PROVYKO

Boilers and Heat Exchangers for Heat and Power Generation

Company Profile

Provyko s.r.o. is a supplier of power generation equipment and provider of services for boiler and heat exchanger installations.

The company currently employs 42 people with excellent knowledge and experience in design, construction, and project management.

Our work is based on an innovative approach to every single project, and open communication with the customer.

Our services include comprehensive care for a wide range of power generation equipment.

Our main products and services include

- Boiler combustion systems
- New boilers and boiler refurbishments
- Denitrification technology for combustion equipment
  - Primary measures
  - Secondary measures (SCR, SNCR)
- Milling circuits
- Heat exchangers, heat-exchanger stations
- Technical services - feasibility study, advisory and consulting services
- Turn-key delivery - from design and project management to regular maintenance

On behalf of the company

Tomáš Hlaváček
CEO

Alojz Boko
CEO

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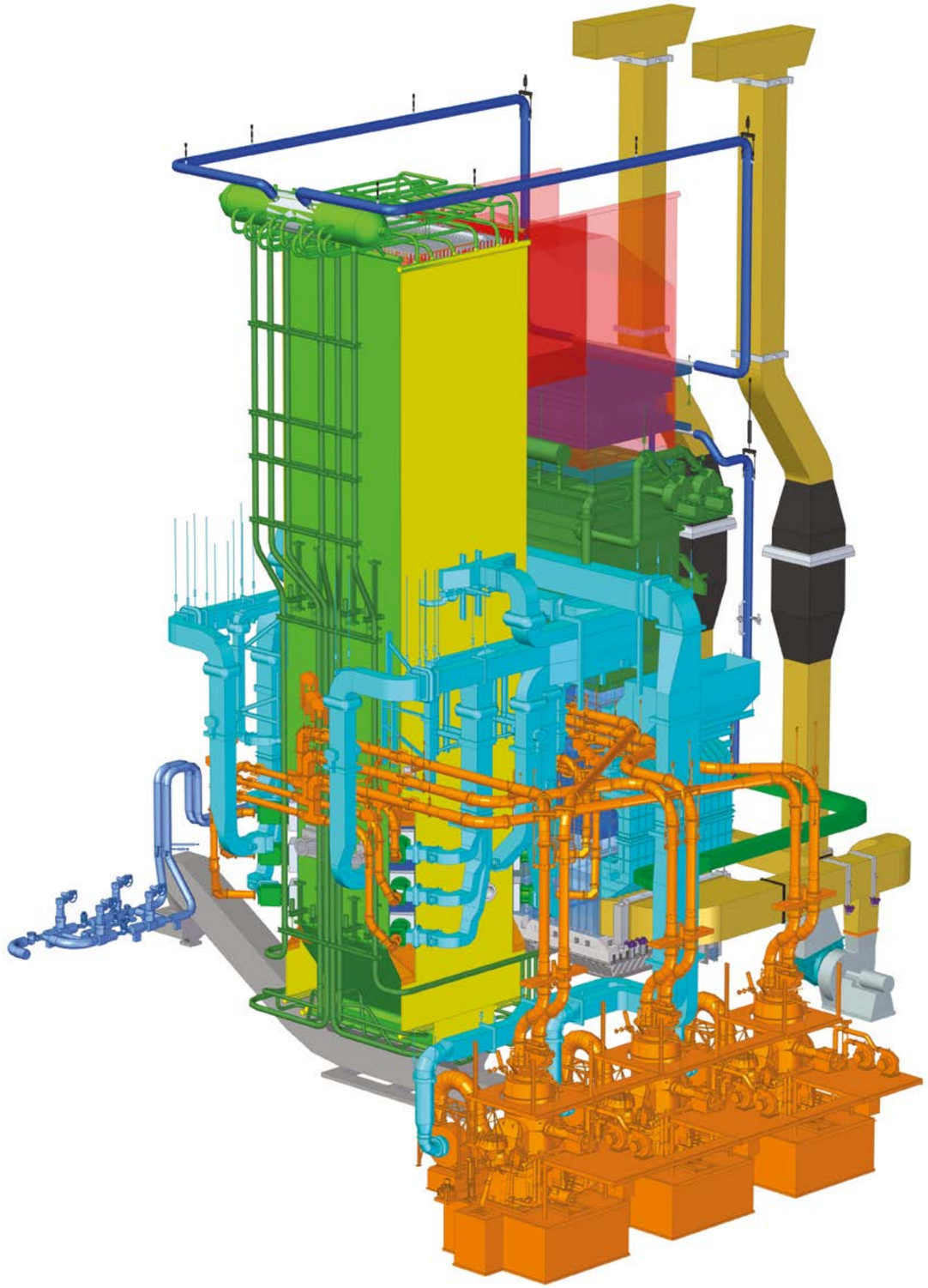


New Boilers

Our offer includes boilers firing solid, liquid and gaseous fuels as well as HRSG boilers. Boilers design, including their accessories, complies with the applicable EN or ASME standards and codes. In addition, boilers meet emission requirements laid down by the Czech and European legislation on air protection in force or customer-specific requirements.

Technical solution of each offered boiler corresponds with the specified fuel, and requirements set down for steam or heating water parameters. At the same time, the solution ensures maximum operational reliability of the boiler and reduces attendance and maintenance to an absolute minimum.

Upon customer request, we are always able to offer an optimal solution with a short delivery term.

Our offer includes the following main types of the boilers

According to the heat-transfer medium

- Gas and oil fired boilers
- Pulverized coal fired boilers
- Refuse - derived fuel fired boilers (RDF) and sludge fired boilers
- HRSG boilers

According to the heated medium

- Steam boilers
- Hot-water boilers

According to the heated medium parameters

- Low pressure boilers
- Medium pressure boilers
- High pressure boilers

Gas and Oil Fired Boilers

Several standardized boiler design options are available based on the specified parameters, and lay-out possibilities.

These boilers are designed for

Gaseous fuels	natural gas, hydrogen, blast furnace gas, coke-oven gas, converter gas, acetylene exit gases, …
Liquid fuels	light fuel oil, heavy fuel oil, waste oils, …

Depending on the heated medium, the boilers are classified into two basic categories

Steam boilers with the max. steam output 420 t/h

Hot-water boilers with the max. heat output 210 MW

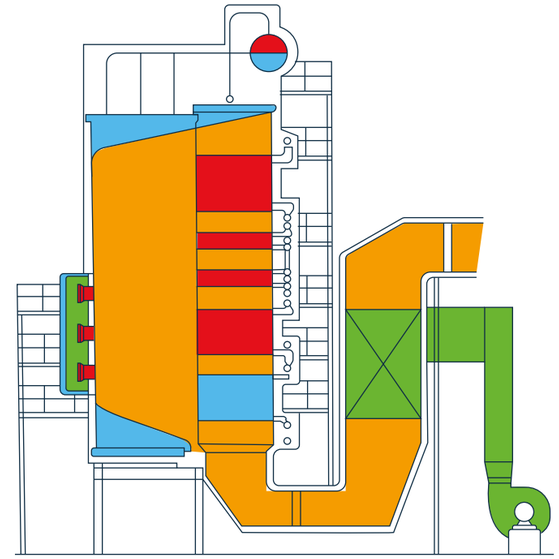
Main features of the boiler design

- Self-supported or suspended design
- One or more passes
- High efficiency
- Front-end or ceiling low-emission burners
- Gastight design with membrane walls
- Single-drum or bi-drum design with natural or forced circulation
- Tube bundles made of bare or finned tubes
- Tube or rotary regenerative air preheater
- Possibility to clean heating surfaces by sootblowers
- Precise control of superheated steam temperature
- Compact and economical solution
- Optimized for the specific area

Parameters of steam boilers

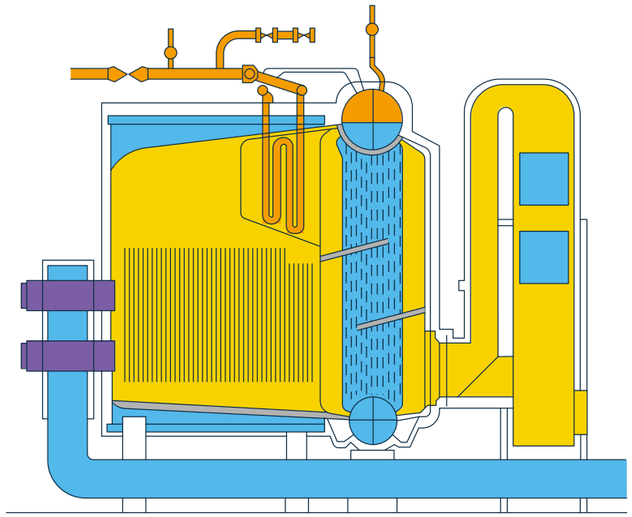
High pressure steam boilers

Steam output	80–420 t/h
Superheated steam pressure	60–175 bar(a)
Superheated steam temperature	max. 570°C



Medium pressure steam boilers

Steam output	50–120 t/h
Superheated steam pressure	30–70 bar(a)
Superheated steam temperature	max. 500°C



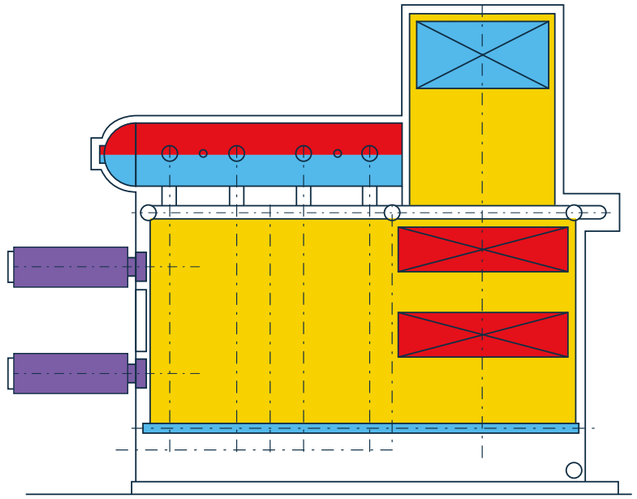
Parameters of steam boilers

Low pressure steam boilers

Steam output	50–130 t/h
Superheated steam pressure	13-45 bar(a)
Superheated steam temperature	max. 450 °C

Low pressure single-drum steam boilers

Steam output	20–80 t/h
Superheated steam pressure	13–60 bar(a)
Superheated steam temperature	max. 500 °C

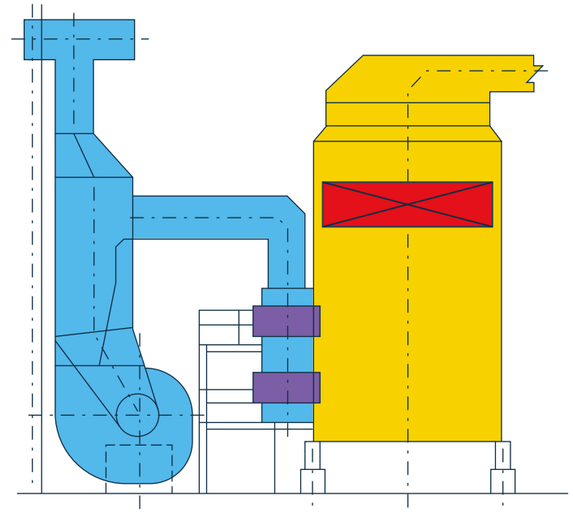


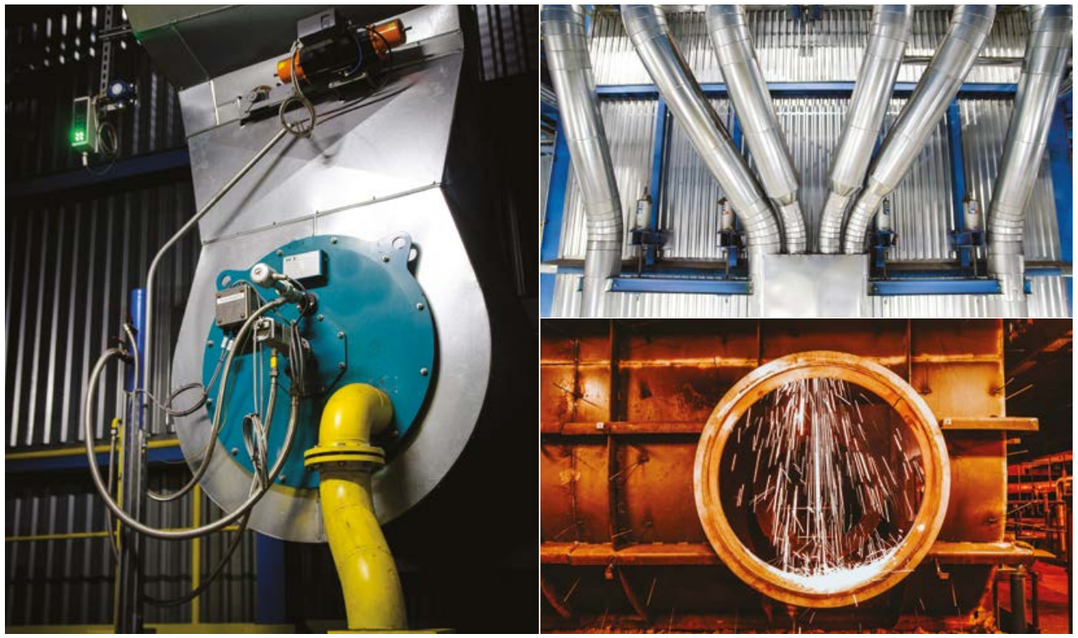
↑ Gas Hot Water Boiler 116 MWt

Parameters of hot-water boilers

Hot-water boilers for district heating

Heat output	max. 210 MW
Water pressure	14–25 bar(a)
Water temperature	max. 180 °C





↑ Photographs of Gas and Coal Fired Burner Installations

Pulverized Coal Fired Boilers

Design of pulverized coal fired boilers respects experience with firing a wide range of various types of coals and other solid fuels; black coal with high as well as low percentage of volatile matters in the combustible, various types of brown coals, and lignites. Biomass, refuse - derived fuels (RDF) and/or gaseous fuels can also be fired as additional fuels.

Main features of the boiler design

- Self-supported or suspended design
- Gastight design with membrane walls
- Design with removal of solid or molten slag from the combustion chamber
- Complete system of preparation and transport of fuel to burners
- Combustion system with low-emission pulverized coal burners
- Ignition and stabilization gas or oil burners
- System of primary and secondary measures to NO_x emission reduction
- High efficiency
- Single-drum or bi-drum design with natural circulation
- Alternative option with steam reheater or biflux
- Tube or rotary regenerative air preheater (APH)
- Cleaning of heating surfaces by sootblowers
- Precise control of superheated and re-heated steam
- Compact and economical solution
- Optimized for the specific area

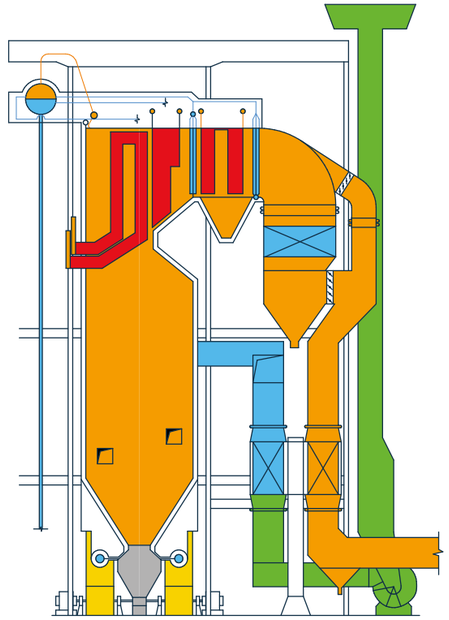
Parameters of steam boilers

High pressure steam boilers

Steam output	80–420 t/h
Superheated steam pressure	94–175 bar(a)
Superheated steam temperature	max. 570 °C

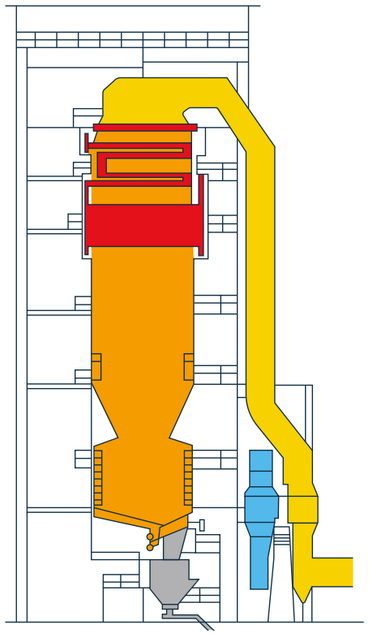
Low pressure steam boilers

Steam output	75–115 t/h
Superheated steam pressure	13–38 bar(a)
Superheated steam temperature	max. 450 °C



Hot water once through boilers to heat network water

Steam output	50–120 t/h
Superheated steam pressure	30–70 bar(a)
Superheated steam temperature	max. 500°C



HRSG Boilers

HRSG boilers use thermal energy contained in various types of waste flue gases to produce steam or heating water. HRSG boilers are primarily used in the combined heat and power generation plants; in connection with gas and steam turbines, these boilers constitute a highly efficient source of electric and thermal heat power.

Furthermore, HRSG boilers can be used for peak sources with combustion engines, in the refining plants, metallurgical plants or compressor stations. As far as possible, the design of HRSG boilers meets given parametric, and lay-out requirements.

Main features of HRSG design

- Tube bundles made of finned tubes
- Gastight overpressure design
- Boiler flue gas ducts with internal insulation and sheet casing and/or external insulation
- Duct burner integrated into the inlet flue gas duct as an alternative
- By-pass stack or flue gas duct with control flap as an alternative
- Installation of catalyst to reduce emissions as an alternative
- Installation of noise silencer as an alternative
- Precise control of superheated steam temperature
- Compact and economical solution
- Delivery to the site in the transportable modules - minimized assembly time
- Optimized for the specific area

Parameters of HRSG boilers

HRSG boilers can be designed as single pressure, double-pressure, and multi-pressure boilers completed with the heating water heater or condensate heater, possibly with an integrated feed water degasifier.

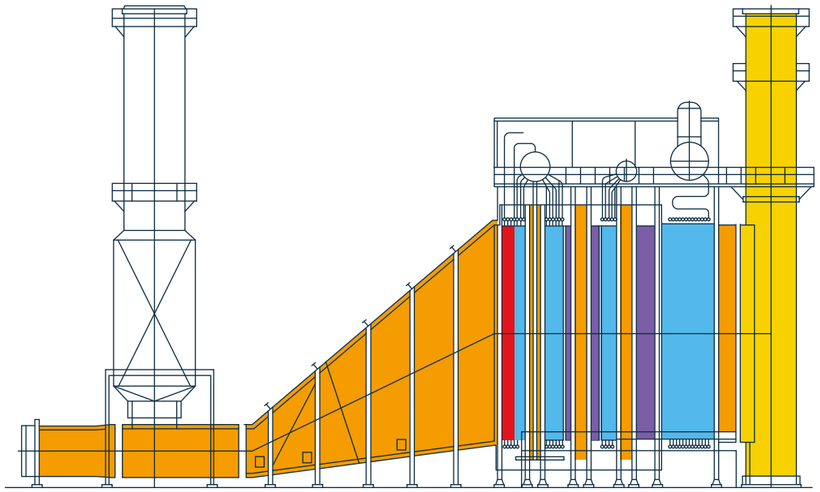
Parameters of the steam part of HRSG boiler are usually in the scope

Heat output	max. 200 MW
Superheated steam pressure	5–120 bar(a)
Superheated steam temperature	190–540 °C

Two basic versions of the standardized design of the boiler depending on the flue gas flow direction

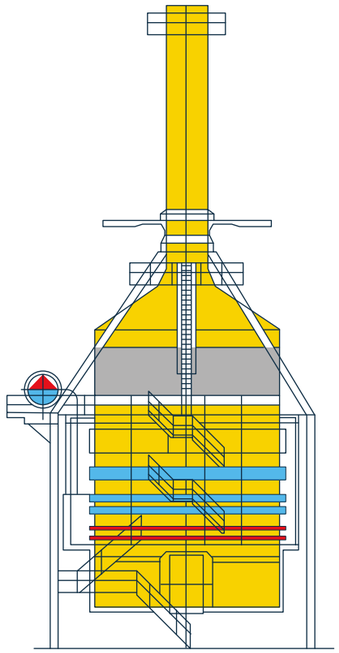
Horizontal boilers

Self-supporting, with natural circulation



Vertical boilers

Suspended in the supporting structure with natural or forced circulation created by circulation pumps



Boilers Firing Refuse Derived Fuel (RDF)

Boilers firing RDF can burn

- Solid, RDF
- Sludge from sewage disposal plants
- Hazardous waste
- Biomass
- Coal
- Various combinations of the above-mentioned fuels

Boiler designs

Stationary fluidized bed boilers

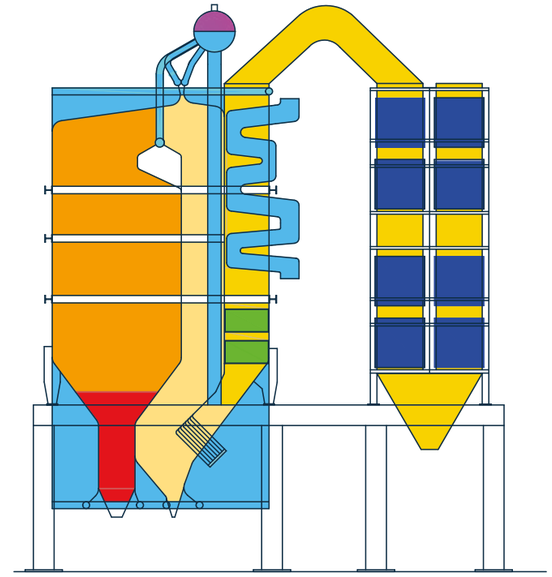
Grate boilers

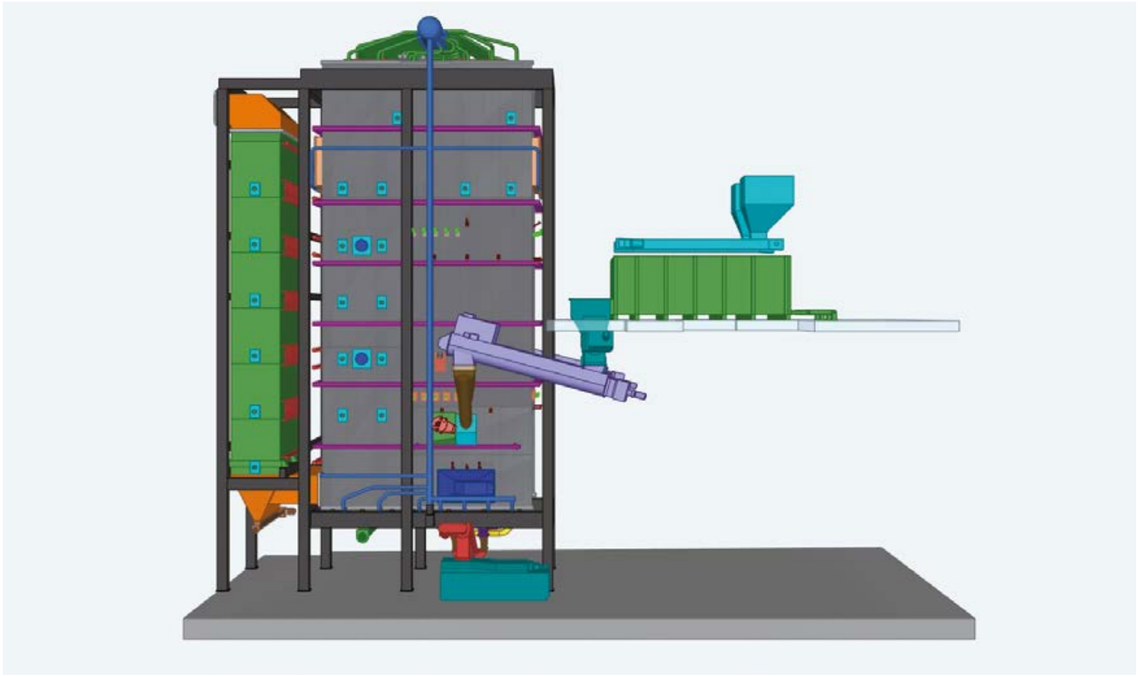
Typically, boilers are designed with multi-passes, membrane walls, drum with natural circulation

Typical parameters of boilers

Steam output	cca 5–50 t/h
Superheated steam pressure	40 bar(a)
Superheated steam temperature	cca 250–420 °C

For boilers firing these fuels, we also offer flue gas cleaning systems (dust, NO_x, SO_x, HCl, HF, PCDD/F, heavy metals) to meet both current and future emission limits.





↑ Design Model of the Sorted Waste Boiler (RDF), 40 MWt

Combustion Systems

We offer projects and deliveries of new combustion systems as well as designs, reconstructions, and modifications to the existing combustion systems for power, thermal and industrial boilers firing solid, liquid as well as gaseous fuels.

All activities dealing with combustion systems focus on NO_x emission reduction under the applicable legislation, improvement in boiler efficiency, extension of performance operating range without stabilization, reduction of slagging, extension of lifetime of components of the combustion system, and improvement in operational comfort of boiler operators.

The major factors affecting NO_x generation are mainly combustion velocity, flame temperature and length, excess of air, and pulverized coal fineness.

Primary methods are one of the methods of NO_x emission reduction technologies applied in the combustion process. These methods include installation of low-emission burners, so-called Low NO_x Burners (LNB), reburning, overfire air zones, flue gas recirculation, and other components supporting the optimization of combustion as to the NO_x reduction.

Scope of Offered Activities in the Category of Combustion Systems

Comprehensive designs, projects and implementation of new combustion systems as well as assessment, enhancement design and its implementation of the existing combustion systems

- Brown coal combustion systems
- Black coal combustion systems
- RDF and sludges combustion systems
- Liquid and gaseous fuels combustion systems
- Combined fuels combustion systems

Designs, projects and implementation of new, refurbished or modified parts of combustion systems

- Burners for all types of fuels
- Pipe routes of pulverized coal and waste vapours
- Pipe routes of air and recirculation flue gases
- Pipe routes of OFA zone including OFA nozzles
- Application of the reburning system
- Design, implementation, and tuning of I+C system of the combustion system
- Regulation elements to control the flow of media in the individual pipe routes including design and type of actuating mechanisms
- Gauges to measure the flow of media in the individual pipe routes
- Assessment and design of modifications to the milling circuits to optimize combustion system activity
- Calculations and assessment of pressure losses in the individual pipe routes including design of modifications
- CFD modelling of the combustion system and its individual parts

Adjustment, tuning, and optimization of operation of combustion systems

Black Coal Combustion Systems

We offer projects and implementation of new combustion systems to burn black coal as well as designs, enhancement, and modifications to the existing combustion systems to burn black coal.

We offer systems both with the direct and indirect blowing of pulverized coal into the boiler.

Combustion systems fire black coal with maintained high efficiency of the boiler, required emission parameters as well as other parameters and, moreover, solutions tailored to our customers' bespoke needs. The primary method of NO_x emission reduction is designed and applied to reduce NO_x emission values.

The primary method is based on the principle of sub-stoichiometric combustion of fuel in the burners with the subsequent reduction in generated NO_x. Reduction in CO and burnup of the residual coal are guaranteed by one or more levels of OFA nozzles.

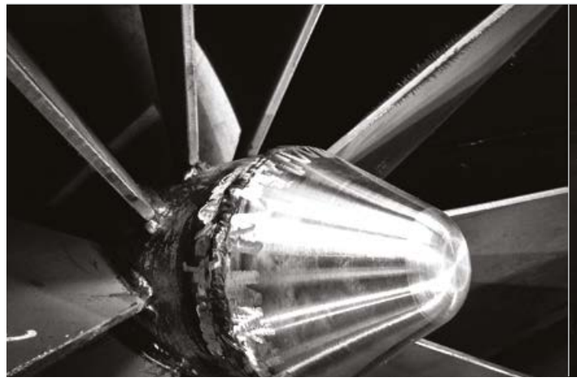
The design of the combustion system for black coal usually includes the following

- Installation of new or refurbishment of the existing swirl or straight flow low-emission burners
- Installation of new or refurbishment of the existing ring, drum or hammer mills
- Installation of new or refurbishment of the existing classifiers
- Installation of pipe routes and OFA nozzles
- Installation of recirculated flue gas pipe routes
- Installation of the fuel staging system - reburning
- Installation of new or adjustment to the existing I+C system of the combustion system
- Application of the combustion stability monitoring and control system
- Inspection measurement, adjustment, and tuning of the boiler combustion system

Benefits for the customer

- Compliance with NO_x and CO emission limits under the applicable and/or future legislation
- Improvement in boiler efficiency, reduction in operating costs
- Extension of boiler performance operating range without stabilization
- Reduction of slagging

↑ Coal Firing Swirl Burner



↑ Fly Ash Separator in the Flue Gas Duct

↑ Waste Vapour Duct with Lining

Brown Coal Combustion Systems

We offer projects and deliveries of new brown coal combustion systems as well as projects, reconstructions, and modifications to the existing combustion systems burning brown coal.

We offer systems with the direct blowing of pulverized coal to the boiler.

Combustion systems guarantee brown coal burning with maintained high efficiency of the boiler, required emission parameters as well as other parameters and, moreover, solutions tailored to our customers' bespoke needs.

The primary method is based on the principle of sub-stoichiometric combustion of fuel in the burners with the subsequent reduction in generated NO_x. Reduction in CO and burnup of the residual coal are guaranteed by one or more levels of OFA nozzles.

The design of the combustion system for brown coal usually includes

- Installation of new or refurbishment of the existing straight-flow low-emission burners
- Installation of new or refurbishment of the existing fan or hammer mills
- Installation of new or refurbishment of the existing classifiers
- Installation of ductworks, and OFA nozzles
- Installation of ductworks of recirculated flue gases
- Installation of the fuel staging system - "reburning"
- Installation of new or modification to the existing I+C system of the combustion system
- Application of the combustion stability monitoring and control system
- Inspection measurement, adjustment, and tuning of the boiler combustion system

Benefits for the customer

- Compliance with NO_x and CO emission limits under the applicable and/or future legislation
- Improvement in boiler efficiency, reduction in operating costs
- Extension of boiler performance operating range without stabilization
- Reduction of slagging

Alternative Fuels Combustion System

We offer projects and implementation of new combustion systems to burn RDF, waste sludges from waste water treatment plants and/or biogas stations or various types of biomass; burning of various combinations of the above-mentioned fuels is also possible.

The combustion system burns alternative fuels while maintaining high efficiency of the boiler as to the combustion system protection against negative effects of the combustion. Alternative fuels are burnt either in the bubbling fluid bed or on the grid. While burning in the bubbling bed, hazardous wastes can also be co-burnt. Compliance with the requested emission and other parameters and requirements as requested by the customer is maintened.

We offer the following activities as the part of design and implementation of the combustion systems for alternative fuels

- Assessment of fuel properties, selection of the most appropriate combustion system, design of the engineering solution and its implementation considering investment and operating costs
- Engineering and implementation of fuel management
- Engineering and implementation of the flue gas cleaning system
- Installation and connection of the equipment
- Putting into operation and tuning

Benefits for the customer

- Complete delivery of the combustion system including fuel transport and flue gas cleaning as the turn-key delivery
- Safe burning of alternative fuels with high operating reliability
- Possibility to burn fuels with a wide range of calorific values
- Adjustment of the boiler output parameters to the request of the customer

↑ Solid Alternative Fuel (RDF)

Combustion Systems to Burn Gaseous and Liquid Fuels

We offer projects and deliveries of new combustion systems burning gaseous and liquid fuels as well as projects, reconstructions, and modifications to the existing combustion systems burning gaseous, and liquid fuels.

Combustion systems burn gaseous and liquid fuels with maintained high efficiency of the boiler, required emission parameters as well as other parameters, and requests of the customer.

The design of the combustion system to burn gaseous and liquid fuels usually includes

- Design and location of the burners in the boiler furnace, determination of performance and type of burners
- Professional cooperation with the supplier of burners for gaseous and liquid fuels up to the project management stage
- Design and implementation of gaseous and liquid fuel management
- Design and installation of air and recirculated flue gases ductworks
- Design and installation of the control system BMS (Burner Management System) – for safe operation of the burners in harmony with the applicable legislation
- Installation of new or adjustment to the existing I+C system of the combustion system
- Inspection measurement, adjustment, and setting-up of the boiler combustion system

Benefits for the customer

- Compliance with NO_x and CO emission limits under the applicable and/or future legislation
- Improvement in boiler efficiency, reduction in operating costs

↑ Ignition and Stabilization Gas Burner

Low Emission Coal Swirl Burners

Coal swirl burners, delivered by our company, are characterized by high technical standards, and quality of workmanship. These features greatly contribute to the optimal operating activity, and low NO_x values.

Swirl burners are primarily used to burn coal with lower content of volatile matters in the fuel. This applies mainly to black coals or high-calorific brown coals.

To meet requested guaranteed parameters, burners can be delivered as new or, if allowed by the technical design of the existing burners, the existing burners can be optimized.

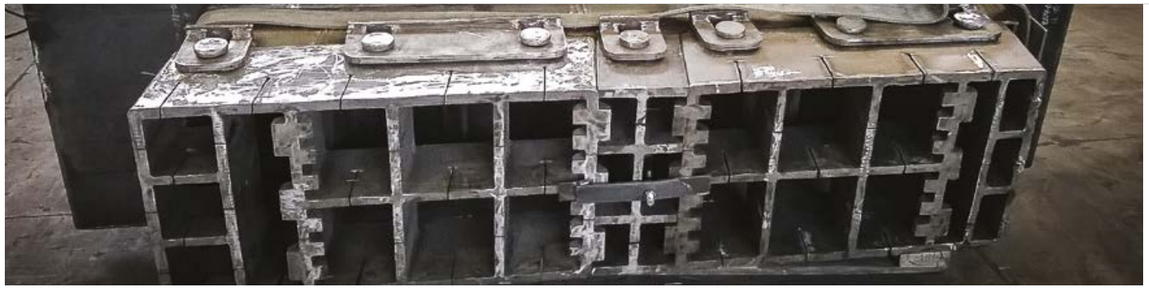
The technical design of the swirl burner will help to achieve

- Reduced NO_x formation by optimal mixing and burning ratios with requested controlled sub-stoichiometry of the combustion air.
- Quality mixing, achieved by optimal turbulence of mixture of the pulverized coal and combustion air supported, in addition, by the special construction of the swirling terminal part of burner nozzles. The intensity of swirling in the air nozzles can be adjusted.
- Continuously controlled distribution of the combustion air in the entire performance range of the boiler, highly impacting the activity of the burner from the point of reduced NO_x generation and decrease of unburnt particles in the fly ash and slag.
- Reduced abrasion to the stressed parts of the burner. The parts of the burner, exposed to abrasion, where the coal mixture flows, are made from an abrasion resistant material.
- Longer lifetime of the terminal part of air and coal nozzles of the burner, which can be manufactured from thermally resistant material or as casted parts more resistant to thermal deformation and contributing to longer lifetime of the thermally stressed mouth of the burner.

↑ Coal Swirl Burner

Benefits for the customer

- Reduced NO_x emissions
- Improved boiler efficiency, reduced operating costs
- Extended boiler performance operating range without use of stabilization
- Longer lifetime of the burner's mouth
- Optimized slagging



↑ Stream Coal Burner with Casted Iron Mouth

Straight-flow Low-Emission Coal Burners

Straight-flow coal burners, delivered by our company, are characterized by high technical standard, and quality of workmanship. These characteristics significantly contribute to optimal operating activity and low NO_x values. Straight-flow coal burners are primarily used to burn brown coals or low-calorific black coals with a higher content of volatile matters.

To meet requested guaranteed parameters, burners can be delivered as new or, if allowed by the technical design of the existing burners, the existing burners can be optimized.

The technical design of the straight-flow burner helps to achieve

- Reduced NO_x generation by optimal mixing and burning ratios with requested controlled sub-stoichiometry of the combustion air
- Quality mixing and fast ignition of the mixture, achieved by balanced concentration of pulverized coal at the mouth of the burner, and appropriate modification to the mouth part of the burner nozzles
- Continuously controlled distribution of the combustion air along the height of the burner in the entire performance range of the boiler, highly affecting optimized parameters of mixing of pulverized coal and air as well as positive impact on the reduced quantity of unburnt matters in the fly ash and slag.
- Reduced abrasion to the stressed parts of the burner. The parts of the burner, exposed to abrasion, where the coal mixture flows, are made from an abrasion resistant material
- Longer lifetime of the terminal part of air and coal nozzles of the burner, which can be produced from thermally resistant material or as casted parts, more resistant to thermal deformation and contributing to longer lifetime of the thermally stressed mouth of the burner

Benefits for the customer

- ⊕ Reduced NO_x emission value
- ⊕ Improved boiler efficiency, reduced operating costs
- ⊕ Extended boiler performance operating range without stabilization
- ⊕ Longer lifetime of the burner's mouth
- ⊕ Optimized slagging

Cast Iron Mouths of Burners

Cast iron mouths of burners are used for all types of low-emission coal burners as well as for a wide range of burnt coals.

Cast iron terminal parts of the burners are designed for burners exposed to the increased thermal stress. Their use - in contrast to all-welded terminal parts- significantly reduces deformation of the geometry of the terminal parts of the burner, extends their lifetime, and maintains the quality of the mixing function of the burner in the long-term time horizon.

The technical design helps to achieve

- Each cast iron terminal part of the burner is specifically produced to suit requirements set down for the particular burner
- Standardized connection of the terminal part to the burner and/or customized subject to the prior consultation with the customer
- The solution to the thermal expansion between the cast iron terminal part and the burner body excludes their mutual deformation

Benefits for the customer

- ⊕ Extended lifetime of the terminal part
- ⊕ Decreased labor demand and shorter time to replace the terminal part
- ⊕ Price comparable with the welded mouth
- ⊕ Lower probability of the deformation of the terminal part

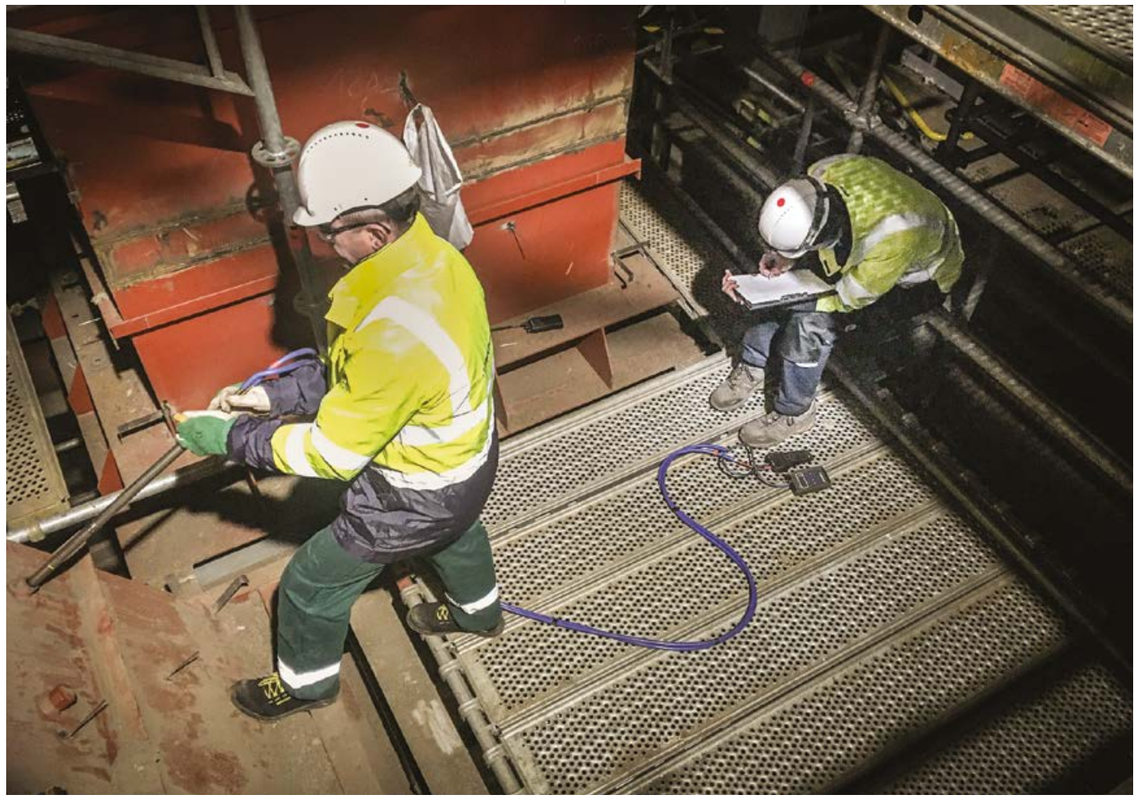
↑ Cast Iron Mouths of Burners

Adjustment, Tuning, and Optimization of Operation of the Combustion Systems

Adjustment and optimization of the operation of the combustion system is the final activity in the sequence of implementation and putting of the combustion system into operation.

As the part of this activity, we offer

- Inspection measurement of media flow through the duct in the point of installed air flow gauges by Prandtl probes with the subsequent calibration
- Putting of the combustion system into the operation, the individual functional generators adjusted in compliance with the designed air/flue gas balance
- Adjustment of the combustion system to the required parameters in the entire operating range of the boiler
- Correction to operating curves of the individual functional generators
- Guarantee tests



↑ Air Duct Inspection Measurement

Flame Quality Monitoring System **FLAMMON**

FLAMMON integrates monitoring and combustion quality analysis with the security system of the pulverized coal fired boiler. The system uses optic sensors, which monitor the radiation of the entire flame in the combustion chamber in the broad spectrum, and analysers, which evaluate flame fluctuation range and counts flame quality to control and protect the boiler.

The combination of flame monitoring with the combustion quality analysis of the burning of the entire flame in the combustion chamber supplies information to the advanced two-stage boiler protection and safe control of the stabilization fuel supply; among others, considerable quantities of stabilization fuel are saved without the risk of boiler outage.

FLAMMON information allows for more effective operating decisions about stabilization of the combustion in the boiler in the stage of boiler commissioning and operating events such as outages of fuel, mills and air distribution, pressure system failures or falls of deposits.

At the same time, the system ensures advanced boiler protection including safe shut-down of the boiler, if unavoidable, thus protecting both the boiler and the attendance staff. FLAMMON provides two levels of boiler protection if burning quality drops significantly:

1st level

The system disables the start of the stabilization if the ignition of unburnt fuel, explosion, and damage to the boiler can be encountered.

2nd level

If the flame quality massively drops, the system activates the safe shut-down of the boiler before the complete loss of the flame, thus protecting the boiler pressure system against damage.

Besides, FLAMMON allows for the automatic start of the stabilization burners if lower stability of coal burning is indicated. For example, this function eliminates outages due to the slow response of the boiler attendance staff or sudden changes in the coal delivery.

FLAMMON meets the following safety criteria

- Boiler protection equipment - EN 12952-9
- SIL 3 acc. to EN 61 508
- Boiler protection against the explosion of unburnt pulverized fuel
- Compliance with the American standard NFPA 85

Offered services

- Advisory and consulting services, studies
- Design and engineering incl. design and installation of the protection
- Delivery of the complete system, i.e., hardware and software
- Installation and connection of the equipment
- Putting into operation and adjustment

Benefits for the customer

- ⊕ Improved safety of the boiler operation
- ⊕ Increased reliability of the boiler
- ⊕ Extended boiler operating range
- ⊕ Saved costs of stabilization fuel
- ⊕ Automatic start of stabilization burners

↑ The optic sensor needs only 15 mm peep slot to the combustion chamber

↑ Modules of the processors of the individual optic sensors and central processor

Denitrification Technologies for Combustion System

Offered services

- Comprehensive and innovative designs to reduce nitrogen oxides in flue gases of the combustion systems
- Integration of primary and secondary technologies developed and designed for specific opportunities, respecting investment and operating costs
- Optimization of processes and improvement in effectiveness to guarantee as low risk to the environment as possible
- Advisory and services addressing both the current as well as future legislative requirements

Denitrification technologies – primary methods

- Primary methods integrated into the combustion system

Denitrification technologies – secondary methods

- SCR - Selective Catalytic Reduction
- SNCR - Selective Non-Catalytic Reduction

Denitrification Technologies

The primary method to reduce NO_x emissions

The primary method reduces NO_x emissions during the combustion process.

The combustion takes place with the controlled air/flue gas balance in the individual height sections of the burner furnace.

To reduce NO_x emissions, sub-stoichiometric air ratios in the pulverized coal burners and controlled admission of air are applied by the installation of additional air and/or coal nozzles along the height of the furnace; besides, these nozzles participate in gradual NO_x reduction and, finally, also CO reduction.

The individual elements of the boiler combustion system are designed accordingly – low-emission burners, tertiary and OFA nozzles, side air nozzles, or as the case may be, independent coal nozzles (so-called "reburning").

In our long company history, we have successfully installed primary methods at various types of boilers, both new and refurbished.

These boilers fired both brown and black coal, also co-burnt gaseous fuels or biomass.

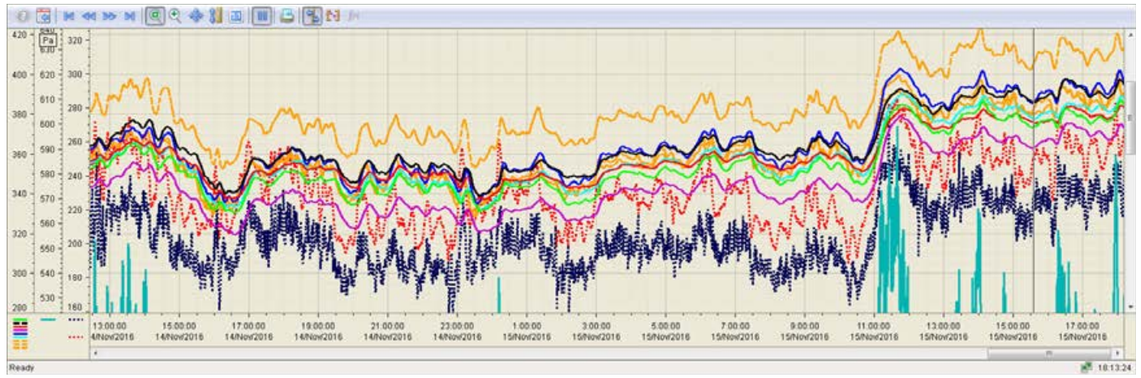
Primary method installation

- Complete design of the primary method taking into account milling circuits and the concept of the entire boiler to meet boiler parameters
- Technical design and deliveries of low-emission burners, either straight-flow or swirl
- Technical design and delivery of pulverized coal ducts
- Technical design and deliveries of tertiary, OFA or side air nozzles
- Technical design and delivery of separate nozzles of pulverized coal mixtures ("reburning" nozzles)
- New design or modification to the I+C system incl. delivery of measurement and controlling elements
- Design and delivery of new or modification to the existing air ducts or possibly also recirculated flue gas ducts

Benefits for the customer

- For its activity, the primary method application does not need any other additional media which would increase operating costs of the entire denitrification process
- The primary method can ensure maximum possible NO_x reduction in the combustion process, thus reducing requirements to NO_x reduction by secondary measures, thus reducing their price, and operating costs
- Optimal design of the primary method helps to maintain the existing efficiency of the boiler
- The primary method is delivered as the turn-key installation

↑ Pulverized Fuel Burner Installation



↑ Record of the Combustion System Adjustment

SNCR

Selective Non-Catalytic Reduction

- The selective non-catalytic reduction is a widely available technology system removing nitrogen oxides from flue gases generated by various combustion systems
- As the part of the flue gas denitrification projects, we offer design and complete delivery of SNCR system applying state-of-the-art technologies

Offered services

- Advisory and consultancy services
- Feasibility study
- Optimization of the existing combustion systems to apply SNCR
- Design and engineering
- CFD modelling
- Deliveries of complete systems, including storage, and reagent preparation
- Assembly and putting into operation
- Servicing activities

Design and deliveries of the equipment

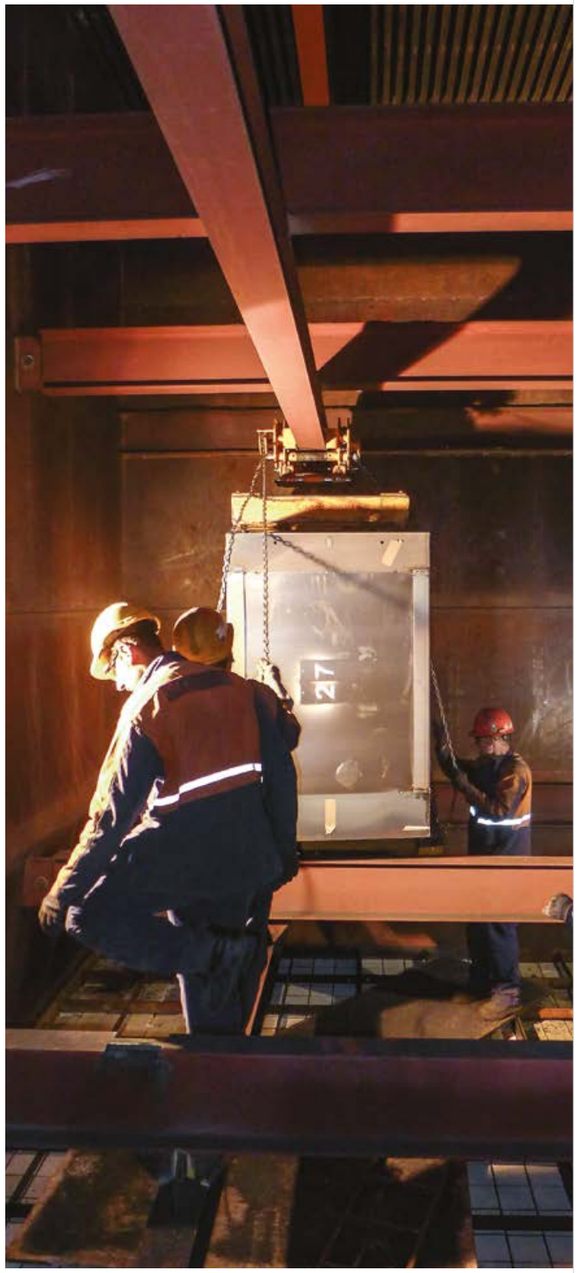
- Deliveries of complete SNCR systems including reagent storage and preparation
- Possibility of integration of nozzle lances into OFA nozzles
- Deliveries of adaptable nozzle lances
- Systems for temperature measurements in the combustion chamber
- Hybrid SNCR system equipment in combination with catalysts to capture ammonia residuals in flue gases
- Emissions measurement deliveries

Benefits of SNCR systems

- Low investment costs
- Excellent results as to the partial NO_x emission reduction
- Fast and easy installation

DeNOx SCR

Selective Catalytic Reduction



↑ Installation of Modules to SCR Reactor

- The selective catalytic reduction is the most effective, already widely available, technology to remove nitrogen oxides from flue gases generated by power generation equipment
- Best available technology (BAT) - advanced technology, the most environmentally friendly
- The reliable path for meeting emission limits in harmony with the existing as well as a newly considered directive, including capturing mercury from flue gases
- Burning of fuel with higher nitrogen content and better economical as well as technical results with the optimal setting of the boiler combustion system
- As part of the project of flue gas denitrification, we offer comprehensive and innovative design of the advanced SCR systems applying the latest technologies.

Comprehensive designs and deliveries of the equipment

Adjustments and modifications to the combustion system to implement SCR

- Modifications to the existing flue gas ducts
- Construction of new SCR reactors
- Modifications to the heating surfaces of the boilers to ensure thermal window for the catalyst
- Regeneration and heating of flue gases for the technology Tail End

The comprehensive and innovative design of the advanced SCR systems with most advanced technologies

- High Dust systems into the existing flue gas ducts
- High Dust systems into the newly built SCR reactors
- Low Dust systems behind the fly ash separator
- Tail End systems behind desulphurization technology shared by more boilers

Deliveries of systems for storage and preparation of the reagent using ammonia water or urea

Emission measurement deliveries

↑ Putting of SCR System into Operation ↗ SCR Module Detail

Offered services

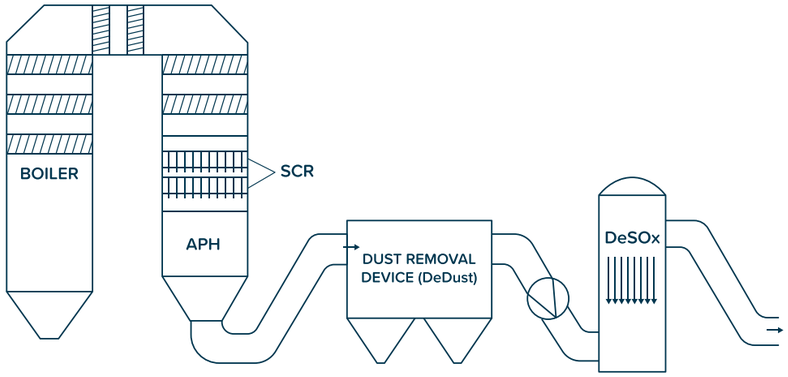
- Advisory and consultancy services
- Optimization
- Feasibility study
- Basic and detail engineering
- Thermal window for the catalyst
- CFD modelling
- Deliveries of complete systems, including storage and preparation of the reagent
- Assembly and putting into operation
- Servicing activities

Benefits of SCR systems

- Reliable and significant reduction of NO_x emissions with keeping the limited ammonia slip
- Compliance with stricter emission limits in harmony with a newly prepared legislation
- Maintenance of high quality of ash matters with the possibility of their later use in the subsequent industrial sectors
- Optimal and independent setting of the combustion system with the achievement of better technical and economical results
- Highly competitive costs from the point of long-term economic evaluation of the operation

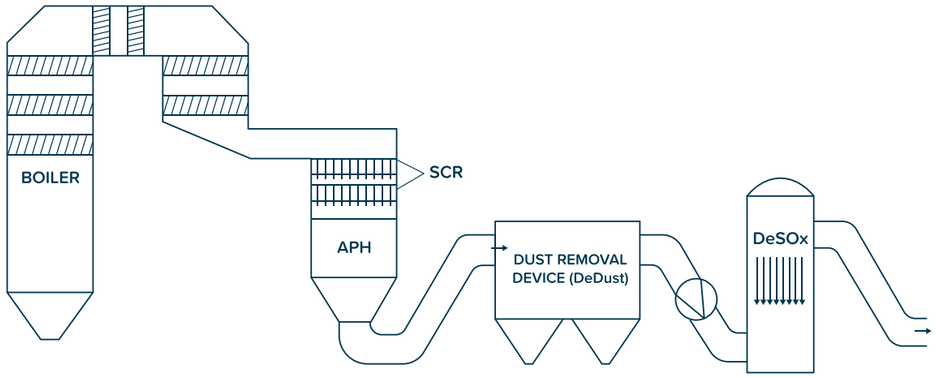
High Dust Systems

Implementation of SCR technology into the existing passes of the boiler



HIGH DUST - installation in the existing 2nd pass of the boiler

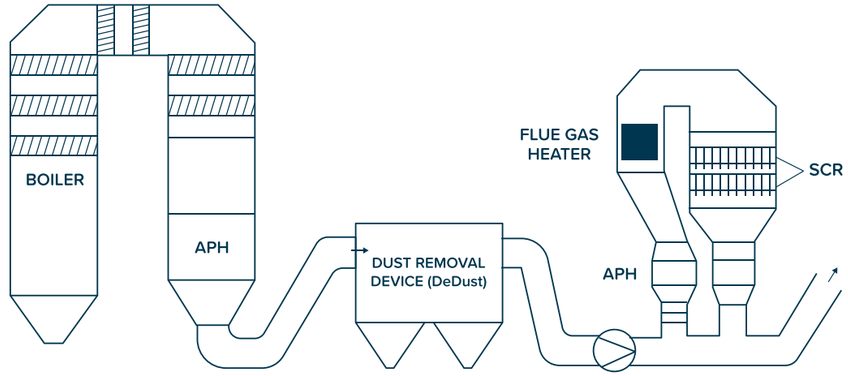
Implementation of SCR technology into the new independent reactor



HIGH DUST - installation in the new independent reactor

Low Dust Systems

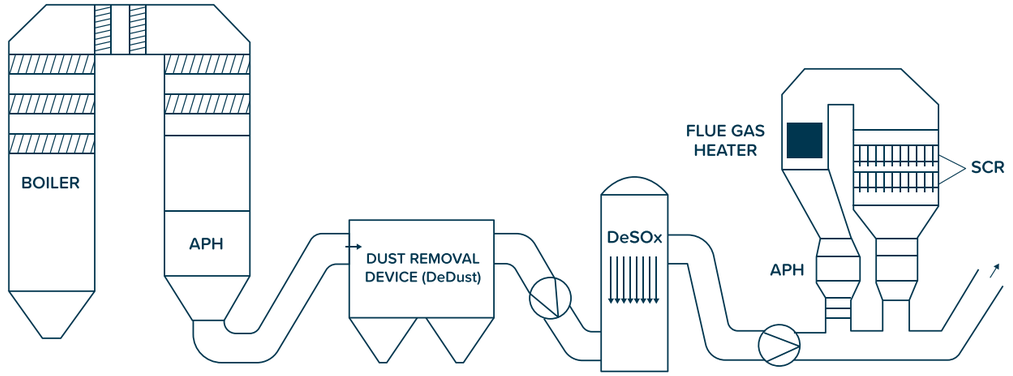
Implementation of SCR technology behind the fly ash separator



LOW DUST - installation behind the fly ash separator

Tail End Systems

Implementation of SCR behind FGD desulphurization systems



TAIL END - installation behind the desulphurization system

Milling Circuits

Our company is dealing with milling systems preparing pulverized coal for dry and wet bottom boilers. Engineering of milling circuits, together with the combustion system and boiler design, ensure effective cooperation and guarantee complex solution from raw fuel bunkers up to the steam supply to the turbine. Technical designs are focused on the milling systems with beater, hammer, vertical, and drum mills. Our team experts can also find solutions focusing on older milling circuits, and adjust their parameters to the new requirements of the customer.

Offered services

- Adjustment of mills to changes in fuel
- Improved performance of mills
- Improved pulverized coal fineness
- Extended mill control range
- Optimized milling process
- Thermal calculations of milling circuits
- Flow modelling FLUENT
- Strength calculations ANSYS
- Measurement of milling circuits including pulverized coal fineness

Design of New Milling Circuits and Transport Routes

We offer projects and installations of new milling equipment for brown and black coal. Primarily, we use the most widespread types of mills, i.e., beater mills to mill brown coals and vertical or drum mills to mill black coals. The design of milling equipment and transport routes always take into account the requirements of the entire combustion system with regard to the NO_x emission and unburned carbon. To design the most effective alternative, high emphasis is laid on the entire lifetime of the equipment and future costs of maintenance and operation of the equipment. Special attention should also be paid to the fire/explosion protection safety equipment, constituting an inseparable part of each milling equipment, and transport routes.

Milling circuits

- with wheel beater mill
- with hammer mill
- with drum mill
- with vertical mill

Offered services

- Advisory and consultancy services
- Feasibility study
- Optimization of the existing equipment
- Project and engineering
- Deliveries of complete systems
- Assembly of the equipment and putting into operation
- Servicing activities

Benefits for the customer

- Improved boiler efficiency
- Improved operating parameters
- Improved equipment reliability
- Reduced operating costs

↑ Vertical Pulley Mills with Tiltable Runners Installation in the Power Generation Source Operation

Adjustment of the Existing Milling Circuits to New Requirements

Adjustment of the existing mills to new requirements is a frequently used alternative which, to the greatest possible extent, exploits potential of the applied design, thus becoming a more economical option. Firstly, the original equipment is technically analyzed as the necessary precondition for the right choice of the new solution. Feasibility study, comparing several technical options incl. investment cost estimation, is the output.

↑ Abrasion Resistant Material Application in the Fan

Engineering Procedures

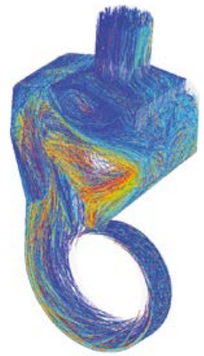
A new solution is always based on the output and thermal calculations of the entire milling circuit, thus taking into account local operating conditions. Milling equipment design is closely connected to CFD modelling of flow. Applying this tool, milling processes can be optimized, in particular, in the classifiers. The technical solution is always designed to emphasize the most appropriate used materials, and needs of the customer. Measurement of the operating parameters incl. pulverized coal sampling with the isokinetic probe is an integral part of the engineering.

Benefits for the customer

- Lower investment costs
- Individualized approach
- Improved mill performance
- Extended control range
- Improved milling fineness
- Reduced backfire

1 **Technical problem** ····▸ 2 **Measurement** ····▸ 3 **Suggested solution** ····▸ 4 **Feasibility study** ····▸ 5 **Implementation**

↑ Milling Wheel Design



↑ CFD Modelling of the Mill with the Classifier

Heat Exchangers

We provide comprehensive services for tube heat exchangers for power generation and industry.

- Control and design thermal and hydraulic calculation
- Design
- Engineering
- Strength calculation acc. to the standards as well as FEM method

We ensure production incl. inspection and approval

Heat Exchangers

We deliver tube heat exchangers for power engineering and industry based on our in-house thermal and engineering design or, as the case may be, on the basis of the assigned basic design of the customer. The design of our exchangers is based on thermal-dynamic calculations, and internationally recognized standards. We make customized designs as requested by the individual operator.

The thermal design of exchangers is prepared in accordance with HEI standard, and our gained experience. The design and strength calculation of exchangers can follow standards EN13445, ASME VIII div. 1, DIN-AD2000M, ČSN 690010. Maximal parameters of strength dimensioning to 300 bar/500°C. Application of the directive 2014/68/EU (PED) is maintained.

We apply the finite element analysis (FEA) for strength calculations of non-standardized parts. In addition, the engineering includes re-calculation of external stress in apparatuses, such as seismicity.

Offered services

- Advisory and consultancy activities
- Thermal proposal of the exchangers
- Engineering and strength proposal of the exchangers
- Production documentation and engineering
- Deliveries of complete systems
- Co-operation in the workshop incl. notified body approval and supervision
- Assembly of the equipment and putting into operation
- Servicing activities

Benefits for the customer

- Improved efficiency of the cycle
- Improved operating parameters
- Waste heat recuperation
- Decrease in operating costs

↑ Low Pressure Heat Exchanger

Standardized Designs

Low pressure heaters

Multi-pass, with U-tubes or straight tubes, removable water chamber, integrated condensate cooler. Horizontal or vertical design in compliance with the lay-out limits or requests of the customer.

High pressure heaters

Most commonly double-pass, with U tubes, either vertical or horizontal design, all-welded structure, water chamber with a self-sealing closure. With integrated internals of the condensate cooler, and steam condenser.

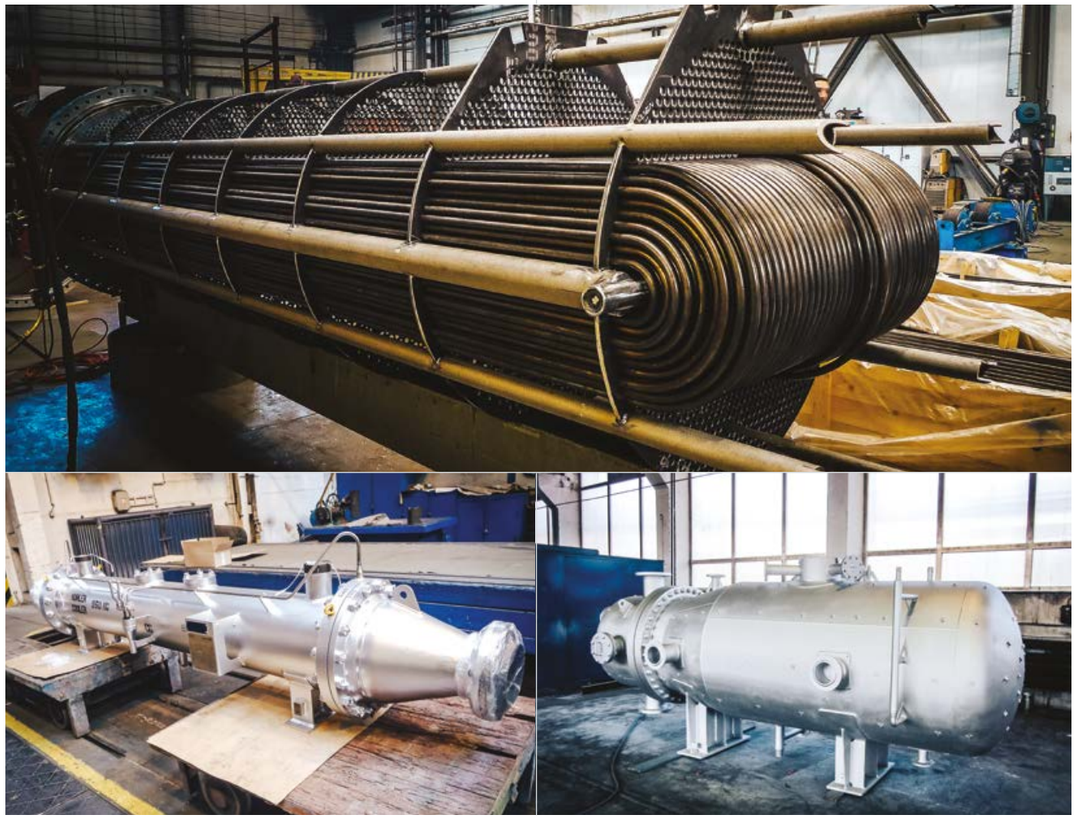
Surface condensers, heaters

Surface condensers for the max. turbine output ca. 100 MW, i.e., condensers to the max. ca. 100 t, and diameter 3.5 m. Either axial or radial steam inlet. The design of condensers allows for continuous cleaning of heat-transferring tubes. Heat-transferring tubes from stainless steel, brass or titanium.

Heaters work in the overpressure and/or mild underpressure mode. Multi-pass, with U tubes or direct tubes, horizontal or vertical design. With integrated internals of condensate cooler, and steam/air mixture.

Special exchangers, pressure and non-pressure vessels

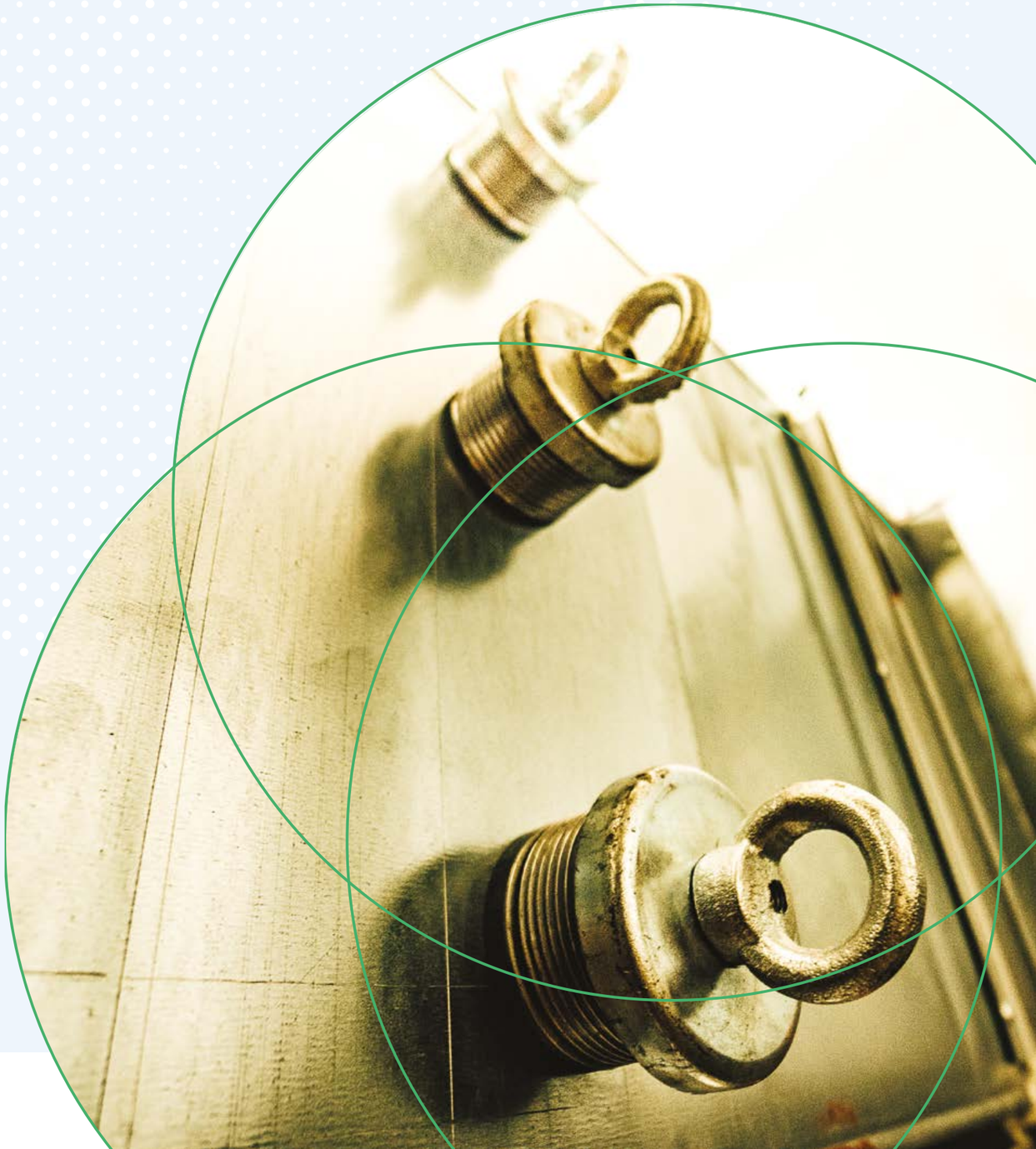
For example, steam air heaters, coolers, pressure, and non-pressure vessels are other heat exchangers.



↑ Photographs of Heat Exchanger Installations

Measurement of Air/Flue Gas Paths of the Boiler, Pulverized Coal Sampling

We measure air/flue gas paths of the boiler to the maximum temperature of the medium 500°C with velocity probes. In addition, we also collect samples of pulverized coal from boilers firing both brown and black pulverized coals with an isokinetic sampling probe. At the same time, we can make an immediate granulometric analysis of collected pulverized coal with an analytical sieve shaker.



Measurement of Air/Flue Gas Paths of the Boiler

We measure air/flue gas paths of the boiler to the maximum temperature of the medium 500°C with velocity probes. In addition, we can also use an apparatus to measure emissions in the outgoing flue gases, for example NO_x, and CO.

By measurement, we can determine:

- Velocity profile in the duct cross-section in the point of the network measurement
- Real flow of the medium in the point of measurement
- Ventilation of milling circuits at the outlet from classifiers
- Correction coefficient, allowing to calibrate operating flow measurement of the specific medium

We use the following types of velocity probes for measurement:

- Prandtl tube: length 0.5 m, 1.0 m, 1.5 m, 2.0 m, and 2.5 m
- Direct probe (S-probe): length 1.0 m, and 1.5 m

Micromanometers and manometers of the company AIRFLOW are used to read measured values.

To measure outgoing flue gases, we use:

- Portable emission analyzer NOVA PLUS from the company MRU

↑ Flue Gas Emission Analyzer

↑ Industrial Endoscope

Pulverized Coal Sampling by Isokinetic Sampling Probe, and Determination of Pulverized Coal Granulometry

We collect samples of pulverized coal, fired in brown and black coal fired boilers by an isokinetic sampling probe.

At the same time, we can immediately analyze the granulometry of such collected pulverized coal by an analytical sieve shaker.

By sampling we can determine:

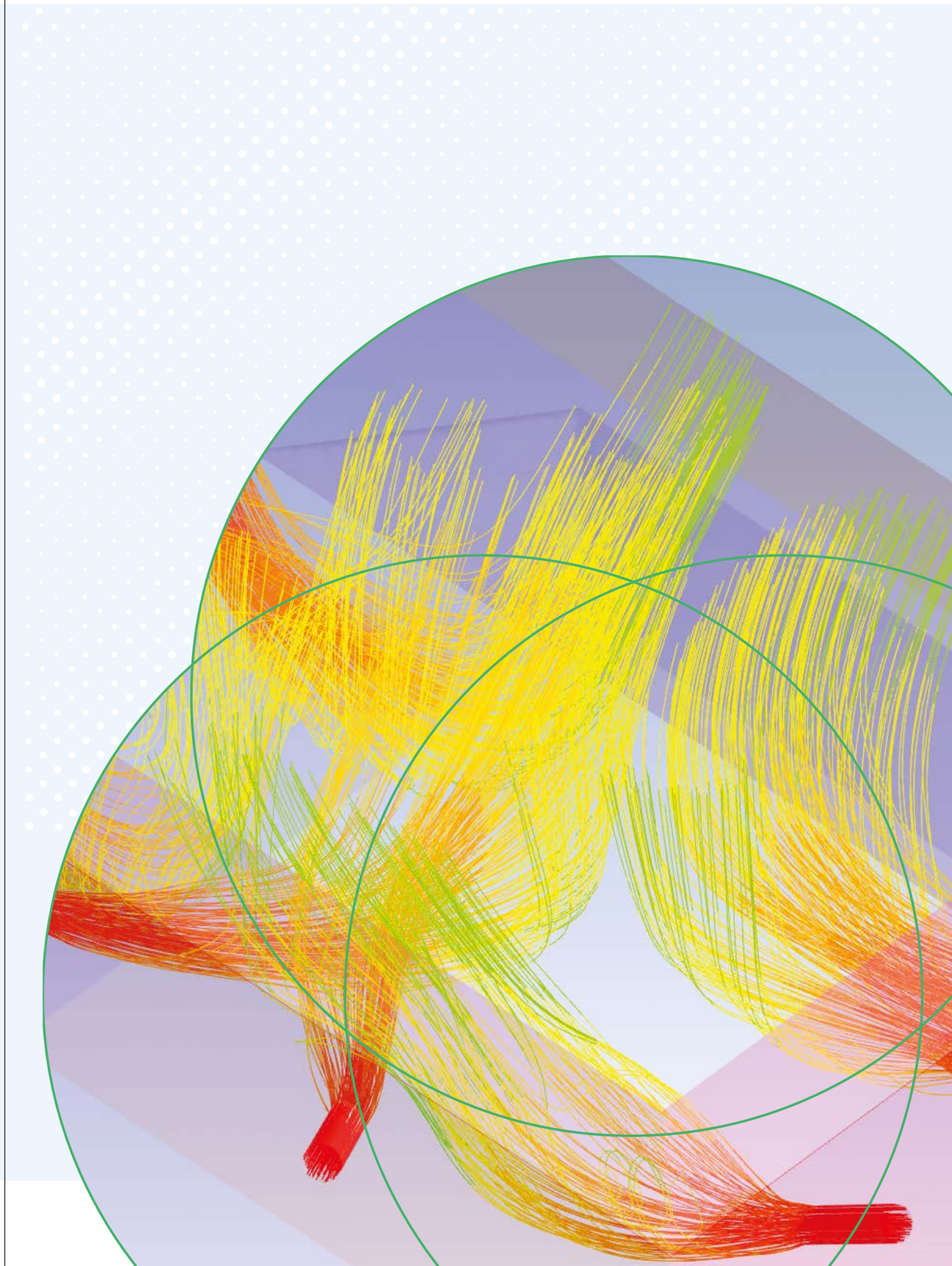
- Weight distribution of the pulverized coal in the pulverized coal duct cross-section in the sampling point
- Granulometric analysis of the collected pulverized coal

We use the following devices to collect pulverized coal and determine granulometry:

- Isokinetic sampling probe
- Analytical sieve shaker AS 200 control
- Precision balance KERN KB 3600-2N

CFD Analyses

CFD analyses, including - in particular - flow, heat transfer, and chemical reactions, are becoming the tool, which can improve both parameters of the equipment, and proper understanding of its function. The combination of numerical methods, classical analytical calculations, and experiments is very effective, and in many cases also indispensable. In certain cases, these calculation methods can reduce the frequency of experiments or can even substitute such experiments for cases where an experiment or measurement is problematic or impossible.



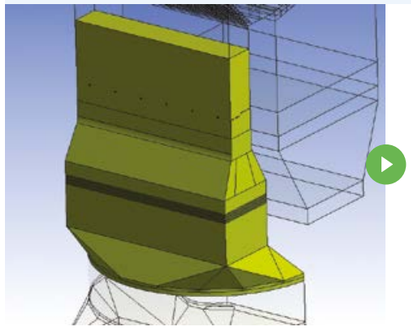
CFD analysis includes, in particular, the following steps (some of them repeatedly)

1. Establishment of the geometry of the calculation domain
2. Grid establishment
3. Selection of modeled physical and chemical processes
4. Definition of operating media and their properties
5. Specification of boundary conditions
6. Solver setup
7. Calculation
8. Visualization of results and their assessment

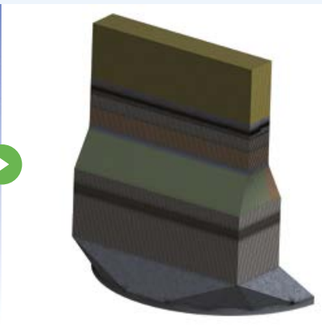
Our numerical studies focus, in particular, on the following aspects

- Single-phase flow in ducts
- Flue gas ducts and their components (bends with internals, flow distribution, etc.)
- Air ducts and their components (bends with internals, flow distribution, etc.)
- Two-phase flow gas - pulverized coal in the milling circuit
- Flow in pulverized coal ducts
- Mixing of air volumes
- Processes in the combustion chamber of pulverized coal fired boilers
- Other applications

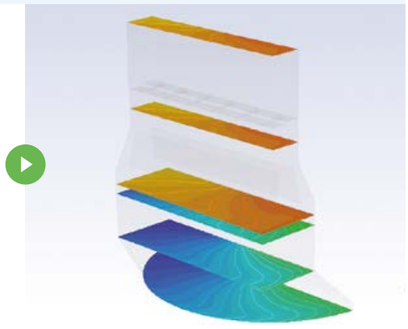
Furthermore, an active role of the customer from the point of delivery of relevant data to assign geometry of the calculation domain (drawing documentation), specification of boundary conditions such as temperatures, pressures, flows (measurement data), operating media (composition of gases, pulverized coal quality), etc. is also essential to prepare CFD analysis of the existing equipment. All too often, delivered data are not consistent, either based on the fact that gauges have not been calibrated or have been installed in an inappropriate point, or not all quantities have been measured at one time. The quality and quantity of measured operating values significantly influence the quality of results.



↑ Geometry

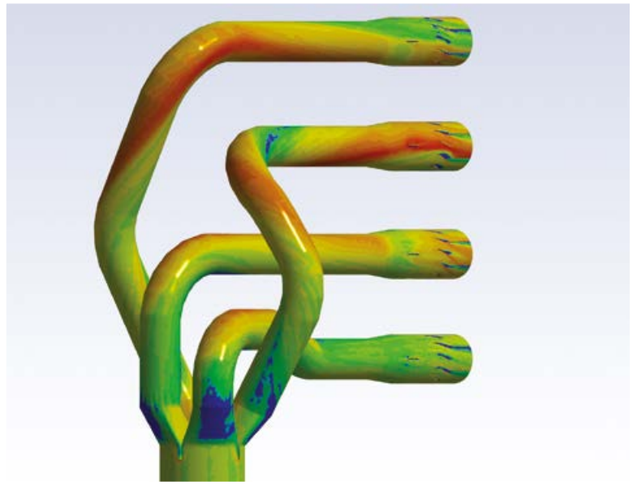


↑ Grid

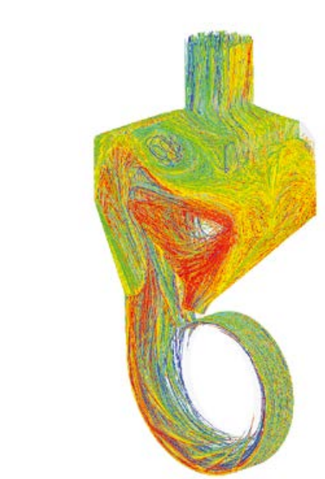


↑ Display of Results

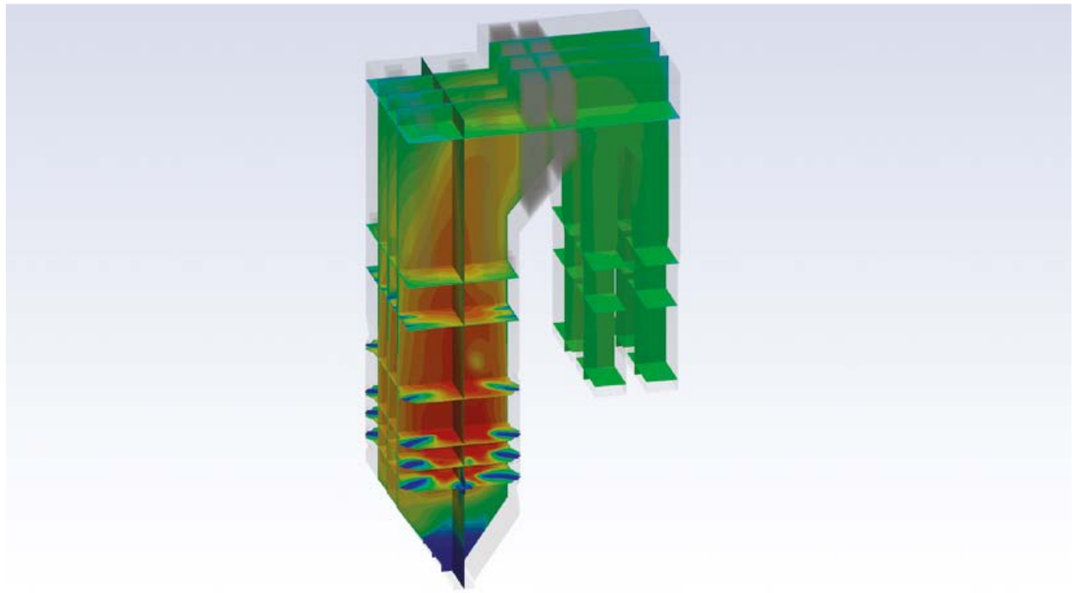
Examples of Models



↑ Two-Phase Mixture in the Pulverized Coal Duct



↑ Two-Phase Mixture in the Classifier Behind the Mill



↑ Thermal Zone in the Boiler

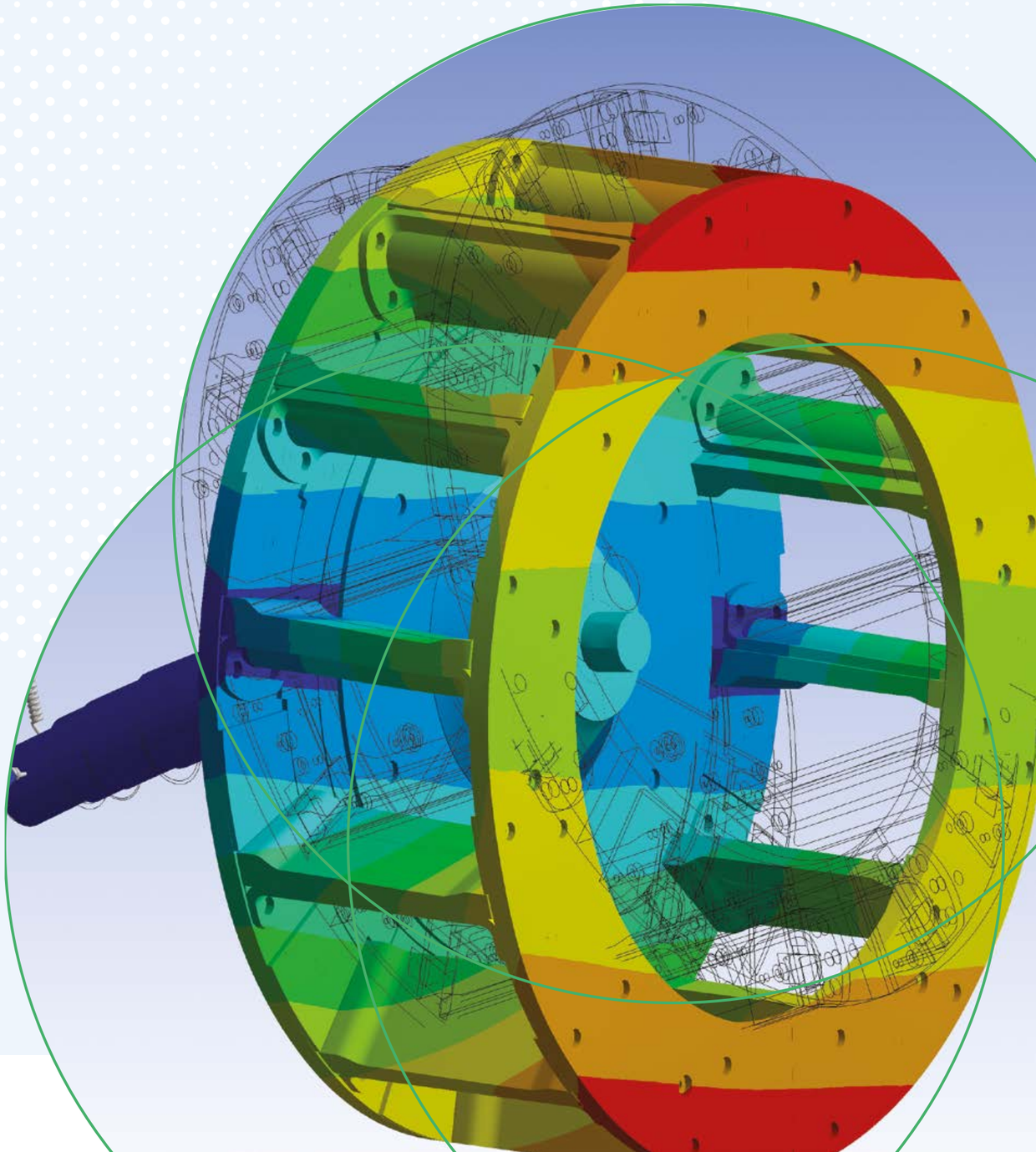
The time necessary to find a solution can vary considerably: ranging from several days to weeks for simple tasks to several months for comprehensive studies. Moreover, many times some boundary conditions can not be assigned directly; consequently, additional analytical calculations or separate rmeasuring of values is necessary.

Strength Calculations

Strength calculations of boilers, exchangers, and other power generation units, which we make, involve a large variety of strength analyses of highly stressed components of the power generation equipment. Firstly, calculations of pressure parts as prescribed by standards. These computations also include calculations of the expected service life of pressure parts, exposed to damage by creeping, and material fatigue. Pressure parts, which can not be computed by calculations because of their specific shape or stress, are assessed by an FEP analysis; among others, expansion calculations of pipe route flexibility are included.

Milling circuits, including calculations of pulverized fuel ducts, classifiers as well as wheels of beater mills, are another important area of interest of strength analyses. Assessment of these parts should include both static strength analyses, and material fatigue suffered from cyclic stress as well as dynamic stress from the wheel rotation which can give rise to dangerous transverse and torsional oscillations.

The third category of strength calculations of the power generation equipment falls within the category of steel structures. This category includes calculations of the bandage of stacks, flue gas ducts, air ducts, SCR reactor, bunkers, stacks, and piping bridges.



Strength Calculations

Strength calculations of pressure parts are made according to the standards

- EN 12952, EN 13480, ASME Sec. I, ASME B31. 1 program PROBAD
- EN 13445 program Sanť Ambrogio
- ČSN 690010 program Mathcad

Expansion Calculations of Piping Flexibility

We make calculations according to the standards EN 13480, ASME B31.1 using the program Bentley AutoPipe. The program effectively solves the complex area of pipe routes. Bentley AutoPipe contains a flexible modeling collection of pipe segments, large libraries of pipe elements, supports, and spring hangers. Ample possibilities of pipe loads allow for static and dynamic pipe analysis. Results achieved by the module Stress Isometric are displayed in dwg. drawings showing route isometry, and outcomes.

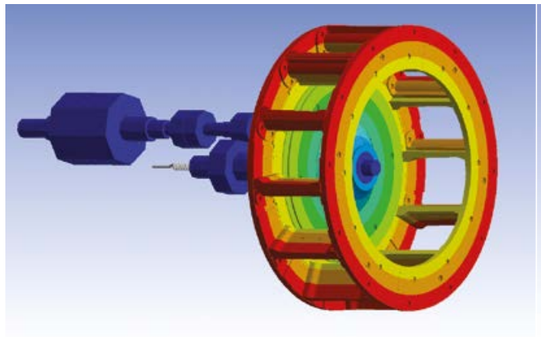
Finite Element Method Analyses

using the ANSYS program are always tailor-made to suit the requirements of the solved topic. Analyses include static structural analysis, thermal analysis, buckling, fatigue life assessment, application of nonlinear plasticity models, and a wide range of dynamic analyses. For example, analyses allow for the assessment of models according to the requirements of the so-called “Analysis Based Design” in compliance with the standard EN 13445-3 or ASME Sec. VIII. The calculation model can either be designed or imported and modified in the environment of 3D modeling software of the program SpaceClaim. The model is further developed in the environment of the program ANSYS Workbench where results are also evaluated.

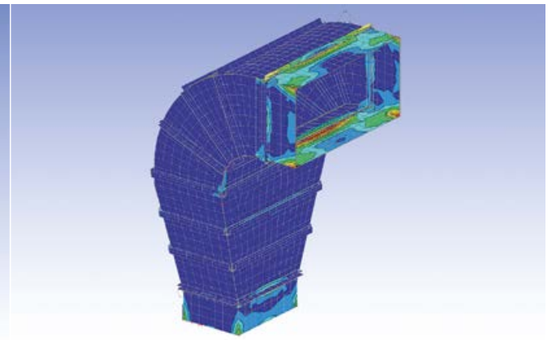
Steel Structures

Implementing the Eurocode methodology, we calculate by the program SCIA Engineer - a FEM application to design bar, and pan structures. SCIA Engineer allows for linear static and geometrically nonlinear analyses, structure stability solutions, and dynamic analysis. The main advantage of the program is the assessment of the structure according to the Eurocode requirements.

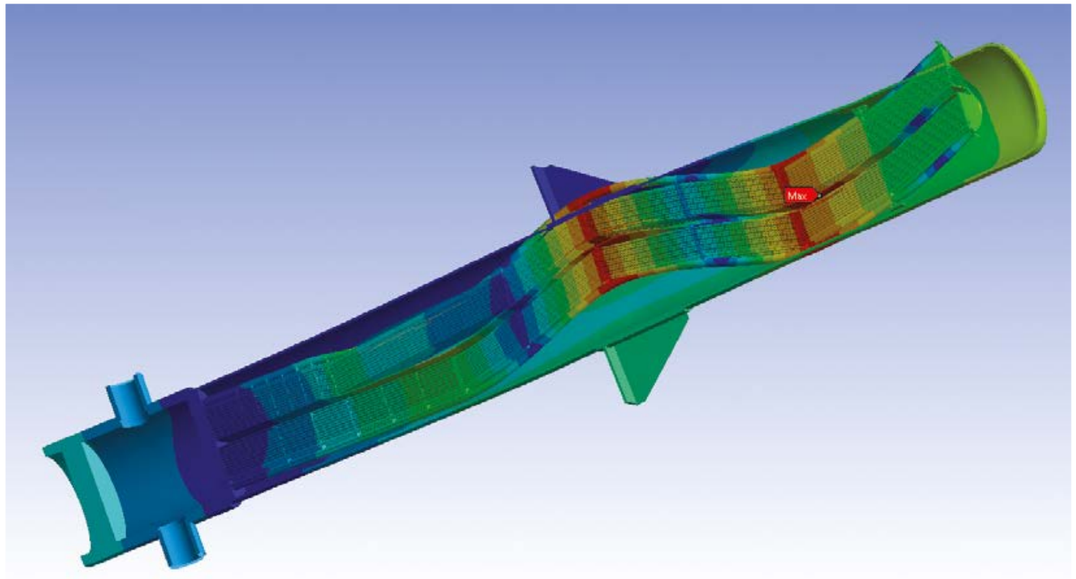
Examples of Models



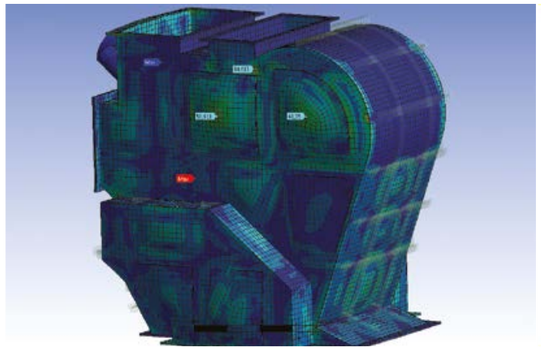
↑ Calculation of Torsional Oscillation of the Set



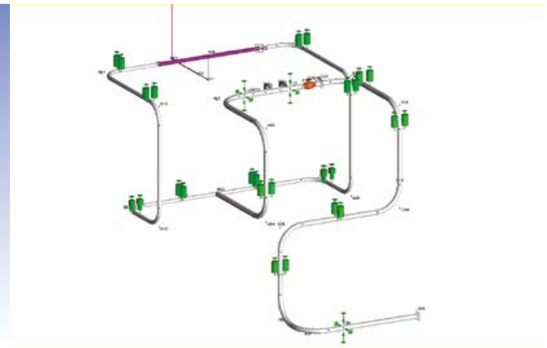
↑ Strength Calculation of the Air Duct



↑ Modal Analysis of the High-Pressure Heater



↑ Strength Calculation of the Classifier



↑ Flexible Analysis of the Steam Piping

Ekooptim

Power generation installations of currently operated power, heating, and industrial plants have great potential for a remarkable improvement in their management, and additional financial benefits through modifications and modernizations of their equipment. These investments can be so effective that their return on investment can take a few years only. EKOOPTIM is a technical-economical product designed to reach measurable, verifiable, and short pay-back additional economic benefit from the power equipment operation compared to its baseline conditions.

Ekooptim

Ekooptim identifies and examines possibilities of the technical improvements in the power-generation operations

Objective: economic benefit with a short-term payback period

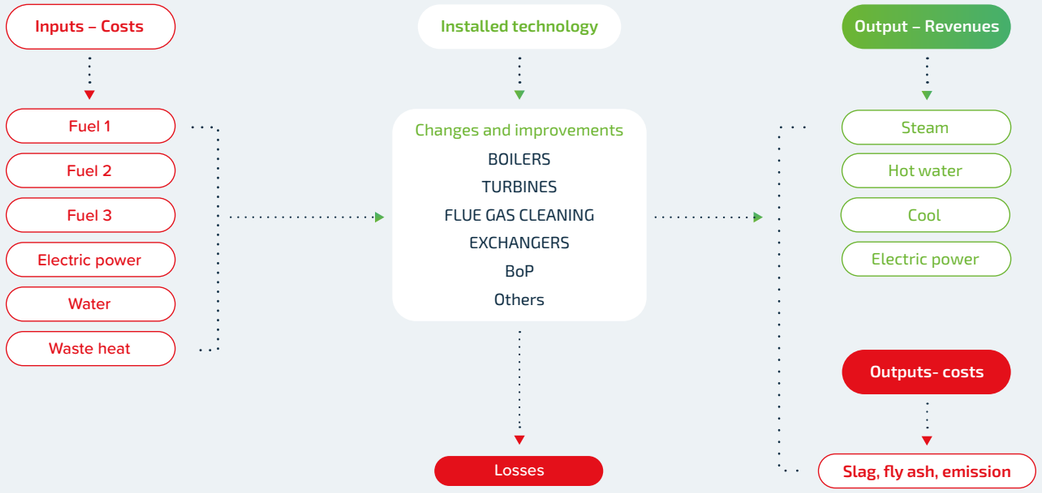
Inputs, starting points

- Detailed inspection of the power-generation equipment at the site
- Available technical documentation
- Information about operating regime
- Basic performance economic data

Data, characteristics, and information collected during the inspection will be used to modify the technical-economic model to the specific needs of the operator.

Benefits for the customer

- Identification of technical solutions, modifications and investments with a very short payback period
- Assessment of additional, so far non-identified, economic potential of power plants, heating and industrial power plants
- Huge increase in the income generated by older and smaller power-generation units
- Identification of latent possibilities to improve economy of well-operated equipment
- Improvement in thermal cycle efficiency, reduction in the own consumption of the components and equipment, improvement in performance, better availability and operating flexibility
- Impacts of changes in the initial conditions, quality and type of fuel, external economic environment to the economy of the operation, measures to mitigate for any negative impacts of changes

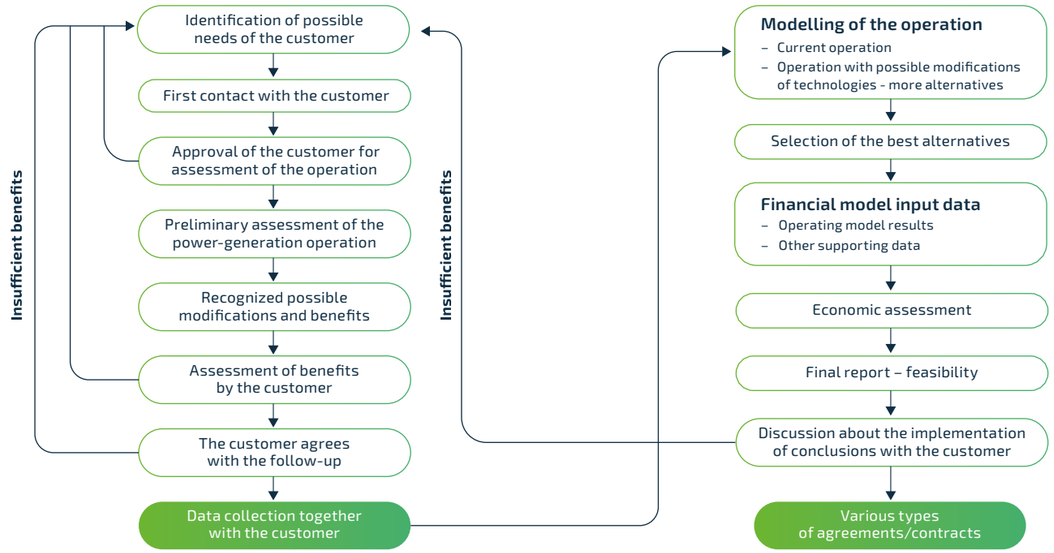


1 Ekooptim 1st stage

- Maximum cooperation between the management responsible for the operation as well as its technical staff and the contractor
- Close cooperation with the management of the equipment owner
- Thorough inspection of the equipment in cooperation with the operator
- Collection of basic technical and economic data
- Assessment of the current condition and operation of the equipment
- Drafting of preliminary conclusions describing possible qualitative benefits
- Preparation of possible modifications, solutions, and investments list
- Report of the 1st Stage jointly prepared and reviewed by the customer and the contractor
- Decision of the customer whether to continue in EKOOPTIM
- Formulation of objectives for the 2nd stage: for instance, expected payback period, limitations, and special conditions

2 Ekooptim 2nd stage

- More detailed technical development of selected technical designs and their parameters
- Modification and adjustment to the technical-economic model of the operation with the existing operating regime
- Modelling of proposed technical changes, and economic objectives
- Assessment of the engineering solutions from the point of technical feasibility and financial benefit
- Benchmarking and modification of particular technical solutions and their impacts on the basis of continuously reached results of modelling
- Inclusion of costs and benefits of the individual modifications, sum of the initial investments, and consequently induced changes in the operating and maintenance costs
- Sensitivity and robustness tests to input changes
- Effort to reach the shortest payback period of proposed solutions



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