Improvement in grinding and classification circuit by the use of Hydrocone at Rakha concentrator

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INTRODUCTION

With increase in demand of metals, depleting ore reserves, falling ore grades and manyfold increase in operational cost, many of the mineral industries are now facing the prospect of closing their operations. However, efforts are being made at every place to reduce the cost of production through innovations and improvement technology.

Beneficiation, which is one of the major steps in recovery of minerals, consumes about 20 percent of cost of production of copper metal. Out of this, 35 – 40 percent is attributed to grinding and classification only. It is thus an accepted fact that the grinding units must be run at maximum throughputs. In this context classification assumes great importance because it is the classifier efficiency which is the improtant factor in controlling the grinding circuit.

Hydrocyclone, which has gained its importance over rake and spiral classifiers of yester years, are being used extensively throughout the world as size separation units. It has its own limitations so far as its efficiency is concerned with its use in conventional grinding circuit. Thus at Rakha concentrator, to improve the efficiency of Hydrocyclone, two-stage classification was introduced with the use of another hydrocyclone in the circuit. This resulted in improvement in classification and increase in grinding capacity by about 10 percent.[1]

The scondary classification using hydrocyclones, though established, requires pumping and thus consumes extra power. The main object of this work is to experiment a new equipment in the field of classification, known as Hydrocone, in the secondary stage. This is an improvement form of gravitational cone classifier and is provided with a wash water system. It does not require pumping and can be installed below the hydrocyclone. The information so obtained about its performance, is of great importance to the operational economics of existing plants and also for saving energy.

PLANT DETAILS :

Rakha concentrator is a 1000 TPD beneficiation plant, treats the ore of Rakha Mines. The ore mineralogy and plant description is given elsewhere.[2]

The grinding circuit has two independent streams of 500 tonnes each. Each stream has one ball mill (2.59m dia x 2.85m long) close circuited with a 600mm dia hydrocyclone through 100 mm size slurry pump. The layout of the grinding circuit is shown in the Figure 1. In order to determine the limiting conditions of the circuit, a hydrocyclone model was developed[1]. From the model is was established that the mills can best be operated at 22 tph with the 600 mm dia cyclone having 125 mm dia vortex and 50mm dia spigot. The feed to cyclone should be around 55 percent solids so as to have

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25 percent solids in overflow. The data around the grinding circuit is given in Table 1.

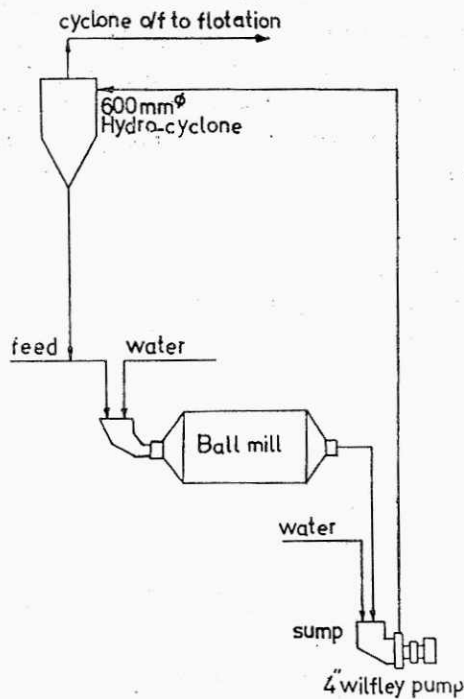## EXISTING GRINDING CIRCUIT AT RAKHA CONCENTRATOR

FIG . 1

It may be observed that the classification efficiency even at the optimum conditions as mentioned above is not satisfactory and is around 50—60 percent at —200 mesh of separation. About 25 to 30 perecent of liberated particles are being recirculated back to the mill, leading to overgrinding

Improvements made :

To improve upon the classification efficiency, two-stage classification system was introduced in one of the grinding circuits with the use of another cyclone in circuit. The underflow product of first cyclone is pumped with necessary dilution to second stage cyclone. The overflow of both the cyclones are then combined and sent to flotation cells for down the line treatment. The underflow of the 2nd cyclone is returned to the mill for regrinding along with the fresh feed. This system resulted in increase of classification efficiency and also led to increase in the throughput from the same grinding circuit by about 10 percent[3].

In view of the extra power, which is still being consumed for pumping in the 2nd stage and also persistance of maintenance problems involved with the pumping equipments, pipe-line etc., a simpler and new equipment known as "Hydrocone", developed by Prof. R. T. Hukki of Finland was incorporated for trial in 2nd stage of classification.

Hydrocone :

It is basically an improved form of hinde-red settling gravitational cone classifier having a wash water ring for cleaning the sand. It also has a vertical rotating mechanism which rotates at slow speed to agitate continuously the sand inside the cone to prevent its accumulation. The fine particles carried by the sand fractions are separated by the wash water, rise with it and overflow the rim. The washed coarse fraction is discharged through the valve as underflow.

Principles of operation :

The classification in hydraulic cone classi-fier is based on settling in an upwardly directed pulp flow.

The sand which is to be cleaned is fed through the feed tube to distributor discs. Pri-mary cleaning of the heaviest / coarsest sand fra-ction takes place on the bigger disc by the retur-ning suspension, crossing the spread out sand layer. The upwardly directed laminar flow takes the fine fractions along which are discharged as overflow.

Below the distribution disc, the coarse material is kept in continuous motion to prevent accumulation of sand layers on the inside wall of the cone. Wash water is introduced under

pressure through wash water ring to the falling sand layer. The fine particles in the sand fractions are separated and they rise with wash water through the central flow tube, back to the classification zone. The washed coarse fraction is then discharged through the discharge valve as underflow[4].

A schematic diagram of the hydrocone is shown in the Figure 2.

FIG. 2

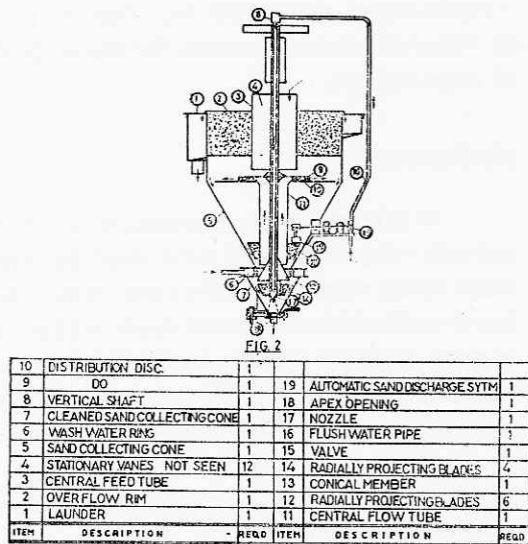| 10	DISTRIBUTION DISC.	1			
9	DO	1	19	AUTOMATIC SAND DISCHARGE SYTM	1
8	VERTICAL SHAFT	1	18	APEX OPENING	1
7	CLEANED SAND COLLECTING CONE	1	17	NOZZLE	1
6	WASH WATER RING	1	16	FLUSH WATER PIPE	1
5	SAND COLLECTING CONE	1	15	VALVE	1
4	STATIONARY VANES NOT SEEN	12	14	RADIALLY PROJECTING BLADES	4
3	CENTRAL FEED TUBE	1	13	CONICAL MEMBER	1
2	OVERFLOW RIM	1	12	RADIALLY PROJECTING BLADES	6
1	LAUNDER	1	11	CENTRAL FLOW TUBE	1
ITEM	DESCRIPTION	REQD	ITEM	DESCRIPTION	REQD

Fie. 2

Trial run with hydrocone :

Based on the principles of Prof. Hukki and on the available publications on hydrocone, a small 1 metre diameter hydrocone was fabricated at site for conducting the trial in one of the grinding circuits.

Due to the headroom limitations and to facilitate gravity feeding to hydrocone, the existing hydrocyclone was shifted to the next higher platform. The hydrocone was then installed

below the hydrocyclone and necessary pipe line connections were made. The mill discharge is first pumped to the hydrocyclone. The underflow of the hydrocyclone is fed by gravity through a launder to the feed tube of the hydrocone. The overflow of both hydrocyclone and hydrocone are combined and sent to flotation cells for further treatment. The underflow of hydrocone is fed back to the mill by gravity through launder for regrinding along with the fresh feed. Circuit with hydrocone is given in Fig. 3.
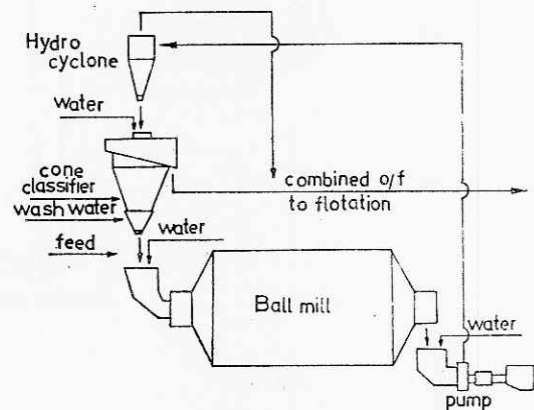
FIG. 3

The new circuit was run initially with 22 tph, the same feed rate as with the original circuit and samples were taken at various points of the modified circuit.

Next the trial was made with higher feed rate of 24 tph and again a set of samples were taken. The sieve analysis data at higher throughput rate is presented in Table 3. Comparative data for the original and modified circuits at different feed rates is given in Table 4.

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Table — 1 : Typical sieve analysis around the mill of existing circuit. Weight percent retained.

Sieve size (mesh)	Mill discharge	Cyclone overflow	Cyclone underflow	Actual efficiency
+ 48	40.49	8.60	53.64	96.14
− 48 + 65	6.06	5.17	6.61	83.67
− 65 + 100	13.90	15.65	13.72	77.82
− 100 + 150	12.08	18.15	9.64	67.99
− 150 + 200	8.18	6.89	3.81	68 85
− 200	19.29	45.54	12.58	52.47

Note :—

1. Feed rate — 22 T/hr.
2. Recirculating load — 390 percent (calculated)
3. Percent solids in mill discharge — 68.29
4. Percent solids in cyclone O/F — 28.12
5. Percent solids in cyclone U/F — 77.27

Table — 2 : Typical sieve analysis data around the mill with the modified circuit at 22 tph. Weight percent retained

Sieve size (mesh)	Mill discharge	Cyclone overflow (I)	Cyclone underflow	Hydrocone overflow (II)	Hydrocone underflow	Combined overflow (I) + (II)
+ 48	25.66	0.00	23.83	0.91	39.51	0.93
− 48 + 65	18.22	0.03	19.62	13.38	24.13	12.00
− 65 + 100	8.62	0.13	10.16	12.98	9.44	8.89
− 100 + 150	15.98	3.20	20.92	28.32	14.96	19.42
− 150 + 200	7.63	6.84	9.20	15.12	5.29	11.25
− 200	23.87	89.79	16.25	29.29	6.67	47.45

Note :—

1. Feed rate to Ball Mill — 22 T/hr.
2. Overall circulating load — 106.9 percent (calculated)
3. Percent solids in mill discharge — 65.79
4. Percent solids in cyclone O/F — 14.82
5. Percent solids in cyclone U/F — 72.72
6. Percent solids in Hydrocone O/F — 40.38
7. Percent solids in Hydrocone U/F — 65.30
8. Percent solids in combined O/F — 24.13

Table — 3 : Typical sieve analysis around the mill modified circuit. Weight percent retained

Sieve size (mesh)	Mill discharge	Cyclone overflow (I)	Cyclone underflow	Hydrocone overflow (II)	Hydrocone underflow	Combined overflow (I) + (II)
+ 48	25.37	0.00	29.63	7.63	39.25	4.98
— 48 + 65	16.42	0.10	19.20	18.90	20.26	10.81
— 65 + 100	8.74	0.21	10.74	13.51	9.70	7.56
— 100 + 150	17.28	4.87	19.89	27.83	16.80	18.25
— 150 + 200	8.01	11.13	7.62	11.42	5.70	12.18
— 200	24.17	83.68	12.89	20.69	8.27	46.19

Note :-

1. Feed rate to Ball Mill — 24 T/hr.
2. Overall circulating load — 112.8% (calculated)
3. Percent solids in mill discharge — 60.00
4. Percent solids in cyclone O/F — 16.36
5. Percent solids in cyclone U/F — 74.66
6. Percent solids in Hydrocone O/F — 43.79
7. Percent solids in Hydrocone U/F — 63.70
8. Percent solids in combined O/F — 25.64

Table — 4 : Comparative data on original and modified circuit with Hydrocone

Stage	Feed rate T/hr.	Circulating Load (percent)	Sieve analysis of final product (Feed to conditioner) (percent)		
			+ 100 mesh	— 100 + 200 mesh	— 200 mesh
Single stage	22	390.0	29.42	25.04	45.54
Two stage	22	106.9	21.82	30.67	47.45
	24	112.8	23.35	30.43	46.10

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Results and discussions :

It was observed that the circuit stabilizes without any difficulty.

From the Table 4, it can be seen that with modified circuit the +100 mesh fraction in the overflow is reduced.

The — 200 mesh fraction in the circulating load, which goes back to the mill is also reduced indicating that overgrinding is minimised.

The circulating load also reduces even with the higher feed rate which indicates that still there is scope of increasing the throughput from the circuit.

Conclusion :

The operating experience so far shows that the use of hydrocone as second stage classifier is feasible and is advantageous because it does not require pumping and saves power. Hydrocone has a definite operational advantages over a conventional hydrocyclone operating as a secondary classifier.

Acknowledgement :

References :

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