

# BORSIG

BORSIG  
PROCESS HEAT  
EXCHANGER  
GMBH

## SYNLOOP WASTE HEAT BOILER IN AMMONIA PLANTS



# ABOUT BORSIG PROCESS HEAT EXCHANGER GMBH



**BORSIG Process Heat Exchanger GmbH**, a member of the BORSIG Group, is the international leading manufacturer of pressure vessels and heat exchangers for cooling gases at very high temperatures (up to 1,500 °C) and high pressure (up to 35,000 kPa) for the chemical and petrochemical industries. These pressure vessels and heat exchangers are used for process stages in plants for the production of basic chemicals where they are installed directly at the downstream end of the cracking furnaces and/or reactors. BORSIG technology is also used in innovative coal gasification processes.

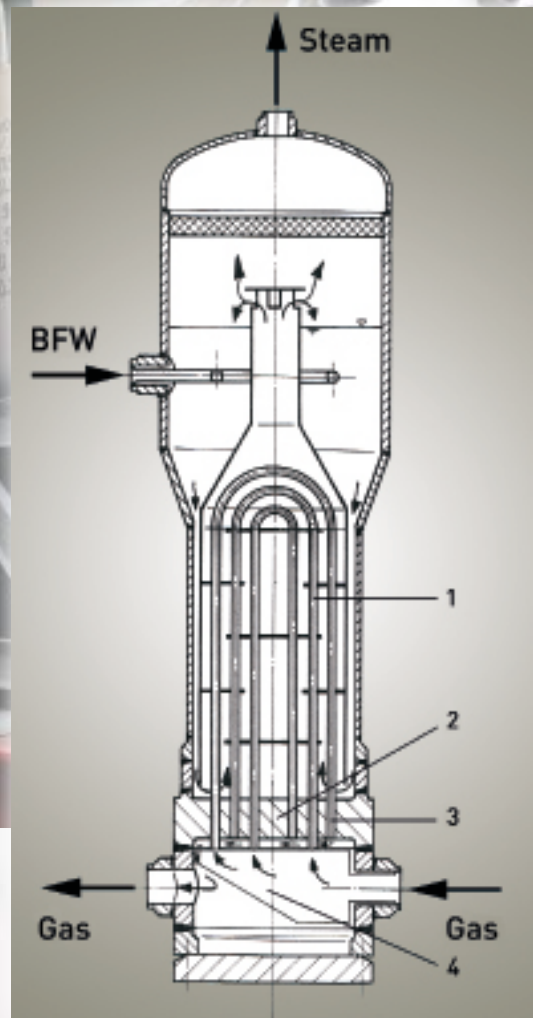
Our comprehensive know-how is based on more than 175 years of company history. The resulting competence, the perfectly trained specialists and our awareness of quality are the basis for the reliability of our products. This symbiosis is the source of our innovative power which is reflected by our unique manufacturing program.

State-of-the-art technology, excellent employees and innovative engineering allow us to always offer our customers the perfect solution. Our products and our service have made and still make us a competent and reliable partner to numerous companies across the world.

Our product range:

- **Waste heat recovery systems** (ammonia plants, methanol plants, hydrogen plants, coal gasification plants, gas-to-liquid plants, nitric acid plants, caprolactam plants, formaldehyde plants, partial oxidation of oil and gas)
- **Transfer line exchangers** in ethylene plants
- **Scraped surface exchangers** for lube oil plants and special applications

# SYNLOOP WASTE HEAT BOILERS IN AMMONIA PLANTS



**BORSIG Process Heat Exchanger GmbH** has been supplying high temperature and pressure process gas waste heat recovery systems for the petrochemical industry for more than 50 years. Our satisfied customers all over the world and our wide range of experience and engineering know-how together with our unique design features have given BORSIG its reputation as leading and most competent manufacturer for process gas heat recovery systems in the world. More clients decide in favor of BORSIG Process Heat Exchanger's HOT/COLD tubesheet design for synloop waste heat boilers for their waste heat recovery systems in ammonia plants, as they are aware of the following advantages:

- Unique patented HOT/COLD BORSIG tubesheet design
- Use of ferritic tubes
- Hydraulic expansion of tubes through thickness of tubesheet

- 1: Ferritic tubes are used, which are not sensitive to stress corrosion cracking, contrary to Incoloy tubes
- 2: Unique patented HOT/COLD tube arrangement which results in tubesheet temperatures below from where nitriding starts
- 3: Hydraulically expanded tubes avoid crevice corrosion
- 4: Hot incoming gas is guided through internal gas chamber directly to tube inlet ends, no special protection of combined gas inlet/outlet chamber against nitriding and hydrogen embrittlement is necessary

- Internal gas inlet chamber
- Tubesheet temperature is below temperature, where nitriding starts
- No stress corrosion cracking
- No crevice corrosion
- No welding overlay of gas inlet channel against hydrogen attack and nitriding

# UNIQUE PATENTED HOT/COLD TUBESHEET DESIGN

U-tubes with hot and cold ends are alternately arranged. The hot shank is surrounded by cold shanks.

Advantage of this design is that the tubesheet and the hot end tube wall temperature inside the tubesheet can be kept below 380 °C to avoid nitriding and to use ferritic tubes.

As a result the inlet ends of the tubes inside the tubesheet as well as the whole tubesheet itself are at gas outlet temperature.

The U-tubes are arranged in such way that each inlet is located adjacent to an outlet end. Inlet end ferrules protrude approx. 50 mm from the thick tubesheet into the channel and are fitted to a dummy tubesheet, which is connected to an internal gas chamber of incoloy for the hot incoming gas.

Fig. 2

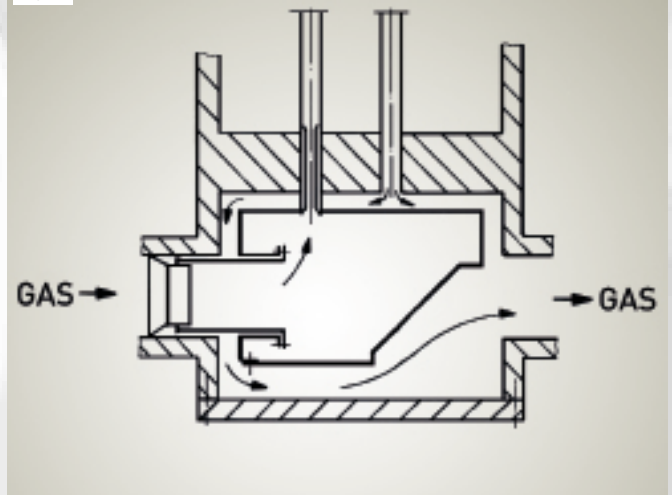


Fig. 1

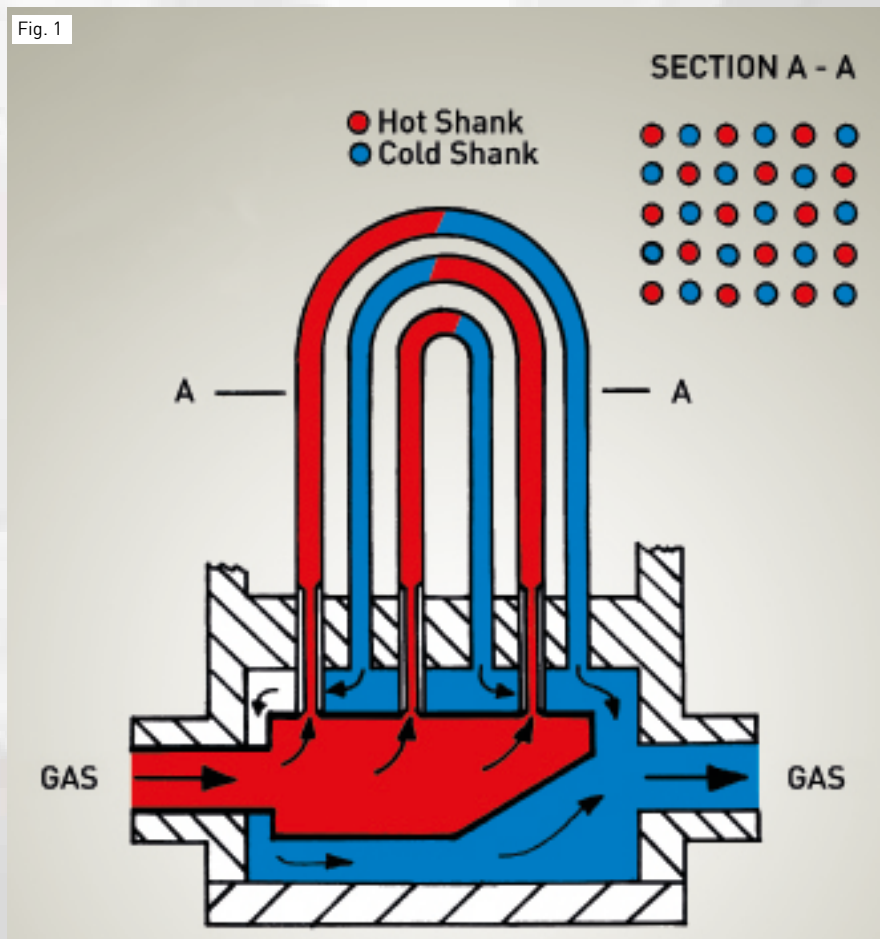
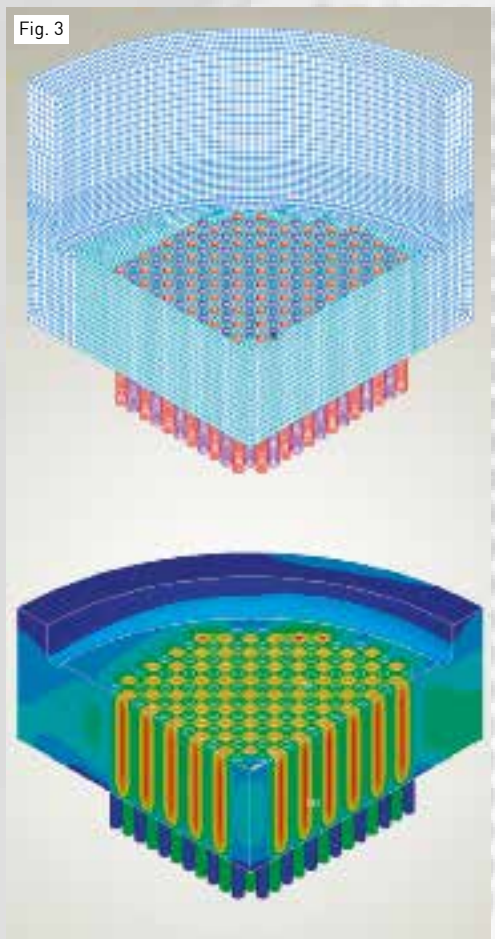


Fig. 3



### Conventional Tube Arrangement Compared to HOT/COLD Tube Arrangement

The diagram on the right side indicates the temperature distribution across the tubesheet thickness. With conventional tube arrangement the tubesheet temperature will be above the temperature, where nitriding starts.

But **BORSIG Process Heat Exchanger GmbH**'s unique HOT/COLD tube arrangement achieves an even temperature distribution across tubesheet thickness, which is below nitriding temperature. This HOT/COLD tube arrangement is the best technical solution.

Fig. 5

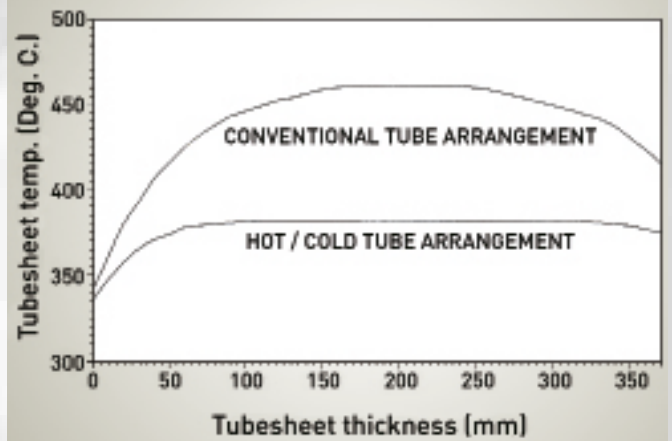
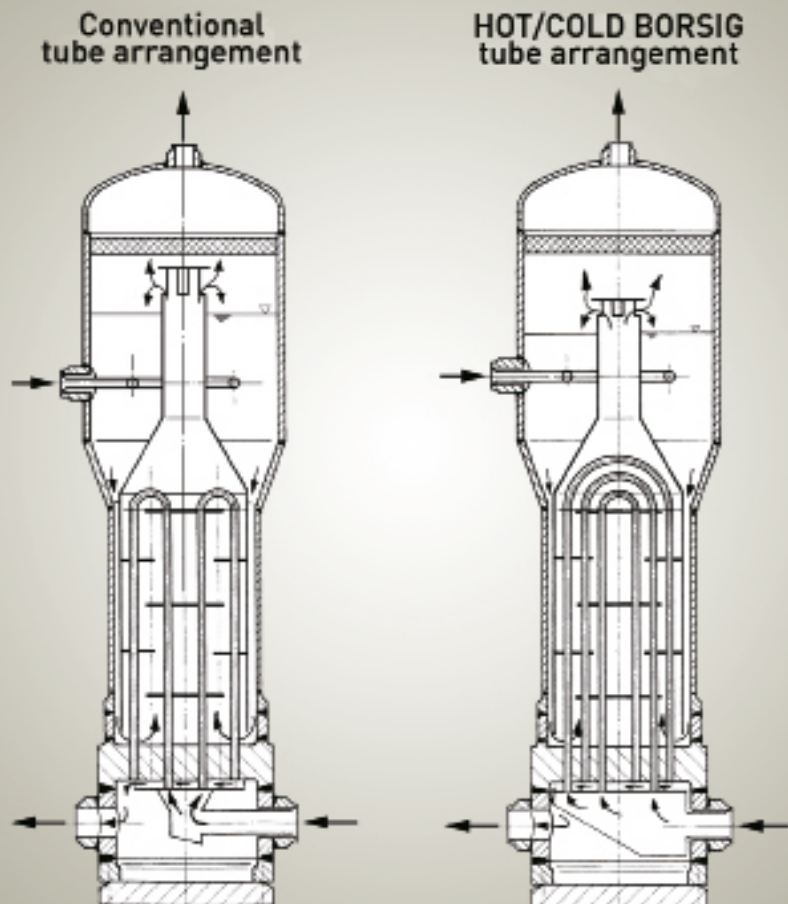


Fig. 4



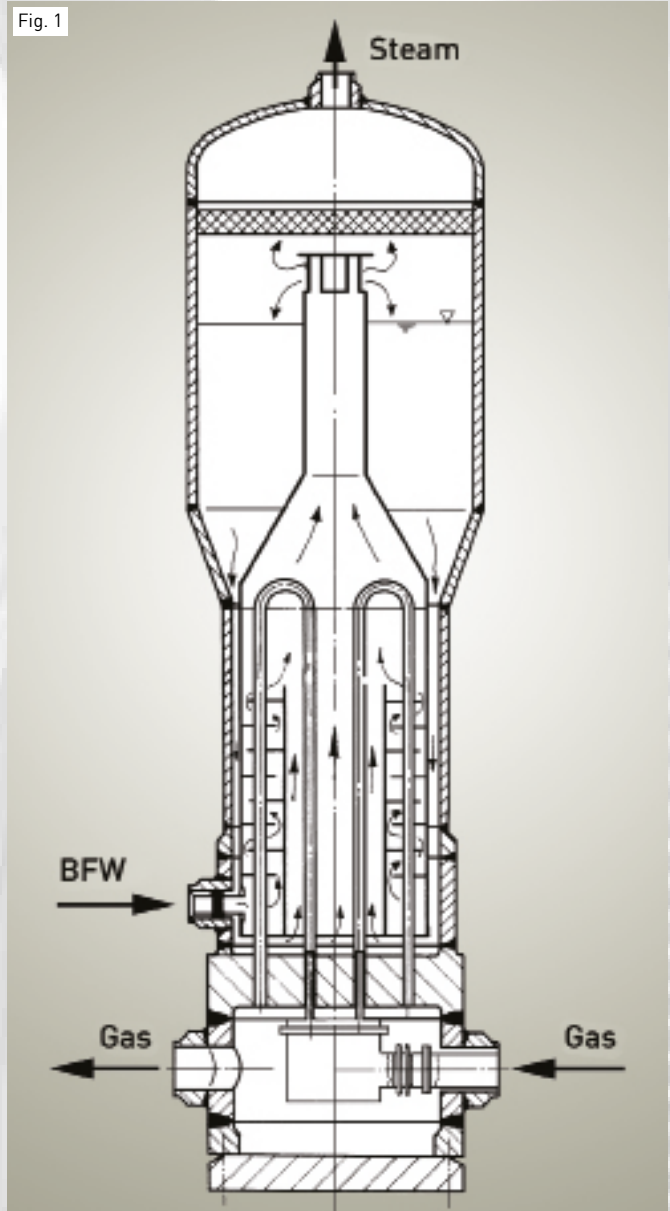
- Fig. 1: Principle sketch of HOT/COLD tubesheet design
- Fig. 2: Combined gas inlet/outlet chamber for HOT/COLD tubesheet design
- Fig. 3: FEM models of HOT/COLD tube arrangement
- Fig. 4: Comparison of different synloop waste heat boiler designs
- Fig. 5: Tubesheet temperature across tubesheet thickness based on FEM-analysis

# SYNLOOP WASTE HEAT BOILER WITH INTEGRATED BOILER FEED WATER PREHEATING ZONE

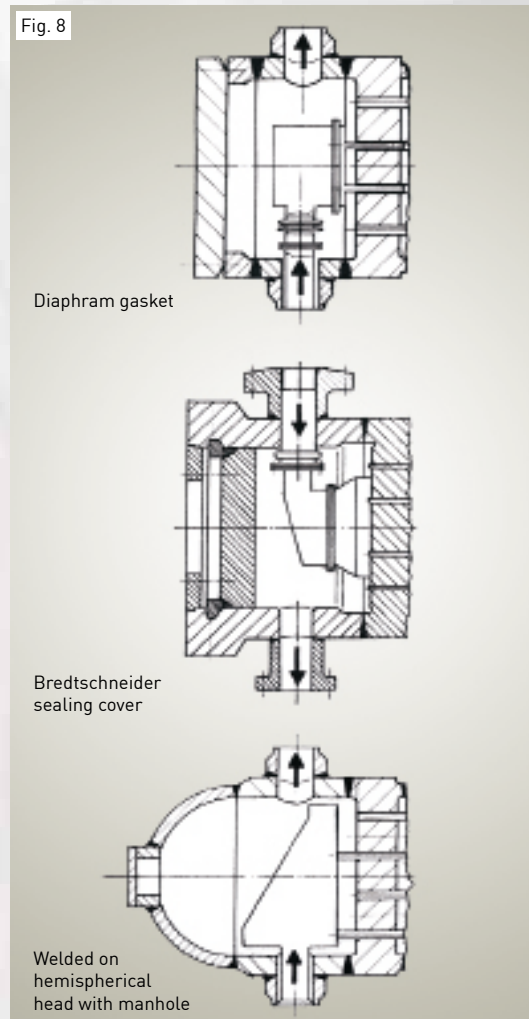
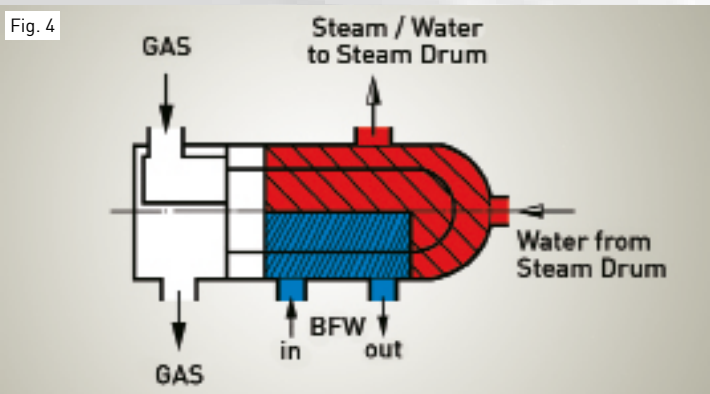
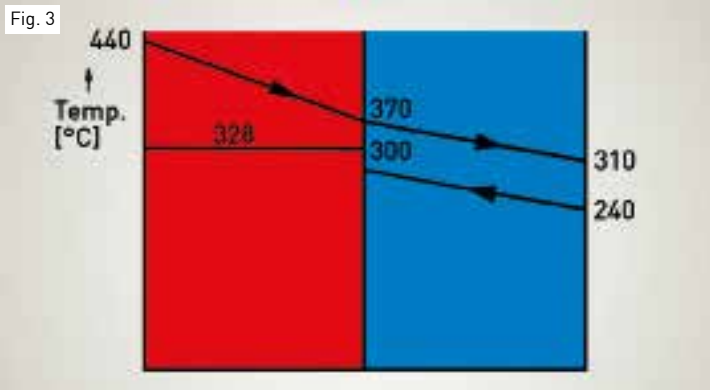
To reduce investment costs, **BORSIG Process Heat Exchanger GmbH** is prepared to offer a design of a synloop waste heat boiler with integrated BFW-preheating section.

The BFW is entering the BFW section close to the bottom of the tubesheet and is passing through it in counterflow to the converter effluent, is heated up close to saturation temperature and is entering the evaporation section. Then the steam/water mixture is flowing upwards through the cone and "chimney". Above the upper end of the "chimney" an impingement plate is arranged to force droplets and water to flow down to the water hold-up volume. The steam leaves the synloop boiler by passing a demister. The down-flowing water is guided through an annular space to the tubesheet. At tubesheet the water flows radially to the centerpart and flows upwards by generating steam.

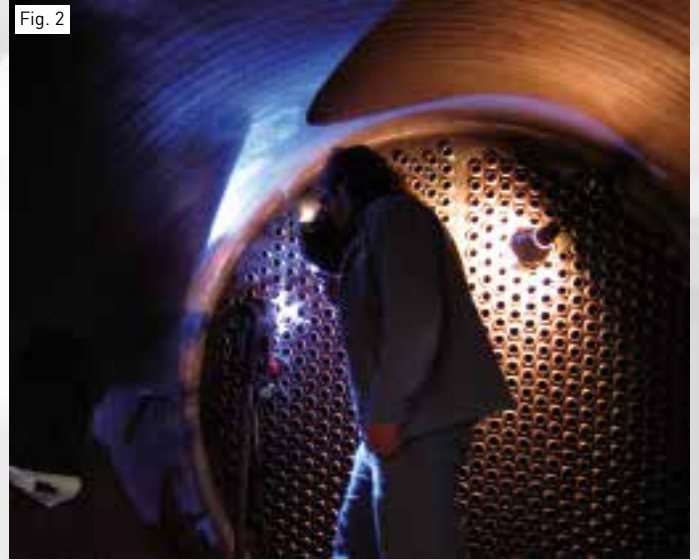
The arrangement of BFW-section, waterjacket and cone with chimney ensures that up-flowing water/steam mixture and downflowing water are separated. This circulation is a natural circulation and the tubesheet is flushed by cooling radial incoming down-flowing water. Therefore no pool boiling areas in the center of the tubesheet are present.



- Fig. 1: Sketch of synloop waste heat boiler with integrated boiler feed water preheating zone
- Fig. 2: Synloop WHB furnished as kettle type
- Fig. 3: Temperature profile of evaporation and BFW-preheating section
- Fig. 4: Principle sketch of synloop waste heat boiler with integrated BFW-preheating section
- Fig. 5: Tube bundle of HOT/COLD design
- Fig. 6: Synloop WHB with steam drum designed as compact unit
- Fig. 7: Gas inlet channel of a synloop WHB
- Fig. 8: Standard high pressure sealing covers for combined gas inlet/outlet channel for synloop WHBs and BFW-preheaters



# SYNLOOP WASTE HEAT BOILER AND STEAM SUPERHEATER



- Fig. 1: Tube bundle of steam superheater
- Fig. 2: Tube to tubesheet welding
- Fig. 3: Tube bundle of Synloop WHB
- Fig. 4: Synloop WHB ready for shipment
- Fig. 5: Steam superheater ready for delivery



Fig. 4



Fig. 5



## Typical Layouts and Arrangements

Fig. 1



Fig. 2

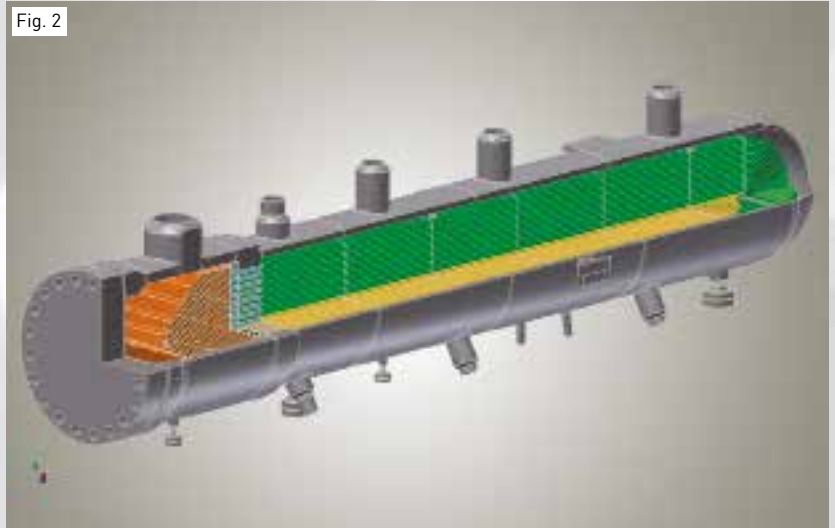
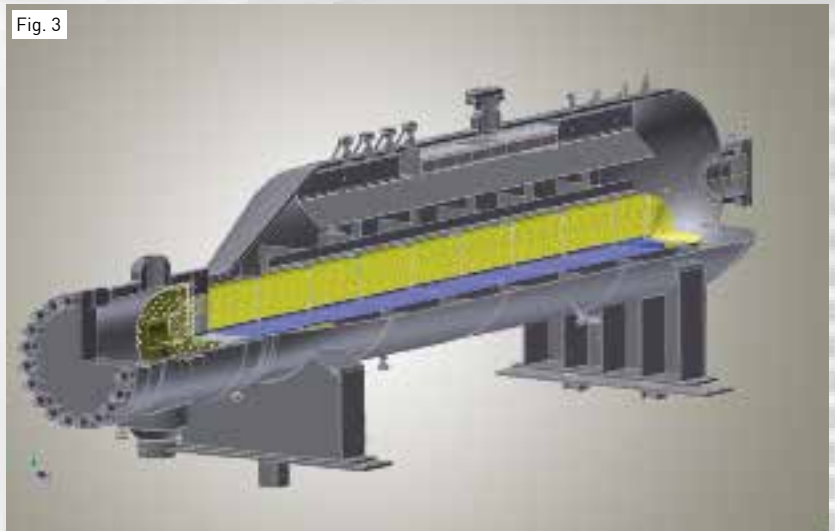


Fig. 3



- Fig. 1: Synloop WHB with integrated steam drum
- Fig. 2: Synloop WHB - horizontal design,
- Fig. 3: Synloop WHB - designed as reboiler
- Fig. 4: Arrangement of reformed and synthesis gas waste heat boilers with one common steam drum
- Fig. 5: Synloop WHB with steam drum designed as compact unit

Fig. 4



Fig. 5



# ENGINEERING



**BORSIG Process Heat Exchanger GmbH** has complete in-house engineering facilities. Thermal layout of heat exchangers and special heat transfer calculations are performed and checked with computer programs developed in-house. For highly complex tasks, the gas flow and heat transfer are calculated by means of three-dimensional CFD models (computational fluid dynamics).

The pressure vessels and heat exchangers are calculated according to all national and international calculation regulations:

**AD-2000 Merkblätter Code, TRD - Power station code, EN standards, ASME CODE I, VIII Div.1 and Div.2, ASME B31.1 and B31.3, PD 5500, CODAP, Stoomweezen, IBR, JIS, Australian Standards, China SQL.**

In the case of critical parts, Finite Element Analysis are carried out.

The flexibility of the tube systems, the resulting support loads and forces are calculated by a special software.

- Fig. 1: Finite element model
- Fig. 2: Temperature distribution
- Fig. 3: Stress analysis
- Fig. 4: Stress analysis of tubesheet
- Fig. 5: Temperature distribution of tubesheet

Fig. 2

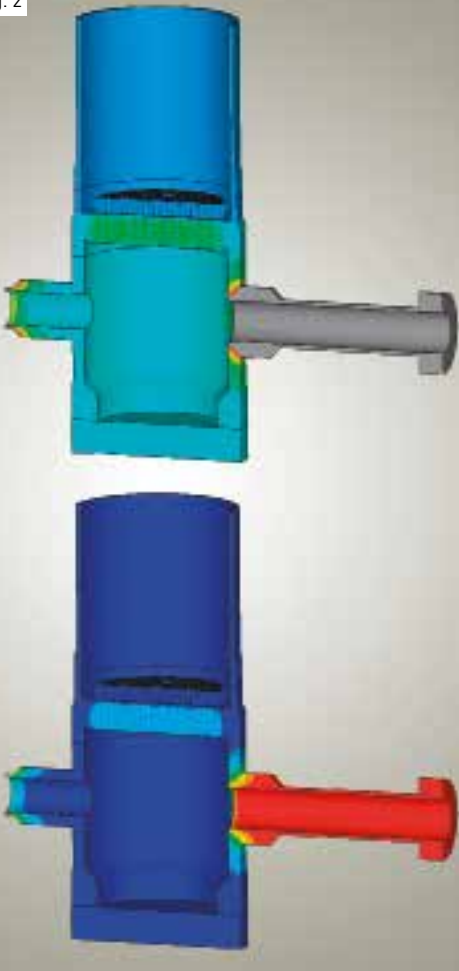


Fig. 4

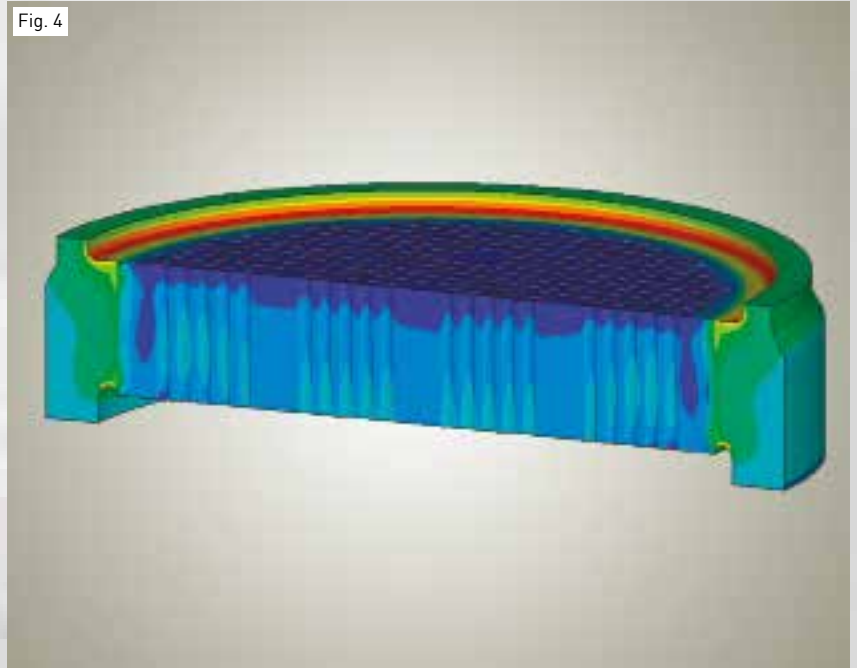


Fig. 5

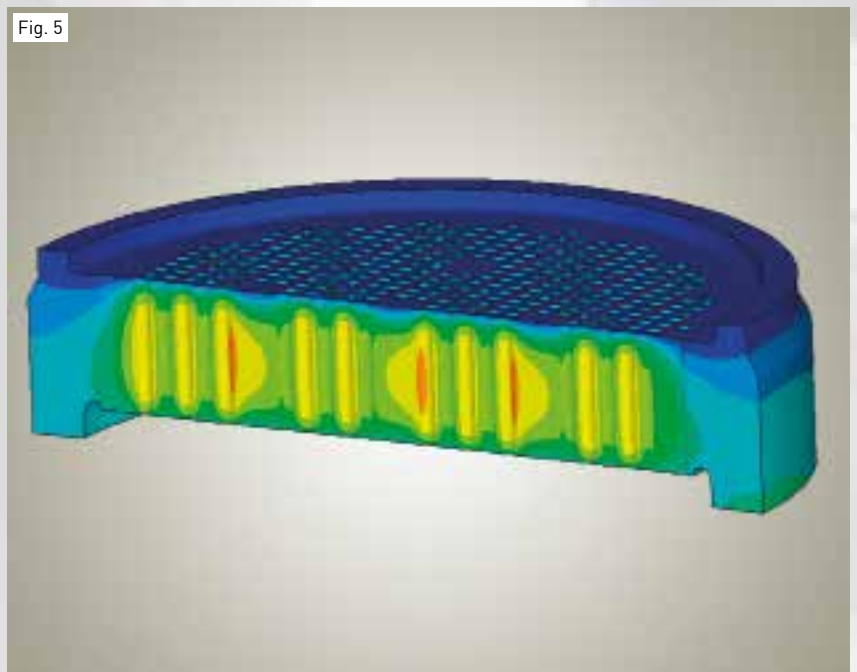
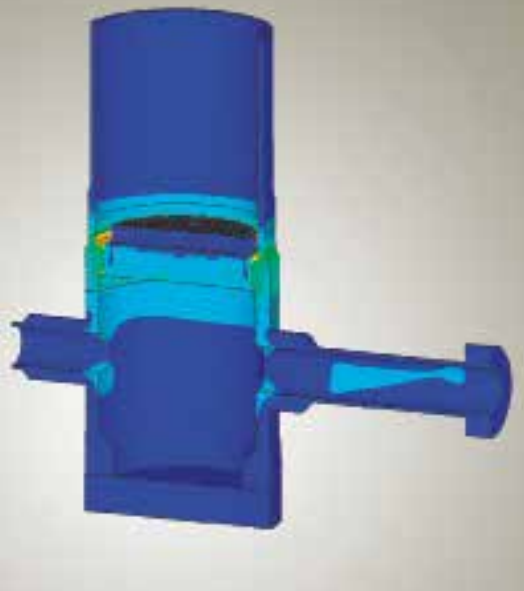


Fig. 3



# QUALITY

Fig. 1



Fig. 2



Fig. 3



Quality assurance and control activities are independent of the manufacturing process or product lines and guarantee that machined and handled materials, components, assemblies, products and service operations are executed in accordance with all specified requirements.

Quality assurance surveys the adherence to national and international specifications, statutory and contract provisions as well as the directives, standards and regulations stipulated by **BORSIG Process Heat Exchanger GmbH**.

In order to ensure even better interaction between quality, work safety and environmental management, the individual management systems were merged to form an Integrated Management System (IMS).

Consistent quality monitoring from the analysis of the customer's needs to design, work preparation, construction, acceptance and handing over to the customer right through to after-sales service ensures that materials to be processed, parts manufactured, products and services are at all times in conformity with the applicable requirements

### Certificates of the BORSIG Process Heat Exchanger GmbH (Extract):

- Quality Management DIN EN ISO 9001
- Environmental Management System DIN EN ISO 14001
- Occupational Safety SCC\*\*
- ASME U, U2, R and S
- SQL licence for PR China (Pressure Vessels A1, A2)
- AD 2000 - Directives HP 0, TRD 201 and DIN EN ISO 3834-2 and DIN 18800-7, etc.

Fig. 1: UT testing

Fig. 2: RT film examination

Fig. 3: Recordable UT

Fig. 4: Recordable UT

Fig. 4



# MANUFACTURING

## **BORSIG Process Heat Exchanger GmbH**

in Berlin owns more than 16,700 m<sup>2</sup> of indoor workshop facilities and is equipped with a 250 t crane capacity. High-tech welding technology is our core competence, such as the laser controlled welding seam guidance system for submerged narrow-gap welding, the use of robot welding systems for the GMAW welding process in the high pressure vessel manufacture, GMAW narrow gap robot systems with integrated 3D cutter systems plasma and autogenous, TIG hot wire welding, RES and SAW strip weld cladding, the automatic tube to tubesheet welding incl. inbore welding of up to 500 mm as well as qualified machining of all steel and nickel-based alloys.

The company has a direct water connection since 2008, the Borsig-Harbor, so that pressure vessels and heat exchangers of any overall size can be transported easily on the water way.



- Fig. 1: Robot welding
- Fig. 2: Works area in Berlin
- Fig. 3: 3D-plasma cutting
- Fig. 4: Assembly of a compact unit
- Fig. 5: Automatic tube to tubesheet welding
- Fig. 6: Welding of an inspection nozzle

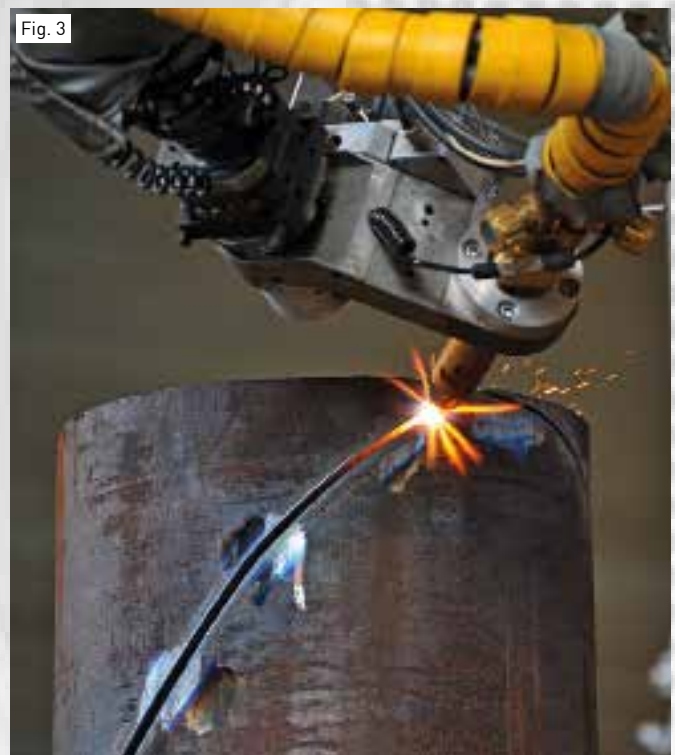






Fig. 4



Fig. 5



Fig. 6

# SERVICES



Fig. 1

The after-sales service and technical product support service of **BORSIG Process Heat Exchanger GmbH** offers a wide range of spare parts services. On request we offer a complete exchange service for pressure vessels and heat exchangers.

Our main objective is to keep the downtime of your plant to an absolute minimum. Our excellent service team is specialized for jobs like these and works out the shortest process based on a detailed engineering plan.

#### **Our service portfolio for technical support:**

- Installation planning and construction site supervision for new installations and repairs
- Damage analysis and cause determination at the location and by remote diagnostics

- Technical consultations in case of corrosion problems
- Evaluation of boiler operating water
- Consultations for preventive maintenance actions
- Review of customer procedures before the start of installations (container cleaning, welding, chemical cleaning, nondestructive material tests, brick lining)

#### **Our service portfolio for spare parts includes:**

- The delivery of spare parts for maintenance
- The delivery of standard spare parts and special designs for repairs
- The delivery of spare parts from other manufacturers (part of the original scope of delivery by BORSIG)



Fig. 1: Synloop WHB on site

Fig. 2: Lifting of a synloop WHB on site

Fig. 3: Positioning of a synloop WHB on site

Fig. 4: Positioning of a synloop WHB on site

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