

Czech Republic

Innovations in Lining of Aluminium Processing Furnaces

Close and fruitful cooperation between this two companies lasts for nearly 25 years. DITHERM a.s. Praha, engaged in engineering, innovative designs and installations of refractory linings of thermal aggregates, and Průmyslová keramika Rájec-Jestřebí, a producer of predominantly non-shaped refractory masses and prefabricates made from these masses. A large number of quality linings have been created by this cooperation. Namely in the power generation industry (power and heating plant boilers firing a broad spectrum of fuels, waste incineration plants, etc.), iron and non-ferrous metallurgy, chemical aggregates, etc. In the following article, the focus is on the development and installation of linings of tank melting and holding furnaces for aluminum, in both design and material terms.

History of the design of linings in the melting and aluminum processing furnaces

The company DITHERM has started to address linings in the melting and aluminum processing furnaces about ten years ago. At that time, a concept of linings installed in melting furnaces with their working layer consisting of tempered refractory castable blocks in the reach of melt in the bottom and on the walls and fireclay bricks installed above the melting zone was considered. As to the holding furnace, the lining was made of bauxite pre-formed shapes fixed in the bottom as well as on the walls of the working lining in the reach of melt and fireclay bricks installed above the melting zone (Fig. 1).

In the case described, it is a furnace unit consisting of the melting and holding furnaces, whose operating mode allows for continuous casting of Al alloy into the pro-

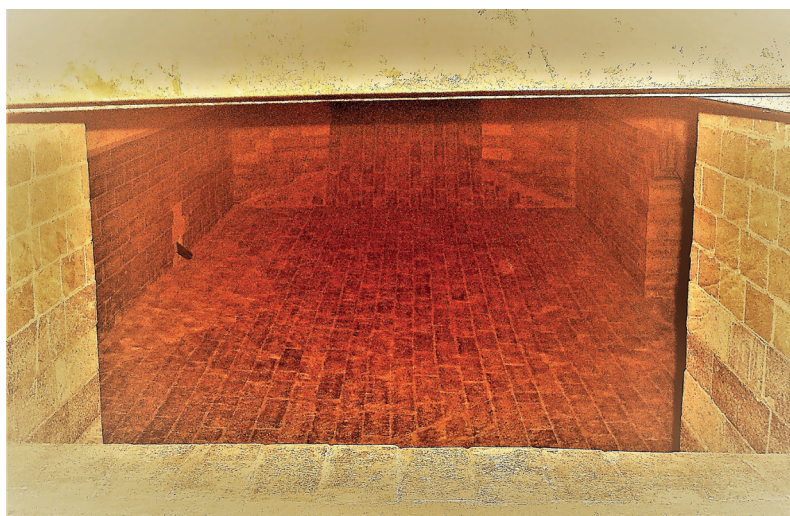


Fig. 1 Previous type of lining made from smaller fired bricks

duction technology. The casting process lasts several days depending on the order volume. Refining salts treat melt composition in the furnace; melt is alloyed in the holding furnace to the requested composition. The charge partially consists of scrap iron, compressed Al filings, and prevalingly of blocks and pigs with defined composition.

Operation of the combined unit melting – holding furnace showed that especially linings, installed in the holding furnace, corroded by zinc-containing melt, prevalingly in the zone of the level of metal. This corrosion gradually penetrated to the wall, finally reaching the furnace steel casing shell. This process stimulated corundum buildups, growing into the furnace and infiltrating

working, safety, and insulation layers of the lining up to the casing shell. Therefore, the company DITHERM introduced a change in the concept of the lining installed in the holding furnace. As the corrosion always started to spread from the gaps of the lining working layer and, later, penetrated the material of pre-formed pieces, it was decided to install concrete blocks from materials for contact with melted aluminum into the walls of the furnace. After consultations held with the producer of these materials, i.e., Průmyslová keramika, a system of interlocking blocks from bauxite LCC castable was selected. The installation of blocks considerably reduced the occurrence of these gaps. The composition of the furnace floor (bottom) remained unchanged.

Vojtěch Kavan
DITHERM a.s.
Prague, Czech Republic
E-mail: kavanv@ditherm.cz

Michal Henek
Průmyslová keramika, spol s r.o.
Rájec-Jestřebí, Czech Republic

Corresponding author: M. Henek
E-mail: michalhenek@prumker.cz

However, it turned out that melt corrosion really starts from gaps in the zone of the "slag line", but very aggressively penetrates to the lining material along the whole length. I.e., after one year of the operation, a replacement of complete lining proved necessary, including insulation layer, as the corrosion again infiltrated the steel structure.

Upon mutual agreement between both companies and the furnace operator, a decision was taken to install blocks from chemically bonded refractory castable with phosphate bonding on the walls of the holding furnace. The agreement with the customer was necessary because of the increased price of the blocks. The company DITHERM, as the main supplier and lining designer, had to guarantee that the corrosion would not penetrate the lining anymore, thus causing its destruction. This request was accepted after the completion of corrosion tests of chemically bonded material.

After the assembly of new blocks on the walls of the holding furnace and inspection after one year of operation, deposits appeared on the lining; however, it was only a surface phenomenon and the lining was not affected. Thus, the furnace can be kept in operation for the period of not less than five years, with only minor repairs made during the scheduled shut-downs under the condition that the lining is regularly cleaned.

Innovative design of the lining

After the successful elimination of the corrosion problem, both companies concentrated on the innovation of the overall construction of linings of both furnaces. This fundamental change involved the construction of the lining of both furnaces using large-format blocks (Fig. 2).

This solution should provide several advantages both for the installation company and the customer:

- Remarkable reduction in the number of gaps.
- All gradients of the bottom, necessary to keep melt flow in both furnaces, are already reflected in the produced and tempered blocks instead of inclination of the bottom by stamping masses and subsequent bricklaying of the working layer.
- It means that the installation company "catches" the horizontal level and needs not to create gradients at the site in a

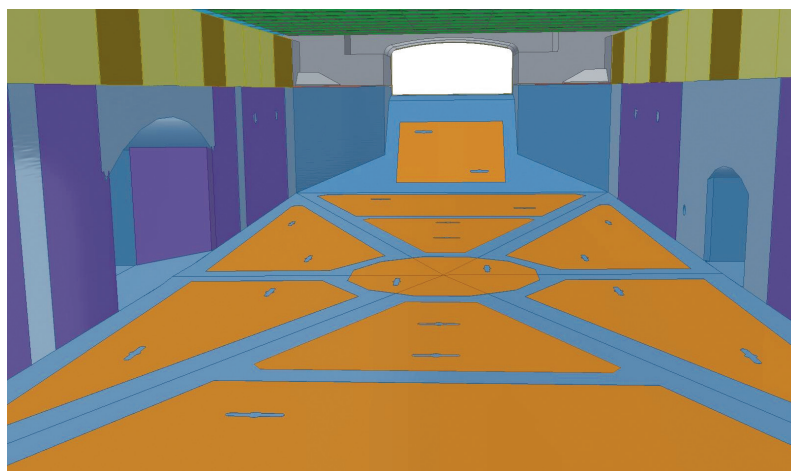


Fig. 2 Lining scheme of large-format blocks



Fig. 3 Lining from the large-format blocks after installation

complicated manner. This aspect is important mainly in the holding furnace from which the melt is released to the technology and must not create any waves.

- The installation is faster and easier with the help of the operating crane compared to tedious bricklaying using small formats. Therefore, more craftsmen and experts are not needed. The lining on the basis of the sol-gel chemistry (coagulation) is installed above the melt layer in the melting furnace by gunite, which also significantly shortens installation time.
- All joints are interlocked. Interlocks are completely sealed with a special stamping mass with chemical bonding. After hardening, the mass features viscoelastic properties; therefore, even with large formats of blocks, the mass partially absorbs stresses created by tempering and first

melts before the overall stress is balanced and the lining "settles down".

The new lining system was assembled in winter 2019/2020 and shows an easier operation of the furnace (Fig. 3). Applying this method, the lining in any furnace can be installed. The engineering department of DITHERM in cooperation with Průmyslová keramika, as the producer of materials, can propose an optimization of lining segments for each smelting furnace and aluminum-processing furnace after examination of operating conditions.

Used refractory castable materials

Used refractory castable material, applied to the individual parts of the furnace, must comply with the above-mentioned construction design of the lining. Expected working

Tab. 1 Basic parameters of used refractory castables

	Classification Temperature [°C]	Main Raw Material Base	Dilution Liquid	Al ₂ O ₃ [%]	SiC [%]	BD (110 °C) [kg/m ³]	CCS (110 °C) [MPa]	CCS (800 °C) [MPa]	CCS (1500 °C) [MPa]
NOVOBET 1600-B-SiC-10	1600	bauxite SiC	water	75	10	2860	90	110	85
UNIBET U-17-2	1600	corundum	REFRAFIX PX	93	–	2880	80	75	120
NOVOBET 1550-B	1550	bauxite	water	83	–	2720	90	65	100
UNIBET U-17-2-patch		corundum	REFRAFIX PX	91	–	2850	75	75	100
CHEMOBET TOR-1550-A-SiC-5-sol	1550	andalusite SiC	REFRAFIX T-40	57	5	2400	80	80	90
CHEMOBET TOR-1550-K-sol	1550	corundum	REFRAFIX T-40	92	–	250	70	90	110
ŽÁROTMEL ALU-170	1700	corundum	–	81	–	2200			

load, continuous material development, experience, and evaluation of previous long-term operating applications are taken into consideration.

- **Material for pre-formed shapes under the level in the melting furnace**
Prevailing stress: mechanical by the charge, melt penetration, level corrosion by slag enriched with refining salts, frequent and extreme temperature changes

Used material: NOVOBET 1600-B-SiC-10 (LCC refractory concrete bauxite lining with the content of SiC, tempering of pre-formed shapes, 1000 °C)

- **Material for walls above the level in the melting furnace**
Prevailing monolithic gunite material: CHEMOBET TOR-1550-A-SiC-5-sol (andalusite gunite mixture with SiC content, bonding system of the type sol-gel)

- **Material for pre-formed shapes under the level in the holding furnace**
Prevailing stress: melt penetration, level corrosion, namely increased corundum at the border of three phases and its penetration into the lining
Used material: UNIBET U-17-2 (corundum chemically-bonded refractory castable, phosphate bond, tempering of pre-formed pieces, 1000 °C)

Your Media Partner

Representative (Italy, Spain, Turkey, Portugal)
Patricia Iannelli, ☎ ++39-0332-240285
 E-mail: p.iannelli@goeller-verlag.de

refractories
 WORLDFORUM

Manufacturing & Performance of High-Temperature Materials

- **Material for pre-formed shapes above the level in the holding furnace**

Used material: UNIBET 1550-B (bauxite chemically-bonded refractory castable, phosphate bond, tempering of pre-formed shapes, 1000 °C)

- **Universal sealer applied both above and under the level**

Used material: UNIBET U-17-2-patch (corundum chemically-bonded refractory castable, phosphate bond, application by stamping, rodding, etc.)

- **Universal connection sealant**

Used material: ŽÁROTMEL ALU-170.

The requirement for identical endurance of all zones of linings is an important factor in the long-term viability of the lining. The proposed composition of refractory castables is very close to this requirement.

Repairs of linings during operation

Guaranteed multiannual operation of the lining without shut-down is not conceivable without minor repairs and care for the lining exercised by the furnace attendance staff (mainly cleaning and compliance with technological instructions) and regular, scheduled repairs. Mechanical damages to the lining are quite common in the charge dosing, damages to door jambs caused by thermal shocks, etc. mainly in melting furnace applications.

Linings are repaired after their inspection before their scheduled shut-down. In particular, non-formed chemically-bonded materials and special fixing elements are employed. Thus, a fast reaching of the operating temperature is possible in contrast to normally used hydraulically bonded castable linings.

The technology of lining repairs by hot guniting of refractory mixtures, without the necessity to shut-down the aggregate, is mastered to cope with unexpected destruction of the lining during the campaign (usually mechanical damage). Two special guniting materials have been developed for this purpose. Mentioned materials can be applied in the full range of temperatures; successful applications with the temperatures ca 1000 °C in the aggregate have been verified. Tab. 1 shows the basic parameters of the guniting materials. These repairs extend the operation minimally until the scheduled shut-down, when the furnace may be cooled-down and repaired without reduced planned production volumes.

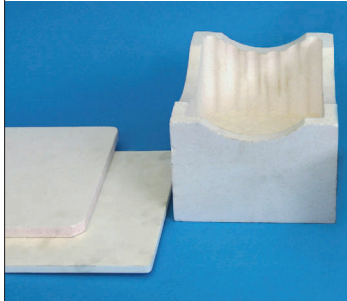
Conclusion

Development of new materials and innovations of the construction and application of linings bring positive benefits by reduced number and scope of necessary repairs needed during the lifetime of linings, easier assembly of new lining as well as repaired parts.

As requested by the customer, the two companies focus on the sensitive points of the lining and try to eliminate them both by construction and material design. They can deliver and install lining for every single customer as a tailor-made solution.



EIRICH



Preparation Technology for Refractory Materials



Reliable technology for more than 90 years

- **Castables**
- **Prefabricated parts**
- **Granules**, e.g. ZrO₂
- **Press bodies** for all types of bricks, including hot mixture
- **Granules for isostatic pressing**

Mixers and complete systems

Let's find the best technical solution for you.

Maschinenfabrik Gustav Eirich GmbH & Co KG
 Wallduerner Straße 50 · 74736 Hardheim · Germany
 eirich@eirich.de · www.eirich.com