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ISSN 0543-5846
METABK 51(4) 457-460 (2012)
UDC – UDK 669.1: 658.5 =111

EVALUATION OF BENEFITS RESULTING FROM INNOVATION OF INPUT RAW MATERIALS DOSING PROCESS IN SINTERING

Received – Prispjelo: 2011-07-19
Accepted – Prihvaćeno: 2012-01-10
Preliminary Note – Prethodno priopćenje

Production of blast furnace sinter is among the processes with the highest energy and material requirements. Fuel consumption is especially significant cost item here. The presence of grate sintered in charge, i.e. return sinter from 12 to 22 mm in size, can have fundamental impact on the technical and economic indicators of the sintering process. Grate sinter can be used as a foundation layer under the sintering mixture, to increase air permeability of charge and to improve the gas-dynamic conditions. The article analyzes the impact of grate sinter on the sintering process, based on an analysis of the acquired production indicators within the scope of the research in question.

Key words: sintering process, iron, iron ore, costs

Procjena prednosti unošenja sirovina doziranih procesom sinteriranja. Proizvodnja visokopećnog sintera je jedan od procesa koji zahtjeva puno energije i materijala. Potrošnja goriva je posebice značajna u cijeni troškova. Nazočnost krupnijeg sintera u šarži tj. povratak s 12 na 22 cm veličine, može imati temeljni utjecaj na tehničke i ekonomske faktore procesa sinteriranja. Krupniji sinter može se rabiti kao osnova sloja ispod mješavine sintera, pojačati zračnu propusnost šarže i oplemeniti plinsko-dinamičke uvjete. Članak analizira utjecaj krupnijeg sintera na proces sinteriranja na temelju analiza usvajanja indikatora proizvodnje.

Ključne riječi: proces sinteriranja, željezo, željezne rude, troškovi

INTRODUCTION

Sintering process can be described as a continuous process which can use fine-grained materials to produced lump sinter suitable for production of pig iron in blast furnaces [1]. In principle, the production of sinter is a process of heating pre-prepared and appropriately selected sintering charge to such a temperature that ensures the mutual fusion of the individual charge elements - grains and it creates caked porous material – sinter [2]. Its formation is the result of softening and melting on the surface of larger particles or, eventually, melting of small particles. The resulting smelt creates liquid bridges between the grains; it becomes solid and thus connects the individual grains in a lump. This is a complex of physical, physical and chemical and thermal processes that change the structure and composition of the input raw materials.

Return sinter is a term used to describe fractions of sorted crushed sinter which are returned as part of charge materials back into the process. These are small parts, arising during imperfect caking with grain fineness below 5 mm. Sorting sinter after production and before the actual filling into the blast furnace brings not only increased productivity of blast furnaces, but of the sintering strands as well. Certain percentage of return sinter improves air permeability, thus increasing the performance of the entire sintering process. One of the ways how to improve the technical and economic parameters of the sintering process is to include not only to return sinter, but also finished sinter with grain fineness from 12 to 22 mm into the charge, which will be hereinafter referred to as grate sinter.

This objective of the article is to assess the impact of the use of grate sinter in the sintering process. The results of measurements over a period of 182 days, which were performed continuously in the monitored blast furnace plant, will be used as the data.

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GRATE SINTER IN THE SINTERING PROCESS

The speed and efficiency of the sintering process significantly affects the cost aspect of production of the main raw material for blast furnace process. The basic method of intensification of the sintering process is based on increasing the speed of filtration of air when it passes through the sintered layer [3]. The sintered layer consists of several zones that have different gas-dynamic properties. The key factor is to act on those zones with the greatest resistance and to increase their permeability. This can be realized by means of: suitable mixture humidity, the correct thickness of the sifted layer, removing the influence of false suction and also by limiting the amount of technological stay time.

Another alternative is the utilization of grate sinter charging in the sintering processes. Grate sinter is used as foundation layer with the thickness of 20 – 30 mm under sintering compound on sintering flow lines [4]. This layer also serves as protection of sintering grate bars and cars during the final stage caking of the charge mixture. It prevents the gaps between grate bars from being clogged and, at the same time, it has positive effect on temperatures in dry scrubber and, as a result of that, on ecology.

Analysis of the effect grate sinter has on the sintering process is rather complicated due to repeated entry of some raw material into the process. In order to evaluate its effect, it is necessary to provide an exact definition of the balance of inputs and outputs from the sintering process [5].

EXPERIMENTAL PART

Measurements and technological tests of the use of grate sinter in the sintering process in the monitored blast furnace plant were taking place during the period of 182 days. The measurements were carried out for two sintering processes, while grate sinter was used as input raw material in one of them.

As for the input raw materials entering the sintering process, for the sake of simplification we can identify the following elements: material from the feed tables (especially homogenized mixture, basic additives, fuel), return sinter and sludge dry residues. Grate sinter was also used as input raw material in the monitored sintering equipment.

On the output side of the sintering process, we can identify the following products: produced sinter, return sinter, sludge dry residues. We must also take into account the losses occurring during the caking process on the output side of the sintering process. The research was based on the assumption that losses (evaporation of water, dissociation of carbonates, carbon burn-up, sulphur burn-up, mechanical losses) are at the expense of material entering the process for the first time. Return sinter and sludge dry residues and therefore not subject to losses and they are fully transferred to the finished sinter.

Table 1 shows the measured values from both sintering processes. The amount of the individual input and output raw materials was measured in tons per hour. Table 1 shows the performance of the sintering process using grate sinter and without its presence. Percentage amount is determined for all input and output variables.

When grate sinter is used as bolstering under the sintering mixture, the speed of sinter production has increased from 95,31 $t \cdot h^{-1}$ to 99,02 $t \cdot h^{-1}$. This difference represents an increase in speed of production of finished sinter by 3,75 %. In the case of using grate sinter, there was also an increase in the volume of return sinter. The quantity and quality of the produced sinter can also be influenced by chemical composition. Continuous monitoring of the chemical composition of the mixtures in both sintering plants was performed within the scope of the realized measurements.

Table 1. **Measured production indicators**

	Input side of sintering				Output side of sintering			
	Without grate sinter		With grate sinter		Without grate sinter		With grate sinter	
	$t \cdot h^{-1}$	%	$t \cdot h^{-1}$	%	$t \cdot h^{-1}$	%	$t \cdot h^{-1}$	%
Produced sinter	0	0	0	0	95,31	61,36	99,02	59,41
Material from feed tables	112,38	72,35	111,26	67,36	0	0	0	0
Return sinter	37,82	24,36	42,12	24,62	37,42	24,09	40,50	24,31
Sludge dry residue	5,12	3,29	4,32	2,17	5,1	3,28	2,96	1,77
Grate sinter	0	0	8,98	5,85	0	0	9,23	5,53
Losses	0	0	0	0	17,49	11,27	14,97	8,98
Total	155,32	-	166,68	-	155,32	-	166,68	-

Table 2. **Sintering mixture composition**

	Without grate sinter	With grate sinter
	$kg \cdot t^{-1}$	$kg \cdot t^{-1}$
Sinter	316,04	361,03
Fine sinter – non-finished	117,90	108,38
Metalliferous concentrate	474,27	472,69
Other ores	3,48	3,65
Slag	45,24	40,66
Clinker	8,01	9,01
Discharge	7,54	5,48
Sludge	1,95	1,15
Dolomite	47,03	52,47
Dolomitic limestone	82,97	79,91
Limestone	3,26	1,82
Lime	20,91	22,58
Fuel	55,47	54,9

Table 2 shows the statistical working data regarding the composition of the sintering mixtures when using grate sinter and without its presence. The values in the columns represent how many kilograms of the given component of the charge are necessary to produce one ton of sinter.

The measured chemical composition of both mixtures is very similar. The amount of ore concentrate, basic additives and the amount of fuel are comparable. Coke dust with grain fineness of 1-3 mm was used as fuel within the monitored period of time. In the case of sintering mixture without grate sinter, there is a higher value of fine unfinished sinter.

Table 3. **Total production volume of sinter in the monitored period**

	Using grate sinter	Without using grate sinter	Difference	
	t	t	t	%
Sinter	2 274 813	2 234 992	39 881	+ 1,75
Return sinter	929 434	859 192	70 242	+ 7,56
Sludge dry residues	86 444	104 101	- 17 657	- 16,96
Grate sinter	230 466	0	230 466	-

These are tiny particles that have been caught bellow the screens during sintering mixture sifting. This component contributes to permeability decrease of the whole mixture. However, we can suppose that the difference in quantity is not such to significantly influence the overall production of the sintering equipment. The total values quantifying the production of sinter in the monitored period of time are shown in Table 3.

The volume of produced sinter when using grate sinter was higher by approximately 39 881 tons. At the same time, there was an increase in the total volume of produced return sinter. This difference amounted to 70 242 tons.

RESULTS AND DISCUSSIONS

The research objective was to identify the impact of the presence of grate sinter on the sintering process. When using grate sinter, there was an increase in the total volume of produced sinter by 1,75 %. At the same time, however, there was significant increase in the volume of produced return sinter by 7,56 %.

It means there was more frequent incomplete caking of the charge which, in combination with the effects of transportation, means the creation of tiny parts with grain fineness below 5 mm. This raw material is returned again to the sintering process. In the case when grate sinter is used, it is also important to pay close attention to efficient sorting of the produced sinter.

The critical limit for the amount of return sinter in the sintering process is up to 30 % [6]. Higher values mean the reduction of ore ratio and hence the performance as well. Dosing of grate sinter to be used in the sintering process must take into account this consequence. A large increase in the amount of return sinter can have potentially negative effect on the metallurgical properties. It is important to continuously monitor the content of FeO, but also the grain fineness of small particles below 5 mm.

Decrease in the total amount of sludge was another consequence of grate sinter dosing. This is also influenced by the fact that the material from the feed tables (homogenized mixture, basic additives, fuel) will split into three parts after the sintering process:

a) the first one becomes part of the finished produced sinter

b) return sinter going back into the process is created from the second one

c) the third one forms sludge dry residue which also returns to the process.

Grate sinter dosing then contributes to the transformation of input raw materials into the first two forms. Last but not least, using grate sinter has also increased the average speed of caking and thus the overall performance of the sintering process.

CONCLUSIONS

Based on the measured values, itcan be concluded that grate sinter has a major impact on the course of the sintering process. During the conducted research, grate sinter was used as bolstering under the sintering mixture on sintering strands. It can be confirmed that there is improving mixture permeability and thus increasing intensification of the sintering process. Grate sinter dosing increases the performance of the sintering equipment, but also the production of return sinter which returns back to the sintering process. In essence, the return material is finished sinter of small grain fineness, and additional fuel is required to pass it through the sintering process again. The processing of increased proportion of return material has a negative impact on the economic indicators of the entire process, which is primarily caused by the constantly rising price of fuel. In this context, it is important to accurately adhere to the granule-metric composition of the ore components. If there is higher production of return sinter when grate sinter is used, even small parts of ill-caking raw materials may mean deterioration in the quality of sinter.

Oversized grains do not worm-though sufficiently during caking and their mutual fusion is accomplished only through thin surface layers. They also absorb heat from their surroundings, which leads to the creation of insufficiently solid places in sinter. Very tiny fractions of the material are not suitable for sintering either. They significantly deteriorate the permeability of the layer and the gas-dynamic resistance escalates as well. In the case of higher volume of return sinter, it is also necessary to carefully monitor the metallurgical properties. The multiple-entry of grate sinter into the process represents an important factor when grate sinter is used in the sintering process. During the conducted research, there were frequent cases when grate sinter was falling out into the flow of return sinter, which had caused its reentry into the process. This impact can be easily minimized by using appropriate construction solutions that will increase the efficiency of sintered material sorting. The increase in volume of produced sinter when using grate sinter may have significant long-term economic benefits.

ACKNOWLEDGEMENT

The work was supported by the specific university research of Ministry of Education, Youth and Sports of the Czech Republic No. SP2011/85.

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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).