Experience with the Erection and Operation of a Chemical Recovery Boiler with Latest Design Features

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SUMMARY

M/s Seshasayee Paper & Boards Ltd., have recently commissioned a Kraft Chemical Recovery Boiler imported from Sweden. Besides being engineered for 24 months delivery and commissioning contract, the unit also incorporates some of the latest design features. This paper highlights the Mill's experience with the boiler and the special features that lend themselves to easy and efficient operation.

INTRODUCTION

M/s Seshasayee Paper and Boards Limited recently completed their second stage expansion programme raising the installed capacity from 35,000 tonnes per annum to 55,000 tonnes per annum.

This expansion programme envisaged completion of the project within 24 months. To achieve this target it was found necessary to import the chemical recovery boiler.

The suppliers of the recovery boiler, Gotaverken Angteknik AB of Sweden, undertook to manufacture, supply, erect and commission the unit within 24 months. The contract also provided for maximum indigenous substitution of non-pressure components, either purchased locally as per Swedish specification or fabricated locally as per detailed fabrication drawings supplied by Gotaverken. Indigenously procured equipment included the electrostatic precipitator, forced draught fans, start up ejector, chemical pumps etc. Indigenous fabrication covered air and flue gas ductings, boiler skin casing, spout hood, ash hoppers, tankages, etc. A detailed programme was drawn up after discussions and the same was incorporated into a PERT Chart. The major time-bound areas were :

Detailed design and engineering.
Preparation of detailed drawings.
Approval of pressure parts drawings and design by Inspectorate of Boilers, Tamil Nadu.
Finalisation of detailed specifications for indigenous procurement.
Preparation of detailed fabrication drawings for indigenous manufacture.
Manufacture and shipment in phased out sequence.
Erection and pressure testing.
Trial run and demonstration of guaranteed performance.

Considerable difficulties were encountered by SPB in maintaining the time schedule on its part. Approval of design and drawings of the pressure parts was required to be obtained from the Inspectorate of Steam boilers within six weeks. This was not possible owing to differences in the manufacturing codes practiced in Sweden and India. Most of the design calculations had to be reworked by SPB as per Indian boiler regulations to justify the soundness of the Swedish design. This resulted in some delay in commencement of manufacture.

Indigenous procurement as per Swedish specifications also did pose its own problems relating to non availability of equivalent materials of construction, detailed design features and, (more often) protracted delivery periods.

BOILER BUILDING DESIGN

The boiler manufacturers, at first, stipulated that the boiler supporting steel structurals should be independent of the boiler building columns and floors so that no additional forces are transmitted to the boiler columns. SPB's Architects & Consulting Engineers had earlier formulated an economically priced building construction which envisaged a tie-up of the building structural columns with the boiler structural columns and beams. This, therefore, required SPB to obtain approval of the boiler suppliers after completing the basic building design.

Despite delays in ocean transport, delayed deliveries of indigenous equipment and other unprecedented set-backs, the above schedule was maintained in the overall perspective and the boiler was

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put into continuous service at rated capacity by 1-12-1977, exactly 24 months from the date of placement of the order.

Due to overlapping of certain sequences of erection works, considerable difficulty was experienced in co-ordinating the simultaneous working of boiler erection, building erection, and erection of utilities.

BOILER ERECTION

The entire erection of the recovery boiler was carried out by an Indian construction company and SPB's departmental erection team with the assistance of only one Erection Supervisor from the boiler Supplier's side.

The erection was carried out strictly according to Swedish codes and practices. Indigenous welding electrodes, wherever used for pressure parts welding, were tested and approved in Sweden. A Swedish welding inspector was deputed for a limited period to test and assess the standards of the welders employed for carrying out the pressure parts welding.

To speed up erection, the main boiler components of membrane wall construction were supplied in full widths and in lengths ranging from 10–11 metres.

All internal and external pressure piping including sootblower piping was supplied in tailor cut and bent-to-shape condition complete with springloaded hangers, etc., according to a three dimensional piping drawing and layout plans with superimposed location of floor beams at various levels to avoid site adjustments.

The sequence for erection of operating platforms and galleries was also preplanned to suit the progress of boiler erection.

SALIENT FEATURES OF THE GOTAVERKEN RECOVERY BOILER

The Gotaverken Recovery Boiler in service at SPB has a rated capacity to process 135 tonnes per day of black liquor solids and generate 17.1 tonnes per hour of superheated steam at 30 atmospheric pressure and 371°C.

The unit is basically a B & W Type Tomlinson unit incorporating the results of continuous and independent improvements carried out by Gotaverken over the years since 1936.

Gotaverken have so far supplied 80 chemical recovery boilers including the largest with a capacity of 1900 tonnes dry solids per day.

The unit incorporates a Tomlinson furnace and a cascade evaporator of the single wheel type followed by an electrostatic precipitator. A steam jet start-up ejector is provided for start-up operations.

The furnace walls are of water cooled membrane construction, fully welded to ensure gas and smelt-tight walls. The tubes adjacent to the airports are bent in the plane of the walls which gives a flat-wall construction with no weak points where smelt leakage can occur. The tubes in the lower section of the furnace are protected from corrosion by a special process of extra-close studding. The openings for air-ports and smelt spont are protected by stacked plates of special alloy steel. These stacked plates are easily renewable. The smelt spont is of special steel and has a steep slope to ensure rapid drainage of smelt.

Preheated combustion air is introduced at three different levels according to a Gotaverken patented "High primary air system". Air flow at each level and through each port can be adjusted through individual and main dampers. Separate F.D Fans are provided for primary and secondary air supply. The Gotaverken patented High primary air system ensures low H_2S emission, better control of charbed, and a more evened out temperature profile at the border line of the bed. A continuous on-stream flue-gas sampler with an Oxygen analyser is provided to exercise proper control of excess air. The auxillary fuel system has been provided with an advanced level oil burner Safety system with differential pressure switches and Flame control equipment. An oil-and-steam control station maintains the desired pressure differential between the oil and the atomising steam pressures. The Flame control equipment is built up around a "Five-eye" self-check system with a special scanner with "back-ground gain control". The basic interlocks ensure the following conditions:

i) Proper Oil-steam pressure differential.

ii) Furnace purge circuit between successive attempts to ignite the oil burner.

iii) Adequate air flow in the windbox to sustain combustion of the oil.

iv) Time limitation for ignited burner to stabilise. Failure to stabilise within the time limit trips the system and the start up sequence has to be repeated.

The above interlocks control magnetic shut-off valves on the oil lines. These valves have positive leak-proof closing action for maximum protection against furnace explosion hazards Mimic panels for each burner provide visual indication of the progress of operation of the various interlocks. In case of emergency, the entire oil-burner system can be trapped-off from the main control panel, which has also a separate burner operation display. Ignition of the burners during start-up can be achieved by a High-energy spark ignitor with a portable ignition lance.

The green liquor system consists of a dissolving tank of mild steel construction, lined on the inside

with special M-300 concrete. This type of construction ensures extremely low noise levels. The spout hood resting on the dissolving tank is of a special design. The mist-pipe is generously dimensioned and is provided with a damper to maintain a slightly negative pressure in the dissolving tank to the extent of minus 10 to 15 mm water gauge. This insures an absolutely mist-free atmosphere near the spout-tending area. The dissolving tank is also provided with an explosion door to relieve any instantaneous development of pressure resulting from a sudden gush of smelt from the spont. The dissolver has no provision for green liquor re-circulating pumps which are featured in older B & W designs. Adequate agitation in this case is maintained mainly by a properly designed side-entry type of agitator. The weak white liquor is introduced into the dissolving tank at mainly two points namely the spout-hood wash nozzles and through the suction pipe of the standby green liquor transfer pump. The green liquor transfer line and the weak white liquor line are interconnected in such a way that when one green liquor transfer pump is in operation, the weak white liquor is introduced through the idle standby transfer pump. These two transfer pumps are located adjacent to the side-entry agitator and on either side of it. Weak white liquor therefore enters at the suction area of the agitator impeller and proper mixing is thus ensured. When the transfer pumps are alternatively run, once in 15 days, it is found that the green liquor lines are practically clear of any scaling. Sediment accumulation in the dissolving tank is almost negligible. The dissolving tank is equipped with top-entry type bubbler system which controls both the level and density of the green liquor.

The black liquor system consists of a cascade evaporator, a salt cake mixing tank, salt cake metering system, Hopper ash addition arrangement, black liquor pumps with mechanical seals, on-line direct contact steam heater with temperature control and a hoseless black liquor sprayer equipped with a spray-pressure controller. Both, the mixing tank and the cascade evaporator are equipped with level controls. The mixing tank level controller can be remotely adjusted from the control panel while the cascade level control is pressed to operate between predetermined levels. Any desired operating load can be maintained by setting the black liquor pressure at the liquor sprayer and any desired level in the mixing tank. These two controls in turn maintain the cascade level and very soon establish a steady state condition provided that the concentration of the black liquor supply to the cascade does not very abnormally. The boiler is provided with a two-stage superheater of the pendant type. Temperature of superheated steam is controlled with a surface type attemperator.

The boiler is equipped with ten automatic retractable soot blowers with sequence control and fault finding relays. The soot blowing pressure can be manufally pre-set to the desired value. A separate timer circuit operates to ensure draining-out of condensate prior to commencement of soot blowing.

For operational convenience, the main three steam valves namely the soot blower main steam valve, the start-up vent valve for the superheater, and the main out-going steam valve can be remotely operated from the control panel by means of a unique air-powered actuator system. These actuators are also equipped with valve position indicators on the panel which indicate the extent to which the valve is open.

The boiler is extensively insulated with imported rock-wool and other grades of mineral wool interleaved with wire netting and aluminium foil. The insul ation material was supplied in the form of blocks of convenient sizes, the surfaces being suitably profiled to match the profile of the membrane walls. While the major part of the insulation is clad with aluminium sheets, the lower part of the furnace upto the secondary air level is clad with profiled stainless steel plates for permance.

The boiler building is provided with AC sheet roofing and side cladding comprised of AC sheet louvres for proper ventillation. The ventillation is further aided by the FD fans which have a long vertical suction duct which draws in all the hot air from the inside top of the building thereby causing an induced draught into the building. The long vertical suction duct also incidentally makes air-flow measurement more accurate.

The electrostatic precipitator is of the single casing dry-bottom type with two fields. Instead of the conventional single rectifier system, this particular design provides for a twin rectifier system using one rectifier for each field. The sizing of the rectifiers ensures that the unit can operate on 70–75% load even if one of the rectifiers fail. The unit has a separate by-pass ducting and suitable DTPA valves for isolation purposes. Since the two fields have separate rectifiers and can function independently, it is observed that the precipitator functions with a "two stage" precipitation effect. The first field precipitates the more coarser particles with very low power consumption while the second field precipitates. A finer particles and consumes more power. The efficiency of the unit has been established at plus 97%.

The boiler building layout and the location of the various floor levels has been designed for maximum convenience in operation and supervision. Almost all the operations normally carried out, are confined to two levels.

INSTRUMENTATION AND CONTROLS

The Gotaverken boiler is equipped with sophisticated instrumentation and controls. The basic controls are :

1. Automatic three-point feedwater controller.
2. Furnace draft indicator-controller. The control operates to vary the I.D Fan speed through the Hydraulic coupling.

3. Automatic superheater termperature indicating controller with the "cascade type control" using "slave" and "Master" controllers.
4. Cascade Evaporator level controller.
5. Mixing tank level indicator-controller.
6. Black liquor spray-pressure indicating controller controller.
7. Black liquor temperature indicating controller.
8. Primary air-flow indicating controller.
9. Secondary air-flow indicating controller.
10. Yarway Drum level indicator.
11. Indicating controllers for dissolving tank level and green liquor density.
12. Drum level indicating controller.
13. Multipoint temperature recorder for Feedwater, superheated steam, Black liquor to sprayer, Flue gas after boiler bank and Flue gas after cascade evaporator.
14. Multipoint flow recorder for feedwater, outgoing superheated steam, Primary air and secondary air.
15. Differential draught guages.
16. Oxygen analyser with indicating recorder.
17. "Fail-safe" auxillary fuel firing safeiy system complete with steam-oil differential control, flame sensors and interlocks. Individual burner stations are equipped with mimic panels and the main control panel has a separate integrated display.
18. Sootblowing control system complete with fault-finding relays and signal lamps for steam valve opening condensate draining, forward movement of sootblower, retraction of sootblower and faulty operation.
19. Remote operation switches with indicators for percentage opening of start-up vent valve, Main steam valve and sootblowing-steam valve.
20. A multipoint audio-visual annouciator panel for highlighting abnormal operating conditions like high and low drum levels, high and low temperatures, high and low levels in mixing tank, failures of I D and F D Fans, etc.

OPERATION

The unit was commissioned on 18-11-77 after completing the preliminary trials. After the initial light up of first burner the entire auxilliary fuel unit was put on auto control and the boiler was brought on range. Since the outlet steam valves connected to the boiler are remote operated from the control panel, it does not require more than one operating personnel to carry out the entire operation.

SPB experienced problems with the cascade evaporator because of the deviation of liquor characteristic from the designed conditions, and baffles were introducted in the inlet and outlet gas ducts on either side, of the rotor near the roof. The boiler was put into service for the designed load of 135 t/day on the third day after start up. A smooth start up could be achieved in a short time with the aid of set point controllers in the instrumentations. The only problem was that steam generation was higher than the designed rating by about 25%.

The unit is normally started up with the aid of the start up ejector and the ESP and I D Fan is commissioned when the cascade outlet gas temperature crosses 140°C.

The unit is run for 90 days continuously before the fouling of superheater and boiler passes necessiates a shutdown. The superheater temperature is controlled automatically by remote control as an attemperator is provided to take care of the temperature even at varying loads. The spot area and the primary ports area have been free of frozen smelt during the entire operation.

The melting down of the chemical bed has never been complete in the melting downs undertaken, the same has not hampered the smooth operations.

The steam production per tonne of black liquor solids is 1:3. The efficiency of the ESP is 97% with reference to the dust collection on the gas loading. The boiler outlet gas temperature is around 350°C and the cascade outlet temperature being 160°C. From observations made during the run of this unit, the increase in solids content of cascade liquor is found to be satisfactory only when the differential across code is around 35.40 mm.

The inlet and outlet concentration of black liquor at the cascade evaporator is 42% and 57–61% respectively. There is practically no black liquor carryover and the precipitated ash is perfectly white in colour. The cascade evaporator runs continuously for about 3 weeks after which the differential across the unit rises to too high a level that necessiates cleaning. This cleaning is done in 3–4 hours without stoppage of liquor firing. During the cleaning period, the liquor in the mixing tank and the dump tank (discharged from the cascade) is utilised to maintain liquor firing at 60% of rated capacity and auxilliary fuel to the extent necessary to maintain the steam generation. To sum up, the performance of the boiler has been extremely satisfactory and it can be said that, once the boiler is started, it runs practically trouble-free for continuous periods of about 90 days. The total availability of the boiler for operation is 94.96%.