The New Tempering Kiln at SLOVMAG

O. Orisenkova, J. Mendheim

To be able to expand the product portfolio SLOVMAG/SK introduced the so called hot technology, which is based on a binder system consisting of a complex mixture of polycyclic aromatic and heterocyclic hydrocarbons. Applying a special heat treatment, the content of the carcinogenic benz(a)pyrene in the binder is drastically reduced.
Hot technology means that mixing and pressing is made at elevated temperatures and the so called carbon bonded bricks are tempered at approx.. 300 °C. The new kiln design is presented in the following.

Introduction

SLOVMAG is a long standing Slovakian company and well-known as producer of basic refractories. Besides a wide range of fired products its portfolio includes also chemically bonded magnesia-carbon bricks. Today, SLOVMAG is part of a group of companies which belongs to Group MAGNEZIT in Russia.
SLOVMAG has been producing resin-bonded magnesia-carbon refractories since 1994. With the introduction of a new hot technology in 2013, the range of carbon-bonded refractories has been expanded. This decision enables the company to implement a wider range of successful applications, thereby improving customers satisfaction.
Thanks to their exceptional mechanical, thermal and chemical properties, magnesia-carbon refractories are widely used in the working linings of steel aggregates, namely in blast oxygen converters, electric arc furnaces and steel ladles. Their main advantage is a high corrosion resistance due to the low wetting by molten steel and slag.

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Tab. 1 Comparison of resin and carbon-bonded refractory products (+) positive features (–) negative features

Resin-Bonded Bricks	Carbon-Bonded Bricks
(+) More simple production process (cold)	(+) Hot production process
(+) Absence of PAH	(–) PAH volatiles presence during first heating
(–) More odorous volatiles during first heating (ammonia, aldehydes, etc.)	(+) Highly oriented (anisotropic) carbon structure, resulting in a high oxidation resistance, excellent stress absorbing structure, excellent coating behaviour by slag
(–) Glassy (isotropic) carbon structure, resulting in a brittle and easier oxidized brick structure, i.e. lower oxidation and thermal shock resistance	(+) Higher coke residue of binder (65 %)
(–) Lower coke residue of binder (35–40 %)	(–) Lower CCS after tempering at 300 °C
(+) Higher CCS after curing at 200 °C	(+) Higher CCS after firing at 1000 °C
(–) Lower CCS after firing at 1000 °C	(–) Higher apparent porosity after tempering at 300 °C
(+) Lower apparent porosity after curing at 200 °C	(+) Lower apparent porosity after firing at 1000 °C
(–) Higher apparent porosity after firing at 1000 °C	

Magnesia-carbon refractories are produced in a wide range of qualities, depending on the raw materials used.
The basic raw material is a fused and/or dead burned magnesite of various MgO content, ranging from 95–98 % MgO. Next is natural flake graphite with defined purity and flake size. Special additives play a very important role together with the binder.
The binder of resin bonded bricks is a synthetic phenolic resin (Novolac) enabling the use of the cold technology. This means that all technological steps are made at ambient temperature and the bricks are cured at approx. 200 °C.
The hot technology is based on a binder which is characterised as a complex mixture of polycyclic aromatic and heterocyclic hydrocarbons.
Thanks to a special heat treatment, the content of the carcinogenic benz(a)pyrene in the binder is drastically reduced. Hot technology means that mixing and pressing is made at elevated temperatures and the so called carbon-bonded bricks are tempered at approx. 300 °C.
The basic differences between resin and carbon bonded bricks are shown in Tab. 1
Tab. 2 shows the comparison of bricks made from fused magnesia with 97 % MgO and without antioxidants, but with different carbon content and both types of binder.
For the introduction of the hot technology, a state-of-the-art tempering kiln was required. In 2013, an order was given to the Czech company PKI-Teplotechna Brno spol. s.r.o. for the design, supply, erection and commissioning of this kiln. In the mean

time, the kiln is already more than four years successfully in operation.

The kiln is indirect heated by three heat exchangers. One of them has an integrated incinerator unit, so that its heat is used for the heating of the kiln. In the incinerator vaporized dangerous Polycyclic Aromatic Hydrocarbons (PAH) and other harmful volatiles are burnt. The gases leaving the incinerator fulfil all local and European regulations about the limits of emissions.

Indirect heating has two advantages: the max allowable concentration of 10 g/Nm^3 of vaporised PAH and other volatiles can be controlled. The second advantage is that not only bricks with a magnesia matrix but also dolomite and dol-mag bricks can be heat treated without the hydration of the product.

Due to the low temperatures of max. 350 °C the heat transfer can only be achieved through convection. Therefore, each of the three heating zones has an own recirculation fan. These fans recirculate the kiln volume approx. 20 times/min and the temperature difference in the kiln cross section is less than ±5 °C.

The kiln body consists of an internal gastight welded kiln casing with the necessary expansion elements. The anchoring at the outside has a steel cladding and between the kiln casing and the steel cladding an insulation mass is filled. It is this special design that allows the tempering kiln to be switched off on weekends and to be heated again in 2–3 h.

One layer of bricks is loaded onto special steel pallets made from open mesh floor (Fig. 2). The pallets are positioned in rack cars (Fig. 3). Up to eight pallets one on top of each other and two pallets behind one another can be arranged on one car. This single brick setting makes it possible that the product is heated fast and evenly from all sides, and the volatiles are vaporised. Cured resin bonded or tempered carbon-

Tab. 2 **Typical physical properties of bricks after curing (200 °C) and after tempering (300 °C)**

	Resin	Carbon	Resin	Carbon	Resin	Carbon
BD tempered	3,08	3,12	3,01	3,05	2,96	2,98
AP tempered	3,5	5,0	3,0	4,5	3,0	4,5
CCS tempered	80	40	50	35	40	30
BD fired	2,99	3,09	2,94	3,03	2,90	2,93
AP fired	8,0	9,0	9,5	8,0	9,5	8,0
CCS fired	30	50	25	30	25	30

Notes:
BD tempered – bulk density after curing at 200 °C (resin) resp. tempering at 300 °C (carbon) [g/cm^3]
AP tempered – apparent porosity after curing/tempering [%]
CCS tempered – cold crushing strength [MPa]
BD firing – bulk density after firing [g/cm^3]
AP firing – apparent porosity after firing [%]
CCS firing – cold crushing strength after firing [MPa]

Fig. 1 **Exit of the tempering kiln**

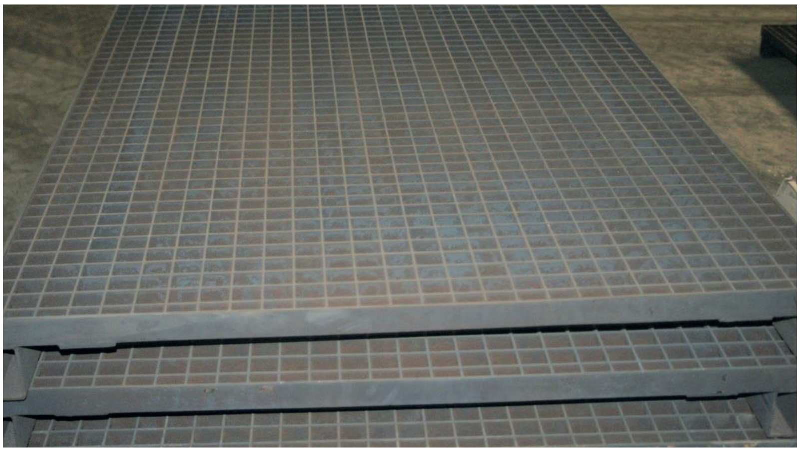

Fig. 2 **Tempering pallets**

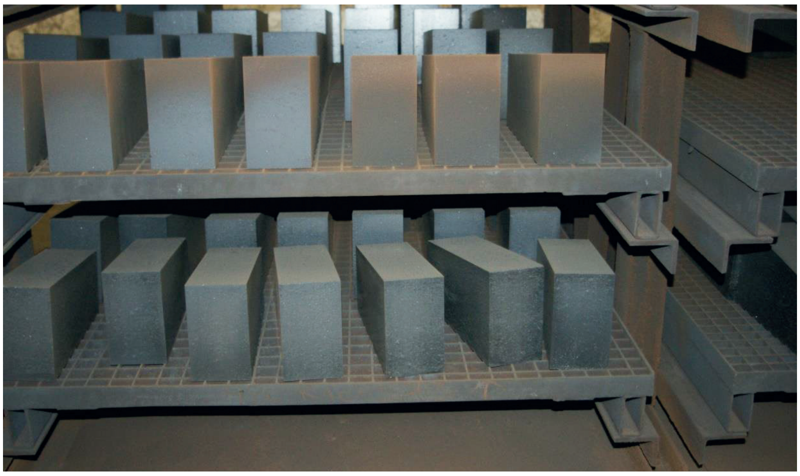

Fig. 3 **Kiln car rack with tempering pallet**

Tab. 3 **Technical data of the tempering kiln**

Capacity	60–70 t/24 h
Max. operating temperature	350 °C
Throughput time	24 h (cold-to-cold)
Length of the tempering kiln	32,75 m
Size of the pallets	1100 mm × 1500 mm
Number of pallets/car	2 × 8
Number of cars in the entry lock	1
Number of cars in the kiln	6
Number of cars in the exit lock	1
Number of cars in the cooling channel	4
Average load/car	6,4 t
Type of fuel	natural gas, calorific value 34 MJ/Nm^3
Number of burners	3
Number of recirculations	3
Capacity of the incinerator	3000 Nm^3/h

bonded bricks are still not completely free of dangerous volatiles. To obtain really "green" bricks, it is necessary to fire them at a temperature of at least 600 °C. At this temperature, heavy boiling hydrocarbons split into low boiling PAH. In an oxygen containing kiln atmosphere, these PAH will catch fire and the carbon in the bricks is burnt. In many very successful tests, it was possible to develop a continuous high temperature firing process without packing the material into coke and without the use of a protective gas. Presently, a kiln for this new tempering process is designed to produce environment friendly bricks.

Of course, such a new firing aggregate will increase the manufacturing cost of the bricks – but the authors are hopeful that the end users will accept this for the sake of our climate.