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# INDUSTRIAL RESEARCHES FOR REDUCING THE DURABILITY OF WORKING LINING OF A CASTING LADLE

*The analysis of critical reasons for increased wear of working lining of casting ladle within the slag-line area and setting points for blowing plugs is made. Changes in production cycles of metal treatment are determined as well as some ways providing the increase of durability of lining's working layer of casting ladle are proposed.*

***Key words:*** *casting ladle, melting, lining, slag line, blow, blow intensity, slag regime.*

A problem and its connection with scientific and practical tasks.

Nowadays many iron-and-steel works are observing a tendency of reducing the durabilty of lining's working layer in casting ladles caused by production cycles of melt treatment in a casting ladle.

The object of analysis was chosen as a plant with converter technology predominantly oriented to melt rank steel grades with their processing at the ladle-furnace station without vacuuming.

Setting the task. The task of this work is to analyze critical reasons of reducing the durability of lining's working layer of casting ladle and to determine the main optimization ways for technological regimes on the processing stage in ladle-furnace station.

At this enterprise they use piece magnesia-carbon bricks (CARBOMAG) for lining a working layer of a casting ladle.

For analysis one has used the following periods: 12 months of 2014 year and 5 months of 2015 year. Histogram of lining service life within studied periods is given in figure 1. From the diagram we see that from the early 2015 it was seen sharp reduce of the average service life of lining's working layer of casting ladle from 71,4 melts in 2014 to average service life of 62,5 melts during 5 months of 2015.

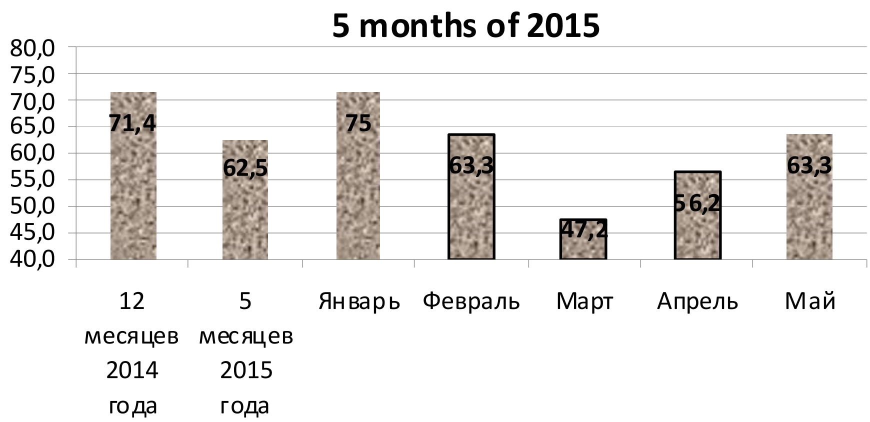


Figure 1 – Diagram of working lining reduce in a casting ladle

**Statement of the investigation and its results.** To determine the reasons of reducing the lining's strength there was made an analysis of wear topography for linings in different casting ladles as well as technological factors which influence negatively the durability of working lining. Schematic diagram of casting ladle is given in figure 2.

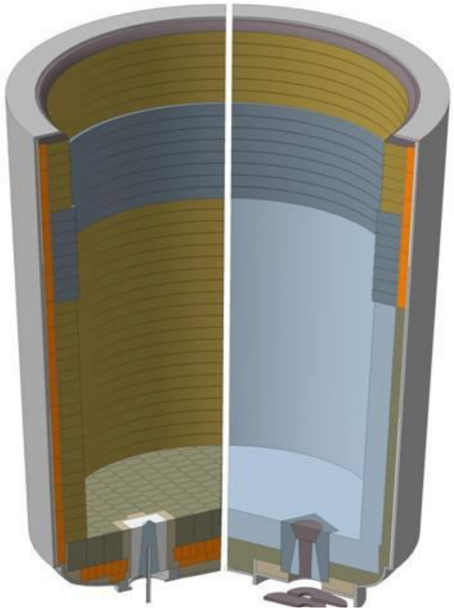

Figure 2 – Schematic diagram of casting ladle

Feature of the lining in working casting ladle is refractories in the area of slag line, which are different from the other lining. In the area of slag lining we use magnesia-carbon refractory bricks DALCAR P-14M2 and DALCAR P-16T1 used to harden the tuyere zone.

There has been analyzed a wear topography of the two zones, especially slag one and blowing plugs zone. Figure 3 presents picture of wear of slag line casting ladle 160 ton charge. For wear gauging we used a wooden plate applying it side to the lining along the generating line and after that wearing depth was measured with a gauge tape.

When analyzing data it was proved that in terms of wearing topography 80% of casting ladles premature taken out of service have 10 cm advance lining's wear along the perimeter of casting ladle that is confirmed by photo in figure 3. Main wear mechanism of slag line is chemical corrosion and mechanical erosion caused by stirring the liquid bath. It is instantiated by deep located irregularly destructions of refractories.

Figure 3 –Advance lining's wear of slag line at strength of 50 melts within the area of a blowing plug

It was determined, that above wear is directly caused by changing the operational conditions of casting ladle within the period analyzed specifically:

– reducing the average from 5-6,5% in stable period to 2-3 % in analyzed period, that under metal processing on the ladle-furnace unit during process progress does not provide maintenance of balanced 'slag-refractory' system thus increasing the solubility of refractories in a slag;

– increasing the average consumption of fluorspar from 2-2,5 kg/ton до 3,3-3,7 kg/ton at reducing MgO content in furnace slag that results in raising the reactivity of slag in a casting ladle due to fluidity and presence of fluoric compositions;

– increasing the average heating time for 'furnace-ladle' system from 16-18 min to 26-27 min (temperature-rate casting regime at continuous-casting machine), that increases temperature load on ladle's lining as well as causes local overheating;

– increasing the average treatment time (blow-down) for metal in 'furnace-ladle' system from 30-33 min to 43–45 as well as increasing the noble gas feed rate within the blowing period from 14 $m^3$/melt to 18 $m^3$/melt.

Except technological parameters during treatment we observed the form of jet causing big and small whirlpools in different zones of a ladle. When blowing is in progress gas-liquid jet flow widens, quality of tiny bubbles increase and cone's size of liquid in cover slag layer increases as well. As a result a great number of bubbles go up the surface of slag and form a spot of a small size. Then at further blowing (while increasing its rate) number of bubbles getting the surface increases becoming bigger in size and a spot widens, while gas-liquid flow of slag takes a form of truncated cone. We also found out, that big bubbles at the surface started to burst producing afterwards the smaller ones added by new appeared bubbles from gas-liquid flow. When consumption of blown gas increases (more than 16 $m^3$/melt) the above described processes go more intensively and the liquid cone formed has originally a bigger size. Specific feature of gas blow of liquid is spraying the part of liquid, which flies out within the boundary of slag layer.

All liquid volume in the ladle actually is divided into two circulation zones of different size. In a smaller one active circulation and stirring of gas-liquid mixture with discrete slag portions take place principally in upper zone beside ladle walls near the 'metal-slag' boundary. At the same time in a bigger zone an intensive circulation of flows is formed, which spread almost over the whole volume of a ladle. Then slag in big portions is absorbed inside liquid volume and sometimes gets the bottom of a ladle. Such a large slag immerse into stirring process one can explain by high liquid flow rate in subzone situated near the spot, i.e. when liquid moves the separation of some slag portions happens with its catching inward the melt.

Central zone of casting ladle remains practically unslagged, whereas slag layer depth beside ladle walls within bigger circulation zone increases 3-4 times. These effects are especially appeared at big air consumption (more 16 $m^3$/melt) and significant displacement of blowing units to the walls from vertical axis of a vessel [1].

On the basis of researches provided we can conclude that recorded since early 2015 sharp reducing of average durability of casting ladle's working lining from 71,4 melts to 62,5 melts is caused by anticipatory wear of slag layer because of negative impact of a number of metallurgical factors as follows:

– reducing MgO content in furnace slag from 5-6,5% to 2-3%. Slag saturation with magnum within 7-10% does not enable a lining dissolving and at certain control facilitates its service life;

– changing the conditions of metal treatment on the 'ladle-furnace' station within: heating time increase for metal (growth of heat loading at the lining), its treatment time (growth of mechanical and chemical loading at the lining), that leads to intensification of mass-exchange processes at the separating boundary both ‘slag-refractory’ and ‘metal-refractory’;

– keeping on a rather high level fluorspar consumption (additional loading on the lining with aggressive slag melt). Fluorspar content in a slag accelerates corrosion of refractories. During metal moving in the ladle being especially intensive within argon blowing, periclase grains are washed out from the refractory with further dissolution in a slag.

Great reduce of service life of casting ladles in the analyzed period is accompanied by synchronous growth of unit expenses of refractories used for their lining. At achieved value of average durability the unit expenses are 2,2 $/ton more, then for reported 2014 period.

Considering the above mentioned and having the aim to reduce loading onto slag belt of casting ladle we can recommend the following actions:

1. Search for optimal regimes of steel blowing by noble gas when melt is homogenized on the ‘ladle-furnace’ station.

2. Use of ladle ‘glaze’ as an effective way to increase the working lining service life of a casting ladle. Appearing of glaze facilitates increasing the refractories resistivity to metal and slag washing out which affects the service life of a ladle’s lining. Applying the ladle glaze allows using of passive corrosion for formation a hard slag layer on refractory’s surface, which afterwards will reduce general corrosion rate. In addition, a ladle glaze reduces oxidizing potential of refractories (prevent their decarbonization) at their contact with oxidizing air (aerial oxygen) on the reaction $\{O_2\}+\langle C\rangle=\{CO_2\}$. Main benefits of the technology are listed as simple implementation, wide range of slag modifiers, and absence of necessity in auxiliary equipment for applying the ladle glaze on the ladle’s walls [2].

3. Increasing the agent of magnum-contained materials for neutralizing negative impact of fluorspar to ladle’s lining. It is worth mentioning, that if adding special materials with MgO content, it results in reducing negative corrosion impact of slag melt due to slag viscosity increase and reducing MgO solubility in MgO-saturated slag [3].

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**ПРОМИСЛОВЕ ДОСЛІДЖЕННЯ ЗНИЖЕННЯ СТІЙКОСТІ РОБОЧОЇ ФУТЕРОВКИ СТАЛЕРОЗЛИВНОГО КІВША**

*Проведено аналіз основних причин щодо підвищеного зносу футеровки сталерозливних ківшів (СК) в зоні шлакового поясу та місць встановлення продувних пробок. Визначено зміни*

*технологічних режимів обробки металу, а також запропоновані заходи, які дозволять збільшити стійкість робочого шару футеровки ківша.*
***Ключові слова**: сталерозливний ківш, плавка, футеровка, шлаковий пояс, продування, інтенсивність продування, шлаковий режим.*

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**ПРОМЫШЛЕННЫЕ ИССЛЕДОВАНИЯ СНИЖЕНИЯ СТОЙКОСТИ РАБОЧЕЙ ФУТЕРОВКИ СТАЛЕРАЗЛИВОЧНОГО КОВША**

*Проведен анализ основных причин повышенного износа футеровки сталеразливочных ковшей (СК) в районе шлакового пояса и мест установки продувочных пробок. Определены изменения технологических режимов обработки металла, а также предложены мероприятия, позволяющие увеличить стойкость рабочего слоя футеровки ковша.*
***Ключевые слова:** сталеразливочный ковш, плавка, футеровка, шлаковый пояс, продувка, интенсивность продувки, шлаковый режим.*