
- The use of the precast pieces concept can allow an optimisation of the wear product consumption: thicker blocks can be used in the runner areas where the wear is less important (close to the skimmer area for example).
- The use of an additional layer between wear and safety linings introduces 2 more interfaces more able to block a crack propagation (should the crack appear from the hot side or from the cold side of the trough).
- The concept of the precast blocks allows a bigger lining stability, a higher flexibility of the trough and diminishes the cracks formation in the wear lining.
- The SiC content of the blocks ensure a relative high thermal conductivity. Our experiences show that the infiltrations through the wear lining are blocked by the precast shapes (freezing effect) without affecting them. A thin layer of hot metal or slag remains in front of the shapes.
- The good thermal conductivity of the precast pieces allows also a better heat transfer via the walls of the runner and as a consequence, reduces the wear in the wear lining.
- In comparison with other materials, as carbon blocks, our castable doesn't fear oxidisation.

REFERENCES & POST MORTEM

Below, the Table 1 shows the various places our concept has been successfully applied.
After years of usage the relining of some runners has allowed us to remove several prefabricated blocks to check their behaviour over the years.

One block was removed from a French main runner in mid 2009 after 8 years of use. This runner has delivered 5.8 million tons of hot metal without any problem during this long campaign.

The block was fully analysed in the laboratory. The visual examination shows 1st the block is “intact”, no cracking, etc. From the chemical point of view, the analysis made on the “hot face” and the “cold face” are close to the chemistry of the initial product. This means no slag or iron have penetrated into the material. Only a little decrease of the SiC content on the hot face (minus 0.8% from 19.5% initial), which can be explained by a very slight oxidation over the 8 years.

From the mineralogical point of view, the analysis of the crystallographic phases proves the material is almost unchanged.

Cold physical properties and permeability are in line with the initial values linked of course to various temperatures (hot face and cold face). Microstructure observation doesn’t show fluctuation except of course a slightly higher sintering on the hot face.

As a conclusion of this post mortem analysis of the CALDE™ CAST LC 70 S20 used as safety lining in a main runner for over 8 years: the material is intact and could have been used for a much longer time.

A similar work was also done in 2009 on a German runner where the prefabricated blocks were installed in 2003. As before the blocks are close to “as new”.

Table 1: references

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The above examples show clearly the concept allows to increase significantly the life and reliability of the safety lining.

CONCLUSION

All the previous given arguments show the concept of precast pieces as a safety lining improves the reliability of the runners as well as it globally allows a reduction of the refractory costs. On one hand, we save money by increasing the campaign life of the safety lining, on the other hand, we save additional money by avoiding the replacement of wear lining when the safety lining has to be changed.

As a consequence, the concept of precast pieces in CALDE™ CAST LC 70 S20 as a safety lining improves drastically the reliability and the profitability of the runners with a reasonable investment in costs.

The Author

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Diploma of Chemical Engineer in 1987 – PhD in technical ceramics in 1991
Start working at Lafarge Refractories in 1991 in the Central Laboratory
Focus on basic monolithic materials for the steel industry
1993 : R&D Engineer for the iron segment
1995 : Technical Engineer for the iron market
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