Effect of low grade copper ore on process control and costing at Mosaboni concentrator

* P. P. Midha and ** A. Gururajachar

INTRODUCTION :

The concentrator was designed to produce 22 — 24 % Cu. concentrate from head value of around 1.5—1.3 % Cu.

Due to change in the method of mining and the lowering of cut-off grade of mined ore, the grade has gone down drastically to 1.12 % which has posed process control problems to maintain and even to increase the concentrate grade without sacrificing recovery.. The decreased ore grade results in low metal extraction thereby production cost increases.

Mining and mineralogy :

The Mosaboni group of mines consists of Mosaboni, Pathorgora, Surda, South Surda and Kendadih which feeds Mosaboni concentrator. The ROM grade differs considerably from one mine to other. The Mosaboni mine gives around 1.4—1.2% Cu. whereas Surda, Kendadih and Pathorgora are producing around 0.9—1.1% Cu. Since the feed to concentrator is the blend from all mines the ore grade gets diluted to around 1.1—1.25% Cu. The blending of ore is not in any definite proportion which results in heavy grade fluctuation in day to day operation.

The gradual decrease in ore grade over the years has posed problems both for mines output and concentration processes. The decreased head value results in low metal output from mines and thereby cost per tonne of ore hoisted also has gone up. Table—1 shows a steep decline in ore grade over the years.

Table—1 : Grade variation

Year	Ore grade
1975—76	1.511
76—77	1.513
77—78	1.499
78—79	1.320
79—80	1.232
80—81	1.110
81—82	1.121
82—83	1.131
83—84	1.179

From the above table, it is clear that the head value is decreasing and the result is low copper metal recovery resulting in high cost of production.

Mineralogy :

Chalcopyrite is the most predominant sulphide mineral in the ore followed in abundance by pyrite, pyrrhotite, pentlandite and the accessory minerals being apatite and magnetite.

The sulphide veins and stringers are present along foliation and fractures as dissemination and minor replacement patches. Sulphide minerals have medium to coarse grained in texture having associated gangue minerals as finely dispersed chlorite, biotite flakes, quartz etc., along with scarcely noted magnetite clots. The ore composition is shown below :

SiO_2	— 58 to 60%	Fe_2O_3	— 15 to 17%
Al_2O_3	— 9 to 10%	TiO_2	— 0.7 to 0.8%
MnO	— 0.07 to 0.09%	CaO	— 2.2 to 2.5%
MgO	— 4 to 4.2%	S	— 2 to 2.4%
Cu	— 1.2 to 1.4%	Ni	— 800 ppm.
Co	— 190 ppm.	Au	— 0.4 ppm. and
Ag	— 3 to 4 ppm.		

* *Senior Manager, (Concentrator)*
** *Senior Process Engineer*
Hindustan Copper Limited, Mosaboni,

Concentration :

Mosaboni concentrator was designed for 2000 TPD. which was later enhanced to 2700 TPD by installing one more ball mill in closed circuit with classifier. The ROM of – 300 mm size will be crushed in three stages to a size of – 12 mm of 80 to 90%. Two lines of crushers will operate at a time out of three lines. The crushed ore is ground in ball mills in closed-circuit with classifiers to a size of 50% - 200 mesh. The classifier overflows are distributed to 5 rows of flotation cells. The concentrate of 24 — 25% is dewatered and the final filter cake containing around 10% moisture is despatched for smelting.

Process control :

The process controlling parameters are :

i) Pulp density

ii) pH

iii) Reagent addition.

The pulp density is maintained in the range of 35 — 40 % solids and the mesh of grind is more or less steady. The pH is maintained at about 9.5 — 10.0 at which good flotation is observed. Reagent addition dosages are well controlled to avoid excess consumption of pine oil and sodium isopropyl xanthate.

Due to wide fluctuations in head value, the recovery of copper in terms of chalcopyrite gets adversly affected which causes problems in cell stabilisation and thus its equilibrium gets disturbed. The low recovery of copper thus enhances the tailing loss. Since there are limitations in operational control to accommodate wide fluctuations in head value, the enhanced tailing losses (Table—2) could not be avoided.

From the Table—2 it is clear that the down-fall in head value did not affect much of concentrate grade but the percentage loss of copper differs. The copper losses in terms of percentage are more when head value is lower.

Table—2 : Tailing losses and recoveries

Year	Head value % Cu	Tailing losses % Cu	Cu % loss	Cu% Recovery
1975-76	1.511	0.059	3.91	96.09
76-77	1.513	0.063	4.16	95.84
77-78	1.499	0.052	3.47	96.53
78-79	1.320	0.050	3.79	96.21
79-80	1.232	0.051	4.14	95.86
80-81	1.110	0.055	4.95	95.05
81-82	1.121	0.063	5.62	94.38
82-83	1.131	0.054	4.77	95.23
83-84	1.179	0.054	4.58	95.42

The above table shows clearly that, even though head value has gone down drastically, the tailing did not come down in the same ratio but it has increased. This picturises the limitation of the process and operation.

It can be also seen that the high recovery to over 96.5% is due to high head value. The recovery has gone down to 95.5% with low head value only. Hence copper metal recovery is going low due to low head value unless high milling is done which is beyond the control by the existing capacity of the plant.

The concentrate grade is remaining more or less in the range of 22 — 23% Cu. over the years.

But with the need of high grade concentrate by the smelter, the grade has to be improved and being tried to +25.00% Cu and with the existing flotation circuit with slight modification. The tailing loss has also increased along with concentrate thereby decreasing the overall copper recovery. The xanthate consumption is also doubled to increase the concentrate grade from 0.011 kg./Ton to 0.025 kg./Ton. Efforts are being made to maintain lower tailing loss.

Costing :

1) Raw materials cost :
   i) Balls, liners.
   ii) Lime, lubricants, reagents.

2) Operation of the equipments :
   i) Power, water.
   ii) Running of equipments.

3) Overheads other than direct operating cost.

4) Manpower, wage revision.

Raw materials :

The raw materials include grinding media, liners, xanthate, pine oil, lime and soda.

The consumption of the above raw materials essentially depend upon milling and concentrate production. Although grinding media consumption remains more or less same but its cost of procurement has increased three fold over the years; like-wise mill liners also. So the price escalation has an adverse effect on cost of production.

Reagents like xanthate, pine oil and lime etc. have the same effect on cost while consumption of the above remained more or less same.

But recently, due to enhancement in concentrate grade, the xanthate consumption is doubled.

Cost of raw materials and their consumption over the years is given in Table-3:

Table — 3 : Raw materials — cost and consumption

Year	Grinding media		Xanthate		Pine oil		Liners	
	Consumption Kg./T	Cost Rs./T	Consumption Kg./T	Cost Rs./Kg	Consumption Ltrs./T	Cost Rs./L	Consumption	Cost Rs./MT
1975-76	—	1650	—	11.25	—	16.00	—	2500
76-77	0.877	1750	0.0327	11.25	0.0393	16.00	—	2500
77-78	0.897	1750	0.0170	11.30	0.0410	17.00	—	2500
78-79	0.860	1395	0.0159	11.30	0.0367	22.00	55000	2580
79-80	0.830	1415	0.0180	19.00	0.0420	23.00	Tonnes	2300
80-81	0.950	1700	0.0160	19.00	0.0400	26.70	ore	2300
81-82	0.910	2706	0.0110	—	0.0360	33.75	milling	3600
82-83	0.860	3137	0.0120	—	0.0370	48.00	per set.	—
83-84	0.820	2900	0.0190	27.00	0.0270	—		3500

1 Set = 19 MT.

From the table, it is clear that the price escalation of raw materials has a direct impact on production cost. Though the cost of the production can be brought down by high production but there is a limit of capacity.

Equipments and operation :

a) Power and water consumption :

The power consumption factor is the most important and the price of unit power is an ever increasing process. The grinding section is the major power consuming section and then crushing.

The power consumption per ton of ore milled remained more or less within reasonable limit. The power constraints are also a cause for low production.

The water consumption remains same but its treatment cost from raw water to cleaned water has increased.

b) Machinery spare parts :

The world-wide increase in prices of machine spares is an on moving phenomenon and the process plants gets affected. The following example will show the fact.

The same spares which were in use when the head value was high are now being used with high cost but now head value is low resulting in low recovery. The prices of spares of all machines, mills, pumps etc. have enormously increased over the years.

Spares like bowl liners and mantle, mill heads, girth gear, pinions of mills, pitmen assembly, pump spares, motors and classifier spares etc. are common items which are of high values. These spares were used when head value is 1.5% Cu. and now also with head value of 1.15 % Cu. the difference is well known technically over their consumptions, wear and tear etc.

Effective running of the machinery is an important factor in utilizing the life of the equipments. Lubrication and scheduled preventive maintenance gives a good life to equipments and availability to production. The maximum availability of machinery to production proves its good maintainance and more production and less cost of production. The availability of machinery to production is above 85—90 % and thus proving the best preventive maintainance.

Though the running hours of mills and their allied systems have increased reasonably, the low grade ore has made the operation costly.

Example :

For producing 11,089 tonnes of copper, the milling was 7,44,857 tonnes in 1977-78 with a head value of 1.499 % Cu. and concentrate grade of 22.79 % Cu. But to produce 9,043 tonnes of copper in 1982-83, the milling has increased to 8,15,819 tonnes with head value of 1.160 % Cu. and concentrate grade of 22.436% Cu.

Though the milling has increased by about 7,000 tonnes, the copper production did not raise rather is less by about 2,000 tonnes. This clearly shows that, to mill about 81,000 tonnes, the plant running hours are more when com-

Table – 4 : Cost in Rupees

Year	Crushing	Grinding	Flotation	Dewatering of concentrate	Others	Direct cost	Over-head	Grand Total
1976-77	—	2241231	926503	168277	—	9406319	2175997	11748269
77-78	—	2724325	1396233	291021	—	9426087	1628980	11232105
78-79	2437605	1999934	1339783	270397	4887688	10935407	2177775	13113182
79-80	2459660	2252777	1698668	322724	5554090	12287919	2489254	14777173
80-81	4300161	3968013	2588136	513472	8814870	20184652	4137146	24321798
81-82	4266231	5638176	2483820	717488	11977475	25083190	7378507	32461697
82-83	5036053	6553045	3215217	614856	12965509	28384680	8154768	36539448
83-84	5164624	5998707	3198637	744567	12356854	27463389	8710874	36174263

Table — 5 : Percentages of total cost

Year	% Crushing A	Grinding B	Flotation C	Dewatering D	Others E	Direct A+B+C+D+E	Overhead
1976—77	—	19.08	7.89	1.43	—	80.07	18.52
77—78	—	24.25	12.43	2.59	—	83.92	14.50
78—79	18.59	15.25	10.22	2.06	37.27	83.39	16.61
79—80	16.64	12.24	11.50	2.18	37.59	83.15	16.85
80—81	17.68	16.32	10.64	2.11	36.24	82.99	17.01
81 – 82	13.14	17.37	7.65	2.21	36.90	77.27	22.73
82—83	13.78	17.94	8.80	1.68	35.48	77.68	22.32
83—84	14.28	16.58	8.84	2.06	34.16	75.92	24.08

Others (E) : Includes process pumping, assaying, sampling, concentrate despatch, ore weighment, power, water, workshop and raw materials etc.

Overhead : Covers building repairs, camp lighting, administration, hospital, road upkeeping, domestic water supply, grain store exp. insurance, sick and injury pay.

Table — 6 : Cost per tonne of ore milled in rupees

Year	Direct	Overhead	Others	Total	Cost per tonne of Concentrate
1975—76	13.31	3.36	0.23	16.90	291.72
76—77	12.57	2.91	0.22	15.70	269.63
77—78	15.24	2.13	0.23	17.60	303.13
78—79	17.63	3.51	0.35	21.49	421.72
79—80	21.92	4.44	—	26.36	561.24
80—81	24.77	5.08	—	29.85	692.95
81—82	32.05	9.43	—	41.58	977.71
82—83	33.92	9.75	—	43.67	1010.22
83—84	33.78	10.72	—	44.50	979.13

pared to 74,500 tonnes milling; this excess running hours amounted to excess power consumption, reagent consumption, water consumption, wear and tear of spares, mandays worked and overhead above all these. This is all due to low head value.

The gangue minerals processing and their recirculation in the system has increased because of low cut-off grade from mines making the overall ore grade very low.

Process loss :

The process losses like tailing containing copper is not recoverable and is sent to mines for back filling. Spillage occuring from mills, conveying systems, flotation cells and filters is further recirculated back to the process and in this respect concentrator has stopped copper loss in spillage to cent percent. So, there is no way for loss of copper except tailing loss which is well under control.

The spilled material is collected in peddocks or catchpits from where it is pumped to process system.

The cost of production which is moving in upward direction due to the following :

i) Low head value.
ii) Increased prices of raw materials.
iii) Price escalation in spare parts.
iv) Increase in power unit cost.
v) Overheads increase.
vi) Wage hike of employees and so on.

The process plants are having only one way of controlling it by maximisation of production.

From the tables it is seen that, the direct operational cost is more or less constant rather it is decreasing but the cost of overheads is increasing. The bulk of percentage goes to crushing, grinding and overheads wherein the overheads is not in the departmental control.

In this regard concentrator has remarkably achieved its production, lessened tailing losses and making the life of the equipments more by way of effective lubrication and schedule maintainance.

Conclusions :

It is observed from data on the plant performance for the last few years that by keeping strict controls on process parameters, preventive maintainance i.e. timely replacing of spares of the equipments, it is possible to get consistant results by maximum utilisation of the plant. Due to this consistancy of performance, effect will be on cost of production. It is observed that in the last few years cost is within the permissible limit.

Discussion :

A. K. Khatry,
GMDC Ltd., Ahmedabad.

Question : *What is the breakeven point for production ?*

Author : 1.2 % Cu with present flotation circuit.