First fluo-solid roaster in India—design and operation

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SYNOPSIS

The paper discusses the practical working of a fluo-solid roaster for zinc concentrates at thc zinc smelter of Debari in Udaipur. Initial start-up data for the new roaster are given in detail. An attempt has been made to present all possible operational data.

THE fluo-solid roaster is a modern device which has passed on to the hands of metallurgists from the oil industry where it was used for the first time by Houndry in 1936, for catalytic cracking of petroleum and since then it has been improved and perfected.

It is now in common application for sulphide roasting to recover gas for acid manufacture and calcines from which metal constituents are extracted. It can also be used for partial oxidation and sulphatation roasting of concentrates and matte to render them suitable for extractive treatments.

Fluid bed operation gives precise control of temperature without any hot spot and feed material to air ratio. These facts are advantageously used in sulphide roasting. The feed is intimately and rapidly mixed with the air or gas introduced from the bottom of the roaster.

The two important operational parameters are particle size and gas velocity ; there are various phases in the operation of the roaster :

(i) Static phase, nearest to the hearth.
(ii) Dense fluidization phase.
(iii) Pneumatic transport (free board).

The coarsest particles remain in the static bed while the finest particles fly-up in the free-board to exit with gas. The free-board portion of the roaster is of larger diameter than the lower portion in order to reduce the velocity of out-going particles and this checks the excessive fly-outs.

In the dense phase, conditions are smooth and uniform. A good quantity of gas is carried from the top of the bed to the bottom with the circulation of the solids. The gas and solids get rapidly mixed with the fluidising air and the materials fed.

Thus, solids are of uniform composition, throughout the phase and the gas also approaches uniform composition.

The mixing of new feed with finished material within a fluid bed, helps in bringing it rapidly to bed temperature. The chemical equilibrium between the solid product and the exit gas is helped by the high ratio of solids to gas and the excellent contact between gas and solids. As fluid beds permit almost complete oxidation of sulphide minerals with low excess air requirements, more heat is frequently produced by the oxidation than can be removed by the end products of the reaction.

Temperature control is essential to obtain the required conditions for extractive treatment, to avoid sintering, to limit ferrite formation for reactivity of product and for the protection of the brick-lining. Therefore provisions are made to remove excess heat from the fluid bed. The common practice is to inject water in the bed through suitable openings in the body of the furnace, although in some designs, cooling coils are inserted in the bed to take care of the extra heat and this system helps in producing additional steam. The cooling tubes are made of normal boiler steel. Heat exchange surface is generally low ; 35–40 square meters are sufficient for a 200-ton roaster for pyrite.

Some of the important reactions which occur while roasting sulphides are :

Oxidation

$$2MS + 3O_2 \longrightarrow 2MO + 2SO_2 \qquad \ldots (1)$$

SO_3 and metal sulphate formation and decomposition

$$2MO + 2SO_2 + O_2 \longrightarrow 2MSO_4$$
$$2SO_2 + O_2 \rightarrow 2SO_3 \qquad \ldots (2)$$

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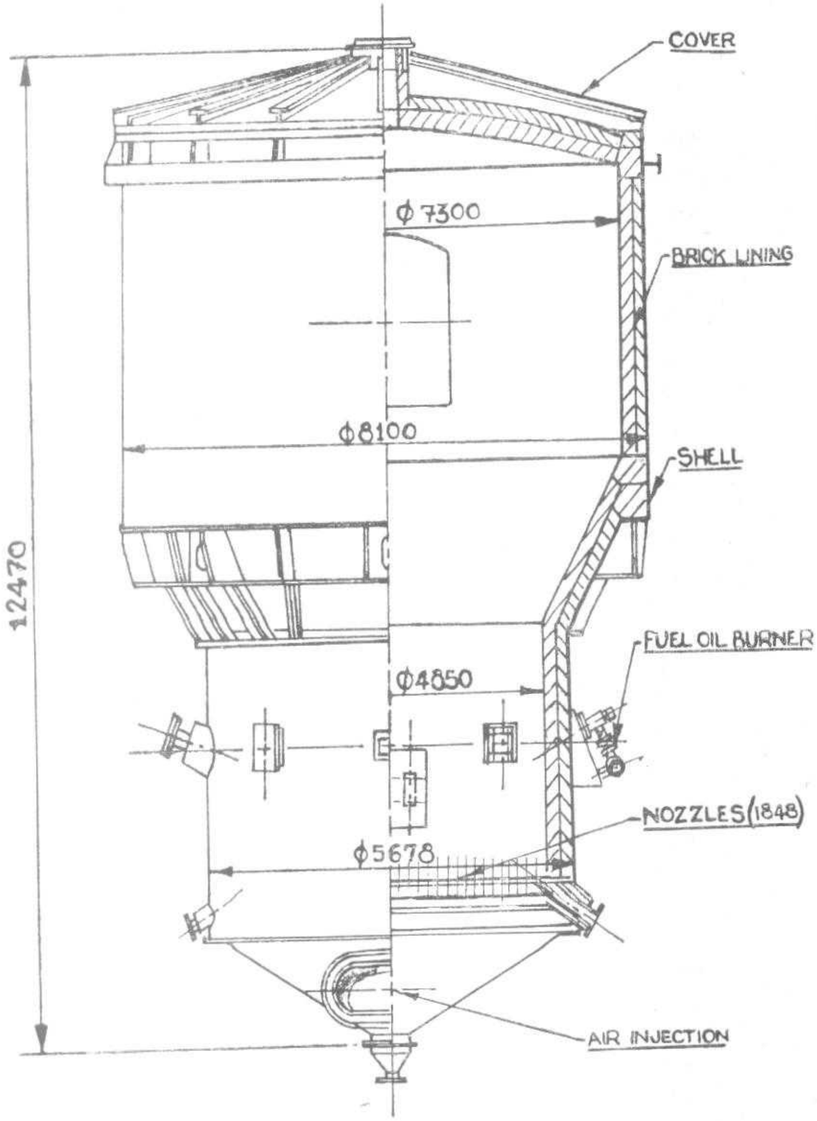

1 *Blende roasting furnace fluodised bed*

Formation of ferrite type compounds

$$MO + M_2O_3 \longrightarrow NOM_2O_3$$

Design aspects

The fluo-solid roaster at the Debari Zinc Smelter of Hindustan Zinc Limited (HZL) is the first and only one of its kind in India. The roaster prepares zinc oxide from concentrates obtained from HZL's own mines at Zawar.

The first fluo-solid roaster of the world for zinc was put up in 1958 by Viellie Montagne at Balen in Belgium and they are the sole patent holder for the process while the engineering design is by Lurgi of Germany. The special aspect of this roaster is that instead of slurry the feed is in the form of dry powder, the usual mill product from flotation cells.

Construction

In appearance its construction is very simple consisting of a shell of 14 mm M. S. plate at the lower portion while towards the top this thickness reduces to 10 mm. The brick lining of the furnace is 450 mm thick ; the top cover of the vessel is lined similarly. The centre of the top is provided with a movable safety plug which flies off in case of high pressure or explosion in the furnace (Fig. 1).

The uniform lining consists of two inner layers of insulating bricks with one outer layer of special fire bricks.

The bottom hearth of the roaster is an assembly of constricted M. S. plates of 10 mm thickness carrying 1848 special steel nozzles of 28 mm bore at the bottom. All are placed vertically at an equal distance of 100 mm centre to centre of each nozzle covering the whole hearth area.

This assembly of nozzles is embedded in a special concrete of Secar 250, which is a highly refractory and acid proof cement. It was cast in two layers with a view to imparting some flexibility to the bed and also as a safeguard against cracks that might develop after long operation.

The furnace is provided with two manholes, two holes for water injection, two underflows for controlling bed pressure in emergency, two burner ports for initial heating of the furnace with oil burners and one peeping window just opposite the burners. There are two overflows for the discharge of calcines and a feed door opposite to them. The average roasting capacity of the furnace is about 6 to 6·6 tons per m^2 of its hearth area.

Feed machine

This is an endless special hard rubber and heat proof belt. The belt moves at a high speed of 72 km per hour. The drive motor is of 10 H. P. The position of the feed machine is so adjusted that the concentrates fall in the centre of the furnace.

Roots blowers

There are two blowers of volumetric type, one of which is always kept as a stand-by. Each blower can give 16 000 Nm^3/hr at a pressure of 1 800 mm W. S. There is an automatic air flow control valve which can regulate the quantity of air passing through the bed. An automatic weighing machine records the feeding rate of the furnace.

The feed can be increased or decreased by adjusting the speed of the dosing tables or its discharge openings. The feed is stocked in two silos each of 70 tonnes capacity.

Gas cleaning

Gas cleaning system comprises an Alstom waste-heat boiler, cyclones—one large followed by four small ones in parallel. There is a pea-body scrubber after the cyclones and four wet type electrofilters. The scrubbed water from the pea-body is partly passed through filter presses (two) to recover solids and the water is recirculated after cooling through plate-type heat exchanger while the other part of the water is pumped to the roaster as water injection to control the temperature needed.

Operational details

Start-up

After the brick lining was laid in the main furnace and the waste heat boiler, it was left for air drying for 15 days. The hearth was gradually heated up with drying wood fire and for the first three days the temperature was maintained at 90–100°C ; the temperature was then allowed to rise to 300°C in 48 hours and kept at this level for 5 days. During this period necessary washing treatment was given to the boiler elements and it was pressurised at 25 kg/cm^2 for 12 hours. The furnace was then allowed to cool of its own accord and after 56 hours man could go inside. The hearth was cleaned of all the unburnt wood pieces and ash and the nozzles were checked for any clogging. Two oil burners were lighted wherein steam and air from the blower were used for atomization and combustion. The temperature was raised gradually at a regular rate as shown in Table I.

Before lighting up the burners, 10 tonnes of calcine (obtained from Cominco Zinc Flash Roaster already in operation at Alwaye) were charged in the furnace to make bed height.

Calcine was charged at various intervals with a feed machine and it was continued till the bed height reached 75 cm. All the while the bed was fluidised for few seconds every hour to ensure uniformity in hearth temperature and this also made the material homogeneous.

An adequate bed with uniform temperature was prepared in 28 hours with 40 tons of calcine including the fly-out through chimney during fluidization.

Some difficulty was experienced in preparing the bed

TABLE I Temperatures at various points—low and high feed

	Bed temp. °C		Roaster exit temp.		Boiler exit		Cyclone outlet	
Time	25-1-68	18-4-68	25-1-68	18-4-68	25-1-68	18-4-68	25-1-68	18-4-68
6 A.M.	915	895	950	860	340	320	300	280
10 A.M.	920	900	965	840	345	315	310	275
2 P.M.	925	915	950	865	350	320	315	285
6 P.M.	910	900	940	880	350	315	315	280
10 P.M.	920	920	950	870	350	320	315	280
2 P.M.	905	910	950	870	350	320	315	280
6 A.M.	925	920	950	875	350	315	315	280

TABLE II Operating data for maximum and minimum feed

	Water addition L^3/h		Air flow M^3/h		Bed pressure kg/cm^2		Steam production T/h		SO_2 conc. %	
Time	25-1-68	18-4-68	25-1-68	18-4-68	25-1-68	18-4-68	25-1-68	18-4-68	25-1-68	18-4-68
6 A.M.	500	Nil	9 000	7 400	1 540	1 840	5·2	2·9	7·8	3·4
10 A.M.	900	Nil	9 000	7 000	1 600	1 830	5·5	2·8	8	3·1
2 P.M.	300	Nil	9 000	7 600	1 540	1 780	5·5	3·0	6·8	4·2
6 P.M.	300	Nil	9 000	7 200	1 620	1 780	5·2	3·0	6·1	3
10 P.M.	500	Nil	8 400	7 200	1 540	1 780	5·6	3·0	8·2	4
2 A.M.	500	Nil	8 400	7 200	1 520	1 780	5·1	3·0	8	3·3
6 A.M.	200	Nil	8 500	7 000	1 560	1 720	5·0	3·1	8·2	3·8

due to the excessive fineness of Cominco calcine (80%–300 mesh); there were heavy fly-outs and the bed started sinking which caused failure in fluidization at the final stage. When we ran short of calcine which could not be immediately transported from Alwaye we attempted to make up the loss by mixing silica sand; a mixture of calcine and sand in the ratio 17 : 25 was used for bringing the bed height to 70 cm; the trial was a great success and, in fact, the new bed behaved even better in many respects.

When the temperature of the bed reaches 500°C at all the six pyrometer points, sulphur charging was started and oil burners were stopped.

Sulphur charging

In the beginning it was attempted to charge sulphur through one of the overflow doors with the help of a specially designed charging gun; as anticipated this did not work and sulphur was charged manually with shovels through the feed door.

The feed belt was not used for charging sulphur as it was feared that the rubber belt might get burnt due to back-firing. Charging of sulphur was stopped at 850°C; 45 minutes were required to raise the temperature from 500°C to 850°C and 3·5 tonnes of sulphur were consumed. During sulphur charging the fluidization was continued with air flow at 7 000 Nm^3/hr at a pressure of 15 000 mm W. S.

After the stoppage of sulphur charging, the temperature first started rising rapidly and then after 15 minutes, it dropped. As soon as the bed temperature started dropping, the roaster was connected to the acid plant and a blende feed was started. During the process of sulphur charging, the rich SO_2, (10–12%) gas was released in the atmosphere; this is no doubt a waste but we did it to avoid elemental sulphur passing to electrofilters and catalysis mass in the contact mass, as this would be detrimental due to the deposition of a sulphur layer and it would have impaired the working efficiency of the converter, although in Belgium and Italy, rich SO_2 gas is taken into the system during sulphur charging.

The furnace has a designed capacity of 120 tons/day but it was run up to 153 tons/day during long capacity tests without any difficulty or side effects. The minimum feed on record during our six months run is 3 t/hr. Operating data are given in Table II for maximum and minimum feed on 25–1–68 and 18–4–68 respectively. Tables III (A and B) give the blende and calcine analyses.

TABLE IIIA Blende analysis %

	Zn (Tot.)	Fe (Tot.)	S (Tot.)	Moisture
25-1-68	53·9	6·8	30·43	1·29
18-4-68	52·8	5·8	30·11	1·80

TABLE IIIB Calcine analysis %

	Zn (Tot.)	Fe (Tot.)	S (Tot.)	S (SO_4)	S. (S^{--})
A	61·2	6·9	3·54	3·17	0·37
25-1-68B	60·8	7·7	4·29	3·80	0·49
C	62·1	6·8	4·12	3·78	0·34
A	59·4	5·5	4·77	4·35	0·42
18-4-68B	59·8	6·7	3·22	3·00	0·22
C	60·1	7·2	2·90	2·68	0·22

TABLE IVA Blende from Zawar mines

	%		%
Zn	55·5	CaO	1·22
Fe	4·5	MgO	0·60
Pb	0·95	SiO_2	1·74
Cu	0·049	Insol.	2·05
Cd	0·33	Na	0·001
Ag	0·0054	K	0·001
Co	0·0008	Li	0·001
Ni	0·0011	Cl_2	0·0024
Ge	Traces	F_2	0·005
As	0·018	S Total	29·87
Sb	0·0019	S (SO_4)	0·16
Mn	0·04	S (H_2S)	29·71
Al	0·58		

The temperature towards the top of the roaster is higher than at the bed because of the after-burning or flash effect of concentrates. Finer and dry blende gave higher temperature in the free-board towards the top than somewhat coarser and wet (4·5% moisture) blende; calcine product weight distribution is as follows:

Reactor overflows	... 25%
Waste heat boiler	... 55%
Cyclones	... 18%
Pea body scrubber	... 2%

Water injection

Water was injected in the furnace through the feed hole (a) 300–500 litres per hour for a feed rate of 5·5 t/h. Additional water wherever necessary was introduced through one of the two holes provided for the purpose.

Blendes from Zawar Mines are known to be the best in the world (Table IV). It has been possible to stop the roaster even at the high bed temperature of 900°C without fluidization for 40–45 minutes and no fusing of bed took place.

TABLE IVB Typical blende and calcine analysis

	Total Zn	Total Fe	Total S	Sul-phide sulphur	Sul-phate sulphur	Chlo-rine	Mois-ture
Blende	52·8	5·6	29·85	29·48	0·37	16 ppm	2·5
Calcine	60·7	6·3	3·63	0·34	3·29	Tr.	—

Stoppages

Planned shut-downs for maintenance work are effected by bringing down the bed temperature to 700°C below which no fluidization is necessary. We could wait for 92 hours without having recourse to oil burners for pre-heating. It is possible to restart the roaster with sulphur alone if the bed temperature does not fall below 250°C, the ignition point of brimstone. Whenever bed temperature falls below 800°C, sulphur charging becomes necessary to bring up the temperature to this level. If, for any reason, bed temperature drops below 200°C, sulphur alone will not help and it will be necessary to light the burners.