A New HERB (High Energy Recovery Boiler) In Asia

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ABSTRACT

Recovery Boiler is always referred as the heart of any pulp mill and is the critical component in the closed loop producing energy alongside recovering cooking chemicals. As long as the heart sustains well, other systems excel. Today the mills, constrained with rising energy cost and security of supply strive to maximize "green energy" to substitute fossil fuel and attain self-sufficiency. ANDRITZ has the solution in their product ***High Energy Recovery Boiler, HERB*** in short.

A new HERB was commissioned in 2011 at Chenming Pulp and Paper Mill at Zhanjiang, Guangdong Province in China. This boiler is among the world's largest at 4500 TDS/day of Black Liquor. The boiler is designed to fire black liquor at 80% Dry Solids to maximize steam output. The boiler generates 670 t/h of steam at 86 bar and 480°C. This high end steam parameters have been made possible by integrating Chlorine Removal System (ARC™) into evaporation plant. This prevents potential corrosion of boiler pressure parts, especially at the hottest superheaters.

Recovery Boilers contribute to improved environmental performance of the mill and Chenming Recovery Boiler is no exception. The boiler is equipped with systems to incinerate Concentrated Non-Condensable gases (CNCG) and Dilute Non-condensable gases (DNCG) from the mill.

Excellent engineering combined with quality workmanship during manufacturing and erection phase and methodological commissioning ensured smooth and on-time start-up and peak capacity was achieved in a very short time. The boiler continues to operate at the rated output guaranteeing mill's overall performance.

Introduction

It is an agreed and established fact that greenhouse gases contribute to global warming and that carbon dioxide (CO_2) is the most important greenhouse gas generated by man's activities. There are also other greenhouse gases, but they disappear from the atmosphere relatively quickly. Using biomass as a fuel is an effective tool to contain CO_2 emission. Pulp and paper industry has always been a pioneer in utilizing biomass as a source of energy.

With rising oil prices and environmental concerns, the pulp mills are hard pressed not only to produce more energy but also save energy. The market is demanding less pollution for each MW of power generation and better utilization of renewable resources.

Non-integrated pulp mills are nowadays totally self-sufficient regarding to the heat and power consumption, but the idea of selling excess also electricity is already a reality at many mills. Even though a mill is self-sufficient in energy, there are normally still many areas where energy could be saved and electricity production could be increased.

HERB Concept And Methodology

The main power production unit in a "normal" kraft pulp mill is of course the recovery boiler. During earlier days, the focus has been mainly on the chemical recovery and not on the power production. The power generation efficiency has always been rather low in traditional boilers. With emerging economic and environmental scenario, the focus shifted to power generation. For this purpose, ANDRITZ developed a concept called ***HERB (High Energy Recovery Boiler)*** to increase power generation efficiency further than what is possible with traditional increase to the steam parameters

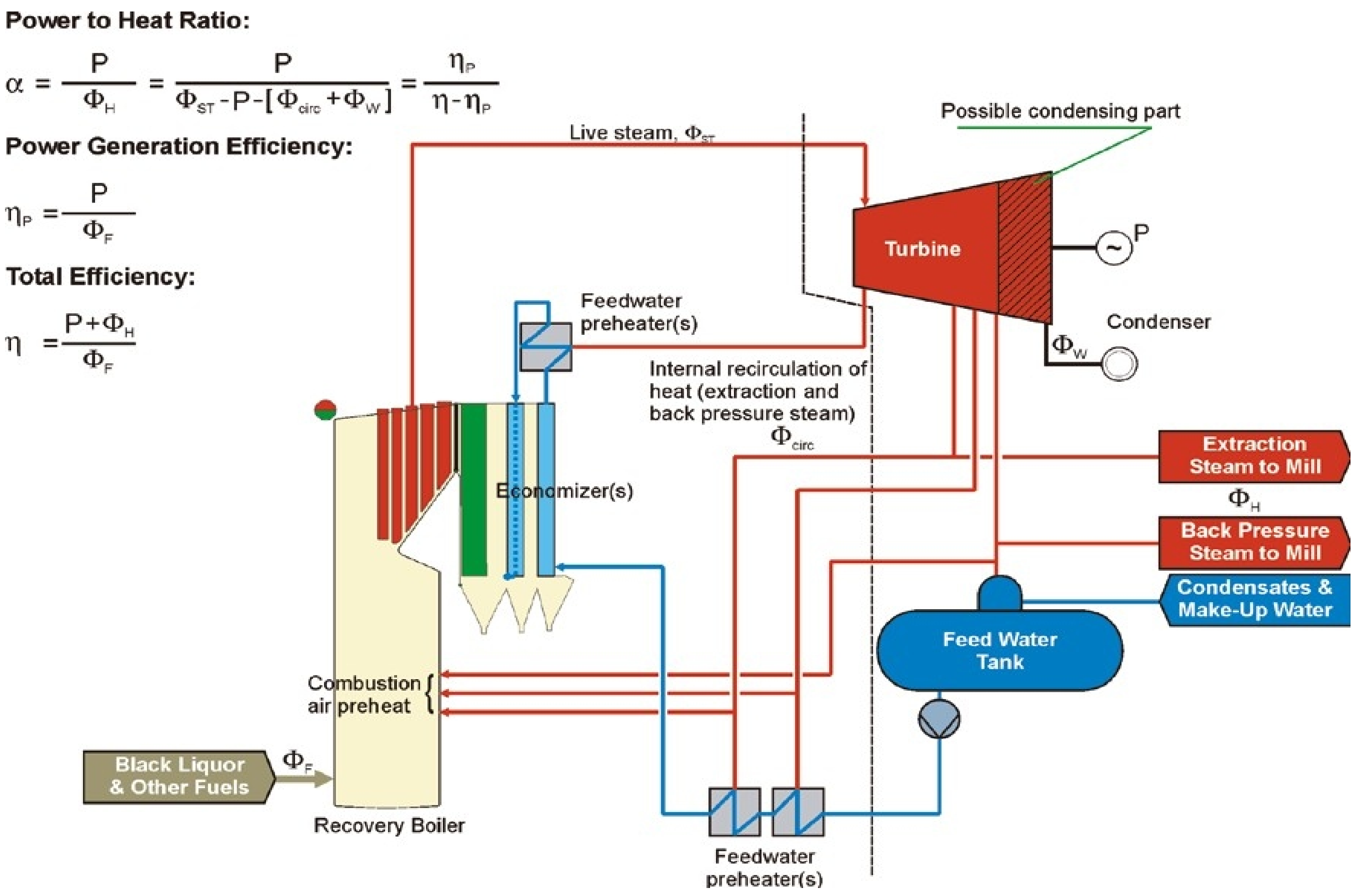

Fig. 1. Power to heat ratio and efficiencies in CHP

Power generation, in combined heat and power system (CHP) is described in terms of the "power generation efficiency (PGE) or the "power to heat ratio", as depicted in Fig. 1.

In order to improve the power generation, HERB employs several technical solutions for the recovery boiler. It is not, however, only in the recovery boiler area where savings can be done, but it is possible to achieve significant savings also in other process areas.

The most common methods for increasing the power generation efficiency have been higher black liquor dry solid content and higher steam values. These methods are practically adopted in HERB and the main limiting factor is the corrosion.

Dry solid content of black liquor has a large impact on steam generation. It is more effective to evaporate the moisture in a multiple effect evaporator with process heat rather than doing the same inside the furnace. The increase in net steam generation for 65% solids as against 85% solids is approximately 7-8%. Further, with high concentration liquor, it is possible to operate with low excess air, which again minimises loss to the flue gas. A comparison of heat balance at different dry solid content is furnished in Fig 2.

Increased seam generation replaces the corresponding amount of steam from fossil fuel with reduction in CO_2 emissions. The reduction is approximately 150,000 tonnes per year of CO_2

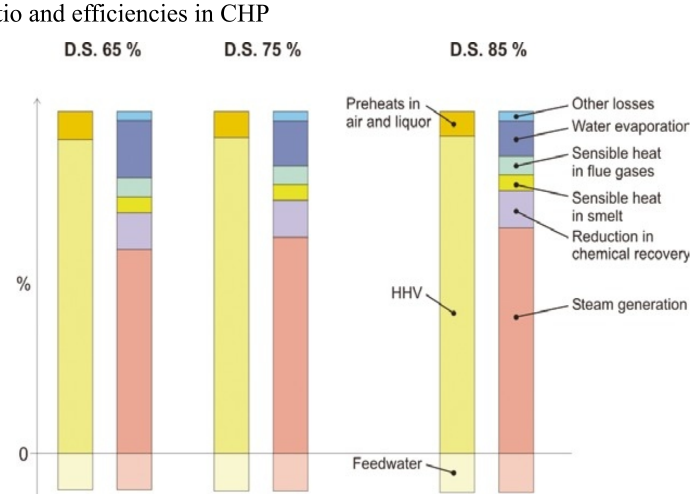

Fig 2. Comparison of heat balances for recovery boilers based on HHV

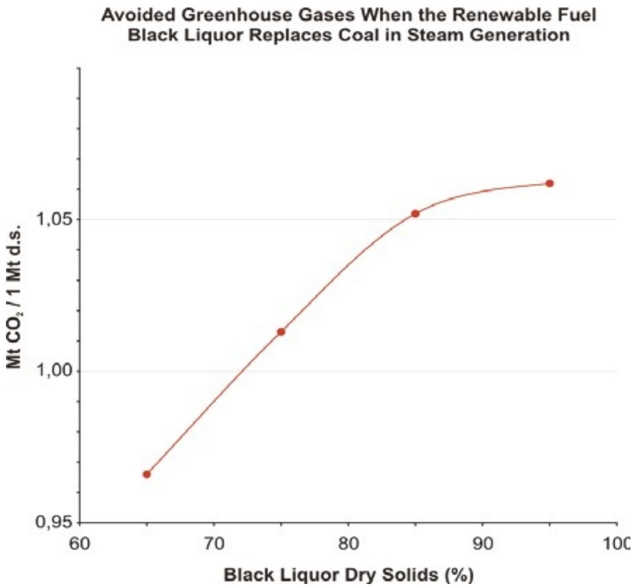

Fig. 3. Effect of dry solids on avoided greenhouse gas emissions compared to coal. Recovery boiler is this case uses 500°C steam temperature and 180°C flue

emissions when operating a 5000 tds/d boiler. The effect on CO_2 emission with increasing dry solids is shown in Fig. 3
Another methodology for improved PGE is higher steam values. High "green power" price in some of the countries is the driving force behind higher steam temperatures. But the corrosion risk in super heaters is the main limiting factor. Black liquor contains Non Process elements (NPE) namely Chloride (Cl), Potassium (K) and unburned sulphur in flue gases, causes corrosion in super heaters at high metal temperatures.

The material selection and boiler design is vital to minimise corrosion with higher steam values. With large furnace and vertical air arrangement in HERB droplet lift in the centre of the furnace is considerably reduced and critical melting behaviour of the carry over is easier to control than in conventional boilers.

With regard to material selection, chloride level in Black Liquor dictates the need of expensive material and potassium content

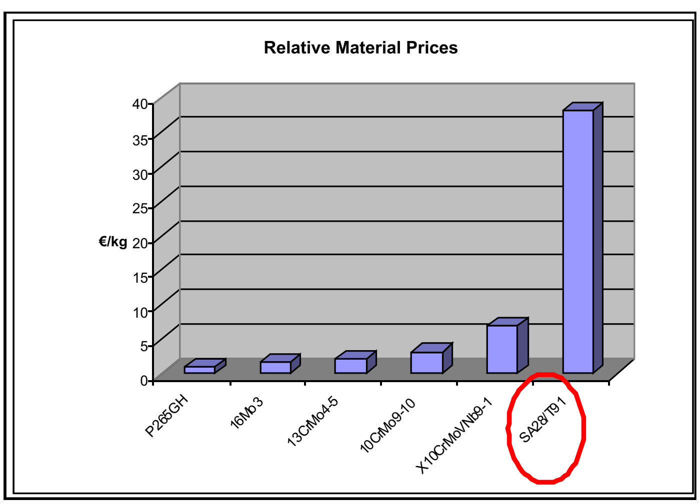

Fig. 4. Relative material prices

determines the maximum steam outlet temperature. However, the benefit of extremely high steam parameters diminishes due to exorbitant cost of material required for such temperatures as given in Fig 4.

Due to these reasons, the maximum steam temperatures in a Black Liquor Recovery Boiler have been 515°C.

In addition to these, new methods of feed water preheating, air preheating with flue gas, combining bio-gas firing to the recovery boiler, reuse of secondary heat streams in the evaporation area, etc. are introduced.

When saturation temperature increases in line with increased drum pressure, feed water heating becomes possible. First, feed water is heated to 145 °C in feed water tank with low pressure steam. It is further heated with medium pressure steam to 160°C before economizer. Feed water can be heated by another 15-20 °C between the two economizer stages. The additional electricity generation, will be ~3 MW for a 4500 tds/d Recovery boiler with a condensing turbine depending on steam and water pressures and temperatures.

Preheating of all combustion airs to 190 °C with different level of extraction steam is also a quite cost effective way to produce more steam and hence improve the power generation efficiency. Traditionally the primary and secondary airs are heated to 120-150 °C. By adding a few air preheaters the power production can be increased further by ~1 MW.

At this stage the power generation efficiency is improved, but the total efficiency of the boiler is slightly lower due to the higher flue gas temperature. In order to improve the overall efficiency the HERB concept also includes flue gas cooling after the precipitator. If the mill has a deficit of low pressure steam or hot water, or is using a condensing turbine, the flue gas cooling should be used. When cooling the flue gases with ~ 100 °C water (water heated to approx. 150 ~ 160 °C) it is possible to set the flue gas temperature in the stack to ~130 °C. The heat from the flue gases can be used for air preheating, hot water production etc. The savings will then be either less fossil fuel consumption to generate hot water or steam, or power production in the condensing turbine. If the heat is used for preheating of combustion air, ~ 4.5 MW can be gained in the condensing turbine due to lowered steam consumption.

In addition to these actions further improvements to the power generation efficiency can be achieved by using extraction steam for soot blowing instead of super-heated steam (additional ~ 0.6 MW generated).

The optimum way to increase the power generation efficiency is to utilize all the methods mentioned above. The HERB concept and methodologies are shown in Fig. 5.

The additional production with the solutions mentioned above for a recovery boiler operating at 92 bar (a) and 490°C with a condensing turbine is presented in Table 1.

The New HERB In Asia

Beginning with an installation in the year 2004, Andritz has been implementing HERB concept to all the Recovery boilers globally with one or more of the methodologies described

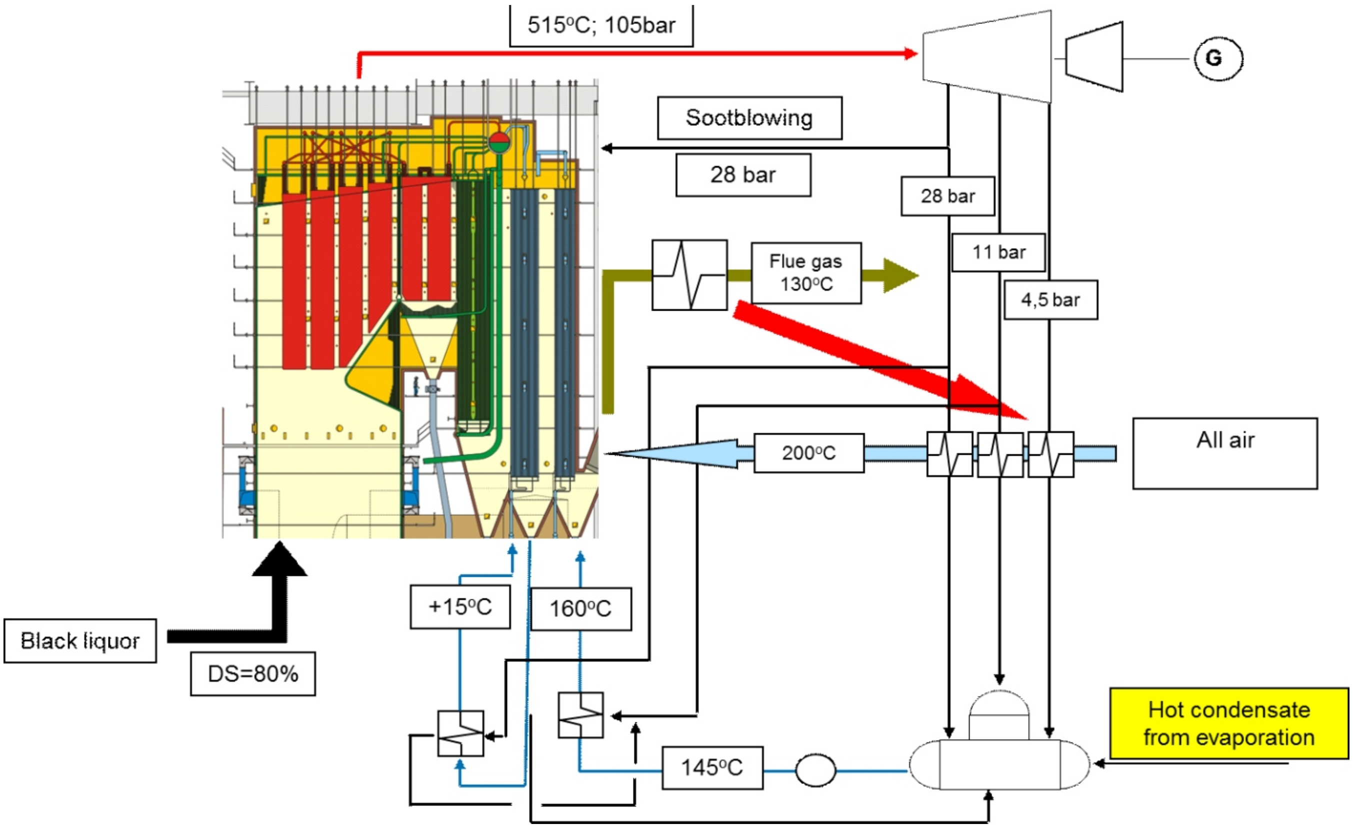

Fig.5. Andritz HERB concept

Features	Net electricity produced
Feed water pre-heating and inter heating	+ 2.7 MW
Air preheating	+ 1.0 MW
Internal Soot blowing	+ 0.6 MW
Hot primary condensate return	0.6 MW
Higher dry solids in BL - 80%	+ 2.0 MW
Flue gas cooling	+ 4.5 MW
Total	**11.4 MW**

Table 1. Additional Power produced with various technical solutions in a recovery boiler operating at 92 bar (a) and 490 °C

above. With few of them under final stages of construction, the latest HERB was commissioned in Chenming Pulp and Paper Mill at Zhanjiang, Guangdong Province in People Republic of China. This is among the largest Recovery Boilers in the world at 4500 tds/day of Black Liquor Solids. Andritz has supplied Woodyard, Fibreline, Recovery Island and Pulp Drying Machine for this mill.

Design features of the boiler

The Chenming Recovery Boiler is designed incorporating some of the HERB concepts and advanced controls to operate the boiler in a safe, efficient and environmentally friendly way.

Some of the features of the boiler are:

- In Chenming RB, Black liquor is fired at 80% dry solids. The mill uses predominantly Eucalyptus as the raw material. Considering the nature of raw material, 80% concentration at the evaporator is really an achievement.
- Chenming Recovery boiler is equipped with ANDRITZ Vertical Air™ system. This is specially designed to mix up air effectively around the burning process. With high solids and Vertical Air™ system, the boiler could be operated at excess oxygen less than 2% at the MCR load conditions.
- As explained, the non-process elements viz. Potassium, chlorides, sulphur have great impact on deciding the steam values. The content of these NPEs in Black Liquor at Chenming was much above the permissible limits. The mill desired to have high steam parameters to enhance their power generation efficiency. The main steam parameters were fixed at 86 bar and 480°C. This was made possible by suitably incorporating Ash ReCrystallization (ARC™) process into the evaporator system to contain potassium and chloride content. ARC system is more selective than an ash leaching process. The potassium and chloride removal efficiency is around 85% and the sodium recovery efficiency is 80%.
- The boiler is designed to incinerate Concentrated Non-Condensable Gases (CNCG) and Dilute Non-condensable Gases (DNCG). The main source for CNCG is the evaporation plant vacuum pump. The gases are collected and burnt in a separate burner in the recovery boiler. The evaporation plant is equipped with a condensate stripping

system and Stripper Off gases (SOG) is also incinerated in the same burner. As a backup, a flare burner is installed in the boiler house.

- In a pulp mill, the main source for DNCG is from Fibreline, Evaporation plant and Recausticizing Plant. These gases along with scrubbed gases from Main Dissolving Tank vent is fired at the Secondary air level through airports located in the rear wall of the furnace. The system and the material selection are suitably designed to handle the corrosive gases. With effective burning system installed for odorous gases, in the recovery boiler, the mill's atmosphere is clean.
- Boiler operational safety is governed by the standard **S**afety **R**elated **S**ystem designed by Andritz Automation. The safe burning of all fuels including odorous gases is ensured by this system.
- In order to optimize the process operation, Andritz has supplied Advanced Control Expert (ACE^{TM}) for this Recovery Boiler. This ACE helps in achieving stable, uniform and optimized operation of processes and equipment. The ACE system has ANDRITZ process and equipment expertise built-in, which functions in combination with predictive models and advanced process controls. In Recovery Boiler, ACE software is implemented for soot blower operation and combustion control.

Involvement of Global Team in The Project

The unique aspect of Chenming Recovery Boiler is the involvement of a global team comprising engineers from Finland, India, China and other parts of the world, in the design, manufacture, construction and start-up. The knowledge and ideas of engineers and technocrats from different countries were put to use effectively in providing a more competitive and advanced technological solutions to the issues emerging during the design and implementation phase.

The design and process engineering activities were carried out in Finland. The most of the detail engineering of the boiler was executed at Andrtiz Indian facility in Chennai. While the critical components for the boiler like lower furnace, superheaters, fuel oil and odorous gas burner, etc were manufactured in Finland, the rest of the equipment was manufactured in China.

The construction and start-up was managed and supervised by specialists from India and Finland.

Start-up

The commissioning and start-up of Chenming Recovery Boiler was executed at world record pace. Excellent engineering combined with quality workmanship and supervision during manufacturing and erection phase helped in adhering to the planned schedule of commissioning activities. Except for couple of equipment in the entire recovery boiler, each of the equipment had a trouble free start-up.

Methodological approach to commissioning checkups ensured smooth and on-time start-up. Every equipment was mechanically inspected with a check list prior to trials. The equipment and system trial went through all safety and process interlocks checks. No surprises with unexpected failures cropped up during the entire commissioning phase.

Being a green field project, hiccups in any of the closed system (Fibreline and Recovery Island) is likely to cause operational difficulties in other areas. During the initial phase, the boiler was operated at varying loads to match the stabilization of the entire mill. However, the peak capacity was achieved in a very short time.

Performance of Recovery Boiler and the Mill

Right from the start-up, the performance of the Recovery Boiler was excellent. The boiler was tuned up and stabilized when the load reached 70% MCR. The boiler load increased as the mill operation picked to reach the rated pulp production. The boiler is in continuous operation at the rated output. The performance test results are excellent. The boiler performance parameters guaranteed were demonstrated in the trial run.

Andritz has been supplying the entire pulp mill system in many of the mills and the experience in connecting the process islands helped in overcoming the minor failures during the start-up phase. The Chenming mill achieved its nominal capacity in only 121 days, a record. During first 310 days of start-up, the pulp production was above the design capacity of 2290 Adt/day for most of the days. The average daily production for the first eleven months was 2260 Adt/day, which is very close to design capacity. Capacity up to 2483 Adt/day has been achievable on a sustained basis. The mill is an integrated mill with 60% of the pulp going for internal consumption. Recovery Boiler is the main power and energy source and self-sufficient for the mill operation.

Conclusion

Maximizing Power Generation Efficiency with minimized impact on environment is the need of the hour for sustained economic development. Adapting to new technologies for improved efficiency and better process heat utilization is the solution in achieving this target. High Energy Recovery Boiler shows the way in maximizing green energy alongside recovering costly chemicals in the process.

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