International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 6; Issue 11; November 2017; Page No. 7397-7402
DOI: http://dx.doi.org/10.24327/ijcar.2017.7402.1141

Research Article

PELLETISATION STUDIES OF IRON ORE FINES OF HOSPET-SANDUR-BELLARY SECTOR, KARNATAKA, INDIA

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ARTICLE INFO

Article History:
Received 17th August, 2017
Received in revised form 29th September, 2017
Accepted 30th October, 2017
Published online 28th November, 2017

Key words:
Blue dust, Hematite, Induration, Pelletisation, Basicity, Binders, Bentonite

ABSTRACT

Mechanization in mining and material handling systems has resulted in the production of large amount of iron fines in addition to natural Blue dust iron ore fines. An effort of pelletisation would improve their quality and thereby increasing the economic value of these iron ore fines. The utilization of iron ore pellets has contributed greatly to the development of the iron and steel industry, replacing iron ores, due to the tailor made properties as indicated in Table 1, to make a good furnace feed.

INTRODUCTION

Pelletisation essentially consists of formation of green balls by rolling fine grained iron bearing material with a critical amount of water and to which an additive may required to be added to achieve a uniform size, even porosity, good mechanical strength and reducibility. The process of pelletisation involves three phases i.e., (a) Raw material preparation, (b) Formation of green balls and sizing, (c) Induration and (d) Cooling of hardened pellets. The rate of production of balls on pelletisation disc is a function of following parameters viz., (a) Diameter of disc, (b) Height of the peripheral wall, (c) angle of inclination of the disc, (d) speed of rotation, (e) Rating of the feed, (e)Moisture content, (f) Nature of feed and (g) Additives. The green balls from pelletisation are indurated in three phases i.e.,(a) Drying at 110^0C to 140^0C,(b) Preheating at 140^0C to 400^0C and (c) Firing at 900^0C to 1300^0C. Influence of additives, firing period and temperature are important considerations in the theory of induration.

Study Area

The Sandur schist belt has rich iron ore and manganese deposits in the Bellary district, Karnataka, India. The Schist belt trends North North West-South South East, with a length of about 53 kilometres spreading over an area of 930 square kilometers.

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The hills of schist belt are "Canoe" shaped, due to the valley on either side of the hill ranges, which extends towards each other with diminishing width, in an attempt to close up at both ends, resulting in the formation of a boat shaped structure. The iron ore deposits of the area fall within "Survey of India" topo-sheet number 57/8 and 57/12, falling between the longitude 76.5436 to 76.66840 E and latitude 14.9832 to 15.08810 N.

Table 1 Blast Furnace Grade Pellet Specifications:

Chemical Composition (on dry basis):		
Fe	63.00 %	
Feo	0.50 %	
SiO2 + Al2O3	8.00 %	(Al2O3 2.00 %)
S	0.01 %	
P	0.045 %	
TiO2	0.20 %	
AS	0.01 %	
Other metals	0.20 %	
CaO + MgO	2.00 %	
Basicity	0.30	
B. Physical Properties:		
Size: 9 - 16 mm	85.00 %	
Below 5 mm	5.00 %	
Bulk Density	2.00 T/M3	
Tumble Index (+ 6.35 MM)	92 %	
Abrasion Index (- 0.60 MM)	6.00 %	
Cold Crushing Strength	250 KG/P	
Porosity	20.00 %	
Reducibility	60.00 %	

METHODOLOGY

Field investigations were carried to understand the geology and representative samples were collected for pelletisation tests. The representative samples were initially checked for different constituents and subjected to pelletisation tests. Four representative samples were collected from different hill ranges and assayed (Table 2).

Table 2 Location Details and Assay percentage values of Test Samples.

S. No.	Mine Location	Range	Fe	SiO2	Al2O3	LOI
1	RPP	NEB	64.57	3.24	2.36	1.65
2	VSL	Devadari	64.43	2.80	2.61	1.98
3	DMS	K Swamy	64.93	2.73	2.53	1.51
4	HRG	Donimalai	64.97	2.67	2.33	1.77

The physical characters of the samples have been measured by carrying out their fractional size analysis and Partial chemical analysis of sieve fractions, which were ground to -325# are indicated in Table 3 A,B,C&D and Table 4 A,B,C&D respectively.

Mean aperture size in mesh no.	Wt % retained	Cum. Wt% retained	Cum wt% passing
120#	5.7	5.7	99.90
170#	5.8	11.50	94.20
230#	10.7	22.2	88.40
325#	8.1	30.30	77.70
400#	15.8	46.10	69.60
-400#	53.8	99.90	53.80
Specific Surface Area : 2760			

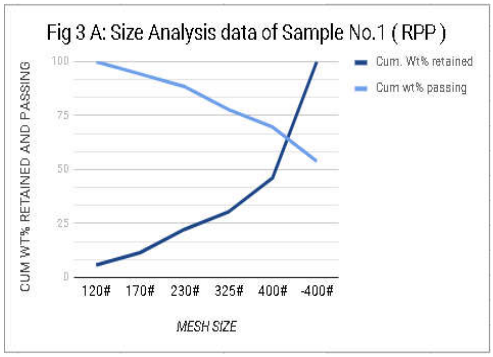

Table 3 A Size Analysis data of Sample No.1 from M/s RPP mines of NEB range

Mean aperture size in mesh no.	Wt % retained	Cum. Wt% retained	Cum wt% passing
120#	-	-	-
170#	1.50	1.50	100.0
230#	5.30	6.80	98.50
325#	7.70	14.50	93.20
400#	17.0	31.50	85.50
-400#	68.50	100.0	68.50
Sp. Surface Area : 2310			

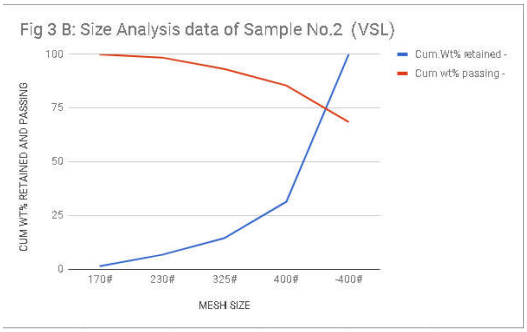

Table 3 B Size Analysis data of Sample No.2 from M/s VSL mines of Devadari range

Mean aperture size in mesh no.	Wt % retained	Cum. Wt% retained	Cum wt% passing
120#	3.60	3.60	100.0
170#	4.40	8.00	96.40
230#	9.0	17.00	92.0
325#	8.40	25.40	83.00
400#	12.80	38.20	74.60
-400#	61.80	100.00	61.80
Specific Surface Area : 2050			

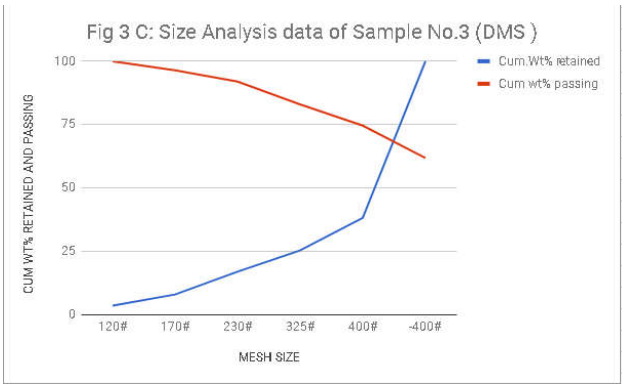

Table 3 C Size Analysis data of Sample No.3 from M/s DMS mines of Kumaraswamy range

Mean aperture size in mesh no.	Wt % retained	Cum. Wt% retained	Cum wt% passing
120#	2.00	2.00	100.00
170#	4.10	6.10	98.00
230#	10.40	16.50	93.90
325#	10.10	26.60	83.50
400#	15.40	42.00	73.40
-400#	58.00	100.00	58.00
Specific Surface Area : 1790			

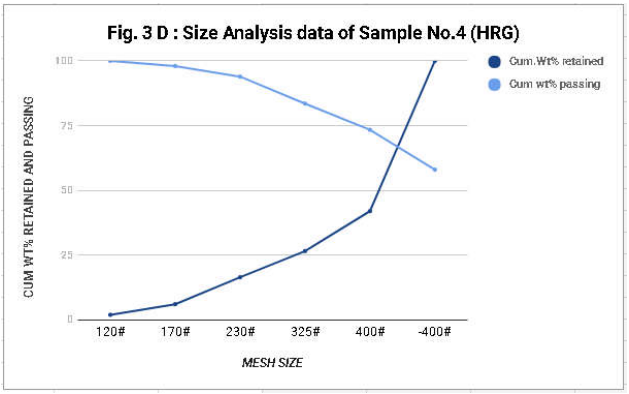

Table 3 D Size Analysis data of Sample No.4 from M/s HRG mines of Donimalai range

Size in Mesh	Wt %	Fe	SiO2	Al2O3	LOI
+10mm	1.2	66.00	2.73	1.50	0.86
+6mm	5.6	65.80	1.00	2.21	1.25
+3mm	16.7	67.80	1.06	1.08	0.59
+10#	14.5	66.80	1.76	1.58	0.86
+20#	12.6	66.70	1.90	1.35	0.97
+35#	8.1	66.00	2.60	1.68	1.07
+48#	4.1	65.90	2.62	1.71	1.12
+65#	2.4	65.80	2.50	2.00	1.20
+100#	3.4	65.40	2.60	2.05	1.55
+150#	3.5	65.00	2.38	2.74	1.76
+200#	2.7	64.20	2.32	3.26	2.20
+325#	3.4	63.10	2.62	4.16	2.58
-325#	21.8	59.80	5.84	5.12	3.02
Head(Calc)	100.0	64.93	2.73	2.53	1.51

Pelletisation tests were carried out in a disc pelletizer having a disc diameter of 19.5 inches and rim height of 5.2 inches. The green pellets were dried at room temperature and later in an oven at a temperature of 120^0 C to remove moisture.

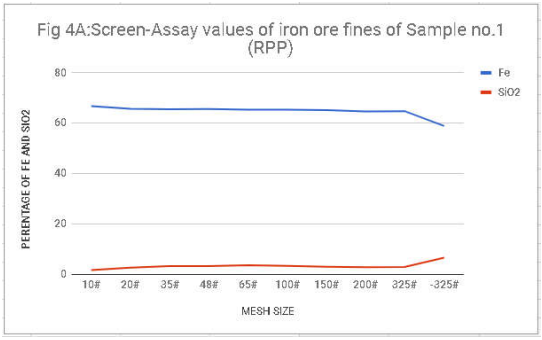

Table 4A Screen-Assay values of iron ore fines of Sample no.1 from M/s RPP of NEB range

Size in Mesh	Wt %	Fe	SiO2	Al2O3	LOI
+10mm					
+6mm	10.0	66.00	1.16	2.50	1.84
+3mm	16.1	66.00	1.48	1.81	1.69
+10#	10.6	66.60	1.76	1.41	0.99
+20#	10.3	66.40	2.00	1.17	1.21
+35#	7.0	65.80	2.20	1.00	1.24
+48#	3.7	65.60	2.28	1.31	1.53
+65#	3.3	65.60	2.56	1.71	1.20
+100#	3.1	65.60	2.60	1.71	1.66
+150#	3.4	65.20	2.10	2.05	1.95
+200#	2.4	64.80	2.20	2.53	2.00
+325#	5.6	63.00	3.00	3.87	2.53
Head(Calc	100.0	64.43	2.80	2.61	1.98

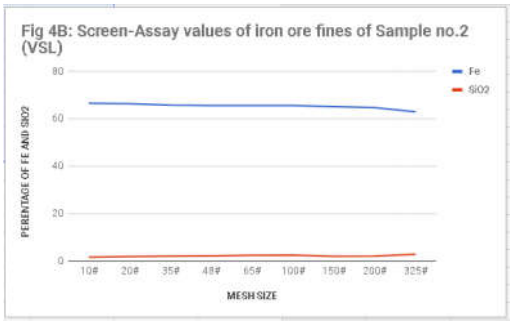

Table 4 B Screen-Assay values of iron ore fines of Sample no.2 from M/s VSL of Devadari range

Size in Mesh	Wt %	Fe	SiO2	Al2O3	LOI
+10mm	1.2	66.00	2.73	1.50	0.86
+6mm	5.6	65.80	1.00	2.21	1.25
+3mm	16.7	67.80	1.06	1.08	0.59
+10#	14.5	66.80	1.76	1.58	0.86
+20#	12.6	66.70	1.90	1.35	0.97
+35#	8.1	66.00	2.60	1.68	1.07
+48#	4.1	65.90	2.62	1.71	1.12
+65#	2.4	65.80	2.50	2.00	1.20
+100#	3.4	65.40	2.60	2.05	1.55
+150#	3.5	65.00	2.38	2.74	1.76
+200#	2.7	64.20	2.32	3.26	2.20
+325#	3.4	63.10	2.62	4.16	2.58
-325#	21.8	59.80	5.84	5.12	3.02
Head(Calc)	100.0	64.93	2.73	2.53	1.51

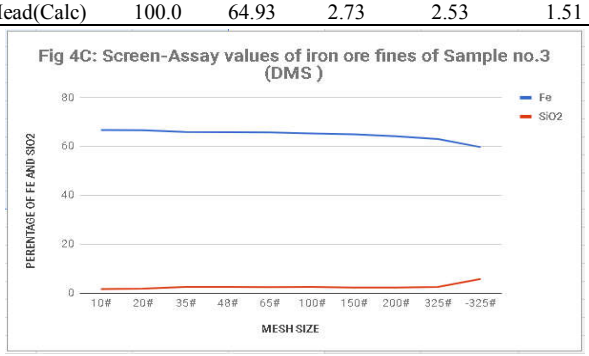

Table 4C Screen-Assay values of iron ore fines of Sample no.3 from M/s DMS of Kumaraswami range

Size in Mesh	Wt %	Fe	SiO2	Al2O3	LOI
+10mm	1.6	67.80	1.12	0.81	0.50
+6mm	11.8	67.60	1.04	1.02	1.12
+3mm	17.8	67.00	1.45	1.30	1.31
+10#	13.4	66.80	1.84	1.46	1.17
+20#	10.1	66.20	2.32	1.43	1.24
+35#	6.7	66.00	2.48	1.49	1.43
+48#	3.1	65.90	2.38	1.83	1.20
+65#	2.6	65.20	2.64	1.98	1.40
+100#	2.4	65.00	2.56	2.35	1.85
+150#	2.8	65.10	2.24	2.47	1.70
+200#	2.3	64.20	2.30	3.22	2.10
+325#	1.4	63.00	2.82	4.67	2.37
-325#	24.0	60.20	5.30	4.80	3.20
Head(Calc)	100.0	64.97	2.67	2.33	1.77

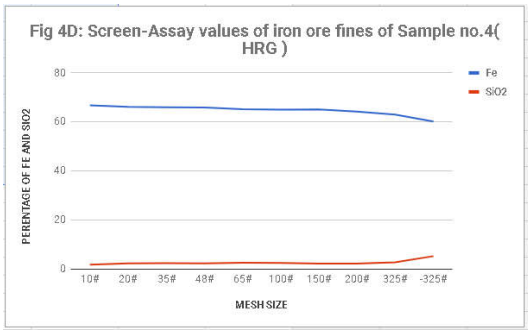

Table 4D Screen-Assay values of iron ore fines of Sample no.4 from M/s HRG of Donimalai range

Angle in degrees	Compression strength in Kg/pellet	
	Green Pellets	Dry Pellets
25	1.2	2.1
32	2.1	2.9
38	2.1	3.2
42	2.7	3.9
48	2.2	3.2

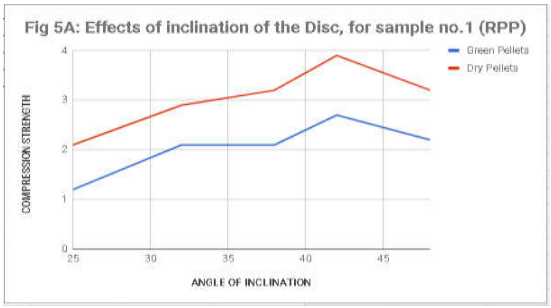

Table 5A Effects of inclination of the Disc, Green ball Vs Dry ball strength for sample no.1 from M/s RPP of NEB range

Angle in degrees	Compression strength in Kg/pellet	
	Green Pellets	Dry Pellets
35	0.8	2.0
40	0.9	2.1
45	1.1	2.5
50	1.0	2.3

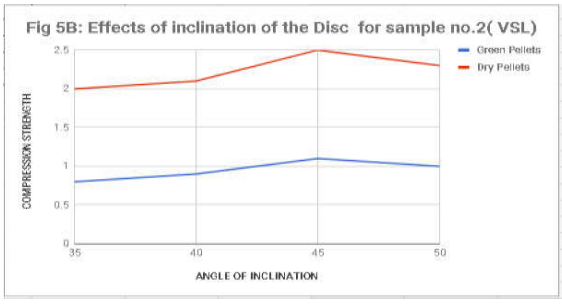

Table 5B Effects of inclination of the Disc, Green ball Vs Dry ball strength for sample no.2 from M/s VSL of Devadari range.

The dried pellets were placed in a muffle furnace for firing, varying the temperature between 800^0 to 1200^0 C. The cooled pellets were subjected to determination of various properties as discussed under results.

RESULTS AND DISCUSSIONS

The iron samples of Hospet-Sandur-Bellary area were subjected to pelletisation studies and experiments were conducted to optimize the operational parameters as follows:

A. ***Effect of Retention time:*** A retention time of 15 to 18 minutes was found to be optimum at which pellets of desirable size and shape developed.

B. ***Effect of inclination of the disc:*** Experiments were conducted on all the 4 samples by varying the inclination of the disc from 25^0 to 50^0, keeping other parameters constant. The results obtained are given in Table 5 A,B,C & D and plotted on graph (Fig.5 A,B,C & D). Pellets of good shape, size and strength were obtained at an optimum angle of $42^{0,}$

Angle in degrees	Compression strength in Kg/pellet	
	Green Pellets	Dry Pellets
35	1.5	2.6
40	1.6	2.8
45	2.4	2.9
50	2.2	2.7

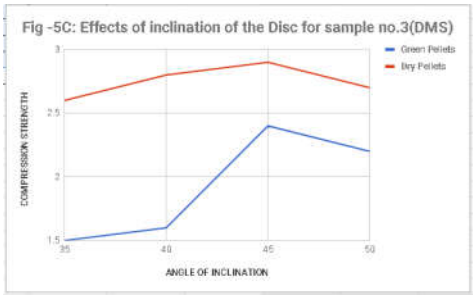

Table 5C Effects of inclination of the Disc, Green ball Vs Dry ball strength for sample no.3 from M/s DMS of KS range.

Angle in degrees	Compression strength in Kg/pellet	
	Green Pellets	Dry Pellets
30	1.9	2.9
35	2.3	3.3
40	2.6	3.7
45	2.8	3.8
50	2.7	3.7

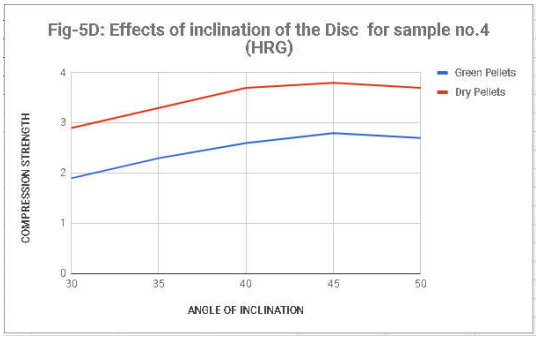

Table 5D Effects of inclination of the Disc, Green ball Vs Dry ball strength for sample no.4 from M/s HRG of Donimalai range.

Speed in RPM	Compression strength in Kg/pellet	
	Green Pellets	Dry Pellets
32	1.0	2.1
38	1.2	2.4
44	3.2	4.3
55	2.1	3.9

C. ***Effect of speed of the disc:*** Tests were conducted by varying the speed of the disc from 32 RPM to 55 RPM and good quality pellets could be obtained at 45 RPM, as indicated in Table 6A,B,C & D and Fig. 6A,B,C & D.

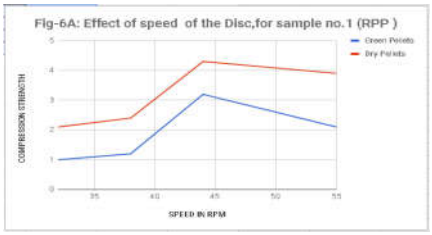

Table 6A Effect of speed of the Disc, Green ball Vs Dry ball strength for sample no.1 from M/s RPP of NEB range.

Speed in RPM	Compression strength in Kg/pellet	
	Green Pellets	Dry Pellets
32	1.0	2.1
38	1.3	2.5
44	3.3	4.6
55	2.2	4.0

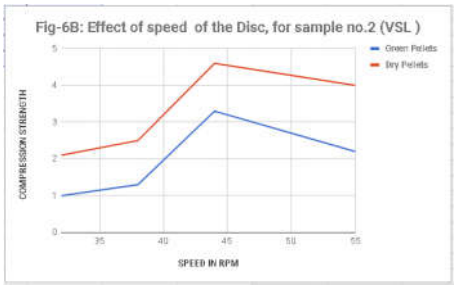

Table 6B Effect of speed of the Disc, Green ball Vs Dry ball strength for sample no.2 from M/s VSL of Devadari range

Speed in RPM	Compression strength in Kg/pellet	
	Green Pellets	Dry Pellets
33	1.9	2.3
38	2.0	3.0
43	2.4	3.5
48	2.2	3.2

Table 6C Effect of speed of the Disc, Green ball Vs Dry ball strength for sample no.3 from M/s DMS of Kumaraswami range.

Speed in RPM	Compression strength in Kg/pellet	
	Green Pellets	Dry Pellets
35	1.8	3.3
40	2.4	4.1
45	2.6	4.1
50	2.4	4.0

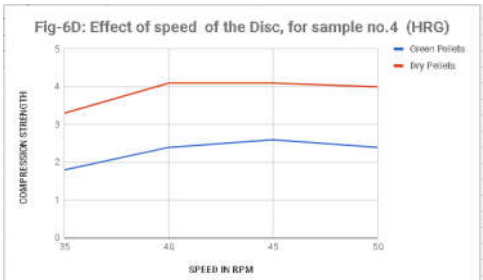

Table 6 D Effect of speed of the Disc, Green ball Vs Dry ball strength for sample no.4 from M/s HRG of Donimalai range.

D. ***Effect of Moisture:*** In order to find out the optimum percentage of moisture to obtain good quality pellets, experiments were conducted varying the moisture percentage from 7.5 to 13%, as given in the Table 7A,B,C & D and plotted in graph Fig.7A,B,C & D. It is seen from the table and graphs that, pellets of good strength were produced at 10-12% moisture. At lower moisture, pellets became brittle and did not grow to required size and at higher moisture pellets became plastic with lower strength.

Moisture in %	Compr. strength in Kg/pellet	
	Green Pellets	Dry Pellets
7.5	0.9	1.4
10	1.2	3.6
11	1.25	3.8
12	1.31	3.9
13	1.10	3.3

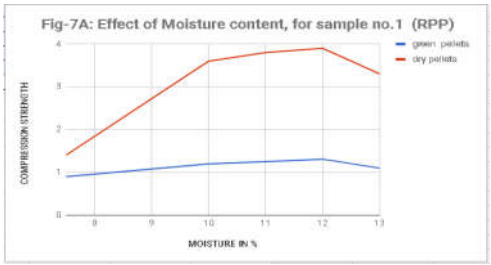

Table 7A Effect of Moisture content, Green ball Vs Dry ball strength for sample no.1 from M/s RPP of NEB range.

Moisture in %	Compr. strength in Kg/pellet	
	Green Pellets	Dry Pellets
7.5	1.0	1.4
10	1.2	3.45
11	1.3	3.79
12	1.29	3.85
13	1.15	2.95

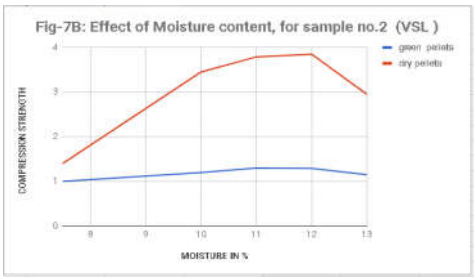

Table 7B Effect of Moisture content, Green ball Vs Dry ball strength for sample no.2 from M/s VSL of Devadari range.

Moisture in %	Compr. strength in Kg/pellet	
	Green Pellets	Dry Pellets
9.5	2.0	4.6
10	2.4	5.4
10.5	3.3	5.8
11.5	3.5	6.0
12,5	3.3	5.5

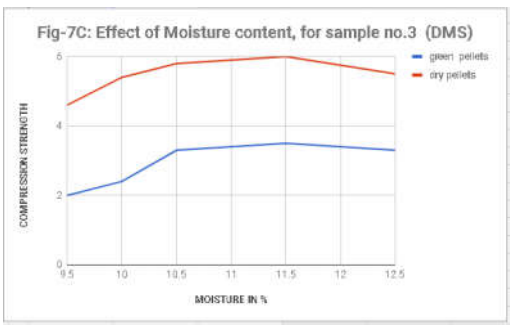

Table 7 C Effect of Moisture content, Green ball Vs Dry ball strength for sample no.3 from M/s DMS of Kumaraswami range.

Moisture in %	Compr. strength in Kg/pellet	
	Green Pellets	Dry Pellets
10	2.1	3.2
10.5	2.8	3.7
11	3.6	4.9
12	3.8	4.9
13	3.6	4.7

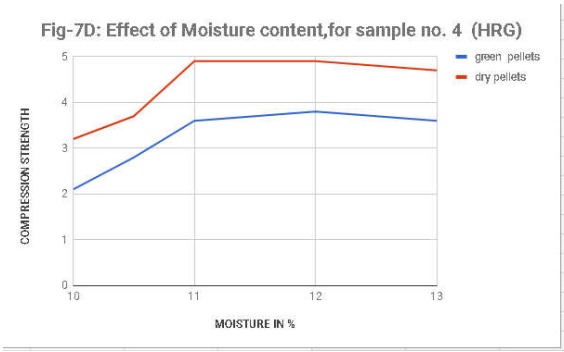

Table 7D Effect of Moisture content, Green ball Vs Dry ball strength for sample no. 4 from M/s HRG of Donimalai range.

E. ***Effect of different binders:*** Pelletisation tests were conducted with sample no.3 from M/s DMS of Donimalai range, by varying the type and concentration of various binders and keeping the other variable at their optimum values. Simple water soluble electrolytes like NaCl, KCl, KBr, NH4Cl and carbohydrates like Starch and Dextrin were used as binders. Other non-soluble substances used as binders are Bentonite and Limestone. The results are given in Table 8 and plotted on graph Fig 8. From the table and graph it is seen that, strength of pellets increases with binder percentage and temperature. Bentonite has given better result with a strength of 225 kg/p at an induration temperature of 1200^0 C.

Table 8 Effect of different binders on the properties of iron ore pellets for sample no.3 from M/s DMS of KS range.

Additive	% of Additive	Compression strength of green pellets	At 1000^0C		At 1200^0C	
			Compression strength	Porosity %	Compression strength	Porosity %
NaCl	0.50	1.4	7	21	30	22
	1.00	2.0	24	25	47	27
	1.50	2.1	31	26	77	27
KCl	0.50	0.6	1	11	11	11
	1.00	1.5	3	17	18	18
	1.50	1.6	7	17	33	18
KBr	0.50	0.9	37	12	22	13
	1.00	1.1	68	22	50	28
	1.50	1.5	69	23	58	28
NH4Cl	0.50	0.6	49	12	43	13
	1.00	1.1	59	27	83	29
	1.5	1.2	68	29	97	30
Starch	0.50	0.2	33	16	60	24
	1.00	0.3	36	26	96	31
	1.50	0.7	36	30	140	32
Dextrine	0.50	0.4	36	21	16	23
	1.00	1.5	63	25	32	27
	1.50	1.7	65	25	74	27
Molasses	0.50	2.5	14	23	13	27
	1.00	4.5	2	30	18	31
	1.50	5.3	30	30	27	31
Bentonite	0.50	1.9	82	26	195	30
	1.00	4.9	111	28	225	32
	1.50	7.1	212	30	225	33

F. ***Effect of Basicity:*** Experiments were conducted with sample no. 2 to find out the effects of basicity on strength of pellets. Basicity of pellets was varied by

controlled addition of limestone. The results have shown that, the strength of pellets increases with basicity values. At a basicity of 0.7 a maximum strength of over 300 kg/pellet is obtained and strength declines with higher basicity values, as given in Table 9 and plotted on graph Fig.9.

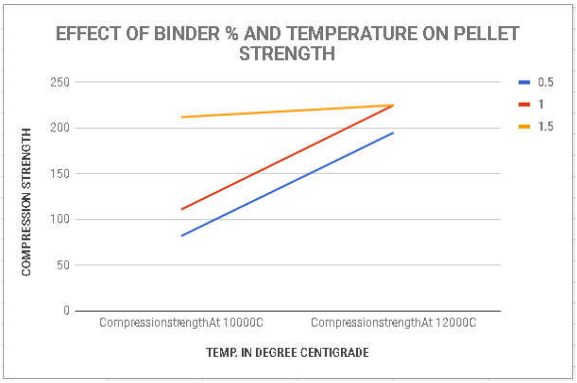

Table 9 Effect of Basicity on the properties of iron ore pellets for sample no.2 from M/s VSL of Devadari range

Sl. No.	Basicity Ratio	Fe %	Al2O3 %	SiO2 %	CaO%+ MgO%	Cold Crushing strength Kg/Pellet
1	0.15	66.2	1.63	2.27	0.60	193
2	0.22	65.7	1.78	2.66	0.98	201
3	0.27	65.6	1.77	2.55	1.25	214
4	0.38	65.3	1.79	2.51	1.65	226
5	0.50	65.4	1.47	2.42	1.95	230
6	0.60	64.8	1.80	2.12	2.35	240
7	0.63	65.8	1.40	1.84	2.04	259
8	0.70	65.0	1.51	2.29	2.68	319
9	0.82	65.2	1.56	1.81	2.76	305
10	0.89	64.5	1.83	1.90	3.32	252
11	0.90	64.8	1.34	2.06	3.05	281

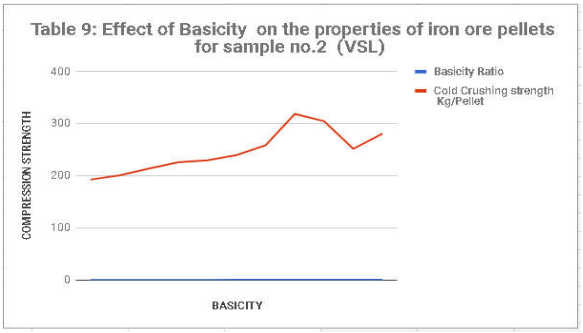

Table 10 Effect of Grain Size on pellet properties for sample no. 1 (M/s RPP) & 2 (M/s VSL)

Sl. No.	Particulars	Details of Results			
1	Sample No.	1	1	2	2
2	Range	NEB	NEB	Devadari	Devadari
3	Source	RPP	RPP	VSL	VSL
4	Surface Area	2760	2760	2310	2310
5	Binder: Bentonite	0.5%	0.5%	0.5%	0.5%
6	Basicity	0.50	0.60	0.50	0.60
7	Green Pellet				
A	Comp. Strength Kg/P	1.4	1.9	1.1	1.5
B	Drop Number	5.0	5.6	3.4	4.6
C	Moisture	7.5	7.5	7.5	7.5
D	Dry Comp. strength Kg/P	7.0	8.0	5.0	6.0
8	Fired Pellets				
A	Comp. strength Kg/P	250	267	230	240
B	Tumbler Index	95.5	96.0	92.5	94.0
C	Abrasion Index	2.5	2.3	6.7	2.7
9	Reduced Pellets				
A	Degree of Reduction %	-	85	66	77
B	Com. Strength Kg/P	-	72	37	78
C	Swelling volume	-	18.5	18	22

G. ***Effect of Grain Size:*** Experiments were conducted on two samples of different fineness. Sample 2 of M/s VSL mines, Devadari range is coarser (Blaine no.2310) and sample no. 1 of M/s RPP, NEB range is finer (Blaine no. 2760). The results are given in Table 10 and it is observed that, the pellets of sample no.1 are better in quality than the pellets from sample no. 2, which is coarser in size.

CONCLUSION

Based on the experimental results enumerated above, following conclusions can be drawn. (a) Pellets of good strength could be obtained under the following conditions: (i) Angle of inclination- 42 to 45^0. (ii) Speed of the disc - 45 RPM (iii) Retention time - 10 to 12 minutes (iv) Moisture - 9 to 12% (v) Induration temperature - 1200^0 C. (vi) Induration time - 45 minutes. (b) Bentonite has good effect on strength of pellets. (c) Pellets of good quality are produced at a basicity of 0.7%. (d) Pellets produced from finer size feed are better in quality. And it can be concluded that, Iron ore fines of Hospet-Sandur-Bellary sector are amenable for palletization.

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