Experiences with bagasse black liquor in chemical recovery operations

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ABSTRACT

High Silica, high viscosity, high scaling and poor burning are the typical characteristics of bagasse black liquor in the chemical recovery operations. Many mills are reported to be operating with limited or no chemical recovery because of the above characteristics. Envisaging the unique nature of the bagasse black liquor, TNPL has tried to overcome these problems in the project planning, design, equipment manufacture and implementation. This paper explains the measures taken in the project stage and subsequent experiences in the chemical recovery operations.

Introduction

TNPL is an integrated pulp and paper mill in operation since 1985 with an installed capacity of 90,000 tonnes per annum producing Newsprint and Printing and Writing paper. The principle raw material to produce pulp is sugarcane bagasse from the nearby sugar mills in conjunction with a low proportion of mixed hardwoods. Both the raw materials are pulped by the Sulphate process.

Planning of the chemical recovery section :

During the basic planning of the chemical recovery section, the following points were considered.

— Poor drainage characteristics of bagasse pulp which tends to carry more chemicals, require more wash water, consequently resulting in dilute weak liquor (6 to 8%) compared to that from other raw materials.

— Weak black liquor from bagasse washing carry more fibre (200 ppm)due to the presence of higher amount of fines which aggravate the scaling problem in the evaporators.

— Silica content in the bagasse black liquor is high of the order of 3.0 – 4.0 percent on dry basis.

— Viscosity of bagasse black liquor is higher compared to that from other conventional raw material. Handling such viscous black liquors is difficult and also increases the scaling tendency in the evaporator tubes.

To overcome the above problems, certain features were incorporated during the project design and implementation and later on while experiencing some other problems.

Evaporators

Hardwood and bagasse pulps are washed separately in two different three stage brown stock washing streets and the weak black liquors are received separately. Hardwood liquor contains 12-14% dry solids and bagasse liquor 6-8%. The weak black liquor characteristics are given in the Table 1.

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TABLE—1

Characteristics of Bagasse and Hardwood Weak Black Liquors

S.No.	Particulars	UOM	Bagasse WBL	Hardwood WBL
1	pH		12.0	11.5
2	Total Solids	%	7.8	13 9
3	Total Suspended Solids	ppm	180.0	165 0
4	TAA as Na_2O	gpl	14.3	24.8
5	RAA as Na_2O	gpl	4.8	1.3
6	Calcium as CaO	ppm	160.0	135.0
7	Silica as SiO_2 (on OD basis)	%	1.7	0.3
8	Inorganic as NaOH	%	32.6	33.6
9	Gross Calorific Value	kcal/kg	3200	3400

The black liquors are screened effectively in a battery of single deck 100 mesh Penwalt vibroscreens to remove fines, stored separately and blended in suitable proportions in the feed tank to the evaporators. The vibroscreens, though maintenance prone, are effective in removing the fines from the black liquor and prevent evaporator from severe scaling problems. However, bagasse black liquor after screening still contains some fines (around 100 ppm) which pass through 100 mesh and aggravate sludge formation creating problems in evaporators. The screen rejects are collected in a storage tank and pumped back to the brown stock washers.

In order to control pH of black liquor above 10 to avoid lignin precipitation in the evaporators, a constant caustic dosing system was incorporated in the feed to the evaporators. However as the pH and R A A of both the black liquors are high, continuous caustic dosing is not needed. As compared to wood, the sludge formation in respect of bagasse black liquor is observed to be more which creates problems in the evaporators. To minimise this problem, the sludge settled at the bottom of the feed tank is removed through a ring header provided with inernal lines with perforated nozzles. The sludge is collected and fired in the boiler along with semiconcentrated black liquor. This has improved the evaporators performance and also reduced frequent cleaning of feed tank.

The evaporators are designed with the following features incorporated to suit the high scaling and high viscous nature of the black liquor and to achieve better steam economy.

- Sextuple effect evaporation system with standby first effect to achieve higher steam economy.
- Forced circulation evaporator with standby heater to overcome the effect of anticipated higher viscosities.
- External preheaters were provided to facilitate easy cleaning.
- Two stream installation to have maximum efficiency of operation by operating at near rated evaporation capacity and also to facilitate water boiling/cleaning of any one stream during low loads.

The Evaporator plant, supplied by M/s Larsen & Toubro consists of two streams of sextuple effect LTV units, concentrating weak black liquor from 8 to 45% solids. The unit is designed for a steam economy of 5 02 with six bodies in service. In the first two years of operation, the evaporators performance proved to be better than average with full capacity utilisation and maximum steam economy. However, in the following years, due to high silica in black liquor, the scaling in the evaporator tubes became severe and reduced the water evaporation capacity. Subsequently, one body had to be constantly cut off for cleaning. The scales are composed of predominantly silica and calcium. A typical analysis of scales of different evaporator tubes is given in the Table 2. The tube cleaning was carried out with conventional cutter cleaing system in the beginning and later on with high pressure hydroblasting technique with high pressure jet pumps. Because of the anticipated high viscosity at 45%, a 220 KW circulation pump for Forced Circulation evaporator and circulation pumps for the second effect were installed. However, the viscosity levels are not alarming at 45% concentration because of higher pH and RAA than the anticipated values. An analysis of the 45% Semiconcentrated black liquor is given in Table 3.

TABLE—2

Characteristics of Tube Side Scale of Different Effects

S. No.	Particulars	UOM	E 1	E 2	E 3	E 4	E 5	E 6	FC	SC
1	Loss on Ignition	%	19.9	22.4	20.1	28.2	32.0	31.0	27.5	40 9
2	Acid Insolubles	%	45.7	46.0	50.1	39.0	17.7	16.5	40.6	4.5
3	Silica	%	36.8	28.6	44.0	28.4	13.6	12.6	35.0	3.5
4	Mixed Oxides	%	1.2	2.3	2.5	18.3	18.0	18.1	1.7	6.0
5	Calcium as $CaCO_3$	%	24.3	35.4	44.6	40 0	51.1	47.7	48.2	78.6
6	Magnesium as $MgCO_3$	%	2.1	6 5	3.4	10.1	2.9	2.7	2.5	6.5
7	Sodium as Na_2O	%	1.7	0.6	0.6	0.3	1.0	1 0	0.5	0.2
8	Hot Water Solubles	%	5.3	2.9	4.3	6.4	—	—	5.2	—

TABLE—3

Characteristics of Semiconcentrated Black Liquor

S. No.	Particulars	UOM	
1	Total Solids	%	44.7
2	TTA Na_2O	%	7.6
3	RAA as Na_2O	%	1.6
4	Silica as SiO_2 (on Dry Solids)	%	0.9
5	Calcium as CaO (on Dry Solids)	%	0.2
6	Inorganics as NaOH	%	33 0
7	Viscosity at 80°C	cps	45.0
8	Gross Calorific value	kcal/kg	3350

As an energy conservation measure, the two stage ejectors of the vacuum system which were originally supplied with the equipment are now replaced with vacuum pumps.

To overcome the scaling problems, and as an efficient energy conservation measure, it is contemplated to retrofit the evaporators with the latest Falling film technology.

Recovery Boiler

As discussed the viscosity of bagasse black liquor is not alarming at 45% solids. However, the viscosity shoots up disproportionately with the increase in-solids beyond 50%. During the basic planning of recovery boiler, the high viscosity and the poor liquor burning and smelt flow characteristics are considered and to overcome the problems, the following features were incorporated:

For high viscosity

- The black liquor concentration is limited to 65% at the outlet of the direct contact evaporators.
- Dilution system by using weak black liquor or dilute caustic is provided at direct contact evaporators.
- Black liquor heaters were designed to have enough capacity to raise the firing liquor to 125°C.
- Positive displacement type screw pumps were provided to fire high viscous liquors.

For poor burning characteristics

- Maintaining high bed temperature with efficient air distribution system and chorme ore refractory on the walls upto spray gun level.

— Effective and strong steam shattering system to break the viscous smelt.

— Maintaining of inlet of spout cooling water temperature at 75°C.

The recovery boiler, supplied by Mitshubishi Heavy Industries, Japan, is a conventional / bi-drum type boiler, two pass mixed flow superheater with a desuperheater in between and vertical economiser. It has been incorporated with the following additional features which facilitates handling of heterogeneous bagasse black liquor :

— A twin cascade evaporator system placed one over the other working in series.

— A novel three zone air distribution system with bi-level primray and interlacing type secondary.

— Decanting type twin spout system for efficient removal of smelt from the boiler.

— 165°C Combustion air temperature to improve the black liquor burning.

With the above special features in the boiler, the performance of the recovery boiler is better even with the bagasse black liquor of heterogeneous characteristics. The bi level primary air system helps to burn some organics on the periphery of char bed, keeping the Oxygen level low, required for the reducing zone, and increases the furnace zone temperature. This phenomenon is conducive for increased reduction as well as improved combustion of the bagasse black liquor which has poor burning characteristics. It also has helped to minimise the auxiliary fuel support to sustain the black liquor firing. Oil is used only for start up and stoppage of the boiler. The boiler is equipped with two oscillatory type hoseless spray gun with quick coupling, one opposite to the other on the two side walls. The liquors is fired at 1.0 to 1.5 kg/cm^2 pressure and 115 to 118°C for an optimum atomisation. With the high furnace bed temperatures and stabilished bed conditions, the oscillation. of the spray guns is suspended and the guns are kept stationary and directed as low as possible to minimise the liquor droplet carry over along with the flue gas. Due to the sharp raise in the viscosities near 60% solids, the load on the cascade evaporator No.2 drive shoots up rapidly. The drive gear box failed in the initial stages due to sudden surges in the loads. The chain links also used to give way frequently. The gear box and the chain were replaced with higher capacities. To control the drive load dilute caustic/weak wash are dosed or the evaporator outlet concentrations are reduced. Because of this dilution, the cascade evaporator outlet flue gas temperatures dropped down and corrosion was observed in the ducts. The ducts are periodically strengthened to arrest the infiltration of fresh air. The boiler also incorporates unique dry ash handling system, in which boiler bank and economiser hoppers soot and electrostatic precipitator ash are conveyed in dry state and mixed in the same mixing tank along with salt cake, in view of high viscosity of the concentrated black liquor. The boiler is also equipped with completely automatic instrument control system for effective operation.

Electrostatic Precipitators

The boiler is coupled with a twin chamber electrostatic precipitators supplied by M/s Bharat Heavy Electricals Ltd. and is operating at a collection efficiency of 98% and above. Though the structures of ash handling system got damaged due to low temperature corrosion, the electrical internals are in good condition A bypass duct to cascade evaporators is installed subsequently to augment the ESP inlet temperature to the acceptable levels. The outlet flue gas tempera ure is maintained at 130°C and above.

Causticizing

The recausticizing plant is of conventional Dorr Oliver system supplied by M/s Hindustan Dorr Oliver. It has three stage mud washing system followed by precoat mud drum filter to minimise the soda losses. The lime is purchased from outside and the filter cake generated is disposed of to a nearby cement plant.

The recovery section has a very effective collection system for black liquor spillages in the evaporators and recovery boiler and liquor spillages in the causticizing plant, to reduce the chemical losses and effluent pollution.

Conclusion

With the special features incorporated as discussed and the better performance of the units, the overall recovery efficiency of the chemical system is good and is maintaining above 91%.

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