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PREHEATING OF SCRAP IN ELECTRIC ARC FURNACES BY HOT BLAST BURNERS

PREDGREVANNJE ULOŠKA ZA ELEKTROLUČNE PEĆI KORIŠĆENJEM GORIONIKA SA PREDGREVANJEM VAZDUHA

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ABSTRACT

A new process for preheating of scrap is based on the characteristics of a hot blast burner which melts long channels into a scrap bulk through which further energy for preheating and melting is supplied. The limited energy input of conventional oxy fuel burners is hereby overcome. From tests performed in a 10-ton pilot plant it can be expected that more than 50% of the energy for an EAF can be supplied by fossil energy with an efficiency of almost 100%.

APSTRAKT

Novi postupak predgrevanja uloška zasnovan je na osobini gorionika sa predgrejanim vazduhom da istope dugačak kanal u masi uloška kroz koji se dalje dovodi energija potrebna za predgrevanje i topljenje uloška. Time je premoštena ograničena mogućnost predaje toplote koja bila nedostatak klasičnih kiseoničnih gorionika. Na osnovu rezultata ispitivanja na 10-tonskom eksperimentalnom postrojenju, može se očekivati da se preko 50% energije potrebne za topljenje kod elektrolučnih peći dobije iz fosilnih goriva i to sa efikasnošću blizu 100%.

Ključne reči: elektrolučna peć, predgrevanje uloška

INTRODUCTION

Today scrap is generally melted in Electric Arc Furnaces. Here oxy-fuel burners are often applied to increase the energy input and to partially replace electric energy. Different systems are in use now, but maximum energy input is more or less limited at all the systems to about 10% of the total melting energy.

Investigations of hot blast jets with fuel additions have shown that their behavior is completely different from oxy fuel burners. The main difference is that hot air blast burners in a short time melt long channels into a scrap bulk through which further energy is supplied. The scrap is hereby preheated and to a certain extent also melted with high efficiency [1, 2].

This paper illustrates the difference between preheating scrap with oxy fuel and hot blast burners and explains the application of the new technique.

TESTS IN A 10-TON PILOT PLANT

For detailed experiments, a hearth type furnace with a capacity of 10 tons of scrap was installed. Tuyeres for hot blast supply with a capacity of about 2.000 m_{STP}^3/h each were installed in the side walls of the furnace. The hot blast was produced by a "pebble heater" as a new type of regenerator. Thermocouples to measure the temperature in the scrap bulk and in the off gas were installed. The composition of the off gas was analyzed by means of a mass spectrometer. For comparison, an oxygen fuel burner was also installed and operated in the same furnace.

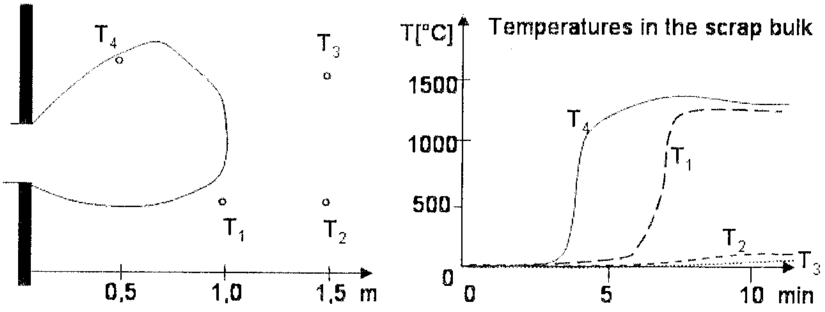

Figure 1 - (left) Shape of cavity molten into a scrap bulk by an oxygen natural gas burner with a capacity of 2.1 MW after 6 minutes preheating. Positions of thermocouples are indicated. The right diagram shows the temperatures of the thermocouples in the scrap bulk during burner operation

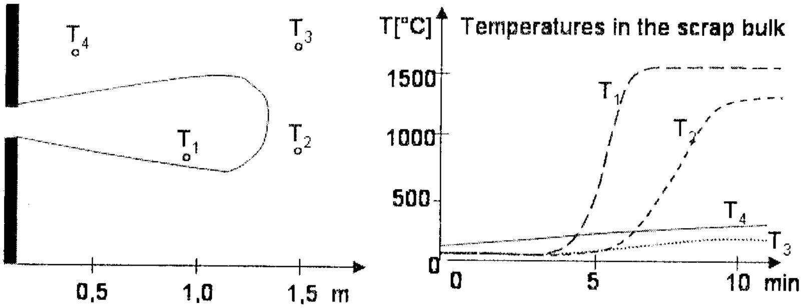

Figure 2 - (left) Shape of cavity molten into a scrap bulk by a hot blast natural gas burner with a capacity of 2.6 MW after 6 minutes preheating. Positions of thermocouples are indicated. (right) Plot of temperatures inside the scrap bulk during burner operation

Figure 1 and Figure 2 show some of the results. In Figure 1 the pattern of the melted scrap in front of an oxy-fuel burner is shown. The burner melts a spherical volume with almost no preheating of areas outside that region. After about 10 minutes a chimney above the spherical volume is formed and the heat of the burner then leaves this volume with limited effect on preheating.

Figure 2 shows on the left side the shape of the molten cavity and on the right side the distribution of the temperature in the scrap bulk for a hot blast burner with a capacity of about 2.6 MW.

After four minutes the hot blast burner already leads to an increase of the temperature at a distance of 1.5 m in the scrap bulk. At locations outside the jet, the temperature also increases very fast. This shows that the hot blast jet burns a channel into the scrap bulk within a short time and simultaneously heats the scrap by a circulation of the hot gas in the gap volume of the scrap. As the hot blast jet penetrates deeply into the scrap bulk, preheating does not have to be stopped after ten minutes as was the case with the oxy fuel burner. A substantial amount of the scrap surrounding the molten channel is thereby effectively preheated.

Main reason for the different behavior is the impulse of the hot blast jet. Compared to an oxygen jet at the same pressure it is about 10 times higher. The sonic velocity of the gas in a tuyere depends on the temperature of the gas. At 1,200°C it is about 2.3 times higher than at room temperature. Together with the nitrogen content of the air it results in a 10 times higher impulse of the hot air jet and is the reason for a high stability of the gas jet. This leads to a deep penetration into the scrap bulk. By the same effect the circulation of the gas in the gaseous gap of the scrap bulk is also tremendously increased by an effective preheating of the scrap in the vicinity of the channel. This information is confirmed by Thermocouple 4. The oxy fuel burner heats up the scrap around the burner resulting in a fast temperature increase in position 4. The hot blast burner temperature in position T 4 stays low during the whole test period indicating that the energy is deeply transferred into the scrap bulk.

PREHEATING OF SCRAP IN AN EAF WITH FOSSIL ENERGY BY APPLYING HOT BLAST BURNERS

The knowledge gained in these investigations is the basis for new proposals to effectively preheat scrap to a high extent in conventional EAFs. Almost all the elements of existing EAFs stay in use as in conventional operation. In one proposal the electrode is replaced by a lance for hot blast supply for a certain time (Figure 3). In a second proposal preheating is done parallel to the usual operation of the EAF (Figure 4).

The new applications are based on the mentioned invention [3] that high speed hot blast jets with some addition of natural gas burn long channels into a scrap bulk within a few minutes. As mentioned before, the hot blast jet also causes an extensive flow of the gases within the gap volume resulting in an effective preheating of the scrap outside the gas jet. It thus solves the fundamental problem of heating up a scrap bulk, as it is generally known that the transfer of heat by a flame or by radiation into a scrap bulk is very limited.

The first proposal mainly consists of two phases. In phase 1 the scrap is preheated and to some extent melted by hot blast burners, whereas in phase 2 the remaining part of the scrap is melted and heated up to tapping temperature by the conventional application of EAF-practice. Hot blast of about 1,200°C is enriched by oxygen addition to about 30 %. The pressure of the hot blast is close to 1 bar enabling a speed of the blast in the tuyere of about 750 m/sec (close to the sonic velocity). Natural gas is added to the hot blast at the orifice of the tuyere. The hot blast lances are located in the openings in the roof for the electrodes. The off gas is almost completely combusted so the volume of the off gas is only slightly higher than the amount of the injected hot blast.

Simulations of the proposed process for a 100 t furnace lead to the following results. It is assumed that the hearth diameter of the furnace is 5.5 m and the height of the scrap column is 3.5 m. Hot blast of 30,000 m_{STP}^3/h is injected through three lances with an orifice of 14 cm each resulting in a blowing rate of 10,000 m_{STP}^3/h each. The three channels melt or preheat a central zone with a diameter of about 3.5 m within 20 minutes. An outside ring with a thickness of about 1 m is simultaneously preheated to an average temperature of about 1,000 °C. The injected gas leaves the scrap bulk mainly through the outer ring of the charged scrap. The oxidation of the scrap during the preheating is about 3% as calculated from the offgas analysis. In the second phase the preheated scrap in the outer ring is melted in the conventional EAF practice. About 65% of the total energy for melting the scrap is supplied by the burner.

The preheating can also be modified for an EAF where the scrap is charged in two baskets. For the 100 to EAF used as the reference facility for the new preheating process the application would be as follows: The first scrap basket of about 60 to will be preheated for about 15 min with 30,000 m_{STP}^3/h hot blast enriched to 30% oxygen. About 60% of the total melting energy for the 60 to of scrap is applied during this preheating. The second scrap basket with about 50 to of scrap is then charged and preheated under the same conditions as the first basket for about 10 minutes. Total consumption of natural gas including preheating of air will be 22 m_{STP}^3/to steel. Oxygen consumption for enrichment of the blast is about 13 m_{STP}^3/to steel.

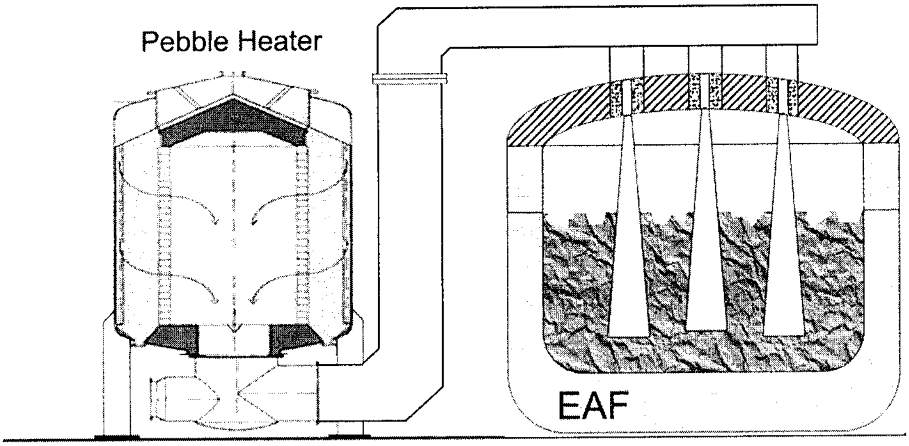

Figure 3. EAF with hot blast jets from the top

Hot blast is produced by a so-called "pebble-heater", a new type of regenerator which was especially developed for the new process. Main advantage compared to conventional cowpers or stoves is that the volume is only about 1/5 and it can be easily heated up and cooled down.

Figure 3 indicates what the facilities would look like. The "pebble-heater" has a diameter of about 3.8 m and an effective height of about 4.2 m. The hot blast main has an outside diameter of 1.4 m. Via a swiffle joint at the top of the main, hot blast is connected to a lance system which operates in a similar way as the electrode moving system of an EAF.

In the second proposal the hot blast is injected through the door or an opening in the side wall of the furnace. Preheating by hot blast burners can then be performed parallel to electric energy input.

Figure 4 shows a top view of the furnace, the main for the hot blast and the tuyere. In this case the tuyere has two openings for two separate jets. Hot blast amount will also be 10,000 m_{STP}^3/h for each orifice. Hot blast injection is extended to about 30 min. For the 100 to furnace, about 19 $m_{STP}^3CH_4$/to steel will be added at the burner for the production of hot blast. O_2-consumption will be 10 $m_{STP}^3$to steel. About 55% of the total melting energy will be supplied by the hot blast heating system.

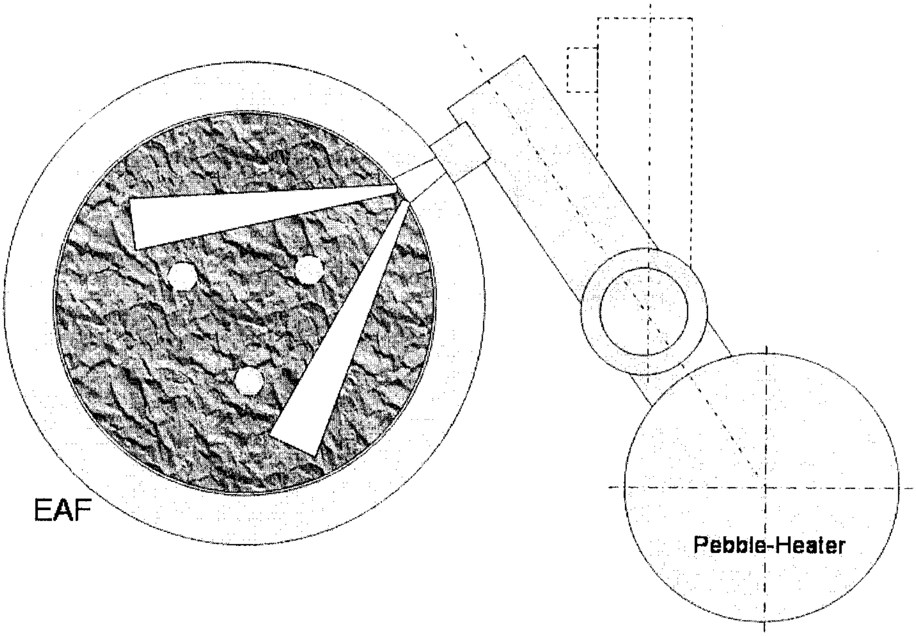

Figure 4: Top view of EAF with two side hot blast burners

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