High Energy, Eco-Friendly, Recovery Boiler Concept

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ABSTRACT

In today's dynamic competitive world, the process industries, including pulp and paper industries, are struggling with the challenges to meet the energy and environmental benchmarks set by technological advancements of the modern age.

Heightened environmental awareness, coupled with stringent standards laid by regulatory authorities, ever increasing energy costs, tight competition for product quality are driving greater interest in optimised mill operations, energy efficient and eco-friendly technologies. As a result, many corporations are beginning to rethink their approach to energy and environmental management.

Historically, most organizations took a defensive, compliance-oriented approach to the environment, focusing on delayed or lax regulation, and implementing end-of-pipe solutions. Today, the pulp and paper industry globally is undergoing a role transition from being merely pulp or paper manufactures to being bio-energy producers as well. The impact of these trends are clearly visible in the changing outlook of industry towards recovery boilers, from being merely combustion furnaces recovering chemicals, to power boosters and sulphur capture equipment, thereby adding more value to the organization, industry, and society. Changes in the energy cost and tight environmental regulations have led the industry to look for various options to achieve holistic energy balances.

Introduction

The main role of the recovery boiler is the recovery of valuable pulping chemicals, in a reliable and safe way, and the technology in this aspect has been conventional and well-proven. The second function of the recovery boiler is to utilize the heat content of the organic matter in the black liquor. It is in this area that competitive methods have evolved for higher power generation with higher efficiencies, without compromising or jeopardizing the safety and availability factors. This paper discusses some of the less explored areas of improving mills captive power generation by optimizing the energy balance of the recovery boiler envelope. Combinations of these methods have already been implemented in many mills around the globe.

Improving The Overall Efficiency Of The Recovery Boiler

The overall efficiency of the recovery boiler can be improved by various ways such as increasing dry solids content of the black liquor, dispensing with direct-contact evaporation and replacing with economizers, having multi-level combustion air system, usage of energy efficient soot-blowers, increasing the feed-water temperature before the economizer, choosing higher operating pressures/temperatures of steam, and increasing the combustion air temperature of primary and secondary, and even tertiary air. The change in the above parameters eventually results in the increase in steam generation, thus resulting in higher power generation.

While it is true that India has ample coal reserves, looking at the future scenario of mega and ultra-mega power projects on the anvil, and considering the vagaries with respect to assured coal supplies, quality, price, ash content, transportation etc, it makes economic sense to increase generation of steam and power from recovery boilers, which use in-house available biomass as fuel.

Although budgets are always a constraint in choosing the best option (for example, choosing a pressure cycle of more than 65 bar and higher black liquor sulphidity levels call for the usage of composite material in lower furnace of recovery boiler), it is always advisable to go in for the most efficient option as the return on investment on high efficiency system is better over a longer period.

Conventional recovery boilers in India operate with pressures of 45 or 65 bar, and steam temperatures of 420 to 465 °C. “As fired” black liquor concentrations vary from 60% to 72% dry solids. Temperature of feedwater entering the economizer are between 110 to 130 °C; combustion air temperatures are 150-160 °C, with tertiary air being at ambient temperature. The Mills' Steam turbines are normally of the extraction-cum-back pressure type, with or without condensing. The methods available for increasing power generation from recovery boiler are presented here, step by step.

Air Preheating

Air preheating with steam is one way to increase steam generation. Normally, combustion air temperature of 160°C can be achieved with about 12 bar(a) extraction steam.

For higher air temperatures, an additional high-pressure extraction zone is needed from the turbine. In pulp and paper mills, steam at a pressure higher than 12 bar is seldom needed from the process point of view. But, with a 90 bar steam pressure boiler, when coupled with turbine extraction steam source for soot blowing, air temperatures of 190 °C can be achieved.

Sootblowing Steam

Soot-blowing steam is generally taken after the primary super-heater, or from recovery boiler main steam outlet line. The pressure of this steam is reduced through reducing valve, orifice, poppet valve etc, to a final blowing pressure of around 16-25 bar. No energy is recovered in this process of pressure reduction. With the build-up of chlorides and potassium in the liquor circuit, soot blowing is a near-continuous requirement, for maintaining boiler cleanability and availability. This steam amount can ideally be allowed to expand in the turbine to the required pressure, generating electric power as it does so. Again, this may require an extra extraction zone for the turbine, but combined with the high air preheating arrangement described previously, the results are attractive. Additionally, from the turbine point of view it is advantageous to have a continuous steam flow through this extraction. In such a case, a constant steam flow to the air preheater smoothes out the fluctuating effect of sootblowing steam.

Feed Water Preheating

Feed Water Tank

Feed water temperature of 115°C can be increased to 135 or even 145 °C in the feed-water deaerator/ storage tank with the available low pressure steam at 3.5 to 4 bar pressure. This will lead to a higher flue gas exit temperature but also leads to increased steam generation, and the net energy gain is still attractive

a. High-Pressure Feed Water Heaters

b. Feed water can be heated further from 145°C with high-pressure preheaters. In this connection steam is needed from the turbine extractions. There are some elements that limit the temperature of feed water. As the temperature of flue gases increases simultaneously, one limiting factor is the operating temperature of the electrostatic precipitator.

It is also possible to locate the high-pressure feed water preheater between the economizers. In this case the temperature of feed water to the first economizer can be lower, but preheating steam at a pressure higher than 7.5 bar is needed between the economizers, to heat the water upto 166 °C. This would be suitable for boilers with 90 bar and above steam pressures, since saturation temperatures are higher.

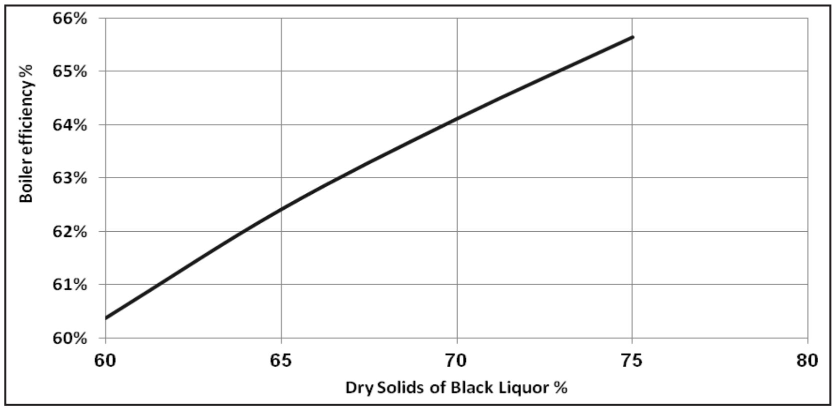
There are means of recovering heat from the clean flue gas after precipitator, but that subject is not part of this paper.

Increased Dry Solids Content

Increasing the black liquor's dry solids content increases the boiler efficiency, since the flue gas loss decreases and the heat needed to evaporate moisture from black liquor is lower. However, the evaporation plant needs more low-pressure steam to produce higher dry solids, but the net effect is still fairly high. Of course, there are limitations to the extent that dry solids can be increased, especially with agro based liquors, owing to viscosity and other factors.

Figure 1 is an indication how boiler efficiency increases with liquor concentration.

Figure. 1 Boiler effiency as a function of dry dolids contents of black liquor



Increased Steam Parameters

Temperature and Pressure

Increased main steam pressure and temperature are effective ways to achieve increased power generation. However, the main barriers to increased steam parameters in recovery boilers are the materials of the heat transfer surfaces of the boiler. Corrosion of the furnace walls due to sulphidation and molten-phase corrosion in the superheater area and floor tubes are the biggest concerns related to steam parameters.

Increasing superheated steam temperature has a marked positive impact on power generation, but it also increases corrosion of superheater heating surfaces, more so with increased levels of potassium and chlorides. Thus, material selection of superheaters and limiting potassium and chlorides in the black liquor need to be addressed while deciding to increase steam temperatures.

Increasing superheated steam pressures to 90 bar and above also gives substantial increase in power generation, but would necessarily call for composite tubing in the lower furnace zone.

With composite tubing in lower furnace, high suphidity liquors can be handled safely in recovery boilers, and odorous gases like CNCG, SOG can be combusted without increasing emission of sulphurous compounds, since the recovery boiler is very effective in sulphur capture.

Vent Gas Heat Recovery

The Smelt Dissolving Tank in recovery boiler releases substantial heat through the vent stack, besides being a source of emission of TRS compounds to the atmosphere. Systems are available nowadays to remove the TRS compounds by scrubbing the vent gases, and also recovering the heat e.g. for cold DM water preheating, before being let off to the atmosphere. The scrubbed and condensed gases, containing mostly air, can even be taken back into the furnace as part of secondary air. Figure 2 depicts such a system

Figure 2: Vent gas System

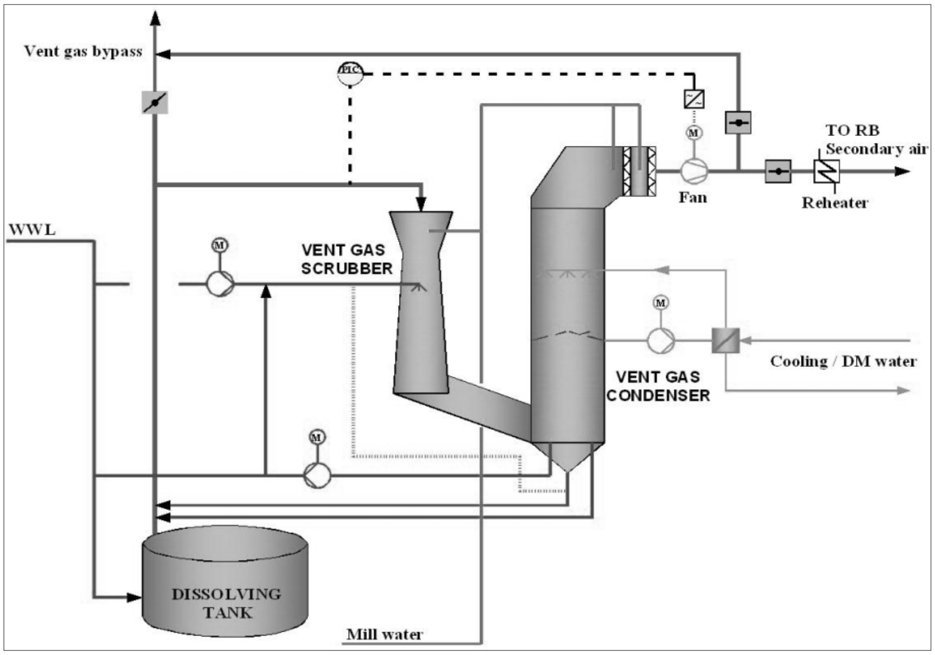


Table 1 shown below gives an indication about the increase in power generation that can be achieved in a recovery boiler of 1000 tds/d, by adopting the different methods explained earlier. Extraction-cum-back pressure turbine has been considered, with no condensing.

Table 1 Power Generation From Recovery Boiler with different operating parameters

Description	Units	Base Case	Case 1	Case 2	Case 3	Case 4	Case 5
Capacity	tds / Day	1000					
Steam Pressure	Bar(a)	65	65	65	65	90	90
Steam Temperature	°C	465	465	480	480	480	480
Concentration	%	60	65	70	75	70	75
Feed Water Temp	°C	115	135	135	135	135	135
Pri mary/ Secondary Air Temp	°C	150	160	160	160	190	190
Tertiary Air Temp	°C	30	30	30	30	190	190
Soot Blowing Steam Source		Internal	Internal	Internal	Internal	External	External
Power generation (Approx)	MW	17.9	19.2	20	20.5	23	23.5

Table 2 Key-reference list for the application of the concept

UPM Kymi, Finland	**Grande Prairie, USA**	**Stora Enso Skoghall, Sweden**	**Celbi , Portugal**	***Aracruz Guaiba, Brazil***
3600 tDS/d, BL 83.9% conc (virgin), 102 bar, 505°C, 169 Kg/s, Kraft process, Interheater Air heating to 190°C Low pressure sootblowing (13,5 bar in economizers)	2180 tDS/d, 103 bar, 510°C, 93 Kg/s, Kraft Process	2200 tDS/d, 108 bar, 500°C, 89 Kg/s, Kraft process	2400 tDS/d, 90 bar, 480°C, 116 Kg/s, Kraft process Interheater Air heating to 190°C Heat recovery from flue gases (to demineralized water)	2200 tDS/d, 64 bar, 455°C, 109 Kg/s, Kraft process Feed water preheater Air heating to 180°C

Conclusion

This paper highlights some of the methods available to enhance the efficiency and power availability from a recovery boiler. For a green field project, all of the methods described in this paper can be adopted and there are instances worldwide where they have been put to practice. In existing plants it will not be feasible to implement some of the features. In such cases better efficiency can be achieved by improving the solids concentration, soot blowing efficiency, air distribution system, feed-water preheating, and vent gas heat recovery. Understandably, case-by-case optimization is needed because process steam consumption and the use of a condensing turbine also must be taken into consideration together with the price of electricity in the region. Further, allowances need to be made for the configuration of the Mills' existing steam and power cycle system, including the power boilers.

Literature Cited

1. Antti Raukola, Tuomo Ruohola And Aki Hakulinen "Increasing Power Generation With Black Liquor Recovery Boiler" 2002 TAPPI Fall Conference & Trade Fair (2002)
2. Tran, H., Arakawa, Y., "Recovery Boiler Technology in Japan", 2001 TAPPI Engineering Conference, San Antonio, Texas. (2001)
3. Syberg, O., Barynin, J., and Sinclair, M., "Pulp Mill Power Generation Trend to High Pressure Recovery Boilers", proceedings from the 1997 TAPPI Engineering & Papermakers Conference, Nashville, Tennessee (1997)
4. Mäkilä, I., Raiko, M., Tuppurainen, T., and Jeskanen, R., "More Efficient Power Plants for Pulp and Paper mills", Paperi ja Puu Paper and Timber vol. 81, No.7, pp. 495-498 (1999).