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IMPROVEMENT OF THE PROCESS OF FEEDING THE SLAG-FOAMING MATERIAL TO THE ELECTRIC ARC FURNACE (EAF), USING OF THE SOUND

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The research described, aimed to determine the value of the sound level (originating exclusively from the operating electric arc) at which the feeding of the slag foaming material to the Electric Arc Furnace (EAF) should start, in correlation with the stabilization of the furnace's active power consumption level. For this purpose, the frequency band generated by the working electric arc was extracted from the entire spectrum of sound emitted by the furnace. Using sound analysis in 1/3 octave bands, the focus was on the band with a center frequency of 100 Hz. It was found that feeding the foaming material should start at a sound level of 103 dB.

Key words: steel, EAF, active power, noise emission, Poland

INTRODUCTION

The quality of slag foaming is an important factor in the electric arc furnace steelmaking processes. Foaming slag contributes to cost reduction by increasing the efficiency of electric energy transfer (converted in the electric arc into heat for heating the metal bath) from about 55 % for non-foaming slag to about 85 % for foaming slag [1]. If a proper slag foaming is ensured, the energy efficiency of the furnace increases. Therefore, scientists are trying to develop useful models for controlling metallurgical processes, including models for optimizing the feeding of the slag foaming materials imto the furnace [2-3].

Currently, research is being carried out in melt shops to enable the use of emitted noise or even the implementation of systems using the noise emitted by the electric arc furnace to control some processes occurring during melting [4-7]. These attempts led to the development of systems based on the analysis of the noise level emitted by the furnace, furnace shell vibrations and FFT current analysis, which control the slag foaming process [8-10].

So far, a limited research has been conducted to define the most appropriate moment of starting injection of coal (foaming agent) into the working volume of the furnace. Definition of such a moment is very difficult without obtaining precise information about the actual degree of completion of the scrap melting process But this is of a critical importance for the proper course of the entire process of melting and superheating of liquid steel.

The [11] presents the results of research showing that relationship between the noise level emitted by the electric furnace and variations of the active power consumption by the furnace can be used to determine the most appropriate starting point of feeding the foaming material into the furnace.

The research presented in this paper was focused on definition the value of the noise level (generated exclusively by the operating electric arc) at which the feeding of the slag foaming material to the EAF should start, in correlation with the stabilization of the furnace's active power consumption level. Therefore, in this stage (stage II), the research consisted in recording the noise level emitted only by the electric arc of the furnace. For this purpose, the frequency band generated by the working electric arc was extracted from the entire spectrum of noise emitted by the furnace. When the furnace is pow-

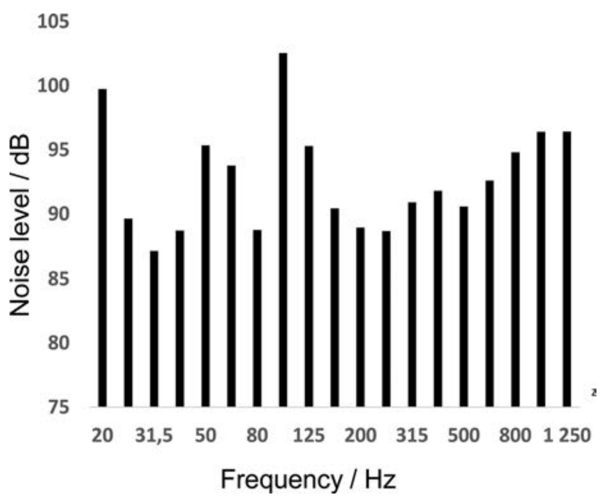

Figure 1 The noise level in individual 1/3 octave bands when the electric arc starts to operate

J. Schwietz (jozef.schwietz@szar.pl) Szar S.A, Częstochowa; B. Panic (bogdan.panic@polsl.pl) Silesian University of Technology, Faculty of Material Science, Katowice, Poland,

ered from a 50 Hz power grid, the arc generates a noise with a frequency of 100 Hz. Using noise analysis in 1/3 octave bands, the focus was on the band on which the noise levels for individual 1/3 bands were marked at the start of the furnace operation. It was assumed that the highest value would represent the frequency of the noise emitted by the electric arc.

As it can be seen from the analysis of the graph presented in Figure 1, the highest noise level was recorded in the band with a frequency of 100 Hz, which confirms the earlier statement regarding the noise generated by the working electric arc.

RESEARCH CONDITIONS

In the first stage of the research (described in [11]), the noise level in the entire audible band was measured using the correction curve A, corresponding to the perception of noise by the human ear. In the second stage of the research, the recording was carried out using the same test equipment as in the first stage and applying the same procedure. However, with the use of SVANTEK software, the time history of the noise measurements in the 1/3 octave band with a center frequency of 100 Hz was separated from the time history record. Later, these waveforms were compared with the record of the active power consumption and the intensity of feeding of the foaming material to find a correlation between these values.

During the operation of the Ultra High Power (UHP) type electric furnace with a capacity of 70 t, a total of 50 tests were carried out during 25 heats with charges composed of two or three scrap baskets. The values of the noise level, active power consumption, and the course of the feeding of the foaming material to the furnace were recorded at intervals of 1 second.

THE RESULTS OF THE RESEARCH WITH A DISCUSSION

Example test results from one heat (including basket II and basket III) are presented in two following graphs. These graphs indicate show moving averages (period equal to 3 seconds) of recorded values of noise level, fluctuations of active power consumption, and the actual condition of the feeding of foaming material, depending on the duration of melting.

The dotted line shows the moving average of the noise level expressed in decibels. The dashed line shows the graph of the moving average of active power consumption expressed in MW. The solid line shows the progress of the blowing of the foaming material into the furnace, but when the line in the graph is horizontal, no foaming material is blown into the furnace.

The analysis of the graphs presented in Figures 2 and 3 shows that the noise level at which stabilization of active power consumption begins, without feeding the foaming material, is 103 dB.

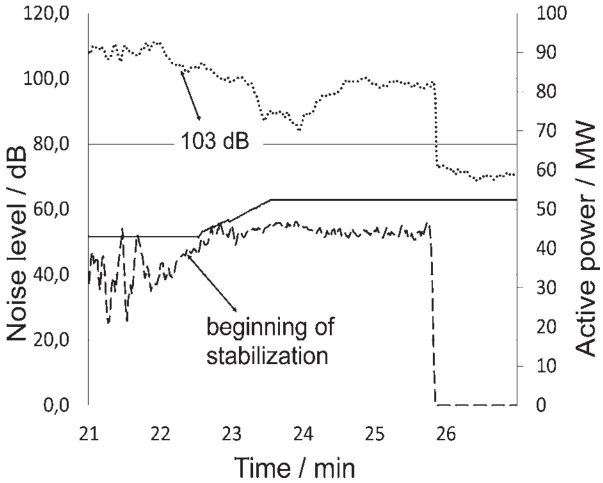

Figure 2 Smoothed values of the noise level (frequency = 100 Hz) and active power using the moving average method, together with the state of feeding the foaming material to the furnace, as a function of the duration of the basket II melting

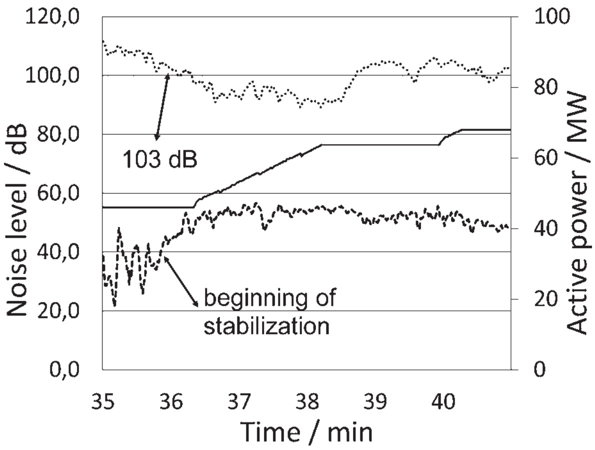

Figure 3 Smoothed values of the noise level (frequency = 100 Hz) and active power using the moving average method, together with the state of feeding the foaming material to the furnace, as a function of the duration of the basket III melting.

On the other hand, the data collected during 50 trials, based on 25 melts (including two or three baskets), were calculated to determine the limit values of the 95 % confidence interval for the average value. Therefore, the normality of the distribution was initially verified, because only a positive result of such verification authorizes to carry out interval estimation. The results of the Shapiro-Wilk test (p = 0,598 – basket II and p = 0,289 – basket III) allowed for further calculations. The results of these calculations are summarized in Table 1.

Interpretation of the obtained results, should state that with a probability of 0,95 (95 %), the average noise level at the moment of stabilization of active power consumption is within the numerical range of 101,92 dB and 102,83 dB for basket II and 101,43 dB and 102,91 dB for basket III.

From a practical point of view, the upper limit of the designated ranges is of primary importance. For both baskets, it is 103 dB, which means that the moment of

Table 1 **Mean values, standard deviations (SD), and 95% confidence limits for the average noise intensity value for baskets II and III / dB**

Basket	Average / dB	Standard Deviation / dB	Lower Limit /dB	Upper Limit / dB
II	102,38	1,09	101,92	102,83
III	102,17	1,79	101,43	102,91

registering the noise intensity of such a value should be considered as the moment of starting the feeding of the foaming material.

The graphs presented in Figures 2 and 3 show the moment at which stabilization of active power consumption begins without feeding the foaming material. The value of the noise level is then about 103 dB.

SUMMARY AND CONCLUSIONS

The value of 103 dB, also determined using statistical processing of the measurement results, is significantly lower than the value of 112 dB determined in the first stage of the research. This may be due to several reasons. In the first stage of the research, the noise level was measured in the entire audible band using the A correction curve and a microphone, only with a windscreen. In the second stage of the research, measurements were made using a microphone also placed on the wall of the EAF control room, but with an additional anti-splashing layer installed. The noise level in the entire audible band is the sum of the levels of all third-octave bands. Measurement in only one 1/3 octave band, selected from the entire audible band, and the use of an additional microphone cover may result in lower values of measurement results.

As a result of the tests, it was confirmed that the electric arc of the furnace generates noise with a frequency of 100 Hz. Using the noise level in the frequency band emitted by the electric arc, it was found that feeding the foaming material should start at a noise level of 103 dB.

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Note: The responsible for English language is Adam Partyka.