Conference Paper

Studies of Conventional and New Technologies for Preparation of Iron Ore Raw Materials at Iron Making Plant of Pao Severstal to Evaluate Prospectives for Reduction of Ecological Load on Environment

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Abstract

The experts of Centre for Raw Materials Investigations (CRMI) have conducted research into the usage of recycled materials in the following technological processes: sintering and briquetting. Research shows variation in emissions containing sinter gases and qualitative characteristics of the finished product (cold and hot sinter strength). It is suggested that involvement of recycled waste products of steelmaking and chemical processes shall be increased using the method of vacuum extrusion.

Keywords: sintering, recycled materials, sinter gas, briquettes.

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Centre for Raw Materials Investigations (CRMI) established in 2005 at Cherepovets Integrated Iron and Steel Works was created for purpose of running tests on determination of metallurgical properties, analysis of quality characteristics of iron ore raw materials used in sinter and iron production, as well as physical modeling of agglomeration processes. Along with such fields of development as the testing of new raw materials for sintering, intensification of the sintering process, improving the quality of sinter and research to form a raw material strategy for the company, one of the goals was to evaluate technological capabilities on reducing the environmental load during sintering process of iron ores.

Complete cycle of physical modeling for all technological stages in sinter manufacturing from charge materials preparation to sinter processing ensures fulfillment of tasks posed by life, production and business (see Figure 1).

Monitoring the composition of exhaust gases regarding O2, CO and CO2 content allows us to evaluate environmental and energy efficiency of sintering process, and the executed in 2018 modernization of the installation provided researchers with the

Figure 1: Sinter manufacturing at CRMI of PAO Severstal.

information on emissions of dust, nitrogen oxides and sulfur oxides. Today, environmental studies at CRMI have reached a new level and provide the possibility not only to calculate, but also experimentally determine the change in amount of emissions with sinter gases.

Some studies demonstrated that increase in the share of utilized waste in sinter charge does not reduce product quality, but can lead to their improvement as well [1]. CRMI test equipment complex includes facilities for determining both “cold” (according to GOST 15137 and ISO 3271) and “hot” (LTD indices according to ISO 13930) sinter strength, which provides additional information on behavior of product manufactured in blast furnace. For instance, there was executed the series of trial sinterings with the increase in charge of specific flow of slag-scrap mixture with aim to evaluate changes of sintering process indicators and sinter qualitative characteristics.

To usual evaluation of changes in specific productivity for sinter, quality yield, mass fraction of iron in sinter, it was shown that the sinter strength indicator, according to GOST 15137, under the considered variants for charge conditions, with increase in specific consumption of slag mixture from 50 to 90 kg/t, practically did not change, and the hot strength index showed steady dynamics to improvement (see Figure 2): with increase in slag mixture consumption, the increase in “hot” strength ($LTD_{+6.3}$) made up 3.3% abs., and with increase in basicity of sinter, there was achieved the increase in sinter “hot” strength by more than 3.8% abs.

The results obtained were considered as the basis for redistribution of steel making slag recycling streams at CherMK, and they allowed to adjust raw material flows in iron production. In laboratory research, special attention is paid to developing technologies for involving new types of waste into recycling [2], which are generated at all conversions

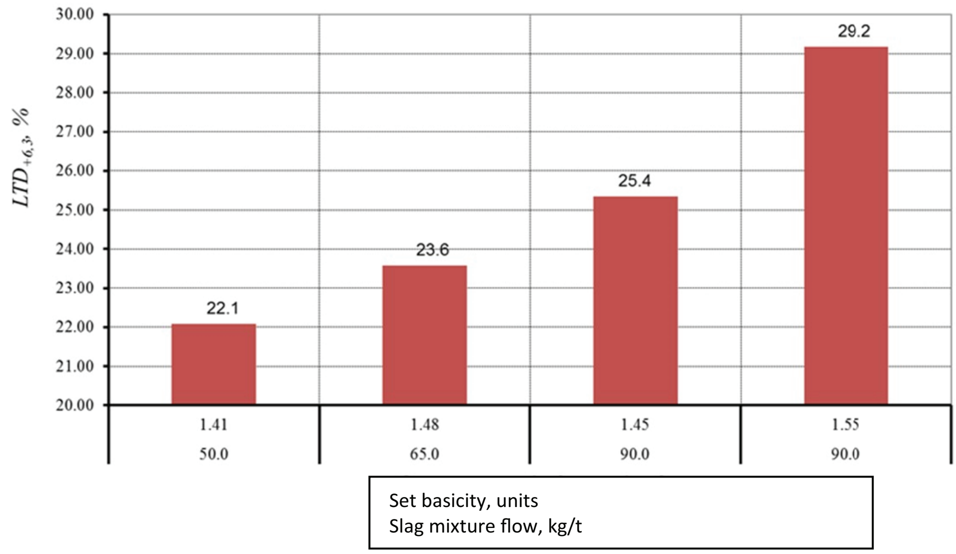

Figure 2: Values of strength index during recovery of ($LTD_{+6.3}$) sinter with different consumption of slag-scrap mixture.

of plant with the launch of modern dust and gas treatment systems for technological gases, namely finely dispersed zinc-containing dry types of aspiration dust. The range of technologies in fine tuning covers ones from minor additions to sintering charge to creation of new products for use not only in Iron Making, but also in Steel Making. This is because the uneven formation, presence of zinc oxides higher amounts, alkaline elements, instability of chemical composition and physical properties of iron and flux-containing waste negatively affect quality of blast furnace flux sinter, blast furnace melting operations and duration of blast furnaces campaign, and limits volumes of their use in Iron Making conversion.

The technology developed by CRMI for alternative processing of sludge and dust from Steel Making — sintering of a special type of sinter — iron flux with the possibility of using it in blast furnaces under the blast furnace process with washing from zinc deposits or using iron flux in pre-repair periods, and in Steel Making as fluxing material or heat cooler. We also investigated possibilities of long-term storage of iron flux when placed on an open area, and the selection was fulfilled of technological modes and charge conditions for industrial scope. This technology was successfully tested in Sintering Shop No. 2 Iron Making plant [3].

An important aspect of the technology fine tuning was the analysis of the phenomenon first obtained in the sintering process - the formation of significant deposits on the grate and the flues of sinter machine (see Figure 3). Chemical analysis results on deposits from vacuum chamber walls showed the presence in this material of a significant amount of alkali element oxides (Na_2O and K_2O) and sulfur oxide SO_3 (Table. 1).

Figure 3: View of deposits during iron flux agglomeration.

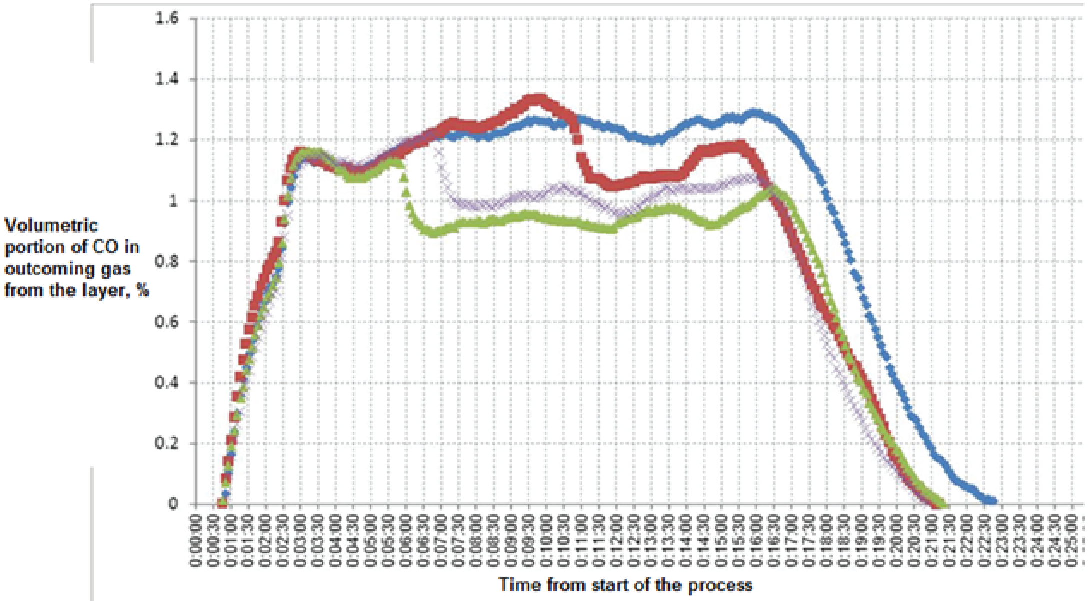

Figure 4: Volume fraction of CO in gas for different options with water spraying of a layer.

Table 1: Chemical composition of deposits (%mass)

Component	SiO_2	CaO	Fe	ZnO	Na_2O	K_2O	SO_3
Deposits	4.10	3.80	52.7	0.27	1.50	2.70	16.4
Zn containing sinter	4.31	11.68	56.00	0.41	0.23	0.16	-
Iron flux	6.90	20.97	45.40	3.61	0.540	0.110	-

Laboratory sintering demonstrated that the long lasting use of sinter production technology using in charge of zinc dusts and sludge from Steel Making can lead to increase of gas-dynamic resistance of the grate field in sintering machines and the gas

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Figure 5: Laboratory Vacuum Extruder in CRMI.

path due to the formation of deposits and build-up with higher content of alkali and sulfur compounds.

As a separate stage of research, there was evaluated the possibility of long storage of product in the open air under weather conditions. A stabilized sample of suitable sinter (larger than 5 mm in size) with a total weight of about 240 kg was placed in a wooden box on an outdoor site. Properties were evaluated by periodically determining strength characteristics according to GOST 15137 (Table 2).

Table 2: Strength indicators for high basicity zinc containing sinter under storage in the open air.

Storage time, mths.	0	1	2	3	4	5	6
Strength index, %	69.7	70.3	68.6	69.4	69.0	70.4	71.8
Abrasion index, %	6.3	5.8	6.2	5.7	6.1	5.9	6.4

One can see the absence of significant changes in strength characteristics of highly basic zinc-containing agglomerate during long-term storage, which makes it possible to organize discrete production of the product with long-term storing in open warehouses with periodic use, depending on production and repair program of the plant as a

Figure 6: Briquettes.

whole. In general, the manufactured under industrial conditions iron-flux fully met the requirements for raw materials for a blast furnace, both by physical and chemical properties. Of course, taking into account allowable zinc load for a blast furnace. In addition, this material was recommended for use in Steel Making as a substitute for flux-forming materials and scrap metal. In just one production period of about 14 thousand tons of iron flux, 4 thousand tons of zinc-containing dust were disposed of, which used to be previously placed on storage sites.

Studies of sintering process with monitoring the composition of sinter gas make it possible to quantify the efficiency of potential technological measures to reduce atmospheric emissions in sinter production. Thus, a series of sintering with spraying water over a sintered layer made it possible to quantify the potential for reducing carbon monoxide (CO) emissions. Figure 4 represents the outcome of decrease CO portion in sinter gas at the time of spraying water of 3, 10 and 15 minutes relative to basic sintering (without water spraying - blue diagram).

It was found that prolonged water spraying above a sinter layer (spraying time of 10-15 minutes) after ignition leads to significant decrease of specific CO emission per ton of good sinter: by 18.7-26.4% rel. Increase of specific productivity for good sinter in this case ranged from 3.5 to 12.1% rel. (for laboratory sintering machine).

New area of research was the mastering of vacuum extrusion technology in CRMI (see Figure 5).

Briquettes of various chemical composition were produced from fine wastes of metallurgical operations (see Figure 6). New direction is aimed at developing a technology for producing briquettes for use in both Iron Making and Steel Making, methods for managing the strength properties of a new type of agglomerated raw materials, and involving more waste from metallurgical and chemical industries into recycling.

Thus, the large-scale and systematic research works carried out at the Center for Studying of Raw Materials at Iron Making Plant of PAO Severstal confirm the real possibility of using technological developments in ferrous metallurgy in our common business for reducing the ecological load on the environment.

References

[1] Patent RU No. 2337978.

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