

An Exploration Of Some Best Practices For Operating and Maintaining The Recovery Boiler Safely and Efficiently, and Achieving Higher Availability

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ABSTRACT

As India's economy accelerates, so does the quest for energy to keep its growth humming. The contemporary industrial challenges, including booming demand for energy, heightened scrutiny of the environmental effects, and intensified business competition, are putting greater pressure on energy-intensive industries such as pulp & paper, to meet the unprecedented challenges of the new age.

The chemical recovery island plays a crucial role in the financial and business wellness of a paper mill. This role is today being acknowledged by Indian industry, and the contribution of the recovery boiler in the papermaking cycle is considered to be significant. With the current changes in the business dynamics, the paper mills are incorporating the environmental and safety concerns into every aspect of strategy and action. This paper explores some of the various practices that are globally in vogue for enhancing safety, efficiency, environment-friendliness and availability of a recovery boiler. Systems and practices such as bed smelt extraction system, auto-air-port rodding, usage of safety roof for maintenance, odor gas handling & incineration, advanced process control and advanced safety interlocks are addressed in the paper

Introduction

During the course of the decade that has passed, Indian paper mills have consciously brought all aspects of the operation and maintenance of the Chemical Recovery Boiler to the forefront. With the constant thrust of mill managements to enhance productivity in all fronts of the recovery process, it has become a necessity for Recovery Managers to use all available tools and practices to ensure that the Chemical Recovery efficiency is not only optimally sustained, but is also improved.

Mill managements are conscious of the benefits that improved efficiency, reduced downtime and improved Health, Safety and Environment (HSE) practices can bring to the bottom line of the company. Today a number of tried and tested products and systems are available to substantially reinforce the parameters of efficiency directly (Advanced Process Controls, MDT vent gas chemical and heat recovery) or indirectly (automatic rodding of airports).

HSE practices are today an integral part of the Operational policies of paper mills. Systems and products such as the SIS (Safety Instrumentation System), Safety Roof and Automatic airport rodding systems enhance the Safety aspects. The SIS has the ability to bring down substantially the probability of incidents involving explosions, with all the attendant large outages resulting in loss of production for weeks on end. Some of these systems as well as others like Ash-Leach™ also contribute to increased availability of the boiler. Innovative methods of Metso, such as the Smelt-X™ method of removing the retained bed smelt from the hearth after a shutdown of the

boiler, would result in reduced turnarounds of the recovery boiler.

In this regard, there are many proven products or solutions commercially available, few of those have been described here, step by step.

a) Bed Smelt Extractor (Based on Suction Mechanism Via An Ejector)

During maintenance, cooling of pressure parts consumes significant time especially lower furnace which contains pool of hot smelt. After cooling, smelt solidifies and becomes hard like concrete, which is a difficult task to remove. The solidified chemicals are also lost during mechanical cleaning. Smelt extractor empties the smelt from the recovery boiler before it hardens. This means that the chemicals in the bottom of the boiler can be recovered. It also sharply reduces downtime (by up to 24 hrs).

The Smelt extractor sucks out the smelt through an ejector. A pipe is inserted into the chemical recovery boiler through each spout opening and connected with compressed air or steam line of pressure of 6 bar. The air/steam causes an ejector effect, providing the suction that moves the smelt through the pipe and down into the dissolving tank. Smelt flow varies from 3 to 7 m³/h (per ejector). An ejector can be mounted in every spout opening. Emptying the boiler usually takes 1 to 4 hours depending on the size of boiler and the number and size of ejectors used. This process is supervised with thermocouples during smelt removal and cooling of the bed.

This extraction mechanism helps in shortening the shut down time, decreases the risk of damage of pressure parts, lessens the requirement of manual cleaning work and reduces chemical losses. The extraction pipes are tailor made for the boiler to ensure optimization of the system.

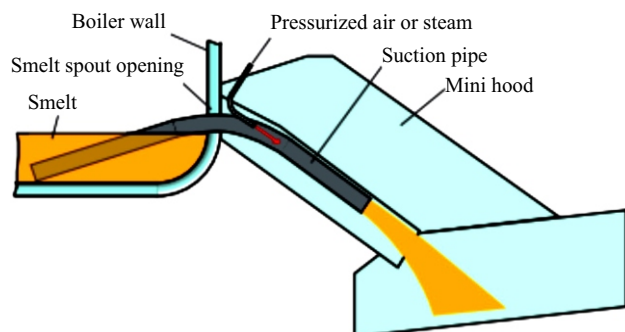


Figure 1. Typical Smelt Extraction System

b) Safety Roof

Traditionally, Temporary scaffolding has been commonly used inside the furnace for inspection of super heaters and upper furnace. Assembly of scaffolding consumes considerable time every time. There are possibilities of accidents, leading to injuries or even, in some cases, fatalities of working people, especially while cleaning and maintaining the boiler. Thus, inadequate scaffolding remains a major root cause for many accidents.

Preventing objects from falling is also essential to ensure occupational safety. Lumps of deposits from super heater have the potential risk to fall onto people who work inside the lower furnace during maintenance.

In this regard, Safety roof serves as a superior maintenance

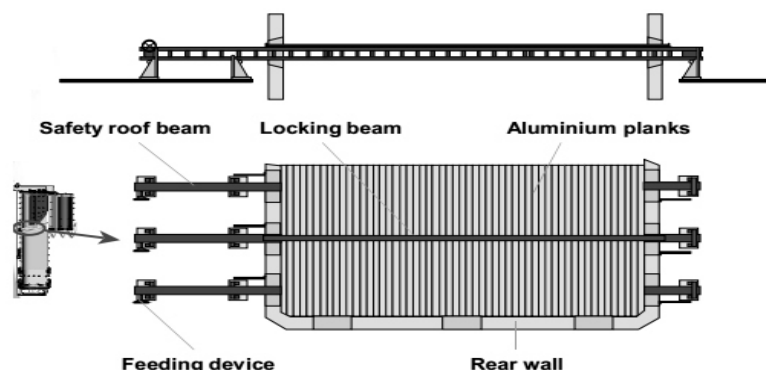


Figure 2. Safety Roof Constructional Details

platform for recovery boilers efficiently meeting the requirements of occupational safety and ensuring faster and cleaner boiler maintenance. Safety roof eliminates the risk of objects falling to the lower boiler, simplifies installation of scaffolding in the upper boiler, and reduces the cleanup requirement for the furnace. The dimensions of the safety roof are adapted to the various furnace configurations, making it fully possible to install in any size of boiler.

Safety roof consists of support beams which can be assembled quickly on the outside of the boiler using just a few sections and bolts. These beams are inserted through access openings using a simple feed stand. The aluminum profile flooring is simply inserted through the openings and secured by locking bars. Support beams are fully enclosed. Rectangular profiles constitutes of solid and sturdy full-length beams without any nooks or crannies (where dirt or corrosive matter can gather), make for easy cleaning and hence no corrosion is encountered. The roof can withstand weights up to about 3000 N/m².

c) Automatic Air-Port Rodding System



Figure 4. Construction details of Air port Rodding System

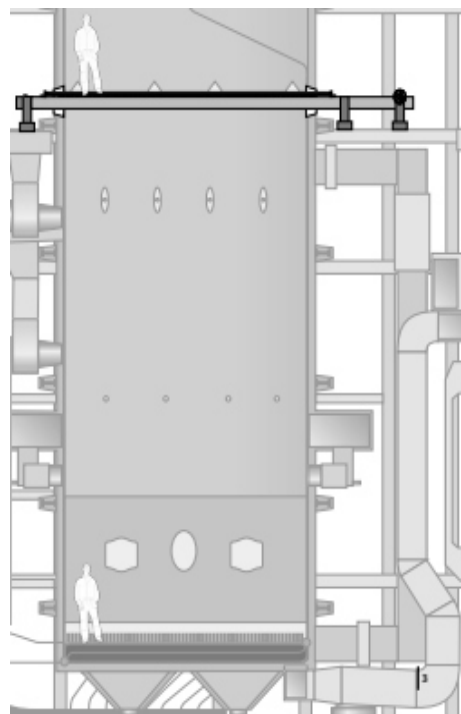


Figure 3. Typical Safety Roof arrangement

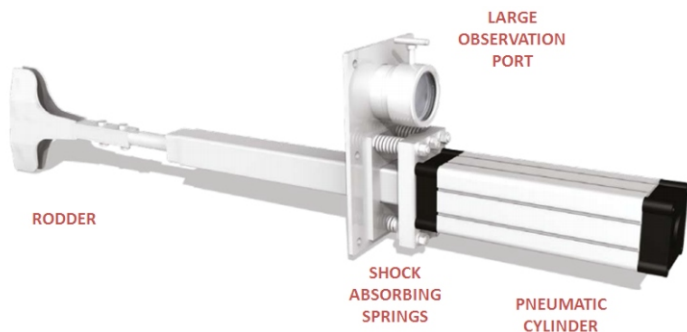


Figure 5. Typical Airport Rodder Construction

For process optimization and to keep a Kraft recovery boiler on line, it is crucial to avoid pluggage of the air and gas passages. However, automation has not been adopted in cleaning the deposits in the airports and manual cleaning of airports remains the popular and most widely used modus-operandi in India.

Furnace stability is largely affected by the combustion air system and the build-up of smelt and char that restricts the airport opening can lead to performance deterioration. A reduction in port area affects air pressure at the port/ air flow through the port. As the air ports become obstructed, the furnace will become less stable and insufficient combustion of black liquor particles will occur, resulting in carryover. This carryover leads to boiler tube depositions. It is critical that these deposits are minimized to obtain efficient heat transfer and an even flue gas flow distribution. This can be accomplished by optimizing lower furnace control. The use of multi-level automatic port rodding system promotes more stable furnace operating conditions. The system requires air at a pressure of about 5-7 bar and consumes energy of less than 10W per solenoid Valve.

In figure 6, the wind box pressure has been drawn as a function of time. It clearly illustrates that the wind box pressure fluctuates over time when manual cleaning of airports is opted while with the adoption of automatic rodder cleaning, this fluctuations can be minimized.

d) Advanced Smelt Shattering System

Smelt Shattering system plays a vital role, in recovery area, of

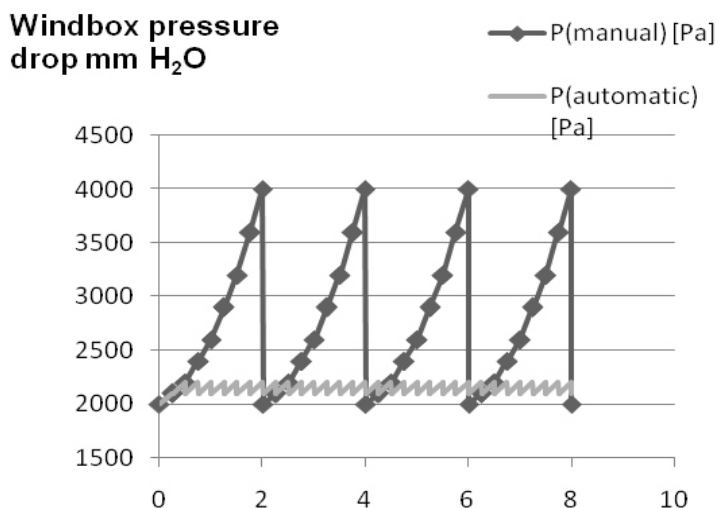


Figure 6. Wind box pressure drop as a function of time

disrupting the smelt flow by supplying the disrupting fluid to the shatter jet nozzle assembly, resulting in shattering of the smelt coming out from the Recovery Boiler.

The advanced dual shatter jet offers a substantial steam savings, which alone can pay for the retrofit in less than one year. Each shatter jet nozzle is typically fully operational with only one of the two nozzles in service. Given the extreme consequences of shatter jet failure and the need for dependable operation, the second shattering nozzle is designed to be supplied by an alternative steam source as recommended by BLRBAC (Black Liquor Recovery Boiler Advisory Committee). The back-up shatter jet supply line can be equipped with an automated control valve for emergencies and is designed for use during heavy runoffs or if a failure/loss occurs in the primary steam supply system.

The highly adjustable shatter jet brackets enable the nozzles to be accurately positioned, allowing the steam consumption to be throttled back to achieve the greatest steam savings while maintaining proper smelt shattering. The jet is positioned at such an angle as to direct the smelt shattering far down inside the dissolving tank and not inside the lower hood, which usually decreases its life span. An enormous benefit of this configuration is mill operators can safely inspect and tune the shatter jet operation without putting themselves in a dangerous position. Improper shattering is directly associated with excessive fuming, decreased density control, a louder spout deck, increased wear/build-up and ultimately more short- and long-term maintenance. The dual shatter jets are also available as a stand-alone retrofit project for any existing recovery boiler.

The smelt shattering system maximizes operator protection from smelt splatter, reduces time and cost for replacing spouts, encloses hood system maximizing reduction efficiency and minimizes tramp air intake into the dissolving tank and eliminates exaggerated flare of dissolving tank collar.

The specially designed nozzle of the system helps in improving density control, improving heavy smelt flow dispersion, minimizing steam consumption, reducing fuming and excess load on vent stack scrubber, operating the boiler when one nozzle is down and reducing wear of hoods by efficiently directing smelt shattering down inside the dissolving tank.

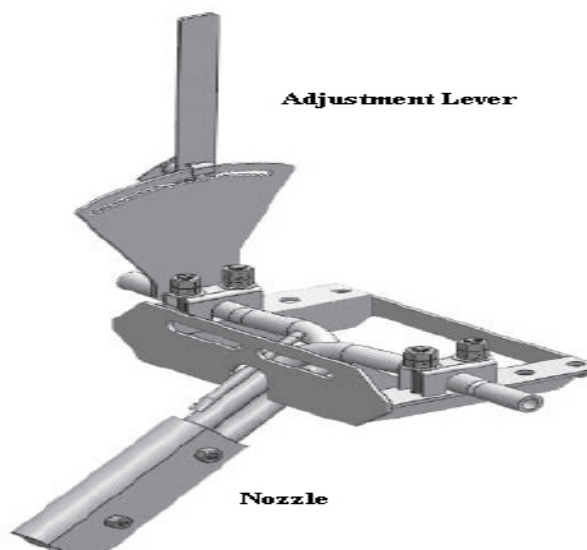


Figure 7. Typical Smelt Shattering System

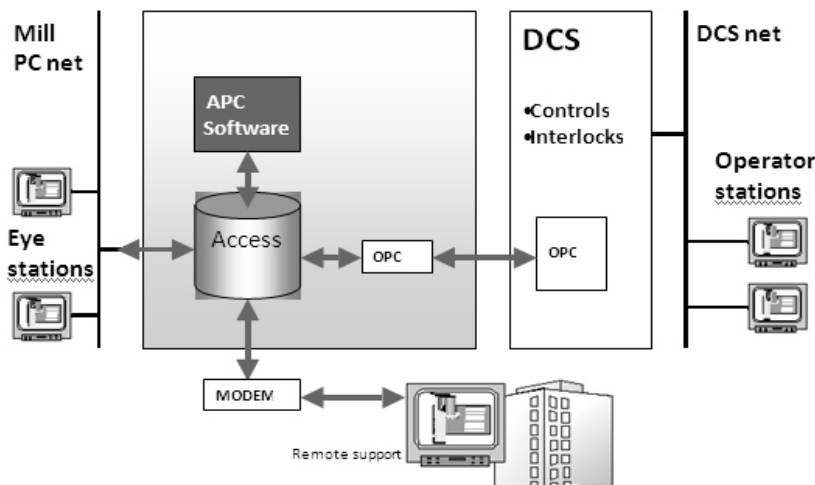


Figure 8. Architectural structure of a typical APC System

e) Advanced Process Control

With the incorporation of advanced process control loops, control system of recovery boilers helps operators and engineers to easily understand, control and improve recovery boiler operation, thus improving and maximizing recovery boiler performance.

With APC system, the mills can receive remote on-line operation and systems support directly from the specialists. Operation support, such as boiler availability follow-up, emissions evaluation, performance follow-up and sootblowing tuning can be availed via APC from solution provider located anywhere in the world. Systems support includes efficient means of tuning and making modifications to control programs

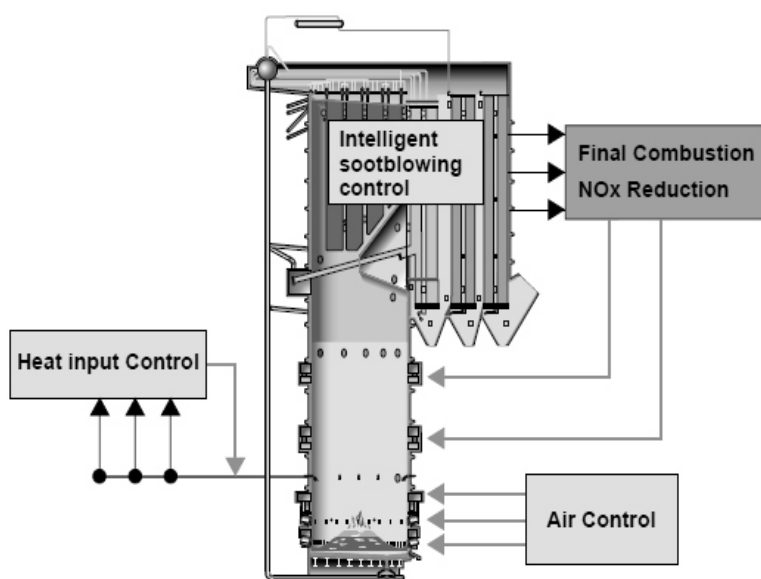


Figure 9. Benefits of APC System

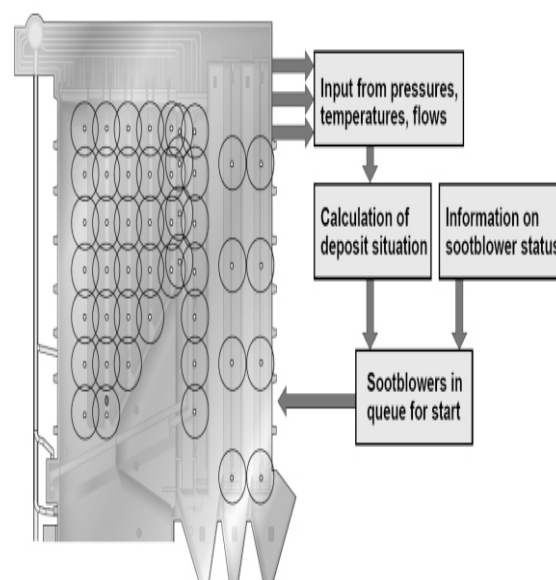


Figure 10. Optimization of Sootblowing steam using APC system

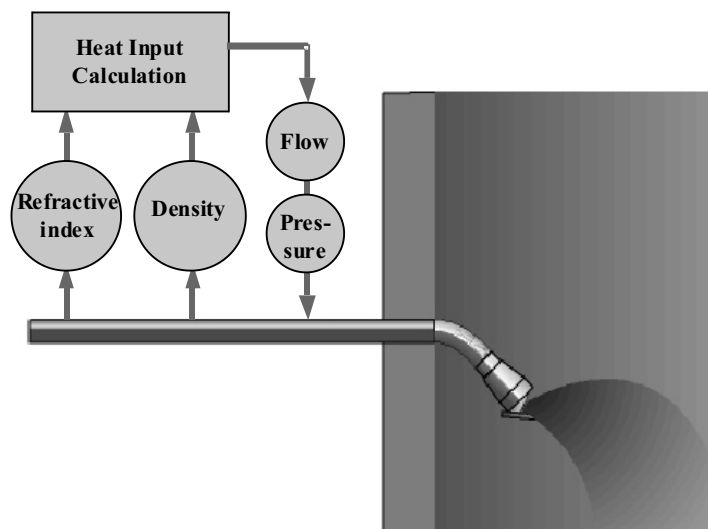


Figure 11. Optimization of Heat Input using APC system

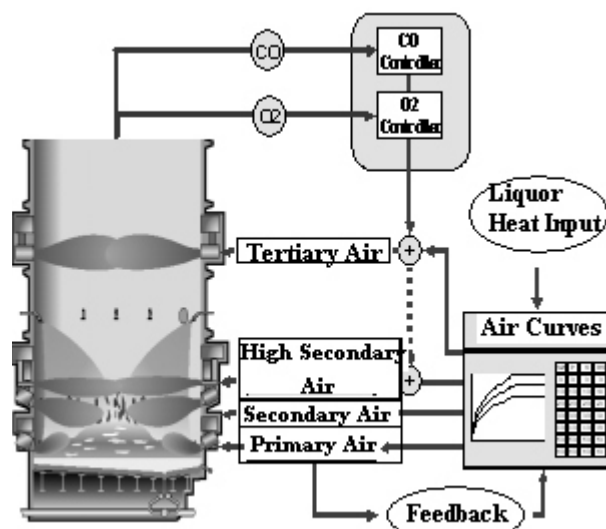


Figure 12. Optimization of Air Control using APC system

The key features of APC for Recovery Boiler are Intelligent sootblowing, Heat input control, Air control and Combustion optimization. The associated benefits are decrease in sootblowing steam consumption by 1-10%, stabilization and optimization of combustion in the higher furnace.

f) Sis (Safety Instrumentation System)

A Safety Instrumentation System (SIS) is composed of sensors, logic solvers, and final control elements for the purpose of taking the process to a safe state when predetermined conditions are violated. It helps in avoiding accidents and associated catastrophic effects. It is designed to fulfil the requirements of IEC 61508, which is an International standard that defines functional safety as: "part of the overall safety relating to the EUC (Equipment Under Control) and the EUC control system depending on the correct functioning of the E/E/PE (Electrical/Electronic/Programmable Electronic) safety-related systems, other technology safety-related systems and external risk reduction facilities". A fail-safe type PLC with IEC certified blocks are used for realisation of safety system in Boiler. The system is designed in compliance with the requirements of BLRBAC (Black Liquor Recovery Boiler Advisory Committee). The interlocks incorporated in SIS are boiler drum level & pressure limits, flue gas path open, rapid drain with emergency stop, furnace pressure limit and boiler purge.

Any failure, trip and maintenance signals are retransmitted to DCS for monitoring purpose. Critical analogue and binary signals are hardwired between the SIS and DCS. Other signal exchange are realized through MODBUS/PROFIBUS DP. The safety system does not need any monitors or operator stations (by any means) for safety reasons. All inputs / outputs are realized via DCS display.

g) Odorous Gas Handling & Incineration

Kraft pulp mills are normally characterized by a distinct foul odor. This odor is caused by sulfur compounds, referred to as

Total Reduced Sulfur, (TRS) that are generated in pulp digesters when wood is cooked with Kraft liquor. TRS can also be generated in direct contact evaporators, in recovery boilers and in lime kilns. The TRS cases involved are hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), dimethyl sulfide (CH_3SCH_3) and dimethyl disulfide (CH_3SSCH_3).

TRS gases that are emitted from digesters, evaporators, turpentine systems, strippers, brown stock washers and liquor storage tanks are contained in gases referred to as "Non-condensable Gases" (NCG) while gases collected from main dissolving tank are referred as "Vent gases".

With the increase in environmental awareness, capturing these compounds and avoiding release to the atmosphere is becoming an urgent necessity.

i. DNCG gases

The concentration of diluted non-condensable gases is below the lower explosion limit, i.e. 1-5 vol-%. Diluted non-condensable gases are formed in brown stock handling and at all the points where black, green or white liquors are treated or stored in such a way that they are in direct contact with air.

The gases typically contain droplets, which must be always eliminated by meticulous design of the condensate collection system. For this reason a droplet separator is located prior to the gas reheater. Furthermore, condensate collection pots are located down stream of the reheater. These design precautions help prevent inefficient firing of the DNCG as well as jamming and clogging of the nozzles. Introducing droplets to the recovery boiler can also cause unwanted corrosion and deposits in the recovery boiler banks.

The reduced sulphur compounds that the DNCG contains, are oxidized by combustion into SO_2 . Small amounts of DNCG can be used as combustion air at a separate concentrated NCG combustion plant, or burned in the recovery boiler. Larger amounts of DNCG are burned in the recovery boiler.

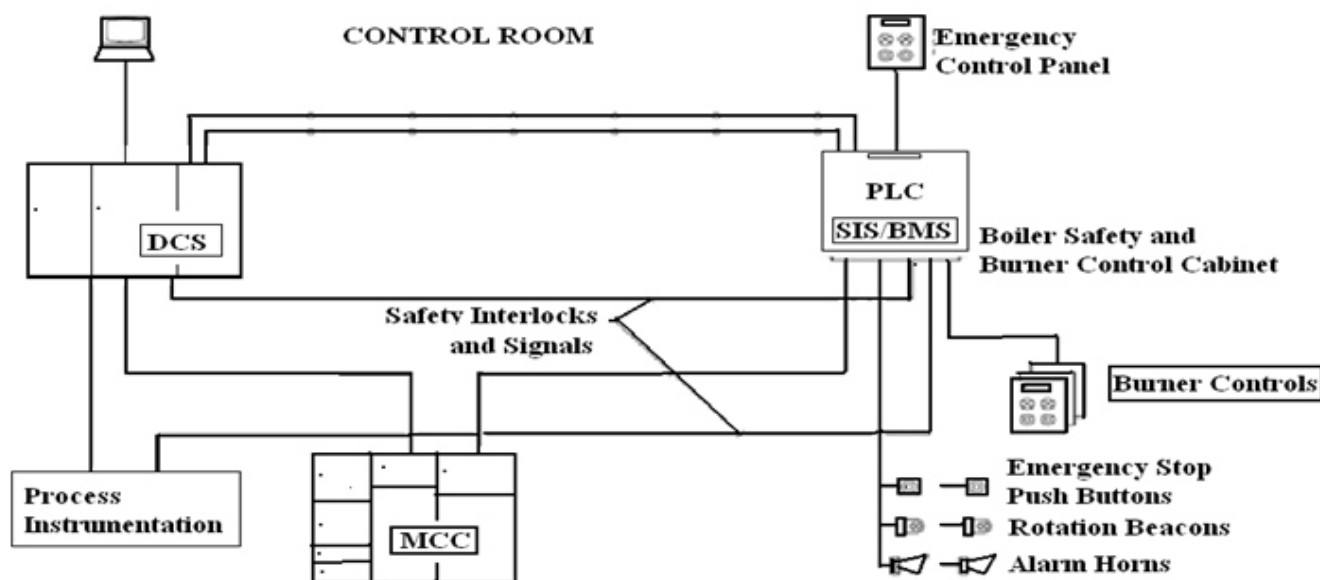
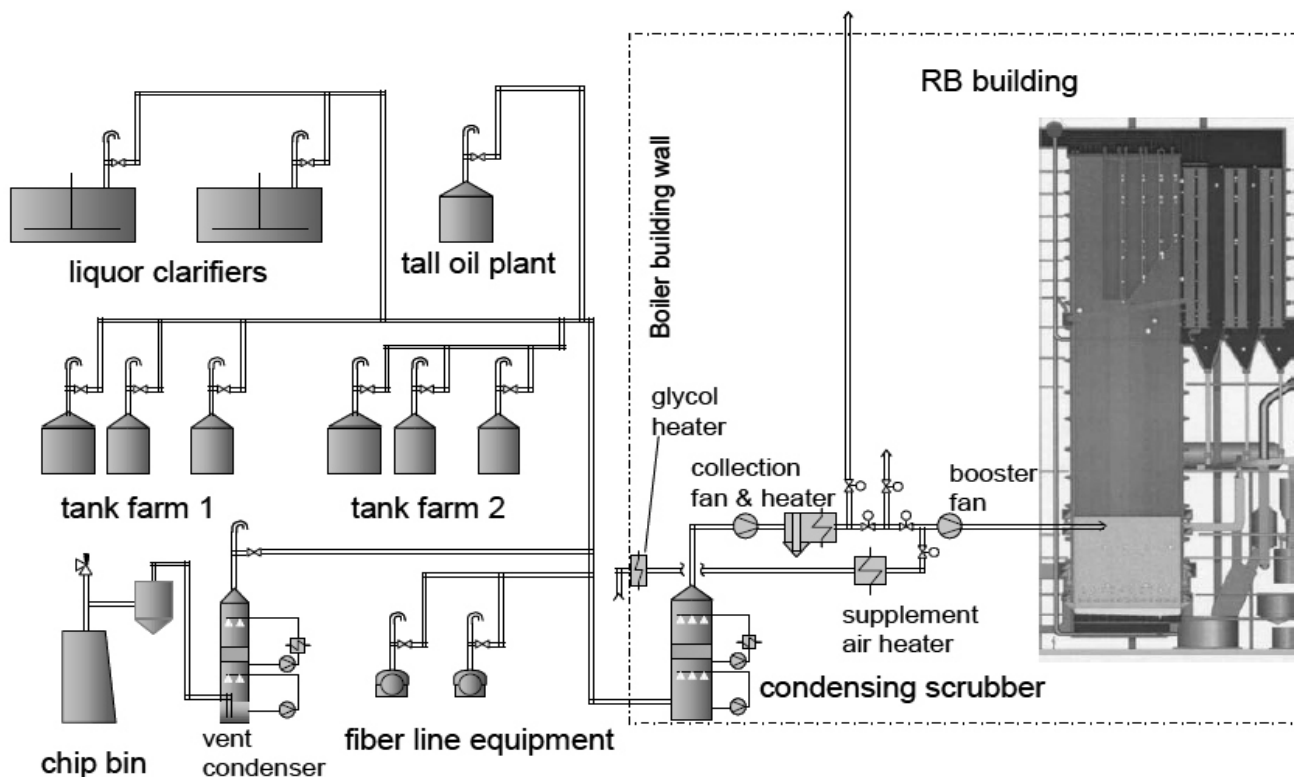


Figure 13. Architectural structure of a typical SIS System



ii. CNCG Gases

The combustion of CNCG in a recovery boiler has many advantages such as reduction in sulphur direct to the process, no separate heat recovery system is needed, the investment is cost-effective and the heat contained in the odor gases is recovered effectively.

The key sources of concentrated non-condensable gases are hot well of evaporation plant, pressurized black liquor tanks and digester. The concentrated non-condensable gases (CNCG) are collected to a collection tank (water seal) and led from there to the recovery boiler CNCG burner through a droplet separator by the means of a steam ejector. The NCG burner is located at the secondary air elevation of the furnace. Stripper off gases (SOG) are also collected and burned in the CNCG burner.

The purpose of the steam ejector is to keep the collection system under negative pressure and to forward the gas safely. The design of the steam ejector is based on the available steam pressure. Pressure close to the burner is closely regulated. Additional steam is fed into the gas

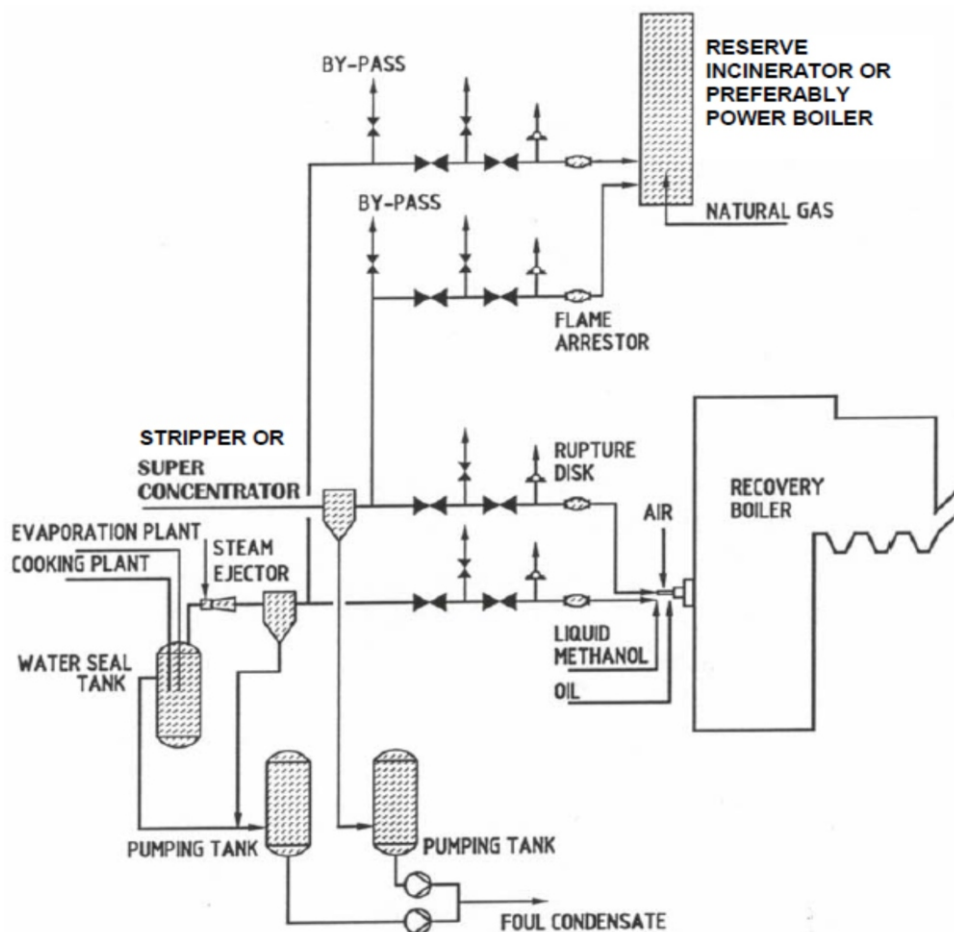


Figure 15. Schematic Diagram of a typical CNCG System

line if pressure falls below a set point, which prevents any flow from the boiler to the collection system. Furthermore, pipelines are furnished with wire mesh type flame arrestors that prevent flames propagating from the boiler to the collection system.

Other safety features include rupture discs, which are needed to direct the gases to the ambient air during excessive over pressure situations such as explosions. Droplet separators are

removes certain TRS gas species. The scrubbed gases can be used as combustion air in the recovery boiler.

When the boiler combustion air system is properly designed the weak TRS gases injected into the recovery furnace with the dissolving tank vent gases are efficiently oxidized and captured as salt cake in the precipitator. The emissions from the recovery boiler stack remains low and practically unchanged.

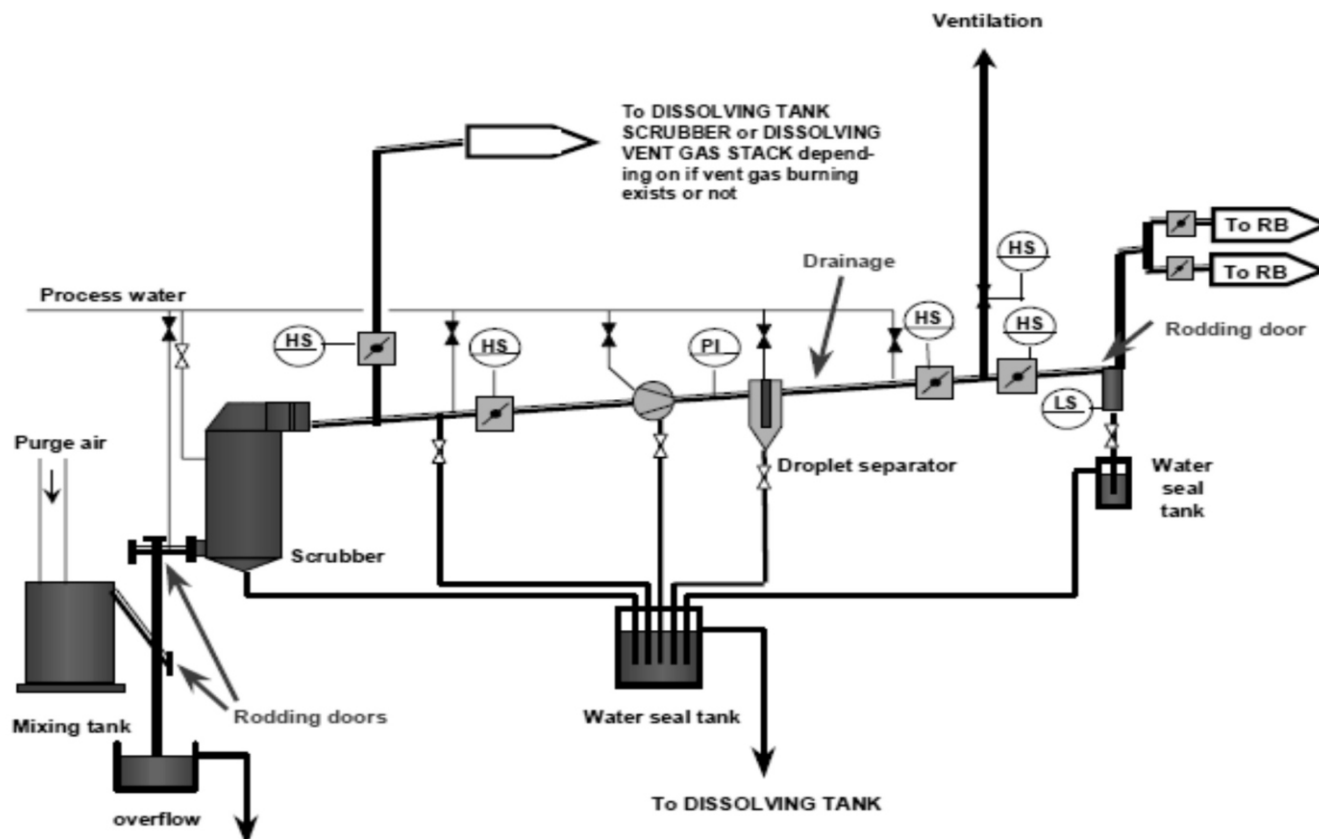


Figure 16. Schematic Diagram of a typical Vent Gas Scrubbing System

required to prevent liquid flow to the incineration point. The chevron type droplet separator element is positioned vertically inside the unit to generate the best available separation efficiency. All condensates from CNCG and SOG systems in the boiler area are collected to pumping tanks and pumped to the evaporation plant (foul condensate tank).

iii. Dissolving tank vent gas

In the dissolving tank, molten smelt from the recovery boiler is dissolved in water to generate green liquor. During this process a large amount of gases with high water vapor content are generated. These gases are laden with TRS gases and particulates.

Vent gas from the dissolving tank is first cooled in a direct contact condensing scrubber. Cooling the gases condenses moisture from the gases. Using alkaline scrubbing solution with sodium hydroxide (NaOH) chemical addition, vent gas scrubbing system eliminates all of the direct dissolving tank vent emissions by conditioning the dissolving tank vent gases. Mechanical action in the scrubber also removes some particulates while contact with the alkaline scrubbing solution

h) Ashleaching

AshLeach is a uniquely simple and effective system for recycling precipitator ash to save money, recovery boiler and the environment. The traditional purging of recovery boiler ash from electric precipitators wastes valuable make-up chemicals, and yet, closing the kraft mill process further by recycling this ash brings about enrichment of chlorides and potassium in the liquor cycle; causing corrosion, cracking, and plugging in recovery boilers. AshLeach treats precipitator ash in a two-step process in which sodium sulfate is recycled, meaning big chemical savings, and boiler-damaging chlorides and potassium are removed.

A part or whole of the ESP ash, which is fed to the black liquor ash mixing tank, is diverted to the Ash leaching tank.

In the first step of the leaching process, ash and water are mixed into slurry. Most of the sodium sulphate remains solid while most of the chloride and potassium dissolve. For each different type of ash it is essential to achieve optimum characteristics for highest removal and recovery performance. This is attained through pH control based on dosing acid into the slurry. In the

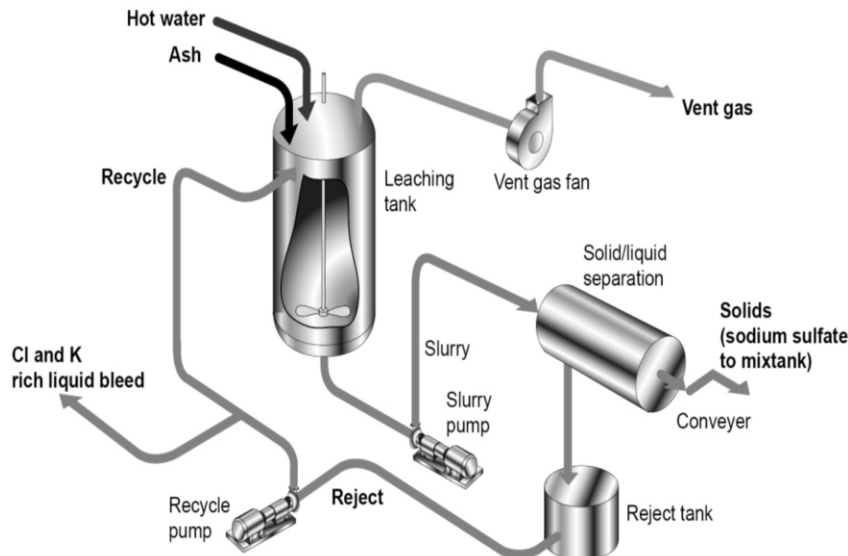


Figure 17. Schematic Diagram of a typical Ash Leaching System

second step, the liquid fraction is separated from the solid fraction by a centrifuge. The liquid fraction, which contains most of the chlorides and potassium, is led to wastewater treatment. The solid fraction, primarily containing sodium sulphate, is returned to the liquor cycle.

The key associated benefits of AshLeaching system are

- Good removal of chlorides and potassium
- Good recovery of cooking chemicals
- Low consumption of utilities (low electricity, zero steam)
- High availability

Easy operation since total system is confined to recovery boiler.

Conclusion

Energy costs represent as much as thirty percent of the total

manufacturing cost of paper in a pulp and paper mill. Recovery boilers have a significant influence on mill energy costs because they utilize black liquor, an in-house bio-fuel, to generate steam - which in turn is used to produce energy. It is thus vital that the availability and productivity of the Recovery Boiler be maximally optimized.

A number of products and systems are available globally to enhance the operatability, availability, safety and environment-friendliness of the Recovery Boiler, as detailed in the paper.. It is important for Indian pulp & paper mills to implement these proven technology solutions in order to bring performance to the next level.

By incorporating these state of the art products or solutions, mill owners will not only be able to address their HSE & performance related concerns but would also be able to maximize their gains from the in-house Bio-fuel i.e. Black Liquor. Thus, proactive mills will be able to gain a competitive edge over their peers.

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Table 1: Key world-wide references of the products and systems discussed above:

SMELT-X™ (Hearth Smelt Extraction System)	ASH-LEACH™	ODOCON™ (NCG & Vent gas gas firing)	SAFETY ROOF	RODDING MASTER™ (Airport rodding system)	BLRBO-ROSE™ (Advanced process control for recovery boiler optimization)
Stora Enso , Oulu, Finland Pietarsaari, UPM Kymmene, Finland Nordic Paper , Bäckhammar, Sweden International Paper , Svetogorsk, Russia	Horizonte Brazil, 230 t/d UPM Kymi Finland, 109 t/d Celbi Portugal, 163 t/d SAPPI N'godwana South Africa 50 t/d) Double A , Thailand 85 tpd (x2)	Kymi Paper Mill Suzano Paper Celulose S.A. Arauco Constitution , Chile RAPP , Indonesia	SCA Munksund Munksjö, Sweden Aspa , Sweden Aracruz , Brasil	Skärblacka Sweden Canfor Canada Suzano Brazil AR Thailand Oji China DMI US	Indah Kiat Perawang, Indonesia Suzano Celulose Papel S.A. , Brazil April Group , Indonesia