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# APPLICATION OF THE NEW MIXING AND GRANULATION TECHNOLOGY OF RAW MATERIALS FOR IRON ORE SINTERING PROCESS

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This paper presents a new technology for preparing the mixture for iron ore sintering process. The nature of component mixing and granulation has been discussed. The application of the intensive mixer in the preparation of the process components has been shown. The results of the analysis of the sintering mixture granulation process using laboratory installation for mixing and granulation have been presented.

*Key words:* iron ore, sintering process, granulation, intensive mixing.

**Primjena nove smjese i tehnologije granulacije sirovine za proces sinterovanje željezne rude.** Članak donosi nove tehnologije za primjenu smjese za sinterovanje željezne rude. Raspravljena je priroda komponenti smjese i granulacija. Prikazana je intenzivna primjena smjese u pripremnom procesu komponenti. Prikazani su, rabljenjem laboratorijske opreme za smjesu i granulaciju, rezultati analiza granulacije sinterovane smjese.

*Ključne riječi:* željezna ruda, proces sinteriranja, granulacija, intenzivno mješanja

## INTRODUCTION

The concept of mixing and granulating in intensive mixer is a new solution for the preparation of the sintering mixture. The proposed sintering mixture preparation technology will allow to eliminate the energy consuming and uneconomic process of stabilizing and bedding during which water and waste materials are added to ore. According to the new concept for the preparation of raw mix only one device is used which ensures full homogenization and granulation of the components of the sintering mixture in one process [1].

## PREPARATION OF THE MIXTURE FOR THE SINTERING PROCESS

The iron ore sintering process serves the preparation of the iron-bearing mixture for blast furnace. Preparation of the sintering mixture is the first stage of the sintering process and comprises of the selection of ore grain size, careful wetting and mixing and initial pelletizing in order to cake the finest grains. The ore grains should not be larger than 6 mm and the mixture should contain as few as possible grains below 0,1 mm. The quality of the sintering and the sintering process' efficiency can be influenced by the selection of adequate components of the sintering mixture and the preparation thereof [2-5]. Already in 1974 E. Mazanek, L. Król i S. Zieliński [6] confirmed that the process of sintering the fine iron-bearing material will play more and more important role in iron making. Thus, new preparation concepts for the components of the sintering mixture are needed. The paper presents new method for the preparation of the sintering mixture components which consists in mixing and granulating in intensive mixer. The literature survey has indicated that several sintering plants in Japan, Germany and Austria conduct research on the preparation technology of the mixture applying novel mixing and granulation methods in intensive mixer. The research conducted in Japan has also confirmed that intensive mixing and granulation influence the improvement of the permeability and productivity of the iron ore sintering process. In Sumimoto Metal Industry in the sintering plant in Kokura several mixing concepts have been compared and the best results according to the comparison were achieved when applying the intensive mixers [7-12].

## MIXING AND GRANULATION IN INTENSIVE MIXER

Appliances which respond to the current requirements in mixing and homogenizing the sintering mixture components and waste materials are the, so called, intensive mixers. The appliances are intensive centrifugal mixers. One of the appliances of this type is Maschinenfabrik Gustaw Erich mixer applied in this research, which is shown on Figure 1 [13].

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**Figure 1** Principle of operation of the intensive mixer [13].

In the Eirich intensive mixers 90 % of the energy is used for mixing the mass in the range of the high-speed rotor, which rotates in the opposite direction to the direction in which the mixer pan rotates. The movement of the material in the device can also run at the level parallel to the axis of the rotor. Components of any consistence can be mixed in the device. The intensive mixer enables to realize the mixture homogenization and granulation process during one technological operation. The way in which the material moves in the mixer and the mixer's construction enable homogenous distribution of the addition in the whole volume of the mixed material. Granulation in the intensive mixer is a process which gives the mass the form of dense and resistant granules, as the result, a dense and at the same time granulated material with required shape and size and high resistance parameters is obtained. The homogeneity degree of the mixture decides the level of quality and influences the recurrence and the properties of the respective material batches. Homogeneity is of a particular significance in case when small amounts of the introduced additions (i.e. binding substances) are used, which have to be homogenously distributed in the total material volume in order to efficiently influence the mixture properties. High mixing degree also means higher resistance of the granulates at a given content of the binder. Granulation in the intensive mixer enables to control the grain size distribution, ensures their high density and gives the granulate surface properties which are beneficial for the rheological properties. The mechanical granulation eliminates the typical granulate defects such as, for example, nutshell structure. The ability to granulate follows from the way in which the material moves which is similar to the material stream in the disc pelletizer, the difference lies in the fact that in the intensive mixer the granulation is much faster and facilitated by the mechanical impact of the mixer and the movement of the pan correlated with the direction of the material stream formed by the high-speed rotor. In comparison to the disc or drum pelletizer, granulation in the intensive mixer runs in the whole volume of the processed material and does not require such a complex control [13-19].

## LABORATORY TEST OF THE MIXING AND GRANULATION PROCESS OF THE SINTERING BLENDS

In the frames of a research project the process of mixing and granulation of the sintering mixtures has been conducted. The research was done in the laboratory of the Faculty of Material Engineering and Metallurgy of the Silesian University of Technology. The objective of the research was a comparison of the density degree of the material particles in raw pellets in the granulation of the material in the disc granulator and in Eirich intensive mixer. The research was conducted with high concentrate share in the sintering mixture from 0 to 100 %, where 100 % means the share of the iron-bearing materials in the sintering mixture - Table 1.

Table 1 **Share of the ores and concentrates in the mixture**

| No | Iron ore | Iron ore concentrates | Disc pelletizer | Intensive mixer |
|---|---|---|---|---|
| 1 | 100 % | 0 % | ✓ | |
| 2 | 75 % | 25 % | ✓ | |
| 3 | 50 % | 50 % | ✓ | |
| 4 | 25 % | 75 % | ✓ | |
| 5 | 0 % | 100 % | ✓ | |
| 6 | 100 % | 0 % | | ✓ |
| 7 | 75 % | 25 % | | ✓ |
| 8 | 50 % | 50 % | | ✓ |
| 9 | 25 % | 75 % | | ✓ |
| 10 | 0 % | 100 % | | ✓ |

Mixtures for the analyses have been prepared in such a way that the material content of the mixture was approximately similar to the typical material content used in national steel plant with full production cycle. For the percentage share of hematite ores and magnetite concentrates assumed earlier, ore mixture was composed in which the sum of hematite ores and magnetite composites was 100 %. The quicklime content was 4 %. The total sum of iron-bearing raw material together with lime created the, so called, averaged mixture which in industrial conditions is additionally seasoned. The next stage was the calculation of the additions of fluxing materials and coke breeze. 1, 5 % addition of dolomite in relation to the averaged mixture has been assumed and the addition of coke breeze in relation to the averaged mixture with dolomite. The amounts were selected based on the amount of feedstock applied in industrial conditions. Basicity of the blend was regulated applying limestone. After the amount of the limestone has been calculated the amount of coke breeze was corrected in relation to the amount first assumed. The foreseen chemical composition of the sinter was calculated including the loss on ignition. The whole iron-bearing was calculated based on dry feedstock state and next recalculated to the natural feedstock state. The content of the sintering blends used in the research is presented in Table 2.

Table 2 **Composition of the sintering blends used in the analyses**

| Mixture No | 1 / 6 | 2 / 7 | 3 / 8 | 4 / 9 | 5 / 10 |
|---|---|---|---|---|---|
| Iron-bearing mixture | 73 % | 75 % | 77 % | 80 % | 82 % |
| Quick- lime | 3 % | 3 % | 3 % | 3 % | 3 % |
| Dolomite | 1 % | 1 % | 1 % | 1 % | 1 % |
| Limestone | 16 % | 14 % | 12 % | 9 % | 7 % |
| Coke breeze | 7 % | 7 % | 7 % | 7 % | 7 % |

Granulates for the research were prepared applying laboratory installation for mixing and granulation comprising of Erich disc pelletizer TR 04 (Figure 2, A) and Erich intensive mixer R 02 (Figure 2, B). Mixtures from 1 to 5, the composition of which has been presented in Table 1, were homogenised in intensive mixer and next granulated using disc granulator. Mixtures from 6 to 10 were homogenised and granulated in the intensive mixer. For the obtained granulates the bulk densities were estimated.

## RESULTS AND DISCUSSION

Together with the increase of the content of iron ore concentrates the bulk density increased by 1,33 g/l for each 1 % of the increase of the content of iron ore in the sintering mixture (Figure 3). In parallel, the bulk density increased when the Eirich intensive mixer was used. In this case the increase of bulk density was roughly 100 g/l in relation to the bulk density obtained when applying disk peletizer. Due to the above the summary effect of the increase of bulk density of the green granules by 15,5 % when using sintering mixture based exclusively on iron ore concentrates using Eirich intensive mixer. In comparison to the conditions in Polish sintering plants, where due to the advanced method used for the preparation of the sinter blends for the process the iron ore concentrate content in the mixture consists around 50-60 % it is possible to increase the bulk density by 3,6 % which can result in additional increase of


**Figure 2** Disc granulator Erich TR 04 (A) and Intensive Mixer Erich R 02 (B)

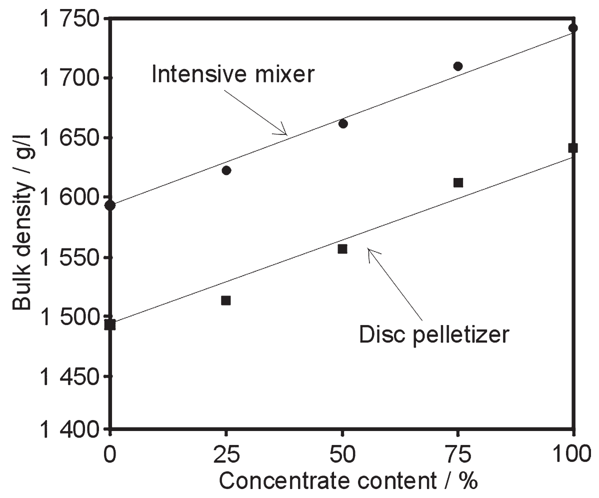


**Figure 3** Change of the bulk density of the granulated mixture in relation to the share of iron ore concentrate in the sintering mixture applying Eirich intensive miner and disc pelletizer.

the efficiency of the sintering plant by around 1,1 T/m$^2$/day (the value has been estimated based on the average efficiency of the process obtained on all sintering devices during the first 6 months of 2010 in one of Polish steel plants with full production cycle).

## CONCLUSIONS

From the above research results it follows that a more beneficial solution from the point of view of the way in which the mixture is prepared is to apply the intensive mixer. When the intensive mixer is applied the bulk density is considerably higher than in the case when traditional disc pelletizer or drum pelletizer is used. This follows from the construction of the tool which beside the standard rotary movement additionally moves in the opposite direction with the high speed rotor located eccentrically in relation to the rotating working pan of the mixer.

Beside the increase of the bulk density observed in case of increase of the magnetite concentrates in the mixture, this is related to the grain size distribution of the materials. In case of iron ore concentrates over 95 % of the material has the granulation below 0,1 mm. In case of hematite ores this is 30 % in comparison to the total mass of the ore. Taking into consideration the fraction below 1 mm (that is the fraction used in the analyses) the share of grains below 0,1 mm consists around 40 %. Due to the fact the concentration of the grains in the granule can be considerably higher.

The proposed mixing and granulation technology will increase the economic and environmental efficiency of the sintering process. New technology of preparation of the sintering mixture will allow avoiding the storage on the blending yards of the mixture components and increasing the homogeneity degree and permeability of the sintering mixture, as well as the efficiency of the process. To the benefits of the application of the mixer also belongs the decrease of the energy and fuel consumption in the process as well as the decrease of the production cost of the sintering mixture. The intensive mixer can also be used in the preparation of the waste for their recycling in iron and steel industry.

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## REFERENCES

[1] S. Serkowski, J. Korol, D. Burchart-Korol: IX International Scientific Conference "Theoretical and Practical Problems of Metallurgical and Industrial Waste Management", Zakopane 2008, Poland, 29-35
[2] D. Burchart: Evaluation of dust and gas emission from the iron ore sintering process. Doctoral Thesis, Silesian University of Technology, Department of Material Science and Metalurgy, Katowice, Poland, (2004), 47-53
[3] W. Sabela, J. Buzek: Hutnik – Wiadomości Hutnicze, 73 (2006) 8-9, 381-386
[4] C. C. Furnas, Industrial and Engineering Chemistry 22 (1930) 7, 721-730
[5] A. Maślanka, W. Sabela: Stahl und Eisen, 13 (1975), 573-581
[6] E. Mazanek, L. Król, S. Zieliński: Spiekanie i grudkowanie rud, Wydawnictwo Śląsk 1974, 67-70
[7] Y. Hadano, T. Murai, Y. Kawaguchi, S. Komatsu, A. Sasakawa, T. Kawaguchi, M. Matsumura:, Ironmaking Conference Proceedings 1995, 535-540
[8] T. Matsumura, K. Miyagawa, Y. Yamagata: The Iron and Steel Institute of Japan International, 45 (2005) 4, 485-491
[9] T. Henk, J. Blatz: Mixing Technologies in the Steel Industry, www.aglodom.com (2011-03-30)
[10] J. Ebner, A. Fulgencio, S. Hotzinger, J. Reidetschlager: Metals and Mining 2 (2009), 26-29
[11] A. Habermann: BHM Berg - und Hüttenmännische Monatshefte, 154 (2009) 5, 211-216
[12] T. Schwalm, W. Gerlach, M. Koepf: Tsvetnye Metally, 2 (2010), 97-102
[13] S. Serkowski, M. Müller, Ceramic Forum International, 4 (2004), 1-4
[14] D. Burchart-Korol:, Prace Instytutu Metalurgii Żelaza, (2009) 5, 9-13
[15] S. Serkowski, P. Izak, Glass and Ceramic, 58 (2007), 31-37
[16] S. Serkowski, Hutnik – Wiadomości Hutnicze, (1996) 4, 196-204
[17] U. Morsch: Wissensportal baumaschine.de 1 (2005), 1-10
[18] P. Nold: BHM Berg - und Hüttenmännische Monatshefte, 152 (2007) 6, 192-194
[19] J. Korol, S. Serkowski, Hutnik- Wiadomości Hutnicze, 72 (2005) 5, 296-300

**Note:** P. Nowak is responsible for English language, Katowice, Poland.