Low Temperature Incinerator System for Agro Based Paper Mills

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Over the years several treatment methods have been developed for Chemical Recovery from agricultural residues like bagasse, rice or wheat straw. Many of them could not be successfully commercialised due to one factor or another. The fundamental problem is to tackle the increase in viscosity with concentration and the problem of silica. Low Temperature Incinerating process developed and implemented at two units in Punjab are successfully working for more than five years. It is not economical to go in for a Conventional Recovery System for small and medium sized paper mills.

INTRODUCTION

Small paper mills are the backbone of paper industry and their survival and growth is a great achievement in developing countries like India. Due to lack of suitable technology for the recovery of cooking chemicals, they all suffer both economically and environmentally. By the year 2005, all the paper mills will have to conform to the environmental norms. With this in back ground, the treatment and processes presently available and the technology that has been working successfully in our country are discussed. The economics of incinerating Black Liquor in Conventional Recovery Boiler along with Causticiser are also discussed.

Several Chemical Recovery Systems have been developed in the past. They all fall under the following broad categories of treatment of Black Liquor:

1. Physical Treatment
2. Biological Treatment
3. Incineration

Physical Treatment

The Physical Treatment aims at the separation of high molecular weight fraction containing mostly Lignin, colouring compounds and bound soda by ultra filtration. Later concentrating sodium compounds in the permeate by subjecting them to Reverse Osmosis.

Though this process eliminates evaporation, combustion and causticising, however, the overall recovery is very low. Further, the critical factor for Membrane Technology to become viable is determined by degree of fouling, flux rate and replacement cost of Membrane. In case of Black Liquor rich in silica, the fouling is aggravated by the precipitation of silica, which occurs as active alkali concentration gets depleted.

Biological Treatment

Under Biological Treatment, the Black Liquor is treated with bacteria under anaerobic condition and the methane produced is used for burning in the boiler. The sludge is suitably disposed. The anaerobic treatment follows the patented Upward flow Anaerobic Sludge Blanket (UASB) process.

However, functionally different microbial population in various phases of bio-methanation process is metabolically dependent on each other in a way that one type of bacteria may affect the efficiency of the other. The bacteria involved in Bio-methanation are sensitive to a number of factors such as temperature, pH of reaction mixture, hydraulic retention time, degree of variation in COD load, quality of Inoculums etc. Though UASB -Bio-methanation process are working in a few mills, but the sensitivity factors listed above and disposal of final sludge, rich in inorganics and left over organics pose a serious deterrent.

Table 1 : Low Temperature Incinerator System Vs. Conventional Chemical Recovery System

Low Temperature Incinerator System	Conventional Chemical Recovery System
Most suitable technology for silica of Agro based Black Liquor	A major drawback
Proven design to handle Black Liquor from any agro based raw materials like Bagasse, Rice Straw, Wheat, Straw, Sarkanda etc or in any combination	Neither designed nor proven
Scaling and viscosity problems do not affect the process	Viscosity and Scaling problems are prominent as Black Liquor is fired at high concentration
A safe process for small medium pulp mills, does not form any smelt	Smelt hazard.
A flexible widely applicable technology Alkali/Neutral Sulfite Black Liquor	Mainly suitable for soda and kraft process
A low cost technology of small/medium pulp/paper mills .	Highly capital intensive
An environment friendly clean technology with least problem	High investment in electrostatic precipitators, lime mud problem pollution
Minimum maintenance	More maintenance of refractories and accessories
Can be scaled down to 30 -35 TPD Pulp Mill - Technology and economics are viable	Difficult to viably scaled down below size 100 TPD in terms of technology and economics
Very low gestation time eg 8 -10 months	High gestation time of 2½ years minimum
Ideal for marginal expansion	Marginal expansion not viable

The above two treatment processes have been tried in India but not proven on a commercial and sustained scale because of the inherent problems listed above. Moreover, the inorganic sludge disposal still has not been addressed.

Incineration Process

The incineration of Black Liquor can be done either directly or indirect gasification. Manufacturing an Technology Conversion International (MTCI) Inc, USA has developed a process of indirect gasification of Black Liquor to produce a high calorific fuel gas.

The gassification takes place in a chamber called "Thermo Chemical Conversion Reactor (TCCR). It comprises of a steam-fluidized bed containing heat transfer tubes, wherein Black Liquor is fluidized and the solids undergo vaporization and pyrolysis. Higher hydrocarbons of pyrolysis products are steam cracked and reformed to produce law molecule weight products. Residual char retained within the bed is more slowly gasified by steam to produce fuel gas with high hydrogen content. The sodium carbonates char is taken out of the reactor dissolved and causticised in the conventional way. In MTCI process pulse combustion heaters are used for indirect heating of the fluidized bed reactor. So far no commercial installation based on this technology has come up in India.

The incineration of Black Liquor by concentration and direct burning in conventional recovery boiler with causticising the green liquor has been tried and implemented in a few mills. If the aim is to make the CRS a power generating source, then the black liquor from bagasse or straw must be concentrated to not less than 60% solids. This is because of the law calorific

Table 2 : Proximate Chemical Analysis of Agricultural Residues

Raw Material	Ash %	Silica (%)	Chloride Content As NaCL (%) (%)	Pentosan (%)	Lignin (%)
BAGASSE	3.50	1.80	0.09 to 0.17	22.5	24.1
WHEAT STRAW	7.20	3.20	0.95 to 1.87	19.2	18.5
RICE STRAW	18.4	11.80	0.40 to 1.30	19.3	13.6

value of these black liquors. The basic problem faced then is the disproportionate increase in viscosity at such high concentrations. The problems of handling, pumping and firing such highly viscous liquor are insurmountable. In fact many of the large mills using bagasse and/or straw, mix black liquor from woods. This is an inalienable fact. Moreover, the high silica present in the black liquor results in glass formation in the recovery furnace leading to possible explosion. The second major problem faced, is in causticiser. This is due to the slow settling nature of the white liquor due to the presence of silica. In a closed loop system, silica gets built up very easily. The burning of lime sludge with high silica is inefficient. So, even disposal to cement mills may be difficult. Finally, if power generation is the sole criteria to go in for conventional recovery system, then it would be profitable if in the existing system there is spare capacity to the extent of handling the steam raised. If, say a 100 TPD mill based on secondary fibres alone is to go in for a conventional recovery with turbo generating system, it will not be economically prudent.

The Fluidized Bed Recovery process developed originally by Copeland was later modified and implemented at M/s. Shreyans Industries Ltd (SIL) with technical support from M/s. Agro Pulping Machinery Pvt, Ltd (APMPL). This Low Temperature Incinerator System has been running since 1900 continuously and efficiently. Another one has also been implemented at Shree Rishab Papers and is working for the past five years without any problem. With constant co-operation and pro-active practices by both APMPL and SIL, several

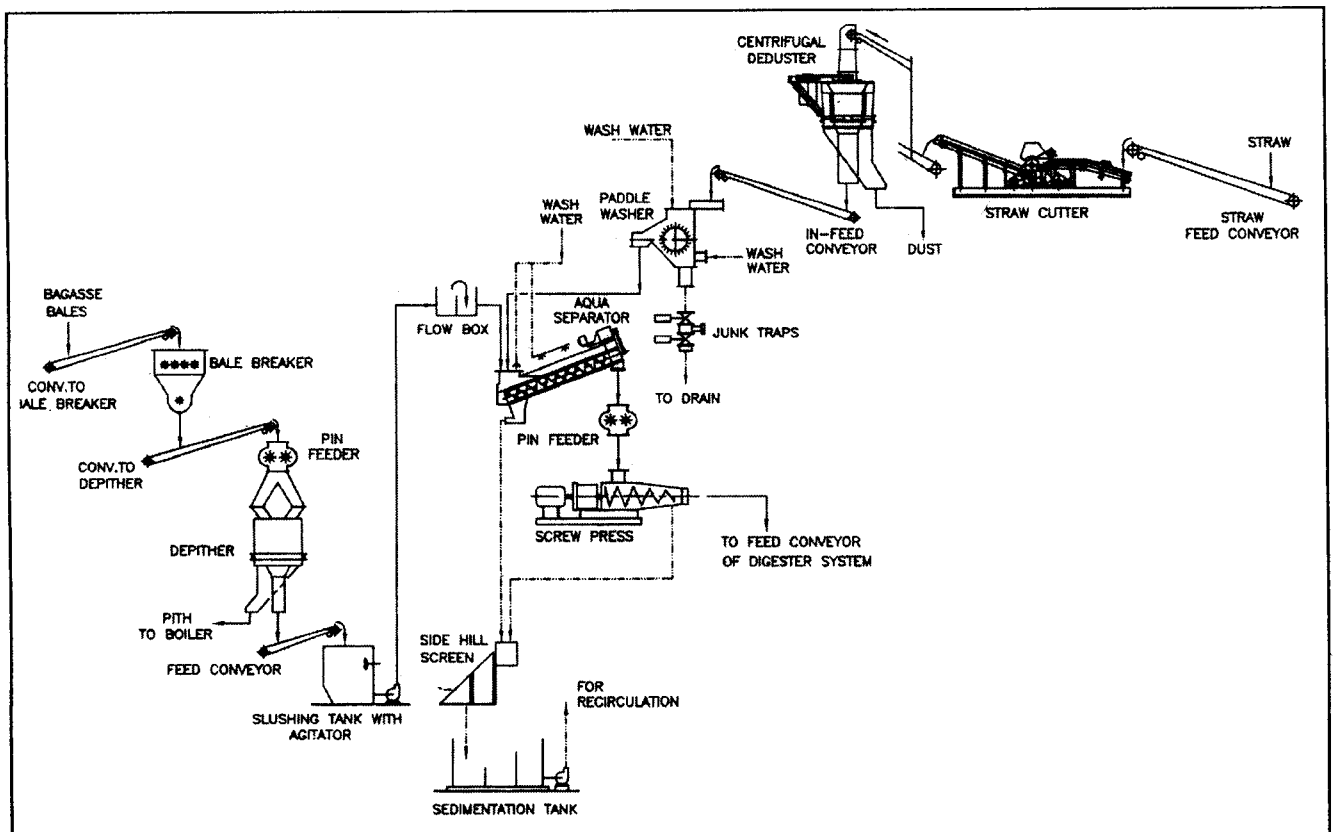

Fig. 1 : Fibre Preparation & Wet Washing System

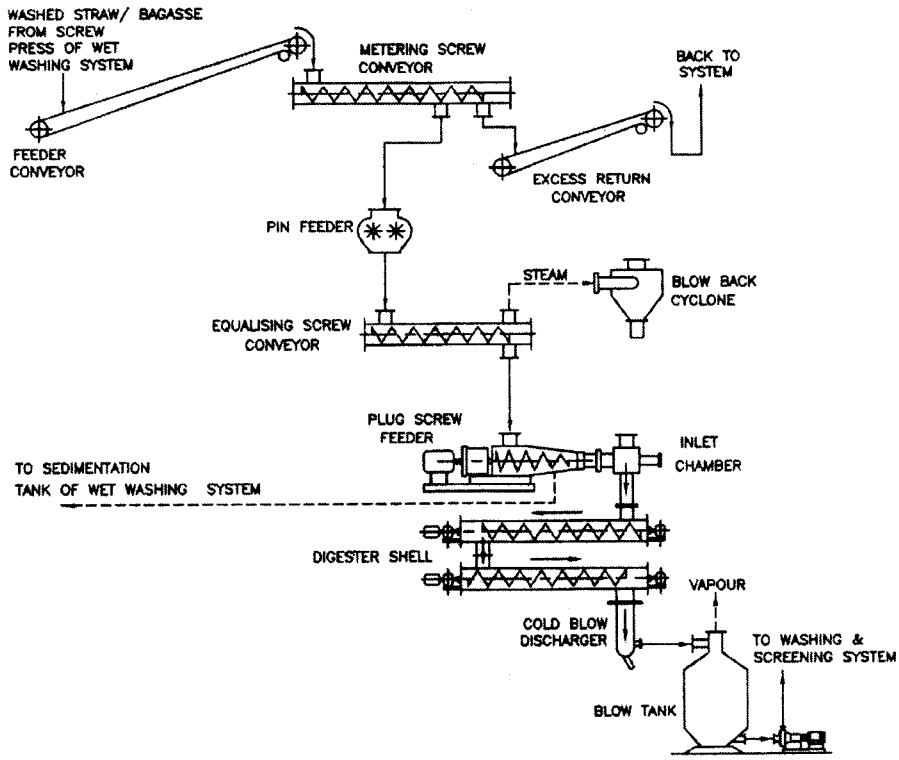

Fig. 2 : Continuous Digester System

modification have been implemented with improved results. A comparison on the various aspects in the Low Temperature incinerator (LTI) and Conventional Recovery System is enclosed (Table1). The major factors on which L TI scores over Conventional Recovery System is that, it is low a cost, simple to operate and low maintenance system with no scaling and viscosity problems. Finally, it is most suitable and affordable even for small agro based mills of 25 to 30 TPD capacities.

The basic criteria for a successful operation of L TI is to cope up with rapid rise in viscosity with concentration

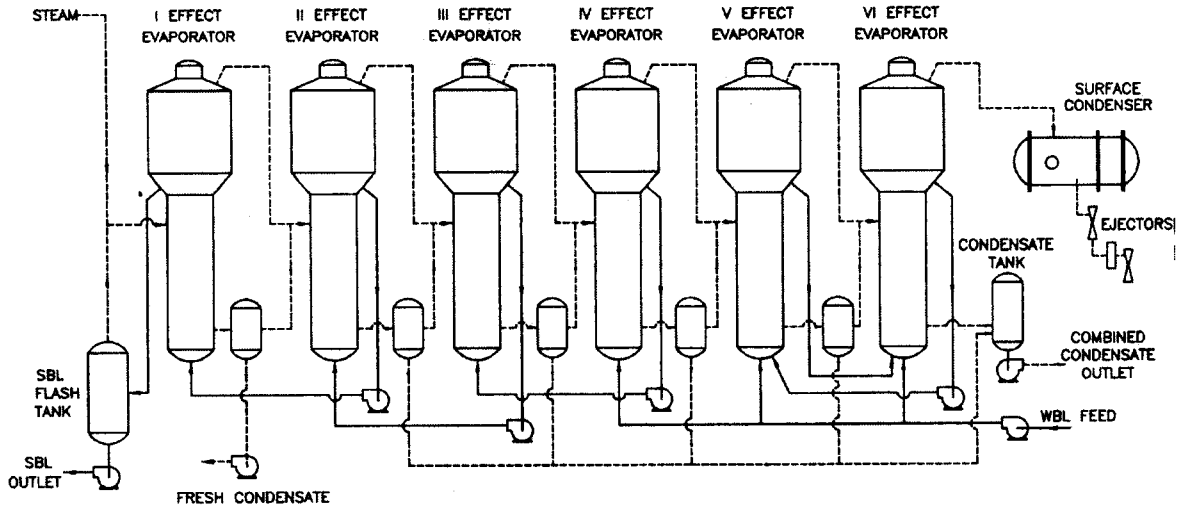

Fig. 3 : LTV Evaporator System

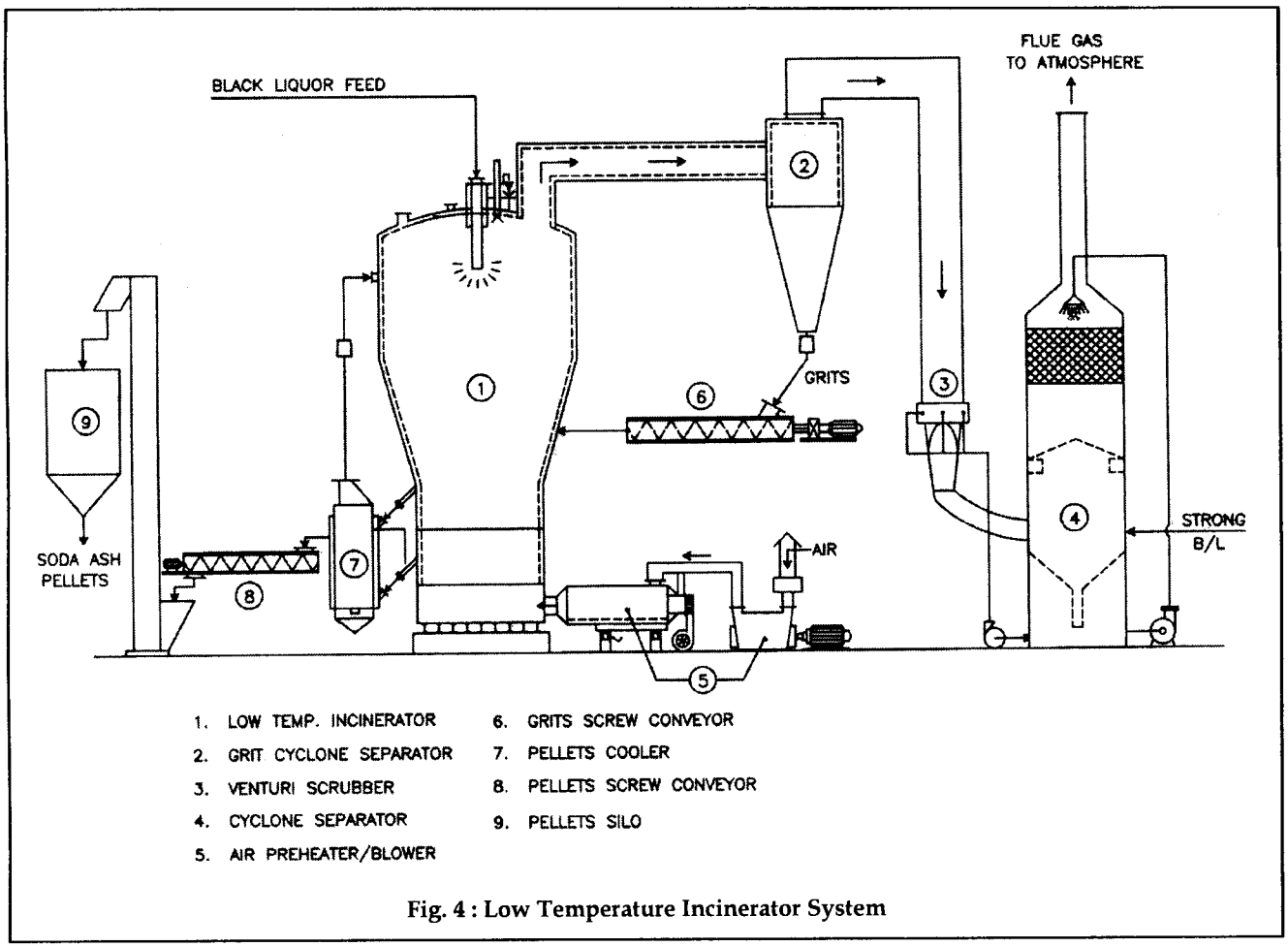

Fig. 4 : Low Temperature Incinerator System

in the evaporators and defluidisation of the bed in the furnace. The former is due to precipitation of lignin and silica at lower pH. The latter is due to chlorides present. A Table showing the silica and chlorides present in major agro residues are given (Table2).

After dry depithing of bagasse and dedusting of straw, a good Wet Washing System is recommended. This will remove the remaining dirt, pith, part of silica and chlorides. The ideal condition to bring down the chlorides especially in wheat straw is that it is soaked in fresh water around 4-5 % consistency, the temperature kept around 30 -35° C and retention time of 15 -20 minutes. The straw is then squeezed in a Screw Press. It has been observed that 75- 80% of chlorides and about 10% of silica were removed.

Accordingly, a Wet Washing System (Fig.1) which can operate for all the three raw materials was designed and developed by M/s. Agro Pulping Machinery Pvt. Ltd (APMPL) and a suitable one was installed at M/s. Shreyans Industries Ltd (SIL). This has been working satisfactorily and there is no problem of defluidisation of the bed in the furnace. The problem of rapid increase in viscosity at higher concentration due to precipitation of Lignin in Black Liquor was solved by increasing the Residual Active Alkali to 6 gpl.

Further, a Continuous Digester System (Fig.2) was also designed, developed and installed by APMPL at SIL. Apart from the usual advantages of uniformity of quality, better runnability etc., the consumption of caustic soda was lower by 1 -1.5% on raw material. This has directly resulted in lesser load on L TI. The concentration of Thick Black Liquor from evaporators was maintained below 25%. Further concentration to 45% solids was achieved without any problem in the Venturi Scrubber System (Fig.3). The soda ash in pellets of very high purity is the final product. This has ready market.

In essence, a simple Wet Washing System, and maintaining Residual Active Alkali at 6 gpl, keeping black liquor concentration from evaporators below 25%

Table 3 : Economics of 100 TPD Black Liquor Low Temperature Incinerator System

	Units	Value
I STEAM COST:		
- Black Liquor Solids to Recovery	TPD	100
- W.B.L Concentration	%	8
- W .B.L Volume	M^3	1250
- T.B.L Concentration	%	22
- T.B.L. Volume	M^3	450
- Water Evaporated	TPD	800
Steam Economy	-	4.2
Steam Required / Day	TPD	190
Steam Required for Ejectors and Heaters	TPD	30
Total Steam Required / Day	TPD	220
Total Steam Required / Tonne of Black Liquor Solids	TPD	2.20
Cost of Steam @ Rs.400/- / Tonne of steam	Rs.	880
II POWER COST:		
Power consumption / Tonne of Black Liquor Solids.	kwh	190
- Cost of Power @ Rs.4.50 per unit	Rs.	855
III FUEL .		
Diesel consumption in Ltrs / Tonne of Black Liquor Solids.	Ltrs	3.85
-Cost of Diesel @ Rs.25/-/ Ltr.	Rs.	96
-Cost of Charcoal	Rs.	10
-Total Cost of Fuel	Rs.	106
IV PACKING		
Cost of Packing /Tonne of Black Liquor Solids.	Rs.	80
T otal Variable Cost/Tonne of Black Liquor Solids	Rs.	1921
Say (A)		1920
V. FIXED COST		
- Installed cost of Evaporator and L TI System to handle 100 TPD Black Liquor Solids	Rs.Lakhs	825
- Interest at 12% on the entire capital	Rs.Lakhs	99
- Add: Maintenance Cost	Rs.Lakhs	21
- Total Fixed Cost per annum	Rs.Lakhs	120
- Annual Fixed Cost / Tonne of Black Liquor Solids (B)	Rs	364
- Total Cost of operating LTI System / Tonne of Black Liquor Solids (A + B)	Rs.	2284
VI REALISATION		
- Soda Ash Pellets / Tonne of Black Liquor Solids.	Kg	350 Kg
- Realisation from Soda Ash Pellets @ Rs. 90001- / Tonne of Black Liquor Solids.	Rs.	3150
VII CONTRIBUTION / TONNE OF BLACK LIQUOR SOLIDS (VI -IV)	Rs.	1230
- Annual Contribution on 330 days	Rs.Lakhs	406
VIII PAY BACK PERIOD		
- Net Profit / Tonne of Black Liquor Solids	Rs.	866
- Annual Profit generated	Rs.Lakhs	286
- Pay back Period	Month	35

Table 4 : Economics of 100 TPD Black Liquor Low Temperature Incinerator System

	Units	Value
- Black Liquor Solids to Recovery	TPD	100
- No.of Hours working per day	Hrs	22
- Inlet concentration of Weak Black Liquor	%	8
- Outlet concentration of Strong Black Liquor	%	60
- Water Evaporated	TPD	1083
- Steam Economy for Rising Film Evaporator	-	4.2
- Steam required for Evaporator	TPD	258
- Additional steam required for Heaters and Ejectors	TPD	22
- Total Steam requirement	TPD	280
- Steam requirement for Evaporators on 22 hour basis	TPH	12.72
- Bagasse Black Liquor solids fired on 22 hour basis	TPH	4.55
- Calorific value of Bagasse	Kcal/ Kg	3300
- Enthalpy of steam at 34 Kg / cm^2 g and 400°C	Kcal/ Kg	770
- Overall Recovery Boiler efficiency	%	65
- Steam raised in Soda Recovery Boiler	TPH	12.70
- Enthalpy of steam at 4 Kg / cm^2 g and 250° C	Kcal/ Kg	706
- Heat released from passing 12.70 Tonnes / hr through back pressure	Kcal/ Hr	8, 12,800
Turbine		
- Power generated in Turbo Generator Set @ 70% efficiency	kWh	662
- Average power requirement for CRS System	kWh	1200
- Power to be purchased	kWh	538
- Cost of purchased power @ Rs.4.50 I unit	Rs.	2421
- Cost of purchased power / Tonne of Black Liquor Solids	Rs.	532
- Add: Cost of Maintenance, Labour, Consumables etc	Rs.	133
- Total operating cost I Ton of Black Liquor Solids (A)	Rs.	665
- Installed cost of 100 TPD Conventional Chemical Recovery Boiler	Rs. Lakhs	1700
System including Evaporators		
- Installed cost of 1.2 MW Turbo Generator System	Rs.Lakhs	300
- Total installed cost of the Combined System	Rs.Lakhs	2000
- Interest at 12% on the entire capital	Rs.Lakhs	240
- Interest cost / Tonne of Black Liquor Solids (B)	Rs.	727
- Total cost of operating the System / Tonne of Black Liquor Solids	Rs.	1392
- (A + B)		
- Annual cost of operating the Sys tem for 330 days	Rs.Lakhs	460

have collectively solved the major problems. Thus in the LTI fumace, black liquor, either from bagasse or wheat straw or rice straw can be concentrated and Incinerated without any problem (Fig.4).

The advantages of the Low Temperature Incinerator (LTI) System are as follows:

1. Low capital and running cost.
2. Quick start and stoppage.
3. Very low maintenance and low shut down period.
4. A Supervisor and two Operators per shift can manage.
5. Support fuel at the start up and later NIL
6. High silica liquor can be used.
7. Simple operating and control systems.
8. No emergency if there is any power failure.
9. The final product soda ash pellets has ready market.
10. If needed, the pellets can also be causticised.

Regarding the viability of LTI System for handling of 100 TPD Black Liquor Solids per day, the details are given (Table 3). It may be seen there from that the net profit generated can repay the capital cost in about 35 months. The L TI System can be scaled down to as low as 25 TPD Black Liquor Solid and still will be viable. Also, if large paper mills want to go in for marginal expansion, LTI System will suit them eminently.

It will be useful to compare the economics of a Low Temperature Incinerator System and Conventional Recovery System (CRS). The comparison can be confined upto Smelt / Soda Ash Pellets discharge stage. This is because the installation of Causticiser and its economics is common for both. Further, it is presumed that a 100 TPD Black Liquor Solids burning System is installed by a paper mill for the first time. Therefore the Conventional Recovery System will consists of an Evaporator, Recovery Boiler and a new Turbo Generator Set. Steam will be raised at 34 Kg/cm^2 and 400 °C and the back pressure will be at 4 Kg/cm^2 and 200 °C required for evaporator. From Table 4 it is seen that the steam raised in the boiler is just enough for the evaportor. Also the power raised is hardly half a Mega Watt against the total requirement of about one Mega Watt. Hence power has to be purchased.

It may be seen from Table 4, that the capital cost will be about Rs.20 crores against Rs.8.25 crores for LTI System. The annual operating cost / Tonne of Black Liquor solids for the CRS works out to Rs.1392/-only. Against this the cost in LTI it will be Rs.2284/-. However, the soda ash pellets from LTI is readily saleable and the realisation per tonne of Black Liquor solids is Rs.3150/-. Hence the LTI System generates a net profit even after considering total purchased power. Therefore, it would be prudent, for all agricultural raw material based paper mills even with a daily black liquor solids generation capacity of 100 Tonnes to go in for an L TI System. This is evidenced by the two mills in Punjab operating successfully for the last seven years.

CONCLUSION

Agro based paper mills will benefit immensely if they adopt Low Temperature Incinerator System, since it requires low investment, is easy to operate and control with minimum labour and maintenance. The final product, soda ash of high purity, can be easily sold. It would be prudent to avoid causticising, because of the burden of disposal of high silica infected lime sludge.

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