Modern methods for power plant condition monitoring

RAINE JOKINEN AFRY TEST SERVICES
AFRY at a glance

INDUSTRIAL & DIGITAL SOLUTIONS
Advanced Automation
Connected Products
Automotive Design & Engineering
Food & Pharma
IT Solutions
Specialized Technical Services
Systems Management

PROCESS INDUSTRIES
Bioindustries
Chemicals
Pulp, board, paper & tissue
Mining & Metals
Smart solutions:
- Health & Safety
- Sustainability
- AFRY Smart Site & digitalisation

ENERGY
Renewable Energy & Thermal Power
Hydro
Transmission & Distribution
Nuclear
Contracting

INFRASSTRUCTURE
Transportation
Buildings
Project Management
Water
Environment
Architecture & Design

MANAGEMENT CONSULTING
Energy Sector
Bioindustry Sector
Market Analysis
Strategic Advice
Operational Excellence
M&A and Transactions

WE HAVE
16,000
Employees globally (as of 2021)

WE HAVE APPROX.
NET SALES
19 bsek
in 2020

NUMBER OF COUNTRIES
WITH OFFICES
>40

NUMBER OF COUNTRIES
WITH PROJECTS
>100

4 Growth Drivers
Infrastructure
Food & Life Science
Clean Energy
Bioindustry
AFRY Test services

— Guarantee, performance and condition monitoring of boilers, turbines and flue gas cleaning systems
— Reliable emission and process values
— Noise and vibration modelling and measurements
— Wind resource energy measurements
— TAS - Technical advisory services
— 3rd party verification - Reliable test results for design and process purposes
— Process analysis and consulting
Condition monitoring

- Vibration measurements
- Noise measurements
- Periodical inspections
- Bearing temperatures
- Elongation measurements
- Performance tests
Performance tests

1. Guarantee tests
   - tests to ensure the delivered equipment perform as promised
   - for total plant and also main equipment (boiler, turbine, flue gas condenser)
   - testing mainly with calibrated test instruments installed expressly for testing purposes
   - test of guaranteed performance indicators
     - e.g. generator power, steam capacity, boiler efficiency
   - comparison to guaranteed values
   - measurement methods defined in standards

2. Condition monitoring
   - similar tests and methods as guarantee tests
   - performed traditionally mainly for steam turbines
   - test of condition monitoring indicators
     - e.g. expansion efficiencies, flow passing capacities, TTDs
   - objective is to find out possible changes in performance indicators & parameters
   - comparison to previous test results
Why performance testing?

1. Guarantee tests
   - needed so the buyer can safely accept the delivered equipment
     - some parameters have absolute guarantees, and some can be settled with liquidated damages
     - baseline for future condition monitoring

2. Condition monitoring
   - no direct measurements for the condition monitoring indicators
     - e.g. the mechanical condition of the rotating equipment are monitored continuously
     - requirement for measurement accuracy and reliability
     - long periods between overhauls
     - get information about possible problems
     - make informed decisions regarding the overhaul
Steam turbine condition monitoring - Example timeline

Regular condition monitoring tests:

- Secure economic and safe operation
- Maximize turbine life span and efficiency
- Information for overhaul planning
Test codes & measurement standards

— Boilers
  — EN 12952-15 Water tube boilers and auxiliary installations - Part 15: Acceptance tests
  — ASME PTC 4 Fired Steam Generators

— Steam turbines
  — DIN 1943 Thermal acceptance tests of steam turbines
  — IEC 60953 Rules for steam turbine thermal acceptance tests
  — ASME PTC 6 Steam turbines

— Gas turbines
  — ISO 2314 Gas turbines — Acceptance tests
  — ASME PTC 22 Gas turbines

— Flow measurement
  — ISO 5167 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full

— Thermodynamical properties
  — IAPWS-97 Thermodynamic Properties of Water and Steam
  — VDI 4670 Thermodynamic properties of humid air and combustion gases
Evaluating measurement results

Based on test average values:

— Flow calculations
— Enthalpy calculations
  — steam, water, flue gas & air
— Mass balance calculations
— Heat balance calculations
— Equipment- & test specific calculations
  — isentropic efficiencies
  — flow-passing capacities
  — boiler efficiencies
  — etc.
— Correction calculations
  — needed to make results comparable
  — e.g. heat balance model correction
— Uncertainty calculations
Measurements & balances

- boiler
- turbine
- FGC
Project example

Guarantee test for new plant:

- 85 MW fluidized bed boiler
- 75 MW steam turbine
- 50 MW flue gas condenser

The tests:

- 6 turbine test points
- 4 boiler test points
- 2 flue gas condenser test points
- over 2 weeks of testing at site

Measurements:

- 60 temperatures
- 25 pressures
- 10 steam & water flows
- flue gas emissions
- indoor & outdoor noise
- surface temperatures
- various samples and analysis

Planning – Executing – Reporting
Continuous online condition monitoring

**Input data**
- Continuous DCS data
- AFRY performance test results
- Client DCS data during performance tests
- Process model

**Analysis**
- Model calculations
- Deviation detection
- Machine learning algorithms

**Reporting and alarms**
- Continuous performance analysis and status of plant
- Condition monitoring highlights
- Improvement options
- Condition monitoring prediction

**Reporting**

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OUR OFFERING – ONLINE MONITORING

2021-09-23 | MODERN METHODS FOR POWER PLANT CONDITION MONITORING
Continuous online condition monitoring

- Continuous overview of the current asset condition
- Improvement area identification based on calibrated process information
- Minimize failure costs and downtime by pinpointing sneaking deterioration early
- Faster troubleshooting and improved process optimization opportunities
- Automated reporting and prediction analysis

Tailored reporting and set-ups typically needed.
Parameter examples

– Efficiency / throughput
– Heat transfer surfaces
– Steam and power flows and values
– Leak survey
– Optimisation of emissions and additives
– Pressure drops
– Terminal temperature differences
– Recovered heat and load
– Turbine constants and performance
– Optimisation and operation strategy
– Measurement fault analysis
Making Future