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THE OPTIMIZATION OF THE PRODUCTION OF SINTER AS THE FEEDSTOCK OF THE BLAST FURNACE PROCESS

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The performance of the sintering process can be increased by means of various procedures. One of the options is increasing the permeability of the sintering charge and improving the gas-dynamic conditions during the combustion. This can be achieved by dosing coarse sinter on the sintering strands. This article analyzes a research conducted in order to experimentally verify the impact of the use of coarse sinter on the performance of the sintering process.

Key words: blast furnace, iron, ore, sintering, production

INTRODUCTION

The sintering of iron ores means heating the powder sintering mixture to such a temperature to achieve the surface melting of the individual charge grains: The resulting melt creates liquid bridges among the grains which, after solidification, facilitate the formation of a solid porous material [1].

Charge for the production of sinter consists of sinter ore with the grain size below 10 mm, coke with the grain size below 3 mm and alkaline additives with the grain size below 3 mm [2]. After mixing and pre-pelletizing of the mixture, the layer is ignited on the surface, forming combustion and sintering zone (combustion front) which is moving towards the grate as a result of the air flow. As soon as the combustion front reaches the sintering grate, the sinter production process ends [3].

The sintered material is discharged from the sintering unit; it is further crushed, sorted, cooled and conveyed to blast furnace storage containers. The sorting leaves certain part of tiny and dust fraction, which is called return sinter. This return sinter is added to the sintering mixture and re-sintered.

The produced sinter is the dominant metal-bearing feedstock into the blast furnace process and as such it fundamentally affects the costs. Higher performance of the ore sintering process can significantly affect the price of the produced metal [4].

We can influence the sintering process in terms of its physical, thermal or chemical conditions [5]. One option is to increase the permeability of the charge and to improve the combustion front penetration. This can be done by adding coarse sinter, which is dosed on the sintering strands. This article evaluates the results of a research conducted by Best Industrial Company, which is engaged in the area of the sintering processes in metallurgical enterprises in the Czech Republic. The analyzed data are based on the results of measurements carried out during one year in a sintering section for two sintering strands.

INCREASING THE SINTERING EFFICIENCY

After the sintering, the produced sintered material is subsequently crushed, cooled, and sorted. The sorting leaves certain part of tiny and dust fraction, which is called return sinter [6]. This return sinter is added to the sintering mixture and its ratio in the produced sinter should be in the range of 20 – 30 % [7].

The higher amount of return sinter reduces the yield and performance of the sintering unit. At the same time, the sintering process can also lead to the formation of sinter of higher grain size (12 – 22 mm), which is called grate sinter [8].

This over-the-limit sinter can be used during the following production of the sintering mixture as the bolstering material, which is dosed on the sintering strands.

The method of intensification of the sintering process is based on increasing the speed of the filtration of air passing through the sintered layer [9]. The sintered layer consists of several zones which have different gas-dynamic properties. The key aspect is to act on those zones that show the highest resistance and to increase their permeability. This can be achieved by means of: suitable mixture moisture, correct thickness of the layer where the air flows, removing the effect of false air intake and also by reducing the number of technological downtimes.

One of the alternative ways to improve the technical and economic parameters of the sintering process is to put the finished sinter with the grain size of 12 - 22 mm into the charge together with return sinter. This coarse material is then dosed on the sintering strands. The input sintering mixture intended for sintering is subsequently dosed on this finished sinter. The coarse pieces

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of sinter should improve the gas-dynamic conditions and the mixture combustion rate as well [10].

This research has also experimentally verified the impact of the use of grate sinter on the performance of the sintering process. First, a layer of 25 to 30 mm of coarse finished agglomerate was placed on the sintering strands, and the sintering mixture intended for sintering was placed on top of that layer.

The research was carried out over the period of one year, during which the performances of the sintering strands and the amount of produced sinter were checked.

EXPERIMENTAL PART

The research has also monitored the impact of coarse sinter dosing on the sintering process. The sintering process was analyzed for two sintering strands. Grate sinter was used alternatively as the base layer on both of the sintering strands. The performances of both sintering strands were monitored during the monitoring period of time, both with the use of grate sinter and without the use of this base layer during the mixture sintering. Detailed continuous measurements of the performance indicators were carried out for both sintering strands. The composition of the input sintering mixture was continuously monitored in order to carry out an objective evaluation.

Table 1 shows the concrete data of its composition for both sintering strands. The data related to feedstock were subsequently converted into a tone of finished sinter.

The production with grate sintered and without grate sinter was run on both of the sintering strands. The production was usually switched after several days. In case of the use of grate sinter, the finished sinter was dosed as the base material on the sintering strands.

The sintering mixture was dosed on this material. In case of feedstock, there was a maximum effort to keep the same composition which would allow a clear comparison of the results and performances. Table 1 illustrates that the differences in the composition of the feedstock are very little for both sintering strands. In most key raw materials, these differences range within the maximum interval of 1 - 2 %.

The key aspects of the research were primarily associated with the established performance and the produced amount of sinter. The output side of the process in terms of immediate performance included the monitoring of the amount of produced finished sinter, return sinter, the amount of sludge and the total losses. Table 2 shows the established statistically evaluated production indicators with the use of grate sinter and without this base layer. In case of dosing of grate sinter on the sintering strands, we can clearly see a larger amount of produced sinter.

In case of using grate sinter (93,96 t/h), the performance increase is 2,83 % compared to the production without the use of finished sinter (91,30 t/h). There is a simultaneous increasing share of return sinter in the produced material (5,46 %).

The experiment with coarse material was performed simultaneously on two sintering strands. The evaluation of the potential benefit was based on the determination of the total volume of produced material.

Table 1 **Mixture composition for both sintering strands**

Charge	Sintering strand 1		Sintering strand 2	
	Without grate sinter	With grate sinter	Without grate sinter	With grate sinter
	kg/t	kg/t	kg/t	kg/t
Sinter	314,20	358,10	315,10	361,10
Fine sinter	118,35	106,40	116,90	108,59
Ore concentrate	469,10	474,70	474,29	473,10
Slag	43,34	42,10	45,98	40,82
Scale	7,80	9,60	7,98	9,06
Flue-dust	8,41	6,15	7,32	5,86
Sludge	2,10	1,30	2,01	1,21
Dolomite	48,50	51,98	47,12	52,98
Dolomitic limestone	83,10	80,15	82,81	79,70
Limestone	3,58	1,910	3,15	1,71
Lime	21,10	22,20	20,83	22,48
Fuel	53,20	54,03	54,90	54,20
Ore	913,20	910,10	911,20	914,16
Wastes	62,30	63,10	64,50	63,70

Table 2 **Measured production indicators**

Production performance	Without grate sinter	With grate sinter
	t/h	t/h
Finished sinter	91,30	93,96
Return sinter	38,90	41,15
Sludge in the form of dry residue	4,10	3,50
Losses	14,10	12,37
Σ	148,4	159,30

The evaluation concerned primarily the produced finished sinter and return sinter, which is repeatedly returned to the sintering process. Tables 3, 4 show the results for both of the monitored sintering strands. During the monitored period, the first sintering strand produced 23 007 tons more sinter when grate sinter was used.

Table 3 **Results measured on the first sintering strand**

Sintering strand 1	Produced sinter	Return sinter
	t	t
With grate sinter	1 210 987	498 785
Without grate sinter	1 187 980	450 917
Difference	23 007	47 868

At the same time, the volume of return sinter increased by 47 868 tons. The second sintering strand produced 18 650 tons more sinter when grate sinter was used, while increasing the share of return sinter by 36 389 tons.

Table 4 **Results measured on the second sintering strand**

Sintering strand 2	Produced sinter	Return sinter
	t	t
With grate sinter	1 180 610	485 690
Without grate sinter	1 161 960	449 301
Difference	18 650	36 389

RESULTS AND DISCUSSIONS

The main aim of this research was to identify the effect of the presence of grate sinter on the performance of the sintering process. In case of grate sinter dosing on the sintering strand, there was an increase in the performance of both strands (1,89 % and 1,58 %). At the same time, the volume of return sinter on sintering strand 1 increased by 9,59 % and by 7,49 % on sintering strand 2. The overall evaluation is shown in Figure 1.

There was a higher incidence of incomplete sintering of the charge, which ultimately means the formation of smaller fractions with a grain size below 4 mm. This material cannot be used in the blast furnace process and must go through the process of sintering once more. The amount of return sinter is a key factor, because its high ratio during repeated sintering can lead to the reduction of the ore fraction (FeO). This naturally affects the process efficiency and the technical and economic indicators during the subsequent production of iron.

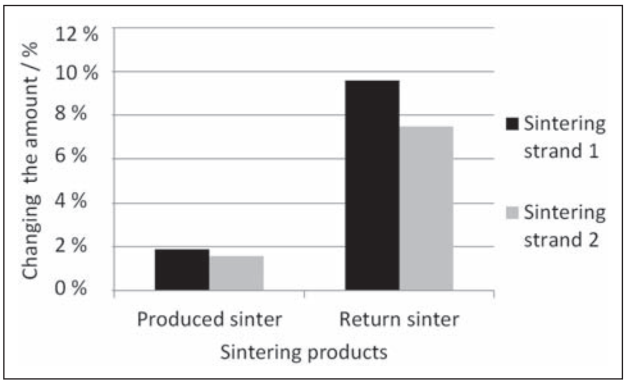

Figure 1 Evaluation of the difference in the production of sinter

The critical limit for the amount of return sinter in the sintering process is 30 %. Despite the identified increase in the amount of return sinter in both sintering strands, it cannot be considered as a negative fact, because its ratio during the measurement varied in the interval of 18 - 23 %. These values can be regarded as adequate from the technological point of view. The use of grate sinter can therefore be seen as positive from this point of view as well.

The secondary consequence of the use of grate sinter can be identified in relation to a decrease in the amount of sludge. This is mainly due to the fact that the feedstock into the sintering process using grate sinter is transformed into the finished or return sinter to a higher extent, while sludge dry residues are formed to a lesser extent. In case of production of sinter without the use of grate sinter, the production of sludge dry residues was 4,1 tons per hour. When grate sinter was used, the production of these sludge dry residues was reduced to 3,5 tons per hour. The overall production of this ballast component was therefore decreased by 14,63 %. This is a fundamental aspect from the long term point of view. The dosing of grate sinter therefore clearly contributes to the transition of feedstock into the finished and return sinter.

CONCLUSIONS

The conducted research and the measured values show that grate sinter has a crucial effect on the performance of the sintering process. Coarse bedding layer was used as the base layer below the sintering mixture on the sintering strands during the research.

The use of grate sinter has lead to an increase in the production volume of finished sinter per hour, as well as to a significant increase in the total production volume during the monitored period. This fact confirms an improvement in the permeability of the mixture leading to an increased intensification of the sintering process. The dosing of coarse bedding layer improves the performance of the sintering unit, but also the production of return sinter, which is returned back into the sintering process. The amount of return sinter, however, corresponds to the technological requirements and does not increase the costs resulting from the re-entry of the raw materials back into the process.

There has been an increase in the amount of produced sinter on both sintering strands by 41 657 tons, which represents a relatively large increase; although it is actually a difference of only between 1 - 2 % of the total volume of sinter produced on both sintering strands. However, when we take into consideration the required amount of sinter for the blast furnace process in one year, even this increase in performance is important. In case of long-term use of grate sinter in the production of sinter, it is possible to gain a fundamental competitive advantage. This can be seen as an essential aspect with regards to the ever increasing pressures on the price of the produced metal.

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Note: The responsible translator for English language is Petr Jaroš (English Language Tutor at the College of Tourism and Foreign Trade, Goodwill - VOŠ, Frýdek-Místek, the Czech Republic). Revised by John Vlcek (Literacy Tutor at West Suffolk College, Bury St Edmunds, England)