Chemical Recovery System for Bagasse Pulp Mills

P. K. Elanchezhian

It is the intention of the author to mainly brief on the special aspects of a chemical recovery boiler for handling bagasse liquor. There are different designs of recovery boilers but the boiler with suspension drying and cascade evaporator alone has been dealt with in detail in this paper. Though the effect of silica has been fully explained, it should be borne in mind that the percentage of silica in bagasse liquor is fairly low compared to that in bamboo, straw, etc. It should be clearly understood, that a successful chemical recovery system calls for proper control of the pulping variables in addition to the boiler and other equipments. With proper control of the various operations, the chemical recovery efficiency, even upto 90%, could be achieved.

This paper attempts to highlight the difficulties that may be encountered in the processing of bagasse black liquor and the design approach for such liquor recovery systems in general and with a special reference to the chemical recovery boilers.

The increasing sizes of bagasse pulp mills would necessitate a proper chemical recovery system. In countries like Argentina and Portugal, bagasse pulp mills of capacities 100 to 300 Tons/day have become common. In India, at present, similar capacity bagasse pulp mills are not existing, their installation in future cannot be ruled out.

This paper confines to the black liquor recovery system for soda or kraft process. The basic liquor recovery cycle for bagasse is the conventional one, as practised for wood liquor. However, the overall equipment design and operating techniques compared to a wood based pulp mill differ considerably. A few additional equipment will be required for handling this liquor because of its special characteristics.

A typical analysis of the bagasse black liquor solids is as follows :

		%
Carbon	:	41.0
Oxygen	:	35.0
Sodium	:	16.0
Hydrogen	:	4.0
Sulphur	:	0.4
Silica	:	1.2
Nitrogen	:	0.2
Other inerts	:	2.2

P. K. Elanchezhian
Product Engineer/Boiler Performance & Proposals
Bharat Heavy Electricals Ltd.
Tiruchirapalli—620014, India.

The higher heating value of this liquor is fairly low, approximately 3300 Kcal/kg, compared to wood liquor having a range of 3500 to 4000 Kcal/kg. An important characteristic to be considered in the design of this liquor handling system is its very high viscosity. The viscosity values vary widely for different species. A typical viscosity characteristic curve for heavy black liquor of concentration 60-63% solids is shown in Fig. 1. Another significant point to be noticed from the elemental analysis is its good amount of silica. Though it is not in the range of 3-4% like in the case of bamboo, which is a serious aspect even this silica content in the bagasse black liquor is itself an important factor that calls for special attention in the design of various equipment.

The major problems associated with the processing of bagasse liquor are as follows :

1. Difficulty in the brown stock-washers
2. Scaling in the Multiple Effect Evaporators
3. Scaling in the boiler
4. Special handling & burning system
5. Increased causticizing time
6. Reduced lime mud recovery

The difficulty in the brown stock washers could be attributed to

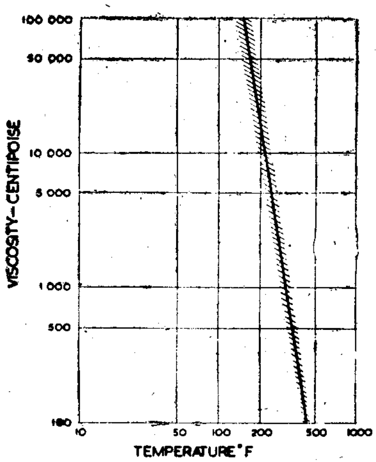

FIGURE 1

the slow drainage characteristics of this pulp and the high viscosity of the black liquor. Because of this, large quantity of water would be required and this in turn would result in higher sodium losses, reduced recovery efficiency and decreased solids concentration of the weak black liquor. The normal solids, concentration obtained is in the range of 8-10%. This problem could be solved by providing more surface area in the washers to obtain low specific loading.

The problems to be faced in the multiple effect evaporators (M.E.E.) are due to the presence of silica and high viscosity of bagasse liquor. The presence of silica causes scale formation on the tubes of the muitiple effect evaporator, consequently, reducing the heat transfer and necessitating frequent shut downs. The short-fiber content of bagasse black liquor also causes fouling in the multiple effect evaporators. The analysis of the scales from the different effects of M.E.E. shows the presence of organic matter, calcium carbonate and silica in the initial, intermediate and final effects respectively. Because of this silica scale forming tendency in the final effects and of the high viscosity of black liquor making the transfer of liquor from one effect to the other increasingly difficult with the increasing concentration, in many of the bagasse pulp mills, it has been found convenient to limit the solids concentration to a range of 35-40%.

The problem of scaling in different effects could be safely dealt with by various cleaning methods as described below :

In the initial effects, the organic matter containing short fibers and fines could be removed by water boiling and draining the effects.

In the intermediate effects, the calcium carbonate scales could be removed by circulation of an inhibited solution of hydrochloric acid at 4% concentration.

The sodium silicate scales are extremely difficult to be removed. This could be solved to some extent by boiling a solution of sodium acid sulphite at 20% concentration for two hours followed by mechanical cleaning. Caustic soda boiling for 4-6 hours in a week, also permits the MEE unit to operate for a longer time without shutdown.

It is obvious from the above that shut down for periodic cleaning is a must. However, the frequency of shutdowns could differ from mill to mill depending on the facilities, say once in 6·8 weeks.

Regarding minimising the scaling, there are a few practices followed by different paper mills. Mills, having extensive storage facilities for black liquor and white liquor, may not face plant shutdowns for cleaning purposes, as a serious problem. Such mills have lime recovery also. There are a number of silica removal systems, as listed below, which are installed to reduce the silica content. The economics of installing such processes are purely an analysis of return on the investment and has to be decided individually for each mill.

1. **Lime Additive Method**

Silica could be removed from the black liquor by the addition of quicklime. The black liquor is heated to around 90C° and quick lime is added. The result is twofold.

(i) Silica precipitation as calcium silicate

(ii) Caustlcization of sodium carbonate

2. **PH Control Method**

The removal of silica from black liquor by lowering of pH with CO_2 is quite effective. The cheapest source of CO_2 is no doubt the flue gas, but It is not recommended unless the flue gas is made free of all dusts and moisture by some means. When CO_2 gas is bubbled through the black liquor, the residual alkali gradually neutralises with carbonic acid and lowers the pH value to a point where the liquor tends to precipitate. Accurate control of black liquor pH value, to precipitate silica without lignin precipitation is very difficult and hence this process has limited prospects, especially for selective precipitation.

The problems pertaining to the high viscosity of bagasse liquor could be easily solved by maintaining optimum quantity of free alkali in the weak black liquor and incidentally minimise the sealing to some extent. Caustic soda shall be added to the weak black liquor collected from the brown stock washers to maintain 6-8 grs/litre of NaOH. This helps to achieve higher concentration not only in the multiple effect evaporators but also in the direct contact evaporator, that is installed next in the line. Adoption of this method for concentrating bagasse liquor upto 65% solids, has not been posing any problem. The higher the free alkali level in the weak black liquor the higher is the final solids concentration of the black liquor possible. However, exceeding certain limits is very much undesirable because, the critical ratio of organic to inorganic content in the black liquor dry solids would be upset resulting in unsatisfactory combustion conditions in the furnace. Coming to the chemical recovery boilers, these units for handling bagasse liquor do not take a radical change in the configuration from that required for wood based liquor. However, the design of these boilers has to be done with due considerations accounting for the presence of silica and the high viscosity.

The presence of silica causes hard, glass-like encrustations in the recovery boiler furnace. These are sodium silicate deposits having a high smelting temperature and it is very difficult to remove them. Further sodium carbonate deposits would be formed on other surfaces like furnace screen, superheater, that are in the downstream gas path. These deposits reduce heat absorption in the furnace and screen resulting in higher gas temperatures entering the superheaters, which would ultimately give rise to higher superheat steam temperatures with over heating of superheater material, lower steam generation and reduced thermal efficiency. Deposits may be formed in the primary air nozzle region also and tend to block the primary air admission.

The deposits on the furnace walls have been found to be the minimum in the case of suspension firing where the liquor is sprayed over the hearth without touching the walls. This also solves the problem of superheat steam temperature shooting up.

All the problems due to these deposits formation could be minimised by a carefully selected furnace configuration, proper liquor burning system and routine manual cleaning of primary air ports at regular periods. Because of the scaling tendency and high viscosity, wide fluctuations in the combustion characteristics of the liqnor could be expected. In order to have proper smelting in the recovery unit the "plan area heat loading" is an important consideration. Since the heating value of black liquor is fairly low the furnace width and depth have to be carefully chosen to maintain the desired temperature at the hearth bed. In cases, were the heating value is very low, it would be very much advantageous to fix these dimensions taking into account a little quantity of auxiliary fuel. Many may be reluctant, at first, to conceive a design of boiler with auxiliary fuel burning even at 100% MCR. But it is needless to impress that such a design would ensure safe combustion conditions in the furnace, operation of the unit without auxiliary fuel stabilisation, when the heating value improves and also that it would have a better over loading feasibility.

The selection of the other furnace dimension, i.e. the furnace height, is by itself another important aspect. This should be carefully chosen considering the requirements of reducing zone (only for kraft process) and drying and oxidation zones as illustrated in Fig. 2. The high viscosity of black liquor will tend to form bigger globules which would call for more height in the drying zone in the case of suspension firing. The

Bagasse Black Liquor Buring System

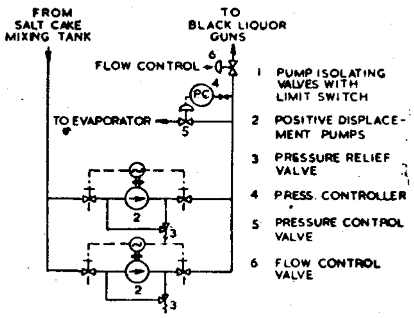

Figure-2

use of more number of black liquor guns to make better utilisation of the drying zone is highly recommended. It is also preferable to have the boiler designed for a lower gas temperature entering the superheater. This would minimise the problems caused by sodium carbonate scales. Therefore the final heights of the units are to be decided based on all these factors. This approach may also result in a judicious dimensioning and choice of unit, where an economiser may not find its place, especially for units of low capacity. The absence of economiser will not affect the performance or operation. In case there is a slight excess heat availability, calling for additional surfaces, even it would be advantageous to adopt or choose taller furnace and bigger screens, that would contribute to the lowering of fouling of heat transfer surfaces, especially the superheaters.

As far as the black liquor handling systems are concerned, they have to be carefully sized with due consideration for the high viscous nature of the liquor. Normally the black liquor handling system associated with the recovery boiler will have the direct contact evaporators in the beginning. The types of direct contact evaporators in vogue are the cascade evaporator and the cyclone evaporator. However, the cascade evaporator is preferred because of its simplicity in the design and operation.

The direct contact evaporators in case of bagasse liquor are supposed to concentrate the liquor in a wider range compared to the conventional cases. This is because of the limited concentration of 35 to 40% achieved in the multiple effect evaporators. The boiler, design would be most economical, when the liquor concentration envisaged for firing is the highest possible. As mentioned earlier by using cascade evaporator liquor firing concentration could be made up to 65% solids. In cases where the concentration entering the cascade evaporators is around 35% solids, the normal gas temperature required at the inlet would be very high. Since higher gas temperatures lead to fire hazards and also plugging, it is better to restrict the inlet gas temperatures to be below 450°C. Recirculation of gases from the outlet of dust collectors to a point well before the inlet to the cascade evaporator would solve this.

If cascade evaporator is used the connected driving equipment are to be carefully selected. The viscosity of black liquor in the cascade evaporator under normal operating conditions is around 15000 to 20000 centipoises. This would mean an increased power consumption of 50 to 60%, compared to the normal wood liquor operation.

It would be safer to provide an outboard bearing in the gear reducer, in such units. In order to be safe in providing for actual excessive power requirements of the wheel, heaters have to be installed at size these heaters corresponding to a liquor temperature rise of 5 to 10°C.

Likewise, all the agitators, and a few such components, coming in the various auxiliary equipment would also require approximately 50 to 60% more power. Also, all the screens coming in the black liquor systems should be adequately sized, to meet the flow characteristics. The design of black liquor piping needs some modifications. The pressure losses in the black liquor piping system could be split into two, the frictional loss in the piping and the loss across the liquor spray nozzle. The formula applicable for piping frictional loss is as follows:

$$H = \frac{f\,l\,u\,v}{f\,d^2}$$

Where f = Co-efficient
l = Effective length of pipe
u = Absolute viscosity
v = flow velocity
p = density of fluid
d = internal diameter

It is obvious from the above formula that the pressure drop is directly proportional to the viscosity. Since the viscosity of bagasse liquor is almost 16 times that of normal wood liquor, the pressure drop also would shoot up to that extent unless the piping is different. Also it could be seen from the above formula that increasing the diameter of pipe reduces the pressure drop. From the above, it can be concluded that doubling the pipe size would result in almost the same of pressure drop as that for the normal liquor However, this results in a very low velocity of flow which might cause solids settlement. In such cases, care should be taken in the layout of black liquor. piping to see that horizonatal run of piping is avoided to the maximum extent. Also steam tracing of black liquor piping is avoided to the maximum extent. Also steam tracing of black liquor piping is a worthwhile proposition to compensate for the heat loss of piping especially because of the increased size.

The pressure drop across the black liquor nozzle in the case of suspension drying system can be split into two components, such as co-axial pressure drop and tangential pressure drop. The co-axial component dictates the discharge capacity of the black liquor burners. The tangential component is meant to give the liquor a swirl, so that, the liquor could disperse into globules as is escapes from the burner. The resultant pressure drop in the black liquor system is more and hence will call for a design of burners, with 30% more pressure drop in the case of bagasse liquor.

The high viscosity of bagasse black liquor straight away calls for positive of displacement pumps. The pump could either be a gear or screw type. One incidental advantage in using these pumps is the lower power requirement because of their higher efficiency with viscous fluids compared to the normal centrifugal pump. All these pumps have to be provided with integral pressure relief valves to protect the pump in case of accidental starting with both the isolating valves closed. Providing limit switches for both the isolating valves closed. Providing with the black liquor pump motor starting is another recommendation. Because of the nature of these pumps the flow control could be achieved only by bypassing excess quantity from the pump discharge.

The equipment that complete the recovery cycle are the smelt dissolvers and causticizers. The performance of the smelt dissolver does not change significantly in the case of bagasse liquor. The high silica contained in the bagasse black liquor finds its way into the green liquor in the form of sodium silicate.

The sodium silicate during causticizing reacts with the lime

Recovery unit furnace zones

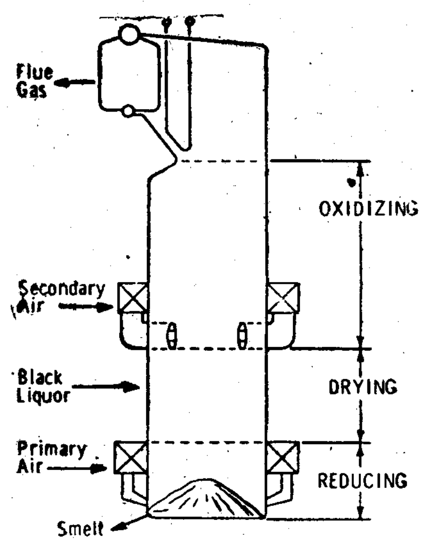

Fig. 4.

to form calcium silicate. The reaction is as follows.

$Na_2SiO_3 + Ca(OH)_2 \rightarrow CaSiO_3 + 2NaOH$

This results in a low mud recovery efficiency and consequently increases the make up lime stone requirement. The effectiveness of this reaction is only 95% in the sense unconverted sodium silicate to the extent of 5% would be present in the strong white liquor sent for digestion. However, the recausticizing equipment can be of a standard design in case of bagasse pulping.

To avoid problems in MEE interrupting the plant performance, it would be worthwhile to provide one spare effect also.

The operating experiences with different bagasse pulp mills are widely varying. The chemical recovery efficiency varies from 75 to 90%. The shut down frequency also ranges from 6 to 8 weeks.

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Bibliography

1. Bagasse Black Liquor Recovery—J. Salaber & F. Maza.
2. Installation and Operation of Chemical Recovery System in Soda Pulp Mills utilising wheat-straw and bagasse as raw material.—D.K. Misra
3. Silica as a source of trouble in operation of chemical recovery units in Indian Pulp Mills.—Dr.A. Panda.