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IMPROVING REDUCIBILITY OF IRON ORE PELLETS BY OPTIMIZATION OF PHYSICAL PARAMETERS

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Abstract

Reducibility of iron bearing material is an important property which represents its suitability of reduction in iron making furnaces. It has direct influence on improving productivity and lowering energy consumption in iron making process. The reducibility of iron ore pellets of a specific chemistry can be improved by the optimization of physical parameters such as induration temperature, improving size distribution of fines, improving apparent porosity etc. In this study, the reference pellet is prepared in a typical plant condition and the properties of the reference pellet are considered as base value to improve reducibility index (RI) maintaining other properties at the acceptable limit without altering pellet chemistry. Optimization of induration temperature at the 1250-1275 ºC shows around 74 % RI, which is 5 points more than the base value of 69.5 %. Furthermore, on optimizing additives size, such as limestone fines and anthracite coal fines at -350 mesh and induration temperature of 1250-1275 ºC, RI is improved to 77 %, i.e., 8 points improvement is achieved with respect to the base value.

***Keywords**: Iron ore pellet; Reducibility index; Reducibility improvement; Physical parameters; Induration temperature*

1. Introduction

Reducibility of iron bearing material is one of the important parameter along with the other properties. It is defined as the percentage reduction of iron oxide materials in solid condition in gaseous atmosphere (800-1000 °C). The reducibility improvement of iron bearing materials can improve the indirect reduction in blast furnace and thereby increase productivity and quality of hot metal and decrease energy consumption. Use of agglomerates such as pellets and sinter in blast furnaces is increasing day by day to utilize fines and concentrates replacing lump ore. Reducibility mostly depends upon the individual ore character and its agglomeration parameters. To increase the performance of pellet in blast furnace, it is required to improve the reducibility of hematite pellet.

Reducibility of iron oxide pellet largely depends upon phase formation during induration, such as fayalite, hercynite, calcium di-silicate and ferrite, SFCA, iron monticellite, calcium magnesium silicate, magnesio-ferrite, secondary hematite and magnetite etc.[1,2]. Furthermore, phase formation in pellets mainly depends upon the gangue materials present in original ore, type and composition of added flux materials and condition of induration.

Shigemats et al.[3], found that the reduction reaction proceeds slowly if SiO_2 and FeO are present in pellet in form of fayalite (2FeO SiO_2). Furthermore, Al_2O_3 enhances to form hercynite (FeO Al_2O_3) which is crystallized out between the grains of wustite. Therefore, dissolved FeO with SiO_2 and Al_2O_3 are hardly reduced. Baldwin et al.[4] reported that fayalite formation in iron oxide pellet is prevented by lime. At the basicity (CaO/SiO_2 ratio) below 0.4, lime, silica and ferrous oxide become fused and form iron monticellite (CaO FeO SiO_2) and free ferrous oxide at the temperature of induration above 1100°C. However, at the basicity of around 2 it forms gamma dicalcium silicate at the same temperature of induration. A study with calcium hydroxide in iron ore pellet [5] showed that with increase in calcium hydroxide, amount of FeO increased because secondary Fe_2O_3 reacted with CaO forming ferrite which helped in decomposition of Fe_2O_3 again to FeO. Thus, with increase in amount of calcium hydroxide, hematite phase decreases due to dissociation of higher oxides to lower oxides. The reducibility increased with increasing amount of calcium hydroxide until 0.5 and then decreased due to increase of divalent oxides which are more difficult to reduce.

Baldwin et al.[4] added 10 wt % of calcined dolomite to suppress the fayalite formation. No

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fayalite was found at any temperature of induration in the range of 700 – 1200 °C. A new crystalline phase, calcium magnesium silicate (merwinie) was formed when dolomite was added with ferrous-oxide –silica mixture and heated above 1200 °C. MgO containing pellets exhibited higher reducibility than acid and MgO free pellets when a magnesium silicate mineral, pyroxenite was used as MgO source [6]. A dolomite [7] and other MgO-bearing materials such as olivine, magnesite [8,9] and serpentine were effectively used as basic fluxing materials to improve both reducibility and reduction degradation index. During induration of MgO containing iron oxides, MgO diffuses in the Fe_2O_3 lattice forming magnesio-ferrite (MgO Fe_2O_3) spinel (melting point 1713 °C). The magnesio-ferrite in the fired pellets improves their strength during reduction and increases the softening temperature. Porosity, pore volume and pore diameter in pellet also increases in presence of MgO in pellet [7].

The presence of alkali and alkaline earth metals [10,11] can improve the reducibility of the FeO due to disturbances generated in the crystalline reticulate by interstitial ions. Nasr et al. [12] studied the effect of addition of NiO on reduction of hematite compacts and they observed that the rate of reduction of NiO doped hematite compacts gradually increased with the increase in reduction temperature and NiO content because of formation of $NiFe_2O_4$ which was more reducible than iron oxide and helped increasing porosity. Botelho et al.[13] invented a process of improving reducibility of iron ore by adding metallic Ni containing materials wherein, the catalytic effect for the reduction was generated by the addition of metallic Ni. Presence of Cr^{3+} also increases the reducibility of iron oxide by CO due to catalytic effect of partially filled d-band and unpaired electron [14].

Reported literature indicates that investigators have studied the basic fundamentals on reducibility and its improvement by changing different parameters mainly through the change in chemistry and phase formation by different additives and fluxes. However, there is hardly any systematic study to improve the reducibility of iron ore by the change of physical parameters. This study aims to improve the reducibility index (RI) of hematite pellet with respect to the current level keeping other properties in the acceptable limit by suitably changing the physical parameters of pelletization such as, optimizing induration temperature, size distribution of fines and improving apparent porosity without altering the chemistry of green pellets or additives.

2. Experimental procedure

Joda iron ore was used for this study. The size distribution of the prepared iron ore fines and its chemical compositions are presented in Tables 1 and 2, respectively. Limestone fines of varying sizes were used as CaO source and olivine was used as MgO source. The chemical analyses of these two fluxes are shown in Table 3. Anthracite coal of varying size containing fix carbon: 80.33 wt%, ash: 13.53 wt % and volatile matter: 4.30 wt%, was used in pellet mix.

The sized iron ore fines were mixed with bentonite (0.3 %) and required amount of fluxes to get desired pellet chemistry in a rotary cone mixer. The mixture was then pelletized with intermittent manual spray of water (7-9 %) for nucleation and growth of pellets in a disc pelletizer having 700 mm disc diameter with 30 rpm speed. The pellet size was maintained between +8 mm and -16 mm. After preparation, the green pellets were discharged and subjected to tests viz. green compressive strength (GCS), green drop strength number (GDSN), dry compressive strength (DCS) and moisture content.

The pellet chemistry of a steel plant, M/s Tata Steel Ltd (TSL) was chosen as typical composition (CaO: 1.0 %, MgO: 1.4 % and C: 1.2 %) to make the reference pellet. First, the reference pellets were made taking iron ore fines of Blaine fineness 2855 cm^2/g as used in TSL, whose size fractions are given in Table 1. Then the prepared pellets were characterized in green and dry condition. Dry pellets were indurated in a chamber furnace at 1325 °C, based on the plant condition. This indurated pellet of above composition was termed as 'reference pellet'. All of its properties were considered as the base value. The RI improvement was targeted with respect to the base value of RI. Accordingly, in the next stage of experiment, the physical parameters of pellet making and treatment condition were changed suitably to get improved RI. Types of pellets made and their treatment conditions are shown in Table 4. All the above pellets were characterized as follows.

Table 1. *Size fraction of iron ore used, (wt%), BIS Mesh*

B. No, cm^2/g	+72	-72+ 100	-100+ 170	-170+ 200	-200+ 350	-350
2855	3.24	8.63	10.31	5.95	8.88	62.99

Table 2. *Chemical Analysis of ore fines, wt%*

Materials	Fe_{tot}	SiO_2	Al_2O_3	CaO	MgO	P	S	LOI
Joda iron ore fines	64.05	1.61	1.78	0.15	0.05	0.078	0.007	3.06

Table 3. *Chemical compositions of fluxes used, wt%*

Flux materials	MgO	CaO	SiO_2	Al_2O_3	LOI
Olivine	48.5	0.29	35.16	0.48	1.29
Limestone	0.69	51.51	1.4	0.65	42.9

GCS was measured just after making green pellets using Hounsfield material testing machine. GDSN was conventionally measured by repeatedly dropping an individual green pellet upon a mild steel plate from a conventional height of 450 mm. The average number of drops accepted by the pellets before breaking was termed as GDSN. The green pellets were dried in an oven at 110 °C for four hours. DCS of oven dried pellets were measured in Hounsfield material testing machine. The moisture content of pellet was measured by the weight loss suffered by a representative sample (20-25 g) of the untreated pellet on heating in an oven at 110 °C for 4 hours to ensure constant weight.

The pellets were indurated (in varying capacity of 0.1 kg to 1.5 kg per batch) in an electrically heated chamber furnace in varying temperature for 10 min soaking using inconel / mullite crucible. After cooling of indurated pellets, the cold crushing strength (CCS) was measured for each of the pellets using Hounsfield Materials Testing Machine (Model: H 10K-S) as per standard: ISO 4700.

Apparent porosity (standard IS: 1528, part-VIII-1974) of indurated pellets was measured in kerosene medium. Extent of reduction of ore in gaseous reducing atmosphere can be measured. Percentage of reduction of ore in reducing gas atmosphere at elevated temperature is called Reducibility index (RI). Good RI is important in BF operation, specially, to achieve good productivity and low coke rate. RI of pellets in this study was measured as per standard: JIS: M 8713-2000. Swelling index (SI) was measured as per standard: IS: 8624 -1995. After 3 hrs of reduction in 30% CO and 70% N_2 in gas at 900 °C, volume change of pellet was measured by mercury displacement method. Percentage of generation of fines (-3.15 mm) after reduction (for 30 min) and subsequent tumbling in a drum of 200 mm length and 130 mm diameter is termed as reduction degradation index (RDI). RDI of several indurated pellets was measured as per standard: JIS: M 8720-2001.

In order to study the existence of several phases, XRD analyses of indurated pellets after making powders of it (-100 mesh) were carried out for phase analysis by a Siemens D500 X-ray diffractometer using Cu-K$\propto$ radiation. The scanning speed was maintained at 2 θ , 1°/min. Existence of several phases was identified by JCPDS files. Selected samples were observed under the optical microscope (Model: LEICA, DM 2500 M) to study the distribution of phases and pores.

3. Results and discussion

The reference pellets (pellet Gr A) were made from the prepared fines (Blaine fineness: 2855 cm²/g) in the plant condition (CaO: 1.0%, MgO: 1.4% and C: 1.2%). The properties of the green pellets from the reference samples are shown in Table 5. The reference pellet was indurated at 1325 °C as it is maintained for hematite pellets in most of the plants. The properties of indurated reference pellet are shown in Table 6. It has acceptable RI (69.5 %) and other properties. RI has been targeted to be improved.

Before taking any steps for improvement of RI of the above pellet, some other tests on the same iron ore have been carried out. First, the lump ore of 10-15 mm was collected from the same heap of the raw materials and tested for RI. Then the pellet was made only with bentonite (0.3%) without any flux and carbon. The pellet was indurated at 1325 °C and tested for RI. In result, the lump ore shows 85 % RI and the pellet shows 86.5% RI, i.e. reducibility of the ore lump and its pellet without any flux is very high. Therefore, it is evident that a suitable adjustment of pelletization parameter can improve the reducibility of pellet to a remarkable extent.

The reducibility of iron ore pellet has been tried to be improved by adjusting the physical parameters viz. optimization of induration temperature, changing pellet size, changing apparent porosity and pore distribution keeping the same green pellet chemistry

Table 4. *Details of pellets made and their codes*

Pellet Group	Blaine Fineness of iron ore, cm²/g	LS size	Basicity	% CaO	Olivine addition, wt %	MgO, wt%	C (source:anthracite coal)		Pellet Size range, mm	Induration temp.°C
		BIS mesh	CaO/SiO_2 ratio				wt %	BIS Mesh Size		
A	2855	-200	0.34	1	2.78	1.4	1.2	-100	8-15	1225-1325
B	2855	-200	0.34	1	2.78	1.4	1.2	-100	6-17	1325
C	2855	-72 to -400	0.34	1	2.78	1.4	1.2	-100	8-15	1325
D	2855	-72 to -350	0.34	1	2.78	1.4	1.2	-72 to 350	8-15	1325
E	2855	-350	0.34	1	2.78	1.4	1.2	-350	8-15	1275
F	2356	-200	0.34	1	2.78	1.4	1.2	-100	8-15	1275
G	2210	-200	0.34	1	2.78	1.4	1.2	-100	8-15	1275

and maintaining the other properties in desired levels (drop nos: 7-10, GCS>1 kg/pellet, DCS>2.4 kg/pellet, CCS> 250 kg/pellet, RDI<15%, SI<15%).

3.1 Effect of induration temperature

Pellets (Group-A) have been indurated at varying temperature and then these are characterized. It has been observed that CCS of the pellets increases with increase in temperature up to 1250 °C and it remains nearly constant up to 1300 °C as shown in Fig. 1. This result indicates that bond formation either through recrystallization or slag formation completes at 1250°C. Beyond 1300 °C induration, CCS again decreases. This may be due to cracks generation. Apparent porosity (Fig. 2) decreases gradually up to 1300 °C due to the increasing amount of slag bond formation and filling up of the intergranular space by slag at higher temperature. Beyond 1300 °C the apparent porosity again increases that may be due to micro cracks formation as it is evident from optical microstructure of indurated pellet at 1325 °C (Fig. 3). This would be another reason for decreasing CCS at this temperature.

Reducibility index of pellet was measured for the above pellets and the effect of induration temperature on reducibility is shown in Fig. 4. RI decreases gradually with increase in induration temperature. This may be due to increasing slag bond formation, which encapsulates the iron ore grains and blocks the pore resulting hindrance to the flow of reducing gas towards iron oxide particles. Fitton et al.[15] also found a decreasing reducibility with increasing temperature of firing. Conforming to Gupta et al.[16], the reducibility of iron oxide decreases with increase in the induration temperature as specimen becomes denser which lowers open porosity and gaseous diffusion.

Thus, relatively lower induration temperature would be more effective to improve RI of iron ore pellet. 1250-1275 °C induration temperature would be more suitable which provides maximum CCS with considerable improvement in RI up to around 5 points (%). From the Table 7, it is obvious that at this temperature, RDI (10.5%) and swelling (12.49%) is also very low. However, at 1325 °C, RDI and swelling deteriorates to 20.2% and 14.18%, respectively. Hence, 1275 °C induration temperature may be considered as optimum.

Table 5. Properties of reference pellet in green/ dry condition

Pellet group	Fineness of raw materials			%C	%MgO	%CaO	GCS, kg/pellet	Drop Nos	DCS, kg/pellet
	Iron ore cm^2/g	Lime stone, BIS mesh	Anthracite coal, BIS mesh						
A	2855	-200	-100	1.2	1.4	1	1.9	13	6.3

3.2 Effect of pellet size

The pellets (Group-B) had been made with varying sizes in the range of 6-17 mm. They had been separated in four different size ranges (6-8, 8-10, 10-12 and 15-17 mm) by screening. The reducibility and swelling index measurement were carried out for all the above pellets. The reducibility of pellets decreases with increase in pellet size as shown in Fig. 5. The reduced samples of 9 mm and 16 mm diameter pellets have been observed under microscope and presented in Fig. 6. The microstructure of 16 mm pellet at periphery contains a very high amount of metallic phase (white) which indicates almost complete

Table 6. Properties of reference pellet after induration

	Induration temperature,°C	CCS, kg/pellet	RI, %	RDI, %	Swelling index, %
Reference pellet	1325	249	69.5	20	14.1

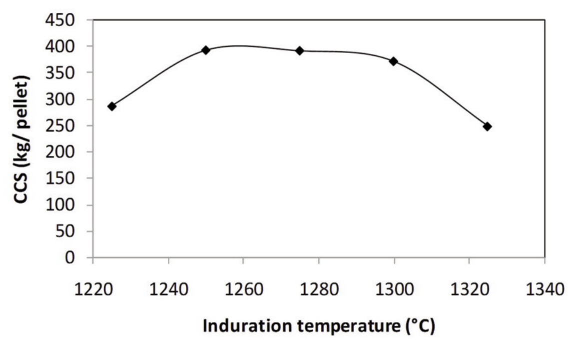


Figure 1. *Effect of induration temperature on CCS of pellet*

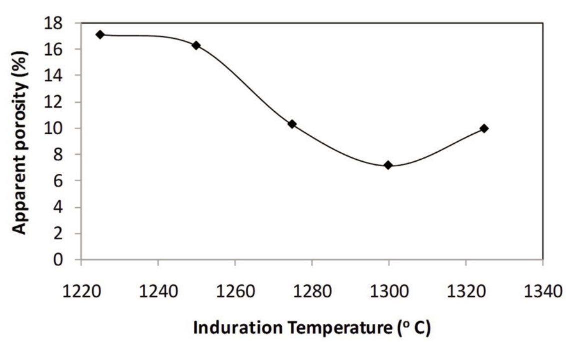


Figure 2. *Effect of induration temperature on apparent porosity of pellet*

reduction and towards the centre, the amount of reduction gradually reduces. Centre shows minimum reduction with mostly unreduced oxides (grey) and pores (black).

In contrary, 9 mm diameter pellet shows almost similar reduced structure in both periphery and centre. Since, the reduction kinetics is topo-chemical (occurs gradually from surface towards the centre), the centre of large diameter pellets remains unreduced unlike smaller diameter pellet. Thus, the extent of reduction in smaller diameter pellet is much higher than the larger one. It may also be noted that there is not much difference in swelling indices as shown in Fig. 7. It is envisaged that swelling index of pellet does not depend upon its diameter. Although, 8 - 10 mm pellet shows much higher reducibility, the selection of pellet size in the downstream process depends also upon other factors such as transportation, bed permeability and distribution in blast furnace bed etc. This experiment provides only information on influence of pellet size on reducibility.

Table 7. *Other properties with change in induration temperature*

Temperature of induration,°C	RDI, %	Swelling Index, %
1225	10	
1250	11.8	
1275	10.5	12.49
1300	9.2	
1325	20.2	14.18

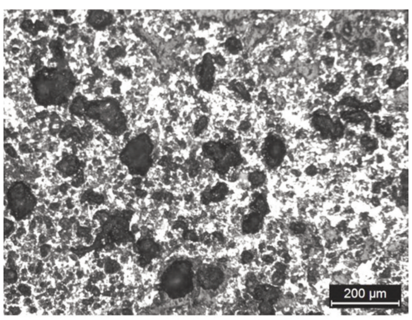
3.3 Effect of porosity

In order to increase the porosity of pellets three different approaches were taken such as (i) changing lime stone fine size (ii) changing anthracite coal size and (iii) decreasing Blaine fineness, while pellet chemistry and other parameters were kept identical. The effects of these three parameters are explained as follows.

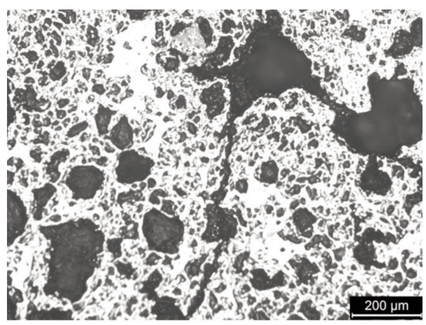
3.3.1 Effect of varying size of limestone

Limestone powder sizes were varying between -72 mesh to - 400 mesh (Pellet Gr. C). The CCS increases with increase in fineness of limestone as shown in Fig. 8. A major improvement happens due to increasing limestone fineness from -72 mesh to -200 mesh. This is due to the significant decrease in apparent porosity as shown in Fig. 9. At -350 mesh and -400 mesh CCS marginally increases, though a slight increase in apparent porosity has been observed in -350 mesh limestone fines.

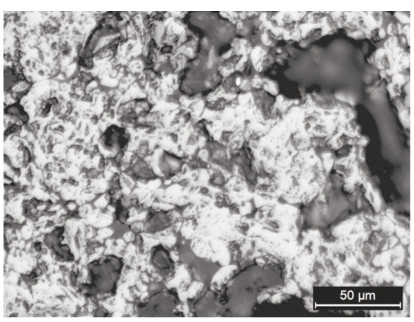
The variation of reducibility index with varying limestone size is shown in Fig. 9. The points on respective curves indicated by dotted line represent



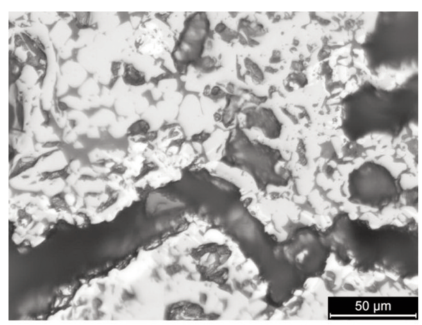
(a) 1275 °C, 100x



(b) 1325 °C, 100x



(c) 1275 °C, 500x



(d) 1325 °C, 500x

Figure 3.*Optical microstructure of Indurated pellet at different temperature*

reducibility index and apparent porosity of the reference sample. The figure shows that with increasing limestone size apparent porosity significantly increases, but RI remains more or less

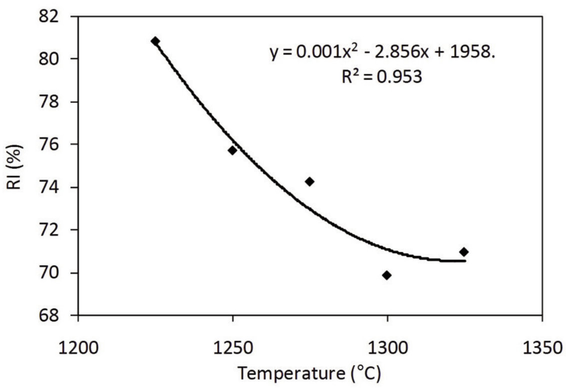


Figure 4. *Effect of induration temperature on RI of pellet*

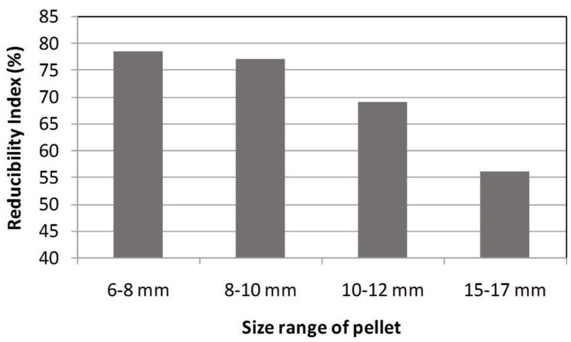


Figure 5. *Effect of pellet size on RI of pellet*

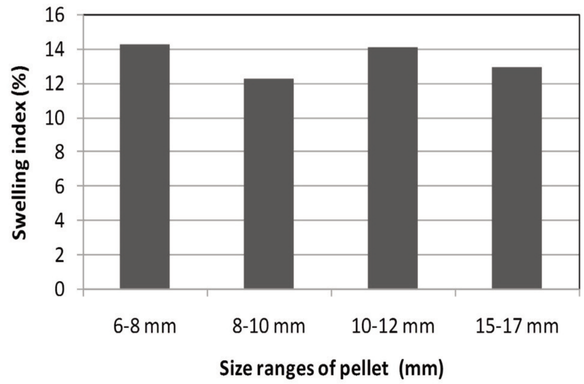


Figure 7. *Effect of pellet size on swelling index of pellet*

constant. Again with increase in fineness to -350 mesh apparent porosity slightly increases and RI significantly increases. This result indicates that RI is not only related with the apparent porosity of pellet. Therefore, microstructure of these pellets have been observed under optical microscope and presented in Fig. 10. For higher size of limestone (LS), the pores look larger in size but less in number than lower size of LS. Conforming to the reported literature, [17,18] $CaCO_3$ in limestone particles in pellet is decomposed to CaO and CO_2 gas during induration. The produced CaO is porous and cracked which is dissolved by forming calcium ferrite, SCA or SFCA phases leaving a pore on the place of original particle. Therefore, with increase in fineness of limestone particles, volume/area of pore decreases and number of pore increases. Thus due to the change in fineness of LS, amount of pores, size of pores and pore distribution changes, which influence the reducibility of pellet.

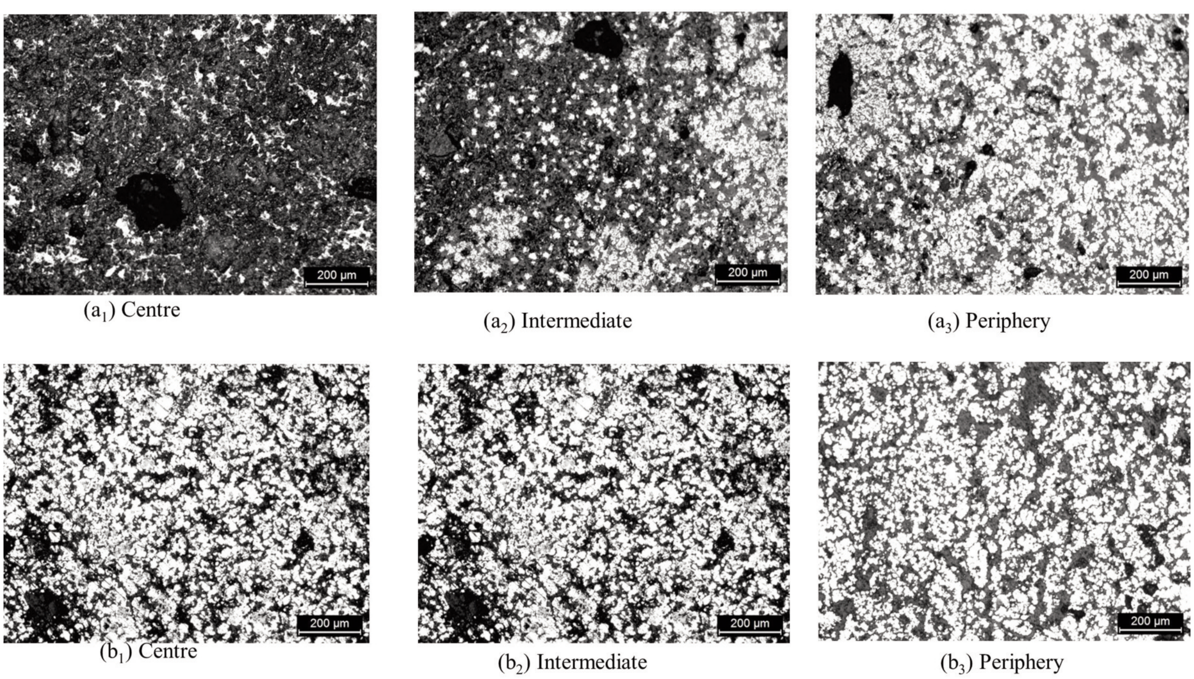


Figure 6. *Microstructure of reduced pellets varying diameter (a1, a2 and a3)16 mm pellet, (b1, b2 and b3) 9 mm pellet*

The maximum RI (75%) has been observed in -350 mesh size of limestone. Other properties such as RDI and swelling index of this pellet are also very good and lower than the reference pellet as shown in Table 8. Therefore, -350 mesh limestone fines may be considered as optimum size.

3.3.2 Effect of varying size of anthracite coal

The carbon in green pellet burns during induration of pellet at high temperature which produces CO or CO_2 gas. The produced gas may come out from the pellet; however, it leaves some pores in pellet [19]. The amount, size and the distribution of pores may be depending on quantity and fineness of carbon particles. Depending upon the scope of the present study the size of anthracite coal fines has been changed between -72 mesh and -350 mesh (Pellet Gr. D) keeping the carbon content constant. CCS decreases with increase in size of anthracite fines as shown in Fig. 11. This may be due to the better distribution of C at higher fineness. This carbon provides exothermic heat due to its burning in oxidizing atmosphere of induration.

The change of apparent porosity and RI with varying fineness of anthracite is presented in Fig. 12.

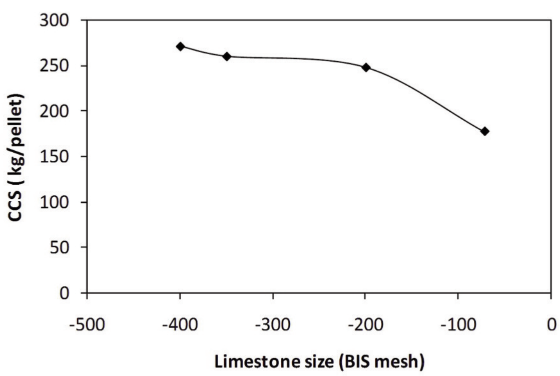


Figure 8. Effect of fineness of limestone powder on CCS of pellet

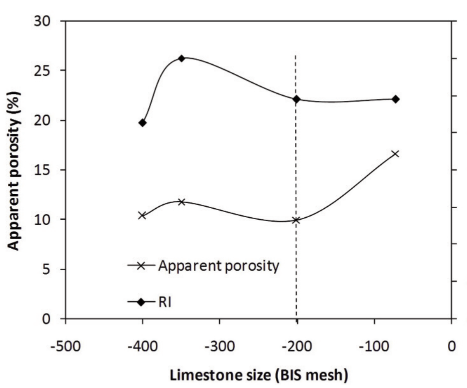


Figure 9. Effect of fineness of limestone powder on apparent porosity and RI of pellet

Dotted line indicates the anthracite mesh size of reference pellet (-100 mesh). When the size of fines is increased to -72, porosity increases to a great extent but RI decreases. This is because of difference in pore size, numbers and distribution. From the Fig. 13 it is evident that there are less numbers of larger size pore than that at the small fineness of anthracite coal.

Depending upon pore size, numbers and distribution, highest RI has been observed in -200 mesh anthracite. However, at this fineness swelling index is 14.4 (Table 9). When fineness of anthracite is further increased to -350 mesh, SI decreases to 12.75% with only a marginal decrease in RI (1.5%). As -350 mesh anthracite favors to decrease swelling index, it may be considered as optimum.

Table 8. Other properties of pellets with varying fineness of limestone

BIS mesh	Induration temp °C	RDI, %	SI, %
-72	1325	10.86	15.45
-200	1325	20.2	14.1
-350	1325	18.14	10.69
-400	1325	22.83	12.22

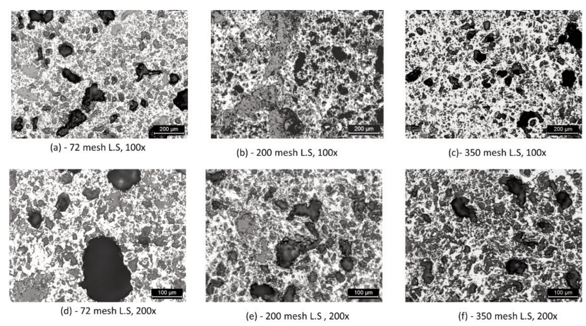


Figure 10. Micro structure of pellet with varying fineness of limestone (LS) powder

3.3.3 Effect of blaine fineness

Blaine fineness in this study is kept very high (2855 cm^2/g) due to the specific plant requirement. However, the study has also been carried out with lower Blaine fineness. The results of which are presented in the Table 10. With decreasing Blaine fineness green compressive strength decreases significantly; however, the drop numbers and dry compressive strength are nearly similar and much above the acceptable limit at constant bentonite content (0.3%). It is also apparent from the table that with decrease in fineness of iron ore, RI increases up to 80%. This may be due to the increase in apparent porosity that allows reducing gas to pass through the pellet inside. Carter et al.[20] also reported that at very high temperature, reducibility decreases with increase in Blaine fineness though it has very little effect at lower temperature. Swelling index is similar for all pellets with varying Blaine fineness of iron ore.

3.3.4 Preparation of pellet in optimum conditions

From the above it is clear that to achieve better reducibility of iron ore pellet, the optimum individual parameters are; Induration temperature: 1275 °C, size of lime stone fines: -350 mesh, size of anthracite coal fines: -350 mesh and Blaine fineness of iron ore: ~2210cm^2/g. Although, good reducibility was

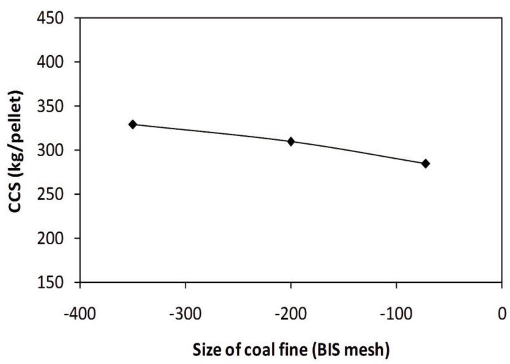


Figure 11. *Effect of fineness of anthracite coal powder on CCS of pellet*

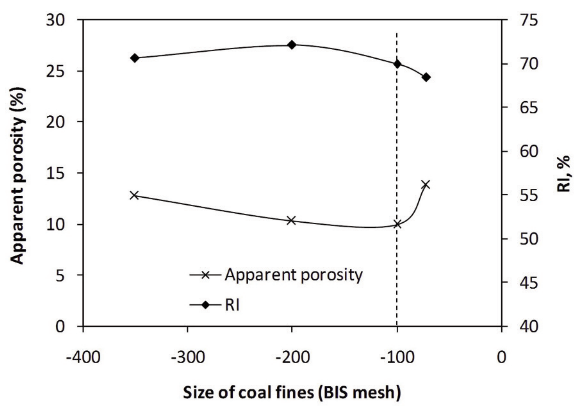


Figure 12. *Effect of fineness of anthracite coal powder on apparent porosity and RI of pellet*

Table 9. *Other properties of pellets with varying fineness of anthracite coal*

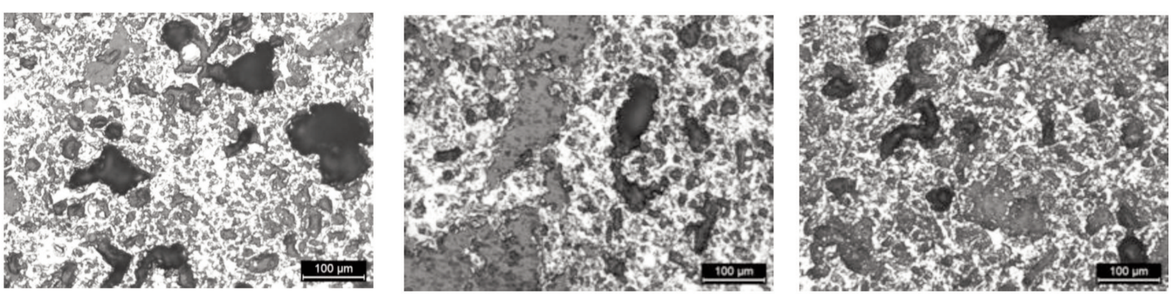
Size of coal, BIS mesh	RDI, %	RI, %	SI, %
-72	11.28	68.4	12.97
-100	20.2	69.5	14.1
-200	15.1	72.1	14.35
-350	16.1	70.6	12.71

observed in lower Blaine fineness, 2855 cm^2/g Blaine fineness was maintained in this study based on the specific plant requirement. In order to examine the pellet properties with above optimized parameter together, the pellet was made with -350 mesh limestone and anthracite coal with same green pellet composition (Iron ore Blaine fineness was kept at 2855 cm^2/g due to the above reason) as shown in Table 11. The produced pellets were indurated and then characterized. The properties of this pellet are presented in Table 12 and compared that with the reference pellet properties. A significant improvement in RI by 8 points (%) has been observed with respect to the reference pellet. RDI and swelling index has also been reduced significantly. Thus, only by change of physical parameters such as limestone size, anthracite coal size and induration temperature, 8 % point RI improvement is possible.

4. Conclusions

Lump ore and pellet without flux and C show very good RI (85-86%). The reference pellet as per plant composition such as CaO: 1%, MgO: 1.4%, C: 1.2% and Basicity: 0.34 has been indurated at 1325 °C and the properties of indurated pellets obtained (CCS: 249 kg/pellet RI: 69.5%, RDI: 20% and swelling index: 14.1%) were considered as base values. The improvement of RI and other properties in pellet has been compared with respect to these values.

RI decreases with increase in induration temperature. At 1325 °C all CCS, RI, RDI and



(a) -72 mesh AC , 200x (b) -100 mesh AC , 200x (c) -200 mesh AC , 200x

Figure 13. *Micro structure of pellet with varying fineness of anthracite coal powder pellet*

Table 10. Properties of indurated pellets with varying fineness of iron ore

B. No. cm^2/g	CaO%	MgO%	C%	Green properties			Induration Temp. ^oC	CCS, kg	RI, %	AP, %	SI,%
				Drop Nos	GCS, kg/pellet	DCS, kg/pellet					
2855	1	1.4	1.2	13	1.9	6.3	1275	380	74.2	10.28	14.1
2356	1	1.4	1.2	15	1.07	5.1	1275	369	75	16.41	14.8
2210	1	1.4	1.2	15	0.96	4.5	1275	359	80.1	17.37	14.8

swelling property deteriorate. The optimum induration temperature has been found to be 1275 °C. ~ 4.5% point RI improvement is possible by reducing induration temperature to 1275 °C from 1325°C.

Reducibility increases with decrease in size of pellet keeping the same pellet chemistry. For pellet size 8-10 mm, RI has been found to improve up to 76% from 69.5% (at 10-12 mm size pellet).

Decreasing Blaine fineness of iron ore increases RI significantly from 74% to 80%.

Significant change in RI is possible with changing particle size of limestone due to the change in apparent porosity, number of pores and pore distribution. It shows highest value at -350 mesh. Small improvement of RI is possible with change in fineness of coal. -350 mesh coal fine is found to be optimum.

~8% point improvement in RI (77.8%) has been achieved when pellets with -350 mesh limestone fines and coal fines are indurated at 1275 °C.

Table 11. Pellet preparation in the optimum physical condition

	Reference sample	Optimum condition
(i) Lime stone fine size, BIS Mesh	-200	-350
(ii) Coal fine size, BIS Mesh	-100	-350
(iii) Blaine fineness, cm^2/g	Same for both (2855)	
(iv) Induration temp, °C	1325	1275
(v) Composition of pellet mix	Same for both	

Table 12. Comparison of properties for the developed pellet with reference sample

Pellets	CCS	RI, %	RDI, %	SI, %	AP, %
Reference pellet	249	69.5	20	14.1	9.9
Optimum condition	374	77.9	12.4	11.3	9.5

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