Growing with Challenges, Opportunities and Innovations

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The most modern monolithic refractory plant of HÖGANÄS Bjuf AB, in Bjuv/SE, started manufacturing since September 2016, with the brand names: HÖGANÄS and Borg. The products include conventional, low cement, ultra-low cement and no cement mixes, catering the needs of various industries such as ferroalloy, aluminium, iron and steel, energy boilers, incinerators, etc. Implementation of modern R&D and processing techniques have offered user friendly products with easy wetting, shorter mixing time and excellent installation behavior. Focusing on sustainable developments has resulted in a new no cement-technology for fast drying, saving time, energy and cost and helping environment related issues.

1 Introduction

HÖGANÄS Bjuf AB, a company belonging to Borgestad Group, with centuries of experience and expertise in refractory brick manufacturing and use, located in Bjuv/SW constructed a most modern monolithic refractory plant, and the manufacturing begun in September 2016. The new monolithic plant with an annual capacity of 30 000 t supplied by Eirich/DE (weighing, dosing, mixing, automation), equipment for packaging from VEBE/SW (paper bag/big bag packaging) and Lachenmeier/DK (stretch hood unit).

The R&D department designed a new generation of mixes, which consists of four product families (conventional, low cement, ultra-low cement, and no cement). The new packaging materials with colour codes are helpful to identify the type of products used by the end-users. The barcode system in the production process ensures the traceability in the complete process of manufacturing to usage. The SmartInstall app for smartphones, which provides product and safety data sheets as well as all necessary installation instructions for the individual products. The mixing tool and the inclination of the mixing pan have been optimally designed to process mixes with a wider particle size distribution and very low level of additives that are homogeneously distributed in the mix. The pneumatic cleaning system in the mixer ensures perfect cleaning when changing one type of product to other.

The new plant has enabled the company to cater the needs of both brick and monolithics in Nordic, Europe, Middle East and the other parts of the world. There have been various trials conducted globally since the inception of plant in several industries such as ferroalloy, aluminium, steel, nonferrous, biomass boilers, incinerators, and cement plants in Europe and Middle-East with excellent results. The success of this new monolithic manufacturing plant has been well supported by R&D and quality control facility located in Bjuv, and the most skilled marketing personnel of Borgestad group. The result of this team work has enabled the new plant achieving the goals as planned successfully.

Research and development

In order to fulfil customer's current and future needs, R&D at Bjuv continuously develop innovative new products and upgrade our existing solutions to incorporate new technical trends and safety requirements. The state-of-the-art laboratory at the production facility in Bjuv and the R&D team is composed of scientists and technologists with deep understanding of various industrial applications of refractories such as Iron and steel, ferroalloy, cement, incinerators etc. Using the latest technology and processing methods, the best products are developed for the most challenging applications. All our materials are subject to comprehensive testing using the most sophisticated equipment. Among the tests we perform are:

1) bulk density, apparent porosity and CCS measures;
2) measurements of thermal conductivity;
3) refractoriness under load (RUL) to understand the deformation resistance under a constant load, with increasing temperature and time;
4) permeability measurements to ascertain how well a refractory castable can be dried-out;
5) hot abrasion resistance test on materials for cement preheaters, coolers and CFB boilers; and
6) exothermic measurements in varying temperatures for optimizing working and setting time of castables.

Through continuous sampling of all incoming raw materials, strict control over the quality of the materials entering the HÖGANÄS Bjuf production system is maintained.

Development process

Products with brand names of HÖGANÄS and Borg have been developed for new monolithic manufacturing facility in Bjuv. These brands include vibratable, self-flowing and pumpable castables, shot-creting and gunning mixes and mortars. The devel-

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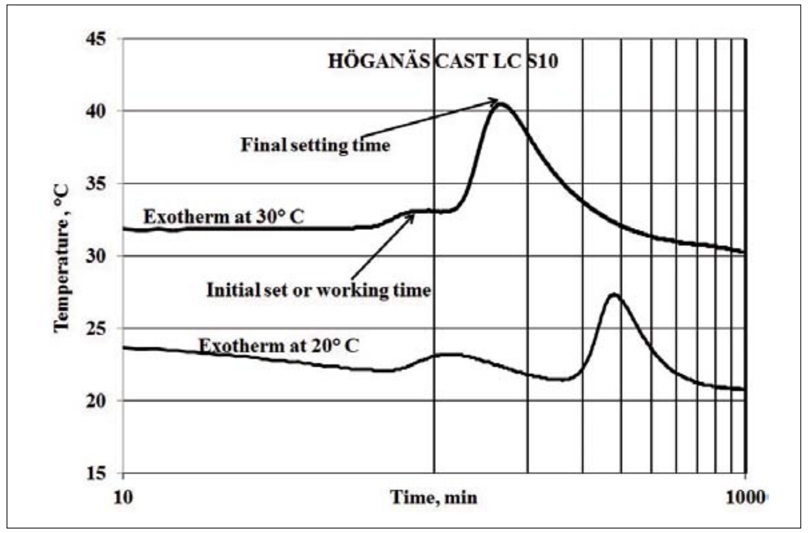

Fig. 1 **Exothermic evolution of HÖGANÄS CAST LC S10 in varying temperatures**

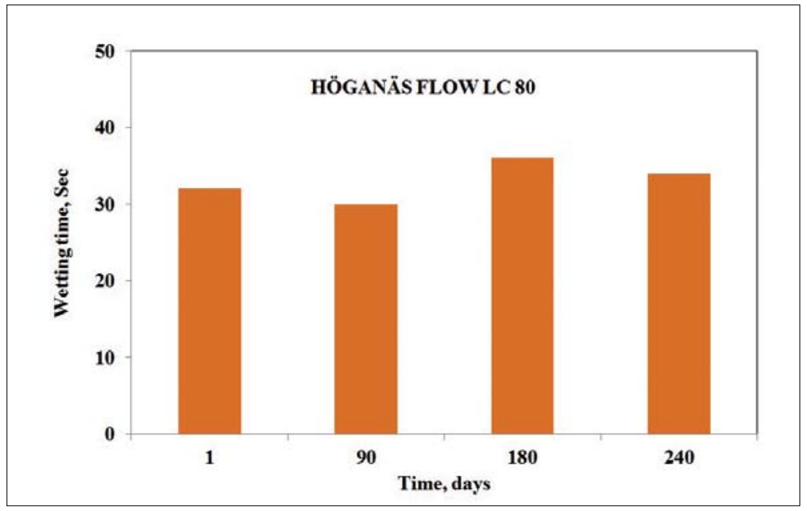

Fig. 2 **Wetting time of HÖGANÄS FLOW LC 80 with time**

opment process of products considered the following objectives:

- Robustness in behaviour
- User friendliness
- Thorough evaluation of products at the developmental stage.

HÖGANÄS Bjuf delivers materials for various applications globally with varying temperatures during installations. The installation temperatures range from 5 °C in Nordic countries to 45 °C in Middle East. During development process, a new climatic room was constructed to verify the flow, flow decay, working and setting time of castable mixes in varying temperature conditions. This methodology is adopted for designing mixes for various locations globally by adjusting admixture package. The exothermic evolutions of a low cement castable HÖGANÄS CAST LC S10 is presented in Fig. 1, to explain the evaluation of working and setting time in varying temperatures. The optimal working time has been ensured thorough right additive packages.

The modern processing techniques in the new plant have enabled the manufacturing of monolithic mixes with user friendliness through designing stable wetting time for long period. Wetting time, is the time required for transforming mixes from dry to wet state when adding water to the mix. Fresh mixes with optimal mix design display wetting time less than a minute which changes to more than 5 min. (even up to 10 min within 2–3 months storage) in extreme case scenario with ageing process of monolithics. In field application, this leads to the addition of more water than recommended and degrade the installed product. HÖGANÄS and Borg mixes maintain stable wetting time (<1 min) with time, as shown in Fig. 2. The wetting time measured over a time period of 8 months is <1 min and remains stable.

Evaluation Process

The product development process in Bjuv evaluates the material thoroughly before release for use. This evaluation process includes gunning, pumping, shot-creting trials, alkali resistance tests, hot abrasion etc., in lab scale.

The gunning mixes and the pumpable castables are thoroughly evaluated in lab scale to make sure a perfect field installation. Macon, an installation company of Borgestad group has made various trials of gunning, pumping and shot-creting material before launch. The pumping and shotcreting trials of HÖGANÄS PUMP LC 50 AR are presented in Fig. 3 and 4 respectively.

Fig. 3 **Pumping of HÖGANÄS PUMP LC 50 AR**

Fig. 4 **Shot-creting of HÖGANÄS PUMP LC 50 AR**

TECHNOLOGY NEWS

Abrasion resistance is a key concern for castables used in various applications in cement coolers, and CFB boilers industries, where the typical operating temperatures vary between 800–1100 °C. High temperature abrasion of refractories is influenced by combination of various factors of thermomechanical and thermo-chemical origin, such as thermal expansion, elastic modulus, hot strength and the reaction between the fine aggregates forming liquid phase and the viscosity of liquid. In addition, the alkali attack, oxidation of ingredients (C, SiC), the change of micro-structure, influence of corrosion and infiltration etc. can also simultaneously influence the abrasion of refractory surfaces [1]. The testing procedure of hot abrasion resistance can be found elsewhere [1–2]. Simulation of hot abrasion resistance is a key evaluation process and the results of Borgflow 85, a bauxite based self-flowing castable is presented in Fig. 5. The hot abrasion is decreasing up to 50 % at both testing temperatures of 815 and 1100 °C respectively.

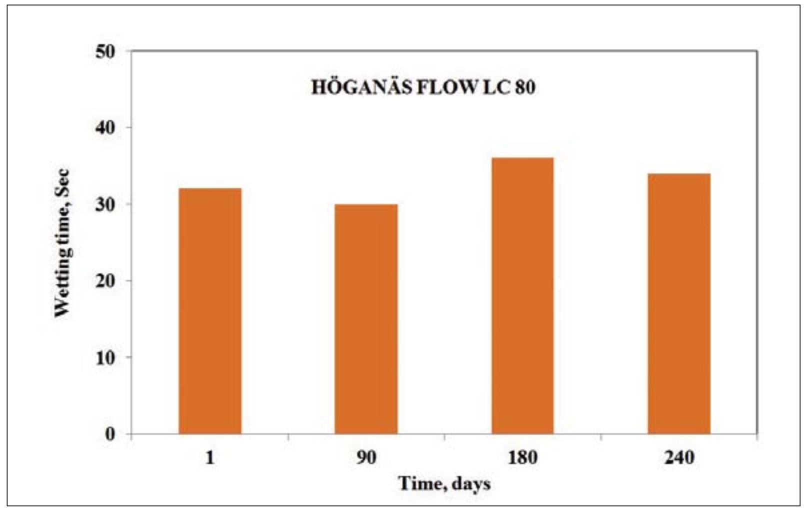

Fig. 5 **Hot abrasion of Borgflow 85**

The surface pattern of abraded samples at 20 and 815 °C respectively, presented in Fig. 6 shows change of abrasion mechanism from room temperature to high temperatures. The sample tested at 20 °C has shown matrix removal as the primary abrasion mode and the coarse grains are less abraded. The loss incurred is though removals of surrounding matrix followed by dislodging coarse grains. The samples tested at high temperature have shown uniform abrasion of both fine matrix and coarse grains. This is attributed to the changes in elastic properties a as well as the thermal expansion characteristics making matrix stronger against abrasion [3].

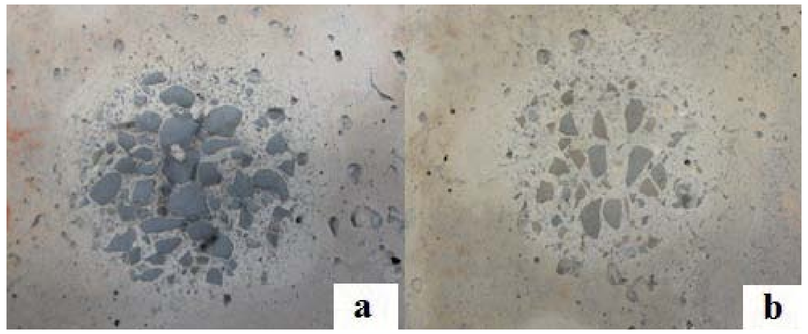

Fig. 6 **Surface nature of HÖGANÄS CAST LC 60 after abrasion testing a) at 20 °C; b) at 815 °C**

Alkalis attack refractories severely. The alkalis generated from various sources degrade the refractories through various mechanisms; the alkalis (K_2O and Na_2O as salt of chloride or sulphate) react with refractory matrix and form various new phases which are several times volumetric and hence generate pressure within the structure. The types and nature of the new alkali-alumino-silicate phases formation is a function of chemistry of refractories; especially the matrix (i.e, alumina, silica and the other elements content in the matrix) part. The alkali resistance materials for applications in cement, boilers etc, are presented in Fig. 7. The alkali resistance testing procedure can be found elsewhere [4–5]. Both the materials HÖGANÄS CAST LC 40 AR and LC 50 AR have shown superior alkali resistance (Fig. 7).

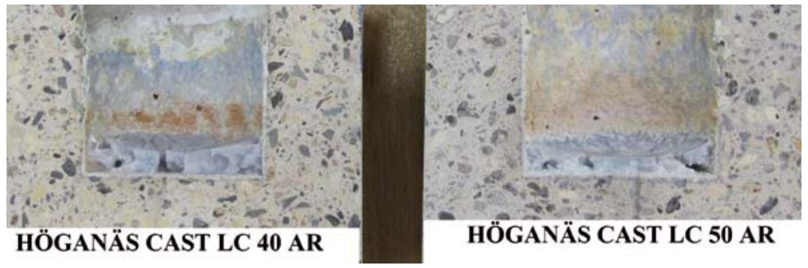

Fig. 7 **Cut sections after alkali resistance tests for castables: HÖGANÄS CAST LC 40 AR and HÖGANÄS CAST LC 50 AR**

Applications involving both alkali and abrasion resistance are key concern in many industries. Increasing alumina content to increase abrasion resistance drastically decreases the alkali resistance. HÖGANÄS PUMP LC 75 AR is a high alumina product developed for CFB boiler and cement plant applications where both alkali and abrasion resistance are prevalent in certain areas. Fig. 8a–b show the superiority of HÖGANÄS PUMP LC 75 AR for both hot abrasion and alkali resistance respectively.

New generation materials

Drying to remove the water from castable is a very critical stage in processing of castable lining. Improper or faster drying

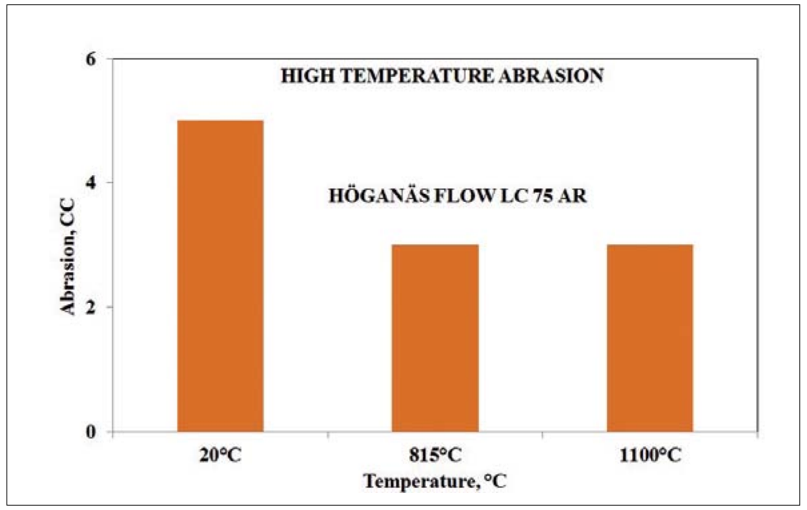

Fig. 8a Hot abrasion resistance of HÖGANÄS PUMP LC 75 AR

Fig. 8b Alkali resistance of HÖGANÄS PUMP LC 75 AR

of castable lining might lead to explosive spalling due to vapour pressure generated inside the castable that exceeds the tensile strength of castable. Careful drying schedules are provided by suppliers to avoid explosive spalling while drying. However, the safer (longer) drying process involves time, energy for drying and production loss in industrial conditions. Also, this involves use of lots of fossil fuels that would lead to carbon foot-print.

There are many variables affecting drying process. One of the important variables is the permeability of castable lining. If the lining material is highly permeable to release water vapour generated while drying, the drying rate can be increased. However, the cement being used as binder reduces the permeability of castables in various ways (especially through hydrate formation and blocking pores). Use of poly-fibers has helped to improve the drying process and reducing explosion risk. However, fibre addition cannot assure the explosion free fast drying process.

One of the potential ways to improve the permeability of castables is changing from cement to cement free binder technology (hydrate free binders). There have been several attempts to innovate new binder technology, but most of them are lacking robustness like cement in terms of flow behaviour, setting, strength development etc. Phosphate bonded castable solves the purpose, but the control of setting time is a key concern with this technology. Phosphoric acid is used as binder for castable. In many occasions the mix sets in 10–15 min after the addition and mixing of phosphoric acid in to the castable mix. In current scenario, one of the convincing technologies that exist in use is "gel bonded castables". Gel bonded castable uses liquid silica sol as the medium to replace water and functions as binder. However, there is a need to send this liquid binder separately and control the setting is also a concern sometimes. Within this context the HÖGANÄS Bjuf explored the possibility of using a cement free solid binder, using water as mixing medium. No need of separate liquid to be sent for mixing at site.

The drying behaviour of new generation cement free castable HÖGANÄS FLOW NC 75 Al in comparison with the low cement counter-part HÖGANÄS FLOW LC 75 Al is presented in Fig. 9. The new generation cement free material loses 92 % of free water at 110 °C compared to 72 % for low cement castable. This indicates an easy drying nature of material below 110 °C. However, the permeability measurements made (Fig. 10) to ensure the faster drying of castable. Complete details of permeability measurements can be found elsewhere [6]. Castable with new cement free binder is permeable even after curing at 50 °C.

Additionally, gel bonded castables for use in various industries have been developed. An example of gel bonded product, Borgcast NC 85 GEL, was developed (Tab. 1) for quick drying application in cement cooler areas where abrasion resistance is a key concern.

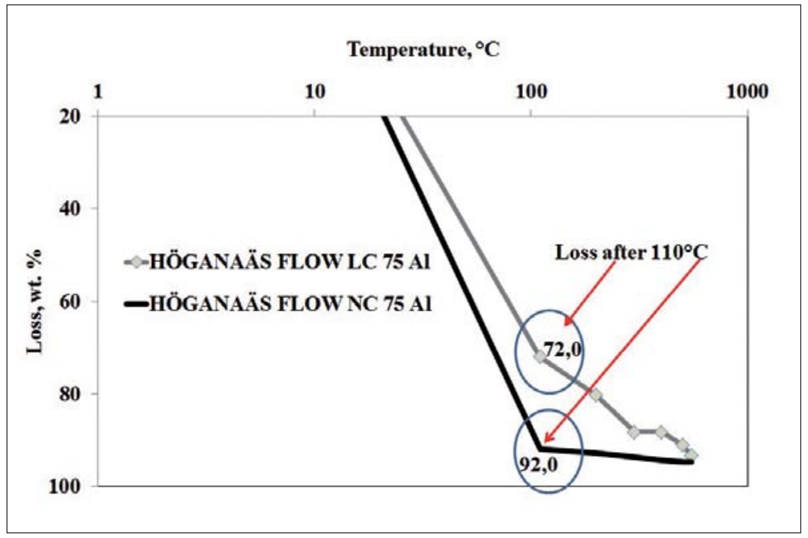

Fig. 9 Water loss vs. temperature

Tab. 1 Gel bonded bauxite based castable with excellent abrasion resistance

BORGCAST NC 85 GEL	
Al_2O_3 [%]	83
SiO_2 [%]	13
CCS, after 110 °C [MPa]	110
CCS after 800 °C [MPa]	140
Hot Abrasion at 815 °C [cm³]	2
Hot Abrasion at 1100 °C, [cm³]	2

Industrial use

Since September 2016, several thousand tons of materials (regular gunning, vibratable, self-flowing, pumpable, shot-cretes, low-cement gunning, insulation) have been produced and used in various industries such as ferroalloy, aluminium, cement, boilers, copper, steel etc. Encouraging feedbacks from customers have created valuable references for the new plant. Some of the industrial uses are presented for references: HÖGANÄS FLOW LC 75 Al is a solution to aluminium contact application. The use of the castable in aluminium filter box is presented in Fig. 11 with excellent life performance in real life conditions. HÖGANÄS CAST LC 801 installed in inlet hood after burner in Boliden Bergsöe AB, Landskrona, Sweden is presented in Fig. 12. Boliden Bergsöe is a secondary smelter for lead

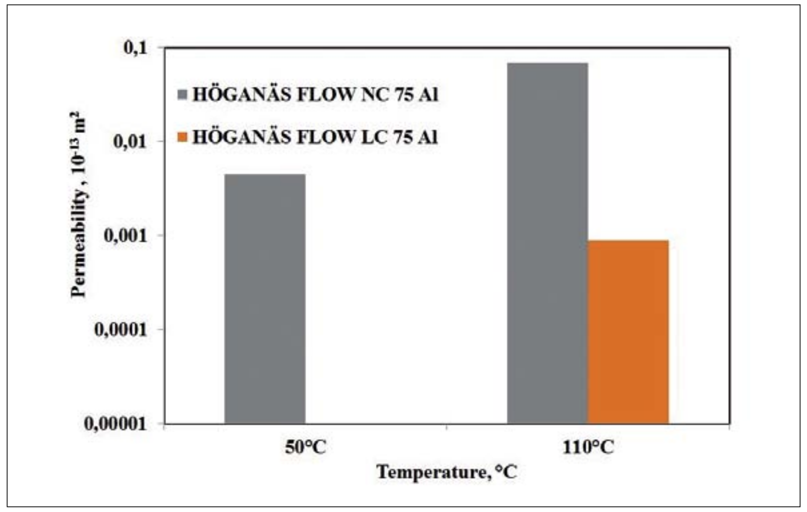

Fig. 10 Permeability measurements on cement free castables

Fig. 11 HÖGANÄS FLOW LC 75 Al in use (Alcoa Mosjoen/NO)

Fig. 12 HÖGANÄS CAST LC 801 – inlet hood after burner – Boliden Bergsöe AB, Landskrona/SW

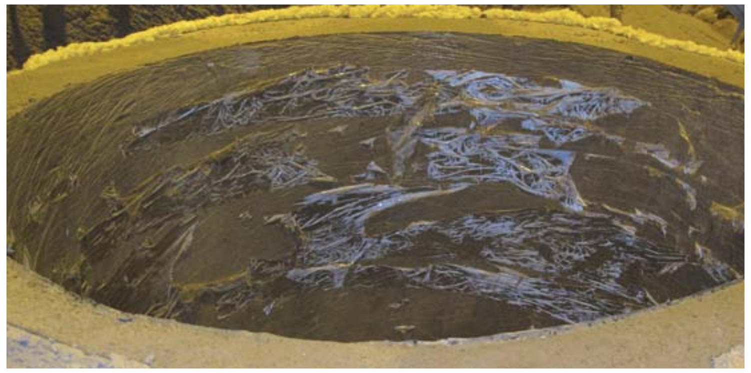

Fig. 13 FeSi ladle lined with HÖGANÄS FLOW LC 80 in Elkem-Rana metal

Fig.14. Hot metal ladle lined with HÖGANÄS FLOW LC 70 at SSAB-Raahe/FI

and recycler of used lead-acid batteries. The product HÖGANÄS FLOW LC 80 has found extensive use in ferroalloy ladles and the ladle lined with this self-flowing castable at Elkem-Rana, Norway, for FeSi processing is presented in Figs. 13,14 presents the use of HÖGANÄS FLOW LC 70 in a hot metal ladle at SSAB Raahe/FI.

Several industries globally have started using HÖGANÄS and Borg materials on regular basis in applications such as FeMn, Si metal and FeSi processing, boilers, incinerators, cement, aluminium as well as iron and steel making.

Conclusions

Höganäs Bjuf AB's new monolithic plant started manufacturing since September 2016, has completed a production of several thousand tons of castables, gunning mixes, pumpables, shotcretes and mortars. The products are being successfully used in various industries such as Ferroalloy, aluminium, Iron and steel, cement and other thermal industries. The results received after installation and use are very encouraging and thanks to the modern processing techniques and continuous R&D effort which supported this success.

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