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Chemical Recovery by Rotary Furnaces

Chemical Recovery (i. e.) the reclamation and reuse of spent chemicals plays a key role in the pulp and paper industry especially in the sulphate process of pulp manufacture of which it is an essential part as the cost of process would be prohibitive in case all the spent cooking liquor are to be flushed down the drain. Moreover they are prohibitively toxic from the view point of stream pollution, which will not be tolerated by the masses. Recovery process includes all those operations in the closed cycle from digester through washing, evaporation, incineration and causticizing to digester again. The economics of Recovery System as a whole is in a large measure a function of solids dehydration and incineration of the mass in the Recovery Furnace, which is the heart of the system. The basic functions of the furnace are (1) recovery of inorganic chemicals (2) recovery of energy from dissolved organic constituents of pulping raw material and (3) elimination of pollution.

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Upto 1925 the popular recovery unit used to consist of Rotary Furnace and smelter for Sulphate Mills. The Wagner Furnace was introduced in 1928 which was a substantial improvement over Roaster Smelter combination. As an advancement over Wagner furnace Tomlinson Unit was developed in 1930 which happens to be the forerunner of the different types of modern units in vogue now.

When Harihar Polyfiber Project was finalised it was decided to have a modern recovery furnace boiler unit of indigenous manufacture. Due to unforeseen circumstances the manufacturing and delivery schedules of Recovery Boiler got very much upset. As our own manufacture of machinery for rest of the plants was going on schedule for start up by early 1972, we had to think of other means of recovering valuable chemicals in the absence of Recovery Boiler. In order to make a low cost investment for the stop-gap arrangement instead of the Recovery Boiler the various alternatives were studied. Taking into consideration the availability of time and material for own manufacture it was decided to go in for the Roaster Smelter without heat recovery unit.

It was decided to install 4 roaster smelter (3 running and 1 stand by) units to take care of the spent liquor available from a daily production of 50 tonnes rayon grade pulp. These units were started one by one from March 1972 onwards. Since the delivery period of the recovery boiler was further enhanced and as we had to step up our pulp production to about 80 tonnes/day, our management decided to go in for 2 more roaster smelter units of higher capacity and improved design.

General Outline of Roaster Smelter Unit

The spent liquor after concentratting in the multiple effect evaporator is fed into the drying zone comprising of rotating cylindrical shell called the roaster where the liquor is dried and from which the dried material is discharged more or less in the form of discrete lumps or aggregates. The dired material discharged from the drying zone is fed to a stationary combustion zone called the smelter. The drying in the drying zone is affected by gaseous products of combustion of organic comounds, these products of combustion being derived from the smelter into which air is supplied so as to affect combustion of organic compounds and formation of smelt of the inorganic materials contained in the lumps of the solids. The flue gas from the roaster is let through a dust chamber for removing coarser particles carried into the gas stream. From dust chamber the gas is passed through a scrubber to further recover the

chemicals and to reduce flue gas temperature to the level suitable for induced draft fan which discharges the gas to chimney.

Detailed Description of Initial Roaster Smelter Units

Roaster :

It is a mild steel cylindrical shell of 9 ft. diameter and 27 ft. length having refractory lining inside with 50% Alumina bricks of 9" thickness. The drum is suitably mounted for rotation on an axis inclined downwards at a slight angle from its black liquor feed end to its discharge end. For feeding the concentrated black liquor to the roaster a water jacketted pipe is mounted through the dust chamber and is extended inside the drum. The lower end of the feed pipe terminates adjacent to the bottom periphery of the drum. A heavy black liquor feed tank of 2.5 M^3 capacity is provided with pumps for feeding the liquor to all the roasters under pressure with individual control valves for adjusting feed to each roaster.

Drum drive motor is 15 HP with suitable reduction gears to give a drum speed of 2 rpm. Normally a slow speed drum drive is a highly expensive and long delivery item in the country today. Any girth gear of 9 ft. to 10 ft. diameter having a circular pitch of 2 inch and above would take at least two years in the country as the casting and gear hobbing facilities for this size are comparatively few. Out of shear necessity we have been able to develop a different type of pin gear drive which practically works out to 50% of the conventional gear cost and can be improvised in a short time. Such drum drives have been in satisfactory operation in our all roasters for the past 18 months.

Smelter :

It is a mild steel cylindrical shell of 10 ft. diameter and 20 ft. height with water cooled top and a water cooled spout at the bottom. The smelter bottom and the combustion zone upto a height of about 7 ft. is lined with one layer of soap stone bricks and one layer of 60% Alumina bricks. Remaining portion of the smelter is lined with 60% Alumina bricks. Water cooled top header is lined with castable refractory with suitable anchoring. Hearth slope is 12° to 14°. Air for the combustion of black ash is led into the smelter through 4 water cooled 6" dia MS pipes set at 60° angle from the smelter wall. The air pipes are located equidistant and opposite to each other. Air at room temperature is supplied to smelter by a positive displacement blower, which is common for two roaster units.

Hot flue gases from the smelter pass into the roaster drum through a brick lined nipple. Clearance between the roaster and nipple is set to minimun to avoid infiltration of air as far as possible.

Dust Chamber

It is constructed of 9" thick standard fire bricks of 30% Alumina content. The chamber is having square cross section of about 11' x 11' and 14' height with an arch at the top. Bottom of the chamber is provided with an opening for hopper connection through which coarser ash particles are collected for reuse in the smelter.

Scrubber

Scrubber for gas has been included as ID fan for handling flue gas temperatures above 350°C was not available. Water sprays are provided counter-current to gas flow. Scrubber not only reduces the flue gas temperature but also recovers part of chemicals being carried away in the gas stream. The scrubber water is used in causticizing plant for dregs washing.

I. D. Fan

Each roaster is provided with an ID fan. Flue gases from two roaster units are going to atmosphere through a common chimney.

Dissolver

Each roaster is provided with a MS dissolver of 10 ft diameter and 10 ft. height with paddle agitator and a vent. Steam shatter nozzle and green liquor circulation is provided for the smelt. Two green liquor pumps are common for two roasters.

Process Details

For start up, the unit is heated by putting firewood in the smelter. The temperature is gradually raised to 500-600° C in about 3 to 4 hours time. Then black liquor of 50 to 52% solids is admitted to the roaster. Heavy black liquor gets dried in the drum by the counter-current flow of hot flue gases from the smelter. The black ash discharged from the roaster having approximate size of 3" to 5" and having about 8% moisture is collected on on the operating floor. After

collecting sufficient quantity of black ash it is fed manually into the smelter through the charging door and the temperature of the smelter is gradually raised to about 1000°C. Ash shovelling to smelter is then made continuous after mixing salt cake. Smelt flow begins after 1 to 1½ hour of ash charging. Due to the self supporting combustion of black ash there is no necessity to use any firewood or any auxiliary fuel during normal running. For each start up about 5 to 6 tonnes of firewood is required.

Operating Data	
Combustion air pressure	100 to 150 mm WG
Smelter draught	± 2 mm WG
ID inlet draught	-100 to-150 mm WG
Smelter temperature	1000°C to 1150°C
Roaster outlet gas temperature	450°C
ID inlet gas temperature	250°C to 275°C
% Reduction	85 to 90

Operating Problems

1. To get the optimum peripheral drum speed for a uniform size of discharge ash from the drum, various roaster rpm were tried. Finally we arrived at 2 rpm speed.
2. Different % solids liquor was fed to roaster. Optimum for our roaster to get the desired quality of black ash was found to be 50 to 52 % solids.
3. Manual feeding of ash from roaster to smelter was a bottleneck and we tried to mechanise the feeding by introducing a trolley in between the roaster and smelter. Even though it succeeded partly we could not continue it longer as mixing of salt cake was not uniform and there was a widc variation in smelter temperature. However. this manual ash feeding problem has been completely eliminated in our improved roaster smelter unit.
4. Refractory lining is a well known chronic problem of these units for which the solution lies in trying out various refractory formulations available within the country. Chrome bricks or magnesite bricks are supposed to be ideal for the smelter but their non-availability and high cost prohibits their use.

Approach to A New Roaster Smelter Design

Having operated the four conventional roaster-smelter units with their inherent problems as already mentioned we have been thinking in terms of developing a roaster-smelter unit which should have the following features :—

1. Automation and less manpower requirement for operation.
2. A unit which can handle higher capacities than the conventional 25-ton per day capacity roaster-smelter unit.
3. A unit which could be fabricated within reasonable cost and stable enongh for continuous mechanical operation.
4. Improved chemical recovery, lesser carryover of solids and smooth operation at the spout.
5. A unit where the various heat zones can be clearly defined for specific operations, and possibility of operation at varying capacities.
6. A unit which would have less agressive refractory conditions so that the indigenously available refractory material can give satisfactory life.

It would be interesting to place certain observations about refractory which becomes a very critical item in the operation of the unit. The drum refractory is subjected to mechanical vibrations from the drum drive, highly alkaline conditions at the liquor feed zone and highly abrasive conditions at the discharge end of the drum. Our experience has been that the drum refractory is stable at the feed end but the life is comparatively shorter at the discharge end. It is due to the fact that towards the discharge end the feed material practically changes from liquid to solids and the overdried part of the solids form quite abrasive physical structure. Hence for satisfactory life of the drum refractory it is necessary that the particles discharged from the drum are not over-dry. Also proper formation of the shape and particle size of the black ash discharge has lot to do with the drum-refractory life. Incidentally maintaining lower dryness in the drum-reduces carry over of fine ash thus contributing to better overall reco-

very efficiency.

If the discharge from the drum is to be still maintained slightly moist for the purpose of improving the drum refractory life, it automatically follows that additional drying zone has got to be established in the smelter. When it comes to the question of smelter refractory once again three clearly defined zones become necessary. The top most zone for completing the process of drying and immediately below the zone for combustion and thereafter the bottom zone for fusion. The above three requirements make the dimensioning of the smelter unit highly critical for a particular capacity of processing. The amount of primary air introduced into the smelter has a function of initiating the combustion at the middle zone, completing the drying at the top zone and at the same time conserving enough heat for the fusion of the chemicals at the hearth. If in the process of drying, the overdried particles come in contact with the high velocity primary air at the tip, these particles get carried over in the air stream impinging on the smelter refractory walls and thus creating a very heavy refractory erosion. The control of the primary air and the control of the zones thus become very important in realising satisfactory life out of the smelter refractory.

Considering all the above, we have designed and manufactured a new type of roaster smelter unit which is much more versatile from operating point of view both in quantity and in quality.

Improved Design Roaster Smelter Unit

As mentioned earlier to step up the pulp production we had to go in for 2 more Roaster Units. From the experience we had in the design and operation of old units we had to incorporate certain changes for better working.

Basically the new units consist of a standard Roaster Smelter arrangement with the following improvements.

1. Roaster

Drum length is made shorter and variable speed drive is provided to handle liquor of different total solids content and different organic to inorganic ratios. This also facilitates in getting uniform quality of black ash with respect to size and dry content which is essential for steady smelter operation.

2. Fully Mechanised Ash Feeding

In order to eliminate the manual feeding of black ash a water jacketted feeding screw is provided between the roaster and smelter. The screw device automatically collects the entire black ash discharged from the roaster and feeds into the smelter ensuring uniform distribution of char. Thereby proper char bed height is maintained for better reduction efficiency and less carry over. Salt cake mixing is done at the screw.

3. Smelter

Hearth area of the smelter has been suitably scaled up to handle more black liquor solids.

4. Scrubber

Necessary modifications have been introduced so that at a late stage it can work like a cyclone evaporator to recover the heat of flue gases.

Capacity and Efficiency of Roaster Smelter Units

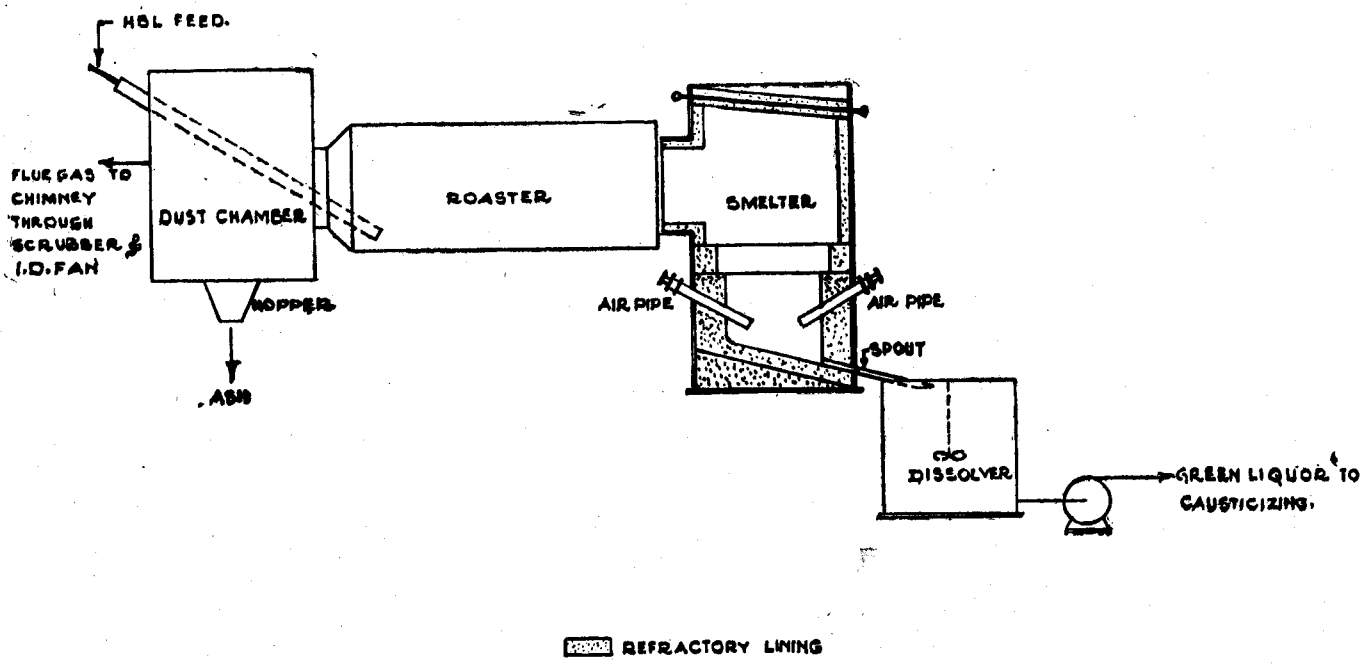
Each roaster smelter unit of the improved design is capable of handling black liquor solids from a production of 40 tonnes paper grade pulp per day compared to 25 tonnes pulp/day capacity of the unit of old design.

The Chemical losses from roaster smelter unit come to about 25% on input alkali to digester. The losses are comparatively lesser from the improved design of Roaster Smelter units as the control of the process is better and operation remains steady due to mechanical feeding arrangement.

Conclusion

1. Investment cost for the Roaster –smelter units as compared to that of a Recovery Boiler is much less.
2. For smaller paper mills upto 60 tonnes/day capacity this type of unit is quite suitable.
3. It is quite feasible and practicable to install and operate a single 60 tonnes/day paper pulp capacity roaster smelter combination of improved design.
4. The operation of roaster smelter unit of improved design requires much less number of persons compared to that of an older type of unit.

GENERAL ARRANGEMENT OF ROASTER SMELTER UNIT



5. Even low heat value waste liquors can be handled without any problem.

6. Heat recovery unit for steam generation if required along with such units need not be of a very special design as any water tube boiler can be utilised for this purpose. Unlike recovery boiler the steam generating unit if installed will be away from the hot zone of the smelter and hence the possibility of any explosion occuring is very greatly reduced.

7. For attaining higher chemical recovery efficiency by such units a venturi scrubber or an Electro Precipitator can be incorporated with the cyclone evaporator.

8. Paper mills already having recovery boiler can also utilise such units to boost up their production capacity for an appreciable gain.

9. Reduction efficiency in Roaster Smelter Unit being good for sodium sulphate there is no practical limitation to maintain even as high a sulphidity level as 22 to 28% in the cooking liquor.