

New Technology for the Production of Hearth and Skid Blocks for Reheating Furnace Applications

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ABSTRACT

A new production process has been developed which is based on the use of gel casting and sintering technology to produce a technically superior alternative to traditional fusion cast hearth blocks for reheating furnace applications. Hearth blocks produced using this process exhibit a number of technical advantages in terms of thermal shock resistance, wear resistance and have other desirable properties. Service trials across a variety of different furnace types have shown improved performance and confirmed the benefits of blocks produced using the new technology.

INTRODUCTION

Fusion cast refractories were first developed in 1925 and widely commercialised over the following decades. Industrial applications were first focussed on the glass industry, but they soon found widespread use in other high wear areas of the steel, non-ferrous metals and other industries. They are now widely used in the high wear areas of steel plant reheating furnaces such as pusher furnace hearth and skid blocks, in walking hearth furnaces etc.

Monocon identified several disadvantages of fusion cast blocks such as high process temperature (typically 1800-2500°C) limited thermal shock resistance and the rapidly changing properties from the outer skin of the blocks towards the inner parts. The outer skin of the block has very high strength and abrasion resistance with a dense and finely crystalline microstructure, but as we move away from the surface and into the body of the block then the crystal size, porosity and pore size increase, while the strength and abrasion resistance rapidly decrease. Many fusion cast blocks also contain large shrinkage voids within the blocks.

Several production processes were considered before we focussed on a combination of a sol gel bonding process and sintering at a moderate temperature ($\leq 1500^\circ\text{C}$) Monocon's Activated Gel Casting (AGC) process had already been found to give excellent performance in a variety of demanding high temperature applications. A variety of base compositions were considered, including those based on alumina-zirconia-silica and a combination of α and β alumina which are typically used for the production of fusion cast blocks used in this application, but an alumina-magnesia spinel material was considered most suitable due to its combination of high resistance to abrasion and chemical resistance to iron oxide.

EXPERIMENTAL

A number of formulations were evaluated with different proportions of alumina and magnesia-alumina spinel grain, reactive aluminas, sol and additives. A range of process variables including sintering temperatures were also evaluated.

Bulk density and apparent porosity of MB1 were determined according to BS EN 993-1:2018. Cold Crushing Strength was determined according to BS EN 993-5:2000. Chemical analysis was determined using x-ray fluorescence and the mineralogical composition was determined using semi-quantitative x-ray diffraction. The properties of a widely used fusion cast hearth block material (MB) were determined from a variety of published sources.

The preferred combination of formulation, sintering temperature and other process parameters was selected and given the name MonoBloc (MB) The physical, chemical and mineralogical properties are shown in tables 1-3, along with the properties of the fusion cast block material FC.

Table 1: Physical Properties

	Unit	MB	FC
Bulk Density	gcm^{-3}	3.14	3.00
Apparent Porosity	%	14.2	12.7
Cold Crushing Strength	MPa	182	200
Modulus of Rupture	MPa	32	-

Table 2: Chemical Properties

Wt. %	MB	FC
Al_2O_3	92.8	75.2
SiO_2	2.2	18.0
MgO	3.9	-
Na_2O	0.2	0.9
ZrO ₂	-	5.0

Table 3: Mineralogical Composition

Wt. %	MB	FC
α -Alumina	76	40
Mullite	1.6	42
Spinel	18	-
Baddelyite	-	5
Glassy Phase	1.4	13

The thermal conductivity of MB was determined using the hot wire (parallel wire) method according to ISO 8894-2. The results for MB and FC are broadly similar although they exhibit some variety throughout the temperature change.

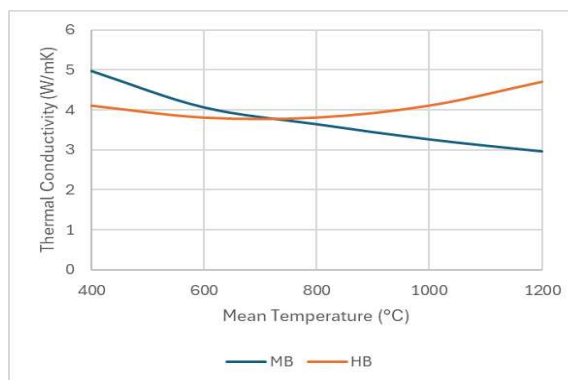


Fig. 1: Thermal Conductivity

The Hot abrasion resistance of MB was determined at 1200°C using a silicon carbide abrasive and 90° testing

direction as per ISO 16282. The abrasion loss was found to be only 0.90 cm³.



Fig. 2: Sample after hot abrasion testing

Reaction with mill scale was examined using in-house crucible test method at 1500°C. There was no significant reaction, and the only noticeable effect was some minor surface staining.



Fig. 3: Mill Scale Reaction test (1500°C)

A variety of hearth and skid blocks of 75-300mm in thickness were produced in a production environment to ensure that laboratory results could be repeated. Trial blocks were then evaluated in pusher and walking hearth furnaces at several European steel plants.

INDUSTRIAL TRIALS

The initial trial of MonoBloc was carried out in a billet pusher furnace that has traditionally used fusion cast skid blocks in the heating section. No wear was noticeable in the heating section and the brand marking was still visible after 1

year. Only minor wear and little reaction was visible after 3 years – see Fig. :4 and 5. These blocks are still in service.

Further blocks were placed into the soak/discharge hearth of the same furnace and were found to be in excellent condition after 2 years. The adjacent fusion cast block was found to be heavily cracked and showed increased wear compared to MonoBloc (MB) – see Fig. :6. It was also noted that the MonoBloc also showed reduced reaction build up in contact with mill scale compared to both fusion cast blocks and those made from an alumina-spinel low cement castable.

A further trial was carried out in the soak/discharge hearth of a walking hearth furnace. Thermal shock was severe in this furnace, which typically limited the hearth life to a maximum of 18 months, when using fusion cast blocks. Fusion cast blocks adjacent to the walking beams were found to be extensively cracked after 1 year, while the adjacent MonoBloc showed no deterioration – See Fig. :7

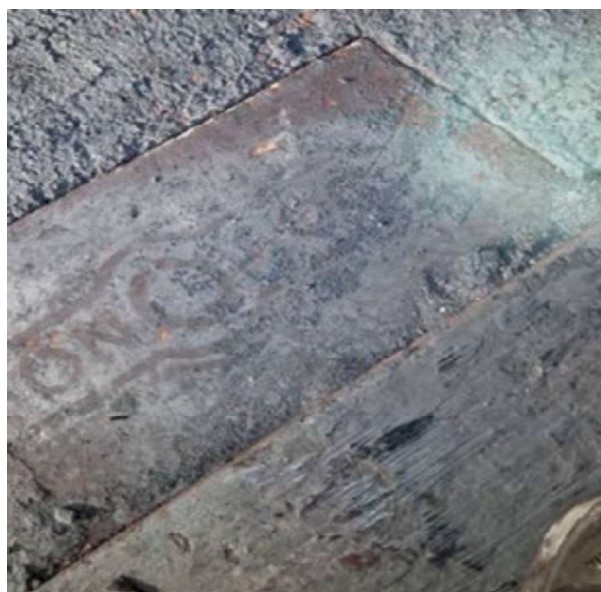


Fig. 4: MonoBloc (MB) after 1 year of service

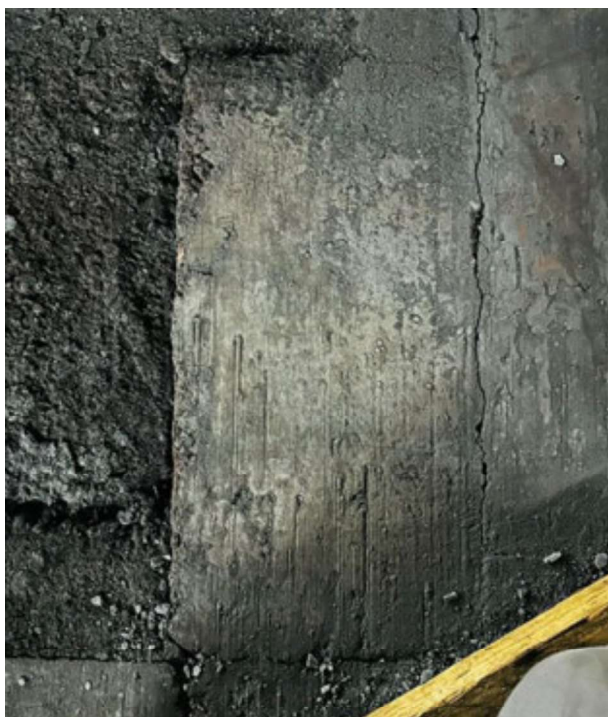


Fig. 5: MonoBloc (MB) after 3 years of service



Fig. 6: MonoBloc (MB) after 2 years of service



Fig. 7: MonoBloc (MB) after 1 year of service

RESULTS AND DISCUSSIONS

Hearth and skid blocks manufactured using the newly developed manufacturing process provide an excellent combination of properties for reheating furnace applications, that are largely uniform throughout the thickness of the block. Industrial trials have shown that they perform very well in service compared traditional fusion cast blocks in terms of wear resistance, mill scale reaction and especially when thermal shock is experienced.

Further industrial trials and a number of service installations are now in place at further customers worldwide, and observed performance supports the initial trial results.

CONCLUSIONS

The new production technology and commercial product, MonoBloc, offer an attractive alternative to traditional fusion cast blocks in a variety of reheating furnace applications. MonoBloc has proven especially suitable in applications where traditional fusion cast blocks suffer from thermal shock damage.

REFERENCES

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², S. Dutta, A. Gupta. "Hearth and Skid Pipe Refractories - a Review"