PROCEEDINGS: PROF–97
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Pelletisation of reactant dosed laterite

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ABSTRACT

The present paper deals with process parameters for pelletisation of laterite mixed with gypsum and coal in various proportions with a view to produce pellets for reduction smelting studies. Results are presented for pelletisation of laterite alone with various binders viz. bentonite, starch and sodium silicate. Bentonite and starch are found to enhance the strength of the pellets. It was observed that higher quantities of gypsum (as stoichiometrically required for converting various metal oxides available in laterite to sulphides) detrimentally affect the pelletising characteristics of the mix. Various mixing methods were investigated. Pellets could be prepared by alternate charging of laterite coal mix and gypsum giving rise to a concentric layered arrangement of constituents. Premoistening followed by attrition mixing was found suitable for producing pellets with good physical properties. Addition of 6% moisture with attrition mixing in a rod mill for 10 mts produced pellets of smooth spherical morphology with drop nos. 6-17/p and air dried strength of more than 4 kg/p.

INTRODUCTION

Nickel is produced mainly from lateritic and sulphide nickel ores. Of the total world nickel production in 1986, 62% came from sulphide ores and the rest from lateritic ores [1]. World reserves of nickel laterites are considerably higher than that of the sulphide nickel ores and hence their importance is expected to grow in future. Pyrometallurgical as well as hydrometallurgical routes have been in use for commercial nickel production from laterites. In India commercial production of nickel has not yet commenced and its entire annual requirement is met through imports [2,3]. Even though India does not have a known sulphide nickel ore deposit, large deposits of nickeliferous laterites estimated at 294 million tonnes are available in the state of Orissa [4,5]. Besides, chromite overburden generated during chromite mining is also an important source of nickel. About 5,000,000 tonnes of chromite overburden is generated each year in addition to the 140,000,000 tonnes

accumulated over the years [4,5]. Extensive studies have been carried out on these Indian laterites for nickel extraction [6.16].

Pelletisation behaviour of Indian laterites have earlier been studied by Mahanty and Coworkers [17] and Ganguly et. al. [18,19,20] Mahanty and coworkers used a disc pelletiser for pilot plant scale pelletisation of laterite mixed with fuel oil. Ganguly and coworkers studied the effect of variation of moisture, bentonite, lime contents etc., on pellet properties. They found that the recovery of sound pellets increased with increase in moisture and bentonite contents upto 10% and 1.2% respectively. They also observed that both temperature and duration of firing made positive contribution towards strength but it was at the cost of permeability. The strengths varied form 0.16 kg –7.25 kg/p. Maximum strength of 7.25 kg/p was obtained on firing pellets (1% bentonite, 4% lime) at 1100°C for 3 hrs. The permeability values varied from 206.4 to as low as 23.2 during the experiments. Imanishi et. al. [21] pelletized nickel residue from laterites. They obtained sufficient green strength even without any binder. On firing at 1220°C they could achieve a strength in excess of 200 kg/p and porosity upto 30%. Higher firing temperature increased the strength of the pellets but led to drastic reduction in porosity.

The present paper deals with the studies to determine suitable process parameters for pelletisation of laterite along with gypsum and coal as required for the smelting reactions. This is an alternate process of recovering Ni and Co from Indian laterite using sulphide route. The process consists of pelletisation of laterite mixed with appropriate amounts of gypsum and coal. Pellets are then reduction roasted to form matte which is then smelted and refined by Mond's process.

EXPERIMENTAL

The present work was done on a laterite sample from Sukinda valley, Orissa and the analysis is given in Table 1. Granulometry of the sample is given in Table 2.

Table 1 : Chemical analysis of sample used

Constituents	Wt (%)
Ni	0.97
Fe	21.22
Co	0.055
SiO_2	57.36

Gypsum used in the experiments was of analytical grade and consisted material mainly of –74 micron size. Non-coking coal having 37% fixed carbon, 33.5% ash and 24.2% volatile matter was used as reductant. It was ground to –105 microns.

Table 2 : Size analysis of the sample

Size, micron	Wt (%)
+ 150	0.2
–150 + 105	4.8
–105 + 75	5.0
–75 + 45	14.5
–45	75.5

Initial tests were conducted to see the pelletisation behaviour of laterite and the effect of binders (starch, bentonite and sodium silicate) on pellet properties. Pelletising property of the mix as well as physical properties of the pellets were found satisfactory. However on heating beyond 200°C the crushing strength of the pellets dropped sharply. Tests with calcined laterite yielded comparably better crushing strength at 300°C. Hence subsequent tests out on calcined laterite.

Subsequently pelletisation studies were conducted with laterite-gypsum-coal mix containing stoichiometric proportions (for smelting studies) and higher amounts of gypsum and coal. Various tests studies were conducted using laterite, gypsum and coal in such proportions that the molar ratio of $MO:CaSO_4:C$ were 1:0:4. 1:1:5, 1:1:5:6 and 1:2:6. the constituents were mixed in a paddle mixer and thereafter charged in to the drum pelletiser for pelletisation. It was observed that seeds which formed immediately after addition of moisture agglomerated with one another due to excess moisture present on the surface. Addition of fresh feed did not help and situation deteriorated further by addition of moisture. With a very slow water addition this problem was minimized but only to a certain extent. Still the pellets had a irregular morphology with rough surface and the duration of pelletisation was longer too.

To obviate this problem laterite and coal was mixed and rolled to form seeds. Subsequently these seeds were grown with alternate charging of the gypsum and remaining amounts of coal-laterite mix. In a similar way pelletising with gypsum at the inner core was also possible. Pellets thus formed were found to be good in shape and physical properties even though it had layered structure. Subsequently mixing method was modified. Here the laterite-gypsum-coal mix was moistened and charged in a ball mill and attrition mixed. Moisture content and the duration of mixing were varied to get the optimum values. A moisture of 6% was found optimum beyond which discharging the mix from the mill was difficult. For mixing a duration of 10 minutes was found to be sufficient. Considerable improvement in the pelletisation characteristics were observed with this modification resulting in the formation of well shaped spherical pellets with comparatively better physical properties.

RESULTS AND DISCUSSION

Effect of sodium silicate, bentonite and starch on pellet properties is depicted in Fig. 1, 2, and 3. The substantial drop in strength, on heating above 200°C might be due to the phase transformations of goethite to hematite. Calcined laterite gave some improvement in the strength of the heat treated pellets.

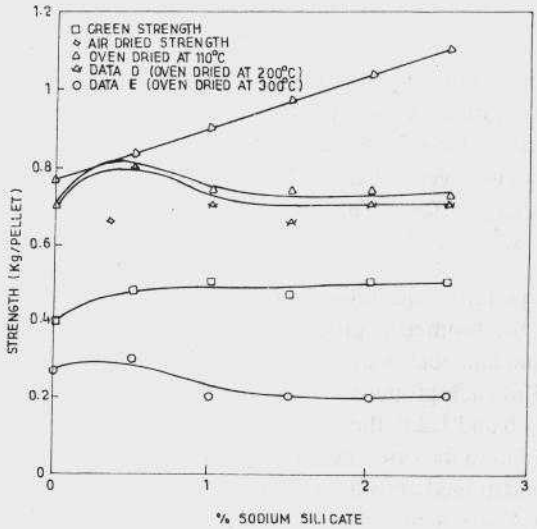

Fig. 1 : Effect of variation of sodium silicate on pellet properties.

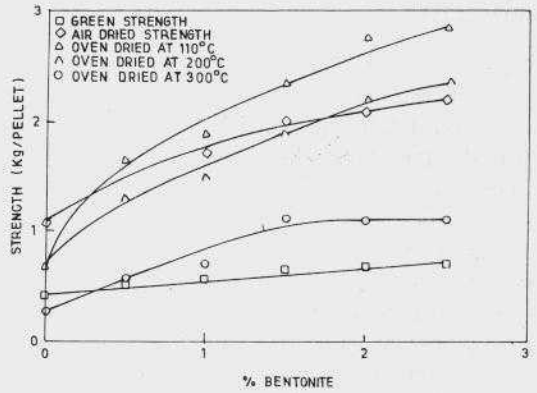

Fig. 2 : Effect of variation of bentonite on pellet properties.

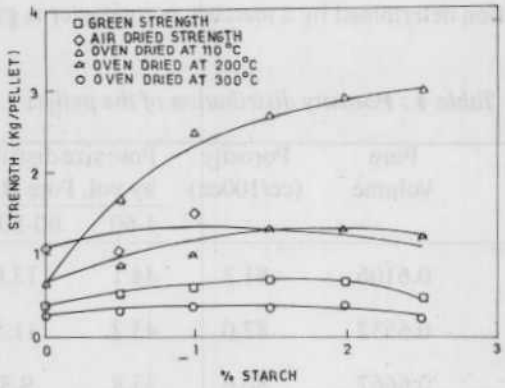

Fig. 3 : Effect of variation of starch on pellet properties.

In the laterite + gypsum + coal mix, higher quantities of gypsum disturbs the water retention capacity of the mix during seed formation. As a result water remains on the surface and they agglomerate with one another giving rise to conglomerate of seeds instead of pellets. By charging the different constituents of the mix alternately, pellets with good shape and physical properties were obtained. The strength of the pellets thus formed are given in Table 3. Here a strength of 2-4 kg/p was obtained. Substantial reduction in strength was noted on heating even though calcined laterite was used. Metallurgically alternate layers of reacting substances will be undesirable.

Pellets produced from premoistened and attrition mixed feed had strength in excess of 4 kg on air drying and were found suitable during reduction roasting studies. But in this case also the pellet strength on heating at 200–300°C or reduction roasting at various temperatures above 900°C decreased and they crumbled on slight pressure. Physical properties of pellets made are given in Table 5.

Table 3 : Compression strength of the pellets

Molar ration	Strength (kg/p)			
$MO:CaSO_4:C$	Green	Air dried	200°C	300°C
1:0.5:4	0.4	2.5	0.69	0.35
1:1:5	0.6	4.0	0.64	0.38
1:1.5:6	0.5	3.0	0.67	0.37
1:2:6	0.7	3.8	0.74	0.44

Porosity distribution determined by a mercury porosimeter is given in Table 4.

Table 4 : Porosity distribution of the pellets

Molar ration MO:$CaSO_4$:C	Pore Volume	Porosity (cc/100cc)	Pore size distribution % pores by vol. Pore Radii in A		
			4-60	60-500	500-75000
1:0.5:4	0.6106	81.2	44.1	13.6	42.3
1:1:5	0.6532	82.0	43.2	11.5	45.3
1:1.5:6	0.6667	80.6	33.8	9.8	56.4
1:2:6	0.7041	84.4	40.5	11.5	48.0

Table 5 : Physical properties of pellets made from premoistened and attrition mixed feed

Molar ration MO:$CaSO_4$:C	Drop No	Compression strength (kg/p)			
		Green	Air Dried	200°C	300°C
1:0.5:4	6	0.5	3.5	0.7	0.2
1:1:5	17	0.6	7.0	2.0	0.8
1:1.5:6	7	0.6	6.8	1.7	0.5
1:2:6	6	0.5	6.5	0.5	0.2

CONCLUSIONS

The poor pelletising property of the laterite-coal-gypsum mix could be overcome by (1) alternate charging and (2) by attrition mixing method. The latter is preferable as the layered reacting substances may not be appreciated metallurgically.

ACKNOWLEDGEMENTS

We express our sincere thanks to Prof. P. Ramachandra Rao, Director, NML for permitting to present this paper. The authors express their gratitude to EEC for providing necessary funding and Dr. Animesh Jha for co-ordinating the project. We also express our thanks to M/s. PDIL, Sindri for porosity distribution measurements.

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