

# Chemical recovery boilers for pulp and paper mills

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## Historic development

In early 1900's, chemical recovery function was achieved in smelters or roasters wherein black liquor was burnt to recover inorganic chemicals and the heat energy was either wasted or partially recovered.

1930's to 1950's saw the introduction of tangent tube water wall bidrum boilers which laid emphasis on chemical recovery and also on heat recovery to produce steam for process.

Present day modern boiler technology has achieved a perfect balance between chemical recovery and heat recovery. Accordingly the two basic functions of present day chemical recovery boilers are :

1. To recover the inorganic chemicals from black liquor.
2. To produce high pressure and high temperature steam for captive power generation and also provide steam for use in Pulp & Paper mill operations.

## Choice of boilers

Before a new paper mill is planned or an existing one is expanded, lot of thinking and analysis has to be done to choose appropriate design of multiple effect evaporators (MEE). For wide range of Indian black liquors, conventional types of MEES could give black liquor concentration of 45% to 50% and in a few cases upto 60%.

Present day international practice is to go in for high performance superconcentrators (MEES) which can concentrate the black liquor upto 75 to 80%. For somewhat difficult Indian black liquors, it should be

possible, to achieve black liquor concentrations of 62 to 65%.

Depending upon black liquor concentration available from MEE, following types of chemical recovery boilers can be chosen.

1. Conventional units having direct contact evaporator (like cascade evaporator) wherein black liquor at 45 to 50% from MEE is concentrated to 62 to 70% solids before firing into furnace.
2. Large economiser units. In these units black liquor at 62 to 70% from MEE is directly fired in to the furnace. In this case a verticle tube extended surface economiser replaces the direct contact evaporator.

Large economiser units have advantages over conventional units viz.

1. 5 to 6% higher thermal efficiencies.
2. Low emissions.

## Desirable features of a chemical recovery boiler

Pulp mill operations totally depend upon the chemical recovery boiler. Generally each paper mill is linked up with one recovery boiler and hence its availability and efficient operation are of utmost importance.

Every paper mill engineer, looks for a chemical recovery boiler which has high availability, best reduction efficiencies, highest steam generation, least down

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time for annual maintenance and most important, flexibility and ease of operation. Foundation of such a boiler is laid during design and manufacturing stage itself. Utmost care has to be taken to choose the right design features, select optimum materials and follow stringent quality control procedures not only during every stage of manufacturing but also during erection at site.

Following proven salient features have been widely accepted internationally.

### **Design features**

1. Fully welded furnace waterwall construction with no refractory on vertical waterwalls.
2. Decanting hearth with multiple smelt spouts.
3. Suspension firing of black liquor with multiple black liquor guns.
4. Properly proportioned drying, reducing and oxidising zones with tangential concentric air system above the black liquor guns.
5. Widely spaced tangent tube superheater with flexible connectors and steam cooled spacers.
6. Single pass baffless boiler bank.
7. Vertical straight tube economiser.
8. Twin wheel cascade evaporator system.
9. Concrete cased electrostatic precipitator with collecting electrodes of corten steel.
10. Forward curved bladed radial induced draft fans.
11. High energy arc ignitors with visible light scanners for start up oil burners.
12. Furnace safeguard supervisory system.
13. Fully automatic soot blower control system.
14. Use of seamless steel tubes for boiler pressure parts.

### **Features to safeguard against explosions**

Due to complex nature of black liquor fuel, chemical recovery boiler presents problems of safety and operation much more than conventional boilers. Besides

auxiliary fuel explosions, severe smelt water explosions have been experienced in recovery boilers worldwide. A study of the various cases reveal following major reasons for causing smelt water explosions.

1. Firing low concentration black liquor.
2. Failure of boiler pressure parts.
3. Introduction of water into furnace through external means.

In order to minimise the explosion hazards, following design and operation safeguards should be adopted in chemical recovery boilers.

### **Black liquor concentration :**

Firing low solids black liquor has been a significant cause of smelt water explosions. It has been recognised that the black liquor having less than 58% concentration is prone to smelt water explosions. Black liquor firing should be suspended, in case the black liquor concentration falls below 58%, during normal operation of boiler. It is a good practice to install a dry solids meter in black liquor piping just before black liquor guns so that boiler operator is always aware of the firing concentration.

At design stage, proper equipment should be selected so that system is geared up to fire black liquor at as high a concentration as possible. With Indian black liquors concentration of 65 to 70% can be achieved with combination of multiple effect evaporators and cascade evaporators.

### **Boiler pressure parts**

Failure of pressure parts like waterwalls, boiler bank, water screens etc can inject water direct into the operating furnace and cause smelt water explosion. The failure of pressure parts could be due to following reasons.

1. Manufacturing defects.
2. Erection defects.
3. Corrosion.
4. overheating due to internal deposits.
5. Plugged tubes due to improper internal cleaning.

It is very important that due care is taken right from raw material selection stage to build a sound recovery boiler. Proper quality control procedures should be adopted during manufacturing and erection to ensure sound weld qualities while fully satisfying the code requirements.

Boiler should be acid cleaned before commissioning to ensure clean internal surfaces. In order to prevent internal deposits and corrosion, demineralised and deaerated boiler feed water should be used. The quality of feed water and boiler water should be maintained strictly as per boiler manufacturer's recommendations on a continuous sustained basis.

It has been observed that boilers operating at and above 64 kg/sq cm(g) pressure at superheater outlet, experience excessive fire side corrosion of lower waterwalls. For such a case either the lower waterwall tubes should be metalized on the fire side or lower waterwalls should be made up of compound tubes.

In order to minimise the chances of smelt water explosion in the event of a pressure part failure, the recovery boiler design should include safety interlocks and control logics for emergency shut down. The design of control logics should cover the steps recommended by "BLACK LIQUOR RECOVERY BOILER ADVISORY COMMITTEE OF USA" for emergency shut down procedure of recovery boiler.

#### **Introduction of water into furnace through external means**

Third main cause of smelt water explosion is due to introduction of water into furnace through the following major external means.

- a) Water cooled doors
- b) Water cooled probes
- c) Air lancing
- d) Bed cooling with water hoses.
- e) Smelt spout leak.

Use of item (a) to (d) should be prohibited in the recovery boilers.

The smelt spout area is a high potential source for accidental introduction of water into furnace. Due care should be taken in design/maintenance of spouts. Spout cooling water system should be properly designed and operated to ensure adequate flow of cooling water through spouts. The water used for spout cooling should be of condensate purity and non corrosive. Above all, the smelt spout should be thoroughly inspected during every shut down. It is a good practice to replace all spouts once a year. It is recommended that spouts should not be repaired or rebuilt.

#### **Recovery boiler operation :**

Drying, reducing and oxidising zones are integral part of the furnace. These zones can be properly proportioned during design stage, however, it also requires best of operational skills to achieve the optimum results.

For highest reduction efficiencies, reducing atmosphere has to be maintained in the lower furnace. For highest steam generation oxidising atmosphere has to be maintained in the upper furnace in order to achieve complete combustion of organic constituents. In addition to the above proper black liquor spray pattern has to be maintained. Even though all the above functions have been successfully achieved in operation, the need for trained operators and dedication on part of the operating staff cannot be overlooked. It is often seen that the same boiler while achieving optimum results during one particular shift falls short of expectations during other shift within 24 hours operation. Hence it is not only enough to have experienced operators, but they should be given regular training and feed backs on the cost effect of short fall in expected performance. It has been experienced that down the line operator taken into confidence, can give best results from boiler round the clock throughout the year.

#### **Sum up**

The preceding features of chemical recovery boiler combine to deliver a unit which is safe, efficient in both the thermal and chemical reduction sense; reliable and finally operator friendly.