Advanced control solutions for steam boilers and power plants

Efficiency and reliability

Innovation by experience

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)

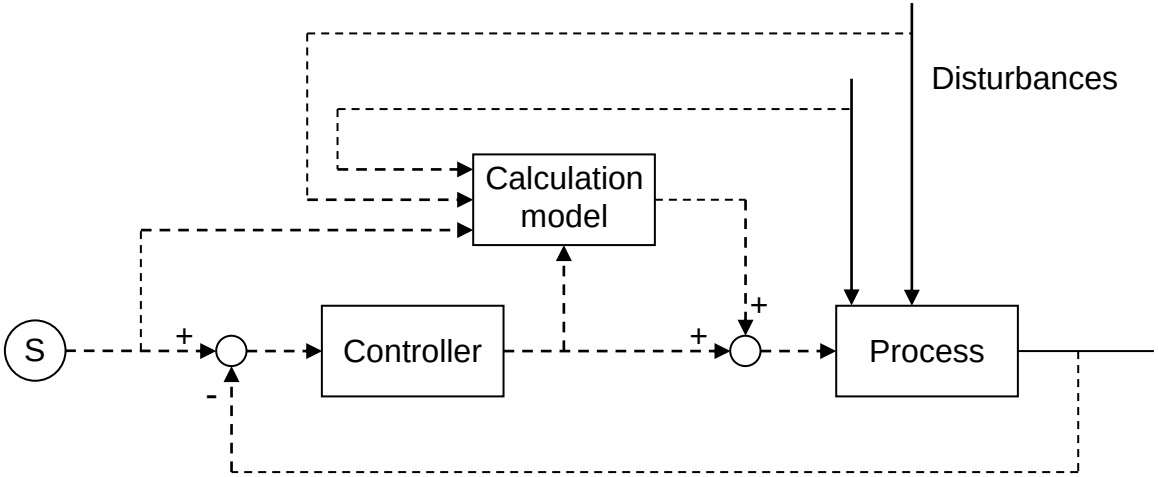
- We know: Process, control, instrumentation and measurement technologies, development of automation systems making it all possible.

Balance+ How?

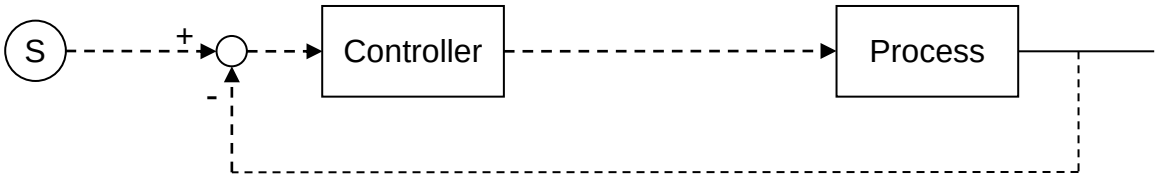
- Concept uses process based adaptive calculation models
- Calculation models are based on available auxiliary measurements and previous behaviour of process.
  - → ”Real-time” control also to slow variables
  - → Disturbances can be compensated before they are shown in the controlled variable
  - →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

Balance+ How?

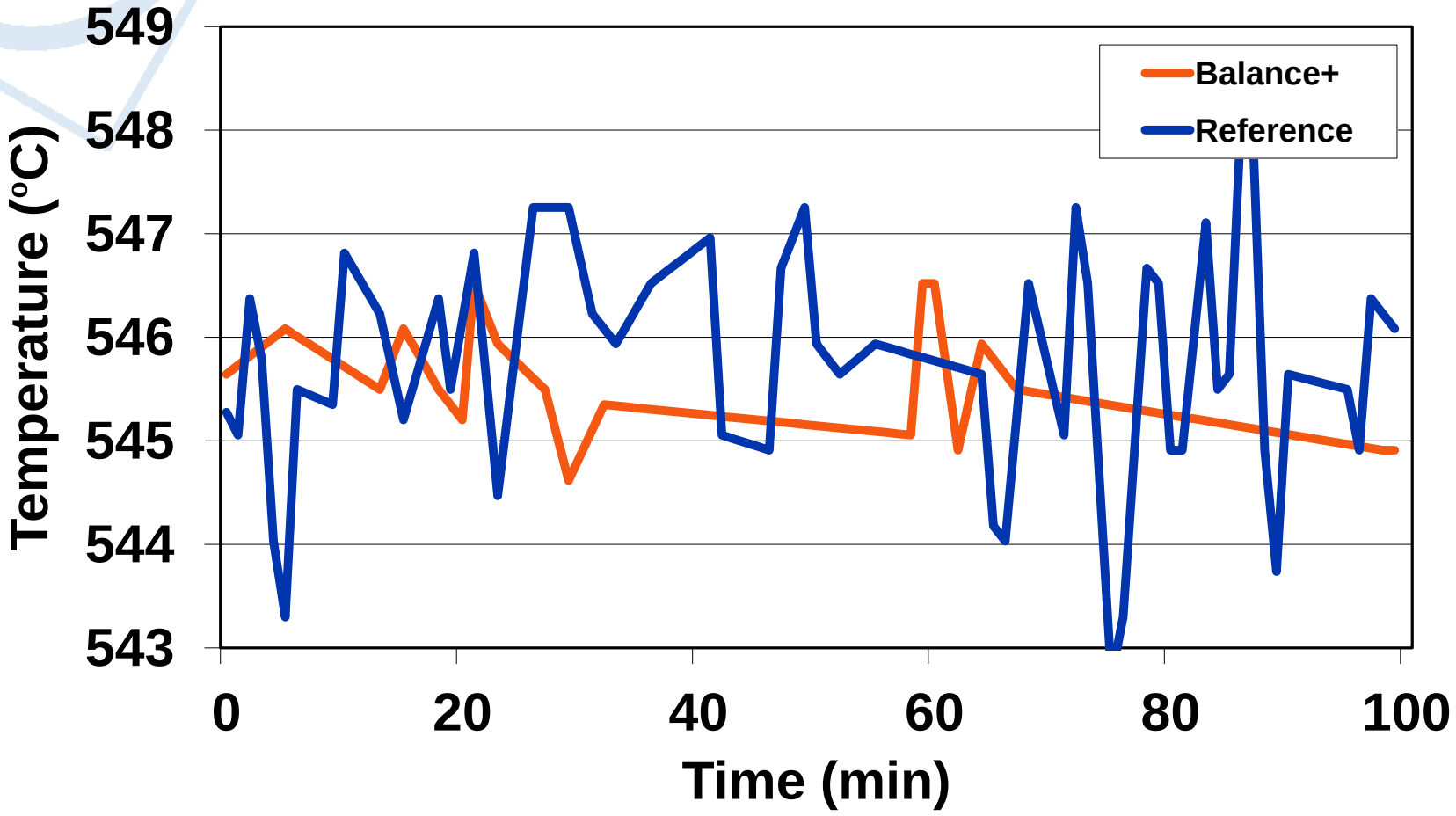
Balance+ calculation model



Conventional feedback PI-control



Balance+ How?



Innovation by experience

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

Innovation by experience

IE-directive's discharge limits

- Discharge limits tighten in 2016

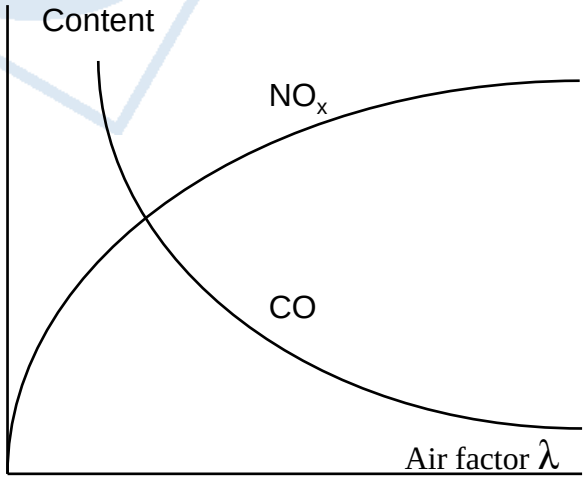
	Biomass	Liquid fuels	Peat	Gas fuels	Mineral coal and brown coal
50-100 MW					
SO_2	200	350 (850*)		35 (5**)	400
NO_x	300	450	300	100	300
Particles	30	30	30	5	30
CO				100	
100-300 MW					
SO_2	200	250	300	35 (5**)	250
NO_x	250	200	250	100	200
Particles	20	25	20	5	25
CO				100	

* Time of operation at maximum 1500 h/a
**For liquefied petroleum gas

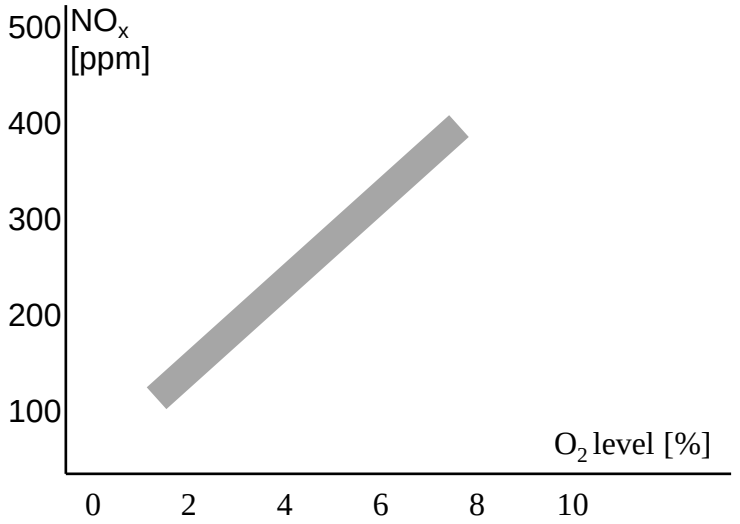
IE-directive's discharge limits

- 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 NO_x –emissions. Stabilization of combustion power and air controls enables the boiler's running at lower terminal oxygen content than earlier.

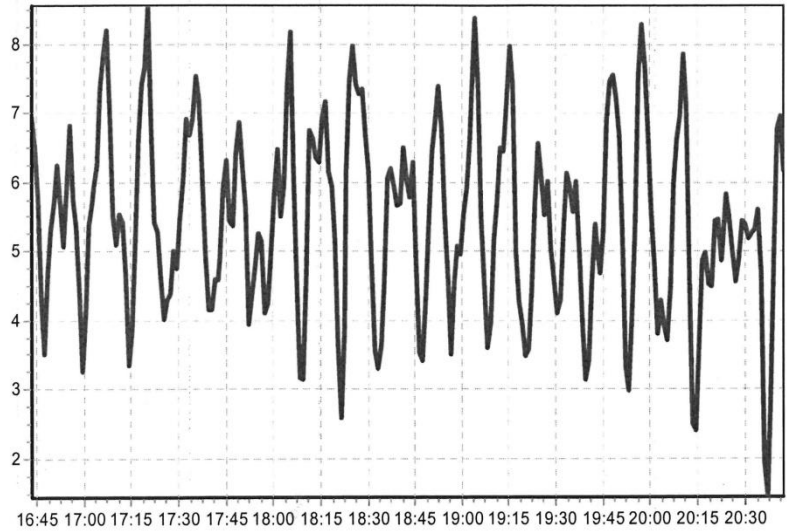


NO_x –emissions' dependence on air factor. As rule of thumb is considered that NO_x –emissions are directly proportional to the boiler's terminal oxygen level.

- 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 NO_x-emissions. (for example Kauttua).

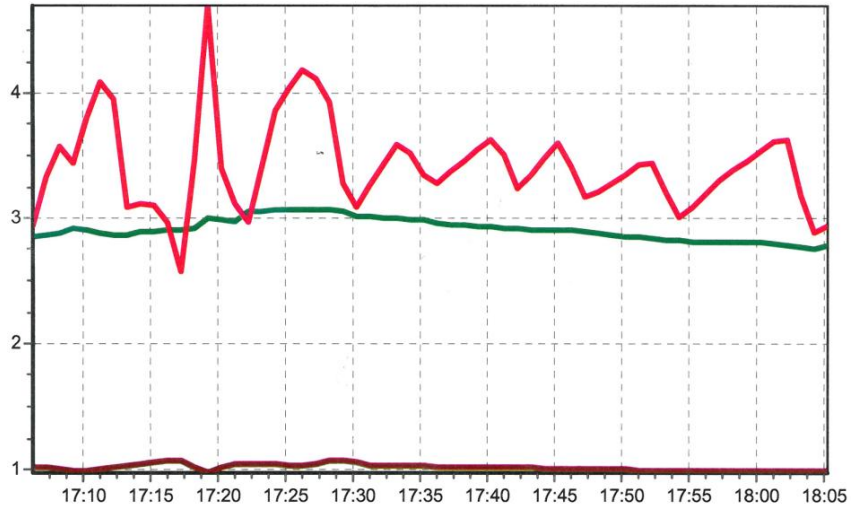
Revision of boiler main controls strategy at a CFB boiler

before



Conventional boiler controls in use.

after



Learning calculation models in combustion and air controls.

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

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