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SOME INTERESTING PROBLEMS IN THE START-UP OF THE ELECTROLYTIC ZINC PLANT IN A DEVELOPING COUNTRY [1]

by

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India is one of the few developing countries which has large reserves of lead and zinc ores and also a market for these metals. Presently, India consumes approximately 75,000 tonnes of zinc per year and this demand is likely to go up to 141,000 tonnes by 1973-74.

At present there are two plants in the country, namely, one at Debari, Udaipur in the Public Sector with a rated capacity of 18,000 tonnes of zinc per annum and one in the Private Sector, namely, Cominco Binani Zinc Limited at Alwaye with a rated capacity of 20,300 tonnes of Zinc per annum.

The Cominco Binani Zinc Plant was started in January, 1967 and is currently producing at about 70-75 % of its rated capacity. This factory has plans to expand its production capacity to 40,000 tonnes per annum in the 4th Five Year Plan and ultimately to 60,000 tonnes per annum. The Government factory at Debari will expand its capacity to 40,000 tonnes per annum in the 4th Five Year Plan and is also considering installation of an Imperial Smelting Furnace for simultaneous production of zinc and lead. The Debari factory was started in November, 1967 and is in regular production since January, 1968. The production during January to March 1968 was at the full rated capacity and even a little more. Subsequently production had to be curtailed to about 70-75% due to difficulties in marketing of the co-product, Single Superphosphate Fertilizer.

There were quite a few interesting problems encountered during the start-up of the factory which have been discussed below:

The Debari factory uses the only FLUO-SOLID ROASTER in the country. As is known, the start-up of the Fluo-solid Roaster requires calcine for the initial charging and the creation of fluidised bed condition in the Roaster. Some forty tonnes of calcine were therefore obtained from the Cominco Binani Zinc Plant in the South India, but this was found to be rather fine in particle size (about 70% passing through 300 mesh) and material quantities were lost during initial start-up of the Roaster. The Roaster was finally started on a mixture of fine silica sand and the Flash Roaster calcine (1:1.35). The final starting was achieved without any foreign technicians and the initiative was entirely with the Indian personnel trained in the operation of Fluo-solid Roaster for a short period of 3 - 4 months. The Fluo-solid Roaster (capacity 120 M.T/day) is of LURGI design and was found to be extremely simple in operation. During the capacity test run on this Roaster from 24th to 26th January, 1968, 152.5 M.T. of blende could be charged in twentyfour hours. The quantity of acid recovered was 121.4 tonnes. The recovery of sulphur was 89.15 % as sulphuric acid. The Roaster diameter is 4.85 metres at the bottom and 7.3 metres at the top (internal). Typical analysis of zinc concentrates fed and the calcine produced were as follows:-

	Concentrate %	Calcine %
Total Zn	54.20	62.11
Acid sol. Zn	-	57.40
Zn- Solubility	-	92.57
Total Fe	5.67	6.26
Total S	30.17	3.87
SO_4-S	-	3.50
H_2S-S	-	0.37
Pb	1.12	1.29
Cu	0.07	0.08
Cd	0.30	0.35
Ni	0.0004	0.0005
Co	0.0041	0.0050
Cl	0.0016	tr.
F	0.0060	0.0070

The gases from the Roaster along with major part of calcine go through a waste-heat boiler followed by a series of dry cyclones.

The gases are then scrubbed in a Pea-body Scrubber and the scrubbed clean gases are sucked by a PVC Blower and pushed through an Electrostatic Precipitator in the Sulphuric Acid Plant. The PVC Blower had been used earlier in other European plants and had to be discarded due to unsatisfactory working. It was expected that this blower would give similar difficulties at Debari also. The plant suppliers, therefore, made arrangements to supply free of cost a special steel blower to be located just before the Pea-body Scrubber. Due to customs clearance formalities, it took quite sometime to receive the blower and this helped the Indian company in seeking the solution to this problem as described below:

As difficulties were expected in the running of the PVC Blower, its speed was reduced from the designed speed of 1550 to 1400 R.P.M. by the inter-change of the motor and the blower pulleys. In spite of this, the first blower was completely destroyed in a minor explosion in the first week of its running. The stand-by blower was erected and a close watch was kept on the mechanical vibrations. It was found that on every third or fourth day of operation; the Impeller of the blower would get out of balance and would require re-balancing. A proper work study of the job was made and procedures developed, so that the impeller could be replaced in about 90 minutes. Two impellers both PVC-lined were kept in operation one after the other and balancing was done by welding PVC strips. It was found that the impeller used to go out of balance not by deposition of any calcins, but due to the creeping of the PVC at the high peripheral speed (5850 metres/mt.) at the operating temperature (about $50^{\circ}C$). In spite of precautions taken, the blower was destroyed once again after a few weeks running. Meanwhile, two or three impellers were made from stainless steel sheets (Type 316), but the life of stainless steel rotor was only about two weeks. Nicromus rotor having the following composition was tried, but the life was only slightly better than that of the stainless steel rotor.

Composition of Nicromus

Cr	-	20.00	%	
Ni	-	25.00	%	
Mo	-	4.50	%	
C	-	0.08	%	Max.
Cu	-	1.50	%	
Si	-	2 to 3	%	

Finally fibre glass epoxy-lined rotor was tried in September, 1968 but this trial was unsuccessful due to improper application of the lining. A second attempt has been successful and the rotor with the fibre glass epoxy-lined material is working since early October, 1968. Periodic examinations of this rotor during the planned shut-downs of the plant have shown so far no effect on the material. The casing of the blower was also made of reinforced PVC, but whenever the temperature of the gases handled would go over 55°C, there would be warping of the PVC. The casing has now been replaced by homogenously lead-lined steel material.

In the last seven or eight months, the blower, handling the wet gases, has been working satisfactorily and is not presenting any problem at all. Its installed horse power is only 50 as against 160 for the steel blower to be put before the wet scrubber. The steel blower has not been installed due to its considerable higher power consumption.

In the Debari plant, leaching is done in two stages. The first stage being neutral leaching followed by the acid leaching of the underflow from Dorr Thickeners. The two-stage purification is done in cold and batchwise. The total volume of the neutral-leaching pachucas is 135 M^3 *and that of the acid-leaching pachucas is 180* M^3. *The total settling area of the Dorr thickeners is 555* M^2 *for the neutral leaching and 370* M^2 *for acid leaching. The acid underflow is filtered on Moore leaf filter having a total area of 360* M^2. *Typical analysis of neutral overflow and the leach residue (Moore cake) were as follows:-*

(a) <u>Neutral overflow</u>

Zn g/l	Co mg/l	Ni mg/l	Cu mg/l	Cd mg/l	Fe mg/l	As mg/l	pH
133.9	2.65	0.95	43	419	tr.	tr.	5.5

***(b)** <u>Leach Residue</u> (Moore cake)*

T-Zn %	Acid-sol. Zn %	Water sol. Zn %	T-S %	T-Fe %	Pb %	Cu %	Cd %
20.67	2.71	1.24	5.31	26.3	5.14	0.08	[illegible].23

The first and second stage purifications of the neutral leach are carried out by addition of zinc powder and α*-nitroso* β*-napthol respectively. Zinc dross, obtained in the low frequency induction furnace making zinc ingots, was also used successfully in place of major part of the zinc powder. The composition of zinc dross which* was found to be suitable for such use is given below:-

Total zinc	-	89.2 %
Metallic zinc	-	70.67 %
Cl	-	0.30 %
Screen analysis	-	64.0 passing through 100 mesh.

The typical analysis of solution after 1st purification with zinc powder and zinc dross were found to be as follows:-

	Co mg/l	Ni mg/l	Cu mg/l	Cd mg/l
1.Zinc powder	2.84	tr.	tr.	1.95
2.Zinc dross	3.61	0.2	tr.	2.40

This helped in sparing some of the zinc powder for the market and also resulted in better overall zinc recovery as there are certain losses during formation of zinc powder and also during retreatment of zinc dross from the induction furnace.

The Zinc Electrolytic Cell plant at Debari consists of 240 cells of the standard Anaconda design. These are 10,000 - ampere cells and the current density is 300 - 350 Amp./M^2. The average analysis of cell feed solution and spent-electrolyte were as follows:-

	Zn g/l	Acid g/l	Co mg/l	Ni mg/l	Cu mg/l	Cd mg/l	Fe mg/l	As mg/l	Mn g/l	Cl mg/l
Cell Feed	134.0	1.39	0.5	tr.	tr.	2.6	tr.	tr.	0.37	21
Spent Electrolyte	54.0	115		tr.					0.05	[illegible]

The typical analysis of Zinc Cathodes produced was Pb- 0.0287%, Cu- 0.0010%, Cd- 0.0028%, Fe- 0.0005%, Zn (by diff.-) 99.967%

The Electrolysis plant not only performed very well with regard to its capacity in the very first months of its start-up, but also continues to give high recovery efficiency. The efficiency of recovery from zinc concentrates to cathodes, for example, during December, 1966, i.e. at the end of the first year of start-up, was 98.7 % and from zinc concentrates to zinc ingots was 87.5 %. The efficiency guaranteed by the consultants of the plant suppliers was 85 % with the iron content in the zinc concentrates of 3 %. The above efficiencies were obtained with an actual iron content of about 6.0% in the zinc concentrates. The average power consumption per tonne of zinc cathodes was 3142 KWH.

Cadmium metal is produced electrolytically at the Debari plant starting from Copper-cadmium cake (obtained during zinc powder purification; Cd- 13.1%, Cu- 1.27%, Zn-69.5%) as per the flow sheet shown in Annexure 'A'. There are six 1000 ampere cells with current density 30 - 35 Amp./Sq.m. The efficiency of recovery of Cadmium is far superior to what was envisaged by the consultants (72.0%) and even superior to what is obtaining in many other plants in the world. The Cadmium recovery efficiencies for the months of December 1968 and January 1969 have been 87.5% and 87.9% respectively from zinc concentrates to Cadmium cathodes. The recovery of cadmium ingot metal from cathodes has been 95 - 96% consistently. The flow-sheet for Cadmium recovery has been modified recently as given in Annexure 'B'. For comparison the typical analysis of cell feed spent electrolyte and the cadmium cathodes as obtained with the old and modified schemes are given below:-

(a) <u>Cell Feed and Spent Electrolyte</u>

	Old scheme		Modified scheme	
	Cell Feed	Spent Electrolyte	Cell Feed	Spent Electrolyte
Cd g/l	109.0	32.7	104.7	26.4
Acid g/l	-	66.5	-	62.0
Zn g/l	66.5	65.8	27.5	26.2
Mn g/l	12.8	12.0	18.10	11.65
Cu mg/l	26.7	-	6.60	4.40

(b) <u>Cadmium cathodes</u>

	Old scheme %	Modified scheme %
Pb	0.0276	0.0120
Cu	0.0095	0.0074
Zn	0.0029	0.0040
Fe	0.0026	0.308
Cd (By diff.)	99.9574	99.9758

Copper too has been recovered as pure metal by batch electrolysis, starting from the copper cement residue.

The cost of electricity at Debari is very high (12 units for Rupee - 1 US$ = Rs. 7.5) and, therefore, it has not been possible to drain the electrolyte after reducing the zinc content. Attempts are being made to make high-grade zinc sulphate from the spent electrolyte and the plant is already in production. A small quantity of zincated superphosphate has also been made available to Agricultural Experimental Stations. A large track of Indian soils is deficient in zinc and if it is possible to market this product, waste electrolyte will be used for manufacture of zincated superphosphate thus providing an outlet for the impurities in electrolyte and a cheaper source of zinc to the Indian farmers.

As mentioned earlier in this paper, India has a large unsatisfied demand for zinc and lead and this will continue to grow in the years to come.

The unsatisfied demand even after the full economic expansion of the two existing plants will be about 50,000 - 60,000 tonnes per annum for 1973-74. Such a large demand can be met more easily by the Imperial Smelter. Major part of India's demand is for galvanizing industries where the product from Imperial Smelter can be used directly without refining. The expanded capacity of the present electrolytic plants could be used for other demands where higher purity zinc is required. The demand for lead is at present being met mostly by imports. The expansion of Government mines at Zawar and Rajpura-Dariba will produce simultaneously large quantities of lead concentrates which can be treated most economically in an Imperial Smelter. The mine development at Zawar and Rajpura-Dariba would necessarily take more time than the installation of an Imperial Smelter. Concentrates and ores could be imported for a few years and an Imperial Smelter is ideal for such customs-smelting as it can treat a variety of concentrates. Later, when the Indian mines meet the demand for the Smelter, bulk concentrates could be produced cheaper than separate lead and zinc concentrates as is being done now.

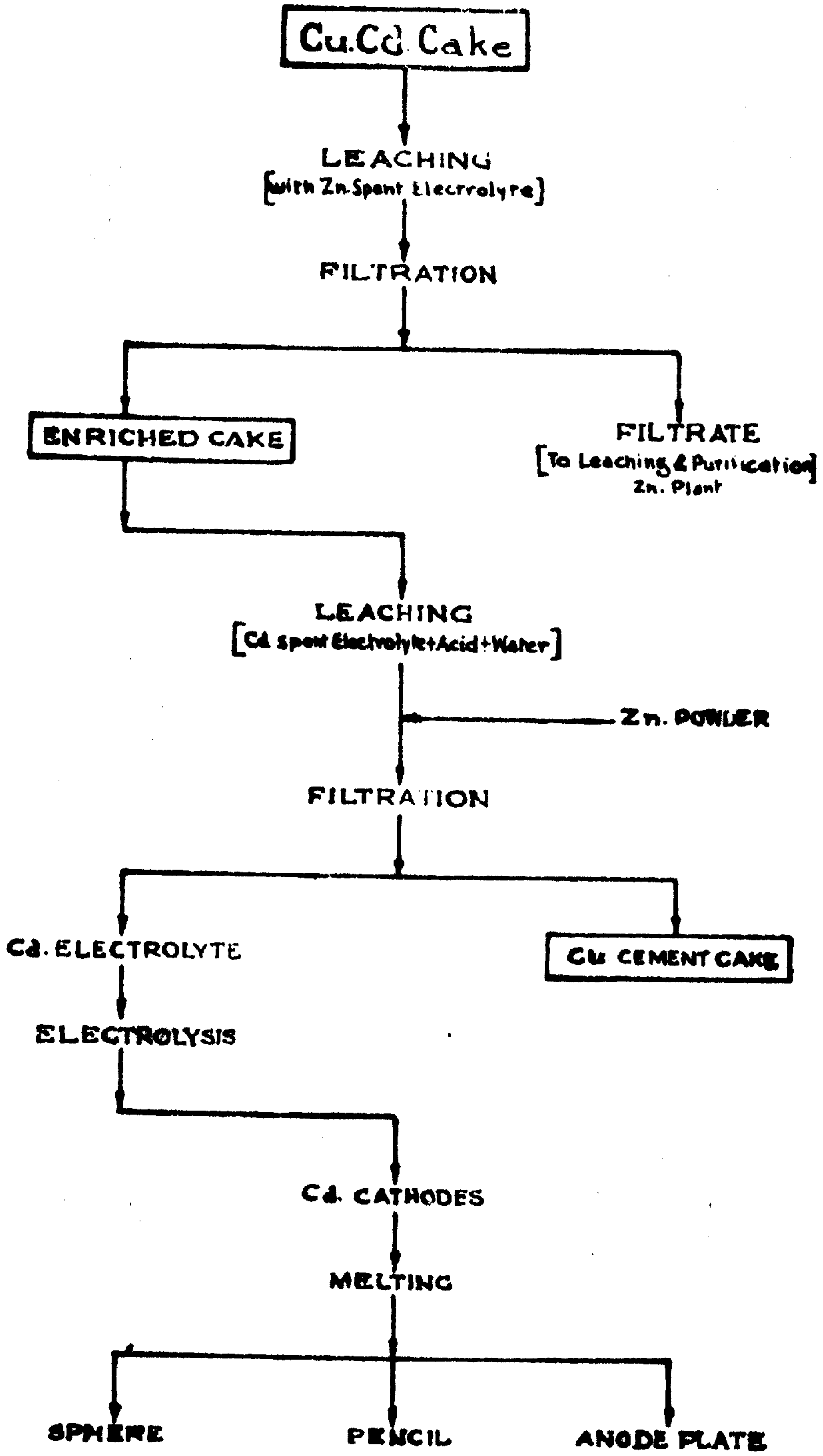
It should, however, be remembered that with regard to a developing country like India, an Imperial Smelter has certain basic disadvantages. One of the minor disadvantages is the non-availability of technical personnel for the operation of the Imperial Smelter which has been made very sophisticated and highly automatic. It is not known for certain whether some of the automation could be done away with for the installation of the Smelter in a developing country. With the development of the highly complex petro-chemical and a modern steel industry in India, more and more technicians are becoming familiar with sophistication and automation. This disadvantage is therefore temporary.

A major disadvantage for Imperial Smelter is a large capital outlay required for putting up the smallest size Imperial Smelter. For example, a capital outlay of £ 3 million Sterling is enough for putting up an economic size electrolytic plant which can be expanded over a period   to a capacity of 50,000 - 60,000 tonnes per year. Such is not the case with an Imperial Smelter where a large amount of capital outlay is required before producing any zinc. The other disadvantage with the Imperial Smelter is that whilst the electrolytic plant can be built almost entirely in India, the foreign exchange requirements for an Imperial Smelter is quite large including equipments, engineering know-how and royalties. Indian coke also has high ash content and this tends to increase the capital cost for an Imperial Smelter per tonne of zinc smelting. All these factors could, however, be taken into account in a proper feasibility study and due to high cost of electric energy in the vicinity of the only lead and zinc mine in India, Imperial Smelting Process has to be given proper consideration.

Enc. Annexure 'A' & 'B'

Annexure-A

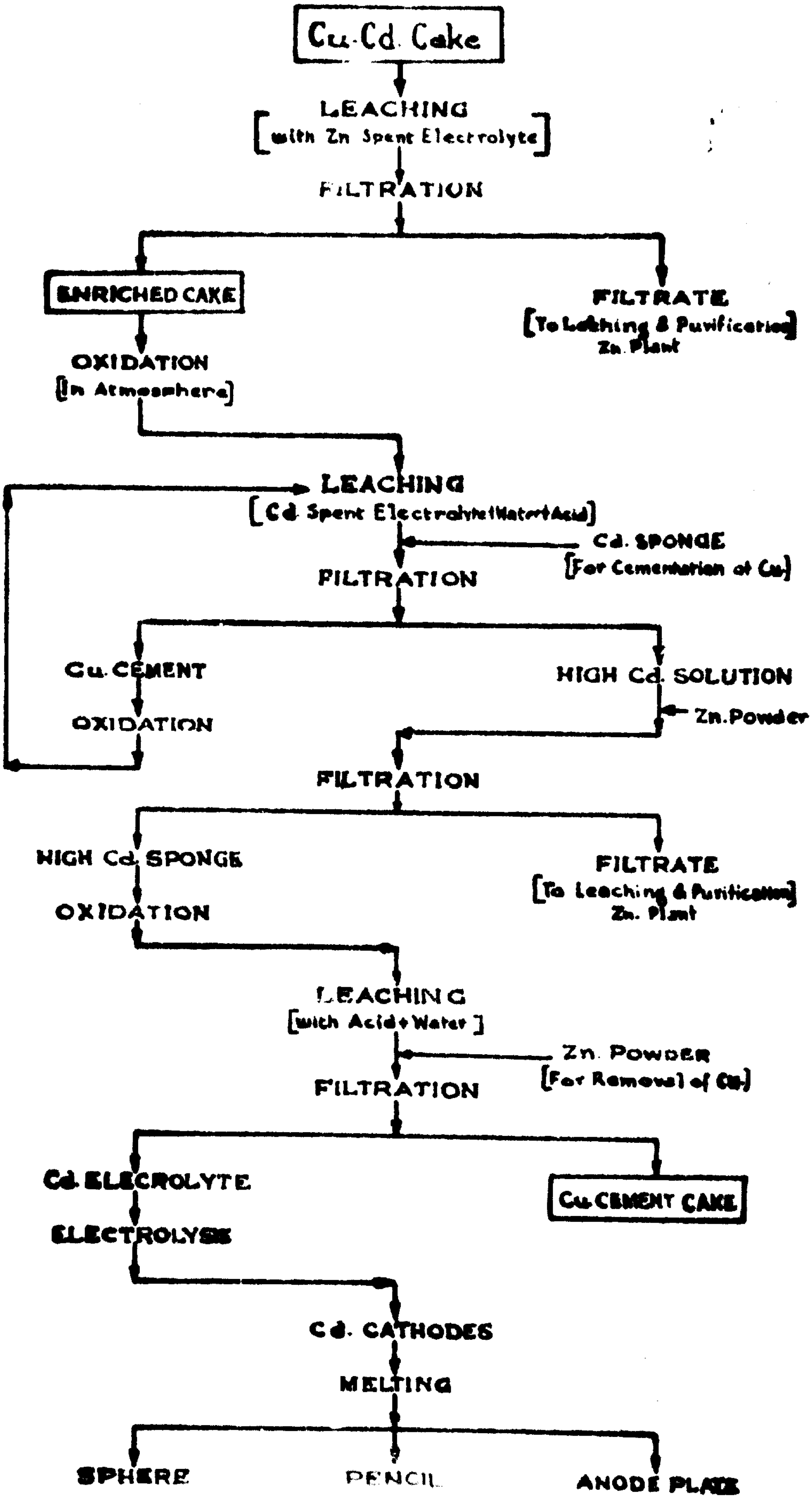
FLOW SHEET OF CADMIUM PLANT



Annexure-B

FLOW SHEET OF CADMIUM PLANT

[MODIFIED SCHEME]



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