Refractory Systems | **HIGH-QUALITY REFRACTORIES FOR HIGH-QUALITY STEEL**

Focus on Progress

Fig. 1 a (left) and b (right): Dry pressing of center runners and runner bricks

HIGH-QUALITY REFRACTORIES FOR HIGH-QUALITY STEEL

Dipl.-Min. Werner Schönwelski, Klaus Ruwier, Stephan Föllbach, Dipl.-Ing. Jens Sperber
STEULER-KCH, Refractory Systems Division

High-quality steel requires the absence of ceramic inclusions, which would restrain the further processing of bottom poured steel blocks by rolling and forging. Silica is the weakest ceramic component in refractory bottom pour materials; consequently alumina content has to be maximized. Latest developments in refractories allocate 92% alumina material as a standard, 99% Al_2O_3 is pending to be upgraded from laboratory to production level. Laboratory investigations show that nitride containing pure alumina material shows no wetting by steel melt.

In application high alumina materials show remarkable less corrosion than standard and especially in big blocks - when long casting times are necessary - ceramic inclusions are avoided.

INTRODUCTION

Non-metallic inclusions of any kind reduce the quality and workability of bottom poured ingot cast steel blocks. Their origins maybe slag components, reoxidation phases and ceramic particles relieved by wear of refractories as well.

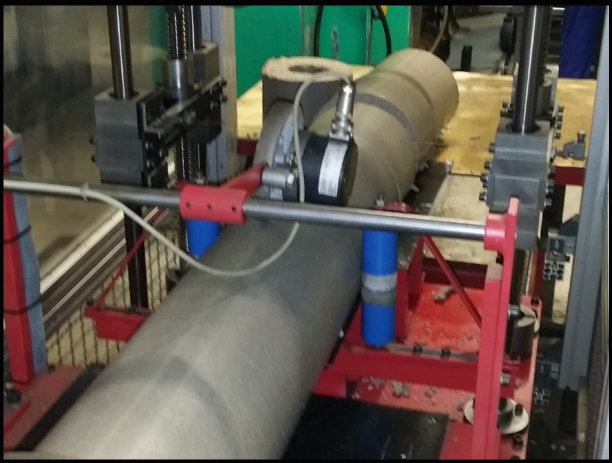
The influence and participation of bottom pour refractory hollow ware on steel quality has been neglected until a decade ago. Declared dead and announced to be replaced totally by continuous casting, bottom pour technology had a renaissance around the turn of the millennium. Standard refractories were made of fireclay, and for common carbon steel grades they still may be sufficient. But with increasing amounts of steel alloys, higher casting temperatures and longer casting times demands on steel quality and purity increased, subsequently the quality of refractories had to follow [1]. So different approaches were made to reduce steel inclusions that refer to corrosion of refractories to a minimum, although only a few producers took care of this subject.

The interactions between alloy metals and ceramic refractory components are known very well, especially those of manganese and chromium against free silica [2]. Consequently one target for refractory producers was to increase the alumina content of bottom pour refractories. One of the first steps, almost 20 years ago, was to get an overall mullitic composition by using coarse high-alumina raw materials. This was finally unsatisfying because the binding matrix remained a weak point.

Therefore further development yielded in refractories still with high-alumina coarse grain like bauxite, but additionally fully mullitic binding matrix and a minimum of free silica content below 1.5%. Today these materials are considered to be called well-established and standard. Nevertheless for special steel grades and big shapes there was still room for improvements. The application of carbon in different forms as a corrosion protection agent was successful if related to material technology [3, 4], but exhibited several disadvantages like releasing volatiles and the liability to oxidation. The development and application of such bottom pour refractories has stagnated.

EXPERIMENTAL, PRODUCTION AND APPLICATION

Our developments were focused to increase the alumina content furthermore. It sounds easy to replace refractory raw materials by others which are higher in alumina content, but technical producibility like shaping and final properties of the product set the limits.



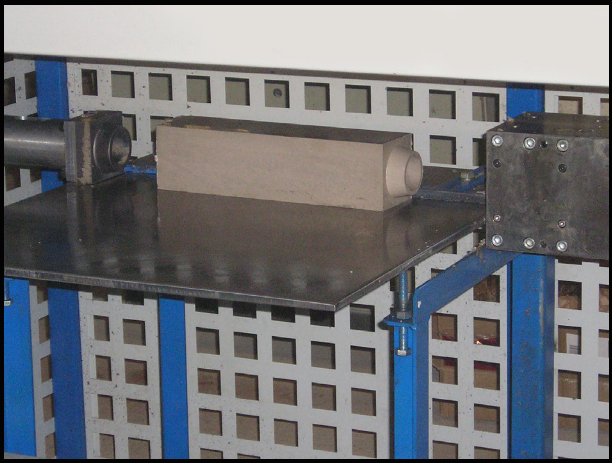


Fig. 2 a (left) and b (right): Plastic shaping of runner bricks, extrusion press and final shaping

Especially bottom pour refractories have to be shaped by half-dry pressing for straight sizes as well as also by extrusion for complicated shapes like spiders and end gates. For extrusion - to get the plastic consistency of the mix - you normally need even higher clay contents than for half-dry pressing, which contradicts the demand for less silica. You also need clay for a minimum of green strength.

Our 92% alumina material accepted the challenge successfully by replacing clay by a bundle of high alumina fines. It is based on corundum and contains a free silica content of zero. This material is designed for long casting times and aggressive steel alloys. Steel bones and refractory parts can easily be separated after casting and sticking is reduced to a minimum.

All refractory qualities were tested for corrosion resistance in lab using steel quality P 900, 2 hours at 1530° C. As expected, with standard fireclay at these temperatures the results were a disaster, while improving with increasing alumina content. Application in different steel works confirmed the lab results, see photos.

In the case of corundum bricks a small zone of 1-2 mm forms which is infiltrated by steel, but still sticks to the refractory. The steel bone itself separates from this "shell" and therefore no ceramic particles are transferred into the steel melt.

For any application where still this alumina content is not sufficient we developed a 99.5% alumina material. Crucible tests show that the remaining "corrosion" that can be observed is related to the oxidation of the steel surface, surely reinforced by the high oxygen affinity of the steel alloys. The surface roughness of the steel bones is further improved and there are no inclusions.

The special challenge for producing a pure alumina material is the absolute absence of clay. This can be solved easier for half-dry pressed material than for an extruded one, by using temporary binders, but for a plastic consistency you must find very special additions. Additionally the firing temperature increases with alumina content. Finally both are available now.

For those who are still not satisfied one preliminary final step can be implemented by including non-oxidic components into the system. Hear a lot of candidates appear as possible additions, mainly Nitrides. It is very well known from literature [3], that silicon nitride reacts heavily with steel melts, although operating successfully with non-ferrous metals. For steel other components have to be found like aluminum nitride or boron nitride. In fact we do already use both of them and see that they peak in absolute no wetting of steel melt (Fig. 10), but the challenge is to integrate such components into the system both technically and economically.

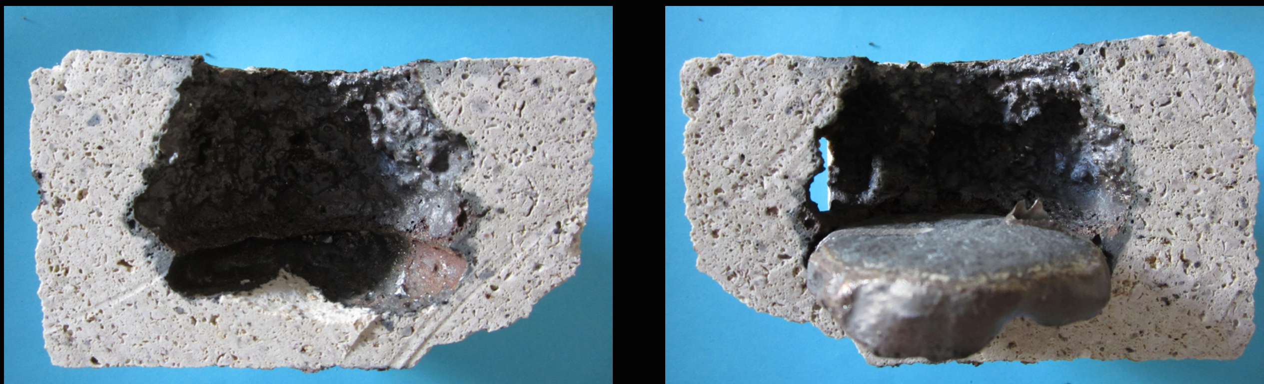


Fig. 3 a (left) and b (right): Crucible test on standard fireclay material with steel P 900, 2 h at 1530 °C, without (a) and with (b) residual steel bone

Fig. 4 a (left) and b (right): Crucible test on improved 1st generation high-alumina (bauxite) material with steel P 900, 2 h at 1530° C, without (a) and with (b) residual steel bone

Fig. 5 a (left) and b (right): Crucible test on improved 2nd generation high-alumina (corundum) material with steel P 900, 2 h at 1530° C, without (a) and with (b) residual steel bone

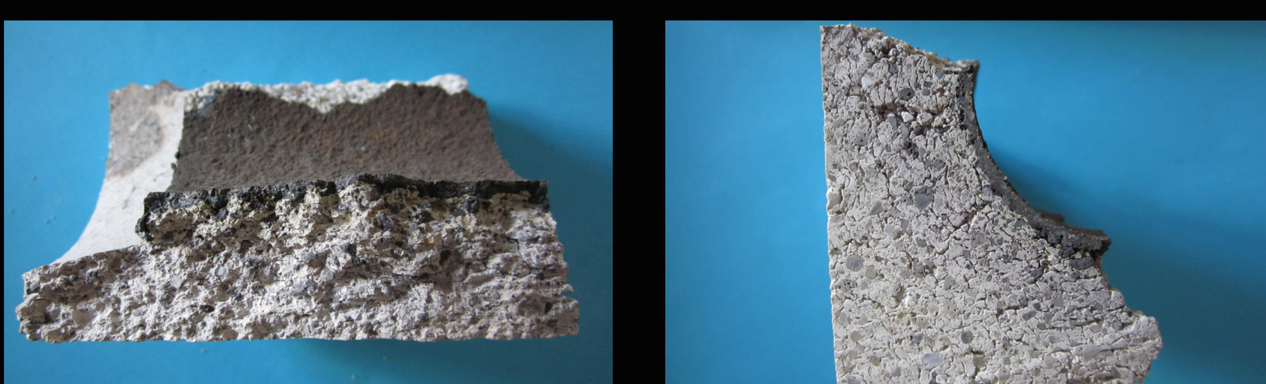


Fig 6 a and 6 b: Bauxite runner brick after use

CONCLUSION

The higher the requirements for steel quality and casting technology are, the higher is the demand for refractory quality. This can be solved by using high-alumina materials up to 99% where it makes sense. Further technical progress can be implemented by introducing special components into the system like nitrides. In terms of price / performance relation bottom pour ceramics may not be the primary target for such products, but it was our intention to show that many things that are necessary are also possible. High-technology bottom pour refractories will not become a mass product, not only because of economic reasons but it is also a big challenge for the producer.

Specifically in the case of nitride addition the fitting partners for steel melts must be identified, and it must be carefully observed that production technology and final product properties are not influenced in a negative way. Bottom pour refractories can be produced as high-tech-materials when the demand is to fulfill their share for cleaner steel.

REFERENCES

[1]. J. EISENKOLB, R. FANDRICH, R. GERLING, H.-P. JUNG, Stahl und Eisen 132 (2012), No. 5, pp 49-59.

[2] WAHLSTER, M. et al,: Archiv f. d. Eisenhüttenwesen 41 No. 1 (Jan. 1970), pp. 37-42

[3] Patent WO2011054872

[4] R. de PAULA RETTORE, E. GUEGUEN, W. RITTER, ICRF Conference Paper 2012

Fig 7 a and 7 b: Corundum runner brick KE 92 UG after use

Fig. 8 a (left) and b (right): Crucible test on 99% alumina material with steel P 900, 2 h at 1530° C, without (a) and with (b) residual steel bone

Fig 9 a and b: End Brick (left) and Center Runner (right) made of pure alumina

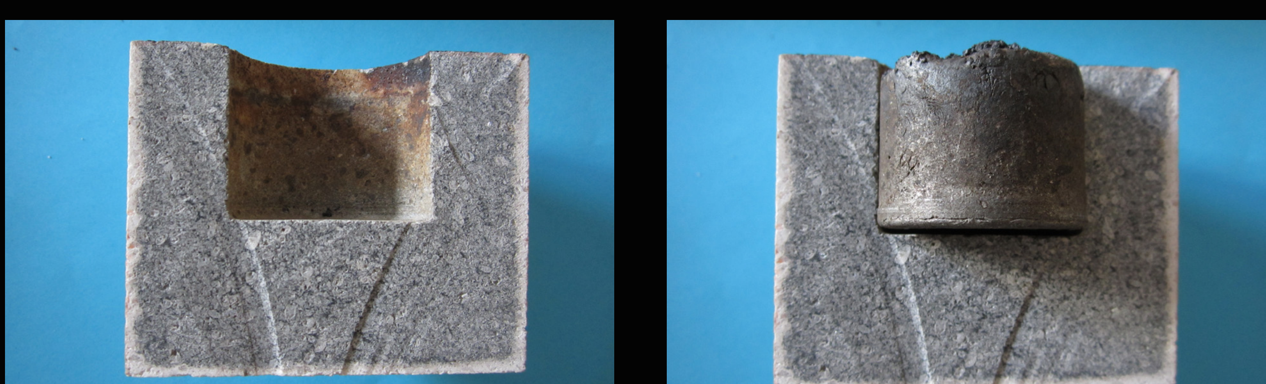


Fig. 10: Crucible test on 99% alumina material containing Nitride Steel P 900, 2 h at 1530° C, without (a) and with (b) residual steel bone. Absolutely no wetting. Consider the crucible is discolored from outside through the test and the grey color inside is original and not caused by the steel test.

STEULER KCH

Steuler Técnica S.L.
Spain

Steuler France S.A.R.L.
France

Ditescor S.A. de C.V.
Mexico

Steuler Maroc S.A.R.L.
Marocco

Alphaplast S.A.
Spain

Steuler Nordic AB
Sweden

Shanghai STEULER-KCH Anticorrosion Engineering Co. Ltd.
China

CIMA S.r.l.
Italy

KCT Sp. z o.o.
Poland

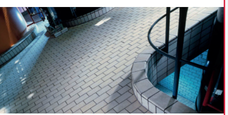
Steuler Industrial Corrosion Protection Pty. Ltd.
Australia

Steuler New Caledonia S.A.R.L.
New Caledonia

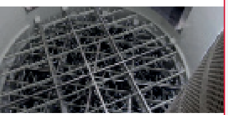
STEULER-KCH
Branch Saudi Arabia

STEULER-KCH
Branch Austria

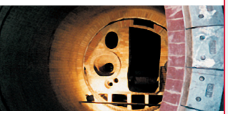
Zusammen mit internationalen Tochtergesellschaften und Vertretungen bietet STEULER-KCH seinen Kunden ein weltweites Netzwerk, das umfassende Anlagenlösungen entwickelt und umsetzt.



OBERFLÄCHENSCHUTZ-SYSTEME
Auskleidungs- und Bodenbeschichtungssysteme, Kitte, Verfugematerialien, Ausmauerungssysteme, Gummierungen

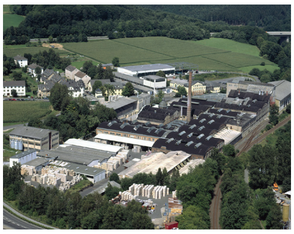


KUNSTSTOFF-TECHNIK
Thermoplastische Auskleidungssysteme
Apparate, Rohrleitungen und Behälter aus Duro- und Thermoplasten



FEUERFEST-SYSTEME
Feuerfeste Auskleidungssysteme

SCHWIMMBADBAU
STEULER-Q^7-System



STEULER-KCH GmbH

Geschäftsbereich Feuerfest-Systeme
Georg-Steuler-Straße
56203 Höhr-Grenzhausen | GERMANY
Phone: +49 26 24 13586
Fax: +49 26 24 13-305
Mail: ff.info@steuler-kch.de

Oberflächenschutz-Systeme
Kunststoff-Technik
Schwimmbadbau
Berggarten 1
56427 Siershahn | GERMANY
Phone: +49 26 23 600-0
Fax: +49 26 23 600-513
Mail: info@steuler-kch.de

www.steuler-kch.de

Fortschritt im Fokus