Development of Recovery Boiler Technology – Present View

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ABSTRACT

Development of recovery boiler technology has focused mainly on three streamlines over the last years: sustainability, safety and reliability and process optimization using advanced process controls, smart sensors and digitalization.

Since the usage of the machinery contributes roughly 95% of the environmental impact during the lifetime, there has been a high focus to minimize air emissions, solid waste and effluent streams. Increase in furnace floor loading (MW/m^2) and in unit size have both enabled higher production per utilized steel weight. Additionally, increasing main steam parameters and adding high power features to increase steam generation and decrease extraction steam consumptions have increased the boiler efficiency and further, increased the electricity production. Compared to conventional recovery boiler, a modern recovery boiler can produce even 20% more electricity.

As modern mills require minimal solid waste and liquid effluents, they have become very efficient and closed systems. Natural potassium and chlorine losses through e.g. ash dumping, green liquor dregs and along with the pulp losses have decreased. Another example is that recycling bleach plant filtrates increases chlorine input to the boiler. This means that potassium and chlorine concentrations have increased making it more challenging to maintain high boiler loading without cleanability issues and set limits to the main steam temperature. The latter challenge has become an optimization question whether better and more expensive stainless steel materials are needed in superheaters or potassium and chlorine levels are lowered using ash treatment technologies, such as ash leaching or crystallizer.

Modern recovery boilers with high floor loading and high dry solids do not generally have SO_2 or TRS emissions. However, NO_x and dust emissions still remain but clearly the trend in both is declining. To decrease NO_x emissions, in addition to air staging, new secondary methods have emerged: selective non-catalytic reduction (SNCR), selective catalytic reduction (SCR) and NO_x scrubber. If lower end of the BAT-requirements (best available technology) or even lower levels are needed, some of the secondary methods need to be involved. Correct technology depends on the NO_x reduction requirement and OPEX/CAPEX evaluation. The size and number of electrostatic precipitators (ESP) units have increased to meet the lower end of the BAT-requirement.

Nowadays there is a high focus on personal safety and therefore Valmet pays a special attention to select correct pressure part materials in critical areas where smelt-water explosions are possible. In practice this means that sufficient alloy 825 coverage in furnace floor and openings are promoted to enable safe and reliable operation for decades. Additionally, many boilers are equipped with smelt spout robot and online reduction rate analyzer to minimize working in the critical smelt spout area. Also, black liquor guns are retractable and equipped with safety doors to enable safe operation during black liquor gun maintenance.

Burner solutions are safe and reliable for auxiliary fuel and odorous gases. Advanced leak detection gives fast alarms and can even point out the possible leak location. Safety system is fully integrated with Valmet distributed control system (DCS).

Valmet has a long experience on developing and implementing advanced process controls (APC) to recovery boilers to optimize the boiler operation (e.g. emissions, thermal and chemical efficiency, cleanability, safety) and to decrease the operator interaction. Some of the APC require additional smart sensors, like reduction rate or ash analyzer, furnace cameras and acoustic pyrometers. These sensors enable reducing the operator involvement even further and paves the way towards autonomous operation. One recent innovation example is using furnace cameras to obtain 3D-model of the char bed. This information can be used to stabilize the char bed size automatically, without operator interference. When this is coupled with acoustic pyrometer, combustion symmetry and carryover can be controlled as well. Another example is measuring recovery boiler ash online and mitigating superheater corrosion and fouling risks with minimal operation costs.

Digitalization has breached also to recovery boilers during the last years. Nowadays, remote connections are utilized and together with cloud-based solutions and applications, plant performance can be improved further. This can be even further enhanced with remote support when needed. One example of cloud-based applications is Valmet recovery boiler combustion diagnostics which utilizes cloud computing and computational fluid dynamics (CFD) to support in boiler tuning and troubleshooting works.

To summarize, modern recovery boiler is a highly loaded piece of equipment, packed with high power and safety features and automation solutions. The unit size of not only the recovery boiler, but also flue gas handling system and ash treatment have increased tremendously over the years to achieve industry's sustainability targets. New ways of utilizing data have been innovated and most probably trend continues the same way in the coming years.