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# PROCESS DEVELOPMENT FOR BENEFICIATION OF IRON ORE SLIMES FROM DONIMALAI AREA

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## ABSTRACT

The Iron ore processing plants have been invariably generating slimes in the range of 10 – 15% of the ROM treated. These losses are in the tune of over 15 million tons of iron values every year. The tailing ponds of most of the iron ore mines are getting accumulated with these slimes and are at the verge of getting filled. In order to utilize the iron values lost in the tailings and to create space for fresh tailings, these tailings are to be beneficiated. The present study deliberates an attempt to utilize the iron ore tailings from Donimalai area. The slimes available are typically in the range of 50 – 60% Fe with varying Silica and Alumina content. The sample subjected to study was processed by desliming followed by wet high intensity magnetic separation in two stages. From the studies, it is possible to produce a combined concentrate assaying 64.36% Fe, 2.23 % $Al_2O_3$ and 2.89% $SiO_2$ with a recovery of 78.74% iron units.

**KEYWORDS**: Slimes, desliming, magnetic separation.

## INTRODUCTION

The beneficiation process invariably end up with an enriched portion of the desired mineral called "concentrate" and bulk of the undesired minerals segregated in the form of "tailing". Iron ore mining and processing is no exception and generate tailings in the tune of about 10 – 15% of the ROM processed. Most of tailing dams associated with iron ore processing are at the verge getting filled by the accumulation of such tailings with iron content ranging from 50 – 60% Fe. With changing environmental laws, it has become difficult to get fresh lease of land for disposal of tailings. Apart from this, with change in the threshold value of Iron to 45% before disposal makes it inevitable to utilize these slimes for recovery of iron units to bring the grade below the threshold limit. The depletion of high grade resources has opened up the options of beneficiating low and lean grade resources. However, it is manifested that with decrease in the feed grade, the quantity of tailings generated would certainly increase depending on the liberation of valuable minerals as well as process efficiency. In such cases, the space required for disposing the tailings will go up further. On the other hand, with the new National steel policy envisaging the production of steel to beyond 200 million tons per annum [1], the onus is on the Iron ore mining industry to cater the requirement of the raw material. Thus both from the mineral conservation point of view as well as under environmental consideration; it is of paramount importance to explore all the possibilities to utilize these slimes to make it suitable for iron making process. The other advantage appears to be that the slimes do not require energy intensive grinding process for liberation of desired minerals.

The slimes contain significant amount of ultra fine particles comprising mainly Alumina and to certain extent silica [2]. Efforts made by earlier researchers primarily focused on flocculation technique for reduction of alumina [3-6] however, the problems associated beneficiation of slimes and need for systematic research was suggested by Pradip et.al. [7]. The beneficiation of slimes from Kiriburu area was studied by Prasad et.al [8] by adopting classification and magnetic separation. Similar studies were also carried out on slimes from Barsua and Bolani area by Das et. al. [9]. The application of multi gravity separator for treatment of slimes was studied by Pradip [10]. The lower capacity of the machine [11] makes is redundant for commercial application. However, the literature on beneficiation of slimes from Donimalai is not available. Hence, in the present study the beneficiation of slimes adopting classification followed by Magnetic separation is presented.

## MATERIALS AND METHODS

***Material***

The slime sample from Donimalai tailing dam was collected and sub samples were drawn after homogenization followed by coning and quartering method. The sub samples drawn were subjected to physical, chemical and mineralogical characterization.

***Methods***

The sub sample drawn was subjected to desliming studies in a two inch hydrocyclone by varying the spigot and vortex finder at different operating pressure to ascertain best operating conditions for getting better grade and yield of the underflow simultaneously eliminating bulk of the ultra fine impurities in the overflow. Thus obtained underflow at optimum conditions with better grade and yield was subjected to wet high intensity magnetic separation (WHIMS) at different intensities and feed pulp densities. At the optimum conditions, the tailings from the rougher stage were subjected to scavenger stage WHIMS to enhance the recovery of iron units. Subsequently, the magnetic portion of the scavenger whims was subjected to reverse flotation in a laboratory flotation cell by using amine collector at dosages varying from 0.10 kg/ton to 0.40 kg/ton and in the pH range of 8.5 to 10.5. Starch was used as a depressant. Final products of the tests were analyzed for Fe, $SiO_2$, $Al_2O_3$ and LOI.

## RESULTS AND DISCUSSION

***Characterization***

The subsample drawn from the bulk was subjected to physical, chemical and mineralogical analysis. The particle size distribution along with size fractional chemical analysis reveal that the sample analyzes 55.30 % Fe (T), 8.28% $SiO_2$, 8.1% $Al_2O_3$, 0.006% P, 0.001%S and 3.73%LOI. The bulk of the Iron distribution i.e. 77% is in the range of 26 to 150 microns. The details of size analysis along with size wise chemical analysis are presented in Table – 1. The mineralogical studies reveal that Hematite and Goethite are the main ore minerals and amounts of 52% of the area of distribution. These occur in the grain size of 100 to 30 microns. Quartz and ferruginous clay are the major impurities and occur in less than 70 microns sizes.

***Table 1. Size analysis and size wise chemical analysis of the feed sample***

| Size in mm | Wt% | Assay Percent | | | | Fe distribution | Cum. Fe distribution |
|---|---|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | $Al_2O_3$ | LOI | | |
| +0.106 | 9.30 | 55.90 | 8.93 | 6.17 | 3.54 | 9.40 | 9.40 |
| +0.075 | 10.36 | 56.50 | 8.22 | 5.92 | 3.36 | 10.59 | 19.98 |
| +0.053 | 7.87 | 57.10 | 7.79 | 5.87 | 3.33 | 8.13 | 28.11 |
| +0.045 | 18.79 | 58.10 | 7.40 | 5.46 | 3.77 | 19.74 | 47.85 |
| +0.034 | 18.60 | 58.67 | 6.15 | 6.43 | 2.73 | 19.73 | 67.58 |
| +0.026 | 9.43 | 57.20 | 6.58 | 8.10 | 3.09 | 9.76 | 77.34 |
| +0.018 | 8.96 | 55.00 | 7.65 | 9.41 | 3.59 | 8.91 | 86.25 |
| +0.012 | 5.57 | 53.60 | 8.48 | 10.44 | 3.98 | 5.40 | 91.65 |
| +0.009 | 1.21 | 50.80 | 9.74 | 11.99 | 4.58 | 1.11 | 92.77 |
| -0.009 | 9.90 | 40.40 | 15.67 | 18.94 | 6.87 | 7.23 | 100.00 |
| **Head Calc.** | **100.00** | **55.30** | **8.28** | **8.08** | **3.73** | **100.00** | |

***Desliming studies***

De – sliming studies were carried out in a laboratory Mozley cyclone test rig with 2” hydrocyclone by varying the vortex finder and spigot dia. The tests were carried out at feed consistency of around 12% solids and inlet pressure of around 14 psi. Products of each test were collected and analyzed for grade and yield. The results obtained at optimum condition are presented in Table – 2. From the results we can observe that about 18% of the slimes report to overflow and only about 10% of the iron units are lost. The underflow has been enriched to almost 61% Fe with 90% of the iron units from the feed.

***Table 2. Results of desliming with 2” hydrocyclone***

| Product | Wt% | Assay Percent | | | | %Recovery |
|---|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | $Al_2O_3$ | LOI | Fe |
| Overflow | 18.16 | 31.20 | 19.64 | 25.06 | 9.79 | 10.22 |
| Underflow | 81.84 | 60.80 | 6.39 | 3.71 | 2.69 | 89.78 |
| **Head Calc.** | **100.00** | **55.42** | **8.80** | **7.59** | **3.98** | **100.00** |

***Beneficiation of cyclone underflow using Wet High Intensity Magnetic Separator (WHIMS)***

The magnetic separation tests were carried out in a pilot scale Jones WHIMS of P – 40 model, which can be operated up to 500 Kg/hr. The tests were carried out at around 150 Kg/hr and at a feed consistency of around 25% solids. The field intensities were varied in the range of 8000 to 18000 Gauss. The results obtained at optimum conditions are presented in Table – 3. From the results it is evident that about 30% of iron units are still present in the non magnetic portion of the product. Further, to recover these iron units, this fraction was subjected to scavenger WHIMS at a lower intensity so as to recover iron units as much as possible. The results of scavenger WHIMS are presented in Table – 4. The concentrate obtained from rougher and scavenger WHIMS are computed to get the grade and yield of the combined concentrate. Similarly, the cyclone overflow and the non magnetic portion of the scavenger WHIMS are computed to get the grade and yield of the final tailings. The results of computed products are presented in Table – 5 & 6 respectively.

***Table 3. Results of Rougher WHIMS at 13700 Gauss***

| Product | Wt% | Wt% wrt'O | Assay Percent | | | | %Recovery |
|---|---|---|---|---|---|---|---|
| | | | Fe | $SiO_2$ | $Al_2O_3$ | LOI | Fe |
| Non Mag + Middling | 35.84 | 29.33 | 51.60 | 13.40 | 7.97 | 4.46 | 30.46 |
| Mag | 64.16 | 52.51 | 65.80 | 1.92 | 1.53 | 1.69 | 69.54 |
| **Head Calc.** | **100.00** | **81.84** | **60.71** | **6.03** | **3.84** | **2.68** | **100.00** |

***Table 4. Results of Scavenger WHIMS at 8500 Gauss***

| Product | Wt% | Wt% wrt'O | Assay Percent | | | | %Recovery |
|---|---|---|---|---|---|---|---|
| | | | Fe | $SiO_2$ | $Al_2O_3$ | LOI | Fe |
| Non Mag + Middling | 48.17 | 14.13 | 43.16 | 20.84 | 11.87 | 4.72 | 40.31 |
| Mag | 51.83 | 15.20 | 59.40 | 6.25 | 4.63 | 3.69 | 59.69 |
| **Head Calc.** | **100.00** | **29.33** | **51.58** | **13.28** | **8.12** | **4.19** | **100.00** |

*Table 5. Computed concentrates from Rougher and Scavenger WHIMS*

| Product | Wt% wrt'O | Assay Percent | | | |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | $Al_2O_3$ | LOI |
| Rougher Mag | 52.51 | 65.80 | 1.92 | 1.53 | 1.69 |
| Scavenger Mag | 15.20 | 59.40 | 6.25 | 4.63 | 3.69 |
| **Head Calc.** | **67.71** | **64.36** | **2.89** | **2.23** | **2.14** |

*Table 6. Computed tailings from desliming and Scavenger WHIMS*

| Product | Wt% wrt'O | Assay Percent | | | |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | $Al_2O_3$ | LOI |
| Cyclone Overflow | 18.16 | 31.20 | 19.64 | 25.06 | 9.79 |
| Scavenger Non Mag | 14.13 | 43.16 | 20.84 | 11.87 | 4.72 |
| **Head Calc.** | **32.29** | **36.43** | **20.17** | **19.29** | **7.57** |

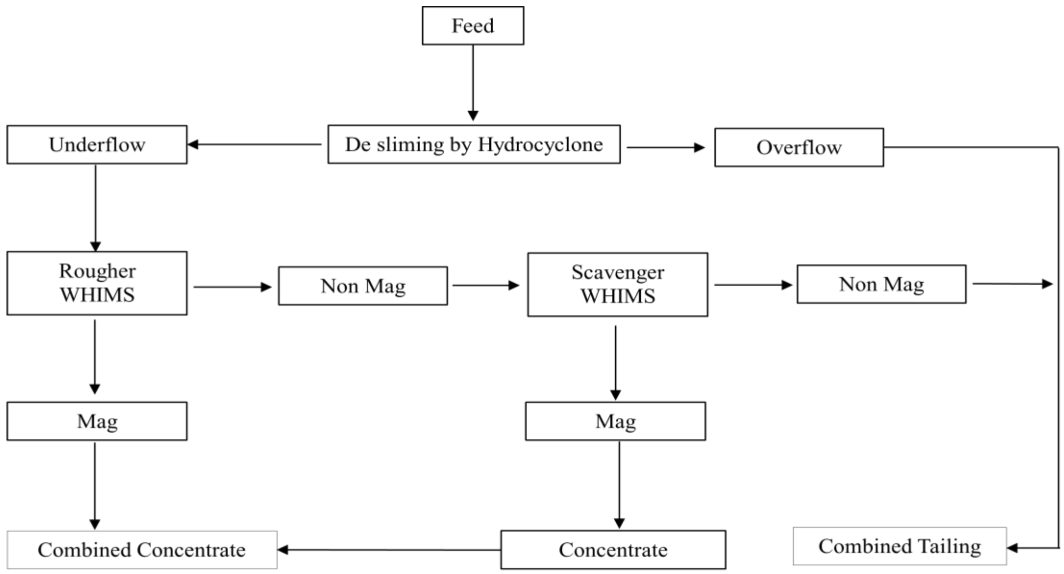


*Fig. 1 Schematic presentation of the flowsheet adopted*

## CONCLUSION

The slime sample from Donimalai area is amenable for beneficiation by adopting desliming followed by two stage wet high intensity magnetic separation process. Desliming eliminate ultrafine particles, mostly less than 26 microns and enriches the grade of the feed. The rougher WHIMS produce concentrate assaying 65.8% Fe with a yield of above 52.5%. The non magnetic portion of the rougher stage on processing in scavenger stage could enhance the iron recovery in the form of scavenger concentrate assaying 59.4% Fe with a yield of 15.2%. The overall concentrate produced from the process analyse 64.36% Fe, 2.23 % $Al_2O_3$, 2.89% $SiO_2$ and 2.14 LOI with a recovery of 78.74% iron units. The tailing generated from the process analyse 36.43% Fe, 19.29 % $Al_2O_3$, 20.17% $SiO_2$ and 7.57 LOI which is well below the threshold value specified by Indian Bureau of Mines (IBM).

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