SAVING ENERGY IN LADLE METALLURGY

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Abstract

Ladle metallurgy is currently one of the most important steps of existing method of steel production. The main part of the ladle metallurgy is the ladle. Its high lifetime period is guaranteed with lining of high quality refractory materials. The research was focused primarily on power consumption reducing in ladle furnaces and saving of fuel gas for heating of ladles between two heats using heat from steel accumulated in the lining and on reducing of the consumption of refractory material for lining of ladles and tandem furnaces by decreasing of tapping temperatures.

Keywords: ladle metallurgy, refractory, insulation, thermal conductivity, temperature

1. INTRODUCTION

Current technologies of the ladle metallurgy and continuous casting of steel tax the ladle refractory linings heavily. The introduction of continuous casting and the enlargement of secondary metallurgy caused that the ladle ceased to be just a vehicle for transport of steel from the primary unit to the caster. It has become a reactor in which metallurgical process continues after separation from the furnace unit. To the ladles there was transferred part of the technological steps originally belonging to the primary unit and added new ones which allow increase the share of special steel qualities and higher utility values, extending the number of grades of steel, shortening the production cycle and rationalizing production. Constantly increasing demands to reduce energy costs as a direct result on reducing emissions of greenhouse gases (especially CO₂) are leading steel mills to increase the rate of applied research and development of new technologies to meet this requirement.

2. INTEGRATION OF NEW INSULATION LAYER INTO THE LADLE LINING

Efforts to minimize heat loss of liquid steel through the ladle lining led to the idea of integration of high-quality insulating layer between the permanent lining and the ladle steel shell. In order to verify a new type of insulation the operational test of insulated ladle was carried out in the ArcelorMittal Ostrava a.s. company. To collect evidence of thermal lining work in the new ladle lining structure, thermocouple sensors were built into the lining. Operational test was performed in the ladle with a magnesium-dolomite lining. Insulation of the ladle was made as follows:

BOTTOM:
1st layer: PROMALIGHT Alu 1000, thickness 10 mm
2nd layer: PROMAPACK 900, thickness 10 mm

WALL:
1st layer: PROMALIGHT Alu 1000, thickness 5 mm
2nd layer: PROMAFORM 1260/500, thickness 10 mm

Characteristics of the thermal insulation materials are as follows:
PROMALIGHT Alu 1000 is a microporous silica-zirconium heat insulation board with the chemical composition of 77,5 % SiO₂, 20 % ZrO₂ a 2,5 % CaO. Classification temperature: 1000 °C.

Thermal conductivity:
- at 200 °C $\lambda = 0,022$ W.m⁻¹.K⁻¹
- at 400 °C $\lambda = 0,025$ W.m⁻¹.K⁻¹

PROMAFORM 1260/500 are tough, vacuum-formed panels of aluminum-silicate ceramic fibers. Classification temperature: 1260 °C. Chemical composition: 44% Al₂O₃, 56% SiO₂.

Thermal conductivity:
- at 200 °C $\lambda = 0,070$ W.m⁻¹.K⁻¹
- at 400 °C $\lambda = 0,090$ W.m⁻¹.K⁻¹
- at 600 °C $\lambda = 0,110$ W.m⁻¹.K⁻¹

Results of operational test can be summarized as follows:
- temperature gradient in front of and behind insulation layers was 650 °C;
- temperature at the interface of work and permanent linings increased by around 150 °C;
- temperature of the ladle shell external surface was 74 °C lower than at the other ladles (241 °C versus 315 °C), which has a positive effect on the ladle shell deformation;
- a positive effect on saving energy has been found;
- increased temperature inside the lining with the small variance in the direction from the inner surface of the lining to the ladle shell indicates the possibility of reducing the tapping temperature of steel [1], [2].

As a result of better retention of heat in the ladle lining, there were shown fuel gas savings during ladle preheating between two heats and electrical savings during heating of steel in ladle furnaces. Another option is to reduce the tapping temperature in the tandem furnace, which would achieve major energy savings especially in the blast of oxygen into the furnace but also in less stress of the working lining of furnace, its campaign could be extended.

In March another two ladles was insulated and by the end of 2010 there should be done a total of 5 ladle insulations, under the current situation in the steel plant of ArcelorMittal Ostrava a.s. These ladles will be monitored not only with the view of the temperatures of the ladle shell and inner walls, but mostly with the view of the consumption of natural gas and electricity in the ladle metallurgy process.

3. OPTIMIZATION OF REFRACTORY MATERIALS OF THE LADLE LINING

In order to increase the life of the working layer of the ladle lining, it is necessary to deal with selecting and testing of high-refractory building materials, which would allow to implement that requirement. Particular attention is paid to the most loaded points of linings, especially slag zone, but also the impact area, places above the purging plug, etc. The solution is focused primarily on the following areas:
- experimental-theoretical determination of the parameters and characteristics of the potential ladle linings for steel plant in ArcelorMittal Ostrava a.s.;
• optimization of the composition and thickness of each layer ladle lining on the basis of corrosion tests of refractory materials of the working lining and simulation of heat losses through the ladle lining;
• verification and implementation of the recommended options in the steel plant operation [1].

Today there will be primarily solved a ladle lining composition with regard to the new vacuum technologies as a part of the steel production, leading to an overall increase of the quality of final products.

4. CONCLUSION

This report contains a brief summary of research activities in the ladle metallurgy, which is currently being implemented in ArcelorMittal Ostrava a.s. This is about optimizing thermal work ladles with effective use of accumulated heat of steel melting earlier in the lining. This will result in considerable savings not only heating mediums with a direct impact on reducing CO₂ emissions, but at a fair observance of covering up a ladle with a lid as soon as the end of casting of steel, incorporating an insulating layer into the ladle lining will minimize heat loss of steel through the ladle lining, which will mean both a more even temperature gradient ladle - tundish and also the possibility of permanent reduce of the tapping temperature with consequent increase of the life not only of furnace linings but also ladles (less thermal "shock" when tapping).

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REFERENCES