

# Recovery of iron values from slimes and dewatering of the concentrate

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## ABSTRACT

*During crushing and wet processing of iron ore on an average 15-18% slimes (-100 mesh) are produced in the iron ore mines of National Mineral Development Corporation (NMDC). About 50 to 65% by weight of slimes can be recovered and upgraded to +64% Fe by process of hydrocycloning. By the process of wet high intensity magnetic separation, the magnetic concentrate assaying +65% Fe with similar recovery can be achieved. Dewatering of hydrocyclone underflow and magnetic concentrate can be carried out by slow speed spiral classification. The classifier sand contains about 18 to 20% moisture. During the process of dewatering the grade of slow speed classifier sand gets improved further. The concentrate obtained by hydrocyclone meets the specifications for blending with normal classifier sand for sinter making. The magnetic concentrate obtained by WHIMS meet the DRI pellet grade specification or for alternative method of iron making. There are difficulties for operation of thickener for water recovery directly from classifier overflow due to higher solid content and faster settling rate. After removal of major portion of ultrafines from slimes as concentrate, the thickener operation becomes smooth and troublefree. On an average 70 to 75% of input water can be recovered by thickener.*

## INTRODUCTION

NMDC is having fully developed iron ore mining and processing complexes at Bailadila in Madhya Pradesh and Donimalai in Karnataka States. These mines were developed primarily for export of iron ore lump to Japan and other Eastern countries as there was demand for lump ore only. During size reduction and wet processing of iron ore on average 15-18% slimes (-100 mesh) are produced. As market for this material is not available, the slimes ore rejected and dumped into tailings dam. But after the commissioning of Visakhapatnam Steel Plant (VSP) where the proportion of sinter in the blast furnace burden is about 80%, the demand

for iron ore fines from Bailadila sector has increased.

With the technological improvements and innovations, now-a-days the -100 mesh fraction in the sinter feed can be accepted upto about 40%, by adopting new techniques such as microballing of the sinter mix prior to sintering. For this reason and to avoid the loss of superfine high grade iron ore in the form of slime, it has become inevitable to process this using a suitable technique. The processing of slimes will increase the quantity of high grade fine concentrate without affecting the quality and will also increase the life of tailings dam.

Exhaustive beneficiation studies have been carried out with these slimes at NMDC's R&D Centre. It has been established through the laboratory as well as Pilot Plant Scale tests that it is economically possible to recover substantial quantity of saleable fines from the slimes. Studies are also carried out in production plant to confirm the test results of laboratory and pilot plant <sup>[1-3]</sup>.

On the basis of above test results NMDC has commissioned slimebeneficiation system in the existing operating plants.

The slime beneficiation system has the following advantages :

- a) Maximising the quantity of saleable products out of existing mines with minimum investment,
- b) Improving the economics of operation,
- c) Minimising the pollution,
- d) Conservation of mineral resources,
- e) Reduction of operation problems in slurry disposal system by reducing the quantity of solids,
- f) Recovery of substantial quantity of water by thickener, for reuse in the process.

## THE PROCESS

### Hydrocycloning

NMDC has adopted a simple process flow sheet for beneficiation of iron on slimes to produce high grade concentrate using hydrocyclone. The dewatering of cyclone underflow is carried out with the help of slow speed spirifal classifier. The slow speed classifier in turn also further improves the grade of concentrate by rejecting the remaining clayee material as classifier overflow. Typical process flow sheet for beneficiation of slimes is shown in Fig. 1 while some typical results obtained during trial tests in the production plant are shown in Table 1 to 4.

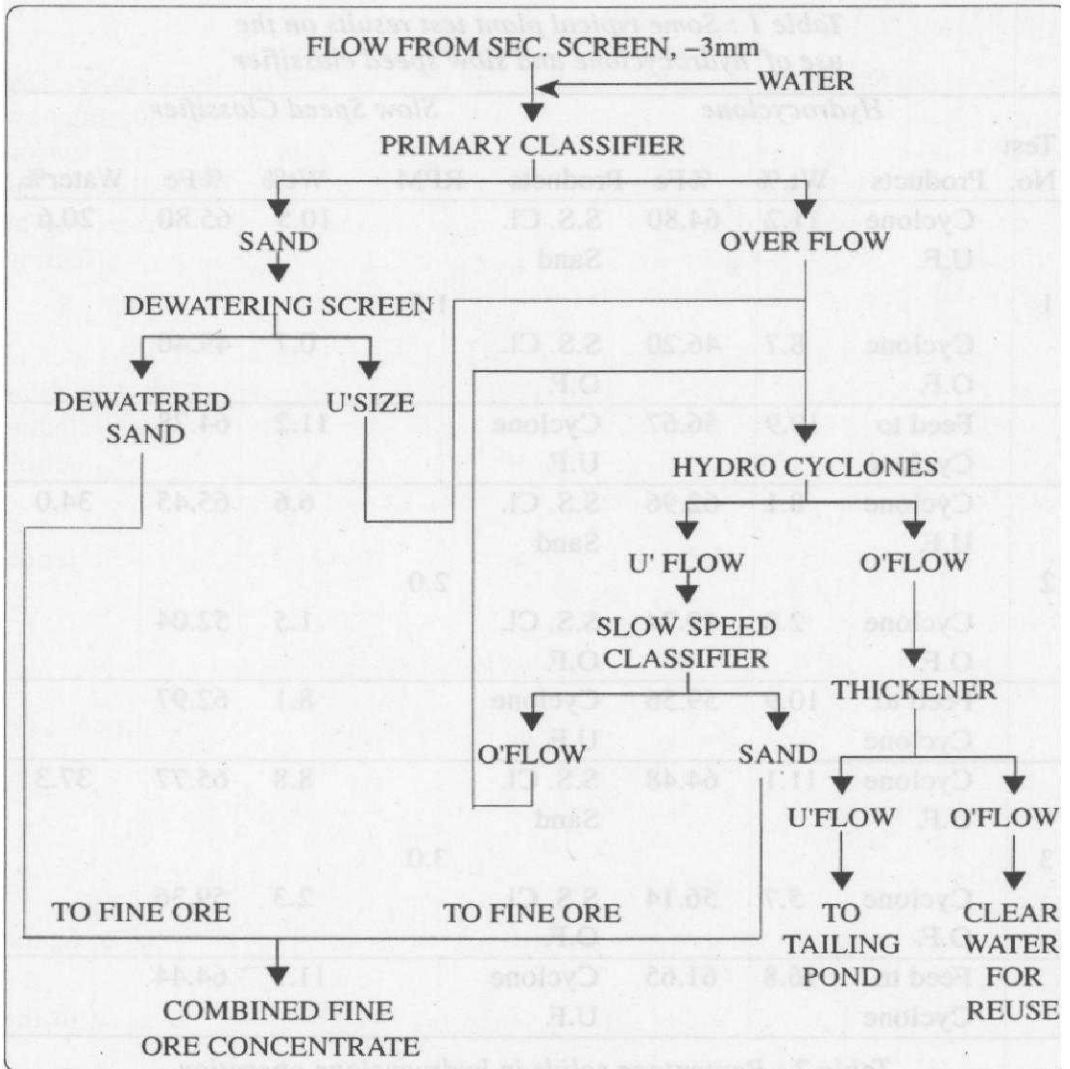


Fig. 1 : Typical flow sheet for slimes beneficiation.

Difficulties encountered in the hydrocycloning process in the plant are :

- Maintaining constant feed rate to hydrocyclone
- Maintaining constant solid content in the feed with minimum variation
- Maintaining constant required feed pressure

In order to avoid these difficulties of maintaining the above parameters by manual method, NMDC is contemplating for the introduction of PLC system for automatic control in future plants.

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Table 1 : Some typical plant test results on the use of hydrocyclone and slow speed classifier

Test No.	Hydrocyclone			Slow Speed Classifier				
	Products	Wt.%	%Fe	Products	RPM	Wt%	%Fe	Water%
1	Cyclone U.F.	11.2	64.80	S.S. Cl. Sand	1.5	10.5	65.80	20.6
	Cyclone O.F.	8.7	46.20	S.S. Cl. O.F.		0.7	49.40	
	Feed to Cyclone	19.9	56.67	Cyclone U.F.		11.2	64.78	
2	Cyclone U.F.	8.1	62.96	S.S. Cl. Sand	2.0	6.6	65.45	34.0
	Cyclone O.F.	2.8	49.74	S.S. Cl. O.F.		1.5	52.04	
	Feed to Cyclone	10.9	59.56	Cyclone U.F.		8.1	62.97	
3	Cyclone U.F.	11.1	64.48	S.S. Cl. Sand	3.0	8.8	65.77	37.3
	Cyclone O.F.	5.7	56.14	S.S. Cl. O.F.		2.3	59.36	
	Feed to Cyclone	16.8	61.65	Cyclone U.F.		11.1	64.44	

Table 2 : Percentage solids in hydrocyclone operation

Products	Test No. 1	Test No. 2	Test No. 3
Feed to cyclone	35.0	20.9	18.6
Cyclone Under Flow	67.1	55.0	52.5
Cyclone Over Flow	8.4	11.2	12.0

Table 3 : Percentage solids in S.S. Classification and dewatering

S.S. Cl. rpm	1.5	2.0	3.0
Products			
S.S. Cl. Sand	79.4	66.0	62.7
S.S. Cl. Over flow	7.5	8.4	12.0

Table 4 : Particle size analysis (S.S. Classifier operation at 1.5 rpm)

Size fraction in mesh	Feed to Cyclone Wt (%)	Cyclone Over flow Wt (%)	Cyclone Under Flow Wt (%)	SS Cl. Sand Wt (%)	SS Cl. Over Flow Wt (%)
+ 48	6.5	—	11.6	12.2	—
- 48 + 65	2.0	—	3.6	4.0	—
- 65 + 100	5.0	0.3	8.9	9.5	0.3
- 100 + 150	6.5	0.1	11.6	12.4	0.4
- 150 + 200	13.2	0.8	22.5	23.8	1.8
- 200 + 250	4.7	0.2	6.5	6.8	0.8
- 250 + 325	8.8	1.5	12.1	12.6	4.2
- 325	53.3	97.1	23.2	18.7	92.5
Total	100.0	100.0	100.0	100.0	100.0

## DEWATERING OF HYDROCYCLONE UNDERFLOW

The cyclone underflow contains about 45 to 50% water. Moreover the material is very fine. The percentage of -325 mesh material is about 25 to 30%. This material is difficult to dewater. The filtration system is found to be ineffective. NMDC has introduced a very simple system for dewatering by slow speed spiral classifier. By actual plant tests, it has been established that 1 to 1.5 rpm of 6 ft dia spiral classifier could produce classifier sand containing around 20% water. Less than this is not found practicable. The loss through slow speed classifier overflow is minimum and this is mostly the remaining clayee material coming along with the water of cyclone underflow. During the process, the grade of slow speed classifier sand also gets improved further.

There are difficulties in handling this material containing about 20% moisture. In order to overcome the difficulties, the primary classifier sand is dewatered by dewatering screens. The slow speed classifier sand is then mixed with the dewatered sand. By doing so the average moisture content of the mix comes to around 12 to 14% and there is no difficulty in handling this material by belt conveyor system for disposal to stockpile/loading station. In the stockpile the moisture gets further reduced by natural process.

## WET HIGH INTENSITY MAGNETIC SEPARATION (WHIMS)

The beneficiated fines obtained by hydrocyclone and dewatered by S.S. Spiral Classifier meets the grade specification for mixing with normal classifier sand for

sinter making. But in order to produce DRI pellet grade fine ore concentrate from slime, wet high intensity magnetic separation is found to be essential. Exhaustive beneficiation studies are carried out at NMDC's R&D Centre on WHIMS test on iron ore slimes from Bailadila and Donimalai mines of NMDC. Test results conclusively proved that by the process of WHIMS the fine ore concentrate of +66% Fe can be easily produced from the slime arising from NMDC's mines. Some typical test results are presented in Table 5.

*Table 5 : Typical results on WHIMS tests*

Test No.	Products	Wt (%)	Wt (%) wrt original	Fe (%)
1	Magnetic Conc	57.8	11.8	67.30
	Non-magnetic Tailings	42.2	8.7	56.08
	Feed	100.0	20.5	62.57
2	Magnetic Conc	65.4	13.4	66.40
	Non-magnetic Tailings	34.6	7.1	55.04
	Feed	100.0	20.5	62.47
3	Magnetic Conc	66.2	13.6	66.00
	Non-magnetic Tailings	33.8	6.9	55.65
	Feed	100.0	20.5	62.50

The production cost by WHIMS will be much higher compared to hydrocyclone. Production of fines for mixing to sinter feed, hydrocyclone. Production of fine concentrate for mixing to sinter feed, hydrocyclone is sufficient so far as NMDC's ore is concerned. Introduction of WHIMS for production of sinter grade fines is found to be uneconomical due to high capital and operating costs.

## **WATER RECLAMATION**

The operation of thickener for water reclamation with the primary classifier overflow is found to be ineffective in the NMDC's iron ore processing plants. This is primarily because of the following reasons :

- a) Presence of coarse material in the primary classifier overflow.
- b) High settling rate of coarse material and fine grained high grade blue dust present in slime.

- c) Difficulty in flow of thickened slurry through thickener discharge pipe line causing frequent jamming of thickener.

The above difficulties are eliminated by removal of major quantity of coarse and high grade fines by hydrocycloning. The thickener operation is smooth with the cyclone over flow and water reclamation is on an average of 70 to 75%.

### CONCLUSIONS

The iron ore slime arising during mechanised wet screening and classification is no longer a waste. The high grade iron ore fines (-100 mesh) can be economically recovered from slime by (i) the process of hydrocycloning and/or (ii) high intensity wet magnetic separation process technique. This material can be suitably mixed with the normal iron ore fines for sinter making. The high grade fines obtained by WHIMS can be utilised for making DRI grade pellet or by alternative method of iron making which is expected to be commercialised in the near future.

### REFERENCES

- [1] Laboratory and Pilot Plant beneficiation studies on slime from Bailadila Dep. 14 mine.', Investigation Report, NMDC, Hydrabad.
- [2] Important studies on beneficiation of Slime, dewatering and water reclamation fro Bailadila Deposit - 14 mine.', Investigation Report, NMDC, Hydrabad.
- [3] Beneficiation of slime from Bailadila 11C mine.', Investigation Report, NMDC, Hydrabad.