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PROTECTION OF TUNDISH REFRACTORY WORKING LINING BASED ON WET SLURRY MIX AGAIN TO SLAG INFILTRATION ON IMPACT JET TUNDISH ZONE

ZAŠTITA RADNE OBLOGE LONCA NA BAZI VATROSTALNOG MATERIJALA OD INFILTRACIJE TROSKE

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ABSTRACT
The impact of chemical corrosion on the durability of tundish working lining based on slurry mix is discussed in this work. The results of chemical and mineralogical analysis in the sample of tundish working layer after lining lifetime are presented. Infiltration of slag effected in a reduced thermal shock resistance resulting in thermal stress on the tundish working lining and causes wear of the impact layer. In order to achieve higher performance in the tundish working lining based on magnesia and to obtain clean steel appropriate measures are proposed.

Keywords: Slurry mix, Tundish working lining, Protection plate

SAŽETAK
U ovom radu je razmatran utjecaj kemijske korozije na trajnost radne obloge lonca. Prikazani su rezultati kemijske i mineralne analize na uzorku radne obloge lonca nakon određenog vremena rada. Infiltracija šljake utječe na smanjenje otpornosti na toplinske šokove što rezultuje pojavom toplinskih napona u radnom sloju lonca odnosno trošenje obloge lonca. Predlažu odgovarajuće mjere kako bi se postigla veća učinkovitost radne obloge lonca, za dobivanje čistih čelika, na temelju magnezija.

Ključne riječi: vatrostalni materijal, zaštitna površina, radna obloga lonca

1. INTRODUCTION
Over 95% of the world's carbon steels and special steels are produced through continuous casting. A tundish, an intermediate vessel, is used to transfer finished steel melt from a ladle to the mould in a continuous casting machine.
Steel tapped from ladle runs into a tundish which plays a role in the distribution of steel in greater number of the casting strands and provide a steady stream of liquid steel.

Besides that tandish has to meet the following targets:

- ✓ safety casting ,
- ✓ quality improving (no metallurgical interactions with steel, heat keeping),
- ✓ productivity increasing (easy setting, repairing, long life time),
- ✓ decreasing of specific refractory cost per ton produced steel,
- ✓ reliability.

Tundish interior is coated with a refractory material and before the start of filling with steel melt must be preheated to a temperature of about 1000 °C. Capacities of tundishs are 30-50 t, depth about 1 m and with automatic level control of the melt, figure 1.

Figure 1. Tundish with a capacity of 35 tonnes with six strands.

Existing installation of various flow control devices, such as weirs, dams, baffles with holes, pour pads, and turbulence suppressers, within the tundish, increase the steel residence time, figure 2. However, in many cases this is not enough to optimize the inclusions removal.

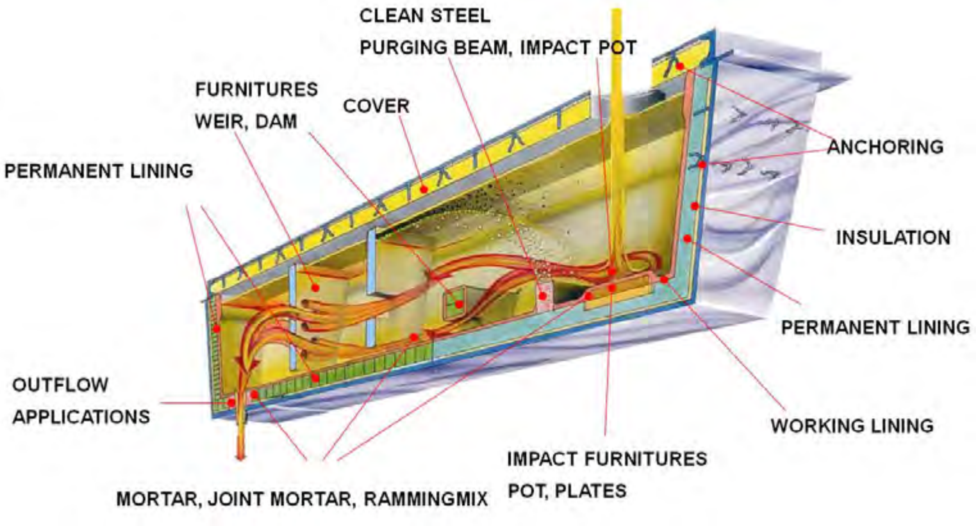

Figure 2. Tundish refractory layout. [1]

Because of the pronounced wear lining of tundish increased number of non-metallic inclusions adversely affects the quality of the cast. Inclusions cause problems during the casting, rolling, and heat treating processes and sometimes result in failure of the steel during its application.

Infiltration of slag effects in a reduced chemical and thermal resistance resulting in thermal stress on the tundish working lining and cause wear of the impact jet zone [2]. Especially the slag type, which is rich in CaO, can accelerate refractory wear rates in this zone. The following study includes postmortem analyses of tundish slurry mix from the impact tundish jet zone after contact with melt and slag, figure 3.

Figure .: Tundish lining based on slurry mix, after lining lifetime.

2. INVESTIGATION METHODS

Post mortem sample part based on slurry mix was taken from a part of tundish refractory after lining lifetime. A piece for a sample was broken out at the tundish impact jet zone, figure 4. This figure shows the sample of post mortem mix based on Ankertun type after being in contact with steel melt and slag. This study includes analyses of the phases formed during infiltration of slag into structure of tundish working lining based on Ankertun wet slurry mix with 78,8% MgO (table 1) and with a grain size of less than 1 mm.

This sample was analyzed using chemical and mineralogical test methods. SEM and XRD micro analyses were used to evaluate the infiltration of different oxides bellow the plaster tundish interface.

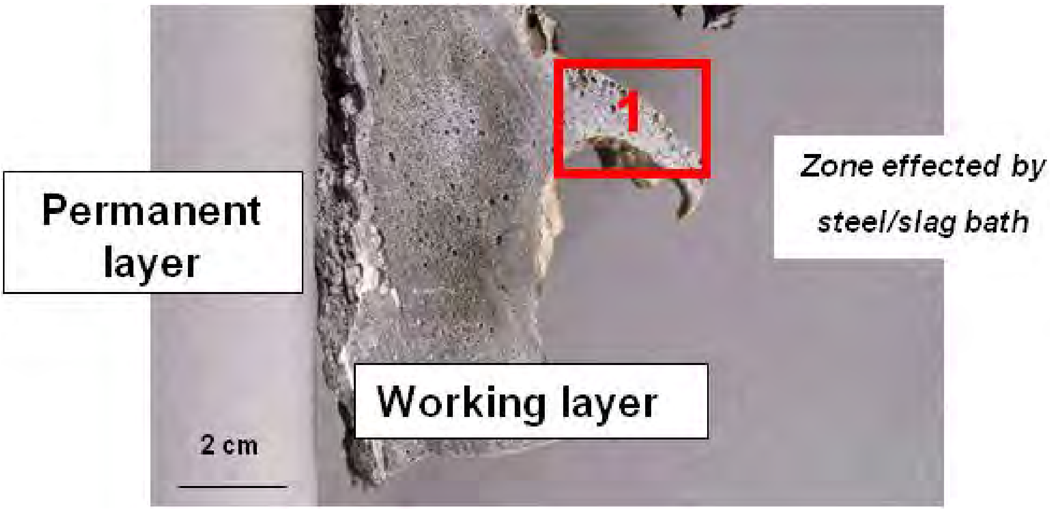

Figure 4. Broken sample of post mortem slurry mix after lining lifetime. [3]

3. CHEMICAL ANALYSES

The chemical analyses and the mineralogical investigations were carried from the area 1 (figure 4) as shown by the table 1[3]. It can be noted chemical change of slurry mix based on MgO components with 78,8%, that means strong exchange in MgO components and also a strong infiltration of CaO, Al_2O_3, SiO_2 in working layer, i.e. in the area 1 (figure 4).

Table 1. Chemical analyses of area 1 (figure 4) after lining lifetime at slag impact zone and data of slurry mix. [3]

Chemical analyses, Wt.%	Area 1	Data of slurry mix
Na_2O	< 0,05	
MgO	26,0	78,8
Al_2O_3	6,05	0,5
SiO_2	35,8	16,0
P_2O_5	< 0,01	
SO_3	0,07	
CaO	29,3	2,2
TiO_2	0,19	
Cr_2O_3	0,03	
MnO	1,82	
Fe_2O_3	0,66	2,5
NiO	< 0,01	

5. MICROANALYSES

Microstructural detail A, figure 5, from impact jet zone from area 1 (figure 4) was studied.

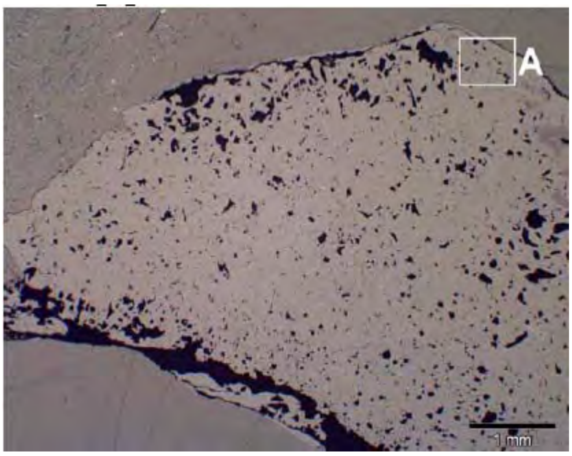

Figure 5. Reflected light image of zone 1 (see figure 4). [3]

Besides phenomena of SEM porosity, by research it was noticed appearance of eutectic mixture of different chemical compositions (figure 6). In certain points of analyzed area, it was also detected apparance of fluor, that also decrease eutectic point.

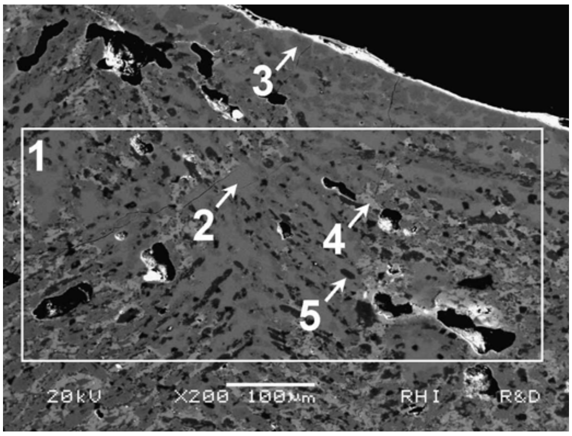

Figure 6. Scanning electron micrograph showing the microstructural detail of area A (see figure 5) showing the eutectic mixture of several phases.

SEM-EDX microanalyses of area A of figure 6 are shown a chemical composition change high in CaO and SiO_2 content and lower MgO content, table 4. Semi- quantative analyses defined strong infiltration of compounds CaO. It is near slag composition [2] and it confirms infiltration and reaction of slag into tundish plaster. High SiO_2 concentration in the tundish slag results in significant refractory infiltration because low melting phases are formed of three components, MgO-SiO_2-CaO system.

Table 2.SEM-EDX microanalyses of area A of figure 6.

Area or spot	%F	%MgO	%Al_2O_3	%SiO_2	%CaO	%MnO	%Fe_2O_3
1	3,0	22,2	6,5	35,9	30,9	1,8	
2		9,9	8,6	40,8	40,1	0,5	
3		28,8		40,3	29,3	1,6	
4	9,5	3,5		32,8	53,5	0,8	
5		50,2		41,9	3,6	3,1	1,3
Area of fig.6	2,0	22,1	6,5	36,1	30,9	2,1	

Participation of MgO in micro structure presented on the figure 6 is about 22,1% and makes only a third of MgO compared to basic initial matrix with 78,8%. Infiltration of Al_2O_3, SiO_2 and CaO compounds is noticeable, as well as the presence of fluor in the value of 2%, and a negligible value of oxide Fe. Particularly negative impact on the stability of the basic matrix have compounds with low melting point, on the basis of fayalite, e.g. monticellite whose melting point combined with fluor is further lowered and under the influence of thermo mechanical stress can lead to the destruction of the basic matrix. The investigation have also showed a high degree of porosity (figure 5) – pores (P) caused by chemical and thermal influence, figure 7.

Figure 7. Scanning electron micrograph showing the microstructural detail of area A (see figure 5) showing the pores (P).

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The highest level of working lining wear of the tundish is in the zone of the heaviest impacts of jet castings. During sequence casting there is a strong impact of metal stream on impact zone in tundish. The reason for such wearing of tundish working lining in impact zone is the design of the tundish. The distance between metal stream and tundish wall is too small. So in that area because of metal turbulence wearing of tundish working lining is much higher compared to other zones in tundish. To avoid such problem it is necessary additionally protect the tundish front side, the area of metal impact zone. This can be achieved by means of installing of tundish protection plate onto the tundish front side [3].

These protection plates, figure 8, should prevented damages of the tundish front side, area of metal impact zone, which directly increases safety of the operation during the casting of steel and improves the degree of cleanliness of steel and increases the duration of sequence casting time.

Figure 8. Protection of tundish front side, area of metal impact jet zone with installing of tundish protection plate. [3]

Especially the ladle slag can accelerate refractory wear rates in impact zone of tundish working layer. To alleviate this problem, installing an electromagnetic slag detection system at the ladle continuously monitors ladle to tundish flow conditions provides slag warning and close-gate command signals to the ladle operator.

6. CONCLUSION

The application of tundish refractory working lining based on slurry mix is discussed in this work. The results of chemical and mineralogical analysis of the sample of tundish working layer after lining lifetime which is based on a slurry mix are presented. These results show the impact of chemical corrosion on the durability of tundish working lining.

In order to achieve higher performance in the tundish working lining based on slurry mix and obtain clean steel following measures can be made:

- additional protection of tundish impact area with installing tundish protection plate and
- using a ladle slag detection system.

Application of listed measures could lead in the future to an increase in casting sequence and produced steel cost reduction.

7. REFERENCE

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