Powitec solutions for Power Plants

Upgradable intelligent solutions for process optimisation
SENSE  
*Sensor Supported Process Description*
Generation of high resolution on-line process characteristics

*PiT Indicator*

ANALYSE  
*Data Mining and Process Intelligence*
Mathematical-statistical correlation analysis via intelligent algorithms

*PiT Data Mining*

PREDICT  
*Soft Computing*
On-line computation of expected development for selected process values

*PiT Predictor*

CONTROL  
*Intelligent Closed Loop Control*
Auto-optimising closed loop control for complex processes

*PiT Navigator*

---

for

- ⚡ Boiler (system of feeder, mill, classifier, pipes, burner, boiler)
- ⚡ Coal Mills
- ⚡ Flue Gas Cleaning
Boiler (system of feeder, mill, classifier, pipes, burner, boiler)

**SENSE**
- PiT Video ................................................................. 4
- PiT Indicator ............................................................. 4
- PiT VibraSensor .......................................................... 5
- PiT FluxStylus .............................................................. 5
- PiT Slagging Detector .................................................. 6
- PiT Reheater Fouling Detection ..................................... 6
- PiT Stabiliser ............................................................... 7

**ANALYSE**
- PiT Data Mining ............................................................. 8
- PiT Process Performance Monitoring .............................. 9
- PiT Online CFD ............................................................. 10

**PREDICT**
- PiT Predictor (NOx, SOx, UCaA, FCoA) .......................... 11
- PiT Leakage ................................................................. 12

**CONTROL**
- PiT Navigator ............................................................... 13
- PiT Navigator Soot Blower ........................................... 14
- PiT Navigator Steam ..................................................... 14

Coal Mills

**SENSE**
- PiT Indicator Coal Mill .................................................. 15
- PiT Indicator PF ............................................................ 16

**ANALYSE**
- PiT Data Mining ............................................................. 17

**CONTROL**
- PiT Navigator Coal Mil .................................................. 18

Flue Gas Cleaning

**CONTROL**
- PiT SNCR ................................................................. 19
- PiT Navigator SNCR ..................................................... 20
- PiT SmartBox (HCL / SO2) ............................................ 21

References & Contact ...................................................................................................................... 22
SENSE:

**PiT Video**
Video camera for permanent visual flame and boiler wall inspection.

**Benefits:**
- Flame inspection allows for in time reaction
- Supervision of slagging at burner mouth, boiler walls or superheater

**Features:**
- Rugged German design
- Endoscope: Electronic is temperature protected
- Air or water cooling
- Supervision of temperatures and cooling media supply
- High availability

**PiT Indicator**
Intelligent Thermography for indicating temperature and flame variations in their transient behaviour

**Benefits:**
- Chronological display of location and volume of flame body and slagging = **Active flame control and slagging detection**
- Temperature Analysis = **Information direct from the boiler inside**
- Integration of Process Control System data = **Correlation of temperatures and slagging with process data**
- Possible upgrade to PiT Navigator = **fully automatic combustion optimisation by closed loop control of the air/fuel ratio**

**Features:**
- RGB Camera = **Reliable temperature analysis**
- Adaptive Electronic Dust Filter = **Clear pictures** even in dusty situations
- Robust German design = **Low Maintenance**
- Freely definable Regions of Interest and Polylines = **permanent information** from decisive areas
- Output from and Input to the PCS = **Correlations** show variations
PiT VibraSensor
Online mill, classifier and pulverised coal dust pipes analysis by vibration sensors combined with sophisticated data processing by analysis of correlations

Benefits:
- Information about changes without intrusion
- Information from spaces without possibility of visual inspection but with changes in resistance or sounds
- **Mill wear**: Mill noise as a direct wear indicator enables the dynamic optimisation of mill operation at long term wear reduction
- **Mill load and mill response**: A frequency based load indicator describes the specific mill loading at different dispatcher trimmings and allows for minimising the load response at optimised grinding degree
- **Burner air trimming**: Detection of grinding degree changes and the coal dust allocation in the pipes allows optimising mill operation and burner air trimming.

Features:
- Rugged German design, following military specifications, fixed by magnets or welding sockets at positions < 160°C
- Sampling with 10kHz, 16bit
- Scalar noise characteristics
- Comparison of frequency bands from several positions with PCS/DCS data
- Sophisticated data processing, spectral characteristics (concentrations), statistic verification and sophisticated data displaying tools

PiT FluxStylus
Spatial defined heat flux measurement

Benefits:
- Spatial temperature resolution even from mounting positions at confined spaces
- Temperature Analysis = Information direct from the boiler inside

Features:
- Measurements 9 to 5 from different positions
- Robust German design = Low Maintenance
- Sophisticated data processing, sophisticated data displaying tools
- Output from and Input to the PCS = Correlations show variations
**PiT Slagging Detector**
Detect the amount of slagging at the steam generator walls and at the super-heater with Powitec's advanced picture analysis tool on basis of optical information in correlation with temperature information. Gained information can be used for alarming function.

**Benefits:**
- Chronological display of position and volume of slagging = Active supervision of slagging
- Temperature Analysis = Information direct from the combustion chamber and the super heater
- Displaying data of process control system = Visual correlation of temperatures and slagging with process data
- Possibility to upgrade to PiT Navigator = Reduction of slagging by auto-optimising grinding degree and air-/fuel-ratio and thus the temperatures

**Features:**
- RGB camera (see page 4) = reliable temperature analysis
- Adaptive Electronic Dust Filter = clear pictures even in dusty atmospheres
- Robust German design = low maintenance
- Air or water cooled
- Optionally: Retraction Unit or Anti Slagging Unit
- Free definable Regions of Interest and Polylines = permanent information from decisive areas
- Bi-directional PCS connection = Correlation analysis

**PiT Reheater Fouling Analysis**
Analyses the amount of fouling (dust) at the reheater with Powitec's advanced tool on basis of vibration information analysing changes in vibration in correlation with temperature information. Gained information can be used for alarming function.

**Benefits:**
- Chronological display of amount of dust = Active supervision of reheater fouling
- Vibration Analysis = Information direct from the reheater
- Displaying data of process control system = Visual correlation of temperatures and fouling with process data
- Possibility to upgrade to PiT Navigator = Auto-optimising the combustion through air-/fuel-ratio optimisation

**Features:**
- PiT VibraSensors (see page 5) = Sophisticated vibration analysis
- Robust German design = Low maintenance
- Sophisticated data processing data displaying tools
- Output from and Input to the PCS = Correlations show variations
PiT Stabiliser
Combination of one or more PiT Indicator with flame scanners and sophisticated software to correlate the analogue outputs with camera signals. Targets: In part load areas increase of the burner and boiler stability (by displaying stability index) and to increase the up-time of the boiler.

Benefits:
- Permanent stability index = Increased part load operation, decreased oil consumption
- Broad flame analysis = Information of 90° to 120° viewing angle in combination with point signal from flame scanners
- Reliable alarming = Early reaction and less operator stress
- Possibility to upgrade to PiT Navigator = Increased efficiency

Features:
- RGB camera = Reliable temperature analysis
- Adaptive Electronic Dust Filter = Clear pictures even in dusty atmospheres
- Robust German design = Low maintenance
- Free definable Regions of Interest and Polylines = permanent information from decisive areas
- Output from and Input to the PCS = Correlations show variations
- Air or water cooled
- Optionally: Retraction Unit or Anti Slagging Unit
- Optionally: Video picture
**ANALYSE:**

**PiT Data Mining**

Analysis of historical DCS/PCS data towards optimisation potential with the aid of statistical software and neural nets; recommendations for hardware modifications; on site test measurement with mobile optical sensor and/or vibration sensors

**Benefits:**
- Optimisation potential with calculated amortisation time
- Information about priorities depending on performance
- Comparability of different production lines
- Findings of new significant correlations
- Discovering new optimisation potentials

**Features:**
- Data mining supported with mobile sensors (PiT Indicator, PiT VibraSensor)
- Data significance analysis with
  - Classification and cross correlation
  - Deviation Analysis
  - Dependence Analysis
  - Multidimensional regressions
  - Clustering
  - Impact Prognosis
- Identification of the most important process channels or process information
- Elimination of idle time through the process sequence
- Recognition of interdependencies
- Generation of models representing the behaviour of processes
- Finding potential areas for optimisation and drafting solution strategies
- Explanation of unusual situations and phenomena of the processes
PiT Process Performance Monitoring
Online analysis of actual and historical DCS/PCS data towards optimisation potential with the aid of statistical software and neural nets.

**Benefits:**
- Online overview: **Data becomes information**
- Information about priorities depending performance
- Comparability of different production lines
- Findings of new significant correlations
- Fast and clear availability of historical data
- Discovering **new optimisation potentials**

**Features:**
- Data significance analysis with
  - Classification and cross correlation
  - Deviation Analysis
  - Dependence Analysis
  - Multidimensional regressions
  - Clustering
  - Impact Prognosis
- **Benchmarking**
- Full automatic feature-extraction, -selection and –reporting
- **Scoring**
- Manual or full automatic reporting
- **Export-Function**
PiT Online CFD
Online CFD (Computational Fluid Dynamics): Determination of temperature, convection, heat radiation, flue gas mass flow every 15 seconds.

Benefits:
- Online inside view of heat allocation (and/or NOx) in the first draft according to the current process status (coal type, slagging, mill status)
- Fast manual interventions
- Discovering new optimums
- Analysis of cause of damage
- Analysis for optimising changes (i.e. SNCR lances/nozzles and spray amount)
- Online analysis in different operating states

Features:
- Modelling of the boiler, online modelling of convection and heat radiation, online calibration against existing measurements
- Refresh rate: Every 15 seconds
- Free definable viewing angles, temperature areas
- Manual or full automatic reporting
- Export-Function

Orange boxes only displaying temperatures between 900 and 1000°C, the optimal temperature window for SNCR spraying
PiT Predictor
Timely knowledge of process changes through permanent on-line information on process values like NOx, SOx, UCiA, FCaO.

Benefits:
◆ Accurate prediction of i. e. NOx, SOx, UCiA, FCaO; Prediction accuracy worldwide unbeaten
◆ Timely knowledge of process changes through permanent on-line
◆ Reduction of off spec filter ash
◆ Energy saving
◆ Process stabilisation

Features:
◆ Continuous Online-Prediction of key process parameters
◆ Self learning adaptive software based on Neural Nets
◆ Integration of additional Information from the process (PiT Indicator, PiT FluxStylus, PiT VibraSensor) where helpful
◆ High availability, security features
◆ Upgradeable to PiT Navigator

Online prediction vs. laboratory values

Powitec FCaO prediction

PIT Indicator Graph

Online prediction vs. laboratory values

Prediction
Laboratory
PiT Leakage
Timely knowledge of upcoming or existing tube leakages through microphone and vibration signal analysis in combination with intelligent data computation

**Benefit:**

- **Prediction of tube leakages** at heating surface banks like Superheater, Reheater and Economiser
- **Early knowledge** about tube leakages at the PF boiler wall tubes
- **Planned and early reaction**, avoidance of unscheduled outages

**Features:**

*Tube Leakage Prediction:*

- Particles cause abrasion and tube shape changes, due to this the sound of the tubes changes at heating surface banks like Superheater, Reheater and Economiser; microphones applied at the boiler wall capture this sound
- Intelligent computation of the sound signals and calibration of the sound against (during outages) measured values from the tubes allows for continuous Leakage Prediction, early indicating the tendency towards tube leakages with a prediction tool having a worldwide unbeaten prediction accuracy

*Tube Leakage Detection:*

- A tube leakage causes a specific sound which can be captured by microphones inside the first draft of the PF Boiler; Vibration Sensors capture vibration oscillations at the boiler wall tubes
- Intelligent signal computation allows for early Leakage Sound Detection in the acoustic characteristics
- Alarm is raised, allowing for planned and early reaction avoiding additional damages and costs
PiT Navigator
Advanced Auto-Optimiser for a permanent optimisation of the air/fuel ratio and distribution.

**Benefits:** (depending on individual target combination)
- Reduced fuel consumption 0.5 - 1%
- Reduction O2-excess air of 25% (1 - 2 points)
- Reduction of Unburned Carbon in Ash of 5 - 50%
- Increased boiler efficiency by 0.3 to 1%
- Reduction of auxiliary electricity consumption
- CO2-reduction of 0.5 – 2%
- CO and NOx reduction up to 30%
- 30% improvement of performance dynamics
- Homogenised temperature distribution
- Optimised temperature distribution over different levels
- Reduction of slagging and soiling at burner mouth and finned walls
- Increased availability e.g. through elimination of backfiring
- Improvement of boiler wall atmosphere
- Increased fuel varieties (Biomass)

**Features:**
- High-Speed cameras observe the combustion chamber and through a patented pattern recognition process - extract significant features of the ignition-, combustion- and burnout- behaviour, temperatures, position and emissions
- Vibration sensors capture mill and pulverised coal pipes vibrations giving early information about milling degree, coal quality and pulverised coal distribution
- Process data from the PCS are permanently correlated with optical and vibration information through a software based on neural nets
- Self learning adaptive software based on Neural Nets, adapting themselves to changing process situations
- Integration of expert knowledge and improving this knowledge self-learning
- Easy changes in optimisation targets without reprogramming or re-parameterisation of software
- Fast installation (2 to 3 weeks on site with 5 to 10 man days of customer involvement)
- Round the Clock, 24-7 closed loop control optimisation of the air / fuel ratio
- Results guaranteed
PiT Navigator Soot Blower
Advanced Auto-Optimiser for a permanent optimisation of the soot blowing

**Benefits:**
- Reduced soot blowing
- Optimised spray positioning
- Increased efficiency

**Features:**
- **High-Speed cameras** observe the combustion chamber and - through a patented pattern recognition process - extract significant features of the slagging and fouling
- **Process data from the PCS are permanently correlated** with optical information through a software based on neural nets
- **Self learning** adaptive software based on Neural Nets, adapting themselves to changing process situations
- Integration of expert knowledge and improving this knowledge self-learning

---

PiT Navigator Steam
Intelligent control of spray amount reduces the spray water amount

**Benefits:**
- Reduced spray water at the super heaters
- Reduced steam variations
- Increased efficiency

**Features:**
- **High-Speed cameras** observe the combustion chamber and - through a patented pattern recognition process - extract significant features of the actual temperature variations
- **Process data from the PCS are permanently correlated** with optical information through a software based on neural nets
- **Self learning** adaptive software based on Neural Nets, adapting themselves to changing process situations
- Integration of expert knowledge and improving this knowledge self-learning
SENSE:

PiT Indicator Coal Mill
Suitable for vertical mills (ball and roller), ventilator mills (lignite) and horizontal ball mills
Indication of mill filling degree, maintenance status, coal type (cluster).

Benefits:
- On-line monitoring
- Reduced maintenance (esp. in Ventilator Mills)
- Increased information about coal type
- Mill load and load response allows for minimising load response at optimised grinding degree
- Burner air trimming allows to optimise air/fuel ratio
- Fast and stable control
- Fast adaptation to changes in coal granularity

Features:
- Vibration sensors (and/or microphones at horizontal ball mills) capture mill and classifier information
- Automatic feature selection and extraction (significance ranking) of existing process data
- Process data from the PCS are permanently correlated with acoustical information through a software based on neural nets
- Self learning adaptive software based on Neural Nets, adapting themselves to changing process situations
- Integration of expert knowledge and improving this knowledge self-learning
- Reproducible trends

Scalar noise characteristics (based on envelope and frequency)
PiT Indicator PF
On-Line Pulverised Fuel Measurement

Benefits:
- Information about changes
- **Mill load and mill response**: A frequency based load indicator describes the specific mill loading at different dispatcher trimmings and allows for minimising the load response at optimised grinding degree
- **Burner air trimming**: Detection of grinding degree changes and the coal dust allocation in the pipes allows optimising mill and boiler operation

Features:
- Rugged German design, following military specifications, fixed by magnets or welding sockets at positions $< 160°C$
- Sampling with $10kHz$, $16bit$
- Scalar noise characteristics
- Comparison of frequency bands from several positions with PCS/DCS data
- Sophisticated data processing, and sophisticated data displaying tools

**PF Allocation in 8 pipes, changes over 10 days:**
**PiT Data Mining**
On site sensor supported analysis of mill and pulverised coal dust pipes towards optimisation potential with the aid of statistical software and neural nets; recommendations for hardware modifications to achieve homogenised coal dust distribution.

**Benefits:**
- Optimised coal dust distribution
- Discovering new optimisation potentials

**Features:**
- Data mining supported with mobile sensors (PiT VibraSensor)
- Data significance analysis with
  - Classification and cross correlation
  - Deviation Analysis
  - Dependence Analysis
  - Multidimensional regressions
  - Clustering
  - Impact Prognosis
- Recognition of interdependencies
- Finding potential areas for optimisation and drafting solution strategies
PiT Navigator Coal Mill
Intelligent Auto-Optimisation of mills, classifiers and coal dust allocation. Suitable for vertical mills (ball and roller), ventilator mills ( lignite) and horizontal ball mills. Optimisation of maintenance intervals, coal dust allocation, grinding degree

Benefits:
◆ Reduced grinding degree deviation (Blaine) by up to 30%
◆ 2% and 6% less specific energy consumption
◆ 10% decreased maintenance
◆ Full automatic closed-loop control
◆ Coal type and coal mixture independent optimisation
◆ Self learning of controller parameters for different coal types
◆ No re-parameterisation at new coal types
◆ Elimination of lab delay
◆ Fast adaptation to process changes

Features:
◆ Integration of additional sensors (vibration sensors at mills, pipes and classifiers)
◆ Automatic feature selection and extraction (significance ranking) of existing process data
◆ Automatic model generation (regression, neuronal networks, probabilistic nets, Gray-Box-Models)
◆ Set point integration into the DCS/PCS
◆ Advanced signal processing on acoustic measurements
◆ Visualisation highly flexible (integration of PCS data); Graphical User Interface with trending and alarming
◆ Modular system: Upgradeable to Boiler-Optimiser
PiT Navigator SNCR
Advanced Auto-Optimiser for permanent optimisation of spray amount, slip and NOx peaks; suitable for Urea or Ammonia.

Benefits:
- Save NOx and slip compliance
- Reduced spray amount and reduced slip
- NOx and slip limits compliance
- Reduced primary NOx
- Reduced NOx peaks
- Less temperature tilts
- Fast adaptation to coal quality changes
- Better measurement, better control

Features:
- Step 1: Combustion Optimisation for primary NOx reduction
  Step 2: Optimising control of SNCR (Powitech SNCR or 3rd party)
- Integration of additional sensors (PiT FluxStylus: Heat flux radiation sensor measuring from 9 different directions; PiT Indicator: Intelligent Thermography)
- On-line CFD (computational fluid dynamics) every 15 seconds: Determination of temperature, convection, heat radiation, flue gas mass flow.
- Automatic feature selection and extraction (significance ranking) of existing process data
- Automatic model generation (regression, neuronal networks, probabilistic nets, Gray-Box-Models)
- Set point integration into the DCS/PCS
- Advanced signal processing on acoustic measurements
- Modular system: Upgradeable to Boiler-Optimiser
PiT SNCR
Complete SNCR with advanced Auto-Optimiser for permanent optimisation of spray amount, slip and NOx peaks; suitable for Urea or Ammonia

Benefits:
- Reduced investment costs (compared to SCR)
- Save NOx and slip compliance
- Reduced spray amount
- Reduced primary NOx development
- Reduced NOx peaks
- Less temperature tilts
- Fast adaptation to coal quality changes
- Reduced steam variations
- Complete solution from a single supplier

Features:
- 'PiT Navigator SNCR' - Optimising-Software-Licence (adaptive, multidimensional and self learning control on basis of neural nets; Nonlinear Model-Predictive-Control, NMPC)
- Optical sensors for image processing
- Urea / Ammonia storage, handling and injection
- Automatic control of reacting agent injection and combustion air using NMPC
- Engineering and commissioning including parameterisation
- Modular system: Upgradeable to Boiler-Optimiser
PiT Smart Box
Optimised spray amount in the dry sorption process. Suitable for white fine lime only or (2-stage MKT-process) combination of white fine lime with activated carbon and hydrate with high surface for the 2nd stage (dry sorption):

Benefits:
- Reduced consumption of reduction additives (5% to 10%)
- Shift towards cheaper additives (15% to 30%)
- At the same time emission improvement (-30% HCl, -20% SO2)

Features:
- Works on the basis of self learning adaptive neural nets
- Permanently analyses different plant values
- Permanent optimising variables are integrated in the DCS
- No fixed control rules or formulas
- Reacts continuously and autonomously to the current plant situation
- Reaches the optimum operation mode
References:

- E.ON Power Station Schkopau (Boiler & Mills)
- E.ON Power Station Scholven (Boiler & Mills)
- ENEL Power Station Vojany (Boiler)
- Evonik Power Station MKV Fenne (Boiler, Mills, SNCR-Control)
- Vattenfall Power Station Tiefstack (2 Boiler & Mills)
- Vattenfall R&D Department (Mapping)

Approved Competency:

2010: German Innovation Award Climate and Environment for Outstanding and Sustainable Technology. Powitec prevailed against a 145 companies field. Scientific evaluation through Fraunhofer-Institute for System and Innovation Research (ISI).

Contact:
Powitec Intelligent Technologies GmbH
Im Teelbruch 134b, 45219 Essen, Germany
www.powitec.de

Telephone: 0049 / 2054 / 937 62 34
Fax: 0049 / 2054 / 937 62 22
Mail: info@powitec.de