

Beneficiation of Fertilizer Minerals — Saladipura - An Experience

* A. K. SRIVASTAVA, ** T. N. JAGGI

Preamble :

India constitutes approximately one sixth of world's population living in 2% earth's land-mass. The need for increased agricultural output by ensuring intensive cultivation can hardly be over emphasised. The most important means of achieving the target is to increase the output of fertilizer minerals and hence chemical fertilizer within the country itself which will enable not only to become self sufficient, but also save foreign exchange under widely fluctuating price conditions.

There is no indigenous source of elemental sulphur; however, we are endowed with vast reserves of pyrites as source of sulphur. Saladipura deposit has 25 million tonnes of sulphur locked in pyrites. This pyrite deposit alone is capable of sustaining a production of 5000 TPD of sulphuric acid for more than 20 years. In addition, pyrites deposit at Amjhore has sulphur reserves of about 300 million tonnes.

The world trend (Table -1) shows that pyrites is being utilised in various countries as

source of sulphur very widely and is meeting about 26.5% of world's requirement of sulphur. Spain and Yugoslavia produce almost their sulphuric acid from pyrites 4 million tonnes and 2 million tonnes respectively. Substantial quantity of pyrites is also being utilized in Greece, Cyprus, Russia, Brazil and Finland etc.

There is rapid world wide fluctuation in the price of elemental sulphur (Fig. 1), non availability of elemental sulphur resources in the country and country's ever increasing requirement of sulphur for fertilizer and other chemical/allied industries, the prospects of exploiting our pyrite reserves is now becoming very promising. Our present import of sulphur is about 1 million tonnes which is expected to rise to 2 million tonnes by 1989-90. This will push up the requirement of foreign exchange from 12 to 24 million rupees.

In order to exploit indigenous resources of pyrites, PPCL has proposed to set up mine, beneficiation plant, acid plant and phosphatic fertilizer plant based on Saladipura pyrites.

TABLE—1 : WORLD PRODUCTION OF SULPHUR

(Quantity in million tonnes)												
	1980			1981			1982			1983		
	Brime stone	Other form	Total	Brime stone	Other form	Total	Brime stone	Other form	Total	Brime stone	Other form	Total
World Total	34.58	19.97	54.55	33.54	20.06	53.60	31.32	18.92	50.24	30.87	20.03	50.9
Western World	25.45	10.27	35.72	24.73	10.44	35.17	22.46	9.39	31.85	21.83	10.13	31.96
Centrally Planned Economies	9.13	9.70	18.83	8.81	9.62	18.43	8.86	9.53	18.39	9.04	9.90	18.94

* Asstt. Manager (Ore-Dressing)

** Chairman-cum-Mg. Director, Pyrites, Phosphates and Chemicals Limited.

Geology & Ore Reserve :

Pyrite/Pyrrhotite mineralisation occurs for a strike length of over 7 kilometers near Saladipura in Sikar District of Rajasthan. The total potential for complete strike length is about 120 million tonnes of ore reserve with around 20% 'S' which has been established by drilling wide space surface boreholes.

Geology :

The sulphide mineralisation at Saladipura occurs in a V-shape for the total strike length. The mineralised zone in the areas occurs in rocks of Ajabgarh series which in turn constitute a part of Delhi system. The rocks that make the Ajabgarh series are quartzite, schist, phyllite, amphibolites and marble. Closely associated with these rocks are intrusive amphibolites and granite gneisses. In mine blocks, the hanging wall is generally amphibolite and the footwall either quartzite or phyllite.

Mining :

The deposit is suitable to be worked out by modern mining method like level to level mining using large deep hole drilling and blasting.

Mineralogy :

The mineralogical studies conducted on Saladipura sample reveal that pyrite and pyrrhotite are predominating ore forming minerals with minor amount of sphalerite and trace amount of chalcopyrite, galena, magnetite and goethite. The primary minerals of economic interest are pyrite in which about 75% of total sulphur is bound and balance to pyrrhotite. The interfering rock forming minerals are dominated by quartz, both types of mica (biotite, muscovite) and amphiboles in association with trace amount of carbonates.

Liberation Studies :

Liberation study of the polished section of —10 mesh representative sample shows a fair liberation of sulphides from non-metallic gangue minerals below 35 mesh with subordinate amount of composite grains having the

disseminated grains of iron sulphide in the rock forming minerals. The enrichment of such disseminated sulphide is uneven and relatively more abundance of pyrrhotite bearing locked grains is present. Thus a fair liberation of the major bulk of iron sulphide minerals may be expected at fairly coarse grind but the disseminated iron sulphide remains locked with the gangue minerals which need fine grind.

Beneficiation Tests :

The average sulphur content of existing Saladipura pyrite deposit-ROM is over 20% S, which cannot be roasted in fluidised bed roaster as such. To ensure the stringent requirement of uniform grade feed stock for smooth operation of roaster, Saladipura pyrite has to be beneficiated. Beneficiation tests have been done on a number of samples by National Metallurgical Laboratory, Indian Bureau of Mines, RTZ Consultants, London and Lurgi GmbH, Frankfurt. In fact extensive continuous pilot plant tests were conducted both at NML and Lurgi to establish the possibility of producing consistent grade of concentrate and also to collect engineering data for plant design. The beneficiation tests have conclusively established that ROM grade pyrite with 22% Sulphur can be beneficiated by single stage flotation process producing pyrites concentrate with 40% Sulphur with about 90% recovery.

Development of Beneficiation Flow-Sheet :

National Metallurgical Laboratory and Lurgi GmbH have conducted extensive test work on Saladipura Pyrites to evolve most optimum flow-sheet for treatment.

BATCH SCALE TESTS :

Batch Scale Tests at NML :

Detailed batch scale beneficiation tests under different conditions were conducted exploring all process routes. The techniques employed were :

- a) Spiralling at — 48+100 mesh size followed by flotation of spiral middlings as well as — 100 mesh fraction.

- b) Straight tabling at —36 mesh size.
- c) High Tension (H. T.) separation at —65 mesh size.
- d) Flotation of H. T. rejects without regrinding.
- e) Flotation of H. T. rejects with regrinding.
- f) H. T. cum flotation without regrind.
- g) H. T. cum flotation with regrind.
- h) Straight flotation at —36 mesh in natural pH with Sod. Isopropyl Xanthate (NIPX) + pine oil.
- i) Straight flotation at —36 mesh at pH 4.1 with SIPX and Pine oil (PO)
- j) Straight flotation at —36 mesh at pH 4.1 with Sod. Isopropyl xanthate (SIPX) and Cresylic acid (CA)
- k) Straight flotation with Pot. Ethyl xanthate (PEX) at natural pH followed by mag. separation of flotation tails.
- l) Flotation at —36 mesh, pH 4.1, PEX, P. O. followed by mag. sepn. of tails.
- m) Flotation at —65 mesh, under different pH values with SIPX and Pine oil.
- n) Flotation at —65 mesh, pH 4.1 with SIPX and Pine oil.
- o) Flotation at 63.2% —200 mesh pH 4.1, PEX and Pine Oil. The summary of above test work can be seen in table—2.

TABLE—2 : SUMMARY OF DIFFERENT BATCH TESTS AT NML

Process Route	Wt%	Concentrate	
		Assay % S	Dist. % S
a) Spiralling followed by flotation	55.6	39.4	90.2
b) Tabling at —36 mesh	37.2	37.4	61.0
c) H. T. Separation at —65 mesh	19.1	34.2	29.5
d) Flotation of H. T. rejects without regrind	37.7	36.4	62.0
e) Flotation of H. T. rejects after regrind.	33.4	39.8	58.5
f) H. T. cum flotation (without regrind)	56.8	35.8	91.5
g) H. T. cum flotation (with regrind)	52.5	37.8	88.0
h) Flotation at —36 mesh, natural pH, SIPX & P.O.	40.7	37.0	73.2
i) Flotation at —36 mesh, pH 4.1 SIPX & P.O.	52.5	40.1	90.4
j) Straight Flotation at —36 mesh, pH 4.1, SIPX, & CA	48.1	37.5	84.6
k) Flotation at —36 mesh, pH normal, PEX, P.O. followed by Mag. Sepn. of tails	32.7	42.0	62.2
l) Flotation at —36 mesh, pH 4.1, PEX & P.O.	52.1	39.3	89.3
m) Flotation at —65 mesh, under different pH values with SIPX & P.O.	50.2	37.8	87.4
n) Flotation at —65 mesh, pH 4.1 with SIPX & P.O.	58.9	37.1	97.6
o) Flotation at 63.2% —200 mesh, pH 4.1, PEX & P.O.	55.1	37.3	92.0

The results indicated that gravity methods of separation were effective with the sample tested in conjunction with flotation. High Tension Separation in combination with flotation also showed possibility of obtaining a part of concentrate to wet circuit of grinding and flotation. Flotation at comparatively coarse size gave good results but recoveries were lower than those obtained employing finer grind.

Batch Scale Tests at Lurgi

Lurgi also conducted batch tests employing different process routes including :

- a) Tabling independently of —1 mm crushed ore segregated into 1 — 0.2 mm size and 0.2 mm size.
- b) Flotation at pH 5.5 using Sod. iso propyl xanthate (SIPX) and Flotol at various grinds of d80 = i) 290 ii) 113 iii) 106 iv) 90 and v) 40 microns

- c) Flotation of d80 = 113 microns in natural pH with SIPX and Flotol
- d) Flotation of d80 = 113 micron at pH 5.5 using Pot. Ethyl xanthate (PEX) and Flotol
- e) Flotation of d80 = 113 micron at pH 5.5 using Indian PEX and Flotol
- f) Flotation of d80 = 113 micron at pH 5.5 Phlsocresol* (PHOSOE)
- g) Flotation of d80 = 113 micron at pH 5.5 using SIPX and PHOSOE (1 : 1)
- h) Flotation of d80 = 113 micron at pH 5.5 using KEX + PHOSOE (1 : 1)
- i) Flotation of d80 = 113 micron at pH 5.5 using IND KEX and PHOSOE (1 : 1)
- j) Flotation of d80 = 113 micron at pH 5.5 with IND KEX in Saladipura water
- k) Flotation followed by magnetic separation of tails.

The summary of results are shown in Table No. 3.

TABLE — 3 : SUMMARY OF DIFFERENT BATCH TESTS CONDUCTED AT LURGI

Process Route	Wt. %	Concentrate	
		Assay % S	Dist. % S
a) Tabling of —1 mm ore segregated into size —1+0.2 mm and —0.2 mm size independently.	45.4	38.3	77.7
b) Flotation at different grinds at pH 5.5 with NIPX & Flotol B into different sizes of d80	i) 155 micron.** ii) 113 " iii) 106 " iv) 90 " v) 40 "	— 43.5 43.8 47.4 50.0	— 88.7 88.1 84.1 45.8
c) Flotation of d80 = 113 micron in natural pH with NIPX & Flotol B	39.2	45.0	76.0
d) Flotation of d80 = 113 micron at 5.5 pH with KEX & Flotol B	45.8	45.1	85.7
e) Flotation of d80 = 113 micron with IND KEX + Flotol	45.4	44.7	86.5
f) Flotation of d80 = 113 micron at pH 5.5 with PHOSOE	53.2	41.0	90.6
g) Flotation of d80 = 113 micron at pH 5.5 with PHOSOE + NIPX (1:1)	53.9	41.2	93.8
h) Flotation of d80 = 113 micron at pH 5.5 with PHOSOE + KEX (1:1)	51.2	41.2	92.0
i) Flotation of d80 = 113 micron at pH 5.5 with IND KEX + PHOSOE (1:1)	49.2	42.2	86.6
j) Flotation with IND KEX + Saladipura water	42.2	45.2	82.3
k) Flotation followed by Magnetic separation of tails	58.8	37.8	94.7

* equivalent to American Aero float 242

** The agitation speed of 1250 r.p.m. was too slow for relatively coarse sized 80% wt. 155 micron. The results indicated that gravity beneficiation would be conceivable only in combination with flotation and the process would consist of classification of the mill product into coarse and fine size, gravity treatment of coarse size, possible return of the tailings from gravity process to mill and flotation of the fines.

Flotation at coarse size appears to be difficult due to sedimentation of coarse size in the cell and also grades are poorer than those obtained with finer grind.

PILOT PLANT TESTS :

The objective of pilot plant tests were to :

1. Confirm the feasibility of laboratory findings on continuous running plant.
2. Observe the operational problem/plant performance.
3. Generate engineering data for formulation of flowsheet
4. Produce concentrate for roasting tests.

Pilot Plant Tests at NML :

Test procedure :

- Two stage crushing of ROM to —12.5 mm size in closed circuit.
- Closed circuit grinding to size 60 — 62% —200 mesh at about 253% circulating load.
- Two stage conditioning of classifier overflow first with sulphuric acid and to maintain pH bet. 4.1 — 4.5 and second stage conditioning with part (40%) of Sod. Isopropyl

xanthate and Pine oil. Remaining 60% of the collector added at discharge of various flotation cells.

- Single stage flotation of conditioned pulp.
- Thickening of concentrate.

Test campaigns :

The total pilot plant operation continued for 22 shifts divided into three different campaigns. The first lasted for 7 shifts with basic objective of producing consistent grade and recovery of concentrate, the second campaign lasted for 6 shifts mainly to see the extent of water recirculation from settling tanks to process stream without any detrimental effect on concentrate quality and also to find out the build up of pH if any, and the third campaign lasted for 9 shifts to observe the plant performance and operational difficulties pertaining to jamming of pumps and sanding of cells.

Test results :

During seven shift operation, the plant could produce more or less consistent quality of concentrate showing wt. recoveries bet. 51 to 56% with 39 to 40% Sulphur and Sulphur recoveries bet. 87 to 92%. The average result of seven shift operation is shown in Table No. 4

Campaign II :

The results indicated that on average about 60% of water circulation resulted in very little change in the average pH producing consistent grade of 40% Sulphur around 90% Sulphur recovery. However, no specific studies were made on reagent consumption.

TABLE — 4 : AVERAGE PILOT PLANT TEST RESULTS

Feed to Mill Kg/Hr.	% Solids		Class. Sand	% Circ Load	—200 Mesh in Class O.F.	Concentrate			Tailings	
	Mill Disc.	Class O. F.				%wt.	%S Assay	%S.Dist	% wt.	% S Assay
492.0	68.2	25.6	76.6	253.1	60.9	56.1	39.0	89.8	43.9	5.7

Campaign III :

The results indicated that smooth operation of the plant was possible with consistent grade of concentrates obtainable per shift. Operational difficulties were mainly faced in pumping of classifier overflow which was occasionally irregular due to some jamming as the material had a tendency to settle quickly into the pipes. Sanding of the flotation cells normally did not happen, but due to occasional pump jamming, some of the cells had to be cleared up before restart.

Pilot Plant Tests at Lurgi :

Test procedure :

- Two stage crushing of ROM in closed circuit.
- Closed circuit grinding at about 230% circulating load into ball mill (1.45 M x 1.45 M) with 120mm dia. cyclones.
- Single stage flotation at pH 5.5 in 8 x 250 litres Denver flotation cells.
- Concentrate & tailing thickening in 2 meter and 3 meter thickeners respectively. Continuous dewatering of thickened concentrate on 2M² drumfilter and tailing on 1.8 M² discfilter.
- Dosing of reagents at desired point of flotation bench. The reagents are H₂SO₄, Ind. Pot. Ethyl xanthate in combination of Phoso cresol (1:1). The process flow-sheet adopted in Lurgi's plant test is shown in fig. 2

Test Campaigns :

The test continued for 60 operating hours at 2.2 to 2.5 TPH capacity of grinding plants. The test runs were conducted for following two campaigns.

The first test campaign was conducted with an aim to produce consistent grade and recoveries of concentrate from the plant without water recirculation and also to observe the

performance/operational difficulties of the plant. The second campaign consisted to study the flotation behaviour by recirculation of water from concentrate & tailing thickening circuit to process stream. The flotation pulp consisted of 25% fresh water (for mills) and 75% thickener overflows for mill discharge.

Test Results—Campaign I :

- The results indicated that a grind between d80 of 95 to 127 micron preliminarily maintained at d80 = 110 micron could produce a consistent grade of 40—42% Sulphur with about 52% weight recovery and over 88% Sulphur recovery yielding a tails of about 5.6% Sulphur.
- The smooth operation of plant was observed at a grind of d80=110 — 120 micron.
- Much difficulties were observed to achieve a coarse grind of d80=130 micron, because the coarse particle size in the mill discharge led to the jamming of pumps and cyclones. With increasing dimensions of the feed size (for example d80 = 155 micron), the first cell of the flotation bench was subjected to 1) an increased load only after short while of operation 2) power intake of agitator motor rose continuously 3) coarse size accumulated in the flotation machine and 4) motors failed. To overcome the sanding of cells, additional air (120 M³/hr) was felt necessary to agitate the pulp, which caused intensified turbulence destroying the froth structure making flotation impossible.

Campaign II :

- To obtain same pH almost double quantity of sulphuric acid were needed with water recirculation.
- Flotation was much sensitive to xanthate coating than without water recirculation and to achieve same grade and recovery almost double quantity of xanthate was needed.

Filtration studies :

Moisture content of the concentrate in the filter cake is critical for roasting operation and generally for smooth operation of fluidised bed system for pyrites should be around 10%. During Lurgi's pilot plant operation, filtration tests were run continuously on the freshly produced concentrate from the down stream on 2 M² size of drum filter. The concentrate pulp was thickened to 68% prior to filtration and was continuously fed on the filter. The results are shown in table 5 and partial granulometry of conc. in fig.—3.

TABLE — 5 : FILTRATION TEST RESULTS

Test No.	Solid content in filter feed	Filter speed rph	Vaccum %	Filter Cake kg/hr/M ²	Moisture Content in filter Cake
1.	68	72	86	1140	7.1
2.	68	72	83	1560	7.1
3.	68	47	83	510	6.8
4.	68	47	82	615	7.4

From the test results it is evident that a moisture content of 6 to 7% can be achieved which has been confirmed on regular stream for about 140 operating hours. The NML finding on filtration data reveal that it was difficult to reduce the moisture content less than 15% on flotation concentrate, though their parameters were different from that of Lurgi i.e. lower vacuum and lower solid content in the thickened pulp and different filter medium. Since the moisture content of the filter cake is critical for roasting operation, the company got few more additional filtration tests on concentrate of similar particle granulometry tried at Lurgi / NML to ensure successful roasting operation. The tests were conducted at M/s. SALA International, Sweden, M/s. Ingersoll Rand USA, M/s. Larox, Finland.

Filtration Studies at SALA :

SALA conducted filtration studies employing standard leaf test. The test results clearly

confirmed the possibility of attaining lower level of moisture (below 10%) with comparable filtration rate by using synthetic cloth of multi-filament propylene type as medium.

Filtration Studies at Ingersoll Rand, U.S.A. :

Another test work employing automatic Lasta Filter Press in the R & D centre of M/s. Ingersoll Rand, New Hampshire, USA using 100% polypropylene medium with air permeability of 1—2 CFM / ft² was conducted. The test results have indicated that moisture in filter cake can be reduced to 5.5 to 6%.

Filtration Studies at Larox, Finland :

The test was conducted on a Larox laboratory pressure filter (area of 0.1 M²) using filter medium of polypropylene cloth type 71—2155 with 61% solids in filter feed. The diaphragm pressure varied from 14 to 15 bars in the tests and air consumption values were 1.0 μ m³ / m² / minute, for the optimum results.

The following results were obtained :

Residual moisture in the product —	7%
Cycle time	— 9.25 minutes
Capacity	— 4.30 Kg/m ² /h

Storage behaviour of Pyrite Concentrate :

As most of pyrite concentrate leads to self-ignition when stored in open air, the storage behaviour of Saladipura were tested in 1) dry 2) wet conditions.

DRY STORAGE :

Method of Test :

Approximately 9.5 T of filter moist concentrate with about 7—8% water was piled to a cone of about 7M² base area and 1.5M height. About half a dozen of thermocouples were arranged at various levels starting from the cone surface to every 10 cm below pile surface upto 50 cm pile surface and readings were taken for 160 hours.

Results :

After about 160 hours, the outside layers had lumped and caked together to about 40 cm deep and hard crust. Perhaps there occurs a chemical reaction in which pyrite and pyrrhotite are oxidised to iron sulphate.

WET STORAGE :

Method of Test :

To save the pyrite/pyrrhotite concentrate from oxidation, next attempts were made to store the concentrate in slurry tank. A large quantity of concentrate for a prolonged time was agitated in a tank and samples were withdrawn at various time intervals. They were filtered and the filtrate water was analysed for $\text{SO}_4 - \text{S}$.

Results :

The values for $\text{SO}_4 - \text{S}$ may be considered as normal for a material with high pyrite content, especially as this material has been treated in a sulphuric acid environment before.

Pyrite/Pyrrhotite concentrate can be suitably and safely stored in slurry form for considerable time with $\text{SO}_4 - \text{S}$ value within normal limit for 92 hours for which test has been conducted.

Process Flowsheet for Plant Design :

General :

Based on the findings of testing laboratories, a comprehensive flowsheet for treatment of 800 TPD Saladipura pyrite to produce 450 TPD of Sulphuric Acid was developed jointly by the engineers of the National Metallurgical Laboratory, Jamshedpur, Lurgi GmbH, Frankfurt, Engineers India Limited, New Delhi for plant design. The process parameters were evaluated in detail to suit the design and smooth operation of plant. The following parameters were jointly agreed to and finalised during discussions.

Process Parameters :

- i) Optimum grind keeping in view the liberation characteristics and operation factors shall be d80 — 113 micron.

- ii) Bond's Work Index for grinding should be taken as 13.07 kwh/ton.

- iii) Conditioning of the ground ore should be done in two stages, first with acid to bring down pH to 5.5 for 3 min. and then with collector for another 4 minutes. The following quantity of reagent should be used :

Sulphuric Acid	— 2.5 kg/T
Sod. Isopropyl xanthate	— 0.4 kg/T
Pine oil	— 0.09 kg/T

The NML suggested an alternate flow-sheet incorporating spiralling of coarse grind feed (—48 mesh) followed by flotation of spiral middling after further grind.

These results are however based on bench scale tests and no pilot plant tests were conducted to establish the reproducibility of the results. From operation point as well as production of consistent grade of concentrate, a mixed flow-sheet of gravity separation and flotation techniques demand stringent control. In view of this a straight flotation route is considered for adoption at this stage to ensure ease of operation as well guarantee the production of consistent grade of concentrate. However on establishing the results in pilot plant alternate flowsheet of NML may be considered for future expansion unit.

Saladipura pyrite ore contains 0.5% zinc. Studies were conducted both at NML and Lurgi to recover zinc in the form of zinc concentrates. Both the laboratories were able to produce a zinc concentrate assaying 5.4% and 6.5% zinc with recovery of 79.8% and 54% respectively. The zinc concentrate thus produced would require 4 to 5 cleanings before a final zinc concentrate assaying +50% zinc is produced. Moreover, overall zinc recovery in the final concentrate is not likely to exceed 30%. In view of the expected low recovery of zinc in the concentrate and high

cost of production, the recovery of zinc from the ore is considered uneconomical and not incorporated in the process circuit.

Both NML & Lurgi observed during their investigation that filtered concentrate oxidises rapidly on storage resulting in formation of hard lumps. This will eventually create problem in the roaster operation. In view of this it was agreed that the concentrate should be stored in slurry form and the filter unit located in the vicinity of roaster plant.

Lurgi observed during the investigation that recirculation of tailing water increased the reagent consumption. This phenomenon occurs due to the formation of thiosulphate and other poly-sulphates by oxidation of xanthate. It was argued that by prolonged exposure to atmosphere, dissolved oxygen would further decompose the poly-sulphates and this makes them inactive. However, by purging some quantity of water and addition of fresh make up water as

envisaged in water reclamation system, would keep the concentration of undesired ion in recirculated water below the threshold limit. Based on the points, the final flowsheet developed for treatment of 800 TPD of Saladipura is shown in fig 5 & 6.

Conclusions :

From the experience of extensive test work on Saladipura Pyrites both at NML/Lurgi GmbH, it is evident beyond doubt that the beneficiation of ROM grade pyrites with about 22% sulphur to a concentrate of 40% sulphur grade with 90% recovery, which is considered to be suitable for manufacture of Sulphuric Acid, is technically feasible. The liberation of pyrites from the gangue is at coarse size, which is too coarse for flotation and too fine for gravity method of separation. For smooth operation of plant without interruption, flotation at a grind of d80 = 113 microns perhaps would be essentially desirable.

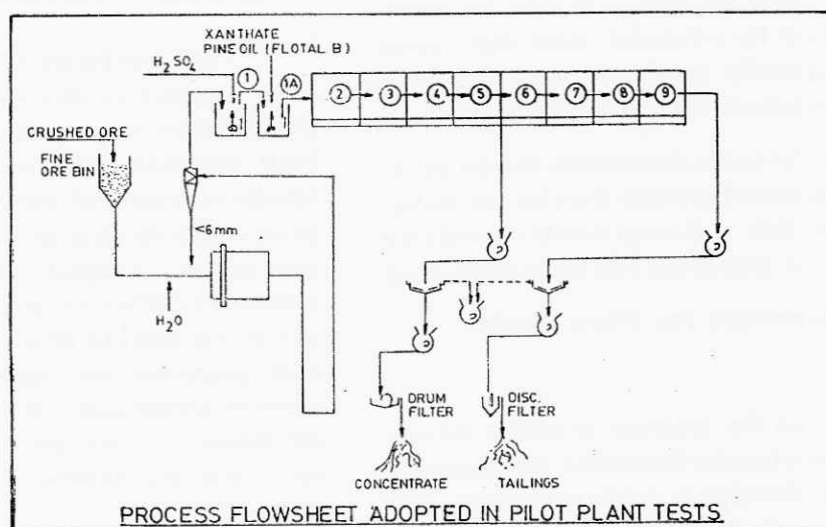


FIG. — 2

Acknowledgements :

The authors wish to thank the engineers/scientists of the National Metallurgical Laboratory, Jamshedpur, Indian Bureau of Mines, Nagpur, Engineers India Ltd., New Delhi, Lurgi GmbH, West Germany, SALA International Sweden, Ingersoll Rand, USA, Larox of Finland for their active participation in the process deve-

lopment, flowsheet formulation and plant design and also rendering all possible help to PPCL in solving out technical challenges.

The authors express their gratitude to the management of M/s. Pyrites, Phosphates & Chemicals Ltd. for permitting to present this paper.

FIG.3 SCREEN ANALYSES FILTER CAKE
CONCENTRATE

FRACTION (mm)	WEIGHT (%)	FRACTION (mm)	COMPL. (%)
>.200	.7		100
.200 TO .125	4.3	<.200	99.3
.125 TO .075	19.5	<.125	95.0
.075	20.9	<.075	75.5
<.045	54.6	<.045	54.6
		SPEC. SURFACE (cm ² /g)	1212

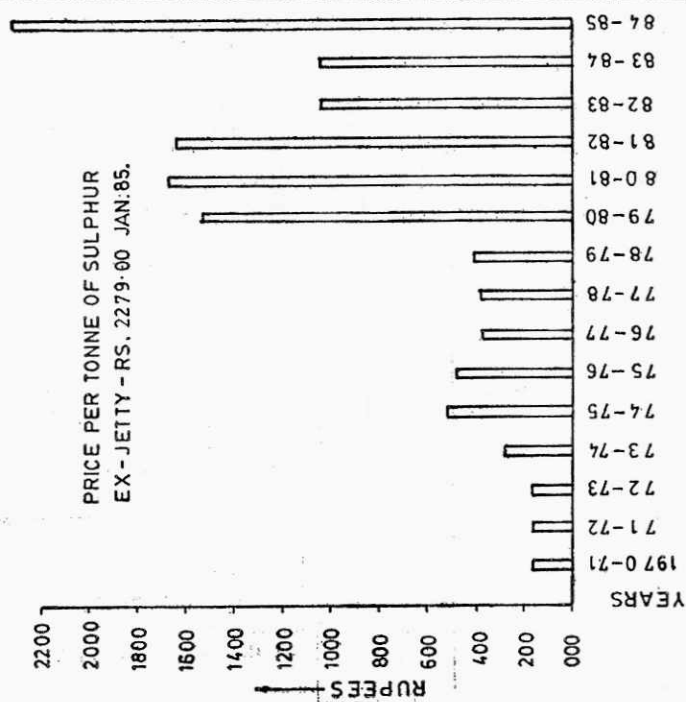
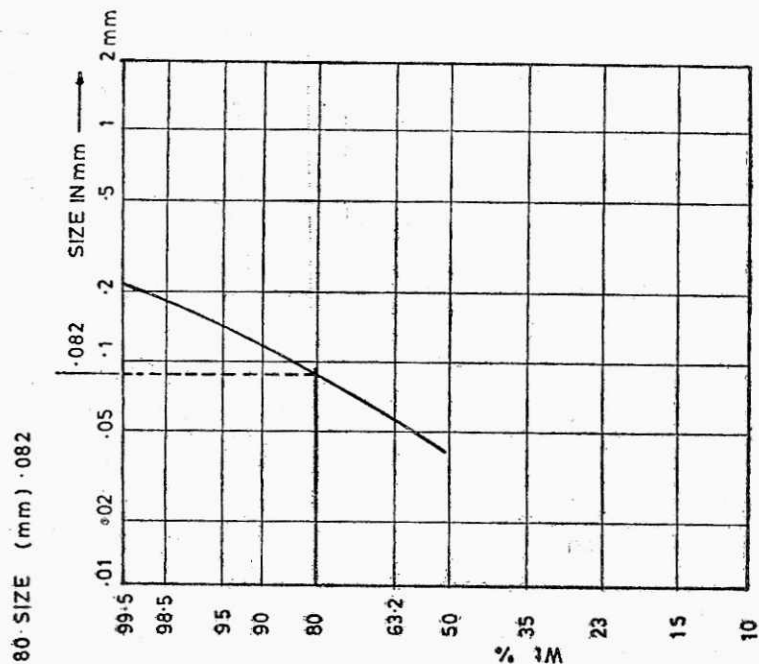


FIG.-1 HISTOGRAM OF TREND OF PRICES
OF SULPHUR

FIG. 4:- FLOW SHEET OF ROM RECEIPT CRUSHING & SCREENING PLANT FOR PROPOSED CONCENTRATOR

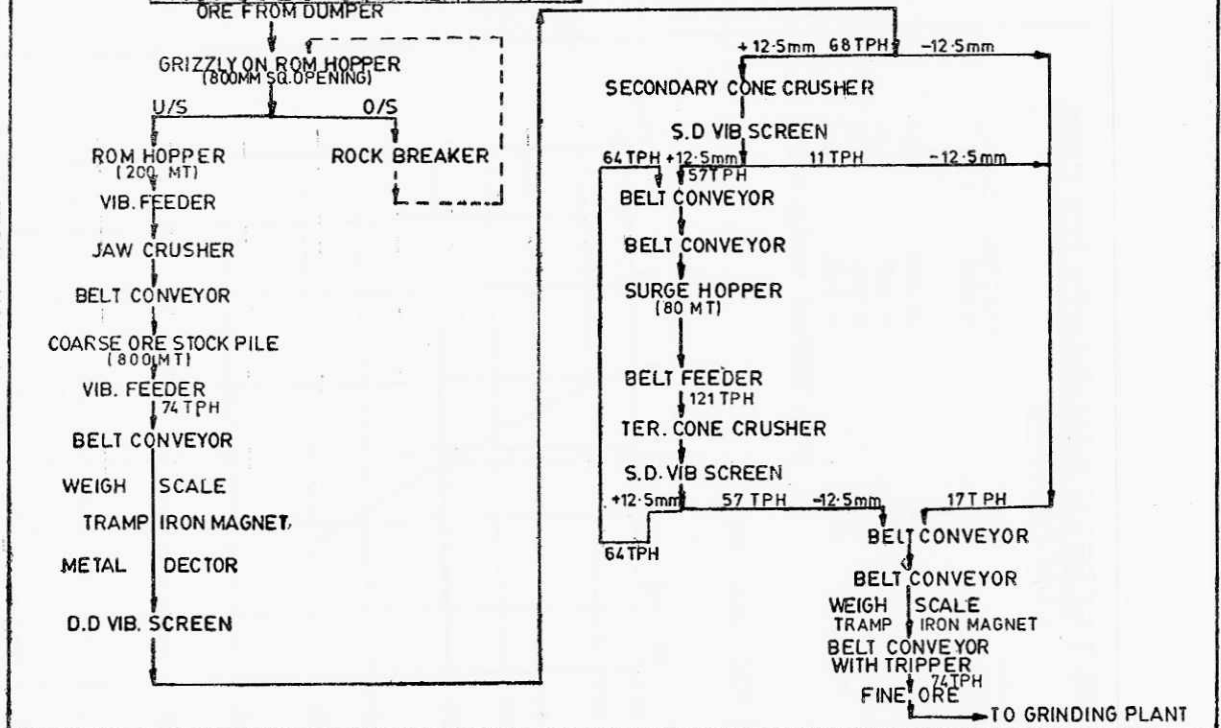


FIG. 5 FLOW SHEET GRINDING FLOTATION AND DEWATERING PLANT FOR PROPOSED CONCENTRATOR

