Some aspects of coal flotation at washeries of Tata Steel

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INTRODUCTION :

The coal mining industry in India is presently on the threshold of intensive mechanisation which would aggravate the difficulty of washing due to the production of a lower top size of ROM coal and a larger proportion of fines coupled with inherent high ash and near gravity material. Even with the open cast mining operations producing larger top size of ROM, the multiple handling of coal on various stages of feed preparation and washing will cause further degradation adding significantly to the quantity of fines and slimes to be dealt with.

In the arena of coal preparation, in a large number of cases, hitherto, the untreated fines were being directly mixed with deslimed washed coal. This practice no longer permits the ash line in clean coal to be held within desired limits. In view of this all the proposed coking coal washeries are seeking to integrate fines up-gradation schemes with the treatment of coarse and smalls. Some existing washeries (which initially did not have such facilities) are now in the process of supplementing their process circuits with froth flotation. A few proposals like the ones at Gidi and Dugda are under execution and many would follow suit soon.

The Tata Iron & Steel Co. Ltd., in their quest for self sufficiency, have installed an integrated new coal washery to treat 1.8 million tonne coal annually at West Bokaro employing two-stage cyclone plant and froth flotation. The old washery at West Bokaro has been supplemented with a 30 tph froth flotation unit. Similarly, TISCO's Jamadoba washery in Jharia coalfields has been hooked with a 60 tph froth flotation plant. While planning these froth flotation facilties, provision was made to treat about 20% of the quantity of run of mine coal which might eventually be generated as −0.5 mm coal fines.

Jamadoba froth flotation plant :

At conceptual stage, TRF sponsored an investigation project at Indian School of Mines to establish amenability to flotation of Jamadoba coal slurry. The findings confirmed that the coal slurry has excellent flotation characteristics and there is possibility of recovering over 80% of fine coal at ash content of about 12%. Details have been shown in Table—1.

Diesel oil and pine oil were used as collector and frother respectively. Increase in pine oil dosages has more significant effect on the response to flotation than the increase in collector dosages. It also came to the fore that at higher level of frother dosage, an increase of collector dosage is detrimental to the yield. While a pulp density from 5 to 20% solids were tried, the yield touched a peak level at 15% pulp density, after which a fall in recovery was registered. Desliming of feed i. e. removal of −100 mesh fraction from the slurry did not cause any significant difference in the grade of the product but an improvement in the yield was noticeable. However, the size analysis of feed coal indicated that −300 mesh fraction has low ash and constitutes a significant proportion of the feed as borne out by the Table −2[1].

In view of this observation, desliming prior to flotation was not resorted to. It was also found that +0.5 mm material in flotation feed

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should be kept to minimum and preferably at zero, as its presence leads to increase in tailing losses. This was established by conducting tests under identical process parameters with and without +0.5 mm fraction in the feed to the flotation circuit. As expected, the recovery was much higher with −0.5 mm fines than the feed containing 6 to 10 % + 0.5 mm material. The following Table—3 corroborates this.

The flotation tests were conducted in three types of laboratory cells presently available in Indian market i. e. Agitair, Fagergren and Denver. The results showed that the performance levels are comparable in all three types of cells and there is no significant difference in the yield and quality of products. However, it was felt that while going in for commercial scale operation, cells with external air addition might be of advantage in closer control of the operation. This point is particularly appreciated at a stage when flotation becomes sluggish towards the end of cells in a row.

The following points become evident while going in for full scale plant operation :

a) to have some arrangement for pulp density control of flotation feed.

b) to provide conditioning of flotation feed with pine oil and diesel oil for about a minute.

c) to design the flotation circuit to provide a retention time of 5 minutes.

d) to keep a minimum of 3 cells in a row to avoid short circuiting.

The above considerations, coupled with a decision to employ the highest capacity of flotation cells then available in Indian market and built-in-flexibility of operation and control measures led to :

i) Installation of 8 nos. of 8.41 M^3 Agitair flotation machines arranged in two rows, each consisting of 4 cells for treating 60 tph of coal which is the normal capacity of the plant.

ii) Provision of a 2.4 M dia × 2.4 M deep conditioner ahead of each row, where pulp can be conditioned by collector and frother at about 15% pulp density.

iii) Pumping the thickener underflow stream, which is the main source of all the −0.5mm material from the existing washery, to a flotation feed sump where it can be diluted to an acceptable level. Chance cone effluent also joins the flotation feed stream at this sump.

iv) Provision of tell-tale sieve bends ahead of conditioners to arrest migration of +0.5 mm material in flotation feed.

v) Inline sampling of flotation feed and tailings through self contained sampling units.

vi) Thickening of flotation tailings to recover and re-circulate process water and hence reduce make up water requirement of the plant.

The process flow sheet which was finally adopted for this plant has been depicted in Sketch—1.

The flotation plant has been interposed between the existing centrifuge house on ore side and a new tailing thickener on the other. Flotation concentrates are dewatered through existing centrifuges. There is flexibility to divert a part of — 0.5 mm coal slurry from fine treatment dense media cyclone circuit to slime thickener & balance directly to flotation feed sump. These two sub-streams can be regulated to achieve the desired pulp consistency of flotation feed. Alternatively, water can be added in the feed sump to dilute the flotation feed.

West Bokaro froth flotation plant.

When Tata Steel intended to integrate their old washery at West Bokaro treating 0.66 million tonne coal annually with a froth flotation

plant, a study was referred to the Central Fuel Research Institute by providing them with some samples of West Bokaro fines. The investigation undertaken at CFRI confirmed amenability of coal fines to flotation at an yield lower than that obtainable with Jamadoba fines. This was quite expected as West Bokaro coals are known for their difficult washing characteristics and high ash content which are bound to reflect in the response of – 0.5 mm coal fines to flotation.

Table—1 : Sample source : Jamadoba Thickener Underflow

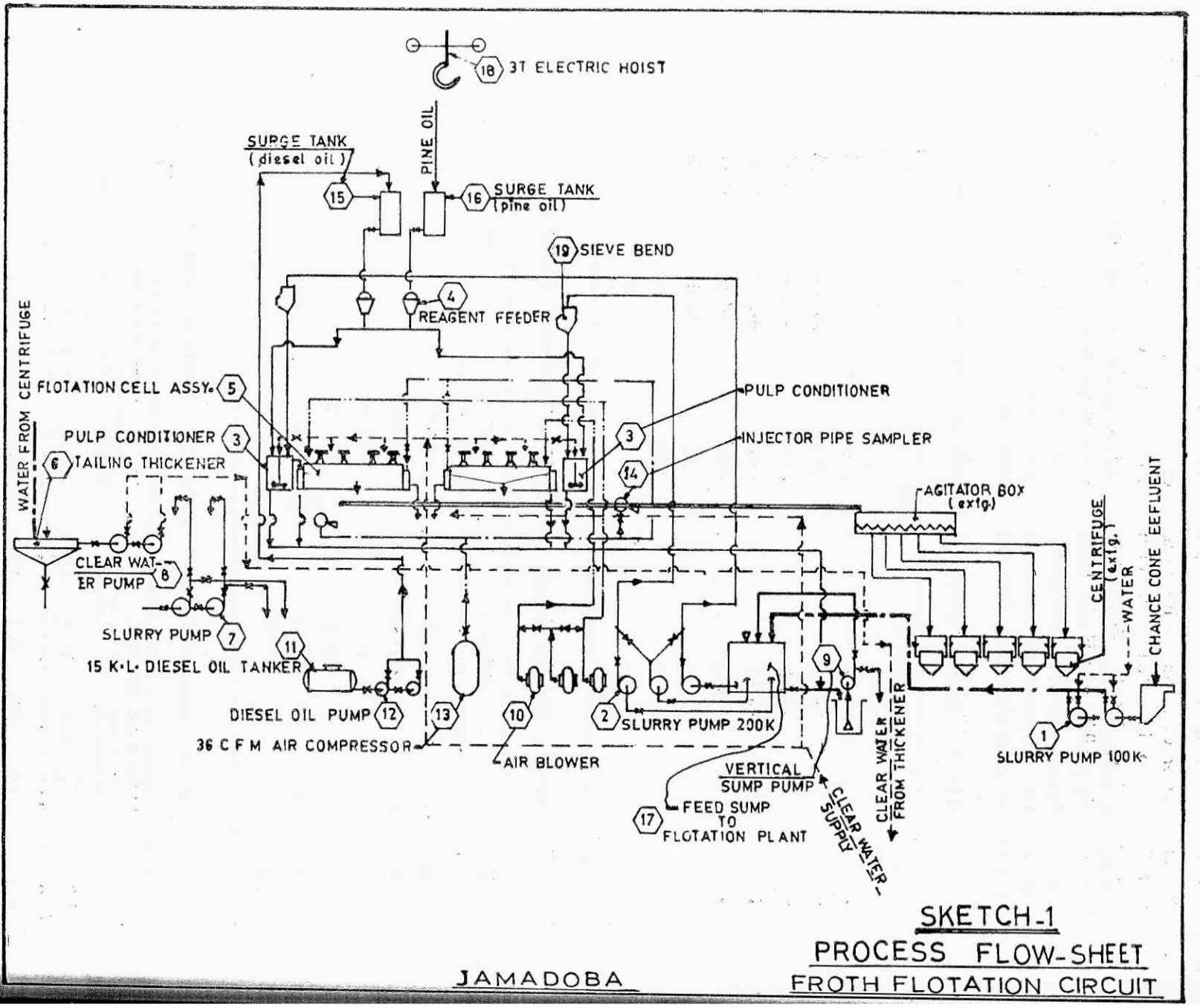
Test No.	Feed Ash %	Flotation time	Concentrate	
		(sec)	Wt. %	Ash %
1	19.50	270	86.08	11.34
2	19.47	240	89.27	11.79
3	19.17	125	89.80	12.58
4	18.50	150	91.28	12.37
5	18.91	120	86.97	12.81
6	22.80	180	79.90	12.50
7	19.99	170	86.36	11.39

Table—2 : Sample source : Jamadoba Thickener Underflow

Mesh size	Weight %	Ash %	Feed ash %
— 30 + 60	9.44	19.57	
— 60 + 72	21.13	17.93	
— 72 + 100	9.07	18.47	19.50
— 100 + 200	22.83	22.32	
— 200 + 300	10.03	22.76	
— 300	27.50	17.50	

Table—3 : Sample source : Jamadoba Thickener Underflow

As received sample					–0.5 mm screened fines				
Overall	Concentrate		Tailings		Overall	Concentrate		Tailings	
Ash %	Wt %	Ash %	Wt %	Ash %	Ash %	Wt %	Ash %	Wt %	Ash %
18.5	77.9	9.9	20.1	52.9	18.6	90.4	12.0	9.6	80.5
21.9	75.4	13.8	24.6	46.6	21.4	86.0	14.9	14.0	61.1
18.2	77.6	12.4	22.4	38·1	17.9	85.8	12.8	14.2	48.7

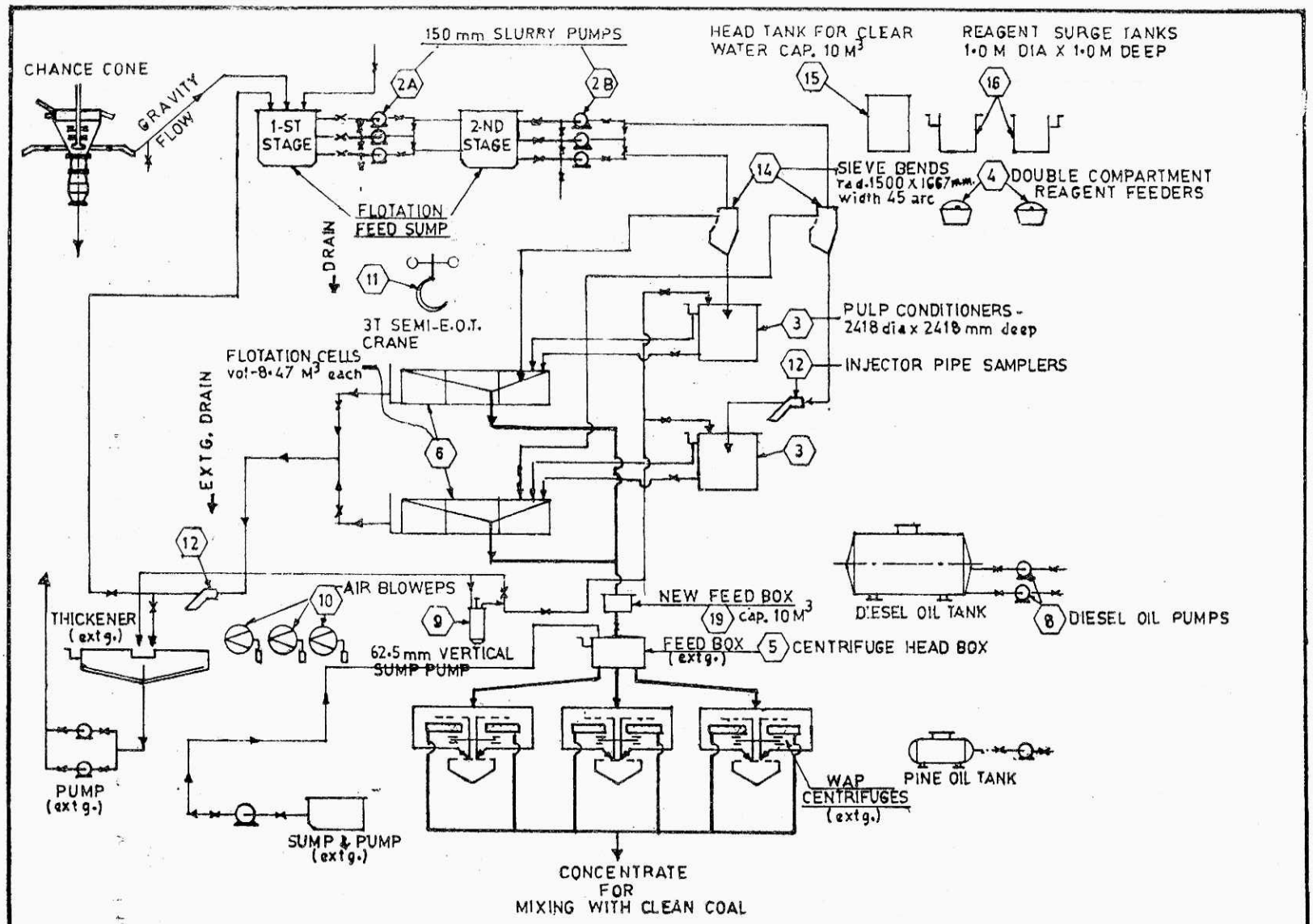


SKETCH-1

PROCESS FLOW-SHEET

FROTH FLOTATION CIRCUIT

JAMADOBA


150 mm SLURRY PUMPS
HEAD TANK FOR CLEAR WATER CAP. 10 M³
REAGENT SURGE TANKS 1·0 M DIA X 1·0 M DEEP
CHANCE CONE
GRAVITY FLOW
2A
2B
15
16
1-ST STAGE
2-ND STAGE
14
SIEVE BENDS rad.1500 X 1667 mm. width 45 arc
4 DOUBLE COMPARTMENT REAGENT FEEDERS
FLOTATION FEED SUMP
DRAIN
11
3T SEMI-E.O.T. CRANE
3 PULP CONDITIONERS - 2418 dia x 2418 mm deep
FLOTATION CELLS vol-8·47 M³ each
12 INJECTOR PIPE SAMPLERS
EXT G. DRAIN
6
3
12
AIR BLOWERS
10
9
NEW FEED BOX
19 cap. 10 M³
DIESEL OIL TANK
8 DIESEL OIL PUMPS
THICKENER (extg.)
62·5 mm VERTICAL SUMP PUMP
FEED BOX (extg.)
5 CENTRIFUGE HEAD BOX
PUMP (extg.)
WAP CENTRIFUGES (extg.)
PINE OIL TANK
SUMP & PUMP (extg.)
CONCENTRATE FOR MIXING WITH CLEAN COAL
LEGEND:
COAL SLURRY
CONCENTRATE
WEST BOKARO
SKETCH-2
PROCESS FLOW-SHEET FOR FROTH FLOTATION CIRCUIT

While process parameters like conditioning time, flotation time and optimum pulp density were maintained identical to the one described earlier in case of Jamadoba froth flotation plant, in view of lower capacity of the plant only 6 nos. of identical capacity i.e. 8.41 M^3 Agitair cells were used at West Bokaro. To provide flexibility of operation these cells were arranged in two parallel rows, each row having 3 machines preceded by a conditioner. The existing slime thickener of the washery was converted to tailing thickner and flotation feed was made available by intercepting the slurry stream being led to the existing thickener. This arrangement, however, has an obvious disadvantage of loss of flexibility of pulp density control of flotation feed. During trial operations, many a times, it was not possible to achieve the optimum pulp density. Two stage pumping of flotation feed became necessary to suit topographical situations of flotation feed sump and the entry point of pulp to the conditioner. Tell-tale sieve bends to indicate possible migration of +0.5mm coal in flotation feed and tailings were employed through self contained sampling units as done in case of Jamadoba froth flotation plant.

Process flow sheet has been shown in Sketch—2.

Yields of about 80% concentrate with ash-content of about 13.5% have been obtained during commercial operation of flotation plant at West Bokaro. This enables not only to improve the quality of washed coal despatches to the steel works but also permits higher ash levels in the coarser fraction which compensates for the yield losses through the tailings in flotation circuit. This is the only commercially established process for treating fine coal below 0.5 mm size and this has been successfully utilized for recovery of metallurgical coal for washery by products like middlings.[2]

Summary

Owing to the growing intensity of mine mechanisation at TISCO collieries, there has been progressive deterioration in the quality of coal fines. In view of this the earlier practice of directly mixing – 0.5 mm coal to the washed coarse and smalls from the washeries has been dispensed with. Coal flotation plants at Jamadoba and West Bokaro have been integrated with the existing washeries recently to beneficiate – 0.5 mm coal.

It has been possible to produce a relatively low ash coal concentrates which, when mixed with washed coal from chance cone and dense media cyclone circuits gives a 'sweetening effect' on coal lowering down the overall ash content.

With progressively higher level of mechanisation and crushing of coal to lower sizes before beneficiation, all washeries both existing and proposed, will have to provide flotation circuits for treating fine coals which may comprise a sizeable fraction of the total production. Besides this, it may also be decided to utilise this technique for upgradation of washery products like middlings in the interest of conservation of prime coking coals.

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References

1. Some aspects of beneficiation of coal slimes in India : Dr. T. C. Rao, L. Prasad & Kripal Singh
Paper presented at Seminar on coal washing organised by the Bureau of Public Enterprises, New Delhi Oct '78.

2. Beneficiation of Middlings from Jamadoba coal washery by flotation : K. J. Pillai, Dr. T. C. Rao, & Dr, S. M. M. Safvi. Published in the Journal, Vol. 61, Pt. MMI July, 1980 of the Institution of Engineers (India).