

BORSIG

BORSIG
PROCESS HEAT
EXCHANGER
GMBH

PROCESS GAS WASTE HEAT BOILERS WITH THIN FLEXIBLE TUBESHEET DESIGN



ABOUT BORSIG PROCESS HEAT EXCHANGER GMBH



Process gas waste heat boiler

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 180 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

"Tunnelflow" transfer line exchangers



Process gas waste heat recovery system



PROCESS GAS WASTE HEAT BOILERS WITH THIN FLEXIBLE TUBSHEET DESIGN

For more than 50 years, **BORSIG Process Heat Exchanger GmbH** has been supplying process gas waste heat recovery systems for high-temperature and high-pressure applications to the petrochemical industry. Thanks to a wealth of experience, comprehensive knowledge, design orientated towards practical application, state-of-the-art production and testing methods and last but not least highly qualified staff, the company has become the leading manufacturer in this area worldwide.

Every process gas waste heat recovery system manufactured by BORSIG Process Heat Exchanger GmbH is designed exactly in accordance with the customer's individual requirements and is provided with special design features for the various operating conditions and applications. The process gas waste heat recovery systems can be used for gas pressure values of up to 350 bar (35,000 kPa), incoming gas temperatures of up to 1,500 °C and steam pressure values of up to 160 bar (16,000 kPa).

Applications of the BORSIG process gas waste boiler with thin flexible tubesheet design include:

- Ammonia plants
- Methanol plants
- Hydrogen plants
- Ethylene plants
- Styrene plants
- MTBE plants
- Oxo-alcohol plants
- Direct reduction iron plants
- Coal gasification plants
- Gas to liquid plants, and others.



Waste heat boiler ready for shipment

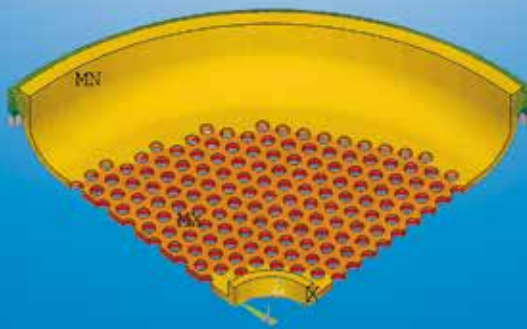
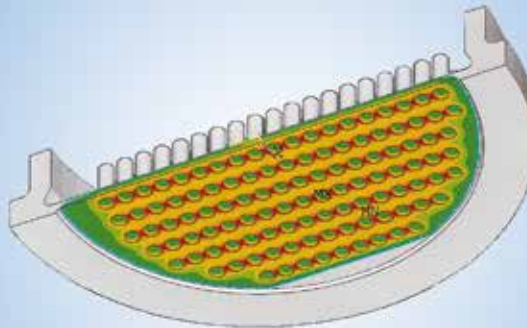
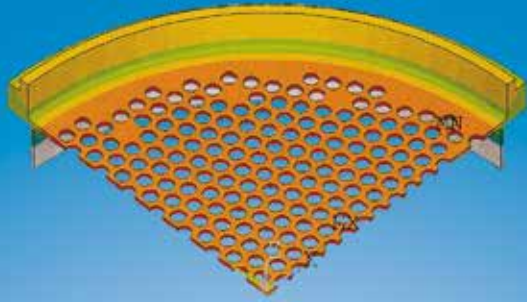
Waste heat boiler at the Borsig-Harbor



Works area in Berlin



FEM ANALYSIS



Varying shapes for thin flexible tubesheet design due to different pressure conditions

In process gas WHBs designed with thin flexible tubesheets, the tubes act as stays between the tubesheets and elongate due to the pressure load on the tubesheets and due to the temperature difference between tubes and shell.

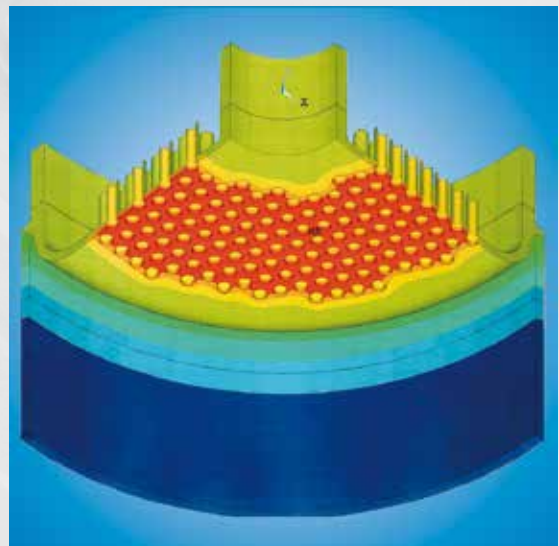
As this is a physical principle, it is independent of the design and the supplier.

As this load is not mainly transferred into the shell, the tubesheets bend in the circumferential area between tube bundle and shell. The bending causes fatigue in this area. Therefore the tubesheets are subject to rigorous stress analysis and low cycle fatigue calculations.

Due to the complex shape and possible elongation it is mandatory to perform a rigorous 3-D FEM analysis of the tubesheets.

BORSIG Process Heat Exchanger GmbH has performed such computer simulations under consideration of all possible loads like internal and external pressure, stresses caused by temperature differences, elongation and bending moments etc.

Temperature distribution for a WHB under operating conditions



TUBE TO TUBESHEET WELD

The tubes are connected to the tubesheet by a full penetration weld by an automatic welding machine, computer controlled by orbital program. No crevice corrosion can occur as there is no gap between tube and tubesheet.

Root pass of tube to tubesheet weld is obtained by fusing edge of tube to edge of tubesheet with filler wire with shield gas to avoid any crevice on waterside. Then multiweld layers are applied.

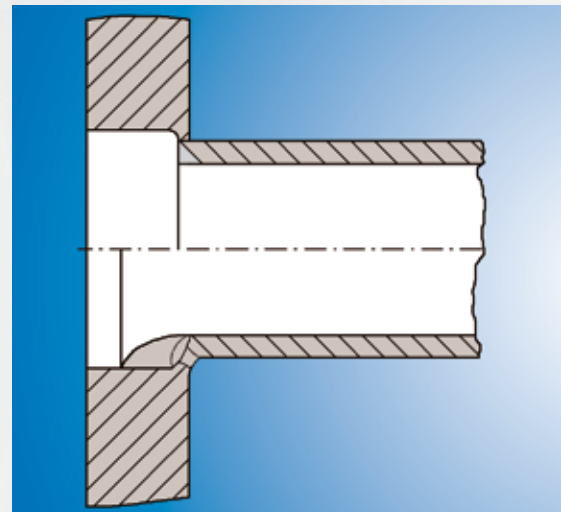
As the tube to tubesheet weld is located on the waterside of the tubesheet, its temperature during operation of boiler is close to the boiling temperature on the waterside.

Advantages of full penetration, crevice free tube to tubesheet weld:

- full penetration
- automatic machine weld
- small weld volume, small heat-affected zone
- well performed root pass, gap is impossible
- crevice corrosion is impossible
- notch-free
- weld is located on waterside of tubesheet, temperature is close to boiling temperature.



Automatic full penetration tube to tubesheet welding

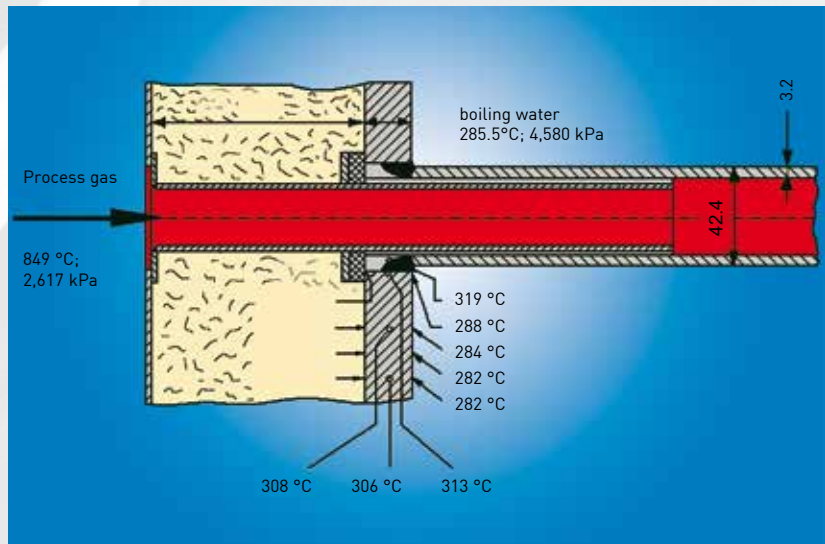


Tube to tubesheet weld

Specimen of tube to tubesheet weld



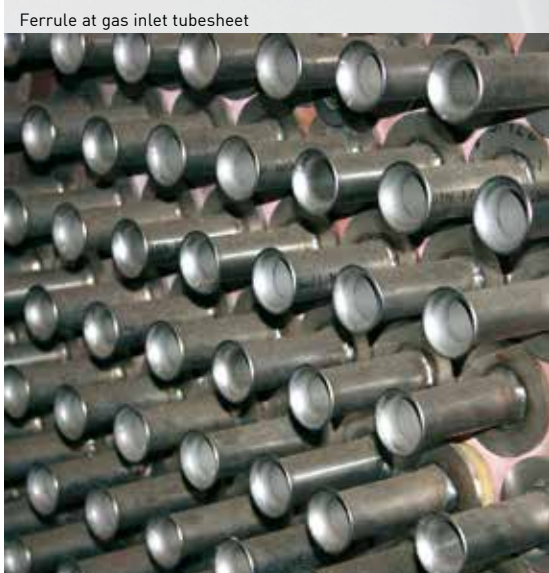
Metal temperature distribution at gas inlet tubesheet of WHB in a hydrogen plant



DESIGN FEATURES

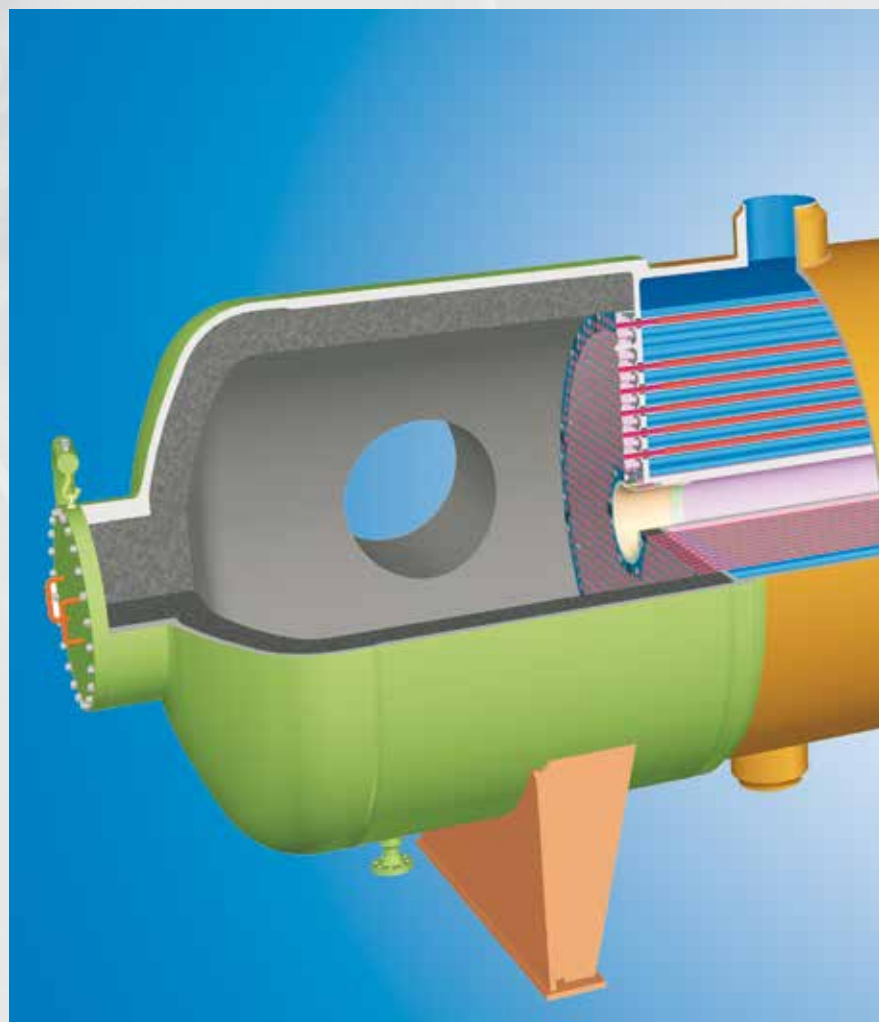


Waste heat boiler

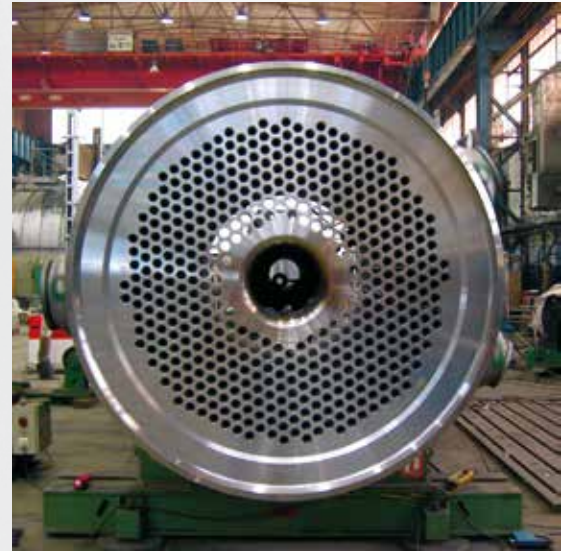


Ferrule at gas inlet tubesheet

- 1) Automatic machine welded full penetration tube to tubesheet weld.
- 2) BORSIG's patented gas side bypass valve.
- 3) Ferrules at gas inlet of tubes protect the tubesheet and the tube to tubesheet weld from high gas inlet temperatures.
- 4) Full penetration tube to tubesheet weld making crevice corrosion impossible.
- 5) Heat shield: For safety reasons a heat shield (liner) on the tubesheet refractory is provided to keep the refractory in position in case of cracks.
- 6) A liner is inserted into the bypass tube. The liner and a ceramic insulation material are protecting the bypass tube from the high gas temperatures.
- 7) Material selection: **BORSIG Process Heat Exchanger GmbH** has a great experience in choosing the required material to avoid failures due to hydrogen embrittlement or metal dusting.



- 8) Natural circulation between waste heat boiler and steam drum:
Downcomer and riser piping will be designed to achieve a sufficient circulation ratio.
- 9) Quality assurance and control activities are independent of the manufacturing process and warrant that the machines and handled materials, components and products are in accordance with all specified requirements.
- 10) Refractory in gas channels and on the gas inlet tubesheet: BORSIG has a great experience in designing refractory layers to avoid dew pointing and to achieve the specified surface temperature.
- 11) The thin flexible tubesheet is welded to a forged ring. Rigorous mechanical strength and heat transfer calculations are performed using FEM analysis.

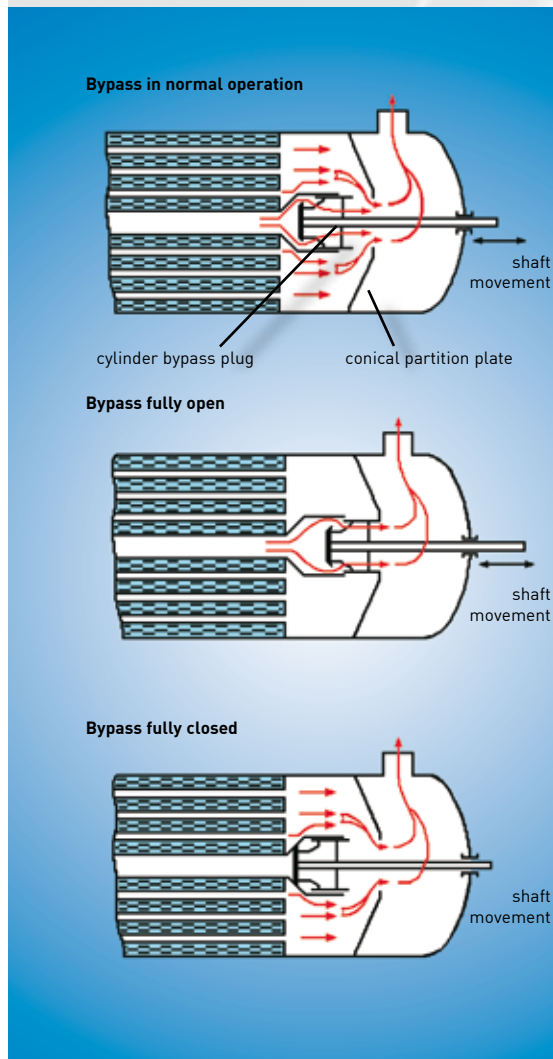


Gas inlet tubesheet with central bypass tube

Typical process gas waste heat boiler with thin flexible tubesheet design



GAS SIDE BYPASS VALVE



Different operation modes of internal gas side bypass valve

To maintain a constant gas outlet temperature with clean and fouled condition of heat exchange surface as well as during start-up and shut-down operation with reduced gas flow, exact control of the gas outlet temperature is essential.

The patented BORSIG bypass valve design - so called internal forced flow - allows exact control of the gas outlet temperature with only one control operation by adjusting the shaft horizontally. The valve changes simultaneously the flow through the bypass as well as through the tubes in the range from 0 to 100 %.

Good mixing of the flow through the bypass and the tubes is obtained by the conical partition plate.

The bypass system can be adjusted to bypass 100 % of the gas flow. This can be required for certain operating conditions, i.e. start-up.

We are supplying our bypass design for hot gas temperatures up to 1200 °C and for gas pressures up to 11,000 kPa.

Assembly of tube bundle



Loading of a steam drum



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).

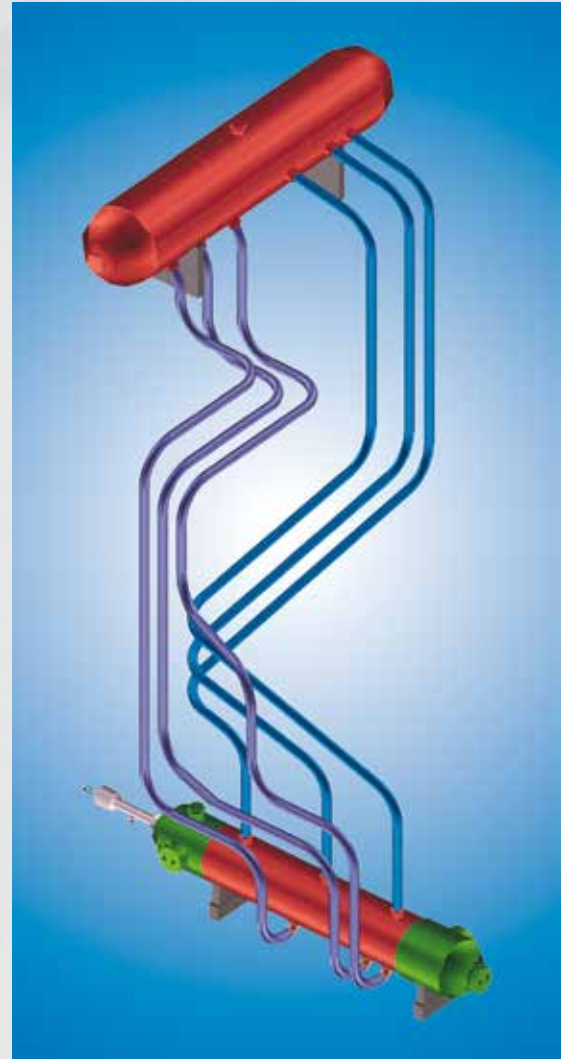
The pressure vessels and heat exchangers are calculated with computer programs developed in-house and commercial software PROBAD or PVELite according to all national and international design standards:

ASME CODE Sections I and VIII (Div.1 & Div.2), ASME B31.1 and B31.3, AD-2000, TRD, EN 13445, PD 5500, CODAP, RTOD, IBR, JIS, Australian Standards, Russian Standards, China SQL and GB 150.

In the case of critical parts, Finite Element Analysis with software package ANSYS is carried out.

Flexibility, foundation loads and nozzle loads on interconnecting piping are calculated by software Rohr2 or CAESAR II.

BORSIG Process Heat Exchanger GmbH supplies also the service of complete replacement jobs of waste heat boilers in ammonia, methanol, hydrogen, ethylene and all other steam reforming plants. BORSIG supervisors are specialized on replacement performances covering the detailed engineering, elaborating the shortest time frame, determining the logistic replacement sequence, mobilization of local personnel and complete supervision from shut down to start-up of plant.



CAD model of a waste heat recovery system

Replacement of a waste heat boilers under BORSIG supervision with mobilization of local personnel



MANUFACTURING

BORSIG Process Heat Exchanger GmbH in Berlin owns more than 16,700 m² 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.



Machining of stiffened tubesheet system
Robot welding



3D-plasma cutting



MAG welding



QUALITY



UT testing

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.

Recordable UT



RT film examination



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