The Use of Prototype Pelletizer for Iron Ore Preparation

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Abstract: In this research, a pelletizer was designed and fabricated as a prototype machine to make iron ore pellets to be used as a blast furnace burden. During the iron manufacturing process, iron ore powder of specified particle size distribution is mixed with a binder, coke powder and calcium carbonate. The raw materials are intimately mixed and thereafter treated with a critical amount of water while the pelletizing is taking place. During the pelletizing process the ore particles are subjected to horizontal and vertical forces applied mechanically coupled with the adhesive forces created by water molecules. The forces acting on iron ore particles would facilitate by bringing the particles together and thereby giving uniformity to the pellet. The addition of water has to be carried out carefully as it is a critical parameter. After careful drying, firstly in air and thereafter in an oven at 110°C for 2 hours, the green pellets thus obtained were sintered to produce the final pellet to be used in the blast furnace.

Keywords: Adhesive forces, Critical moisture, Green pellets

1. Introduction

Sri Lanka is blessed with iron ores such as limonite and magnetite. Presently, these raw materials are un-utilized in the making of iron because of the escalating energy cost of mining, processing, and iron making. From the metallurgical point of view, the final product of modern iron ore preparations is a highly porous and tough pellet or sinter with their unvarying physical and chemical properties and have, proved to be far more valuable than the crude ore from which they are produced (UN report, 1966).

In other words they are more economical to use, and the tendency throughout the world therefore is to use pellets or sinter in blast furnaces and steel making plants instead of crude, unprepared or merely graded ore. The objective of the research is to prepare a suitable pellet using a pelletizer designed and fabricated in the laboratory.

2. Characteristics of iron ore as pellets.

The essential quality of iron ore for use in the blast furnaces is its reducibility. The proportion of iron oxides which will

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be reduced through direct contact with the gases as compared to that reduced through direct contact with the fuel. The latter must be as small as possible. Reducibility depends largely on permeability to gases and hence on the porosity.

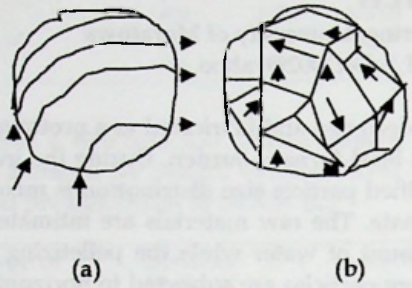

Figure 1. Reducing gas penetration through porosity of the pellet

3. The process of reduction

This process is as follows:

$$2Fe_3O_4 + 8\,CO\uparrow \longrightarrow 6Fe\ (metal) + 8\,CO_2\uparrow \quad \ldots 1$$

Process of slag formation is given by,

$$CaO + SiO_2 \longrightarrow CaSiO_3 \quad \ldots\ldots\ldots\ldots 2$$

In order to effect reduction carbon monoxide has to pass through the pores as shown in Fig 1 a & b and inside the blast furnace 90% of the oxide must be reduced to the metal via reaction 1. The balance will take place when the ore is in contact with the reductants such as coke. The reductions are facilitated by the slag formation and slag metal reactions occur at high temperatures. The slag formed is mainly Calcium silicate.

4. Iron ore preparation and why it is utilized

- To improve the physical and mechanical properties of the ore by crushing and screening it to remove the fines.
- To obtain an ore which is uniform in its chemical composition, especially as regards the content of iron and of the main slag forming components.
- To raise the iron content, i.e. to obtain concentrates rich in iron after removing its impurities.

5. Design and fabrication of a pelletizer.

The designing and fabrication was done in stages by making use of the meagre facilities available in the Earth Resources Engineering workshop. The fabricated final equipment after a series of failures during its fabrication is shown in figure 2.

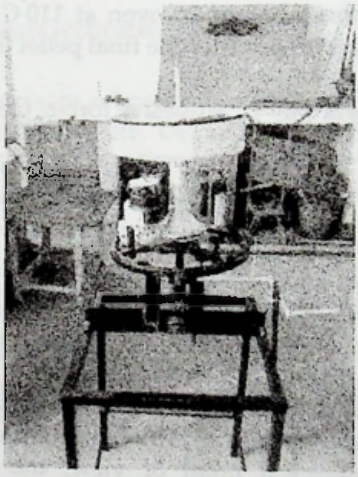

Figure 2. Fabricated pelletizing machine

The iron ore obtained from Dela deposit was subjected to crushing, grinding and sieving to collect < 180 micron particle size. A known weight of the iron ore powder was mixed up with coke, and cement powder using the same sieve in the proportion of 20: 3: 1 and mixed well. Thereafter it was placed on the rotary disc of the pelletizer. Water was

added to the mix in stepwise manner until there was gradual pellet formation. As the pellets started to appear the disc was inclined to 30°, 45° and 50° horizontal, in stages, as shown in Figures 3 and 4.

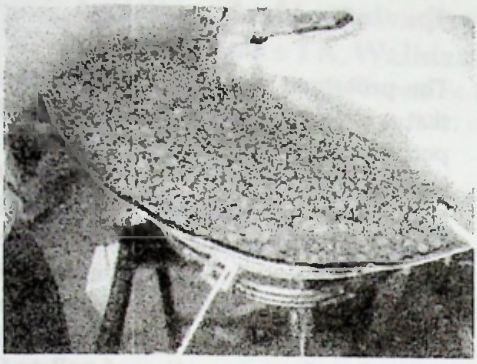

Figure 3. Fabricated machine while making the pellets

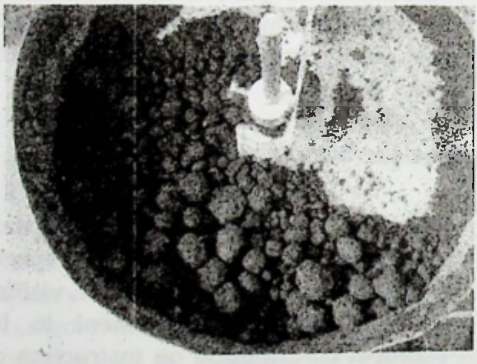

Figure 4. Pellet formation taking place in the pelletizer

6. Results and Discussion

The Dela ore was subjected to the chemical analysis and following results were obtained.
The mixed fractions of the Limonite, coke & cement in the mixture are shown in table 2

Table 1. Chemical analysis of the ore

constituent	Weight percentage %
SiO_2	4.25
Al_2O_3	2.22
Fe_2O_3	80.11
MnO	0.94
TiO_2	-
CaO	0.11
MgO	-
S	0.19
P_2O_5	1.75
LOI	11.02

Table 2. Green Pellets composition

Materials used	Weight (g)	Weight Percentage %
Limonite (Dela)	1000	86.96
Coke	100	8.70
Cement	50	4.35

Sample mixing time = 10 minutes in the Ball mill

Optimum angle of pellets formation in the pelletizer = 36°

Speed of the pelletizer disk = 50 rpm

Collected pellet samples were dried to find the moisture content (table 3).
Average moisture content of pellets at the critical moisture content = 14.4%

Green Pellet Drying and Firing sequence

Oven drying of pellets is at 110°C for 2 hrs
Heating rate is = 10°/minute
Firing temperature = 1300°C
Soaking at the maximum temperature is = 20 minutes

Prepared fired pellet specifications

Sample density = 4000 kgm-3

Pore size of micro pores < 40 microns
Porosity = 20 %
Pellet strength (Fired) = 230 kg (minimum)

Table 3. Drying sequence of moist pellets samples in oven 110°C

Sample No.	Initial weight (g)	After 2hr (g)	After 4hr (g)	After 6hr (g)	Final Moisture Content %
1	17.60	15.40	15.39	15.39	14.36
2	15.90	13.88	13.86	13.86	14.72
3	31.90	27.99	27.94	27.94	14.17

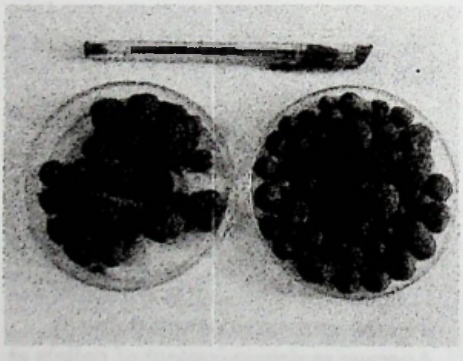

Figure 5. Pellets before (LHS) & after sintering (RHS)

The preparation of pellets using disc pelletizer is an accepted method compared to the other methods. The main parameters which affect the pellets are the moisture content, angular velocity and the inclination of the disc during the pelletizing. By changing these parameters the size of pellets can be controlled. If the angular velocity of the disc is too high, the pellets are thrown out. They start to break when the speed is low. If the moisture content is not enough the balling process cannot proceed. The materials get stuck on the disc when the moisture content is high. Therefore the moisture of the mixture is a critical factor here.

7. Conclusion

The prototype machine (disc pelletizer) that was fabricated has proved to be the perfect choice for the manufacture of iron ore pellets, because this is the established procedure worldwide. Therefore it is necessary to go ahead with a pilot scale plant utilizing the parameters of pellet making thus obtained. This method could also be utilized in the preparation of pellets for direct reduction process using the induction furnace, electric arc furnace to make steel as in the SLRN process. The final steel so obtained may be used successfully to produce quality steel for spring wire castings, reinforcing rods, tool steel, forgings and ductile iron castings.

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References

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