THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 4 – 2014, ISSN 1453 – 083X

STUDY ON THE REFRACTORY MATERIAL USED FORTHE WEAR LAYER OF THE TUNDISH

Beatrice TUDOR
“Dunarea de Jos” University of Galati
e-mail: btudor@ugal.ro

ABSTRACT

The continuous casting of steel is a modern and efficient process for the production of semi-finished products required for the other components of steel industry. In order to improve the quality of continuous cast slebs and to reduce costs, I have carried out a study on the refractory materials used in the tundish. This study highlights the advantages which result from the application of improved technology for the achievement of continuously cast semis.

KEYWORDS: refractory, tundish, continuous casting, macroscopic analysis

1. Introduction

The continuous casting process of steel is now recognized by all professionals as a process which, besides productivity and efficiency, offers quality improvement.

The conditions that determine the continuous casting product are the result of several combined influences of metallurgy, thermotechnics and machine building. Of a particular importance among these conditions is the solidification process of the slebs in the continuous casting plant.

The continuous casting of steel is a modern and efficient process for the production of semi-finished products required for the other components of steel industry.

Upgrading and refurbishment of the continuous casting machines are considering improving the business of manufacturing, cost reduction per tonne of steel slabs, reducing defects and increasing competitiveness of manufactured products.

Getting good results in continuous casting is mainly conditioned by the following factors:

- synchronization of the activity with LD steelworks which provide steel for casting;
- maintenance of the casting machine and related facilities in perfect working order, especially by applying preventive maintenance;
- existence of operating and maintenance personnel, trained and disciplined in all departments;
- ensuring the materials and spare parts needed.

2. The role of the tundish in continuous casting

The tundish is designed as an intermediate assembly between the ladle and the crystallizer, serving to distribute the liquid steel in the crystallizer and to prevent temperature losses, and allowing coarse impurities to rise to the surface of the metal bath.

A special role of the distributor is to protect the jet of steel against the secondary reoxidation and gas uptake.

The tundish must also allow for precise control of the flow of steel in the crystallizer and provide enough storage capacity for changing the pot in the case of sequential casting.

During the steel flowing in the tundish, various phenomena occur which can result in products of lower quality:

- the steel jet distributed by the protection tube favors turbulence and waves on the surface of the metal bath. These turbulences destroy the surface of the metal bath which is covered with dust coating and slag, along with inclusions captured, and direct them to the crystallizer through immersion tubes. In the same time, this break in the flow of coating at the metal bath allows the steel to be exposed to strongly oxidizing atmosphere.

• the strong jet of the steel, which is focused by the jet protection tube, causes the erosion of the refractory lining of the tundish;

• the process of filling of the tundish leads to splashing (sprinkling) with steel and entrainment of air bubbles.

For a continuous reduction of the costs and for eliminating non-metallic inclusions in the cast steel, in addition to constructive modifications of the tundish, the refractory material lining was replaced.

To highlight the need to replace the material the tundish is made of and the economic efficiency resulting from this substitution, I have made a comparison between the old technology of making fabric tundish with KERMAG LTD 90 and the new technology that uses material TUNDEX 160AS. Consequently, the study highlights the advantages of using the new material.

3. Methods used to create the distributor

3.1. Version A-tundish with KERMAG LTD90

In version A, the tundish of gunite with KERMAG LTD90 is used to make a refractory lining at the tundish with a greater resistance to the number of castings, using two types of refractory concrete. The composition and properties are presented in Tables 1 and 2.

Table 1. *Chemical composition of the materials for concrete*

Material	Al_2O_3	Fe_2O_3	CaO
ULTRACAST BSR	84.3%	max 0.9%	max 0.5%
PHLOX 1560 SR	59.1%	max 1.1%	max 2.2%

Table 2. *Properties of the materials for concrete*

Materials	Grain max.[mm]	Density [t/m³]	Temperature max. [° C]	Quantity of water [l/100kg]	Rock for the manufacturing
ULTRACAST BSR	5	3.03	1680	4.5-6	bauxite
PHLOX 1560 SR	5	2.6	1650	6.5-8	andalusite

Pouring concrete is accompanied by vibration, for better compaction of the walls. Hardening of the concrete lasts 24 hours, and then the formwork is removed. Drying continues for 72 hours in the open air before placing the tundish under the dryer, after which drying is running according to the drying diagram (Figure 1).

The liner of the wear was made with shotcrete KERMAG LTD90.

The composition and properties for making the lining of the wear by guniting are shown in Tables 3 and 4.

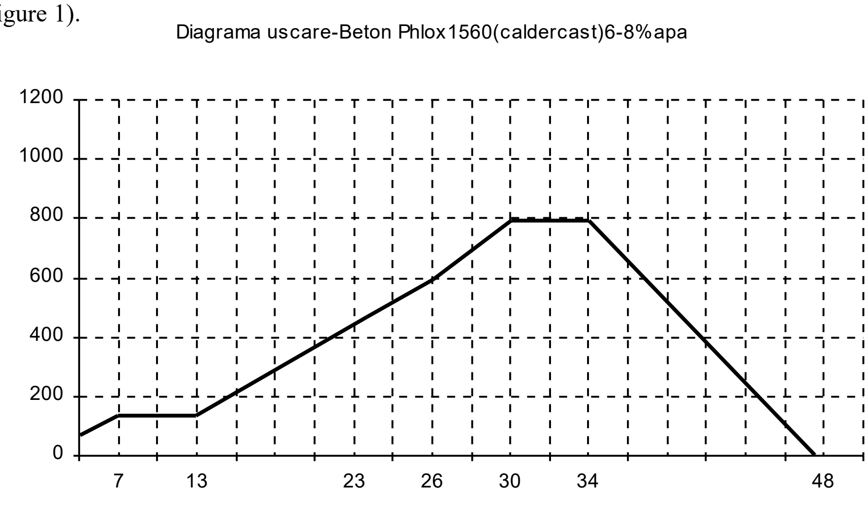

Fig. 1. *Drying diagram of the concrete, Phlox 1560*

Table 3. *Chemical composition of the material-KERMAG LTD 90*

Material	MgO	CaO	Al_2O_3	Fe_2O_3	SiO_2
KERMAG LTD 90	89.3%	2%	max 1.2%	max 0.4%	max 0.5%

Table 4. *Properties of the material KERMAG LTD-90*

Material	Grain max. [mm]	Density [t/m³]	Temperature max. [°C]	Quantity of water [l/100kg]
KERMAG LTD 90	1.2	3.03	1650	17-21

Guniting begins with filling all depressions, then filling hearth and continues with the walls of the tundish from top to bottom. To obtain a quality wear layer, plastering materials must provide a good grip at the walls, must not slip on the walls and must not react with the refractory mass. The deposited layer will have a thickness of 25-35 mm at the walls and 35-45 mm at the hearth (Figure 2).

After guniting, the tundish is left to dry in the open for at least 30 minutes, then it is forced dried with gas, according to the drying diagram (Figures 3 and 4).

Fig. 2. *Tundish with shotcrete*

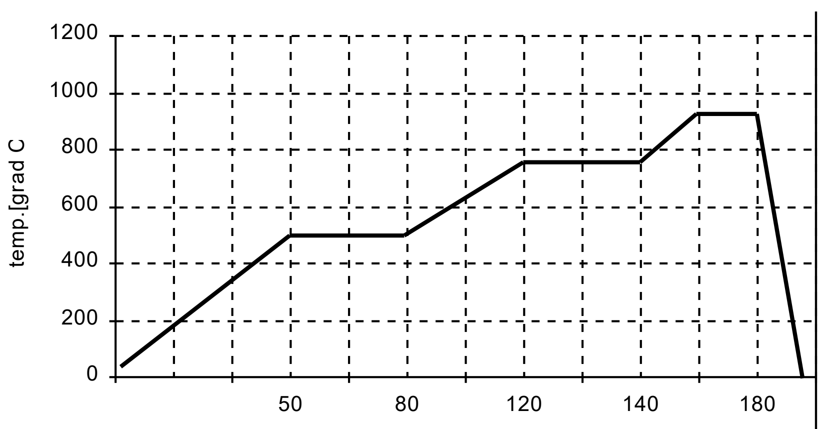

Fig. 3. *Drying diagram of the tundish (winter)*

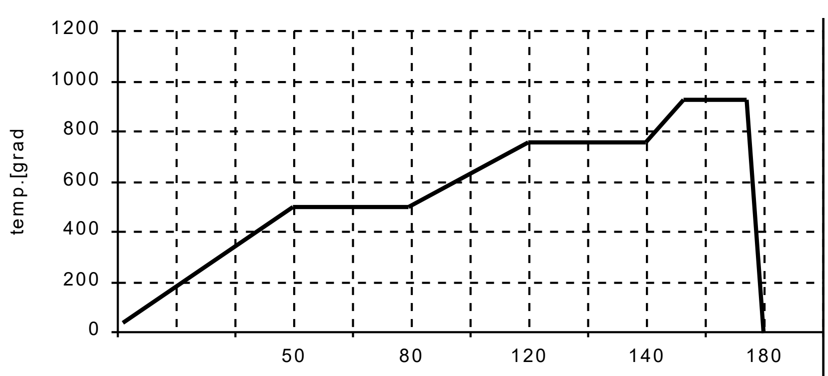

Fig. 4. *Drying diagram of the tundish (summer)*

The degree of drying is checked by measuring the temperature of the refractory shotcrete or concrete, with special thermocouples.

Fig. 5. *Tundish gunited after drying*

3.2. Version B-tundish with TUNDEX 160AS

The wear lining of the tundish was achieved with Tundex 160AS, with the chemical composition shown in Table 5.

The Tundex 160AS material will be poured into the space created between the formwork and the permanent masonry, at about 50 mm from the top edge of the wall, taking care not to obstruct the outlet of the tundish.

To obtain a quality wear layer, plastering materials must provide a good grip at the walls, must not slip on the walls and must not react with the refractory mass. The deposited layer will have a thickness of 25-35 mm at the walls and 35-45 mm at the hearth.

After completing these operations, the drying with gas is carried out according to the diagram in Figure 6.

Table 5. *The chemical composition of the TUNDEX 160 AS*

Material	MgO	Si O_2	CaO	Fe_2O_3	Al_2O_3	C	Density
TUNDEX 160 AS	60-65%	23-28%	<2%	5-7%	<2%	2-5%	1.5-1.7 g/cm^3

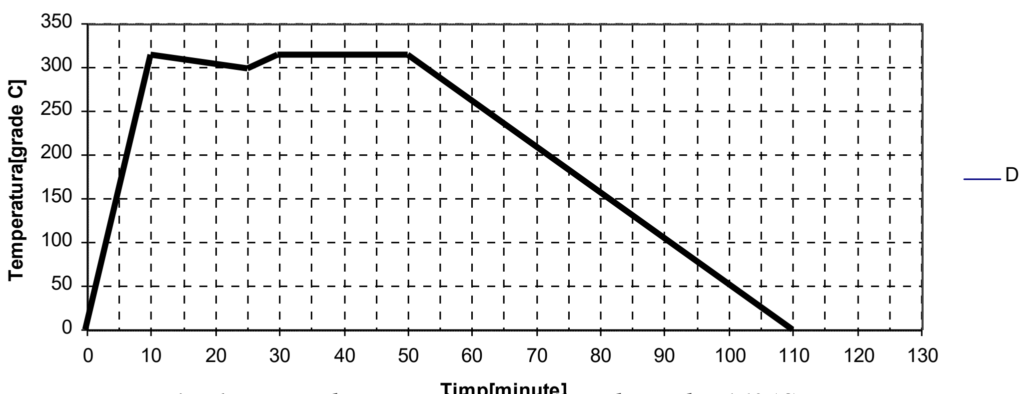

Fig. 6. *Drying diagram of the tundish with Tundex 160AS*

Fig. 7. *Tundish with Tundex 160 AS after drying*

4. Macroscopic analysis of the materials used for the tundish

The macroscopic analysis of the refractory materials used in both embodiments of the tundish highlighted this wear according to the number of castings.

The studied material samples were taken before and after casting, from the top of the tundish lining, the place where the contact with the metal bath erodes the material.

The photos were taken with the optical microscope NEOPHOT 2 with digital acquisition of the image and soft Optika Vision Lite2.1.

4.1. Analysis of KERMAG LTD90 samples (A version)

Before casting:

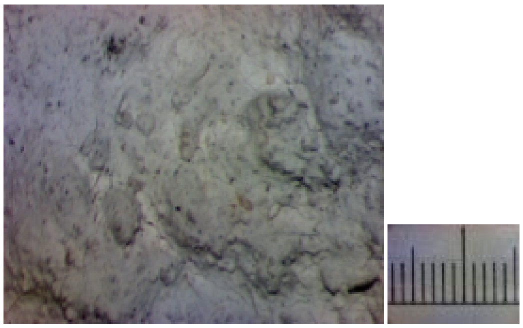

Fig. 8. *Macrostructure of the KERMAG LTD90 sample before casting (calibration 63x stereomicroscope)*

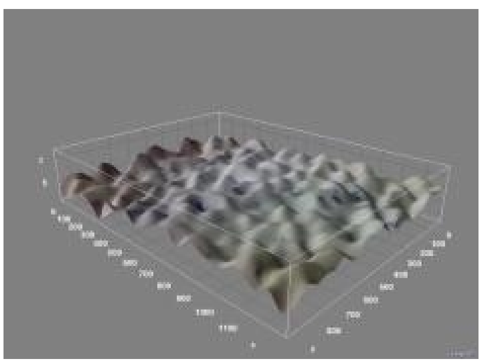

Fig. 9. *3D image of the KERMAG LTD90 sample before casting*

After casting:

Fig. 10. *Macrostructure of the KERMAG LTD90 sample after casting (calibration 63x stereomicroscope)*

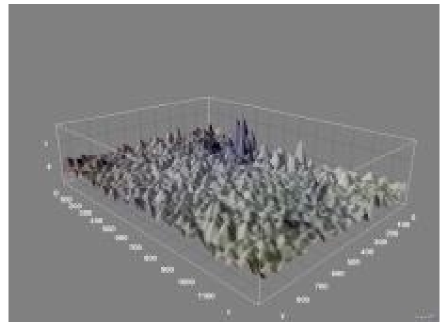

Fig. 11. *3D image of the KERMAG LTD90 sample after casting*

4.2. Analysis of TUNDEX 160 AS samples (B version)

Before casting:

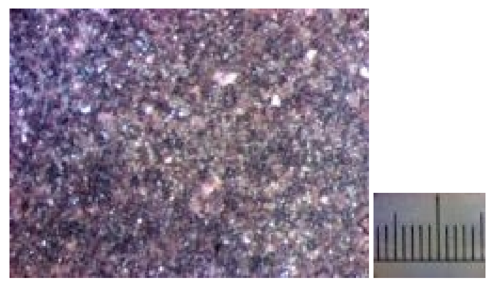

Fig. 12. *Macrostructure of the TUNDEX 160 AS sample before casting (calibration 63x stereomicroscope)*

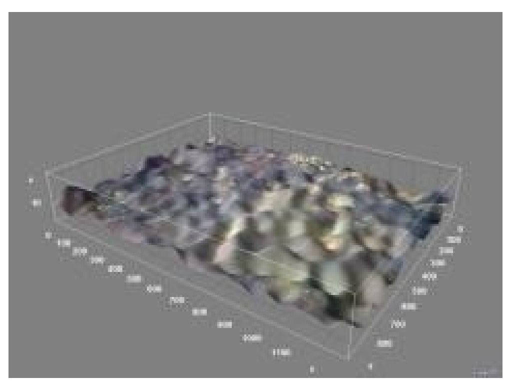

Fig. 13. *3D image of the TUNDEX 160 AS sample before casting*

After casting:

Fig. 14. *Macrostructure of the TUNDEX 160 AS sample after casting (calibration 63x stereomicroscope)*

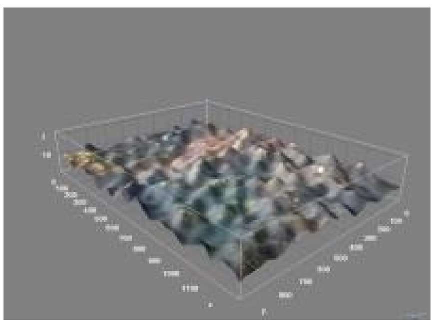

Fig. 15.*3D image of the TUNDEX 160 AS sample after casting*

5. Conclusions

The improvement of the casting technology by replacing the material for the wear layer led to greater protection of the lining, the default of the duration of use of the tundish was higher, these resisted to casting for a larger number of charges: 1700 with TUNDEX 160 AS versus 1000 charges with KERMAG LTD 90.

The analysis of the macrostructures and the 3D images of the sample materials TUNDEX 160AS and KERMAG LTD 90 showed a less worn surface after casting at the TUNDEX 160 AS material, and fewer non-metallic inclusions in the cast slabs.

Increasing the number of castings in the tundish leads to a more efficient casting process by using a smaller number of tundish, respectively 5 to 8. The preparation of the tundish cycle is shortened from 4 to 12 hours, there is economy of gas, electricity and labor.

There is also lower consumption of natural gas because the drying temperature of this material is 320 ºC, compared to the wet material that requires a temperature of 900 °C, resulting in less drying time: 50 minutes compared to 180 minutes for the tundish that does not require additional heating before casting begins.

The new material used shows at the end of the casting process a surface with less roughness, in the slabs casting.

The absence of water in the material composition led to a lower risk of expansion and greater occupational safety.

References

[1]. Irving W. R., *Continuous Casting of Steel*, Institute of Materials, Cambridge, 1993.
[2]. Butnariu I., Geantă V., ş.a., *Turnarea continuă a semifabricatelor de oţel*, Editura Tehnică, Bucureşti, 2000.
[3]. *,** *Casting and Solidification of Steel*, IPC Science and Technology Press Ltd, Guildford, Luxembourg, November, 1977.
[4]. *,** *Continous Casting Ceramics*, Firma Foseca, 1984.