Effect of pellet feed removal on the sintering process at ArcelorMittal Monlevade

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Abstract

The Hybrid Pelletized Sinter (HPS) process was implemented at ArcelorMittal Monlevade to enable the use of iron ore from the company's own mine while maintaining high productivity. Limitations in ore availability increased the pellet feed share in the sinter mix to approximately 60%, negatively affecting process performance. This study aimed to evaluate, through an industrial trial, the effects of the complete removal of pellet feed from the sintering process. A threeday industrial trial was conducted using exclusively sinter feed with standard granulometry, while the main operating parameters of the sintering machine were kept constant. Productivity, bed permeability, sinter yield, and mixture moisture were monitored, and the sinter was characterized through chemical, physical, mineralogical, and metallurgical analyses, including tumble strength, Reduction Degradation Index (RDI), and reducibility. The results showed an average increase of approximately 5% in sintering productivity, associated with improved bed permeability due to the coarser particle size distribution. In addition, an average reduction of 5 percentage points in the RDI was observed, with no significant changes in mineralogical characteristics or overall sinter quality. The test results showed that pellet feed removal improved sintering efficiency and supported ore blend optimization.

Keywords: Sintering process; HPS; *Pellet Feed*; Productivity.

1 Introduction

In 2002, ArcelorMittal invested in the HPS installation (Hybrid Pelletized Sinter) process in the sintering of the Monlevade plant (AMM), a cold agglomeration process that uses discs, focusing on the consumption of 100% of its own ore (sinter feed with a high percentage of fraction <0.150mm).

Currently, the iron ore supplied to the plant is composed of three different materials, referred to in this paper as sinter feed A, sinter feed B, and pellet feed C. The sinter feed A has a common sinter feed grain size (<6.3 mm), sinter feed B is the coarsest grained (2 mm to 12 mm), and pellet feed C is the thinner material (65% < 0,150 mm). Despite the grain size, it is worth noting that there are no major mineralogical variations between the materials that make up the ore supplied by AMM. Due to the current mine situation in terms of iron ore availability, there was a considerable increase in the pellet feed C dosage, reaching 60% in the mix, thus promoting the iron ore thinning applied in the industrial sintering plant, with a significant reduction in the fraction >1 mm impacting sintering productivity, even with a significant increase in burnt lime consumption [1,2].

Therefore, an industrial test was carried out on the sintering of AMM with total removal of pellet feed C and exclusive use of Material A, common granulometry of sinter feed, to support the company's strategic definitions and the evaluation of the process and sinter quality.

2 Methodology

2.1 Materials

The materials that are used in AMM are presented in Figure 1. The chemical and grain size composition of sinter feed A used for the industrial test are presented in Tables 1 and 2. For comparison purposes, the results of pellet feed C, taken in the industrial test, and the mix generally offered to AMM are presented. It can be

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Figure 1. Iron ore types supplied to AMM.

Table 1. Iron ores chemical composition

Analysis	**Results - %**			
	Sinter feed A	**Sinter Feed B**	**Pellet feed C**	**Mix**
Mix composition	15.0	25.0	60.0	100.0
FeT	64.91	63.22	66.58	65.18
SiO_2	4.78	6.65	3.93	4.94
Al_2O_3	1.34	0.74	0.51	0.76
Mn	0.072	0.125	0.063	0.06
P	0.042	0.071	0.023	0.036
LOI	0.18	0.17	0.18	0.18

Table 2. Iron ores size analysis

Analysis	**Results - %**			
	Sinter feed A	**Sinter Feed B**	**Pellet feed C**	**Mix**
Mix composition	15.0	25.0	60.0	100.0
> 6.35 mm	24.78	36.80	0.00	12.01
> 1.00 mm	44.08	88.52	14.66	28.59
< 0.150 mm	28.79	6.75	63.61	41.38
<0.106 mm	17.56	5.04	44.73	25.21
(1 a 6.35 mm)	19.30	51.72	3.74	16.58
(0.150 a 1 mm)	27.13	4.73	32.65	30.03
(< 0.150 mm)	28.79	6.75	63.61	41.38

observed that sinter feed A has a good iron content and low contaminant levels. Furthermore, it has a good result for fraction >1 mm, however, with a high presence of fraction >6.35 mm. The pellet feed C, as mentioned, is an iron ore with fine grain size for application in sintering. Furthermore, the material has a low specific surface area (300 cm^2/g), which tends to impair the cold agglomeration process and, consequently, sintering productivity [3].

2.2 Methods

2.2.1 Iron ore mineralogical analysis

Iron ores of type A and type C were subjected to mineralogical analysis using optical microscopy to quantify hematite types and crystal sizes. X-ray diffraction analysis was also performed to quantify the ferrous and gangue phases using the equipment Empyrean from Malvern Panalytical.

2.2.2 Industrial trial

An industrial trial using exclusively sinter feed A was carried out over a three-day period. During the trial, the productivity of the sintering machine, bed permeability, sinter yield, and moisture content of the sinter mix were systematically evaluated, together with the quality of the produced sinter. The results obtained during the test period were compared with those from subsequent operational days after the standardization of the iron ore blend supplied to the plant. To ensure the statistical representativeness and reliability of the results, the main operational parameters of the sintering machine were maintained constant throughout the trial.

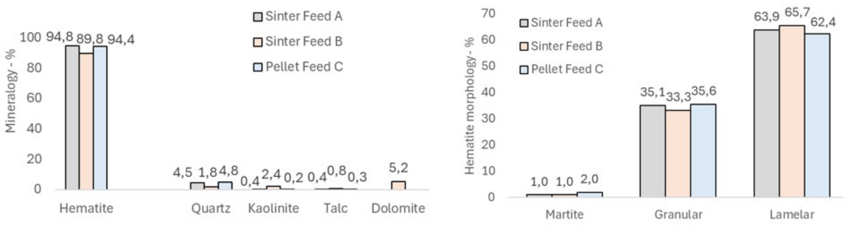
2.2.3 Physical, chemical, mineralogical and metallurgical analysis of sinter

Sinter samples were subjected to tests for chemical, mineralogical, mechanical and metallurgical properties evaluations. The mechanical strength (tumbler test) and metallurgical (RDI and Reducibility) tests followed the JIS M8712 [4], M8720 [5] and M8713 [6] standards, respectively for the tumbler, RDI and Reducibility tests.

3 Results and discussion

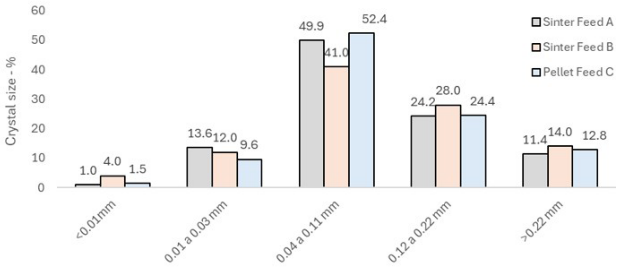
3.1 Iron ore mineralogical analysis

The results of the mineralogical analysis of the iron ore samples are presented in Figure 2. As expected, there is no significance between materials A and C. It is noteworthy that they are hematitic iron ores with a predominantly acicular



(a) mineralogical phases.

(b) hematite morphology



(c) hematite crystal size

Figure 2. Iron ores mineralogical analysis

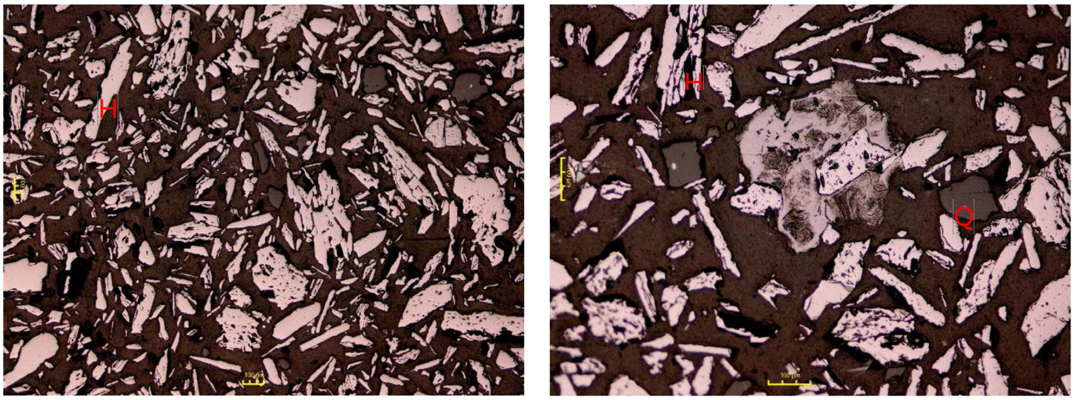
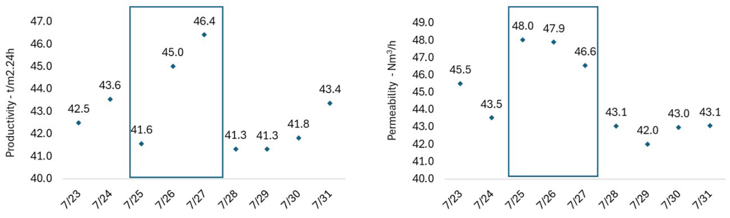
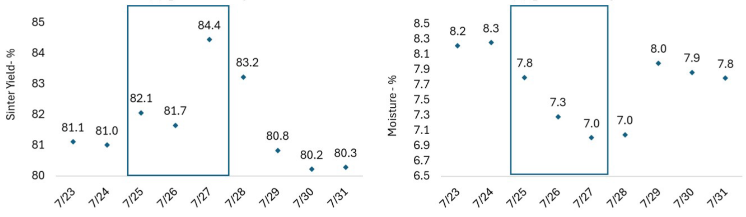


Figure 3. Micrograph of iron ore highlighting hematite (H) particles and quartz (Q) by optical microscopy

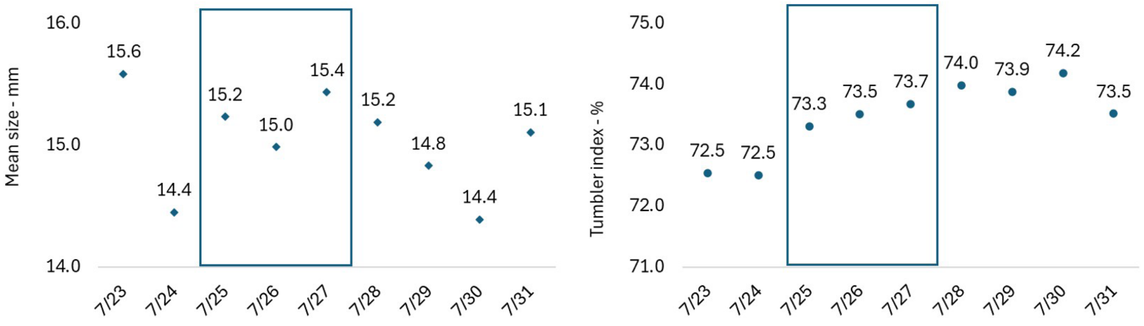


(a) productivity (b) permeability



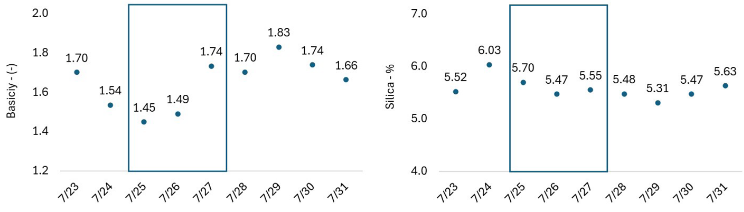
(c) sinter yield (d) moisture

Figure 4. Industrial trial main results.

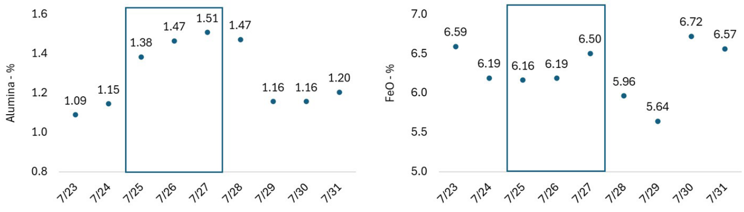


(a) mean size (b) tumbler index

Figure 5. Mean size and tumbler index of sinter samples.



(a) basicity (b) silica



(c) alumina (d) FeO

Figure 6. Main sinter samples chemical results.

morphology and medium crystal size. The mean size results were 0.23 mm, 0.13 mm and 0.25 mm for sinter feed A, sinter feed B and pellet feed C, respectively.

The materials are presented in Figure 3. The presence of acicular and granular hematite can be observed, in addition to the iron ore separated from the quartz. The

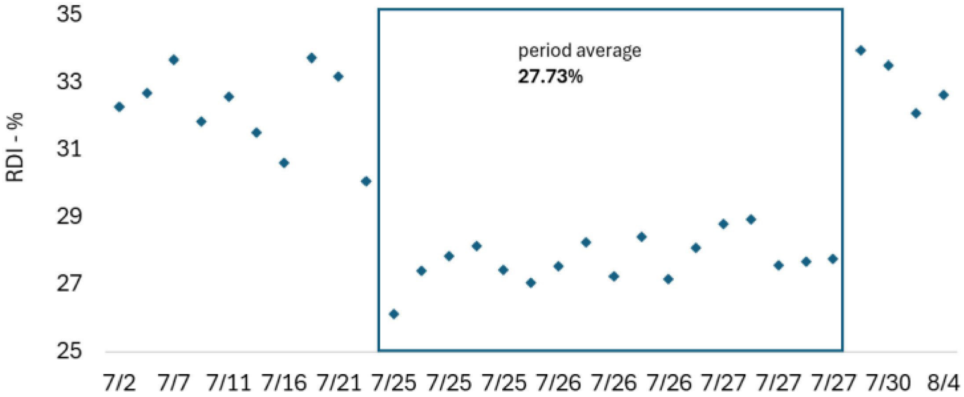


Figure 7. Sinter samples reduction degradation index.

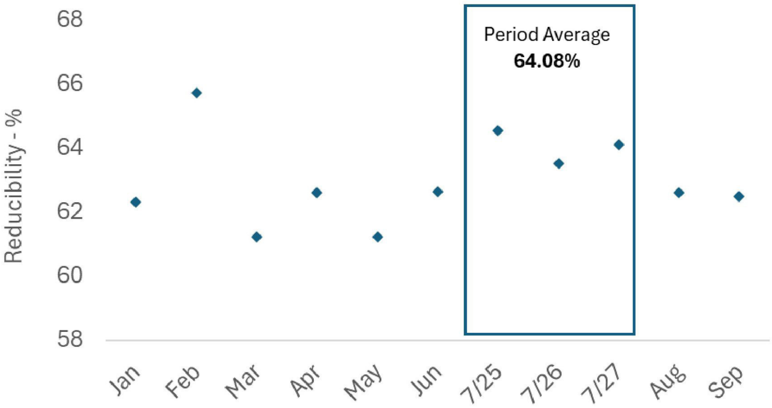


Figure 8. Sinter samples reducibility index.

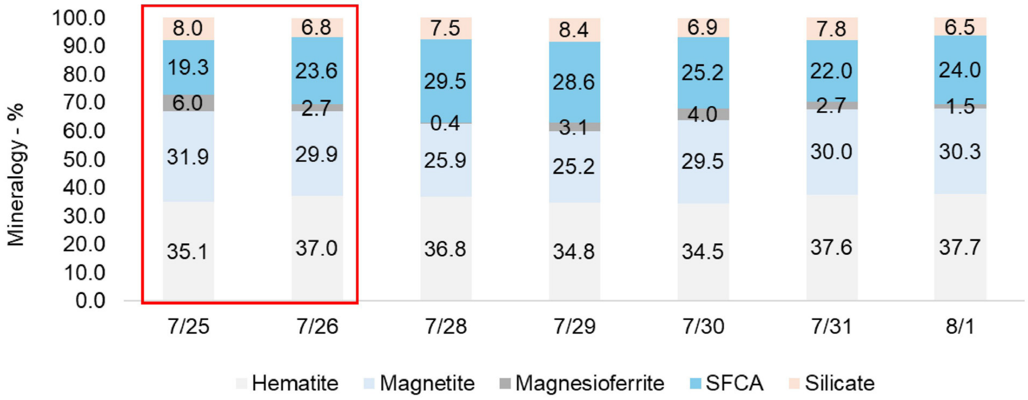


Figure 9. Sinter samples mineralogical quantification.

photomicrographs presented correspond to the iron ore blend used during the test period.

3.2 Industrial trial

During the test period, Figure 4, the sinter machine productivity increased, reaching 46.4 t/m^2.24h and an average result of 44.3 t/m^2.24h, an increase of approximately 5%, given that the productivity during the period in which pellet feed C was used was 42.33 t/m^2.24h. This result can be explained by the greater permeability of the sinter bed due to the higher nuclean/adherent ratio of ore A, which, in turn, favoured cold agglomeration. The sinter yield results were also satisfactory during the period; another highlight is the reduction in moisture required in the process due to the higher particle size of the mix during this period. The exclusive

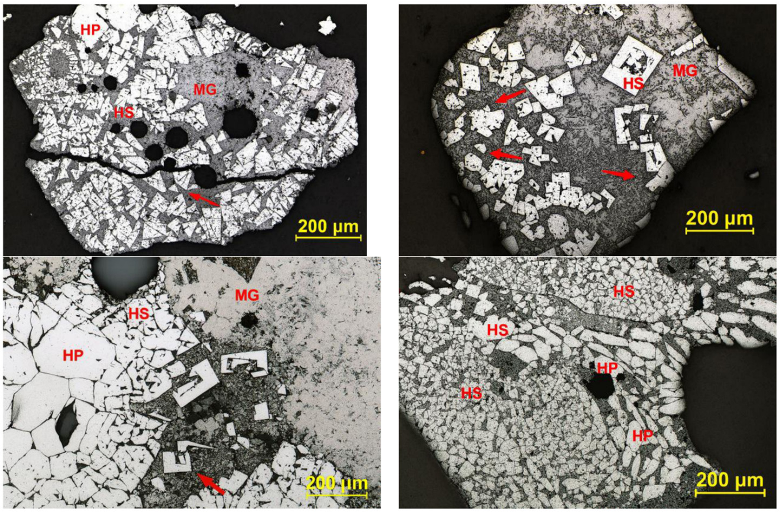


Figure 10. Micrograph of iron ore sinter highlighting primary hematite (HP) secondary hematite (HS) and magnetite (MG) by optical microscopy.

use of iron ore A did not affect the physical and mechanical quality of the sinter, Figure 5. The chemical quality results of the sinter indicated that, during the industrial test, there were no significant variations in the main elements controlled in the process, Figure 6. A reduction in sinter basicity was observed because of the increased silica content in the sinter, associated with the reduction in the use of pellet feed C, while the addition of burnt lime was maintained. In addition, the removal of material C contributed to an increase in the alumina content of the sinter.

Regarding the metallurgical properties of the sinter, it is observed that during the test excellent RDI results were obtained, with an average of 27.73% for the period (Figure 7), despite the higher alumina content of the sinter during this period [7]. It is worth noting that, due to the particle size distribution of sinter feed A, its alumina tends to be retained in the nucleating fraction of the ore, which mitigates the impact of alumina on the metallurgical properties of the sinter [8]. Furthermore, the reducibility results were superior to most of the results for the year, Figure 8.

Regarding the mineralogical properties of sinter, no significant changes were observed that could mainly justify the better metallurgical results of sinter, Figure 9. In general, a high presence of secondary hematite, a high presence of magnetite and acicular calcium ferrites is observed in most of the matrices of the analysed sinters, Figure 10. Also noteworthy is the good presence of original hematite from the ore, primary, mainly with granular morphology, followed by those with an acicular structure.

The industrial test carried out at the Monlevade plant showed that the high use of pellet feed negatively affected sinter bed permeability and, consequently, process productivity, in agreement with trends previously reported in the literature [3,9-11], even for an HPS sintering plant. The outcomes of this test supported further internal studies and the development of new sintering plant projects.

4 Conclusion

Sinter production without the addition of pellet feed was evaluated industrially at the ArcelorMittal Monlevade sinter plant, given that the current consumption of this material at the plant could impact process productivity and sinter quality. The results indicated that removing the material resulted in an average increase in sinter productivity of approximately 5% and an average reduction of 5 percentage points in the RDI. This increase in productivity is associated with the larger ore grain size, which allowed for greater bed permeability. It is also noteworthy that there were no significant changes in the mineralogical characteristics of the sinter when the ore mix supplied to the plant was changed during the period, indicating the impact of ore fineness on the process and sinter quality, mainly due to the low specific surface area of the pellet feed supplied to AMM.

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