Amenability to Processing of Manganiferous Iron Ore

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Abstract

Manganiferous iron ore from Karnataka state was investigated to upgrade the iron content with lowering of manganese in concentrate. Mineralogical studies show that it is comprised of microplaty hematite, martite, goethite, pyrolusite, cryptomelane and minor amount of quartz and kaolinite. The sample contains about 51.4% Fe, 4.75% Mn with 8.5% SiO_2 and 2.8% Al_2O_3. The crushed to 1mm and 3mm samples were subjected to reduction roasting using producer gas. The reduction roasting converts the hydrated iron oxide mineral into more magnetic materials which facilitates the magnetic separation at low intensity leaving manganese minerals in non-magnetic. The reduced products were subjected to magnetic separation at very low magnetic field to recover magnetite. The final concentrate containing 64.1% Fe and 2.3% Mn is achieved with a yield of 73.5% from -1mm sample. This product can be blended with the low Mn- hematitic concentrate with 65% Fe to generate a pellet feed.

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1. Introduction

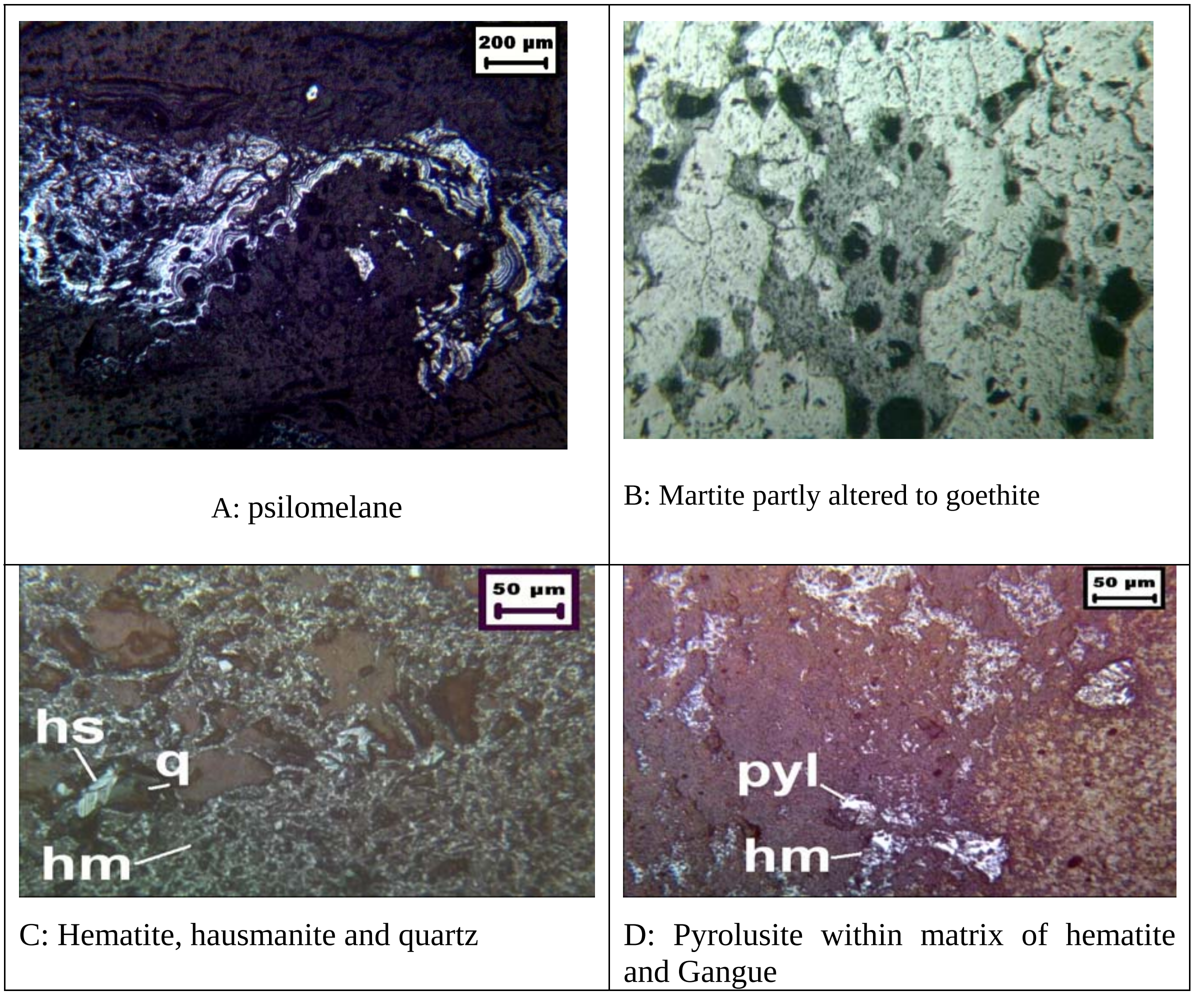
In India, the production of steel is increasing tremendously. It is expected to be 110 million tonnes (more than double of the current level of around 42 million tonnes only) of steel per annum by 2020 which would require around 190 million tonnes of iron ore. The reserve of iron ore is about 25 billion tones which will last for 75 to 85 years. Around 200 million tonnes of iron ores produced every year [1]. The beneficiation of the iron ore is very important part for improving the efficiency of blast furnaces. Various techniques, based on the sizes of the iron ores, are adopted for improving the grade of Fe from 56-57% to 64-65%. As the demand of iron ore is increasing, it is necessary to treat the low grade iron ore. These iron ores need fine grinding for getting adequate liberation. In that case it is difficult to get blast furnace feed or sinter feed. The process product can be utilized for making pellets. In India, there are few pellet based furnaces are available, but in near future many more pellet based furnace may come up due to increased efficiency of the blast furnace. In India, high grade iron ores available in Orissa, Jharkhand and Gua are hematitic ore with quartz, kaolinite association where-as that in west Dhrawar Craton and especially in Karnataka are hematite-magnetite type in association with manganese, quartz and kaolinite. The beneficiation of the former is focused on upgradation of Fe in concentrate and lowering of alumina, whereas the latter is focused for the lowering in Mn-content as well.

The objective of this present investigation brings the light on the amenability to processing of manganiferous iron ore and its utilization for pellet feed.

2. Experimental Procedure

2.1 Material Characterization

The sample is lateritic in nature with ochreous brown colour. There is wide range of grain size from fine to as coarse as 10mm. It is dominantly fine grained, having hardly about 5.5 % by weight of size +10mm lump and about 20.6% of -32 micron. The mineralogical study indicates that the sample dominantly consists of goethite, hematite and martite with minor amount of pyrolusite, psilomelane, hausmanite quartz and kaolinite. The grains of larger size class are dominantly of microplaty hematite, martite and goethite with no or rarely present magnaniferous phase. Goethite is the most dominant mineral in the ore giving it an ochreous appearance. Due to the dominance of goethite and its association with interlocked clay minerals (kaolinite), the alumina and silica content may be high. The MnO_2 is contributed by pyrolusite, cryptomelane-psilomelane and hausmanite (Fig.1).



A: psilomelane

B: Martite partly altered to goethite

C: Hematite, hausmanite and quartz

D: Pyrolusite within matrix of hematite and Gangue

Fig. 1: Microphotographs of manganiferous iron ore

2.2 Method

The representative sample was taken for chemical analysis and is given in Table 1. It shows that the Fe content in the given sample is about 51% only and high LOI in the sample indicates the presence of hydrated iron mineral. In this case it is envisaged that direct processing of the ore may not give successful results. To improve the grade of Fe and to reduce the Mn content in the concentrate, the sample was crushed to finer sizes. Even though the liberation was poor at coarser size, the sample was crushed to 1mm to minimize the losses at finer size and carry out the reduction roasting in a tubular furnace using producer gas. The loss in weight after heating was recorded. The test was also carried out at two different temperature, viz. 570^0 C and 650^0C. The roasted sample was ground to finer sizes and subjected to low intensity magnetic separation at very low magnetic field (>1000 Gauss).

Title 1: Chemical analysis of Feed sample

Fe (%)	SiO_2 (%)	Al_2O_3 (%)	Mn (%)	CaO(%)	MgO(%)	LOI(%)
51.36	8.50	2.82	4.75	0.52	0.61	8.15

3. Results and Discussion

3.1 Reduction roasting of -1 mm sample followed by magnetic separation

Magnetising reduction roasting with reducing gas under the heat treatment converts iron oxide/hydroxide mineral into hematite or magnetite. This facilitates to separate the magnetic particles at low intensity leaving out the manganese in non-magnetic fraction. The results of reduction roasting at two different temperatures are given in Fig. 2. These tests were carried out in a tubular furnace using producer gas for one hour at two different temperatures, viz. 570^0 C and 650^{0}.C. The loss in weight after heating was recorded. In both the cases, the Fe content in the reduced product is about 60%. The roasted sample was subjected to wet magnetic separation at a low magnetic field (>1000 Gauss). The magnetics recovered in 570^0 C is more than that at 650^0C (Fig. 3). The stability diagram of different iron oxides tells that temperature higher than 570°C, hematite (Fe_2O_3) is first transformed into magnetite (Fe_3O_4), then into wustite ($Fe_{1-y}O$), and finally into metallic iron whereas at temperatures below 570°C, magnetite is directly transformed into iron since wustite is not thermodynamically stable [2].

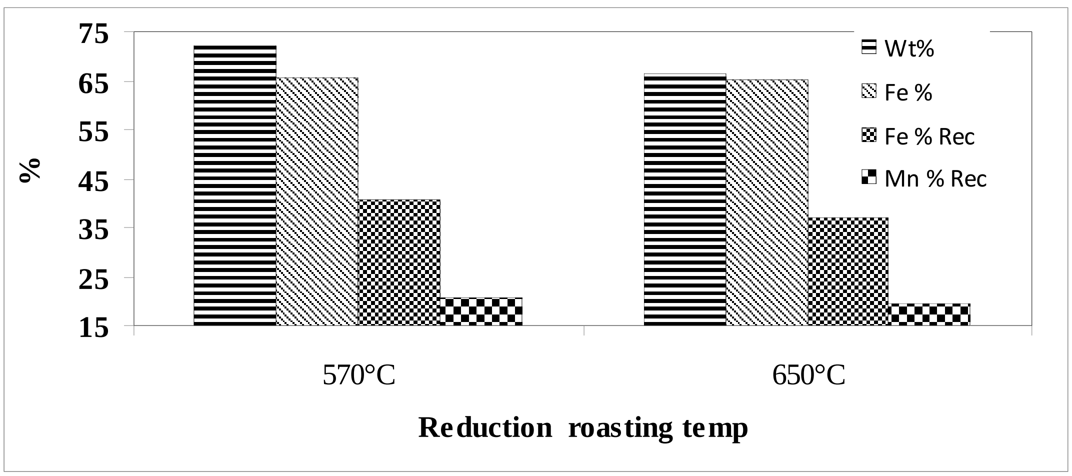


Fig 2: Reduction roasting of -1 mm sample at two different temperatures

The magnetic separations carried out with roasted samples at different time at 550°C are given in Fig. 3. The study indicates that as the duration of roasting is increased, the more materials get reduced as it can go into the deeper surfaces. The recovery of Mn in magnetic concentrate goes down as the roasting time increases from 30 to 60 minutes; extending the time, reduces the recovery of Fe substantially. The recovery of Mn in the concentrate reduces after 90 minutes which is essentially required to reduce the weight % of Mn in the final concentrate, but at the same time, the yield reduces by 14% when compared with 60 minutes. The longer residence time for roasting transforms the magnetite to wustite which reduces its tendency to report to the magnetic concentrate. A further increase in time to 120 minutes hardly causes any change [2,3].

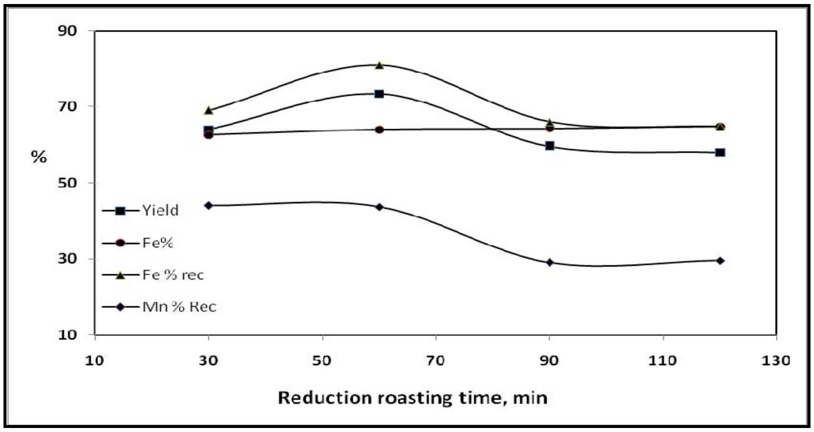


Fig. 3: Magnetic Separation of -1 mm reduced sample at different time

The results are quite encouraging. All the tests indicated that a product with above 63% Fe could be obtained. With the encouraging results as obtained by reduction roasting of -1 mm followed by magnetic separation, the size was increased to -3 mm.

3.2 Reduction roasting followed by magnetic separation with -3 mm

Keeping in view, the encouraging results from reduction roasting of -1 mm sample, attempts were made to carry out reduction roasting at coarser size, i.e. crushed to 3 mm. The experimental conditions remained same. With this sample, the tests were performed only at 550°C. The % loss is more in case of 90 minutes roasting time and that subsequently increases the Fe-content in roasted product (Table 2). It shows that longer duration (90 min roasting time) is required for the phase transformation as the minerals are less liberated and more soaking time needed at coarser size.

Title 2: Reduction roasting of -3 mm sample at 550°C

Reduction Time, min	Product	Wt %	% loss	Fe%	SiO2 %	Al2O3 %	Mn %
60	Roasted sample	90.5	9.5	56.77	9.44	3.13	5.22
90	Roasted Sample	87.5	12.5	58.54	9.75	3.22	5.51

The roasted sample was subjected to wet magnetic separation after crushing to 1mm to get better liberation (Table 3). The Fe-content and yield of the concentrate, both are less than the same recovered from -1mm feed. Title 3: Magnetic Separation of -3 mm reduced sample

Reduction Time, min	Product	Wt% wrto	Fe%	SiO2%	Al2O3%	Mn%
60	Magnetic	60.14	62.65	3.85	2.35	2.78
90	Magnetic	66.61	63.33	3.62	2.20	2.63

The Mn-content in the above concentrate is marginally higher than required level for pellet feed. This product can be used as pellet feed after blending with low Mn- hematitic concentrate with 65% Fe to reduce the Mn-content to 1%. The presence of manganese in the iron concentrate to a level of 1%

increases the compression strength of the pellet in the blast furnace, but has detrimental effect in the blast furnace when above 1%. Some work had been carried out by adding additives like manganese and other in the pellet feed, to study the pellet strengths with a corresponding loss of reducibility [4,5]. Therefore, considering the growing demand of iron ore to be prepared as pellet feed for blast furnaces and direct reduction roasting in steel making, the processing of iron ore containing manganese as gangue minerals has an added advantage.

4. Conclusions

The time variation reduction roasting studies with producer gas followed by magnetic separation shows significant improvement in iron-content. The comparative studies made with different feed-size are concluded below:

- Longer reduction roasting time is required for -3mm feed to achieve the same grade of Fe and recovery of Mn in final concentrate than -1mm feed.

- Reduction roasting for 60 minutes with -1mm feed can produce a concentrate of 73.5% yield assaying 64.1% Fe and 2.3% Mn, which is 8% and 1.0% more in yield and Fe respectively when compared with -3mm.

- Concentrate produced can be blended with low Mn- hematitic concentrate with 65% Fe to produce a pellet feed. The combined manganese contained to 1% level can give enough strength to the pellets.

5. Acknowledgement

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