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Feasibility of an eco – friendly disposal method for Iron ore tailings

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ABSTRACT

The greatest challenge ahead of the Iron ore mining industry is to tackle the issues related to management of tailings. The tailing disposal and storage methods are sensitive to the environment and care must be taken to keep them at the helm. The method being practiced for disposing the tailings is as thickener underflow at around 45% solids. The development of paste thickener & deep cone thickener are encouraging and can dispose tailings at around 65% solids. However, they are yet to be established over different range of mineral tailings and also the economic aspects related to their transportation are yet to be resolved. Thus the development of improved tailing disposal system is of paramount importance and need of the hour. Filtration of tailings after thickening is an alternative to current practices. However, the suitability of this application is to be assessed for tailings of different nature. In this perspective an attempt has been made to assess the filterability of tailings generated from beneficiation of slimes from Donimalai area. From the studies it is evident that the application of filtration process to these tailings is encouraging. By adopting pressure filtration technique it was possible to produce filtered tailings with moisture in the range of 16 - 21%. It is possible to get the filtration rate in the range of 200 – 300 Kg/hr/m^2 while operating in the aforesaid moisture range. The greatest advantage ascertained is in the reduction in volume of tailings to be disposed by around 63% which is significant apart from increase in the water recovery by about 10%.

Key Words: *Tailings, Filtration, Moisture.*

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I. INTRODUCTION

The beneficiation processes invariably end up with an enriched portion of desired mineral - “Concentrate” and an enriched portion of undesired minerals - “Tailing”. The proportion and nature of tailings generated in every beneficiation process differ from ore to ore and reflects the characteristics of the feed processed. The traditional method of tailing disposal in many mineral processing industries has been to dispose them as thickener underflow at around 45% solids. Though, it had certain advantages of transportation with ease but contribute to a greater volume occupied in the tailing dam. This prolonged practice and failure to utilize the space available in the tailing dam judiciously has endangered the mining industry. The tailing management has become the toughest task to the mining industry and most of the mines are running out of space for disposing the fresh tailings as many of these are at the verge of getting filled. The present scenario is attributed to various reasons starting from want of technology, lack of serious consideration on the problems that would arise, additional CAPEX and OPEX to be incurred etc.

“As for any other form of tailings management, there are a number of issues that require careful consideration prior to selecting filtered tailings for a given project.” (Davies, 2004)

“Tailing disposal adds to the cost of production, and consequently, it is desirable to accomplish their disposal as economically as possible. This requirement for low cost led to development the upstream method of tailings dam construction, which was the standard for tailings disposal up to the mid-1900’s, irrespective of site conditions. With the advent of sound engineering practice, it became recognized that there are significant weaknesses and risks in the upstream method of construction under many site conditions”. (Davies, 2002)

II. BACKGROUND

The present practice of Iron ore mining and processing is generating tailings at the rate of 10 to 15% of ROM treated. These generated tailings have already occupied the designated tailing dams to the large extent. In order to increase the mine life, it is obligatory to effectively utilize these tailings so that space can be created for fresh tailings. On the other hand, depletion of high grade reserves and revision in the threshold value of Iron ore to meet the country's demand for steel, beneficiation of low & lean grade Iron resources has become mandatory. The utilization of low grade Iron ores ends up with higher quantity of tailings. There are multiple issues to be addressed with respect to processing of low / lean grade Iron resources like scarcity of water for processing, scarcity of space for tailing disposal and probable threat to the environment. Under the present circumstances it is the demand to the mining industry to look for the solutions which can address these threats to a greater extent. The solutions derived should show the way to the co-existence of mining industry and environment with harmony.

The efforts are on to increase the solid content of thickener underflow by the introduction of High Rate Thickener, Paste thickener, deep cone thickener etc. However, the issues related to suitability of thickening for varying nature of Iron ore and distant transportation is yet to be proven. The other alternative being explored is to filter the thickener underflow to form a compact solid mass which can be transported to a greater distance and successful filtration will also increase the water recovery from the process.

The classification of tailing types based on their nature, solid content and transportability are presented in Figure – 1. In view of certain advantage of filtration of tailings, an attempt has been made to study the feasibility of producing filtered tailings amenable for dry stacking adopting pressure filtration technique for tailings generated from beneficiation of slimes from Donimalai area.

III. EXPERIMENTS

The Iron ore tailings / slimes from Donimalai area was subjected to bench and pilot scale beneficiation studies. The feed sample analyzed 55.27%Fe, 6.3% SiO_2 and 6.68% Al_2O_3. The process resulted in concentrate assaying 66.4% Fe with 61.54% yield where as the 38.46% tailings analyze 37.48% Fe, 23.66% SiO_2 and 13.71% Al_2O_3.

The generation of about 38% of feed as tailings demands for large area for their disposal. The success in beneficiating the slimes is followed by the challenge of handling large quantity of tailings. In view of the problems associated with tailing disposal, it was planned to study the feasibility of filtration of these tailings before disposal.

From the settling studies, it was possible to get the thickener underflow at 42% solids. Hence, the tests were carried out at this feed consistency. The size analysis and size fractional chemical analysis of the tailings are presented in Table – 1. It is apparent that about 80% of the tailings are less than 60 microns.

The experiments were conducted with an objective to study the feasibility of producing filtered tailings amenable for dry stacking. The aim was also to assess the possibility of lowering the moisture content of the filtered tailings suitable for easier transportation and disposal. Bench scale pressure filtrations studies were carried out using the tailings generated from the pilot scale beneficiation studies on slime sample. The tests were carried out at a feed consistency of 42% solids and at 7 bar pressure.

Initially, tests were carried out for selection of suitable filter cloth. The cloth selection was done based on the clarity of the filtrate produced. The first three experiments conducted using filter cloths designated as A, B and C resulted in producing a turbid filtrate. Subsequently, the fourth Cloth – D with an air permeability of $6m^3/m^2$could able to give a clear filtrate and considered suitable for this application.

The feed slurry is prepared by mixing the pre decided quantity of sample with appropriate amount of water and homogenized so as to make it 42% solids. This feed slurry is then pumped in to the filtration chamber by an air operated diaphragm pump till the chamber is filled and no further filtrate is coming out from the chamber. Further, pressing and drying were carried out to remove as much water as possible from the filtration chamber. The tests were conducted by varying the drying time and filtration chamber.

After completion of the each, weight of the wet cake and after drying weight of dry cakes was measured to ascertain the moisture content in the filter cake. The details of tests carried out and corresponding observations are presented Table – 2.

Based on the experiments, a hypothetical calculation is made to assess the additional recovery of water and reduction in the volume of tailings to be disposed. Considering a feed slurry of 100 TPH dry solids at slurry consistency to 10% solids as input to the thickener and the underflow is discharged at 45% solids, water recovery calculations are made. This is compared with the results obtained by filtration of tailings and corresponding recovery of additional water and reduction of volume of tailings. The details are presented in Table: 3 to 6.

Discussions

From the results it is evident that the sample is amenable for filtration and it is possible get the filtered tailings with moisture in the range of 16% – 21%. The corresponding filtration rate achieved is in the range of 200 to 300 Kg/hr/m^2. The relation between moisture content and filtration rate are shown in Figure – 2.

By adopting pressure filtration to the thickener underflow, it is possible enhance the recovery of water by about 10%. The process water recovery from filtration is in the tune of about 80%. The ability of filtration process thus helps in minimizing the makeup water required for the beneficiation plant. The relation between the moisture content of the filter cake and % increase in the recovery of water by filtration is presented in Figure – 3.

It is evident from the results and calculations carried out that it is possible to reduce the volume of the tailings by about 60 – 65%. The compaction achieved by filtration enables the slurry to form a cake which can be easily transported by mechanical means to any distance. The area of the tailing dam will certainly comedown apart from the environmental hazard that would arise by seepage or breaching of bund. The relation between the moisture content of the filter cake and the decrease in the volume of tailings to be disposed is presented in Figure – 4

IV. FIGURES AND TABLES

Table – 1: Results of Size analysis

Size	wt.%	Cum. Wt% Passing
+106µm	6.45	93.55
+75µm	4.29	89.27
+63µm	5.90	83.37
+42µm	21.79	61.58
+31µm	13.54	48.04
+20µm	16.34	31.70
+12µm	18.32	13.37
+9µm	5.12	8.25
-9µm	8.25	
Head	100.00	

Table – 2: Results of Filtration test

Expt. No.	Pumping time in min	Pressing time in min	Drying time in min	Cycle time in Hrs	Wt. of Wet cake in Kg	Wt. of Dry cake in Kg	% Moisture	Filtration rate Kg/m^2/hr
1	3	8	2	0.30	0.949	0.785	17.28	213.20
2	3	8	2	0.30	0.954	0.788	17.40	214.01
3	3	8	3	0.32	0.936	0.778	16.88	200.18
4	3	8	3	0.32	0.954	0.794	16.77	204.29
5	7	8	2	0.37	1.720	1.370	20.35	304.43
6	7	8	2	0.37	1.680	1.342	20.12	298.20
7	7	8	3	0.38	1.705	1.368	19.77	290.77
8	7	8	3	0.38	1.710	1.374	19.65	292.04

Table – 3: Water Recovery from Thickener

Feed to Thickener	100	TPH
% Solids	10	
Wt. of Slurry	1000	TPH
Wt. of water	900	TPH
Thickener U/f	100	TPH
%solids	45	
Wt of Slurry	222.22	TPH
Wt. of water	122.22	TPH
% Water Recovery	86.42	

Table – 4: Calculated Recovery of Water Recovery from filtration of tailings

% Moisture of filter cake	Wt. of filter cake TPH	Wt. of water TPH	% Water Recovery	% increase in water recovery
17.28	120.89	20.89	82.91	11.26
17.40	121.07	21.07	82.76	11.24
16.88	120.31	20.31	83.38	11.32
16.77	120.15	20.15	83.51	11.34
20.35	125.55	25.55	79.10	10.74
20.12	125.19	25.19	79.39	10.78
19.77	124.63	24.63	79.84	10.84
19.65	124.45	24.45	79.99	10.86

Table – 5: Calculation of volume of tailings from thickener underflow

Thickener Underflow	100	TPH
% Solids	45	
Wt. of Slurry	222.22	TPH
Wt. of water	122.22	TPH
Volume	154.48	m^3

Table – 6: Calculated reduction in volume of tailings after filtration

% Moisture of filter cake	Wt. of filter cake TPH	Wt. of water TPH	Volume of filter cake m^3	% Reduction in volume
17.28	120.89	20.89	53.150	65.59
17.40	121.07	21.07	53.324	65.48
16.88	120.31	20.31	52.567	65.97
16.77	120.15	20.15	52.409	66.07
20.35	125.55	25.55	57.806	62.58
20.12	125.19	25.19	57.444	62.81
19.77	124.63	24.63	56.893	63.17
19.65	124.45	24.45	56.712	63.29

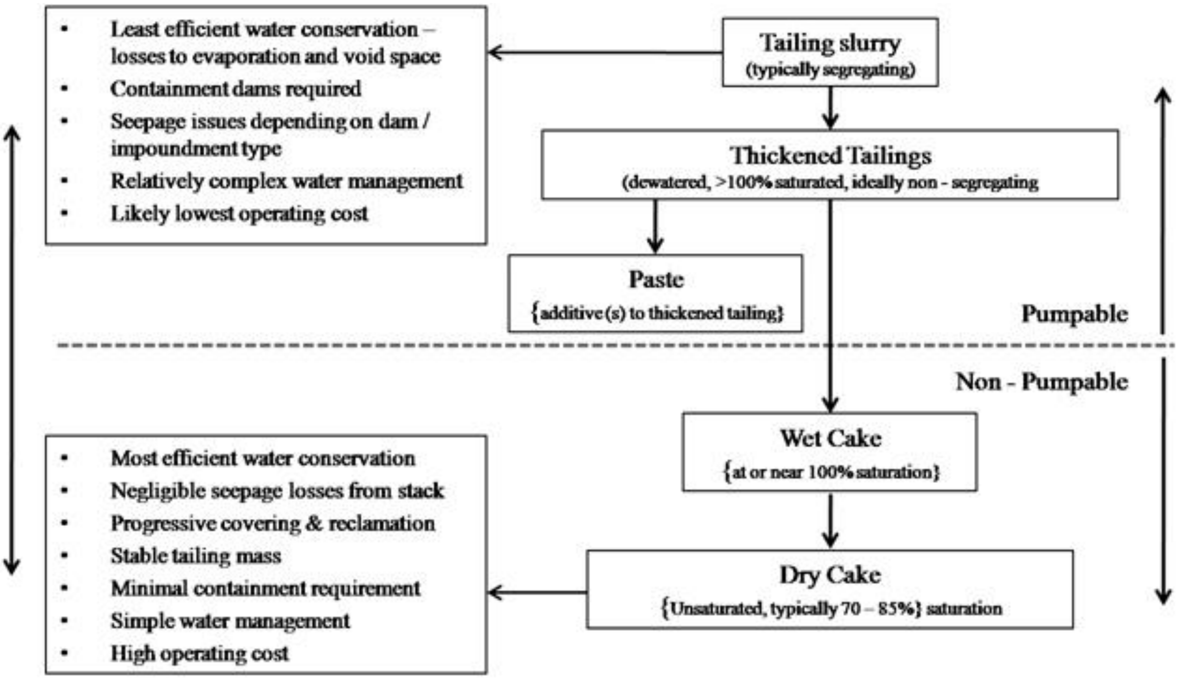

Fig.1: Tailings continuum (after Davies, 2011)

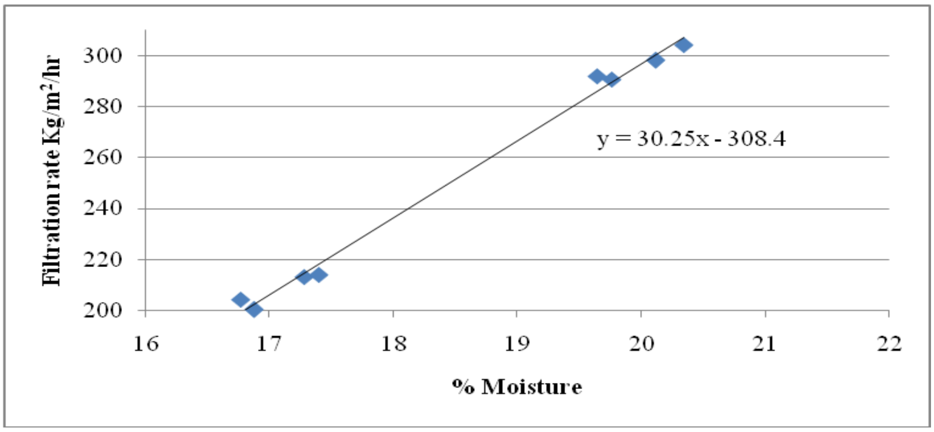

Fig.2: % Moisture Vs Filtration Rate

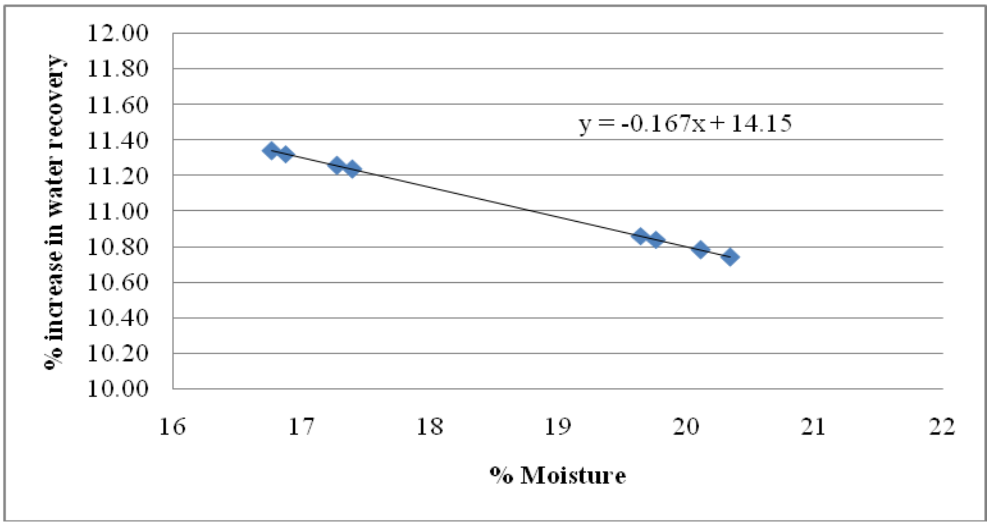

Fig.3: Relation between moisture and increase in water recovery

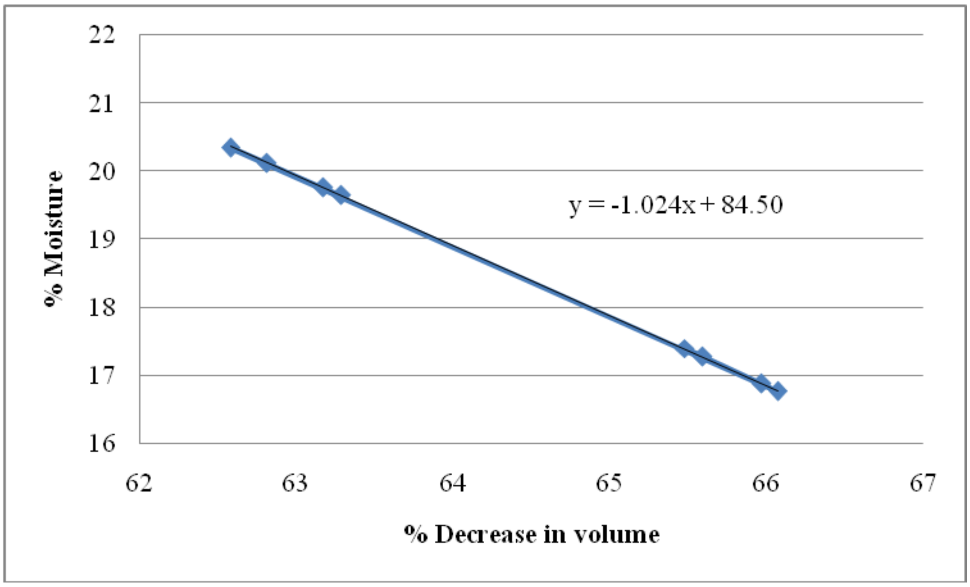

Fig.4: Relation between moisture and decrease in volume of tailing

V. CONCLUSION

- The tailings generated by beneficiation of slimes from Donimalai area are amenable for filtration.
- It is possible to achieve the moisture content of 16% to 21%.
- The increase in water recovery from filtration is about 80% and overall increase in process water recovery about 10 – 11%
- There would be a decrease in volume of tailings to be disposed by around 63%.
- The decrease in volume of tailing would enhance the mine life.

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