Advanced control solutions for steam boilers and power plants

Efficiency and reliability
Difficulties with conventional solutions:

- Boiler is a highly interactive process
  - Example steam temperature control

- Process changes / disturbances
  - Slow (eg slagging… )
  - Fast (eg fuel heat value, failures… )
  - Load changes

- Slow asymmetric dynamics of boiler
  - Firing disturbances: O2→ Temperatures→ Pressure & Flow→ Electric power
  - Response depends on load level and fuel quality
Why go advanced?

- The complex boiler process can be optimized.
  - Stabilize the process
  - Cut down the margins

- **Impact on**
  - Utilization rate
  - Utilization degree
  - Efficiency
  - Own consumption of electric power
  - Maintenance
  - Emissions
ÅF’s solution: Balance+

Advanced control solution for steam boilers

- Differs from conventional solutions
- Self-learning calculation models

- Concepts for drum and once through boilers
  - Interactions between control loops into consideration

- Proven, patented technology

ÅF APC (advanced process control)

- We know: Process, control, instrumentation and measurement technologies, development of automation systems making it all possible.
Balance+ How?

- Concept uses process based adaptive calculation models

- Calculation models are based on available auxiliary measurements and previous behaviour of process.
  - "Real-time" control also to slow variables
  - Disturbances can be compensated before they are shown in the controlled variable
  - Reduction of over and undershoot in control
  - Models adapt to process changes
  - "Tuning parameters" can be defined from process values before commissioning
Balance+ How?

Balance+ calculation model

Conventional feedback PI-control
Balance+ How?

![Graph showing temperature changes over time for Balance+ and Reference](image-url)
Benefits with better performance

- Utilization rate
  - Reduced downtime due to less actuator failures
  - Less stress to heat exchangers and masonry
  - Reduction of safety interlocking

- Utilization degree
  - More accurate control
  - Boiler can operate closer to designed maximum parameters (pressure, temperature, excess oxygen…)

- Efficiency
  - Less over and undershoot in combustion control
  - Higher steam temperature, Lower O2 content of the flue gases
Benefits with better performance

- Own consumption of electric power
  - Reduction of feed water pump, air- ja ID-fan power
  - Optimization of pressure losses and air flow

- Maintenance costs
  - Less wearing to actuators due to less control actions
  - Minimization of pressure differences reduces wearing
  - Reduced downtime expenses
Benefits with better performance

Friendly for environment

- Optimization of O2 level and stabilization of the combustion process
  - NOx-, CO- and particle exhausts
  - Tightened emission levels due to legislation

- Savings in some executed projects comparable to ~1% better efficiency
  - Balance+ valuation
IE-directive’s discharge limits

- Discharge limits tighten in 2016

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* Time of operation at maximum 1500 h/a
** For liquefied petroleum gas
IE-directive’s discharge limits

- Boiler’s combustion control optimization to improve the emissions.
- Efficiency and NOx emissions can be optimized with more stable combustion control.
- The possibility to avoid or decrease expensive process investments or solutions based on secondary methods for taking emissions to the level of new requirements.
- Improvement possibilities have to be estimated according to each plant.
Flue gas’ excess oxygen level effect to NOx

Optimization of terminal oxygen level on the grounds of CO-emission rate reduces NOx – emissions. Stabilization of combustion power and air controls enables the boiler’s running at lower terminal oxygen content than earlier.

- In our projects made for forest industry we have been able to reduce boilers’ combustion gas’ excess oxygen level 0,5 - 2%. This means 15-40% reduction to NOx - emissions. (for example Kauttua).

NOx – emissions’ dependence on air factor. As rule of thumb is considered that NOx – emissions are directly proportional to the boiler’s terminal oxygen level.
Revision of boiler main controls strategy at a CFB boiler

before

- Excess oxygen level decreased 2%
- NOx-emissions decreased 40%
- Fuel consumption decreased 1%

after

Learning calculation models in combustion and air controls.

*Automaatioväylä* magazine article 7/2010 about benefits achieved to Kauttua.

Conventional boiler controls in use.