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Experimental analysis of the use of superabsorbent polymers in moisture reduction and initial characterization of sinter feed.

Experimental analysis of superabsorbent polymers for moisture reduction and initial characterization of sinter feed

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Summary

This study evaluates the application of superabsorbent polymers in reducing free moisture in iron ore sinter feed through bench tests and initial characterization analyses. Two commercial polymers were investigated, applied in different dosages, with monitoring of moisture reduction over time. Samples were analyzed by X-ray diffraction and particle size analysis to verify possible structural changes. The results indicated a significant reduction in moisture, without relevant mineralogical modifications, demonstrating the initial technical feasibility of the application. The findings contribute to the development of alternative solutions for moisture control in iron ores.

Keywords: Iron ore. Superabsorbent polymer. Moisture. XRD. Particle size distribution.

Abstract

This study evaluates the application of superabsorbent polymers for reducing free moisture in iron ore sinter feed through bench-scale tests and initial characterization analyses. Two commercial polymers were investigated at different dosages, with moisture reduction monitored over time.
Samples were analyzed by X-ray diffraction and particle size distribution to verify possible structural changes. Results indicated significant moisture reduction without relevant mineralological modifications, demonstrating the initial technical feasibility of the application.
Keywords: Iron ore. Superabsorbent polymer. Moisture. XRD. Particle size distribution.

1. Introduction

The high moisture content in iron ore fines represents one of the main

Operational and logistical challenges of the mineral supply chain. The presence of free water compromises the

Handling increases transportation costs and can result in risks associated with cargo liquefaction.

Conventional drying methods have technical and economic limitations, especially in

Large scale. Superabsorbent polymers stand out for their high retention capacity.

Water-based and are being investigated as an alternative for humidity control in different sectors.

industrial applications. However, their application in mineral processing is still limited. Given this

In this context, this work aims to evaluate, on a bench scale, the efficiency of these polymers.

in reducing moisture in sinter feed.

2. Theoretical Framework

Moisture in particulate materials has a direct influence on their mechanical behavior and

operational, affecting properties such as fluidity, cohesion, and stability during handling and

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transport. In the case of iron ore fines, the presence of free water favors the formation of Liquid films on the surfaces of particles and the development of capillary bridges, intensifying the interparticle cohesive forces and compromising the flow of the material (PINTO et al., 2015; ZHOU et al., 2018).

Moisture retention in iron ore fines is directly related to their microstructure, specific surface area, and the presence of hydrated minerals, such as goethite and Iron hydroxides. These constituents promote the adsorption of water on the surfaces of the particles. intensifying the formation of liquid films and capillary bridges, responsible for increasing cohesion. interparticular. This phenomenon compromises the fluidity of the material and favors the formation of clusters, especially under conditions of high relative humidity and temperature variations during storage and transport (LUZ; SAMPAIO; FRANÇA, 2010; CHEN et al., 2017).

In addition to physical aspects, particle size distribution plays a fundamental role in Water retention in particulate systems. Materials with a higher fraction of fines exhibit greater specific surface area, which intensifies adsorption and capillary action mechanisms, making it more difficult the natural drainage of free water (LI et al., 2019). In this way, moisture control in sinter feed This represents a significant technical challenge, especially in large-scale logistics chains.

Superabsorbent polymers are three-dimensional hydrophilic polymer networks. characterized by a high capacity for water absorption and retention, capable of incorporating hundreds times its own mass in water without dissolving (BUCHHOLZ; GRAHAM, 1998). Its structure The cross-linked structure favors osmotic interactions and hydrogen bonds with water molecules, resulting in the formation of stable hydrogels (ZOHURIAAN-MEHR et al., 2010).

The performance of superabsorbent polymers in mineral particulate systems is associated with its ability to capture free water present in intergranular voids and in Particle surfaces. In mineral matrices, PSAs act predominantly through mechanisms physical agents, reducing fluid mobility and the formation of continuous surface films, without significantly interfering with the chemical composition of the substrate (VENTER, 2003; ORDÓÑEZ, 2013). This behavior is particularly relevant for applications in mineral processing, since it preserves the material's properties for subsequent steps.

Previous studies demonstrate that the application of superabsorbent polymers in materials Minerals can contribute to improved dewatering, physical stability, and... handling of fines, especially under high humidity conditions (VENTER, 2003; (SRIKAKULAPU et al., 2020). However, most of these investigations focus on tailings, coal or mineral pulp, and the literature related to the application of these materials is still limited. in iron ore sinter feed, especially in the context of logistics and port operations.

In this sense, a deeper theoretical understanding of the interaction between polymers

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Superabsorbents, free water, and mineral particles form a fundamental basis for the interpretation of experimental results obtained in this study, as well as for the evaluation of application potential of the proposed technology on an industrial scale.

3. Materials and Methods

3.1 Material

The material used in this study corresponds to iron ore sinter feed from... of a mining operation located in Brazil, representative of the industrial production conditions and commercialization. The samples were collected directly after the processing stage, being packaged in airtight containers to preserve moisture content until the procedures are carried out. tests. The ore exhibits a predominantly fine particle size distribution, characteristic of sinter feed, and mineralogical composition typical of hematitic ores, with the presence of iron oxides and hydroxides. Two commercial superabsorbent polymers were evaluated. anionic nature and reticulated structure, identified as KE-0806 and KE-0807, selected in due to its commercial availability and potential application in industrial processes.

3.2 Sample Preparation

The ore samples were initially homogenized and subjected to determination. from the initial moisture content by drying in an oven at 105 ± 5 °C until constant mass, according to recommendations of the ABNT NBR ISO 3087 standard. Subsequently, the samples were packaged. in controlled containers and adjusted to moisture contents representative of the conditions operational results observed during transport and storage, through the controlled addition of water. distillation and mechanical homogenization.

3.3 Bench Tests

The benchtop tests consisted of applying the superabsorbent polymers to the samples. previously prepared, in different dosages previously defined in preliminary tests. The Polymers were added gradually and homogeneously, followed by manual and mechanical mixing. aiming to ensure its uniform distribution in the material. After application, the samples were kept in open containers, under controlled environmental conditions, for monitoring behavior. of moisture over time. The determination of residual moisture content was carried out in regular intervals through oven drying until constant mass, allowing for evaluation of Efficiency of polymers in reducing free water. Each test was performed in triplicate, aiming to to ensure the reproducibility of the results.

3.4 Particle Size Analysis

The particle size distribution of the samples, before and after the application of the polymers, was

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determined by dry sieving, using a set of standardized sieves, according to
The methodology is described in the ABNT NBR ISO 3086 standard. The test was performed with time and amplitude.
controlled, with the mass retained on each sieve subsequently determined for the construction of the
Particle size distribution curves and analysis of possible changes in particle size distribution.

3.5 Mineralogical Analysis by X-ray Diffraction (XRD)

The mineralogical characterization of the samples was performed by X-ray diffraction (XRD).
using a diffractometer equipped with Cu-Kÿ radiation, operating under voltage and current suitable for
Analysis of mineral materials. The samples were previously pulverized and stored in
appropriate sample holders were used, ensuring a flat and homogeneous surface. The diffractograms were
obtained in the angular range of 5° to 70° (2ÿ), with step and counting time defined to ensure
adequate resolution. The identification of the mineral phases was carried out by comparison with standards.
available in the ICDD (International Centre for Diffraction Data) database.

4. Results and Discussion

Bench tests have shown that the application of superabsorbent polymers
promoted a significant reduction in the moisture content of the samples compared to the initial conditions and
to the control samples. The steps of sample preparation, addition of polymers and organization of
The experimental system is illustrated in Figures 01 and 02 below.

Figure 1: Addition of the polymer to the iron ore sample.

Figure 02: Preparation of samples on the bench after addition of the polymer.

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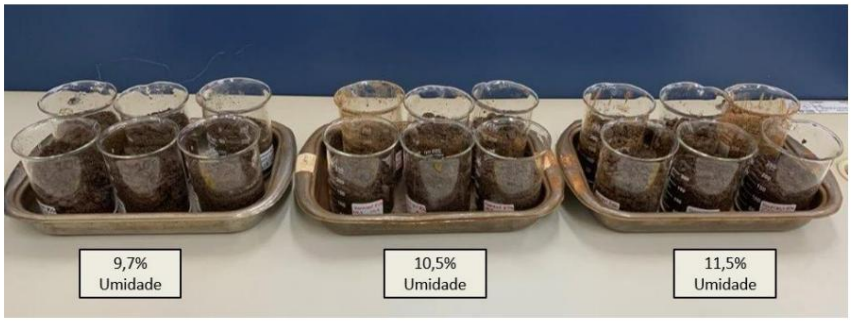
The evolution of the reduction in humidity over time is shown in Figure 03. evidencing behavior characterized by rapid initial absorption of free water, followed by stabilization of residual values. This behavior is associated with the high affinity of superabsorbent polymers with the water present in the intergranular voids.

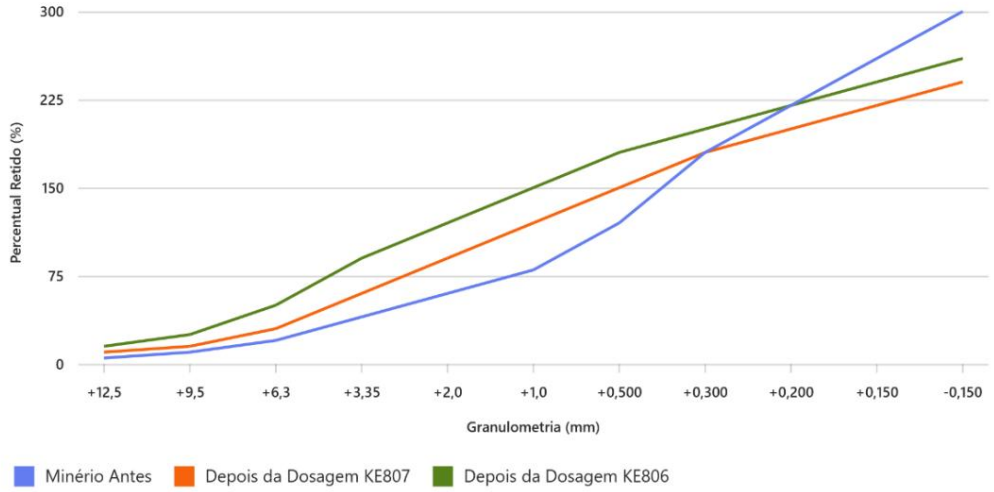
Figure 3: Records of sample monitoring over time



The comparison between the evaluated polymers indicates that the KE-0806 material presented... superior performance compared to KE-0807, promoting a greater reduction in residual moisture content in within the first few hours after application. This result can be attributed to the greater absorption capacity and structural stability of the polymer, as discussed in the theoretical framework.

Particle size analysis was performed with the aim of verifying possible alterations in Distribution of particles resulting from the application of superabsorbent polymers. Figure 04 It presents the particle size distribution curves obtained for the samples before and after treatment.

Figure 4: Effect of each polymer on the particle size distribution of the ore.



It is observed that the application of PSAs did not promote significant changes in Particle size distribution of the sinter feed. The curves show similar behavior. highlighting the maintenance of the predominant particle size fractions.

This result indicates that the polymers act without causing degradation.

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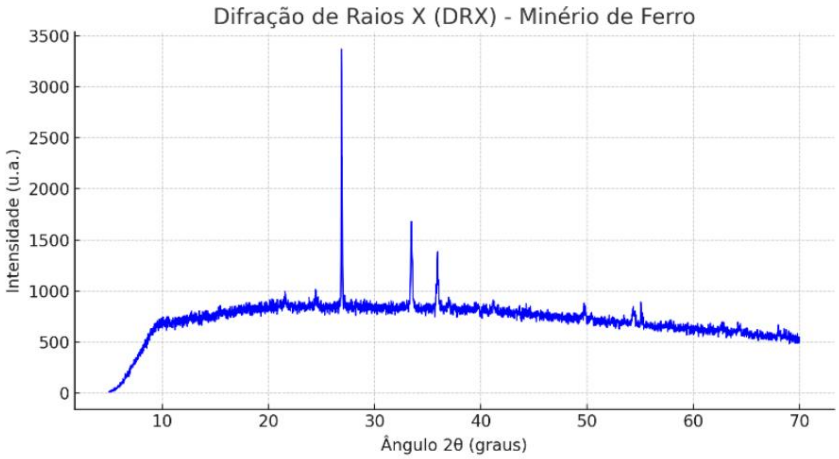
mechanical, excessive agglomeration or segregation of particles, preserving physical characteristics. of the material. Maintaining the particle size distribution is a relevant factor for the industrial viability of application, since it does not compromise the specifications of the product being sold.

The mineralogical characterization of the samples by X-ray diffraction was performed with the objective to evaluate possible structural changes in the ore after the application of polymers superabsorbents. The diffractogram representative of the analyzed sample is shown in Figure 05.

Figure 5: XRD image of an iron ore sample.



Analysis of the diffractogram shows the predominance of mineral phases typical of sinter. The feed featured hematite, magnetite, and goethite. No additional peaks were observed. significant shifts or changes in relative intensity that would indicate chemical reactions, formation of new compounds or structural modifications resulting from the application of polymers. These results confirm that the action of PSAs occurs predominantly through mechanisms physical properties of free water retention, without significant interference in the mineralogical composition of ore, preserving its properties for subsequent processing steps.

The combined analysis of the results for moisture reduction, particle size distribution, and XRD reveals that superabsorbent polymers act efficiently in capturing free water present in sinter feed, promoting improvement in the physical behavior of the material without compromising its structural characteristics. The significant reduction in moisture observed in bench tests, Combined with maintaining particle size distribution and mineralogy, this indicates that the application of PSAs It does not negatively affect the quality of the product. On the contrary, it contributes to its improvement. Fluidity, reduced adhesion, and greater material stability during handling. Furthermore, the The results obtained are consistent with previous studies on the application of polymers. superabsorbents in mineral systems (VENTER, 2003; SRIKAKULAPU et al., 2020), reinforcing The potential of the technology for industrial-scale applications, especially in logistics contexts.

and operational.

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5. Final Considerations

This study evaluated, on a bench scale, the application of superabsorbent polymers.
in the reduction of free moisture in iron ore sinter feed, as well as its effects on the
physical and mineralogical properties of the material. The results obtained demonstrated that the polymers
The evaluated substances were able to promote a significant reduction in moisture content, with particular emphasis on...
Material KE-0806 showed the best performance. X-ray diffraction analyses indicated
maintaining the characteristic mineral phases of the sinter feed after the application of polymers,
highlighting that the action occurs predominantly through physical mechanisms, without alterations.
Relevant structural elements. In addition, particle size analysis showed that the treatment
It did not cause significant changes in particle distribution, preserving the characteristics.
Physical properties of the ore. The combined action of superabsorbent polymers in reducing free water,
Combined with the maintenance of particle size and mineralogy, this indicates that the technology is viable.
Initial technique for application in moisture control in iron ores. These results reinforce
the potential of PSAs as an alternative to conventional methods of moisture mitigation,
especially in large-scale contexts. Although the results are promising, it is worth highlighting...
This study is preliminary in nature, and further investigation is necessary.
Operating conditions closer to industrial reality. Future studies should consider...
pilot-scale assessment, analysis of impacts on pile formation and discharge.
maritime, as well as the economic and environmental viability of the application. Therefore, this work
contributes to the advancement of knowledge about the use of superabsorbent polymers in
mineral processing, establishing technical bases for the development of innovative solutions
aimed at improving the logistical and operational performance of the iron ore supply chain.

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