An Experience in Running A Fluid Bed Recovery System For Agricultural Residues Black Liquor At M/s. Shreyans Industries Limited, Sangrur

* Sharma S.K., Sharma N.K., Bhargava K.S.
** Das Gupta S., Viswanath G.K., Parthasarathy S. and Senthil K.

The installation of a technically and economically efficient Chemical Recovery System has become a matter of survival for the small and medium mills based on agro raw materials and non-wood fibers. Considerable work has been done on pulping of these materials and their pulping and quality is well established.

Approximate volume of water evaporated from various black liquors to attain different concentrations.

Type of Initial Black Liquor	Concentration of Weak black liquor	Evaporated Water tonnes per tonne of unbleached pulp 45%	50%	65%	20%
Wood	14 - 17%	6.3-5.6	6.57-5.93	6.64-6.17	
Agro Residues	7 - 10%	13.9-10.0	14.2-10.36	14.8-10.95	9.14-6.00

The Kraft Chemical Recovery System is well established in the large scale sector of the Indian Paper Industry. The scaling down of these recovery equipment is both a technical and commercial problem- a problem of economy of scale. The agro based liquors with their typical nature present the following problems which make them difficult to be handled in a conventional system.

- The high viscosity which results in low heat transfer at evaporators.
- Low concentration of black liquor (7-10%) compared to wood/bamboo liquor (14-17%). The evaporation steam requirements are higher for the same end product concentration.
- Higher silica causing fouling and scaling at evaporators.
- Low combustibility.

The factors listed above have been highly discouraging to adopt the conventional kraft recovery technology to the agro pulping sector. Moreover the increasingly stringent pollution control laws and the realisation that environmental concerns are social obligations which must be honoured in order to survive have provided a challenge to the Paper Industry.

As a result, a number of alternatives and studies were considered for mills having pulping capacities ranging from 40-100 TPD based on agro raw materials like bagasse, cereal straw and sarkanda an annual grass. These mills had been handicapped

** Agro Pulping Machinery Private Limited,
23, Anu Apartment, IV Floor,
39-B, Chevaliar Sivaji Ganesan Road,
Chennai-600 017
* Shreyans Industries Limited,
(Unit: Shreyans Papers)
Post- Ahmedgarh-148021
Dist- Sangrur (Punjab)

due to the absence of a simple, safe and low cost technology.

In the year 1992, APMPL established a contact with **M/s. Enders Process Equipment Corporation, Illinois, USA,** having activities in the field of Fluidisation Bed Technologies. APMPL, in the meanwhile, made an elaborate study/appraisal of the **Fluidisation Bed Technology Process** and found its application to be a suitable solution for the problems of small sized mills, mainly on the following merits:

- A successful proven technology with operating experience of more than three decades.
- A low temperature system suitable for Agro-Residues Processing.
- No smelt formation, therefore a safe technology for small mills.
- Flexibility in usage of raw materials and pulping process particularly alkaline, sulphite, neutral sulphite and bisulphite processes.
- Most manpower effective-only two persons can operate the reactor.
- Products sodium carbonate in solid pellet form which can also be marketed directly.
- Suitable for marginal expansion of a big unit.

APMPL subsequently entered into an arrangement with EPEC, USA, for collaboration in the year 1993. **M/s. Shreyans Industries Limited, Punjab,** on the other hand, equally keen on the Fluidisation Bed Technology, came forward to promote it in order to establish a total system to handle the Black Liquor, effectively and economically. This plant has been commissioned in May'96 and is functioning successfully.

Senior technical personnel from APMPL and Shreyans visited South Africa, United States and Mexico to study Fluidised Bed Reactor producing Sodium Carbonate pellets from bagasse black liquor. They found that bagasse black liquor is concentrated in M.E. Evaporator upto 25% and further concentration is achieved in Venturi scrubber with the Reactor flue gases.

The spraying of black liquor @ 40-42% solids into the FBR and consequent conversion to sodium carbonate pellets was discussed with the technical personnel available there and had a first hand information on the process parameters.

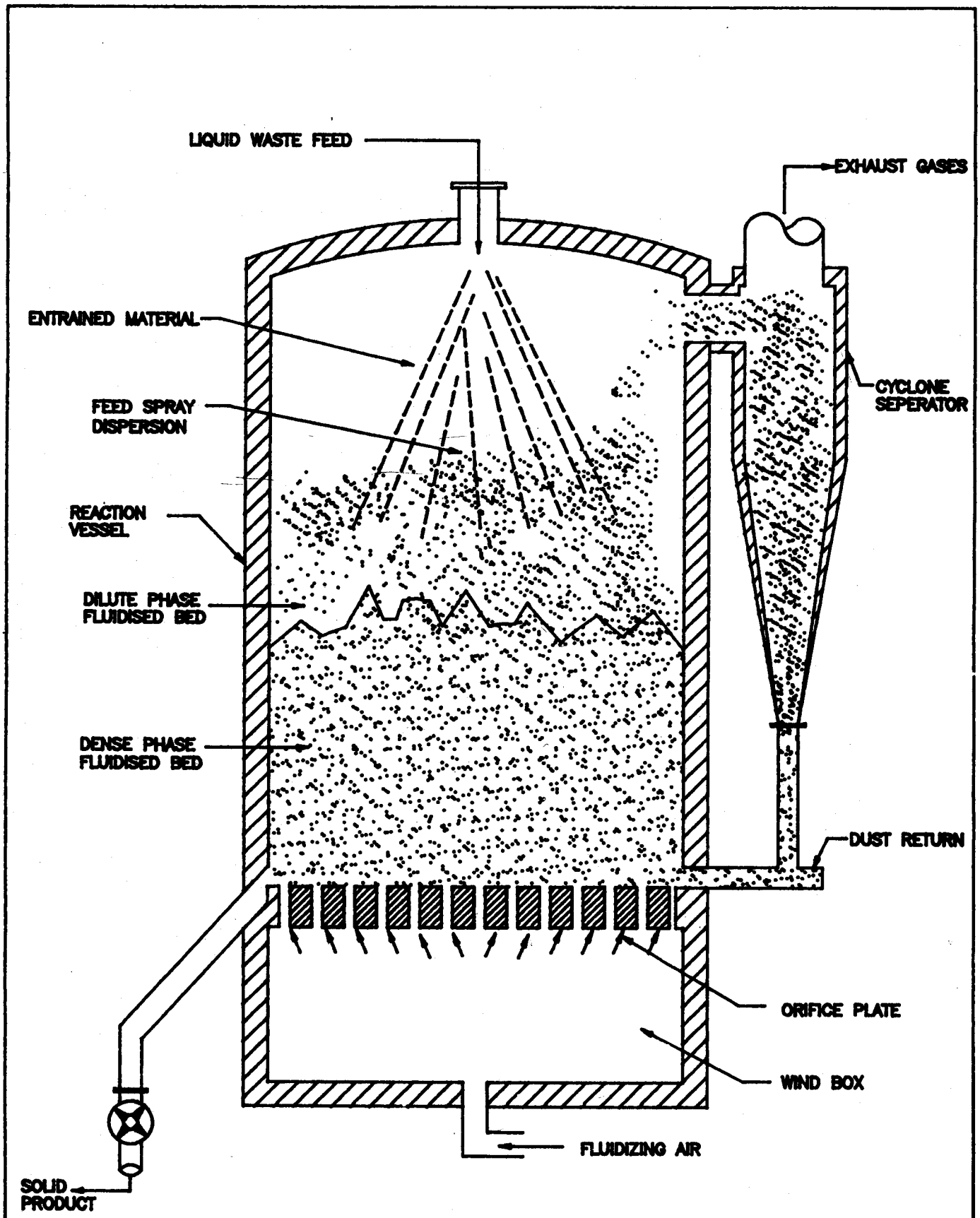
Collective efforts under excellent good leadership of SHREYANS & APMPL is the secret of success of this project. Now the Fluidised Bed Reactor is being run for over 12 months period without any major problem and heavy black liquor is being converted successfully into Sodium Carbonate pellets without use of any auxiliary fuels except during the startup of the plant.

FLUIDISED BED SYSTEM-FEATURES

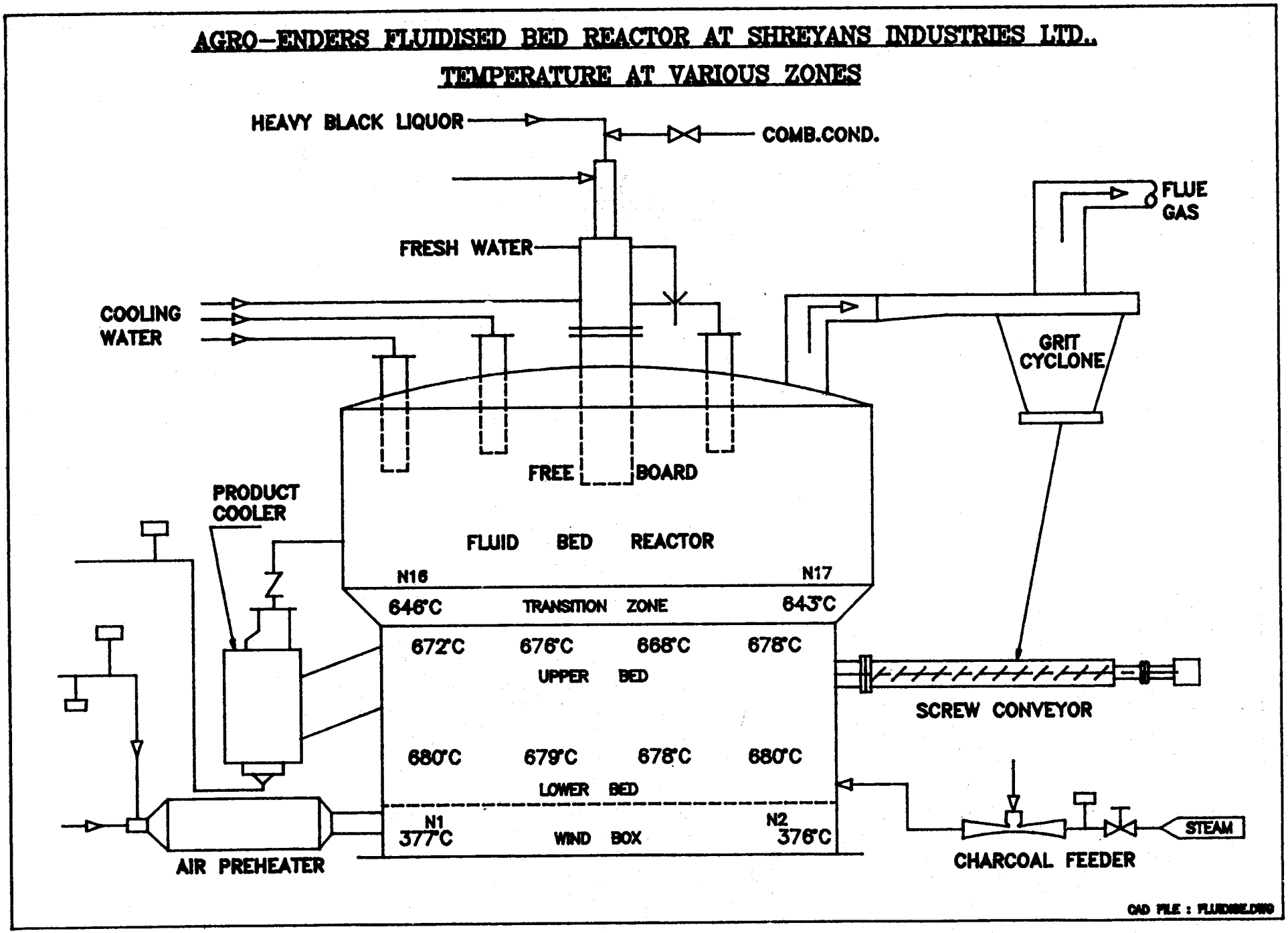
During the period that the fluidised bed technology has been developed, it established its potential for industrial use. The high thermal efficiency of fluid bed incinerator provides total combustion of organic matter in waste flows with low heating values, or those that are too dilute to burn in conventional furnaces.

Basically the fluid bed efficiency is related to the following features:

1. Enormous surface area on which combustion can take place.
2. Intimate contact between combustible material and combustion air.
3. A large reservoir in fluid bed of uniformly heated bed material which provides a heat sink to stabilise the reaction rate.
4. A disengaging zone above the fluid bed (called the freeboard) which permits the solid particles to separate out of the flue gas before leaving the furnace and simultaneously provides opportunity for heat exchange/evaporation of water between incoming feed and combustion zone.



FLUIDISED BED PROCCESSING


AGRO-ENDERS FLUIDISED BED REACTOR AT SHREYANS INDUSTRIES LTD.,
TEMPERATURE AT VARIOUS ZONES
HEAVY BLACK LIQUOR
COMB.COND.
FRESH WATER
FLUE GAS
COOLING WATER
GRIT CYCLONE
FREE BOARD
PRODUCT COOLER
FLUID BED REACTOR
N16
N17
646°C
TRANSITION ZONE
643°C
672°C
676°C
668°C
678°C
UPPER BED
SCREW CONVEYOR
680°C
679°C
678°C
680°C
LOWER BED
N1
377°C
WIND BOX
N2
376°C
STEAM
AIR PREHEATER
CHARCOAL FEEDER
CAD FILE : FLUIDISE.DWG

The fluid bed reactor consists of the main sections as shown in **Figure-1**, a wind box where air is admitted to the reactor separated by a distribution plate from the fluid bed zone and a free board or disengagement zone in the upper section.

Air at 8.5 psig is admitted into the wind box and passes through the distribution plate called orifice, which is designed to give complete dissemination of air over the entire cross sectional area of the plate into the fluid bed zone. All combustion takes place at the fluid bed zone which consists of sand or residual inorganics recovered after combustion.

The dispersed air passes through the fluid bed particles and causes them to take on a heterogeneous motion and sets up a continuous violent mixing up action on pellets, air and combustibles. The bed increases in volume by about 30% and the particles take on a fluid motion. In this state, the bed particles obey the hydraulic laws and the bed is like a body of boiling fluid. Combustion under these conditions take place as a surface phenomenon and no visible flame is seen. The whole mass of fluid glows at temp. of 670°C to 710°C depending on the application.

The flue gas is scrubbed before letting out to the atmosphere. The typical scrubbing equipment includes wet walled Venturi scrubbers spray type scrubbers, turbulent contact scrubbers. The flue gases after scrubbing will conform to the standards of emission under the air pollution code.

Out of the many successful applications of this technology, paper industry finds a number of applications and the use for Recovery of Soda Spent Liquor is important. There are atleast thirty such installations which are operating in different parts of the world.

M/s. Shreyans industries, Punjab came forward to adopt this technology and M/s. Agro Pulping Machinery with collaboration with M/s. Enders have supplied the entire recovery plant.

The plant capacity was calculated to handle a total solid capacity of 80 TPD. But the plant has a built in capacity. This unit can safely handle upto 100 TPD total black liquor solids.

USAID and ICICI came forward to finance this project as a pilot commercial venture and trend setter for Indian Agro based paper mills. The first 12 months of operation has given us a fund of information which will be used for improving the performance of future designs.

A. PROCESS PROBLEMS-RECTIFICATION-PRESENCE OF CHLORIDES

The Fluidisation of sodium carbonate pellets in FBR is very sensitive to chlorides and potassium content in black liquor. With their increase in black liquor, the eutectic melting point of sodium carbonate pellets goes down, Generally the mills operating in the agro sector operate on multiple raw materials like Bagasse, Cereal Straws and annual grasses like Sarkanda which have differing chloride contents. Maximum chloride was found in wheat straw.

Even at the rate of 630-690°C temperature of the free board, sodium carbonate pellets start getting agglomerated, if **Chloride content in black liquor is more than 0.6% as NaCl,** and finally resulting in defluidisation of the sodium carbonate pellets in the reactor. It was observed that chloride content as NaCl in black liquor should not exceed 0.5% to avoid agglomeration. To ensure this sodium hydroxide of Rayon grade having very low chloride content is being used. It was observed that if wheat straw, rice straw and sarkanda are used as such, the chloride contents in black liquor goes as high as 1.6% as NaCl.

A series of experiments conducted by the R&D department of SHREYANS show that the chloride content in agricultural residue can easily be brought down to the desired level by washing agricultural residues with fresh warm water. This fact has been confirmed by reports from Nalco pulping also. Now plant and equipments have been installed to carry out wet washing of agricultural residues especially for wheat straw to bring down chloride contents in raw materials to the desired level. If the chlorides content in agricultural residues is brought down below 0.4% then these cellulosic raw materials can be used without any trouble in recovering sodium

carbonate pellets from black liquor in Fluidised Bed Reactor. After washing of raw material is practiced by SIL they have run the mixed black liquor with 25% wheat straw and 75% bagasse. Further improvement in washing is aimed to eliminate/reduce chloride further.

In case causticising is to be carried out, chloride could be removed by crystalisation technology which is available and can be adopted in the green liquor stage. However washing the raw material by appropriate equipment provides an easy method of chloride removal.

B. RESIDUAL ACTIVE ALKALI IN BLACK LIQUOR

Residual active alkali in black liquor play a very important role to avoid lignin precipitation. On a few occasions, it was found difficult to handle heavy concentrated black liquor especially in pumping heavy concentrated black liquor to reactor feed gun from the storage tank and to have good recirculation of black liquor in venturi scrubber. On analysis it was found that residual active alkali was below 6 gram per litre though total titratable alkali was found to be normal. To maintain required fluidity and avoiding lignin precipitation in black liquor proper dosing system to maintain Residual Active Alkali at 8 gpl by direct dosing of caustic in black liquor has been installed.

C. COMPOSITION OF BLACK LIQUOR

It was found that if black liquor is circulated for very long time in venturi scrubber or percentage of fines are high in flue gases after Grit Cyclone, percentage inorganic in HBL goes beyond 45% then auto combustion of black liquor gets affected and auxiliary fuel Charcoal may be required to maintain the bed's temperature. Therefore, during the startup of bed introduction, water is circulated to take care of fines, which are not completely removed in Grit Cyclone and water rich in sodium carbonate is used for pellet dissolving for dilution of caustic lye. Semi concentrated black liquor solid content is kept above 20%-22% so that it is not recirculated in venturi system for long time which increased the inorganics as well as the concentration is maintained at desired level.

D. PARTICLE SIZE DISTRIBUTION IN THE BED

Particle size distribution of sodium carbonate pellets in the bed of Reactor is most important to maintain the bed in fluidised state.

For favourable fluidisation of bed, the following size distribution of sodium carbonate pellets are to be maintained.

Mesh size	Percentage retention
10	2
20	10 to 35
30	15 to 35
40	15 to 30
50	8 to 20
below 50 mesh	2 to 10

None of same size fraction of Sodium carbonate pellets in the bed is allowed to go beyond 35% and fines are being maintained between 2 to 10% in the bed. Particle size plays very important role in the autogenous burning and pellatisation. Care is taken by maintaining proper ratio of fines by introduction of fines from attrition mills.

OPERATIONAL EXPERIENCE-MODIFICATIONS ADOPTED

Certain modifications were carried out in the equipments to cater the local conditions & technology was adopted based on laboratory trials.

a. GRIT CYCLONE DISCHARGE FEED

Cast Iron steam eductors were replaced with a Screw Conveyor to feed the Grit discharged from cyclone continuously.

b. CHARCOAL INJECTION SYSTEM

Charcoal injection is a very important step in the start up of the F.B.R. This operation is started after the temperature of the lower bed is brought

to 480°C by firing diesel, and continued to bring the temperature to 680°C slowly. At this stage firing of black liquor is started and when this starts burning autogenously, other fuels are cut off. To maintain this standard temperature condition the particle size of charcoal has been standardised and the position of injection of charcoal is lowered. pneumatic valves with remote controls have been provided to control the injection of charcoal and fines.

After these changes shreyans industries have been able to have a trouble free and uninterru -pted run.

c. METERING SCREW

The positioning of the Metering Screw was modified as there was frequent bearing failure and after repositioning the bearing failure is eliminated and the plant is running absolutely free without any break down.

d. METERING ROTARY FEEDER

The Metering Rotary Feeder had jamming trouble due to the positioning of the discharge point. This was corrected and also the variable speed was changed to single speed and it is running with out any problem. In doing so, the product cooler was maintained at 40% level. This retention time is available to reduce the temperature of the pellets and it improves the life and condition of metering screw and other equipments.

e. COOLING SPRAY SYSTEM

Cooling spray system has been modified by adding a booster pump. This has helped in controlling the free board temperature within desired limits. The Cooling spray gun is periodically checked for its clean condition to allow the spray of water whenever there is rise in temperature.

f. BED HEIGHT

The important matter in the operation is the discharge point of pellets and the bed height. This will vary according to the raw material requirement and heat inside the furnace. SIL had fixed the bed height at 152 cm which was later increased 188 cm to improve the pellatisation of the black liquor considerably. SIL has started running the FBR in April'96 and stabilised by july'96, and the unit is running successfully for the past 12 months.

g. REDUCING CHLORIDE CONTENT

SIL has planned to introduce a Screw Press in the raw material washing street to further reduce the chloride content, so that higher quantity of straw black liquor could also be processed. This will be operational very shortly.

SIL is selling sodium carbonate pellets to end users and are not causticising it at present in order to avoid handling of lime sludge which is a solid waste.

CONCLUSION

SIL & APMPL with the assistance of USAID and ICICI have successfully completed this project and have dedicated it to the Indian paper industry. The Management and staff of both SIL & APMPL have made this project a grand success due to their unstinted effort and total dedication. Grateful thanks are due to Mr. Joseph T. Enders for giving his total involvement and valuable time for this endeavor. We are also equally grateful to Mr. Anil Kumar, Executive Director of SIL for his bold decisions and guidance.

The experience at Shreyans has established that this low temperature combustion technology is suitable for agro mills of 40-100 TPD in India. There has been no problem in handling black liquor from bagasse, and mixed straw liquor at SIL.

While installations with higher capacities can go in for elaborate causticising operations, smaller installations could manage to sell carbonate. The cost of capital equipment for causticising equipment, subsequent loss of alkali, handling of lime sludge which is a toxic solid waste could be avoided.

Since, the expansion of paper industry on forest based resources are remote unless captive plantations are created and managed, we can conclude that the future belongs to the non-wood sector.

In such a mill we have to consider a fibre cleaning and washing plant, a continuous digester a belt washer which could give a higher black liquor concentration and operate on a low dilution factor, and an FBR system. Under such an integrated mill both chemical and energy balances could be worked out in such a way that optimisation is achieved.

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