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Experience report on microporous heat insulation boards in steel industry plants

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For modern steel making technologies insulation of the plants is absolutely necessary. The following report describes features, advantages and applications of microporous insulating boards. The effective insulation of steel ladles, tundish and torpedo cars resulted in reduced steel case temperatures and less heat losses without affecting corrosion velocity of the front lining materials.

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Introduction

In times of continuously rising energy and raw material costs, the use of heat resistant insulating materials is more important than ever. This applies in particular to areas where energy-intensive processes are carried out, such as those found in the steel industry. Among heat insulation materials, microporous heat insulation boards are extremely important. They possess the lowest thermal conductivity of all types of insulating materials - even below that of still air - and are used wherever extreme insulating properties are required in the narrowest of spaces. Such sections of plant in the steel industry are steel casting ladles, tundishes and torpedo ladles. A further example of the use of PROMALIGHT® microporous insulating boards is for improved heat insulation in electric arc furnaces for the melting down of scrap.

The material

Microporous insulating boards are produced from nanopowders by dry compression without binding agents and therefore possess low bending and breaking strengths. Since 2000 Promat have been producing microporous insulating boards at their own plant under the brand name PROMALIGHT® (**Fig. 1**).

In order to improve the handling and breaking strength there are various versions available from Promat, which differ from one another in the method of fabrication.

PROMALIGHT®-320 is the standard version, in which the microporous board is sealed by the manufacturer in a thin PE foil.

PROMALIGHT®-330 is coated on both sides with a thin mica folium and PROMALIGHT®-1000 is enclosed by an aluminium foil (**Table 1**).

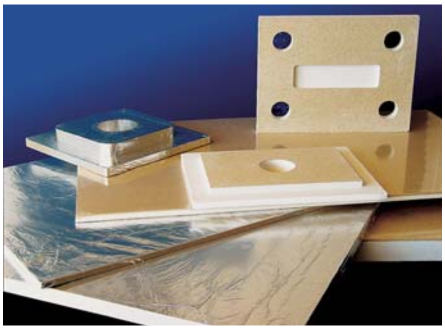

Fig. 1: PROMLIGHT – boards and shaped parts

Table 1: Technical data of the Promat® insulation material

Technical Data	PROMALIGHT® -330	PROMALIGHT® -1000	PROMATON® -135/110	PROMAPACK® -700	PROMAFORM® -1430	ALSIFLEX® Paper -N
Board thickness [mm]					5 - 25	
Colour	silver/grey	silver		light grey		white
Classification temperature [°C]	1000	1000	1350	1000	1430	1260
Shrinkage	12h at 900°C < 2 %		24h at 1350°C 0.5 %	24h at 1000°C 2.6 %	24h at 1300°C 3.2 %	24h at 1260°C < 4 %
Bulk density [kg/m³]	310	300	1100	960	300	210
Bending strength [N/mm²]	0.5	0.20				
Cold compressive strength [N/mm²]	3.3	1.4	5.4			
Tensile strength [N/mm²]				2.5 - 5.0		
Specific heat capacity [kJ/kg K]	1.05	1.05		1.2	1.13	1.13
Thermal conductivity [W/m K]						
200°C	0.020	0.022	-	-	0.06	-
400°C	0.023	0.025	0.32	0.10	0.08	-
600°C	0.033	0.035	0.36	0.11	0.11	0.08
800°C	0.038	0.044	0.40	0.13	0.15	0.11
1000°C	-	-	0.45	0.14	0.20	0.17
Chemical analysis [%]						
SiO_2	77.5	77.5	57	44	47 - 54	50 - 54
ZrO_2/SiC	20	20	-	-	13	-
CaO	2.5	2.5	-	0.6	-	-
Al_2O_3	-	-	34	34	27 - 33	46 - 50
Fe_2O_3	-	-	1.2	-	-	-
LOI	-	-	-	19	6 - 7	< 12
Reversible thermal extension at 1000°C [%]			0.50			

Table 2: Results of steel ladle tests in comparison to common linings

Parameter	Pilot ladle (working Magnesia - Carbon layer, insulation of walls and bottom)	Conventional ladle	
		Magnesia - Carbon lining	Lime - Magnesia lining
External shell face temperature (average)	202 - 235°C (211°C)	220 - 295°C (259°C)	204 - 270°C (235°C)
Average loss of steel temperature in ladle during transit from vessel to refining station	51°C	64.1°C	56.5°C
Average rate of steel cooling in ladle during transit:			
from vessel to refining station,	5.1°C/min	6.4°C/min	5.6°C/min
from refining station to CCM and during casting	0.63°C/min	0.71°C/min	0.67°C/min

This considerably improves the handling of the board. Further positive effects are:

- the lowest conductivity in the case of PROMALIGHT®-330 due to the scattering effect of the mica
- high mechanical strength, particularly in the case of PROMALIGHT® -330
- virtually "hydrophobic" due to the PE- and Al foil (PROMALIGHT®-320 and PROMALIGHT®-1000).

PROMALIGHT® differs from competitors' products through the use of PROMAXON®, a microfine calcium silicate, which improves the strength of the board and leads to dust free surfaces.

For most applications it is not the bending strength that is of greatest importance, but rather the compression strength, which with values of 1 to 3 N/mm^2 for PROMALIGHT® is completely sufficient, as any mechanical stresses are absorbed by the front material, which is made of more dense refractory materials.

Applications

Steel casting ladles represent an important link between the melting unit and the casting line. Through the use of modern ladle technologies, refractory materials of increasingly higher quality are required at the front of the unit with a high level of corrosion resistance to liquid steel - and mostly possessing high thermal conductivity levels. For reasons of energy efficiency and durability - steel can only be subjected up to a temperature of 400 °C over a prolonged period without deforming - the use of high-quality heat insulation materials becomes essential.

The spread assumption that ladles may only be insulated to a limited extent, as otherwise the working lining is subjected to advanced closure, is erroneous. The internal thermal load is determined only by the temperature of the steel. The thermal load on the "cold" side of the working lining is higher due to the heat insulation, lying as it does within the range from 1300 to 1350 °C, i.e. approximately 200 K higher on average. However, at the same time the temperature gradient, which is responsible for thermal stresses, is lower by the same amount, which may have a positive effect on the lifetime of the lining.

In our experience, high-quality refractory materials are capable of being insulated with microporous boards without any reduction in durability.

The changeover of the working lining from lime-magnesia bricks to magnesium-carbon bricks for 350-tonne steel casting ladles in a Russian steelworks was made possible by the use of PROMALIGHT®-1000 microporous insulating boards.

The thermal conductivity of magnesia-C (10 to 14 W/mk) is much higher than that of lime-magnesia (2 W/mk), and so would lead to greater heat losses and extremely high steel casing temperatures.

This was counteracted by the following refractory lining:

Wall:

- 200 mm magnesia-C brick
- 10 mm filling material
- 100 mm fireclay brick
- 5 mm PROMAPACK®-700
- 5 mm PROMALIGHT®-1000

Bottom:

- 300 mm corundum-magnesia-C brick
- 200 mm fireclay brick
- 125 mm PROMATON®-135/110
- 10 mm PROMAPACK®-700

The steel refining temperature lies within the range 1600 to 1690 °C with a residence time of approximately 80 min.

Table 2 shows the results achieved in comparison to the traditional lining. It was possible to reduce the steel casing

Fig. 2: Insulation of steel casting ladle

Fig. 3: Installation of PROMALIGHT®-1000 in a tundish

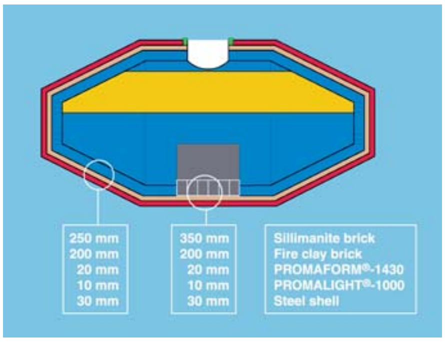

Fig. 4: Sketch of torpedo ladle lining

temperature by 48 K, as well as the cooling rate of the steel. This had a positive effect on the further processing of the steel.

It was decided to change all ladles with magnesia-C lining to the Promat solution.

For continuous casting processes the tundish has to ensure stable conditions. The key point with respect to stability is a narrow temperature interval, which can be achieved by using improved insulating materials.

In another steel plant the following tundish lining was successfully used:

- 50 mm gunning mass
- 140 mm concrete
- 10 mm PROMALIGHT®-1000
- 1 mm ALSIFLEX®-1260 paper

Fig. 2 shows the installation of the insulating materials. The application referred to is now applied to all other tundishes.

Another application of PROMALIGHT® in steel production is its use in torpedo ladles. The main targets are slowing down the temperature drop of pig iron and reducing the steel shell temperature. This increases safety during transportation.

In **Fig. 3** the composition of the lining is presented. In order to obtain a clear overview of the temperature profile across the lining a number of heat loss calculations were performed. On the basis of the results, special insulation materials and thicknesses can be designed.

Three versions of the heat loss calculation were performed (**Fig. 4**):

- 100 % working lining (1, 4)
- 30 % working lining (2, 5)
- 0 % working lining (3, 6)

Curves 1, 2 and 3 are the temperature profile without insulation, whereas 4, 5 and 6 are with insulation.

Fig. 6: Installation of PROMALIGHT®-330 and PROMATON® in an electric arc furnace

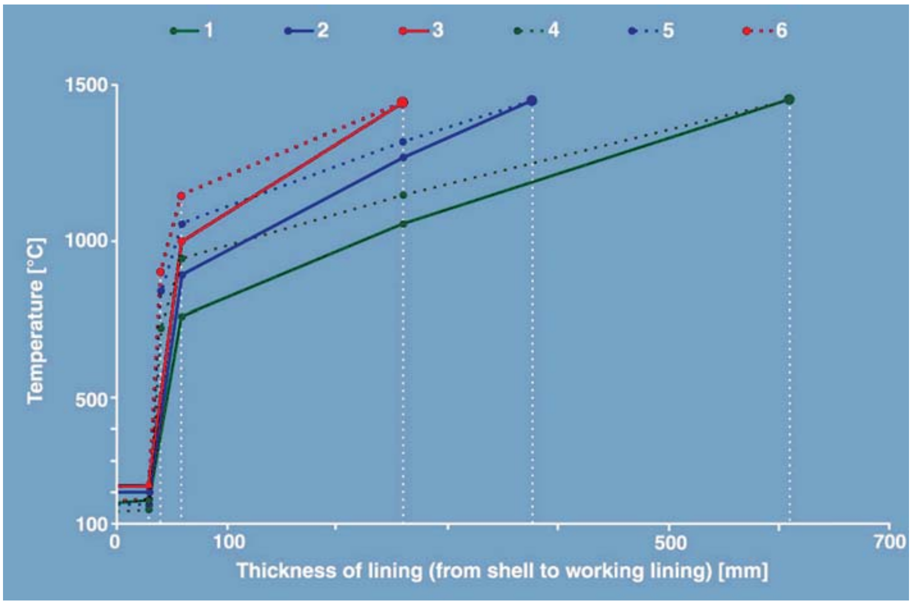

Fig. 5: Temperature distribution diagram

The first torpedo ladle was installed with the new concept at the beginning of 2005. It has been in operation for more than 18 months. The steel shell temperature was measured with a thermovision camera. The results confirmed a shell temperature drop in the range of 27 to 43 K. Up to now two other torpedo ladles with a capacity of 300 and 400 tonnes have been relined with the Promat solution.

Promat engineers are currently working on an insulation concept for electric arc furnaces. Initial projects show notable results with respect to energy consumption. A reduction in energy consumption by 4 to 6 % appears to be realistic. In illustration 5 the installation of PROMALIGHT®-330 in a thickness of 10 mm can be seen.

Conclusion

The use of PROMALIGHT® microporous materials results in highly improved insulation linings in steel applications. In each case it was possible to reduce the steel shell temperatures and the heat losses without affecting the corrosion velocity of the front lining.