Recovery Boiler Optimization and Environmental Compliance

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Abstract

During recent years, European legislation has dictated that operators of industrial installations prevent, or reduce pollution from their operation, (The Directive on Integrated Pollution Prevention and Control 96/61/EC)[1]. The objective is to achieve a high level of protection of the environment through measures to prevent or, where that is not practicable, reduce emissions to air, water and land. The IPPC Directive and resultant local regulatory initiatives have placed great demands on the control and operation of the recovery boiler, a major source of atmospheric emissions in a kraft pulp mill. Metso Automation has been working with customers and gaining valuable experience in several aspects of improved recovery boiler control. The systems developed are operating with equal success on existing older designs of boiler as well as state-of-the-art new installations. This paper shows how process control optimization for improved combustion control and boiler load levelling together with comprehensive emission monitoring and reporting solutions support best available techniques (BAT)[2] for the pulp mill to achieve sustainable environmental compliance that meets present and future planned legislation.

Keywords

Recovery Boiler, emissions, environment, process control, Best Available Techniques (BAT)

Otimização de Caldeiras de Recuperação e Conformidade Ambiental

Resumo
Nos últimos anos, a legislação européia tem ditado às instalações industriais a prevenção ou redução da poluição ocasionada por suas operações (A Diretriz de Prevenção e Controle Integrado da Poluição 96/61/EC). O objetivo é alcançar um alto nível de proteção do meio-ambiente através de medidas que previnam ou, onde isso não for possível, reduzam as emissões para a atmosfera, águas e solo. A Diretriz do IPPC, juntamente com iniciativas de órgãos reguladores locais, tem imposto várias demandas para controle e operação das caldeiras de recuperação, uma das principais fontes de emissão atmosférica das fabricas de papel e celulose. A Metso Automation tem realizado trabalhados conjuntos com seus clientes e tem ganho experiências valiosas em diversos aspectos para a melhoria do controle das caldeiras de recuperação. Os sistemas de controle desenvolvidos estão operando com o mesmo sucesso em modelos mais antigos de caldeira, bem como nas instalações mais modernas. Este artigo apresenta como a otimização do controle de processo para melhoria do controle da combustão e nivelamento da carga da caldeira, juntamente com monitoração de emissões e relatórios de processo, suportam as melhores técnicas disponíveis (BAT) para que as fabricas de celulose alcancem conformidade ambiental sustentável, satisfazendo a legislação atual e futura.

PALAVRAS CHAVE

Caldeira de Recuperação, emissões, meio-ambiente, controle de processo, Melhores Técnicas Disponíveis (BAT).

Background

The IPPC Directive provides an integrated approach to establish pollution prevention. As part of the overall strategy it stresses that the most effective measure for the reduction of emissions is the implementation of the best available process and abatement technologies in combination with the following: -

- Training, education and motivation of staff and operators;
- Process control optimization;
- Sufficient maintenance of the technical units and the associated abatement techniques;
- Environmental management system that optimizes management, increases awareness and includes goals and measures, process and job instructions etc.

The integrated approach means that the permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure. For the recovery boiler, optimization through improved process control has shown to have a great effect in reducing emissions.

Emissions

Emissions to the atmosphere originate from the recovery boiler, lime kiln, bark furnace, chip storage, cooking digester, pulp washing, bleaching plant, bleaching chemical preparation, evaporation, screening, washing, white liquor preparation, and various tanks. The main point sources are the recovery boiler, the lime kiln and bark boilers.

For bleached and unbleached kraft pulp mills the BAT emission levels to air from the kraft pulping process are shown in the following table. The emission levels refer to yearly averages and standard conditions. Emissions from auxiliary boilers are not included.

Dust	SO2 (as S)	NOx (NO+NO2 as NO2)	TRS (as S)
0.2-0.5 kg/Adt	0.2-0.4 kg/Adt	1.0-1.5 kg/Adt	0.1-0.2kg/Adt

Table 1. Achievable emission levels for a kraft pulp mill using best available techniques[2]

The values refer to the contribution of the pulp production only and are intended as a guide to what can be achieved. The actual permit limits for the recovery boiler are set by national and local authorities and take into account local regulations and circumstances. The actual conditions of the permit may also affect the degree of monitoring and reporting required as well as short term versus long term emission limit averages and permitted peak levels.

Minimizing Recovery Boiler Emissions

Best available techniques for reducing emissions from the recovery boiler are:

- Reduce TRS emissions by efficient combustion control and CO measurement;
- Control SO2 emissions by firing high dry solids concentration black liquor and/or by using a flue gas scrubber;
- Control of NOx emissions by ensuring proper mixing and division of air in the boiler
- Flue gases cleaned with efficient electrostatic precipitators to mitigate dust emissions.

Good process control and some form of upper-level supervisory controls for the recovery boiler and evaporation process are essential for the first three emission control techniques. Recovery boiler optimization relies on coordinated control of black liquor burning, air feeding and furnace processes to stabilize the burning process. The objectives are to increase safety and improve efficiency as well as reducing emissions. Feedforward controls, which recognize changes in production rate, liquor temperature and specific gravity; adjust liquor viscosity to get the optimum droplet size (Figure 1)

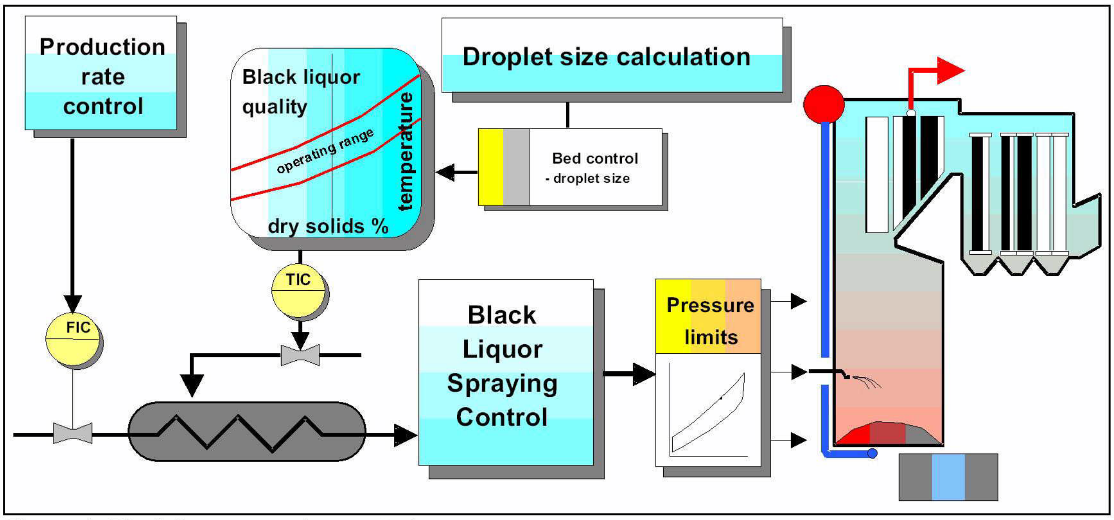

Figure 1. Black liquor spraying control

Additionally, combustion air controls improve the degree of reduction, decrease sulphur emissions and improve the cleanliness and efficiency of heat transfer surfaces (Figure 2). Residual oxygen, carbon monoxide and boiler temperature profile measurements provide feedback for the control optimization package. The result is more stable operation with an increased reduction degree, optimal excess oxygen level, and reduced flue gas emissions. The more stable furnace operation also tolerates black liquor quality deviations while maintaining maximum heat generation with the virtual elimination of SO2 and TRS emissions.

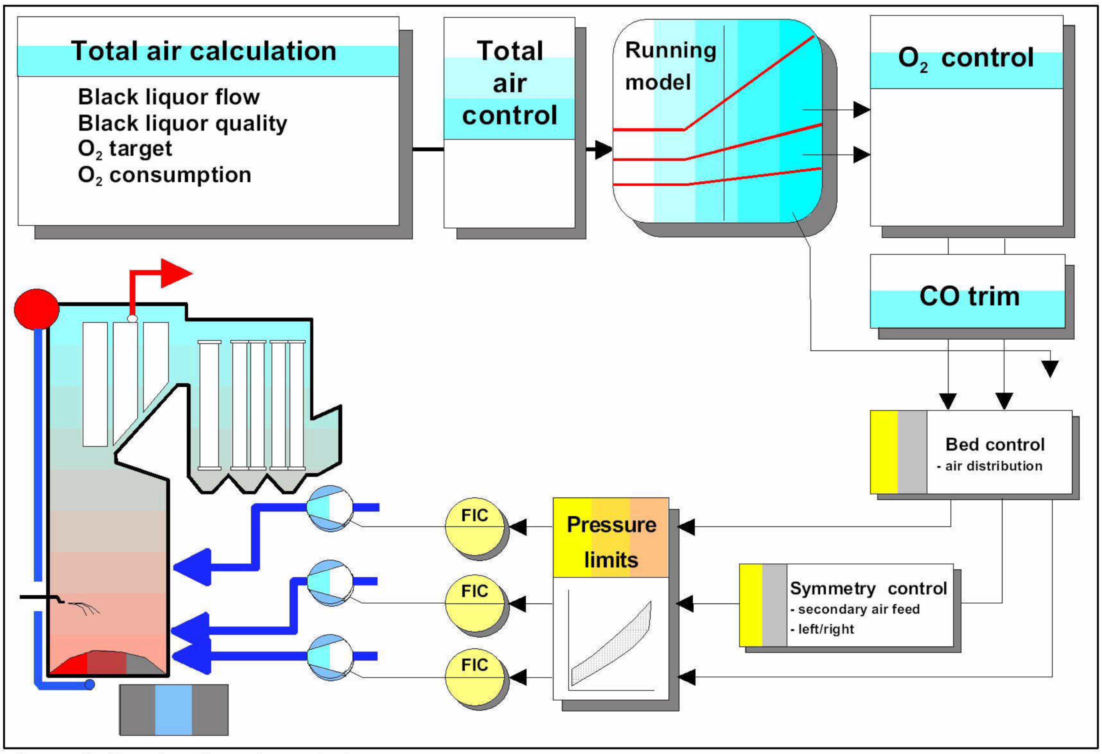

Figure 2. Combustion air control

Boiler section fouling, which reduces thermal efficiency, is constantly monitored by calculating the heat transfer coefficients of the various surfaces in the boiler. Changes in heat transfer distribution indicate which heat transfer surfaces need soot blowing thus helping to direct the soot blowing to correct positions. Sootblowing is scheduled only when needed, without wasting steam or production time. By storing historical data, long term monitoring of gradual deterioration, such as accumulation or blockages, can be made with corrective action scheduled before they cause unpredicted shutdowns.

A stable steam network for lower emissions

Stable recovery boiler operation for lower emissions is also reliant on stabilizing the load. Model predictive controls (MPC) have been successfully used to combine steam demand, steam generation and network pressure information to maintain stable conditions in the steam headers. The multivariable model predictive control system enables precise control of the steam network (Figure 3).

The system keeps steam pressure and temperature within set limits, efficiently manages fast changes in consumption and gives load setpoints to boiler units. It also uses compensating process components (deaerators, dump condensers etc.) to soften disturbances in the steam network. Steam load leveling reduces the speed of load fluctuations to the boiler, which helps to reduce emissions, improve the utility ratio and reduce the risk of boiler damage. In case of production disturbances, compensators can discharge steam instantaneously from the reserve while standby boilers are given time to run up to full output.

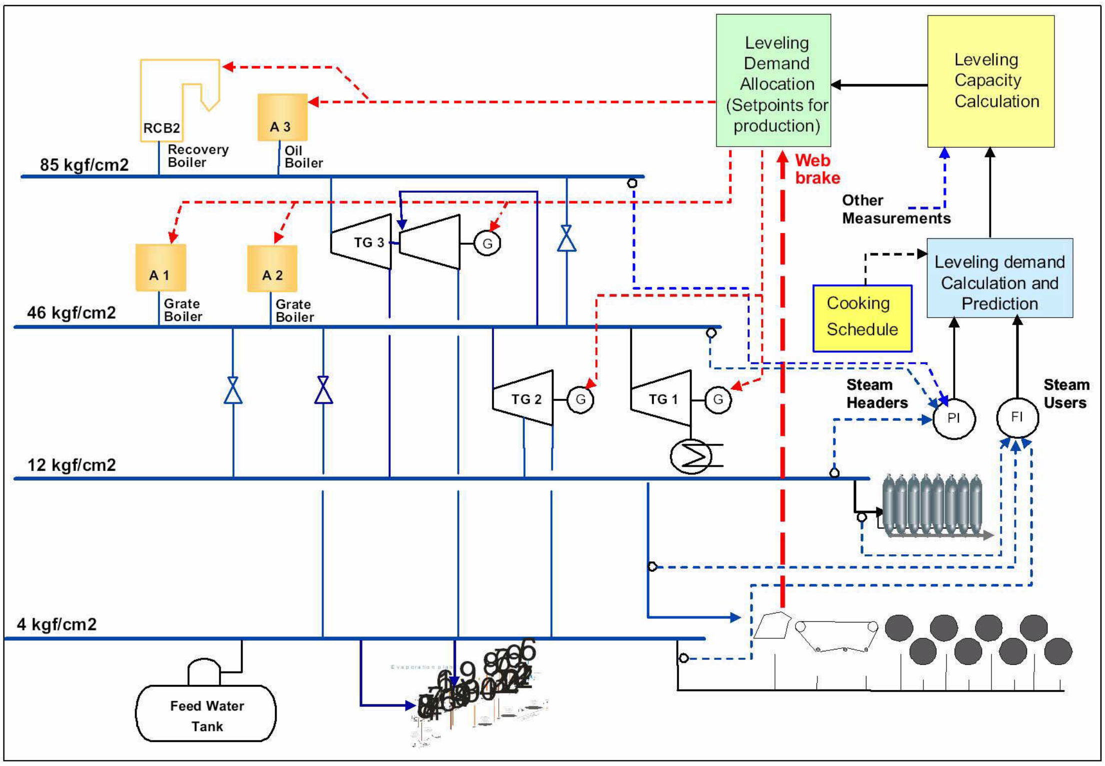

Figure 3.

The leveling demand calculations are based on calculating the steam balance between steam production and consumption. The actual steam flow and steam pressure measurements are constantly compared with predicted values. A change in the process steam demand can also be predicted before it can be even seen in the measurements provided that there are indicative binary signals available from process upsets (e.g. web break, start-up on a paper machine or grade change)[3].

The true advantage is found when the short-term model predictive controller is combined with long-term demand forecasts for steam and electricity. By combining financial decision making with production estimations and short-term optimal pressure control, the plant can achieve true economical benefits without risking the environment. Optimal boiler set-points, calculated by the control are transferred to the steam network controller as an indication of the most economical boiler load. This provides target values for the boiler loads, with actual boiler loads set to meet dynamic requirements. Steam production can be divided, so that all running units are kept between minimum and maximum limits and all boilers can operate within permit limits.

Emission Monitoring

Close cooperation with customers and environmental authorities has led to the development of comprehensive emission monitoring and reporting solutions that enable both new and existing plants to comply with environmental legislation and relevant standards. Optional emission forecasts and mean value calculations can also be used to improve both recovery and auxiliary boiler control. All relevant environmental events and information are collected, stored and reported with the ability to add comments, classify entries for further action and automatically alert personnel to take appropriate corrective and preventive actions.

The emission reporting system design, implementation and operation needs to take into account the specific environmental considerations for each installation. Web-based reporting facilitates the various departments in the mill to have access to data for comparison and real-time monitoring of emissions provides increased effectiveness. The system automatically generates custom reports to fulfill the requirements of the particular legislative authorities as appropriate (Figure 4).

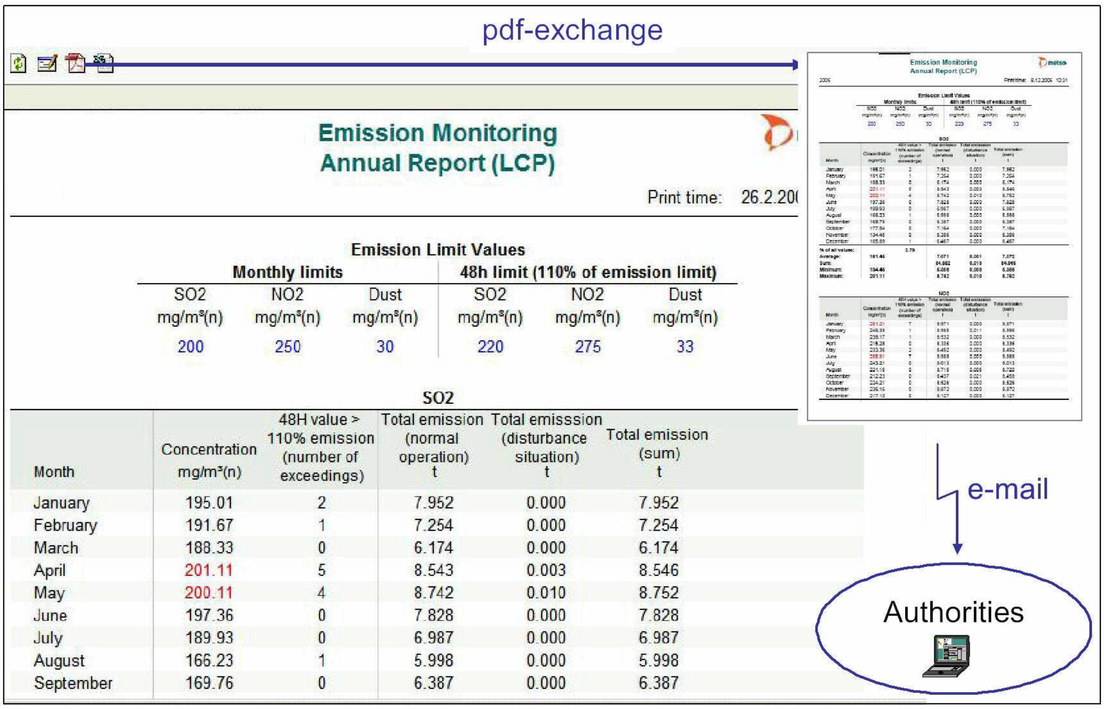

Figure 4 Automatic emission reporting fulfills permit conditions.

Conclusion

Optimizing the recovery boiler operation pays economic dividends as well as decreasing emissions to the environment. Good combustion control and steam load leveling help to reduce the impact of disturbances elsewhere in the process and additionally reduce the risk of boiler damage. The continuous monitoring of emissions provides a valuable tool for operators in developing optimal ways of operating as well as fulfilling environmental permit conditions.

Bibliography

1) European Union Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control.
2) European Commission: “Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Pulp and Paper Industry”. December 2001.
3) Management of Recovery Line Processes, ABTCP2007 paper by Mauri Loukiala