Possibility of recovering iron fines from tailings by Hydrocyclone

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INTRODUCTION :

Although India is having vast reserves of iron ore, lack of consistency with respect to SiO_2 /Al_2O_3 ratio makes these unsuitable to use directly in the blast furnace without proper beneficiation. Beneficiation processes mostly applicable are sizing, washing and jigging in case of hematite and magnetic and gravity separation in case of magnetite to obtain acceptable grade lumps and fines for agglomeration for further use in blast furnace. During the washing operations, enrichment with respect to iron is marginal and gangue reduction with particular reference to favourable SiO_2 / Al_2O_3 ratio is limited.

About 27 million tonnes of hematite ore is being washed every year at six iron ore washing plants situated at Daitari, Barsuan, Bailadila-14, Bailadila-5, Donimalai and Kiriburu. During the process of washing about 6 million tonnes of slimes are produced and being lost as tailings which contains 52-60% iron[1] . Details regarding tailings produced at different washing plants are given in table 1. As most of the tailings are rich in iron, it is desirable to recover these iron values from the point of view of conservation and ecology considerations.

Characterisation studies carried out at Regional Research Laboratory, Bhubaneswar on the tailings generated at different washing plants indicated[2] that most of the gangue is accumulated in finer fractions and the possibility of using hydro-cyclone is studied. This paper describes the possibility of beneficiating the tailings generated at Barsuan, Kiriburu, Donimalai, Bailadila-5 and Bailadila-14 using hydrocyclone and further use of the concentrates as sinter-mix feed in the existing steel plants.

EXPERIMENTAL :

Equipment :

75 mm hydrocyclone supplied by M/s. Liquid solid Separation, London with adjustable feed inlet, Vortex finder and open diameter was used. The equipment is shown schematically in figure.

Raw material :

Raw materials used in these studies were obtained from the iron ore washing plants at Barsuan, Kiriburu, Donimalai, Bailadila - 5 and Bailadila - 14. The tailings generated at these washing plants were collected in wet slurry form. The water was decanted after settling and the wet slurry was dried and used as feed stock for beneficiation studies. The size and chemical analysis of different samples is given in table 2.

Procedure :

Tailings collected were thoroughly mixed and sampled. 5.0 kg sample was mixed with 28.3 litres of water and made into slurry (15% solid concentrates). The slurry was added to the hydrocyclone feed tank. The hydrocyclone pump was started and the slurry was homogenised for 10 minutes by circulating in close circuit. Then the pressure was adjusted to pre-determined

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value using the by-pass valve. The slurry was kept circulating for further 5 minutes to attain steady state. Then both under-flow and over-flow samples were collected simultaneously for a particular time. These products were dried and analysed for iron values.

The effect of pressure, apex diameter and dispersant (sodium hexa metaphosphate) were studied in each case. The design parameters and operating conditions were optimised in each case to get better grade product with high recoveries.

Results and discussions :

The results obtained on all the tailings are shown in tables 3 to 7. Concentrate obtainable from Barsuan tailings is given in table 3. The apex diameter has got significant effect on recovery. Recovery increases with increase in diameter but grade decreases. Pressure has got marginal effect both on recovery and grade. Both grade and recovery can be increased by adding suitable dispersant(sodium hexa metaphosphate). It is possible to obtain iron fines products containing 60.8% iron with 61% recovery from a feed containing 49% iron.

The results obtained on Kiriburu slimes are given in table 4. Even though pressure is not effecting significantly on the performance of the cyclone at higher apex nozzle better results were obtained. The use of dispersant has not improved the results. The concentrate with 65.0% Fe can be obtained with 75% iron recovery.

The results obtained on iron fines from Donimalai tailings are given in table 5. Iron fines with 64.5% Fe can be obtained with 80.0% iron recovery from the tailings containing 57.9% Fe.

The results of Bailadila-5 and Bailadila-14 are shown in table 6 and table 7 respectively. In both the cases, effects of apex nozzle, operating pressure and effect of dispersant were studied. It is possible to obtain concentrates with 65.0% Fe by recovering 85% of iron values from Bailadila-5 tailings which contains about 61.2% Fe whereas a concentrate with 68.4% Fe can be obtained with same recoveries from Bailadila-14 tailings which contains about 62.8% iron.

Conclusions :

It is interesting to note that in all the cases good grade iron fines concentrates can be obtained using simple equipment like hydrocyclone to recover most of the iron values lost at present from the washery tailings. The high grade iron ore fines can be used in the sinter feed to some extent without affecting the sinter qualities using suitable sintering techniques.

In order to get the raw material at lower cost the utility of super grade iron fine concentrates obtainable from Bailadila-14 should be studied for chemical and paint industries.

In is concluded that almost all the iron lost in tailings at the six iron ore washing plants could be recovered with marginal investment thereby increasing the profitability of the respective washing plants.

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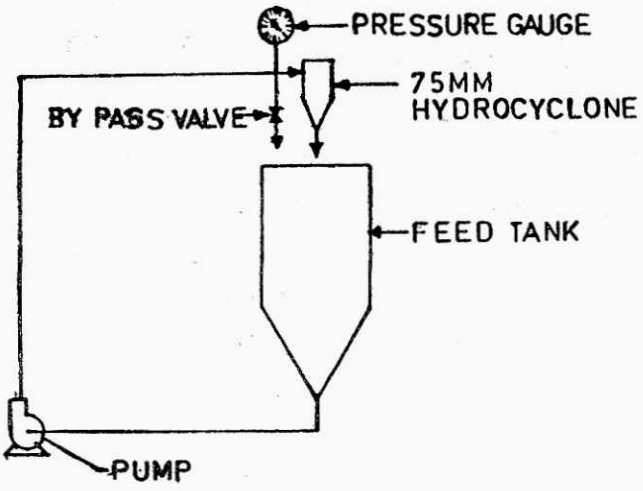

FIG. SCHEMATIC DIAGRAM OF EXPERIMENTAL SET-UP.

Table 1 : Details of tailings lost at different washing plants

Sl. No.	Plant	Loss of material m tpy	Iron content %
1.	Daitari	0.3	60.0
2.	Barsuan	1.0	52.5
3.	Kiriburu	1.6	60.4
4.	Bailadila-14	1.2	62.8
5.	Bailadila-5	0.5	61.2
6.	Donimalai	1.0	57.9
7.	Kudremukh	15.1	34.3

TABLE—2 Size and chemical analysis of different samples

Size in Microns	Barsuan		Kiriburu		Donimalai		Bailadila-5		Bailadila-14	
	Wt, %	Fe, %	Wt, %	Fe, %	Wt, %	Fe, %	Wt, %	Fe, %	Wt, %	Fe, %
+ 210	6.6	52.5	7.2	61.9	—	—	12.2	56.8	—	—
— 210 + 150	4.1	57.0	3.2	61.5	2.6	44.1	4.5	54.8	6.5	48.6
— 150 + 105	5.6	57.0	4.2	62.6	4.0	48.1	9.2	59.9	2.7	64.5
— 105 + 75	3.2	59.5	4.0	63.6	6.6	56.9	9.4	64.5	17.8	66.4
— 75 + 45	10.1	58.6	6.5	64.2	23.0	62.6	24.9	65.4	24.7	67.8
— 45 + 30	5.4	58.6	8.5	62.3	21.9	62.1	10.9	67.2	9.2	67.4
— 30 + 20	5.4	55.9	10.6	63.6	17.9	64.1	10.1	65.2	12.1	67.1
— 20	58.8	43.6	55.7	58.7	24.2	51.3	18.8	53.1	27.0	56.9
Head	100.0	48.9	100.0	60.4	100.0	57.9	100.0	61.2	100.0	62.8

Table — 3 : Results obtained on Barsuan tailings

(Feed : Fe = 49.0%, SiO_2 = 11.40, Al_2O_3 = 8.9)

A. Effect of pressure and apex diameter :

Apex dia, mm	Pressure	Product %		Recovery %
	PSI	Fe	Wt,	Fe,
3	5	61.4	40.2	50.6
	10	59.8	45.4	54.6
	15	59.8	44.5	52.7
	25	59.8	43.8	52.9
5	5	59.2	50.4	61.1
	10	58.6	50.0	64.4
	15	57.5	48.4	57.1
	25	56.8	49.5	57.6
7	5	59.8	54.1	66.3
	10	58.6	53.3	64 0
	15	58.6	49.3	59.2
	25	57.5	55.9	65.6

B. Effect of Sodium hexa metaphosphate :

Sodium HMP	Pressure	Product %		Recovery %
gms/Kg	PSI	Fe	Wt,	Fe
1 gm	5	60.3	40.0	49.4
	10	60.3	47.6	54.6
	15	60.3	44 8	52.7
	25	59.8	47.0	52.9
2 gm	5	60.6	39.6	49.2
	10	61.4	47.2	58.6
	15	60.3	48.7	59.3
	25	60.8	49.7	61.1
3	5	61.2	39.4	49.4
	10	60.3	45.4	56.1
	15	60.8	45.6	56.9
	25	61.4	39.2	49.3

Table – 4 : Results obtained on Kiriburu tailings

Feed : Fe = 60.4, SiO_2 = 2.96, Al_2O_3 = 4.96

Apex dia, mm	Pressure	Product %		Recovery %
	PSI	Fe	Wt	Fe
3	5	65.9	36.8	40.2
	10	65.3	31.9	37.0
	15	65.9	37.1	40.5
	25	65.9	39.7	43.3
5	5	65.3	48.2	52.1
	10	64.8	49.2	52.7
	15	64.8	50.9	54.6
	25	64.8	51.7	55.5
7	5	64.8	55.8	59.8
	10	65.3	54.6	59.1
	15	65.3	63.3	60.5
	25	64.8	69.7	74 8
Sodium hexa metaphosphate : 1.5 gm/kg :				
7	5	65.3	62.1	66.6
	10	62.7	65.9	67.9
	15	63.7	67.02	70.7
	25	61.2	65.9	66.8

TABLE—5 : Results obtained on Donimalai tailings

Feed : Fe =57.9, SiO_2 = 6.42 ; Al_2O_3 = 6.23

A. **Effect of cyclone geometry :**

Apex dia, mm	Pressure	Product %		Recovery %
	PSI	Fe	Wt.	Fe
3	5	65.1	37.3	41.9
	10	63.7	32.0	35.2
	15	64.8	36.3	40.6
	25	64.8	38.8	43.4
5	5	63.4	53.7	58.8
	10	61.4	77.1	81.8
	15	62.0	76.4	81.8
	25	62.0	77.9	83.4
7	5	62.8	65.6	71.0
	10	61.4	69.9	74.0
	15	62.0	73.9	79.1
	25	62.0	75.6	83.8

B. **Sodium hexa metaphosphate :**

Apex diameter : 7.0 mm, Pressure : 10 PSI

SHMP, gms/kg	Product %		Recovery, %
	Fe	Wt	Fe
0	61.4	69.9	74.0
1	63.7	76.7	84.4
2	62.8	77.1	80.6
3	64.5	75.7	81.1

TABLE—6 Results obtained on Bailadila-5 tailings

Feed : Fe = 61.2%; SiO_2 = 6.8%, Al_2O_3 = 2.8%

Apex dia, mm	Pressure	Product, %		Recovery, %
	PSI	Fe, %	Wt	Fe
5	5	64.2	65.1	68.4
	10	64.2	71.6	75.2
	15	64.2	71.3	74.9
	25	64.2	74.0	77.7
7	5	64.8	72.5	76.4
	10	64.8	74.5	78.9
	15	64.8	75.1	79.6
	25	64.8	80.4	85.0
Sodium Hexa metaphosphate : 1.5 gms/kg.				
7	5	64.2	73.0	76.6
	10	64.2	76.3	80.1
	15	64.8	74.9	79.3
	25	65.3	71.6	76.5

TABLE—7 Results obtained on Bailadila-14 tailings

Feed : Fe = 62.8%, SiO_2 = 3.68%, Al_2O_3 = 4.26%

A. **Effect of cyclone geometry :**

Apex dia, mm	Pressure	Product %		Recovery %
	PSI	Fe	Wt	Fe
3	5	68.4	37.0	40.3
	10	68.4	33.4	36.2
	15	67.9	36.2	39 1
	25	67.6	40.0	43.1
5	5	68.4	75.8	82.6
	10	68.1	75.5	81.9
	15	67.6	75.9	81.7
	25	67.9	75.5	81.6
7	5	64.18	70.8	76.8
	10	67.6	74.0	79.7
	15	68.1	79.5	86.3
	25	67.6	82.9	81.2

B. **Effect of Sodium hexa metaphosphate :**

Apex dia : 7.0 mm, Pressure : 10 PSI

SHMP, gm/kg	Product %		Recovery %
	Fe	Wt.	Fe
0	67.6	74.0	79.7
1	67.8	79.0	85.0
2	67.9	80.5	87.0
3	67.02	82.0	87.5

Discusion :

Pradip, TRDDC, Pune.

Question 1 : Have you tried any other dispersant? I would think Na silicate may be more effective and perhaps much cheaper ?

Author : The following dispersants were tried in case of Barsuan slimes. Sodium silicate, polymer developed by RRL, Jorhat, pH regulated by NaOH, Na_2CO_3 and lime. The detailed results are reported in International Journal of Mineral Processing 13, 259-269 (1984). The best dispersant was used for other slimes like Kiriburu, Donimalai etc.

Question 2 : During the cycloning, is there any change in the SiO_2 / Al_2O_3 ratio from feed to concentrate.

Author : The ratio of SiO_2 / Al_2O_3 has been changed from 1.3to 0.8 in case of Barsuan slimes and the ratio remains constant in the cases of other slimes.

Question 3 : Is the separation is merely on size or sp. gravity difference also helpful ?

Author : Beneficiation by hydrocyclone is the combined process of size and gravity separation aided by centrifugal force.

Dr. S. Pattnaik, NINL, Bhubaneswar.

Question 1 : Have you made any quantitative assessment of the tailings at Barsuan ?

Author : About 1.0 MT of slimes per year are being produced at Barsuan iron ore washing plant.

Question 2 : What was the sampling method adopted while drawing the samples from the tailing dam ?

Author : The sample was collected not from the tailings dam but from the slurry forming feed to the hydrocyclone. The sample was collected at hourly intervals over a period of one week and mixed thoroughly.

Question 3 : Have you any size distribution study on the bulk sample collected? If so, please throw some light on it.

Author : The details are given in table-2 of the paper.

Question 4 : By any chance, If any cost study has been made in the recovery ?

Author : Preliminary cost estimation was carried out in case of Barsuan slimes. The cost of treating one tonne of tailings is around rupees Ten per tonne.

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