Review Article

Alternative to deal with high level of fine materials in iron ore sintering process

Vinícius de Morais Oliveira a,*, Valdirene Gonzaga de Resende a, Alei Leite Alcantara Domingues a, Mauricio Covcevich Bagatini b, Luiz Fernando Andrade de Castro b

a Ferrous Technology Center, Vale S.A., Nova Lima, MG, Brazil
b Metallurgy Department, Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, MG, Brazil

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A B S T R A C T

Nowadays, as the demand for iron ore increases together with the depletion of high grade ore deposits, mining companies have been investing to produce iron ore concentrates, such as pellet feeds (95% lower than 0.15 mm) with low level of contaminants. It is well-known that its lower particle size negatively affects the permeability of the sintering process, restricting its use to small quantities. In this way, this work was focused on the use of this fine material in sintering process by replacing regular sinter feeds. The pellet feed was prepared in roller press aiming different levels of specific surface. The iron ore mixtures were evaluated in a regular preparation route composed by two drums, one for mixing and another for granulating. To carry out this study, 25% of pellet feed was added to the mix replacing sinter feeds. The mixtures were tested in pilot sintering pot test under process conditions close to the industrial practice. The results obtained in pot test showed that the previous mechanical treatment of pellet feed is suitable to enable the use of this fine material in sintering process. It was possible to obtain an optimum performance in the granulation step, promoting good process permeability conditions without causing any significant metallurgical or strength demerit in sinter product. The productivity increased from 25.8 t/day/m² to 29.4 t/day/m² by adding raw pellet feed and treated by roller press, respectively. Additionally, solid fuel decreased from 69.3 kg/t to 65.9 kg/t, respectively.

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1. Introduction

The iron ore sintering process consists in high temperature agglomeration method where mainly sinter feeds together with fluxes, solid fuel, other ferrous materials and additives are mixed and charged into the sintering machine. The sinter product is the main raw material for hot metal production, which will later be transformed into steel. According World Steel Association (WSA), this technological route accounts for more than 70% of global steel production and its world production increased from 850 Mt (in 2000) to 1,628 Mt (in 2016). In this scenario, the massive use of iron ore leads to the depletion of high grade sinter feeds and make viable the exploitation of lower grade iron-containing rocks, leading to the production of finer, lower contaminants and high grade iron concentrates, known as pellet feed. This material is extremely attractive to be used as a chemical corrective in sintering due to its good chemical quality, however, its use is limited due to its small particle size.

To use pellet feed in sintering process it is necessary to adjust the conventional raw materials preparation route, normally mixing and granulating steps, which requires different process conditions, and also adjustments in additives consumption. Some examples of recent applied technologies were cited in literature, such as [1,2]: (i) selective granulation, allowing to use lower grade sinter feeds; (ii) MEBIOS (Mosaic Embedding Iron Ore Sintering) and HPS (Hybrid Pelletizing Sintering), for use of finer materials in the mix; and (iii) intensive mixers combined with special additives. Additionally, the mechanical treatment of pellet feed or concentrates by roller press to increase the specific surface area has been studied to prepare pellet feed for agglomeration processes [3–5]. Other alternatives raised were: (i) the production of an artificial sinter feed with similar characteristics of natural ones, by using additives which allow to produce high strength agglomerates [6]; and (ii) the implementation of a previous briquetting process to enlarge the size of iron ore fines particles, before its use in sintering [7]. Both alternatives show good results due to the decrease in the amount of fine materials, below 0.15 mm, in the iron ore mixture. Recently, the combination of intensive mixer with different level of binder were investigated by different authors as an alternative to use pellet feed in sintering process. One of these authors achieved similar level of productivity of reference case without any pellet feed [8].

Another one reported an improvement in productivity in cases when the concentrates were grinded (mean size of 0.01 mm), mixed with intensive mixer and when a dedicated granulation process were applied [9].

In this context, the present work aims to evaluate the pretreatment of pellet feed in roller press as an alternative to replace regular sinter feeds in iron sintering process. The amount of pellet feed tested was fixed with different levels of specific surface, achieved by passing it several times in roller press. The focus was on the evaluation of this alternative in extractive metallurgy, working mainly in the areas of thermodynamics and transport phenomena applied to ironmaking and steel processes (sintering, pelletizing, blast furnace, steelmaking and secondary refining of steels).
Table 1 – Iron ore mixtures tested.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference case</th>
<th>Case I (25% PF A)</th>
<th>Case II (25% PF B)</th>
<th>Case III (25% PF C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian sinter feeds (ores A and B), %</td>
<td>69</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Brazilian sinter feeds (ores C, D and E), %</td>
<td>31</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Pellet Feed A (PF A), %</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pellet Feed B (PF B), %</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Pellet Feed C (PF C), %</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
</tbody>
</table>

the regular preparation route, which consists of one drum for mixing and another drum, in sequence, for granulation. Sintering pot test was carried out with different mixtures to verify the effect of these replacements on the sintering process and in sinter product chemistry, physical and metallurgical quality. Additionally, to better understanding of the mechanism involved during the use of pellet feed, granulation test and quasi-particles evaluation by drop test and optical microscopy were carried out.

2. Methodology

2.1. Pellet feed

A Brazilian pellet feed was previously prepared in a laboratory roller press (LABWAL model, manufactured by Polysius AG). The pellet feed passed through roller press once and 5 times. The pressing parameters were the same for both situations, i.e. 80 bar of pressure and 8% of moisture.

The specific surface of natural and pressed pellet feed was determined using different laboratories techniques, one based on air permeability test (Blaine index) [10] and another one based on nitrogen adsorption method (B.E.T.) [11–13], using Quantachrome equipment (NOVA 1000e model). Through determination of hysteresis of adsorption–desorption isotherms, information regarding the distribution of the pores was obtained.

Qualitative image analyses of the samples, aiming to investigate the shape and roughness of the particles, were performed by means of Scanning Electron Microscopy (SEM), using a Carl Zeiss® microscope, EVO MA15 model. The mineralogical composition of the pellet feed was determined by optical microscopy, using a Carl Zeiss microscope.

2.2. Sinter feeds and sintering mixtures

Sinter feeds from Australia and Brazil were used in this work. Table 1 shows the iron ore mixtures tested. The reference case was formed by a mixture of sinter feeds from Australia and Brazil. The pellet feed of Cases I, II and III was introduced at a fixed ratio of 25%, with different specific surface and different size distribution. It mainly replaces the Australian regular sinter feed, Ore A, which has a high level of coarse particles. The mineralogical composition of the sinter feeds was determined by optical microscopy.

2.3. Sinter pot test

To evaluate the sintering behavior of the materials, sintering pot tests were conducted. In these tests, the cold agglomeration route was composed by two drums in series, one for mixing and another one for granulating.

Sintering pot test evaluation was based on the French simulation technique, which consists in balancing return fines condition, where coke breeze was added until the amount of return fines achieves the aimed value [14–16]. After the definition and establishment of moisture and fuel for each condition, the valid sintering pot tests were performed for a minimum of three times. Process parameters, as solid fuel consumption and productivity, were determined. Table 2 shows the experimental conditions established for sinter pot test evaluation and details of the conditions employed for the preparation route tested.

To collect samples, the sinter cake was disintegrated using an ASTM drum device with 50 revolutions. After that, the sinter was screened in different sizes from 5 mm to 80 mm and size distribution of the sinter was determined. This procedure was repeated for each valid burn and each size fractions is separated and later used to samples preparation for characterization. To obtain representative samples for all characterizations, the required weight is obtained through quartering the material in an automatic equipment.

Beyond chemical analysis, the quality of sinter obtained from each mixture was evaluated considering physical properties, size distribution and mechanical strength (tumbler ISO 3271 and shatter index JIS M 8711), and metallurgical performance (Reduction Degradation Index, RDI–ISO 4696-2 and Reduction Degree, RI–ISO 7215). Additionally, the mineralogical composition and porosity were determined by optical microscopy and mercury intrusion porosimetry, respectively.

2.4. Quasi-particles evaluation and granulation test

For a better understanding of the phenomena involved during the granulation step, quasi-particles evaluation and granulation test were carried out. A quasi-particle is formed by a nucleus containing a coarse particle surrounded by fine particles [17].

The sample of quasi-particles were collected just before the loading of the sinter pot test and evaluated by optical
microscopy, using a Carl Zeiss* microscope, Axio Imager Z2 m model.

The granulation and quasi-particles drop tests were carried out using the same mixtures, applying a small drum. The setup conditions for mixing and granulation are reported in Table 2. After mixture preparation, samples were collected, dried out at 120 °C and split for the two tests.

Concerning the granulation test, the sample passed through a dry sieving process and the amount of fines below 0.25 mm was determined. Then, the sample passed through wet sieving process and quasi-particles, which grew up and formed micropellets, were disaggregated, and finally the amount of fines below 0.25 mm was measured again. The granulation index was calculated and represents the amount of fines that remains forming the quasi-particles and micropellets. The higher this parameter, the better the granulation and permeability in sintering process.

The quasi-particles drop test was carried out with a procedure based on the standard JIS M 8711 used for Shatter Index determination of sinter product. In this test, the amount of fines below 0.15 mm was measured before and after 2 drops. These results were compared with the amount of fines below 0.15 mm of the iron ore mixture before drum mixing. Finally, an estimative of the amount of fines that is still joined to the nucleus particles was determined.

3. Results and discussion

3.1. Raw materials characterization

Table 3 shows the chemical analysis of the iron ores, whereas Table 4 shows their mineralogical composition. The sinter feeds A and B, from Australia, have the highest Loss On Ignition (LOI) due to their mineralogical composition, mostly formed by goethite. On the other hand, sinter feeds C, D and E, from Brazil, have lower LOI and are mainly composed by hematite. In terms of level of contaminants, i.e. Al₂O₃ and P,

the Brazilian sinter feeds have the lowest value, while SiO₂ content, except for sinter feed C, have the highest values. The pellet feeds, PF A, B and C, have the lowest amount of contaminants and LOI, as they are mostly composed by hematite.

Concerning hematite crystals morphology (Table 5) ore B presents a mixture of martite and lobular hematite. Ore C were mostly formed by microcrystalline hematite. Ores D and E present a mixture of granular and specular hematite and finally, pellet feeds were mostly formed by specular hematite.

The fluxes and solid fuel, used in sinter pot tests, have similar characteristics of that one used in industrial scale sintering plant in steel mills. Tables 6 and 7, show the chemical characterization and immediate chemical analysis of the fluxes and solid fuel, respectively.

Table 8 shows the results of specific surface obtained for each pellet feed, both techniques, Blaine and B.E.T., presented the same trends although with different absolute values. The increase on the number of times passing in roller press leads to a higher specific surface area. The differences in absolute values is that the B.E.T. measures the total specific surface area, i.e. including the surface area relative to pores.

Isotherms of adsorption–desorption were presented in Fig. 1(a). The characteristics of this curves show similar results of the ones reported in literature for iron ores [13,18]. The amount of nitrogen adsorbed increases with the increase of specific surface of pellet feed. The shape of the isotherms
indicates a small distribution of size of pores for all considered pellet feed (Fig. 1, b).

Fig. 2 shows the size distribution of sinter feeds, natural pellet feed (PF A) and pressed pellet feeds (PF B and C). As expected, the pellet feeds, in comparison to sinter feeds, are much finer. Comparing the pellet feeds, the increase in the number of times passing in roller press leads to a production of much finer material. SEM images were collected and shown in Fig. 3. Note that the higher the specific surface is, the higher the amount of ultra-fines particles produced.

### Table 9 – Details of iron ore mixtures tested.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference</th>
<th>Case I (PF A)</th>
<th>Case II (PF B)</th>
<th>Case III (PF C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron ore mixture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sinter feeds</td>
<td>100</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Pellet feed</td>
<td>0</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>LOI, %</td>
<td>7.4</td>
<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
</tr>
<tr>
<td>+1.000 mm, %</td>
<td>53.1</td>
<td>39.3</td>
<td>39.3</td>
<td>39.3</td>
</tr>
<tr>
<td>−0.150 mm, %</td>
<td>24.9</td>
<td>42.9</td>
<td>42.9</td>
<td>43.7</td>
</tr>
<tr>
<td>−0.045 mm, %</td>
<td>17.0</td>
<td>26.3</td>
<td>26.3</td>
<td>31.9</td>
</tr>
<tr>
<td>Sinter product</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe, %</td>
<td>56.8</td>
<td>57.5</td>
<td>57.5</td>
<td>57.5</td>
</tr>
<tr>
<td>SiO₂, %</td>
<td>5.97</td>
<td>5.73</td>
<td>5.73</td>
<td>5.73</td>
</tr>
<tr>
<td>Al₂O₃, %</td>
<td>1.72</td>
<td>1.41</td>
<td>1.41</td>
<td>1.41</td>
</tr>
<tr>
<td>P, ppm</td>
<td>50</td>
<td>44</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>CaO/SiO₂</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
</tbody>
</table>

### 3.2. Sinter pot test results

Table 9 shows more details of the iron ore mixture tested. The use of pellet feed allowed an improvement in the quality of the mixture and as consequence in sinter product, the Fe content increased with the decrease of SiO₂, Al₂O₃, P and LOI. On the other hand, the iron ore mixture became much finer.

The results of productivity and fuel consumption obtained in sinter pot tests for each case are reported in Fig. 4. These results showed that when natural pellet feed is introduced in the iron ore mixture, a decrease in productivity was observed.
This result could be explained by the increase of the fine particles in iron ore mixture affecting the permeability of the process and was in line with the one reported in literature [7, 8, 19]. Partial recovery of productivity was achieved when pressed pellet feed with intermediate specific surface was used. Fully recovery of productivity was achieved only with the highest level of specific surface of the pellet feed. So, in these cases, even with the increase of the amount of fines (pellet feed replacing coarse sinter feed) better productivity was achieved contradicting the literature reported. Similar behavior was reported by Jian et al. [5] only when high specific surface pellet feed replaces iron ore concentrates.

Table 10 shows the main parameters which affect productivity in sintering process, i.e. flame front speed, sintering yield and charge density. Additionally, it also shows the moisture of the mixture and a permeability index, JPU (Japanese Permeability Unit). The flame front speed is an indicative of the permeability of the process and should be as high as possible without compromising other sinter properties, for instance strength and mineralogy. If the flame front speed is too fast part of the iron ore mixture could be unburned or if it is too slow excessive melting formation may happen.

Sintering yield is the ratio of the amount of sinter in the size range able to be use in blast furnace to the amount of iron ore

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Sintering yield is the ratio of the amount of sinter in the size range able to be use in blast furnace to the amount of iron ore

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Fig. 3 – SEM images: (a) PF A, natural pellet feed; (b) PF B, pressed pellet feed once in roller press; and (c) PF C, pellet feed pressed five times in roller press.

Fig. 4 – Effect of the use of pellet feed replacing regular sinter feeds in sintering productivity (a) and solid fuel consumption (b), relative to base case for regular granulation process.
mixture (including return fines, fuel and fluxes). The higher the sintering yield is, the better the productivity is and less fines are generated by the produced sinter. The charge density is also another parameter that directly affects productivity: the higher the charge density, the better the productivity is.

So, when the reference case is compared with the other cases (Table 10), where pellet feed was introduced in the iron ore mixture, the parameter that was negatively affected is the flame front speed which had decreased. The permeability index, JPU, also decreased. As previously mentioned, this result was expected, as the size distribution of the iron ore mixture became finer. On the other hand, sintering yield and charge density increased in all cases with the addition of pellet feed, independently of the mechanical treatment. These results, sintering yield and charge density, were in line to those reported in literature [20–24] when high LOI ores (goethite ores) were replaced by hematite ores.

Coming back to the flame front speed results, it increased with the increase of specific surface of pellet feed and also with the amount of particles below 0.045 mm of the iron ore mixture, see Fig. 5. For Case III, with pressed pellet feed with 1,460 cm²/g of specific surface (Blaine Index), flame front speed reaches a value enough to allow the full recovery of the productivity. Additionally, it is also observed an improvement in the permeability index. So, the improvement in granulation step could be the main hypothesis that better explain this result.

About solid fuel consumption, Fig. 4(b), no expressive changes were observed for the Case I with natural pellet feed. Concerning Cases II and III, a decrease on this parameter was achieved. This result was in accordance with the one reported in literature [20–24] when high LOI ores were replaced by hematite ores. The hypothesis raised to explain the behavior of Case I was related to the lower permeability of the process which leads to a higher fuel requirement to achieve suitable sinter strength and was in accordance with the findings of Yang et al. [25].

### 3.3. **Quasi-particles and granulation evaluation**

To better understand the sinter pot test performance of the mixtures with natural and pressed pellet feed and to confirm the hypothesis raised about the improvement in granulation step, an investigation of the quasi-particles formed during balling step before the pot test was performed using optical microscopy. Fig. 6 shows the main differences between Case I and Case III with natural pellet feed and with pressed pellet feed, respectively. The images show a better quasi-particles formation in the case where pressed pellet feed was used (five times in roller press, Blaine index of 1,468 cm²/g), which explains the improvement in permeability observed in this case, leading to a higher flame front speed and better productivity.

Additionally, the drop test carried out with samples collected for these two cases (Fig. 7) showed that more fines below 0.15 mm remain agglomerated to quasi-particles or micropolletized for Case III as compared to Case I. The quasi-particles formed with the pressed pellet feed (Case III) was stronger than the quasi-particles formed with natural pellet feed (Case I).

Finally, the granulation test results were also in line with the observations previously reported confirming the hypothe-
Fig. 6 – Quasi-particles collected after granulating step before sinter pot test for regular granulation process (two drums in sequence, one for mixing and another for balling): (a) PF A (Blaine index: 433 cm²/g) with not well formed quasi-particles (white arrows) and (b) PF C (Blaine index: 1,468 cm²/g) with well-formed quasi-particles (rounded shape aspect).

Fig. 7 – Amount of fines below 0.15 mm that remain agglomerated after drop test for the Case I (25% PF A) and Case III (25% PF C), moisture of 7.5% of iron ore mixture.

Fig. 8 – Granulation index results for Case I (25% PF A) and Case III (25% PF C), moisture of 7.5% of iron ore mixture.

Fig. 9 – Shatter and tumble index of the sinters produced with pellet feed replacing regular sinter feeds.

3.4. Sinter characterization

Fig. 9 shows the results of sinter strength, i.e. shatter and tumble index. In general, an increase in sinter strength with the introduction of pellet feed (hematite ore) replacing coarse Australian sinter feed (goethite ores) was achieved. The increase of fines particles in iron ore mixtures does not compromise sinter strength. Some reports in literature [23,24] about the replacement of goethite by hematite sinter feeds presents similar results.

About metallurgical performance, Fig. 10 shows the results of RDI and reducibility. Regarding RDI, Cases I and III presents similar values of the reference case. These results were in line with microstructural characterization of these sinters, Table 11. Case II presents the highest level of RDI and could be explained by the higher level of magnetite, lower level of acicular ferrites and higher porosity.

The results of reducibility were slightly improved when the hematite pellet feed replaces goethite sinter feed. This result could be explained by the decrease in alumina content of the iron ore mixture which were concentrated in adherent fines, introduction of pellet feed with very low alumina content, which promote similar segregation obtaining when selective granulation method is applied in sintering process leading to an overall better sinter quality as reported in literature [26–28]. The results were also in line with microstructural characterization, except for Reference Case, which should have higher reducibility.
The use of hematite pellet feed in sintering process is a good alternative to improve the chemical composition due to the high iron content and a lower level of contaminants, i.e. SiO$_2$, Al$_2$O$_3$ and P. Additionally, depending on the ore replaced, better solid fuel consumption could be achieved due to its lower LOI.

- The mechanical treatment of pellet feed in roller press leads to an increase in the ultrafine fraction of the regular pellet feed, i.e. amount less than 0.045 mm and less than 0.010 mm, which is helpful for the granulation process. On the other hand, without pretreatment the present pellet feed does not have a positive effect on the granulation step due to its lower ultrafine fraction.

- The use of pellet feed with higher specific surface leads to an increase on the productivity of the sinter pot test. This is due to the better granulation behavior of pressed pellet feed when it is compared to the non-pressed pellet feed, leading to a better permeability (higher flame front speed). Comparing with the reference case, which has no addition of pellet feed, charge density as well as sintering yield (higher sinter strength) also contributed to a better productivity.

- In terms of sinter quality, the sinter strength results showed an increase of tumble and shatter index as consequence of the introduction of pellet feed (hematite ore) replacing Australian sinter feed (goethite ores). Considering metallurgical performance, interesting results were achieved and RDI results were in line with the microstructural characterization of the sinters. Case III, with the highest specific surface (pressed pellet feed five times in roller press), showed better results than Case I, with lowest specific surface (natural pellet feed, not pressed).

**Table 11 – Mineralogical composition and mercury intrusion porosimetry of the sinters produced in pot test.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference (PF A)</th>
<th>Case I (PF A)</th>
<th>Case II (PF B)</th>
<th>Case III (PF C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineralogical composition (wt. %)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granular Ferrites</td>
<td>11 ± 1</td>
<td>8 ± 1</td>
<td>2 ± 1</td>
<td>6 ± 1</td>
</tr>
<tr>
<td>Accicular Ferrites</td>
<td>22 ± 1</td>
<td>20 ± 1</td>
<td>17 ± 1</td>
<td>20 ± 1</td>
</tr>
<tr>
<td>Primary Hematite</td>
<td>4 ± 1</td>
<td>2 ± 1</td>
<td>3 ± 1</td>
<td>5 ± 1</td>
</tr>
<tr>
<td>Secondary Hematite</td>
<td>34 ± 1</td>
<td>37 ± 1</td>
<td>37 ± 1</td>
<td>35 ± 1</td>
</tr>
<tr>
<td>Magnetite</td>
<td>20 ± 1</td>
<td>21 ± 1</td>
<td>34 ± 1</td>
<td>24 ± 1</td>
</tr>
<tr>
<td>Silicate</td>
<td>8 ± 1</td>
<td>10 ± 1</td>
<td>7 ± 1</td>
<td>10 ± 1</td>
</tr>
<tr>
<td>Quartz</td>
<td>0 ± 1</td>
<td>2 ± 1</td>
<td>1 ± 1</td>
<td>1 ± 1</td>
</tr>
<tr>
<td>Mercury intrusion porosimetry (%)</td>
<td>21.3 ± 0.5</td>
<td>20.9 ± 0.5</td>
<td>23.6 ± 0.5</td>
<td>20.6 ± 0.5</td>
</tr>
</tbody>
</table>

In general, the use of hematite pellet feed with different levels of specific surface replacing goethite sinter feeds from the market does not compromise the overall quality of the produced sinter.

**4. Conclusions**

The use of pellet feed in sintering process replacing regular sinter feeds of the market was studied through sinter pot tests (25% of iron ore mixture). It was shown that the alternative of pre-treatment of the pellet feed in roller press is interesting to promote the use of it in this process. Based on the present work, the main conclusions were:

**Conflicts of interest**

The authors declare no conflicts of interest.

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**References**


