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ASSESMENT OF SLAG INFILTRATION INTO TUNDISH PLASTER BASED ON WET SLURRY MIX

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ABSTRACT
Tundish refractory lining has a defined lifetime depending on the lining quality and slag type. In the industrial applications for tundish working lining a wet slurry mix is mostly used. The slag chemistry and strong impact metal stream are resulting in considerable wear of the originally well function in refractory working lining.
This work focuses on the phases formed during slag infiltration which accelerates refractory wear rates in the slag zone of tundish working lining and causes corrosion of the magnesia. It was investigated the impact area of tundish working layer which is most sensibility compare to other tundish area.
Keywords: steel production, tundish slag, slurry mix, slag infiltration

1. INTRODUCTION
Tundish refractory lining has a defined lifetime depending on the lining quality and slag type [1]. Chemical reaction between the tundish refractory working lining layer and tundish slag has a great importance especially in a case when high sequence casts are required. In practice tundish slag varies widely in composition also during a single sequence [2]. Thus, no one refractory composition will work best for all slag conditions [3]. In the industrial applications for tundish working lining a wet slurry mix is mostly used worldwide with approx. 60 % [4]. The product of a wet slurry mix is offered in a range of MgO content. However this refractory lining in the tundish steel casting process are subject to different stresses resulting from the thermo-chemical load. The slag chemistry and slag viscosity are resulting in considerable wear of the originally well function in refractory lining also based on wet slurry mix.

Tundish working lining based on wet slurry mix of Ankertun type is composed of MgO up to 70% with SiO_2 and with a grain size of less than 1 mm. This study includes postmortem analyses and 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.

2. INVESTIGATION METHODS
Post mortem sample part based on wet slurry mix was taken from a part of tundish refractory after lining lifetime in ArcelorMittal Zenica Bosnia and Herzegovina. A piece for a sample was broken out at the tundish impact slag zone for investigation. Figure 1 shows that the postmortem sample after being in contact with steel and slag is porous and also shows infiltration and densifilication up to the permanent layer, figure 1. Aiming to investigate this, there was a need to analyze the chemical change in steel/slag zone.

In a surface area of working refractory lining effected by steel/slag melt has been followed changes in matrix and this zone has been shown as zone effected by steel/slag melt. Due to fact that this zone was mostly exposed to thermo-chemical impacts, it can be assumed that the biggest percent of matrix damages was made just in this region.

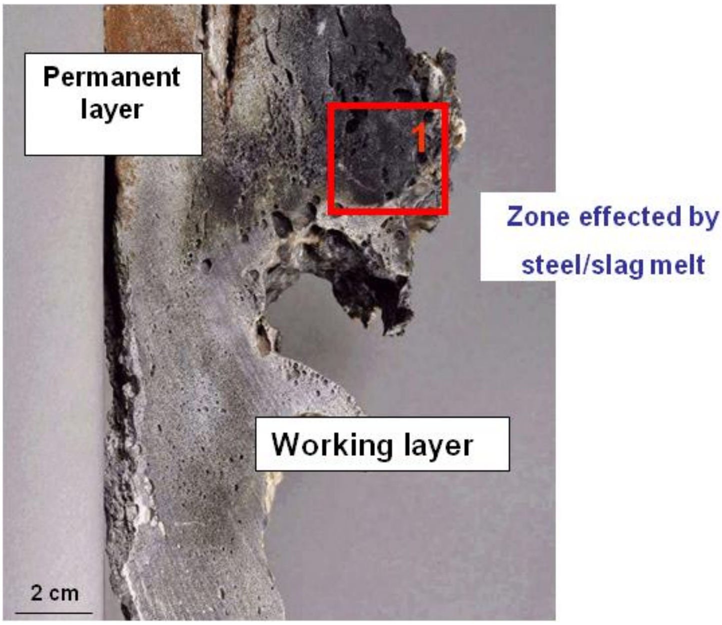

Figure 1. Broken sample of post mortem of wet slurry mix after lining lifetime. [5]

The postmortem sample was used for analyses by the light and the JEOL 6560 scanning electron microscope.

3. MICROANALYSES OF ZONE 1 EFFECTED BY STEEL/SLAG MELT

The mineralogical investigation was carried out on polished section from the zone 1 (figure 1) using a scanning electron microscope. In this zone at the surface of working refractory lining, effected by steel/slag melt, there are softening, damage and partly destruction of matrix high in MgO. More detailed researches of micro-structure in zone 1, figure 2, have been completed in two regions A and B (figures 3 and 4).

In the zone A of figure 2 it has been defined significant infiltration of oxides as SiO_2, Al_2O_3, CaO, as well as appearance of low-soluble eutectics. Semi-quantative analyses defined strong infiltration of compounds CaO. In those regions there are significant presence of oxide SiO_2, Al_2O_3, CaO, TiO_2, SO_2 and Fe_2O_3.

In certain regions those oxides are marked at figure 3, while mass percents and its values have been shown in table 1. The infiltrated slag is rich in CaO, SiO_2 and Al_2O_3. The reaction between MgO of tundish lining with CaO and SiO_2 of slag develop phase such as moticellite and forsterite, figure 5, and the reaction between MgO of tundish lining with Al_2O_3 of tundish develop spinel.

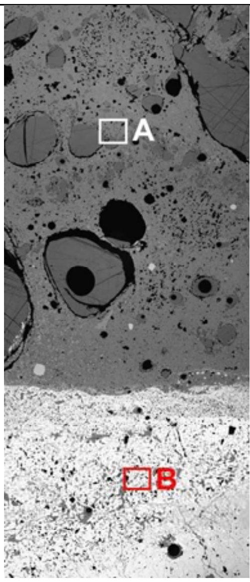

Figure 2. Reflected light image of zone 1 (see figure 1) [5]

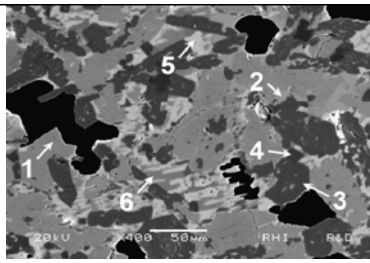

Figure 3. Scanning electron micrograph showing the microstructural detail of area A (see figure 2)

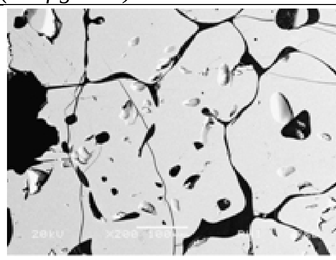

Figure 4. Scanning electron micrograph showing the microstructural detail of area B (see figure 2)

Table 1. SEM-EDX microanalyses of figure 3.

Area or spot	%F	%MgO	%Al_2O_3	%SiO_2	%CaO	%TiO_2	%MnO	%Fe_2O_3	%SO_3
1		28,2		39,6	28,7		2,1	1,4	
2		9,6	8,9	41,3	38,9		0,6	0,7	
3		51,1		42,8	4,3		1,8		
4		27,4	66,5	1,3	0,4		1,2	3,1	
5	9,7	4,8	2,1	34	47,2		1,6		0,6
6		11,4	19,2	40,8	24,2	1,5	0,8	2,1	
area of fig.3	1,9	28,9	4,8	37,0	24,2		1,4	1,8	

It can be concluded, that the cover powder was strongly contaminated with calciumaluminate carry over slag from the ladle. High amounts of monticellite $CaMg_2SiO_4$ and forsterite Mg_2SiO_4 have been formed. The result of this slag attack was corrosion of the magnesia as main wet slurry mix component. The forsterite has higher melting temprature but in contact with SiO_2 and Fe gives the olivine group ((Mg, Fe) $_2SiO_4$) with significant lower melting temperature. Additionally fluoride has been detected in the infiltrate which indicated that he first melting phases can occur even at lower temperatures.

Monticellite $CaMgSiO_4$
melting point ~1454°C

contact with SiO_2 and Fe

Forsterite Mg_2SiO_4
melting point ~1890 °C

Figure 5. Formation of olivine group with significant lower melting temperature which occurs tundish working lining corrosion

In Steelwork ArcelorMittal Zenica 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 steel stream on impact zone in tundish. To avoid such problem it is necessary to additionally protect the tundish front side, the area of steel impact zone. This can be achieved by means of installing of tundish protection plate Ankoform onto the tundish front side, figure 6 [5].
Upon trial period of the tundish with installed Ankoform protection plate the duration of sequence casting time was increased for additional 1 hour. Also, these protection plates have prevented damages of the tundish front side, area of steel impact zone, which directly increases safety of the operation during the casting of steel and improves the degree of cleanness of steel.

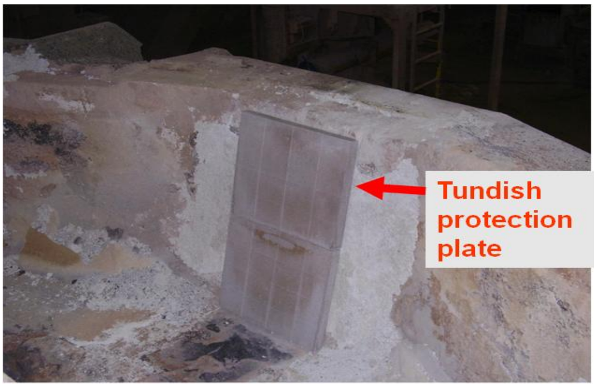

Figure 6. Protection of tundish front side, area of tundish working impact zone with installing of Ankoform protection plate. [5]

4. CONCLUSIONS

The chemical corrosion of tundish working lining based on wet slurry mix is discussed in the work.
The results of chemical and mineralogical analysis in the sample of working lining of tundish already exploited which is based on a slurry mix of Ankertun type is presented in the work. In order to achieve higher performance in the tundish working lining in Steelwork ArcelorMittal Zenica based on this wet slurry mix and obtained clean steel can be made with:

- a change of the quality of covering powder,
- using of the wet slurry mix with lower percent of SiO_2,
- additional changes in protection of tundish impact area with installing Ankoform protection plate.

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

5. REFERENCES

[1] Pal A.R., Bharati S., Krishna N.V.S., Das G.C.; Pal, P.G.: The effect of sintering behaviour and phase transformations on strength and thermal conductivity of disposable tundish linings with varying compositions, Ceramics International, Vol. 38, Issue 4, p.3383-3389, May 2012.,
[2] Hepuţ T., Comşa A., Osaci M., Petre D.: Study on the surface pressure in the slag systems used at the continuous casting, 11th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology" TMT 2007, Hammamet, Tunisia, 05-09 September, 2007.,
[3] Skurikhin, V. V.: New Refractory Materials and Products for Metallurgy, Metallurgist, Vol. 48 Issue 5/6, p. 281-285, May/Jun 2004.,
[4] Turen J., Kosatepe K., Karakas I., Kandan E. : Wettability of tundish periclase lining by steel, Refractories & Industrial Ceramics, Vol. 47 Issue 1, p. 68-73. Jan. 2006.,
[5] Mahmutović A., Eder J., Henjaković M., Karić I., Kablar O.: Measures to improve the durability of a tundish working lining based on slurry gunning mix, RHI Bulletin 1, Steel Edition 2013..