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Desenvolvimento de shatter automático para a caracterização de aglomerados de finos de minério de ferro

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DEVELOPMENT OF AUTOMATIC SHATTER FOR CHARACTERIZATION OF IRON ORE FINES AGGLOMERATES

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Figure 1. Iron ore products timeline in iron and steel chain

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Development of the iron and steel production chain, the use of iron ore has always been linked to subsequent steelmaking processes:

***Lump* ore (-30 +6.35 mm)**

Pelletizing -0.15 mm

Sintering (6.35 +0.15 mm)

Briquetting -8 mm/-0.15 mm

Iron ore and steel chain

Figure 1. Iron ore products timeline in iron and steel chain

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- In the iron ore and steel industries, the agglomerate, whether sinter, pellet or briquette, needs to withstand the stresses imposed by handling, transportation and storage in piles from the agglomeration plants to the ironmaking.
- In addition to physical stresses, such as breakage due to impact, compression and abrasion mechanisms, the associated effects of bad weather and high temperatures in reduction reactors have a significant influence on the behavior of the agglomerate.

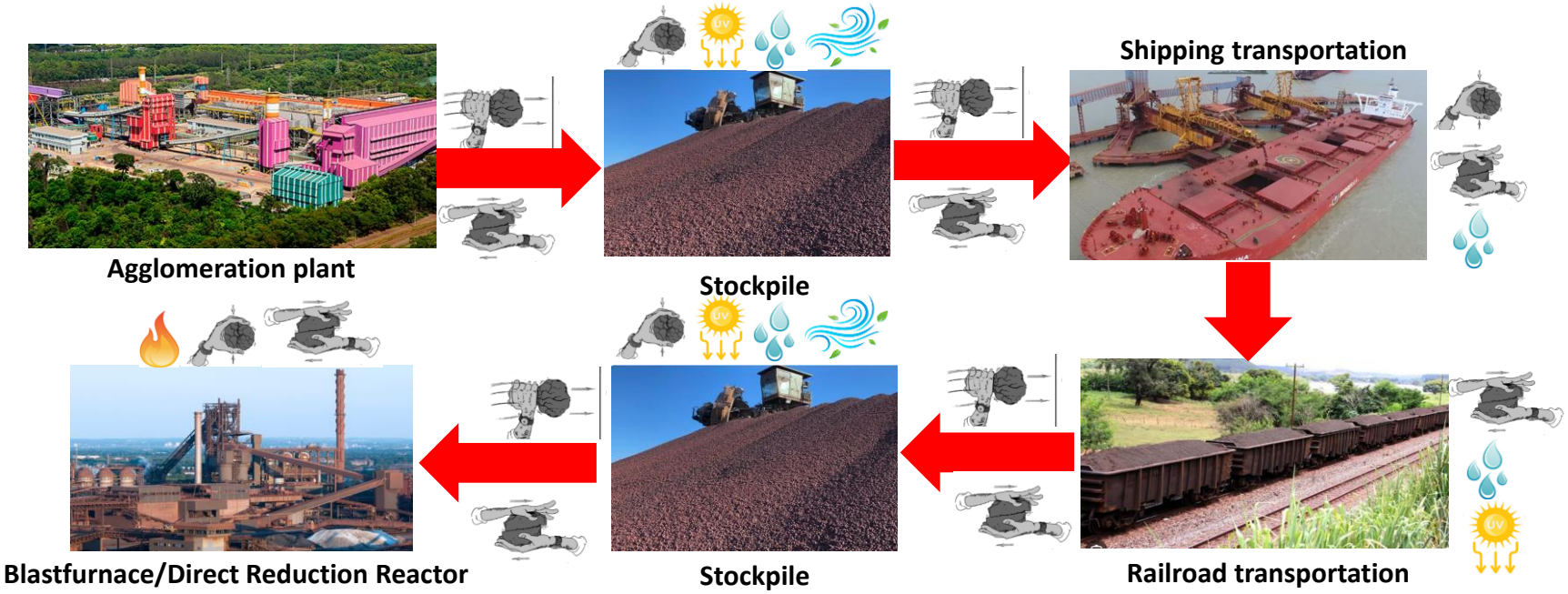

Figure 2. Physical stresses and weather conditions imposed on the agglomerate during handling, transportation and reduction operations

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- The mechanical performance of sinters and pellets is assessed by standardized tests developed by national and international technical associations.
  - Pellet compression: ISO 4700 (2015).
  - Tumbling (abrasion + impact) of pellets, sinters and lumps: ISO 3271 (2015).
  - Shatter (impact) in sinters according to the method developed by JIS M8711 (2011).
- There are no specific standards for assessing mechanical performance for briquettes.
  - Compression: adaptation of ISO 4700 (2015), in which the briquettes are positioned at 0° with the horizontal plane.
  - Tumbling and Shatter: adaptation of ISO 3271 (2015) and JIS M8711 (2011).

Figure 3. Equipment used in physical characterization of iron ore products.

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- JIS M8711 (2011) procedure;
  - In general, carried out on sinters
  - 20 kg of material
  - 4 successive drops from a height of 2 m
  - Shatter index: % + 10 mm
  - Not sufficient to characterize high mechanical strength agglomerates such as pellets and briquettes.
  - Stressed shatter test:
    - 1 kg of agglomerates
    - The number of drops is recorded to obtain 85% of material retained in 10 mm.
    - Carried out on manual apparatus
    - High labor consumption
    - Operator fatigue.

Development of Automatic Shatter

Figure 4. Manual Shatter

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Automatic Shatter:

- Allow JIS M8711 and Stressed Tests
- Stressed Shatter Test:
  - The sample is fed into the lower box. This box is subjected to a 180° rotation to be positioned at a height of 2 m. The gate is opened and the agglomerates fall by gravity onto the box located in the lower region.
  - In the lower box, the gate is opened and the material is directed to the vibrating screen that removes the fines -10 mm to a tray attached to the scale, located in the lower part near the floor.
  - Based on the mass of fines (-10 mm) recorded on the scale, the control system repeats the cycle until a certain percentage below 10 mm is reached.
  - In the case of stressed Shatter, this percentage is 15%.

- Automatic Shatter also allows you to set the number of drops and record the mass below 10 mm.

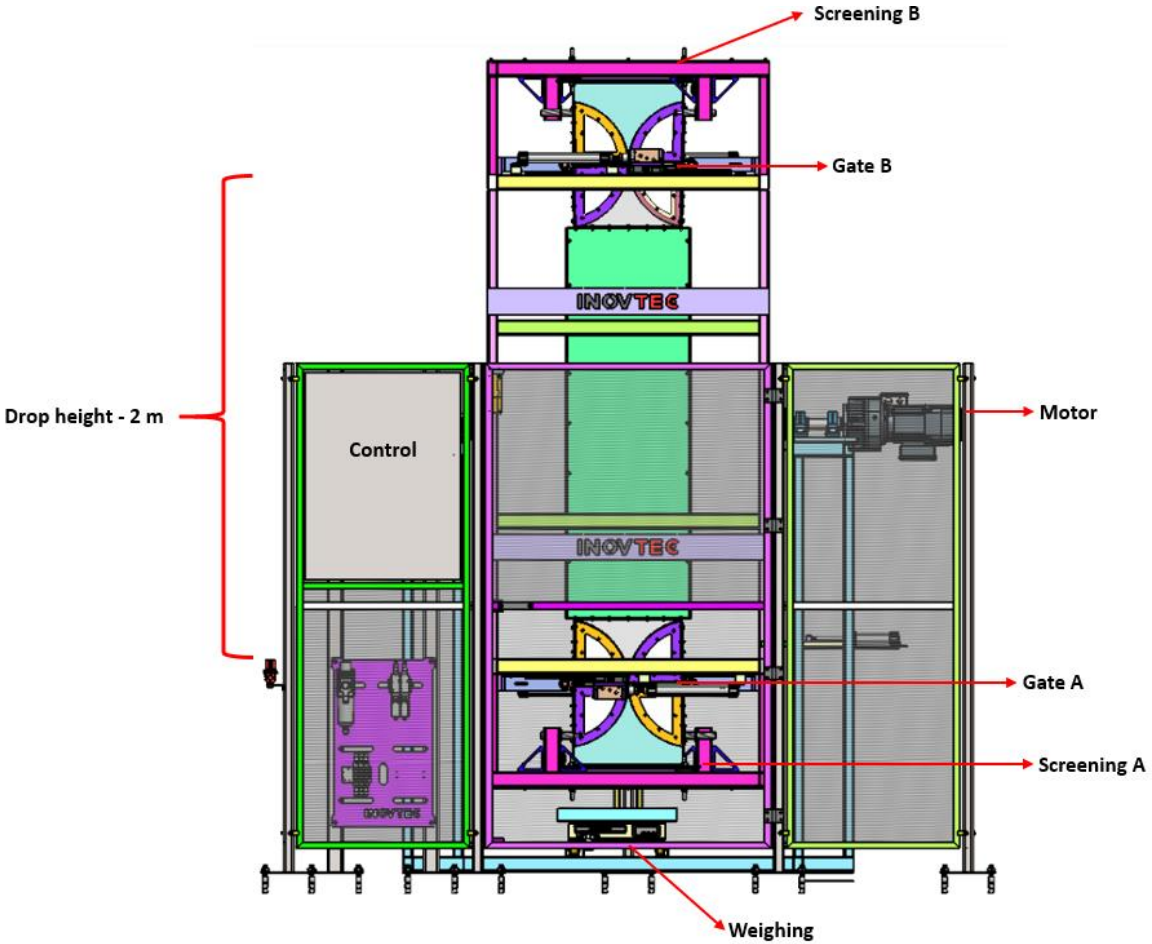

Figure 5. Automatic Shatter scheme

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Figure 6. Automatic Shatter

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- Validation of the proposed methodology:
  - Tests performed in duplicate using the manual Shatter and the automatic Shatter.
  - 3% difference between the result obtained with the manual Shatter and that obtained with the automatic Shatter.

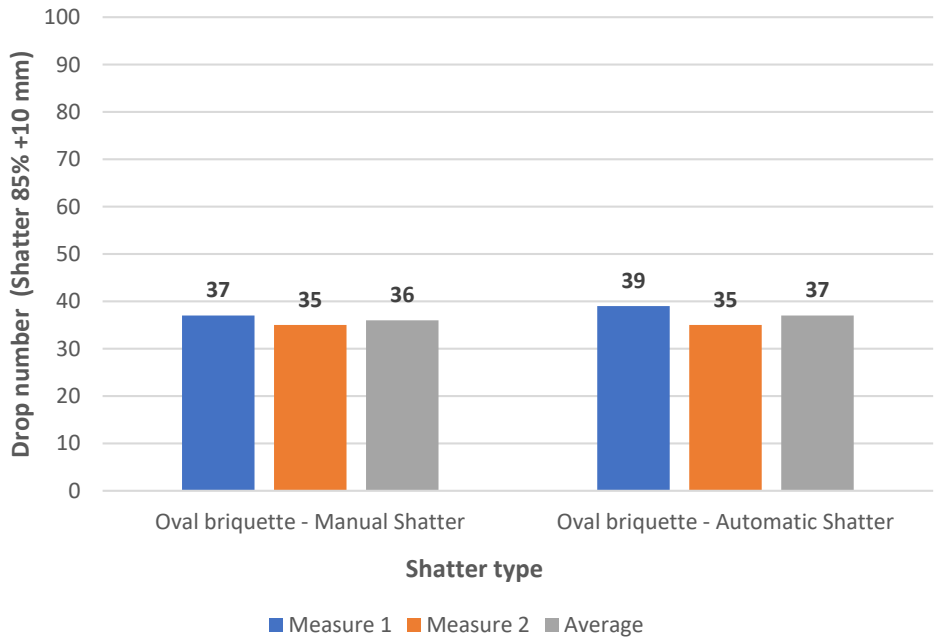

Figure 7. Comparing results from Manual and Automatic Shatter

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- Tests with different types of agglomerates:
  - Significant variation in results when comparing briquettes of different masses and shapes, when a similar composition is evaluated.
  - The number of falls supported by pillow briquettes is:
    - 2.3 times higher than the number of falls supported by oval briquettes, when composition 1 is considered.
    - 1.4 times higher than the number supported by oval briquettes, when composition 2 is considered.

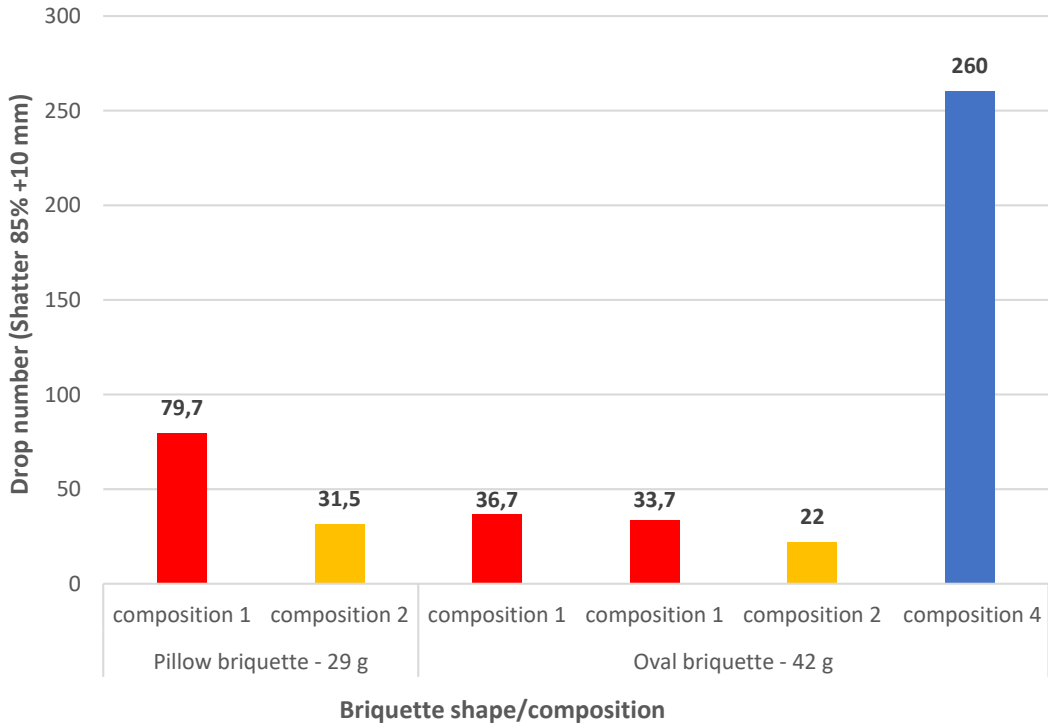

Figure 8. Comparing results from briquettes shape and composition

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- Tests with different types of agglomerates:
  - The difference in results for pillow and oval briquettes can be explained by the difference in the masses of these agglomerates.
  - Lower mass implies lower gravitational potential energy, less breakage.
  - The energy applied to the oval briquette (42 g) is 45% higher than that applied to the pillow briquette (29 g).
  - Since the energy applied to the oval briquette is significantly higher, it is expected that the oval agglomerate will have lower impact resistance when compared to the pillow agglomerate.

Table 1. Gravitational Potential Energy from different briquette shape

	Pillow briquette	Oval briquette
Briquette mass (g)	29	42
Gravity acceleration - g (m/s²)	9,8	9,8
Drop height (m)	2,0	2,0
Gravitational Potential Energy (J)	0,57	0,82

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- Reproducibility of Automatic Shatter Tests:
  - In general, the variation between measurements is low with coefficients of variation below 7.5%.

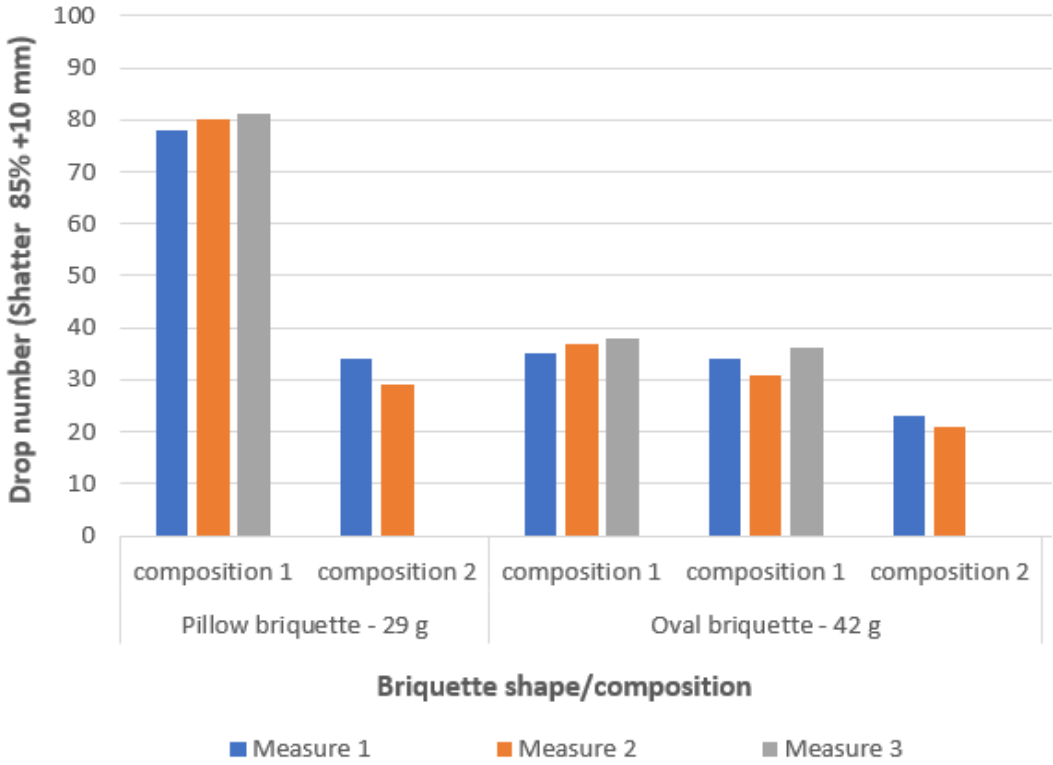

Figure 9. Comparing results from briquettes shape and composition

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Final considerations:

- Automatic Shatter capable of performing tests in automated mode has been proposed. This equipment brings the following advantages over conventional Shatter:
  - reduced labor consumption
  - less exposure of employees, which minimizes the risk of accidents
  - less human interference in the tests greater reliability of results - collected via Wi-Fi, which can be integrated into a cloud database
- Although Automatic Shatter has a higher investment cost than Manual Shatter, operating costs should be reduced, especially when labor is assessed.
- The aforementioned advantages qualify the proposed method for use in R&D centers and to quality control in mining and ironmaking industries.

Thank you!

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