Measurements in Power Plants

Efficiency measurements
Efficiency measurements

- Guarantee measurements
- Condition monitoring
- Efficiency optimization
- Quality control of AMS (Automated measuring systems)
Measurements
- Flue gas temperature
- Flue gas O2-content
- Unburnt fuel (gas/particles)
- Radiation and conduction losses
- Internal consumption

Boiler efficiency
**Boiler efficiency**

**Measurements**
- Flue gas temperature
- Flue gas O2-content
- Unburnt fuel (gas/particles)
- Radiation and conduction losses
- Internal consumption

**Issues**
- Dirty boiler
- Wrong dimensioning
- Wrong way to operate
- Faults in continuous measurements
- Fuel problems

- Wrong cleaning procedures
- Soot blowers placement wrong
- Not enough soot blowers
- Burning problems
- Fuel composition
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Possibilities to improve boiler efficiency
- Wrong cleaning procedures
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Annual Savings and Expenses
- Wrong cleaning procedures
- Soot blowers placement wrong
- Not enough soot blowers
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- Fuel composition
Mittaukset
Savukaasun lämpötila
Savukaasun happipitoisuus
Palamaton polttoaine
Säteily- ja johtumishäviöt
Omakäyttötehot

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Boiler efficiency

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Standards

- **SFS-EN 12952-15 (DIN 1942) for boilers**
  - Used in Europe
  - Direct calculation
  - Indirect calculation
  - Based on lower heating value

- **ISO 3046 and ISO 8178 for engines**
  - ISO 3046: Reciprocating internal combustion engines – Performance
  - ISO 8178: Reciprocating internal combustion engines – Exhaust emission measurement

- **ASME PTC 4.2 for boilers**
  - Based on higher heating value
  - Used in USA and Asia
Efficiency based on direct calculation
Efficiency based on direct calculation

Fuel power
Efficiency based on direct calculation

- Free enthalpy
- Fuel power
Efficiency based on direct calculation

- Electrical power
- Free enthalpy
- Fuel power
Efficiency based on direct calculation

- Electrical power
- Free enthalpy
- Fuel power
- Boiler power
Efficiency based on direct calculation
Heat balance

- Fuel power
- Free enthalpy
- Electrical power

Losses

Boiler power
Efficiency based on indirect calculation

- Efficiency = boiler power/(boiler power + losses)
- Losses calculated
- Iteration to get heat input = heat output, by changing fuel power
Losses
Losses

Flue gas losses
Flue gas losses
Radiation losses
Flue gas losses

- Radiation losses
- Unburnt (CO+ slag/dust)
Flue gas losses

- Radiation losses
- Unburnt (CO+ slag/dust)
- Other losses
Flue gas O2-content vs. efficiency, example

Flue gas O2-content
Flue gas temperature vs. efficiency

Flue gas temperature vs. efficiency
Measurements 1

- Temperatures
  - Feed water
  - Steam
  - Other water- and steam flows
  - Flue gas
  - Combustion air
  - Fuel
Measurements 2

- Pressure measurements
  - Feed water
  - Steam
- Flow measurements
  - Feed water / Steam
- Analyses
  - Fuel
  - Unburnt in slag/dust
Measurements 3

- Flue gas analysis
  - Measurements in dry gas condition
  - Measurements in wet gas condition
  - O2-content
  - CO-content
Measuring equipment 1

- **Temperature**
  - Conventional thermometers
  - Thermocouples
  - Resistor sensors
  - IR-measurement

- **Pressure**
  - U-gauges
  - Conventional pressure meters
  - Pressure transducers
Measuring Equipment 2

- **Flow measurements**
  - Pressure difference measurements
    - Flanges
    - Venturi tubes
  - Vortex, magnetic, ultrasound

- **Electrical Power measurements**
  - Clamp meters
Measuring Equipment 3

- **O2-content**
  - Paramagnetic sensors
  - Zirconium cells
  - Electrochemical cells (portable devices)

- **CO-content**
  - IR-absorption
  - Electrochemical cells
Data collection

- Plotters
- Data loggers
- PC-based data collection systems
Quality Assurance

- Traceability
  - Unbroken chain to national/international measuring standard

- Laboratory Calibrations
  - Single devices
  - Repeatability

- Field Calibrations
  - Whole measuring chain