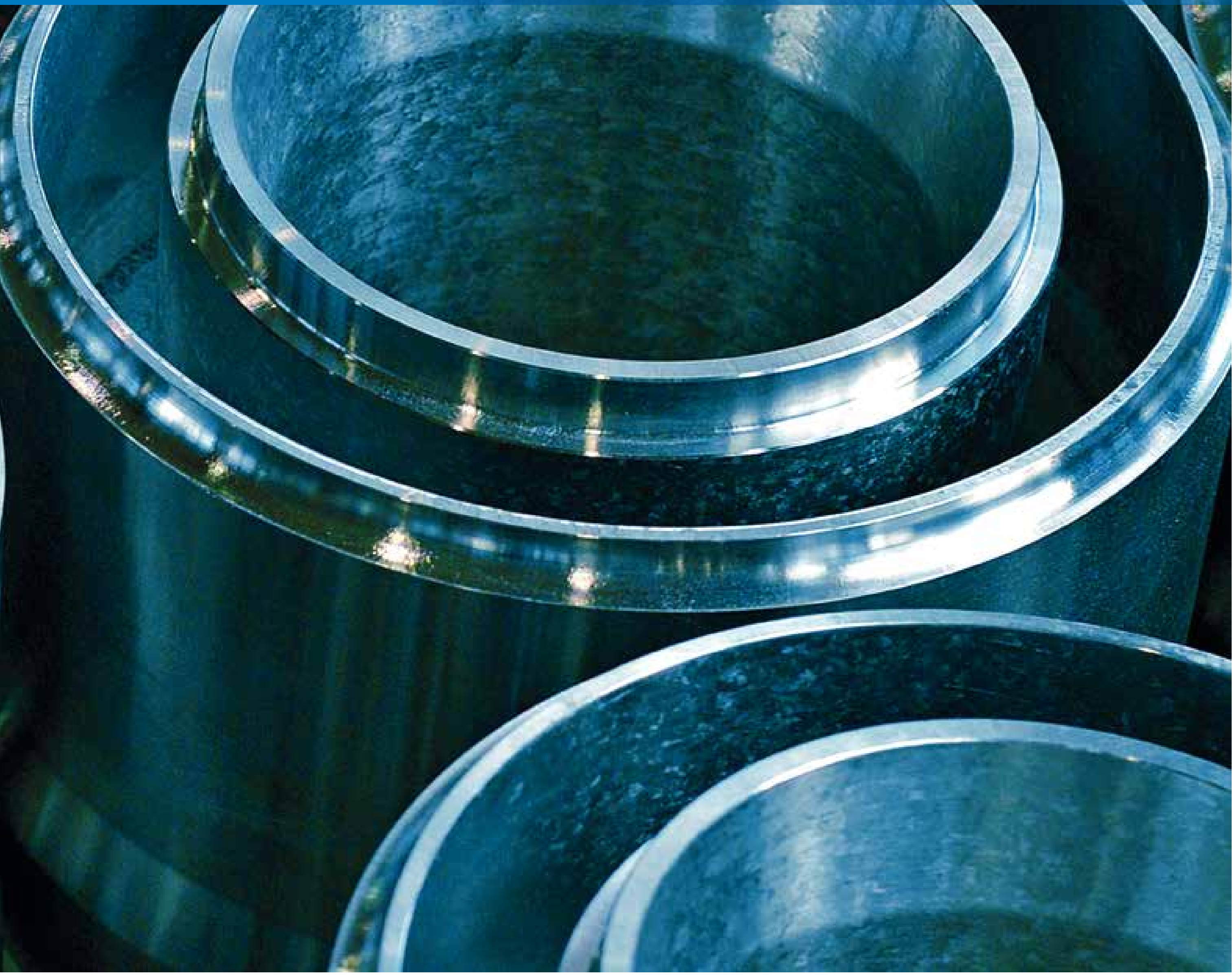
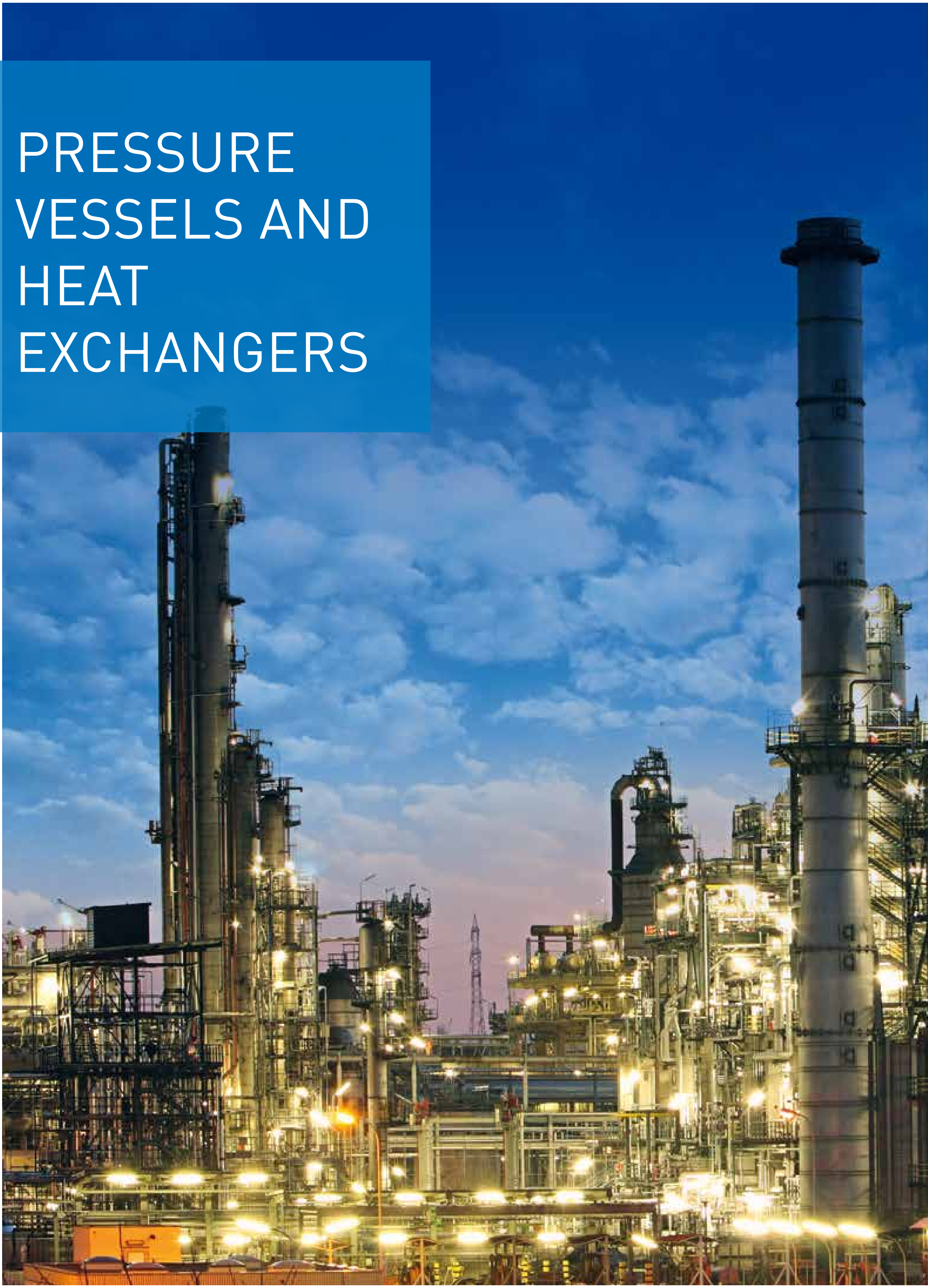
BORSIG PROCESS HEAT EXCHANGER GMBH

TRANSFER LINE EXCHANGERS FOR ETHYLENE CRACKING FURNACES



PRESSURE VESSELS AND HEAT EXCHANGERS



ABOUT BORSIG PROCESS HEAT EXCHANGER GMBH

BORSIG Process Heat Exchanger GmbH is a member of the BORSIG Group and the leading international designer and manufacturer of pressure vessels and heat exchangers for cooling gases at very high temperatures (up to 1,500 °C) and at high pressure (up to 35,000 kPa) for the chemical and petrochemical industries. The company also offers comprehensive after-sales and industrial services. Our pressure vessels and heat exchangers are used in 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 expertise is based on more than 180 years of company history. Our competence, trained specialists and awareness of quality guarantee the reliability of our products. This symbiosis is the source of our innovative power, which is reflected in our unique manufacturing program.

State-of-the-art technology, committed employees and innovative engineering enable us to consistently provide our customers with the perfect solution. Our products and services have cemented our position as a competent and reliable partner to numerous companies around the world.

Our product range

→ **Waste Heat Recovery Systems**
for ammonia plants, methanol plants, hydrogen plants, coal gasification plants, gas-to-liquid plants, partial oxidation of oil and gas, one-to-one replacement boilers in nitric acid plants, caprolactam plants and formaldehyde plants

→ **Transfer Line Exchangers**
for ethylene plants

→ **Scraped Surface Exchangers**
for lube oil plants and special applications

TRANSFER LINE EXCHANGERS

Fig. 1

TWO DIFFERENT PATENTED DESIGNS

BORSIG transfer line exchangers are the result of 55 years experience and more than 9,000 units supplied worldwide.

Ethylene is the basic substance used in the fabrication of plastics. Ethylene (C2H4) and some other by-products like propylene are produced by thermal cracking of hydrocarbons in pyrolysis furnaces in the presence of steam. Ethane, naphtha and other mineral oil fractions are predominantly used as feedstocks.

The gas produced by cracking, which leaves the furnace at a temperature of around 850 °C (1,500 °F), must be cooled down rapidly (quenching) after leaving the reaction zone of the furnace to prevent secondary reactions and stabilise the gas composition in order to obtain the optimum product yield. This rapid cooling of the cracked gas is performed by transfer line exchangers (also known as quench coolers or TLEs) in all modern ethylene processes, thereby producing high pressure steam.

One or more parallel TLEs per furnace cell are connected by riser and downcomer piping with one common, elevated steam drum forming the so called quench system.

Fig. 1: BLQs ready for shipment
Fig. 2: Manufacturing of TLEs
Fig. 3: TLEs ready for shipment
Fig. 4: Shipment of BLQs

Fig. 2

Up-to-date, tailored-to-practice design and modern manufacturing and testing methods in combination with the special workmanship of our staff result in a high-quality quench cooler that meets today's requirements for mechanical and operational reliability.
These advantages consistently allow performance guarantees to be met and have gained the BORSIG transfer line exchanger an outstanding reputation at home and abroad.

We follow up on delivery and commissioning with an excellent after-sales service.

BORSIG Process Heat Exchanger GmbH offers two different patented designs

→ BORSIG "TUNNELFLOW" TRANSFER LINE EXCHANGER (TLE)

→ BORSIG "LINEAR" TRANSFER LINE EXCHANGER (BLQ).

Fig. 3

Fig. 4

TRANSFER LINE EXCHANGERS

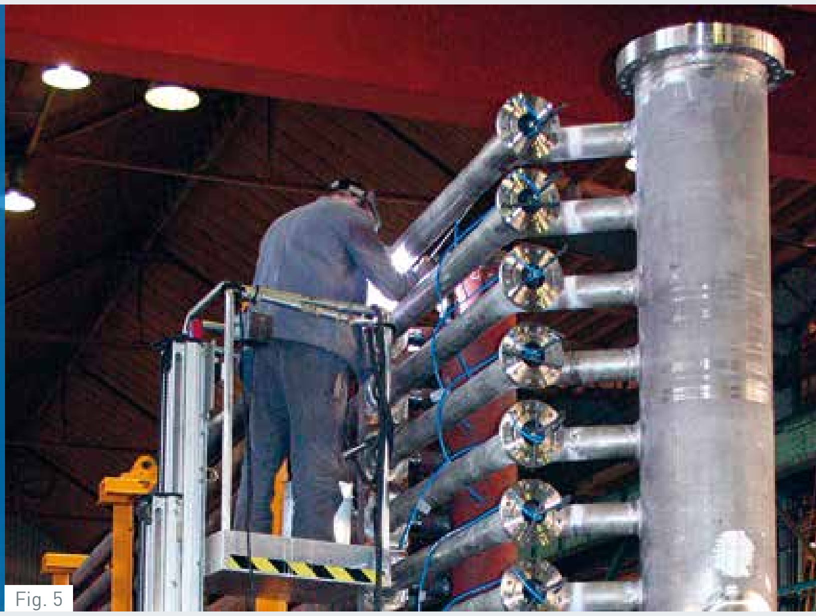


Fig. 5

MANUFACTURING AND QUALITY CONTROL

High-tech welding is our core competence.

BORSIG Process Heat Exchanger GmbH owns more than 16,700 m^2 of indoor workshop facilities in Berlin and is equipped with a 250t crane capacity.
The Gladbeck site of the company covers an area of 38,000 m^2 of which 5,250 m^2 is heated and has crane capacities of up to 100t.

Since 2008 the Borsig Harbour has enabled the company to transport pressure vessels and heat exchangers of any size with easy access to international seaports via the national waterways system.

High-tech welding technology is our core competence and includes the use of laser controlled welding seam guidance system for submerged narrow-gap welding, robot welding systems for the GMAW welding process in the high pressure vessel manufacture, GMAW narrow gap robot systems with integrated plasma and autogenous 3D cutter systems, TIG hot wire welding, RES and SAW strip weld cladding, automatic tube to tube sheet welding, including in bore welding of up to 500 mm as well as qualified machining of all steel and nickel-based alloys.

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

Fig. 5: Manufacturing of BLQ
Fig. 6: Testing of BLQ
Fig. 7: Manufacturing of BLQ
Fig. 8: Penetration testing of TLE


Fig. 6

Our quality assurance monitors the adherence to national and international specifications, statutory and contractual 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, individual management systems have been merged to form an Integrated Management System (IMS).

CERTIFICATION FOR 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
- SELO license for PR China (Pressure Vessels A1, A2)
- Korea license for specified manufacture equipment
- AD 2000 - Directives HP 0, TRD 201 and DIN EN ISO 3834-2 and DIN 18800-7, etc.

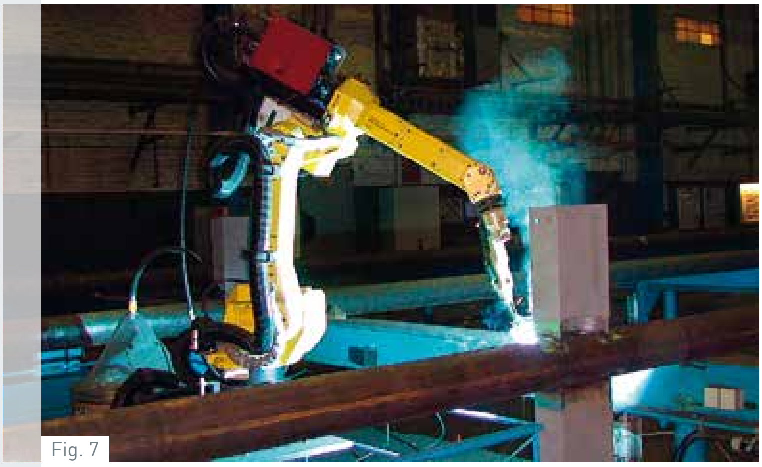


Fig. 7


Fig. 8

„TUNNELFLOW“ TRANSFER LINE EXCHANGERS

Fig. 9

RAPID COOLING DOWN OF CRACKED GAS IN ETHYLENE PLANTS - SHELL AND TUBE DESIGN

A quench system from **BORSIG Process Heat Exchanger GmbH** consists of one or more "Tunnelflow" coolers with a steam drum and riser and a downcomer line. The "Tunnelflow" cooler can be mounted vertically or horizontally in a plant.

We supply "Tunnelflow" transfer line exchangers for every required mass flow and heat duty.

VERTICAL

The most common arrangement for a quench system is shown in Fig. 10. This vertical arrangement of one or more TLEs to serve one common elevated steam drum is in most cases the only feasible arrangement for connecting it with the furnace cell. In most cases, the location is on top of the radiant section of the furnace.

HORIZONTAL

A true horizontal arrangement of the BORSIG „Tunnelflow" transfer line exchanger is also possible if favoured by the ethylene furnace designer. In this case, the steam drum can either be mounted piggy-back on top of the quench cooler or at an elevated height within the steel structure.

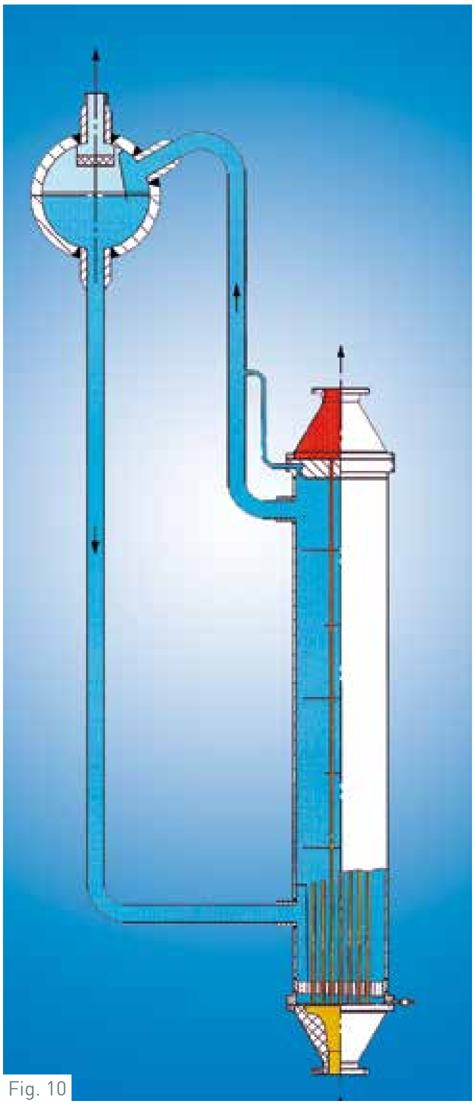


Fig. 10

Fig. 9: Quench system, vertical arrangement
Fig. 10: Quench system

„TUNNELFLOW“ TRANSFER LINE EXCHANGERS

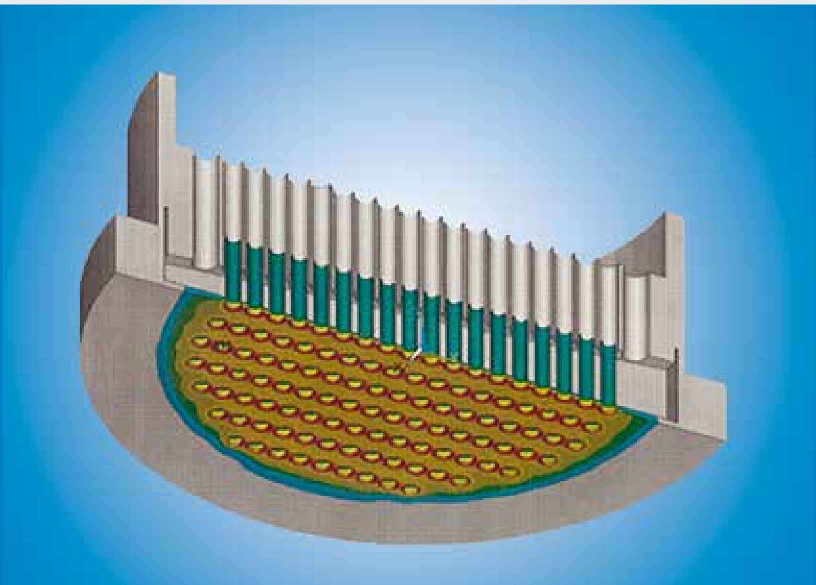


Fig. 11

GAS INLET TUBE SHEET DESIGN

Unique BORSIG design

A design is necessary which combines two requirements:

1. The high pressure on water side (up to 150 bar g) requires a thick tube sheet.
2. The high gas inlet temperature and the high heat transfer coefficient on the gas side requires a thin tube sheet in order to keep the metal temperature low.

A thick tube sheet is clearly impracticable because the heat of the gas transported through the tube sheet would raise the temperature of the metal. The cooling effect of the water on the water side face of the tube sheet is insufficient to cool such a thick metal sheet. Neither ferrules nor a refractory can be used to protect the inlet tube sheet and the tube ends as the cracked gas would cause coke deposits in the small voids of the refractory and behind the ferrules. As the coke deposits grow, they would destroy the refractory and ferrules.

A solution with thin tube sheets anchored by bundle tubes would allow tube sheet to be cooled sufficiently but has considerable disadvantages. Thin tube sheets deflect in the transition between the tube bundle and shell, and a malfunction can be expected in this area after a certain number of cycles. The bundle tubes also act as a stay and elongate due to pressure load on the tube sheet and differential thermal expansion between the shell and tubes. Consequently, the stress concentration in the tube to tube sheet welding is fairly high and can also lead to malfunction.

Fig. 11: Temperature acting on the „Tunnelflow“ gas inlet tube sheet
Fig. 12: Stresses acting on the „Tunnelflow“ gas inlet tube sheet
Fig 13: Design principle

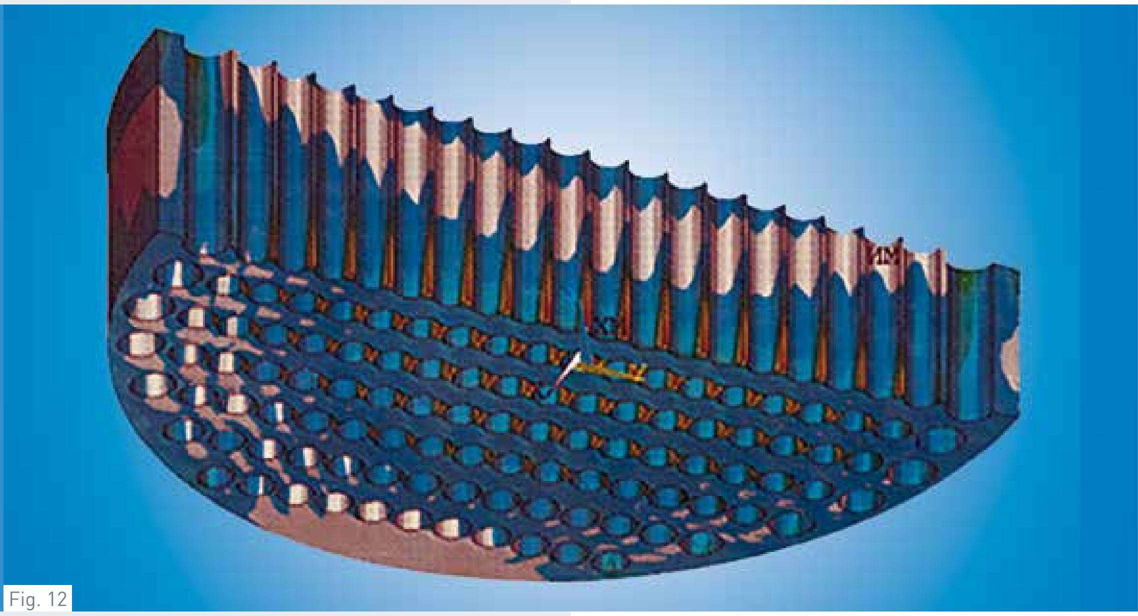


Fig. 12

The principle of a design, developed by BORSIG in 1965 and which effectively combines the two requirements regarding pressure and temperature is shown in Fig. 13. A thin tube sheet (1) of only approx. 10-15 mm thickness is reinforced by a thick forged anchoring plate (2). The water side pressure load on the thin tube sheet is transferred via anchoring ribs (3) to the thick anchoring plate (2) and from there to the cooler shell (4). The anchoring ribs (3) are machined out of the thin tube sheet (1) and the thick forged anchoring plate (2) thereby forming tunnels, hence the name “Tunnelflow” TLE.

THE ADVANTAGES ARE CLEAR

- Since the inlet tube sheet (1) is thin, very efficient cooling and low metal temperature is achieved.
- The gas inlet tube sheet (1) does not deflect and remains flat under all conditions because it is reinforced and held in position by the thick anchoring plate via the anchoring ribs (3).
- The tubes (5) do not act as anchors and the stress in the tube to tube sheet welding is therefore low (differential thermal elongation between tubes and shell is of almost same magnitude as the shell elongation due to water side pressure on the tube sheets).
- Low metal temperature of the metal inlet tube sheet (1) and tube ends allow ferritic steel with 0,5% Mo to be used, which does not require any post-weld heat treatment.
- No pressure limitation on water side

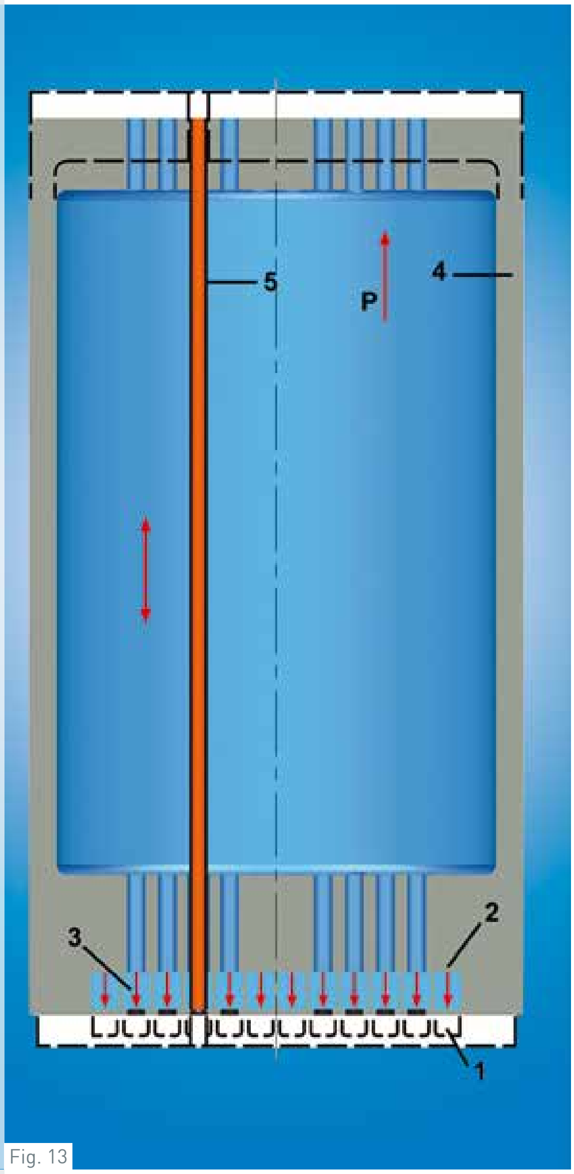


Fig. 13

„TUNNELFLOW" TRANSFER LINE EXCHANGERS

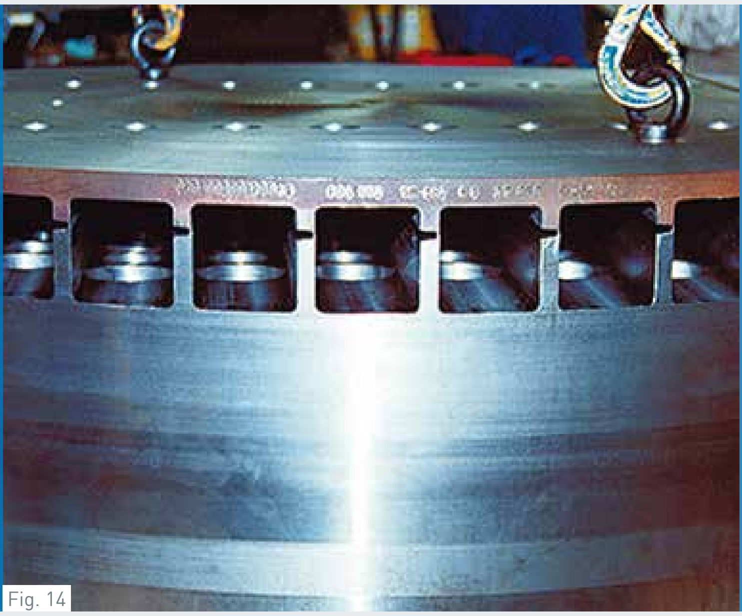


Fig. 14

WATER FLOW AT GAS INLET TUBE SHEET

High water velocity

With vertically arranged coolers, where the inlet tube sheet is the lowest point of the water system, high water velocity across the gas inlet tube sheet is important in order to avoid problems caused by solid particles settling. Small solid particles quite often enter the water, especially during commissioning. In addition, the water side surfaces produce Fe_3O_4 (magnetite). The magnetite layer protects the steel and constantly renews itself slowly on the metal surface at operation temperature, releasing a small amount of magnetite particles into the water.

The BORSIG "Tunnelflow" design (Fig. 16, 17 and 18) provides guided water flow across the gas inlet tube sheet.
Water flows from the downcomer (1) into an internal water chamber (2). The water flows downwards in the water chamber (2) and enters the flow tunnel (3) through inlet holes (4). Each tunnel has a single inlet hole. The water flows to the opposite side of the tunnel at high velocity, preventing any solids from settling on the thin tube sheet.
Water flows upward through the outlet holes (5) on the opposite side to the main shell space. A certain amount of the water enters the main shell space via annular gaps (6) around the tubes in the thick anchoring plate. This design ensures high water velocity across the tube sheet and prevents solids from settling as well as overheating and hot water corrosion.

Fig. 14: Thin tube sheet / thick tube sheet
Fig. 15: Welding of „Tunnelflow" tube sheet
Fig. 16: 3D view of „Tunnelflow" TLE
Fig. 17: „Tunnelflow" TLE, water flow principle
Fig. 18: Cross section of „Tunnelflow" TLE

Fig. 15

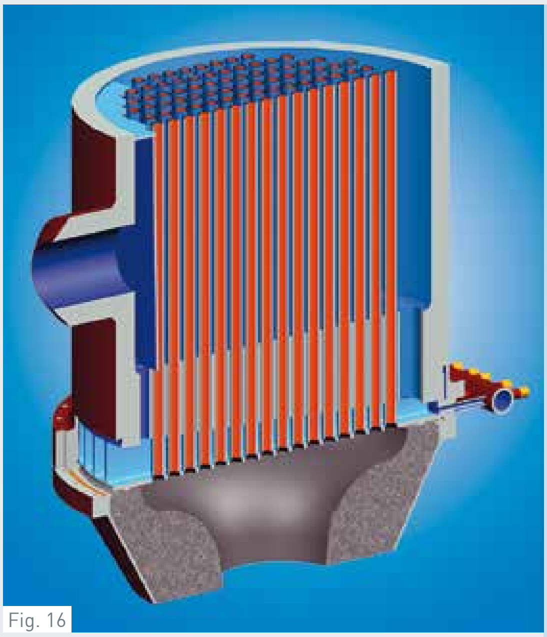


Fig. 16

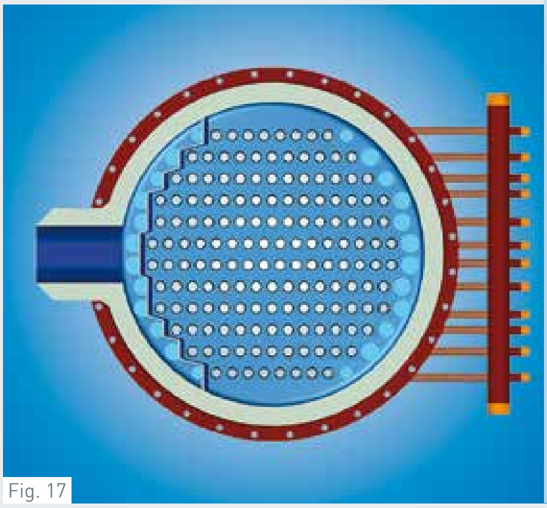


Fig. 17

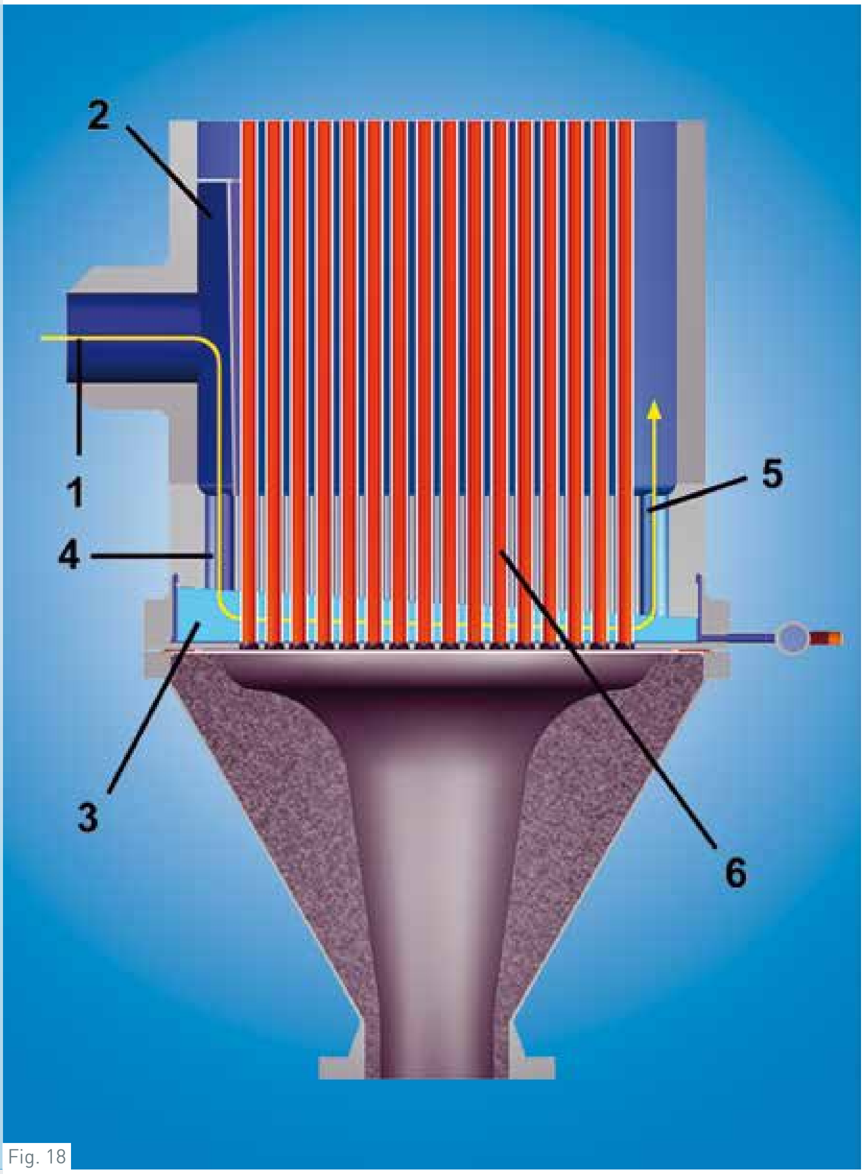


Fig. 18

„TUNNELFLOW“ TRANSFER LINE EXCHANGERS

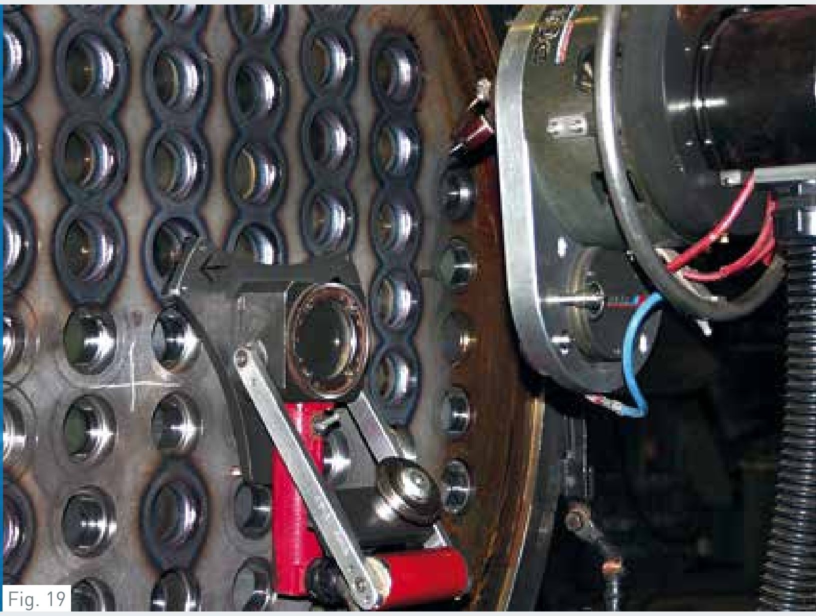


Fig. 19

MANUFACTURE OF GAS INLET AND OUTLET TUBE SHEET

Special tube to tube sheet welded seams

TUBE TO TUBE SHEET WELDING AT GAS INLET

The tubes are automatically welded to the gas inlet tube sheet. This full penetration welding is computer controlled using an orbital program. The root pass of the tube to tube sheet weld is obtained by fusing the edge of the tube to the edge of the tube sheet with filling wire, protected by shield gas.
Multiple welded layers are applied following the initial root pass welding procedure resulting in a gapless weld joint between the tube and tube sheet. This ensures that no crevice corrosion on the water side can occur.
As the tube to tube sheet weld is located on the water side of the tube sheet, its temperature during operation of the TLE is close to boiling temperature on the water side.

ANCHORING RIB WELDED TO GAS INLET TUBE SHEET (FIG. 22)

The anchoring ribs are machined out of two solid forgings. The short ribs of the thin gas inlet tube sheet are weld connected to the longer ribs of the thick anchoring plate by means of full penetration automatic TIG welding.

TUBE TO TUBE SHEET WELDING AT GAS OUTLET

A gas outlet tube sheet is used as shown in Fig. 23. The tubes are expanded inside the hole and fillet welded with a multilayer seam. 0.5 Mo material is used which requires no post-welding heat treatment. A vent bore is provided in the upper tube sheet and connected to the nearest riser. This prevents steam accumulation.

Fig. 19: Fully automatic tube to tube sheet welding
Fig. 20: Assembly of „Tunnelflow“ tube sheet
Fig. 21: Tube to tube sheet weld
Fig. 22: Anchoring rib to gas inlet tube sheet weld
Fig. 23: Gas outlet tube sheet
Fig. 24: Specimen of tube to tube sheet weld

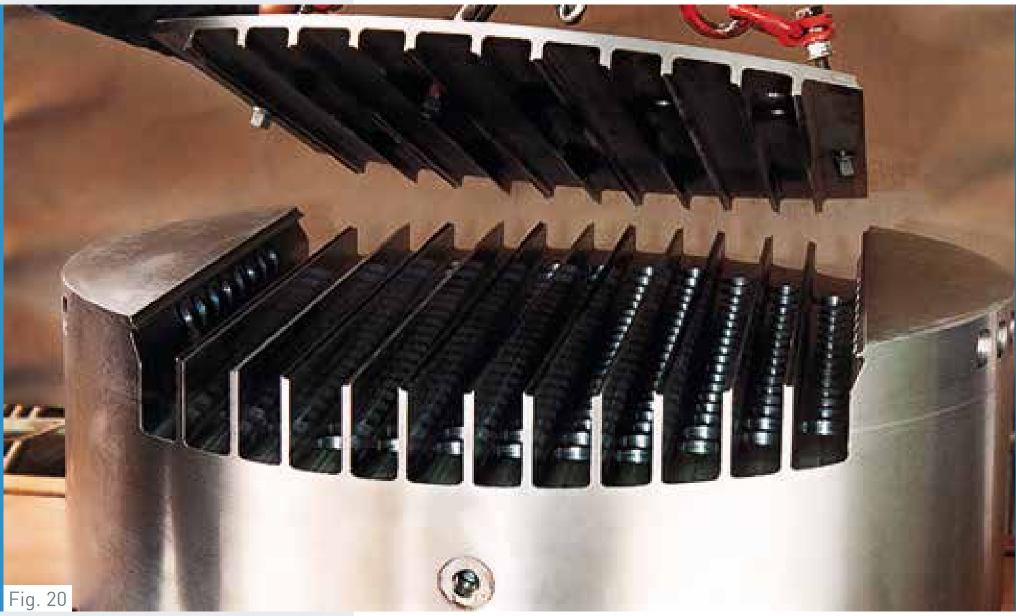


Fig. 20


Fig. 21

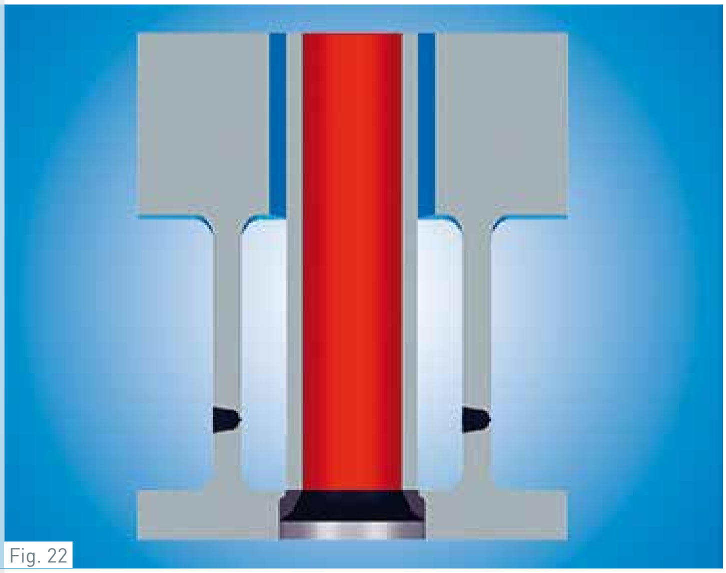


Fig. 22

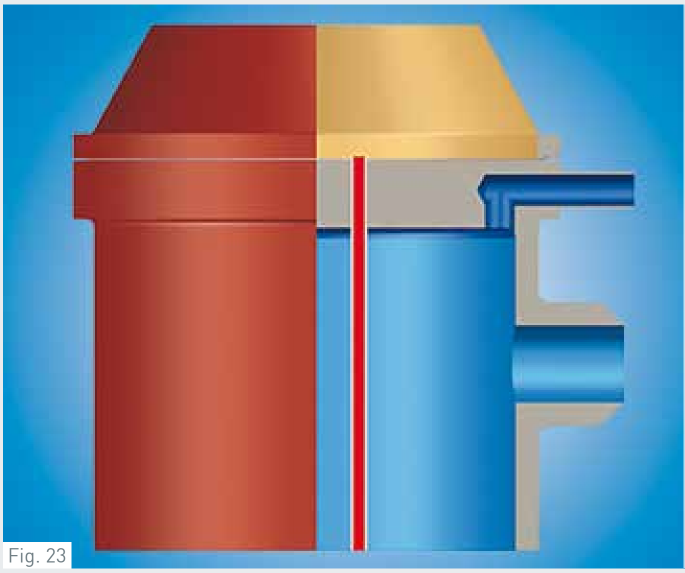


Fig. 23

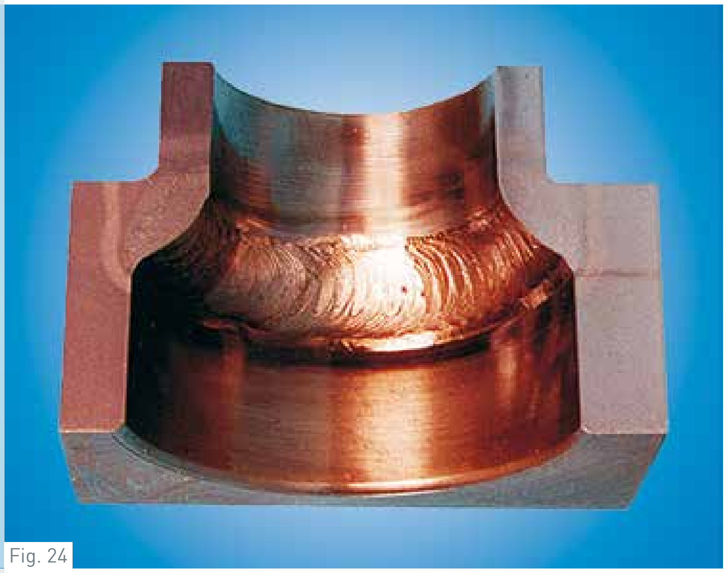


Fig. 24

„TUNNELFLOW“ TRANSFER LINE EXCHANGERS

Fig. 25

OTHER DESIGN FEATURES

Gas inlet channel, steam drum and interconnection piping

GAS INLET CHANNEL

The inlet channel design must ensure uniform gas flow to all tubes, minimum residence time within the channel and a low drop in pressure. The gas inlet channel design has been optimised by computational fluid dynamics (CFD) and fulfils all these requirements. Neither anchors nor metal liners are required as the high density refractory contains stainless steel needles to add reinforcement and high abrasion resistance. Hard coke particles in the gas flow may cause erosion of the gas inlet tube sheet and tube inlets. **BORSIG Process Heat Exchanger GmbH** has developed a protective shield which is anchored in the refractory of the channel.

STEAM DRUM

The steam drum is provided with all necessary nozzles - including nozzles for risers and downcomers. Access to the inside of the drum is possible through a hinged, oval manhole. The design of drum's internal fixtures are based on over 50 years of company experience. The feed water nozzle is designed as "thermo nozzle" and fitted with an internal feed water distribution system. The downcomer nozzles are fitted with vortex breakers. We use a demister package as a steam/water separator.

Fig. 25: Manufacturing of steam drum
Fig. 26: Steam drum internals
Fig. 27: Erosion protection shield
Fig. 28: Shipped steam drums

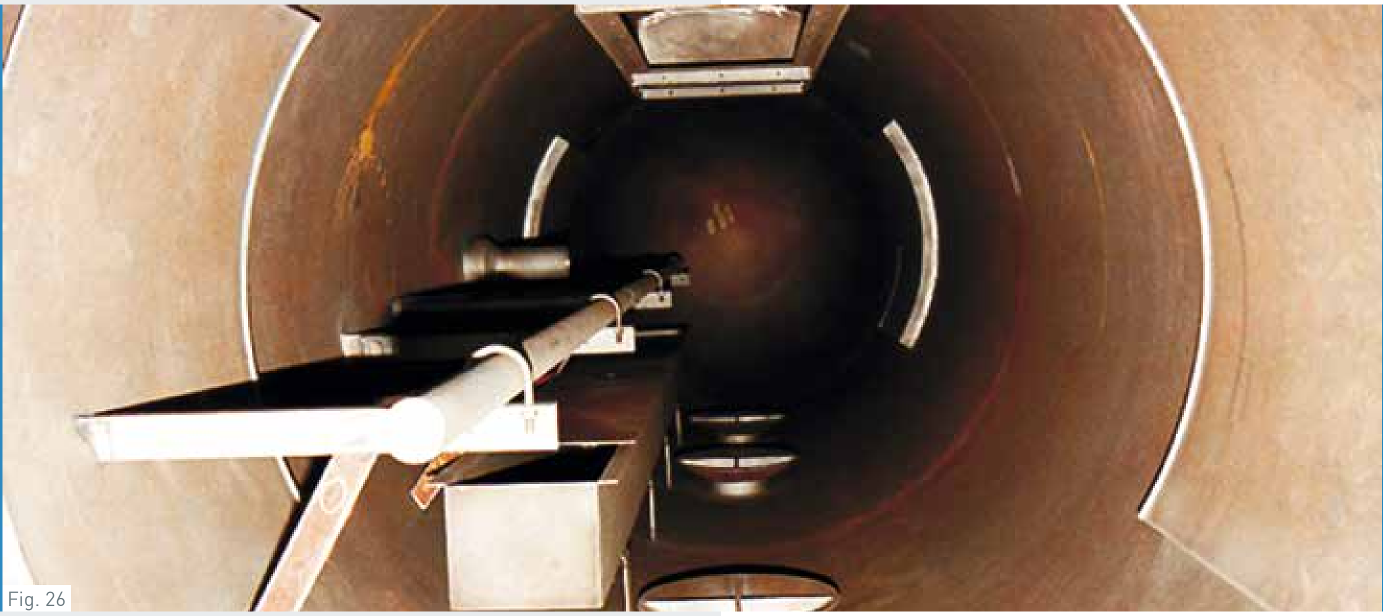


Fig. 26

INTERCONNECTION PIPING

The design of the vertical quench system only requires one downcomer and one riser per "tunnelflow" cooler. This reduces the installation time considerably. The pipes are prefabricated in the workshop to the furthest possible extent. Only minimal circumferential welding is necessary on location. Each riser and downcomer line is provided with spring hangers and pipe clamps if necessary. A pipe stress analysis test is carried out to determine the forces and moments acting on the TLE and drum itself and the steel structure into which the TLE and drum are installed.

Fig. 27

Fig. 28

„TUNNELFLOW“ TRANSFER LINE EXCHANGERS

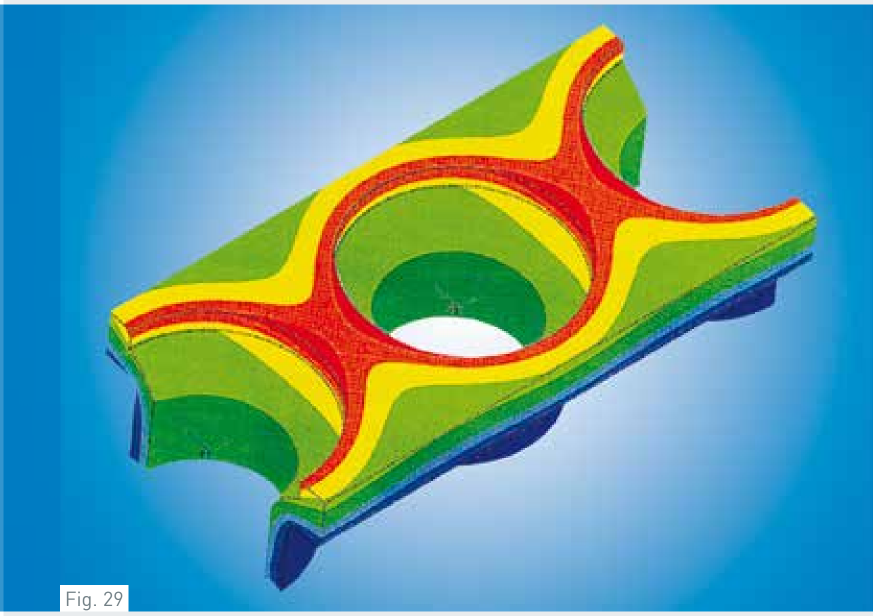


Fig. 29

ENGINEERING AND AFTER-SALES SERVICE

Complete in-house engineering facilities

BORSIG Process Heat Exchanger GmbH has complete in-house engineering facilities. Thermal layout and special heat transfer calculations are performed and checked with internally developed computer programs.

Complex problems affecting gas flow and heat transfer are calculated using three dimensional finite element programs (computational fluid dynamics).

Calculations of pressure vessels and heat exchangers are performed in accordance with all internationally established codes including AD, TRD, ASME, BS, Raccolta VSR, Codap, Stoomweezen, IBR, JS, Australian Standard and others. Critical components are subject to additional strength calculations with the finite element method, if necessary. Computers are used to calculate the flexibility and foundation loads of the interconnecting pipes and the forces acting upon them.

BORSIG Process Heat Exchanger GmbH also supplies and fits all replacement parts for its heat exchangers.

After the TLE has been mounted in the furnace structure on its supports, the coil outlet can be connected to the TLE gas inlet channel. Once the steam drum has been set up, the interconnecting piping between TLE and steam drum can be installed. The pipework is bent and prefabricated as much as possible in the workshop and only requires a few circumferential welds during the installation process.

Fig. 29: Temperature distribution on "Tunnelflow" gas inlet tube sheet
Fig. 30: 3D view of installed tube bundle
Fig. 31: Stresses acting on „Tunnelflow" gas inlet tube sheet
Fig. 32: Gas inlet channels of installed TLE

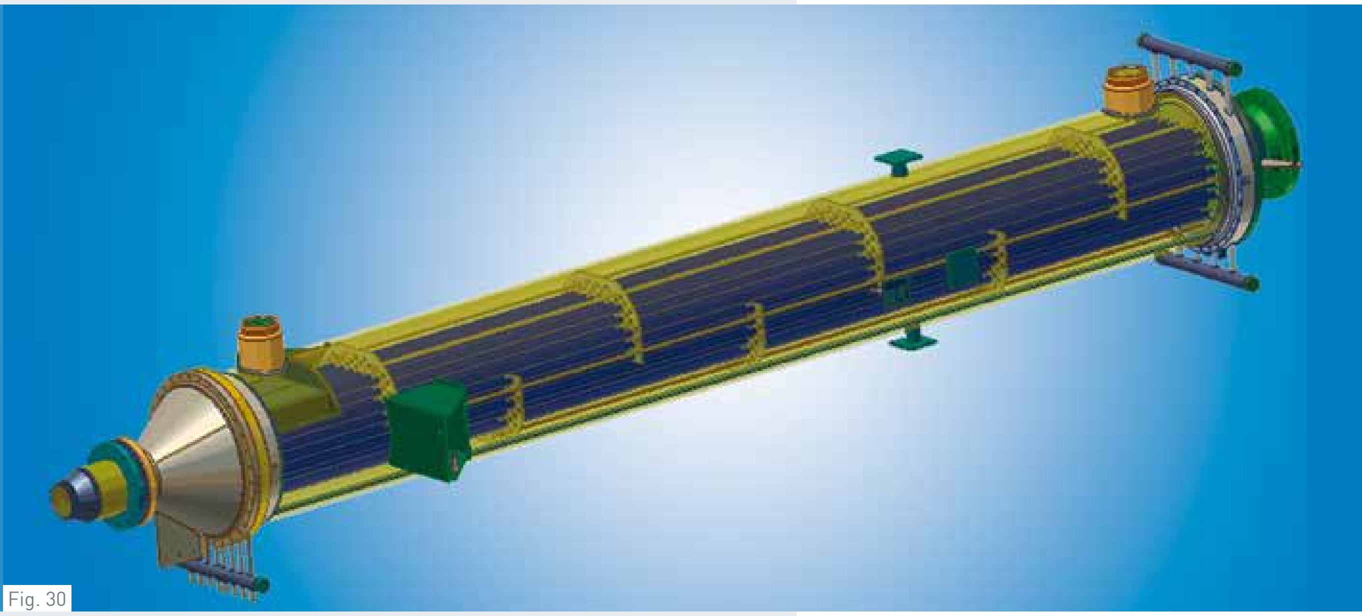


Fig. 30

Experienced BORSIG supervisory engineers accompany the on-site construction and commissioning. An instruction manual covering installation, activation and maintenance is provided for each job. The water side of the entire quench system including upstream units have to be cleaned carefully prior to activation to guarantee that a homogeneous protective layer of magnetite builds up on all water side surfaces.

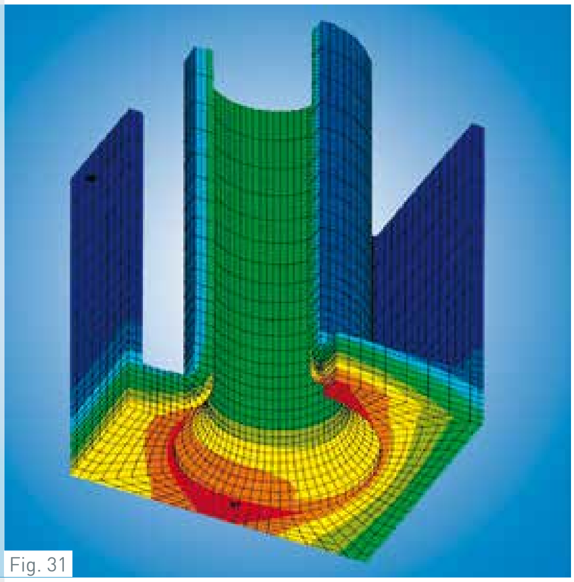


Fig. 31

Fig. 32

„TUNNELFLOW“ TRANSFER LINE EXCHANGERS


Fig. 33

KEY FEATURES

More than 1,100 „Tunnelflow“ transfer line exchangers built and supplied

- Tube bundle heat exchanger - large water volume, a robust shell around the bundle tubes
- Thin, reinforced tube sheet at the gas inlet for very efficient cooling - low material temperatures, low tension
- Special tube to tube sheet welded seams - no sharp edges, full penetration weld, crevice free
- Guided water flow with high water velocity across the thin inlet tube sheet - accumulation of deposits is prevented
- No limits on the operating pressure on the water/ steam side
- Only one or two risers/ downcomers per exchanger
- 0.5 Mo material - no heat treatment required after welding process
- Uniform gas distribution of the gas to all bundle tubes due to special trumped shaped design of inlet channel
- Optional erosion protection shield - protects the inlet tube sheet against erosion
- Optional blowdown possible via quick open valve
- Easy maintenance

The complete quench system from **BORSIG Process Heat Exchanger GmbH** reduces your man-hour expenditure.

The BORSIG "Tunnelflow“ transfer line exchanger is used by virtually every contractor and company active in the construction of ethylene plants worldwide.

Fig. 33: Shipment of „Tunnelflow“ TLEs
Fig. 34: TLE ready for shipment
Fig. 35: Installed „Tunnelflow“ TLE
Fig. 36: Installed „Tunnelflow“ TLEs

Fig. 34

Fig. 35

Fig. 36

„LINEAR“ TRANSFER LINE EXCHANGERS

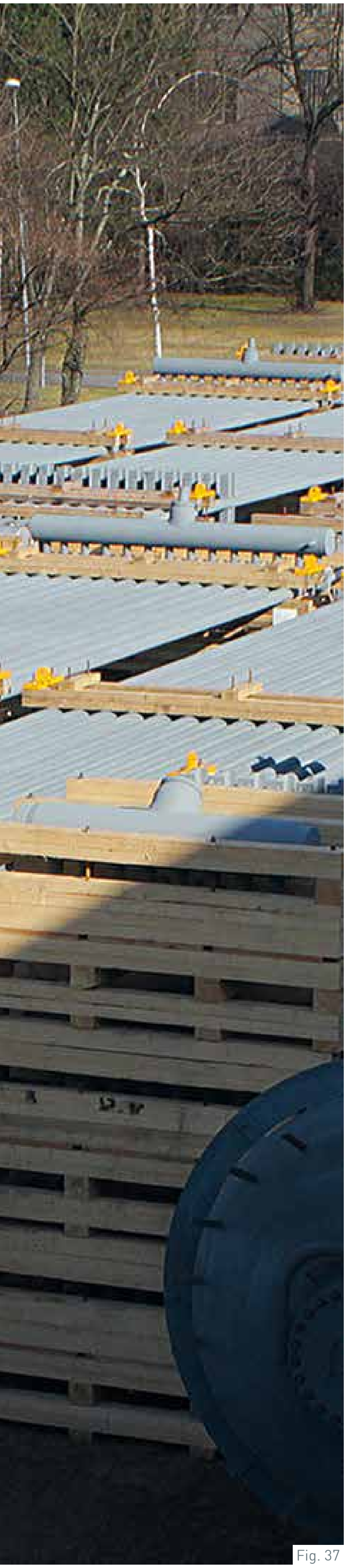


Fig. 37

RAPID COOLING OF CRACKED GAS IN ETHYLENE PLANTS - DOUBLE PIPE DESIGN

The patented BORSIG linear quencher (BLQ) consists of a number of linearly arranged double pipe elements each of which is directly coupled to one of the furnace's radiant coil outlets.

The process effluent from each single radiant coil is quenched individually in its own double pipe element.

The BLQ is a versatile exchanger design with a range of optional orientations varied enough to fulfil the specific design requirements of every ethylene furnace.

BORSIG Process Heat Exchanger GmbH provides the complete quench system comprising the design of the BLQ, the riser and downcomer pipework and the steam drum.

BORSIG Process Heat Exchanger GmbH has provided over 6,000 BORSIG linear quenchers with more than 29,000 double pipes to all parts of the world since 1990.

All engineering companies and contractors active in the construction of ethylene plants worldwide rely on BORSIG linear quenchers.

Fig 37: BLQs ready for shipment

„LINEAR“ TRANSFER LINE EXCHANGERS

Fig. 38

BASIC DESIGN CONCEPT

Patented BORSIG linear quencher (BLQ)

The patented BORSIG linear quencher (BLQ) consists of a number of linearly arranged double pipe elements each of which is directly coupled to one of the furnace's radiant coil outlets.

The process effluent from each single radiant coil is quenched individually in its own double pipe element.

A common downcomer header uniformly distributes the circulating boiler water coming from the steam drum to each of the "Turboflow" inlet chambers.
A riser header collects the steam/water mixture from the upper outlet chambers.

The diagram Fig. 41 shows a typical BLQ arrangement. Other arrangements are possible, including a twin leg arrangement, if space in furnace structure is limited.

Fig. 38: Cracking furnace with BLQs
Fig. 39: BLQ ready for shipment
Fig. 40: BLQ in the furnace structure
Fig. 41: Typical BLQ arrangement

Fig. 39

Fig. 40

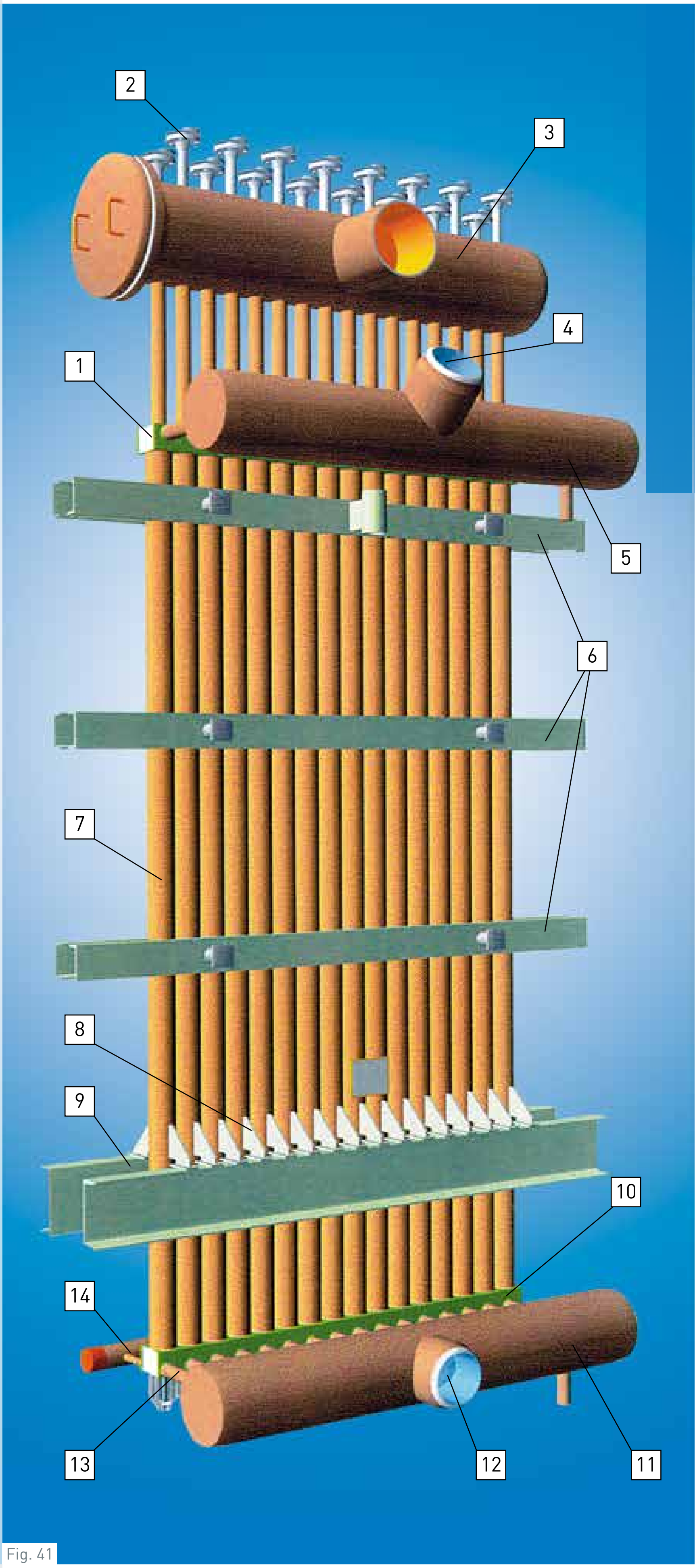


Fig. 41

Typical BLQ arrangement
1. Outlet chambers
2. Inspection/Clean out nozzles for hydro-jetting
3. Gas collection header
4. Riser nozzle
5. Riser header
6. Guides
7. Double pipes
8. Supporting brackets
9. Supporting frame
10. „Turboflow" inlet chambers
11. Downcomer header
12. Downcomer nozzle
13. Gas inlet nozzle
14. Blow down header

„LINEAR“ TRANSFER LINE EXCHANGERS

Fig. 42

ARRANGEMENT AND DESIGN

Customised BORSIG linear quencher (BLQ)

ARRANGEMENT

The BLQ is a versatile exchanger design with a range of optional orientations varied enough to fulfil the specific design requirements of every ethylene furnace.
Single leg and the twin leg are the most common arrangements.

DESIGN

The BLQ is a modular design, which permits very narrow spacing of the double pipes and allows tube configurations that perfectly meet the individual coil and furnace layout requirements. The pipes can be arranged linearly or offset as required. The very narrow inline pipe spacing is possible due to individual manufacture of the double pipe elements. The close proximity of the neighbouring pipe does not prevent the outer pipe from being welded to the water chamber.
After the double pipe elements have been individually manufactured and non-destructively tested, they are assembled into a register of double pipes with all necessary headers, nozzles, brackets and supports. The pipe spacing can be as close as the outer diameter of the outer pipe if required. The “Turboflow” chamber design makes a virtually unlimited number of coils in a single radiant coil module with the same narrow spacing possible.
The BLQ can be designed and manufactured according to all internationally recognised codes and standards including the German AD-Merkblätter (German Pressure Vessel Code), ASME etc.

Fig. 42: BLQ during shipment
Fig. 43: Secondary transfer line exchanger / steam drum unit
Fig. 44: Computer simulation of two naphtha cracking furnaces
Fig. 45: Ethane cracking furnaces

Fig. 43

Fig. 44

Fig. 45

„LINEAR“ TRANSFER LINE EXCHANGERS


Fig. 46

DESIGN FEATURES

„Turboflow“ concept

INDIVIDUAL “TURBOFLOW” CHAMBER

The BORSIG “Turboflow” design uses a tangentially arranged water inlet nozzle on the chamber to ensure a rotating water flow (turboflow) around the process gas pipe. This design evolved out of our unique conventional “Tunnelflow” TLE which accelerates the boiler water across the hot tube sheet. Applying this concept to the double pipe BLQ ensures that any potential solid deposition is eliminated at the hot inlet of the exchanger.
The independence of each “Turboflow” chamber results in a singular water flow path that is unaffected by the adjacent pipe and results in a lower overall annular water side pressure drop compared with the traditional oval header design.

ELIMINATION OF DIRT POCKETS

The water inlet nozzle is flushed to the bottom of the “Turboflow” chamber which eliminates dead zones or dirt pockets that could lead to corrosion at the inlet of the BLQ.

WATER SIDE DEAD ZONES ARE ELIMINATED

The “Turboflow” design with individual and independent water chambers eliminates possible dead zones in the lower and upper water headers between adjacent pipes on the water side.

GAS INLET HEAD

Each double pipe on the process side is directly connected to a radiant coil outlet by a refractory lined gas inlet head guiding the cracked gas from the coil to the inner pipe. No steam purge is required. The BORSIG BLQ uses a patented and proven proprietary three refractory design with metal sealing ring. This design is superior to the traditional single

Fig. 46: Gas inlet heads with BfW supply header
Fig. 47: „Turboflow“ chambers with optional blowdown/ drain pipe
Fig. 48: The BORSIG „Turboflow“ concept
Fig. 49: CFD analysis of water flow in BLQ „Turboflow“ chambers

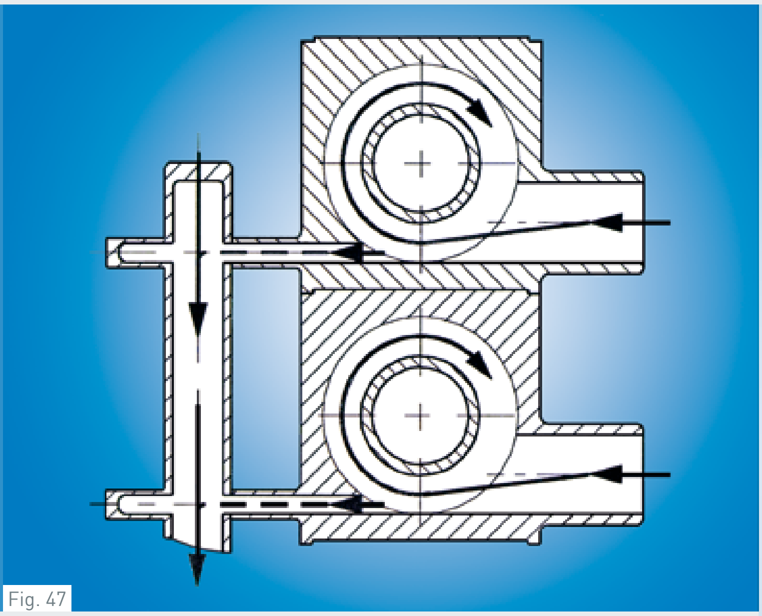


Fig. 47

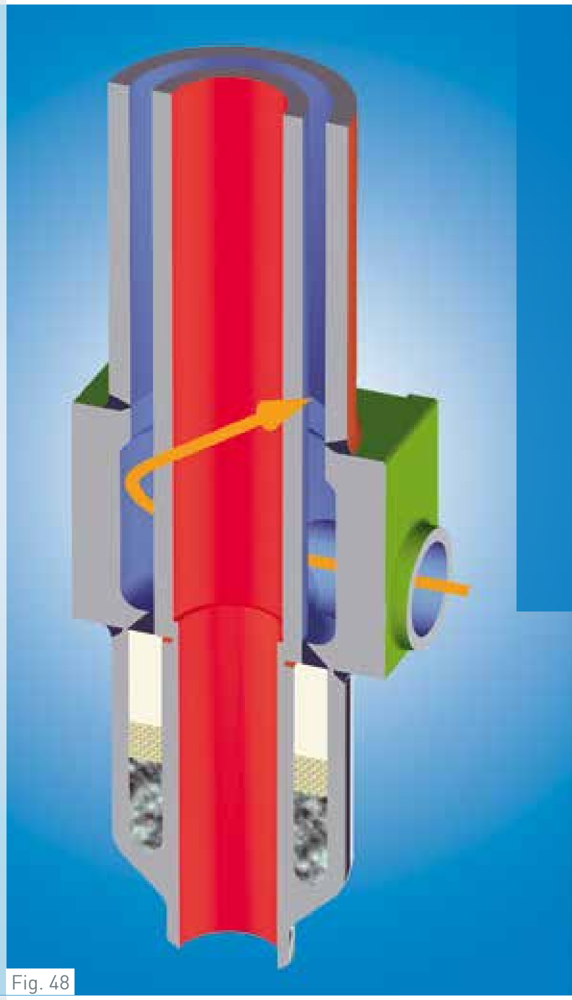


Fig. 48

The BORSIG „Turbolow“ concept

1. Double pipe
2. „Turboflow“ chamber
3. Metal sealing ring
4. Gas inlet head
5. Water inlet nozzle

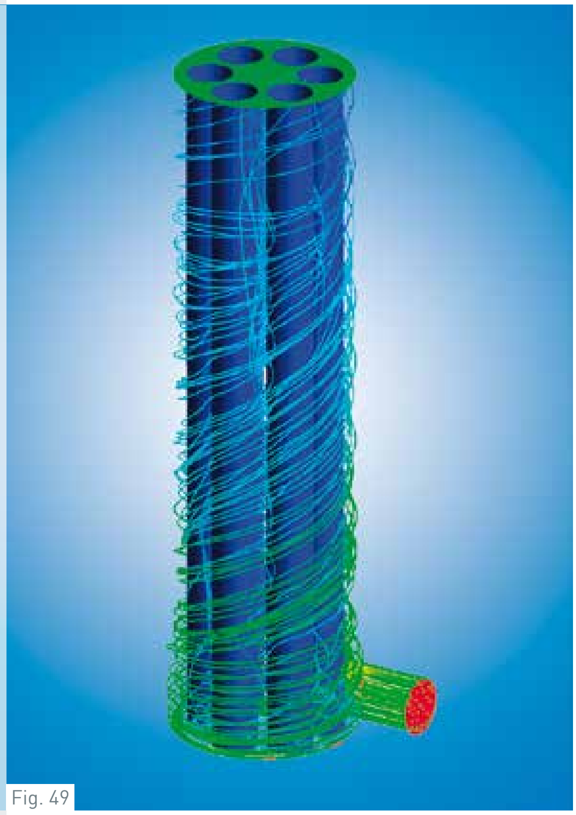


Fig. 49

layer design with regard to temperature and stress distribution because the thermal gradient along the gas inlet head is reduced more uniformly. The metal sealing ring provides the refractory with additional protection from hydrocarbon infiltration.

INDIVIDUAL EJECTION NOZZLES WITH COMMON HEADER

Unlike comparable designs that typically only have one drain for a group of water side tubes, each “Turboflow” chamber has its own solid ejection nozzle located at the lowest point of the quench system, meaning debris can easily be ejected during start-up or operation and all cleaning fluid can be removed. The nozzle can also be used as drain and to inspect the “Turboflow” chamber during routine maintenance. The individual ejection nozzles can be easily connected to a common location for blowdown purposes.

ALIGNMENT

Recesses are provided to align the individual “Turboflow” chambers and guide them in the transverse direction male/female. This ensures a ridged connection between the “Turboflow” chambers without welding.

MANUFACTURING

The water chambers are manufactured from a solid block of steel into which the circular “Turboflow” chamber is machined.

„LINEAR“ TRANSFER LINE EXCHANGERS

Fig. 51

SIZES AND DIMENSIONS - STRESS ANALYSIS

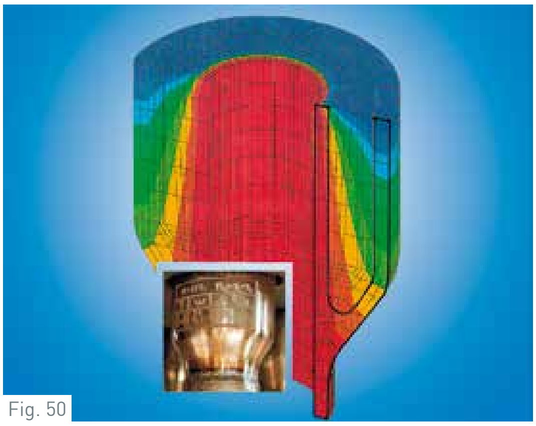


Fig. 50

Fig. 50: Gas inlet head
Fig. 51: Twin leg BLQ for gas cracking
Fig. 52: Connection of primary and secondary leg of twin leg BLQ
Fig. 53: Gas inlet and water chamber model for FEA
Fig. 54: Modulized BLQ elements
Fig. 55: „Turboflow“ chamber contour showing stress intensity

INNER PIPE

The BLQ pipe size range is practically unlimited, however, furnace engineers tend to typically choose sizes with an inside diameter of between 45 - 150 mm. A low overall drop in system pressure is strongly favoured for liquid cracking in ethylene production. To achieve this, a furnace engineer often uses small diameter radiant coils with short residence time and low pressure drop although, in the past, the choice of exchanger configuration to match this coil design was limited. The BLQ increases the choice of quench exchanger by providing each radiant coil with its own quench exchanger even if the coils are very closely grouped. With inner pipe internal diameters similar to the internal radiant coil dimensions, the BLQ can often perform with a single exchanger the heat recovery of two or more exchangers found in some furnace designs. Many furnace engineers select larger diameter coils with larger internal diameter quench exchanger pipes for gas cracking. The BLQ can also meet this requirement using a variety of orientations such as roof, side or bottom mounted locations. The BLQ can be designed with a single primary leg or primary and secondary leg combined into one unit for small or large diameter coils depending on the feedstock and furnace configuration.

LENGTH

The length of the exchanger is limited to the location of the steam drum in the furnace structure. The centreline of the steam drum must be placed above the

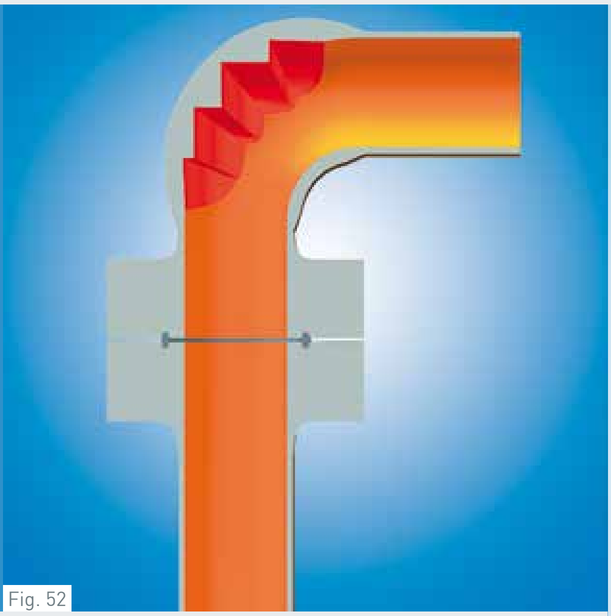


Fig. 52

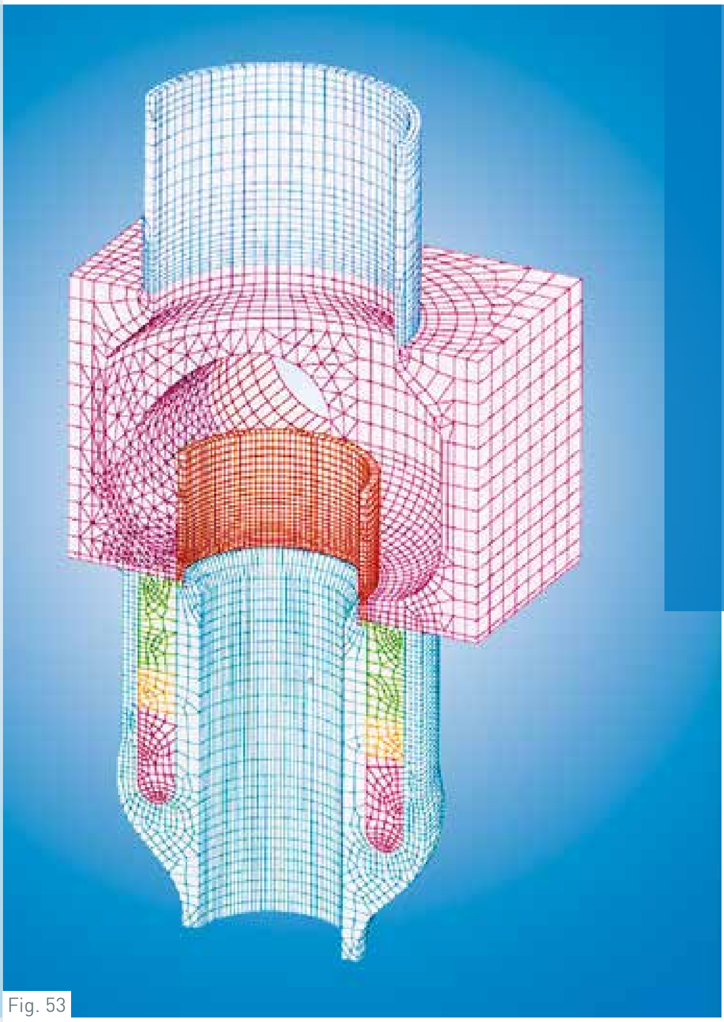


Fig. 53

top water chamber for the thermosiphon system to operate adequately. Current designs can be over 20 meters (approx. 60 feet) long although future designs could exceed this length.

EROSION RESISTANT RETURN BEND

The erosion of fittings and bends caused by coke particles is well known. In the case of U-type BLQ´s (primary and secondary leg), we provide a stepped type bend located at the end of the primary leg. We are able to supply the conventional inverted U-bend design but we recommend our stepped bend for gas cracking.

STRESS ANALYSIS

A detailed structural analysis of the “Turboflow” chamber is performed with FEA. The wall thickness of the “Turboflow” chamber provides sufficient strength and a low enough stress level to satisfy the ASME VIII, DIV. 2, Appendix 4 requirements even with large diameter pipes.

Fig. 54

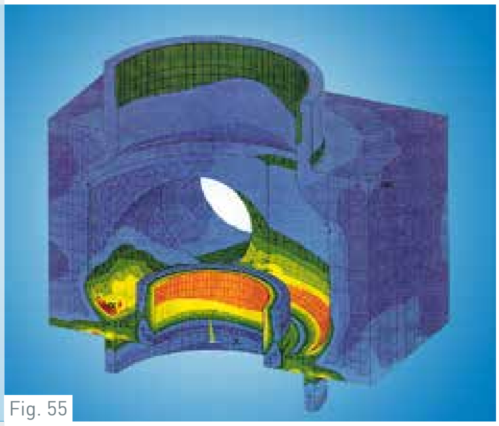


Fig. 55

„LINEAR“ TRANSFER LINE EXCHANGERS

Fig. 56

ENGINEERING AND AFTER-SALES SERVICE

Complete engineering facilities and ease of maintenance

BORSIG Process Heat Exchanger GmbH has complete in-house engineering facilities. Thermal layout and special heat transfer calculations are performed and checked with internally developed computer programs. Complex problems affecting gas flow and heat transfer are calculated using three-dimensional finite element programs (computational fluid dynamics).

Calculations of pressure vessels and heat exchangers are performed in accordance with all internationally established codes including AD, TRD, ASME, BS, Raccolta VSR, Codap, Stoomweezen, IBR, JS, Australian Standard. Critical components are subject to additional strength calculations with the finite element method, if necessary. Computers are used to calculate the flexibility, foundation loads of the interconnecting pipes and the forces acting upon them.

MAINTENANCE

The modular construction of the BLQ eases repair in case of damage. A single damaged element can easily be removed and replaced. After cutting the process and water side connections, the double pipe element can be lifted upwards and removed leaving the remaining double pipes in the furnace structure unaffected.

TRANSPORTATION TO SITE

Even the twin leg BLQ is shipped as a single prefabricated module with the downcomer, riser and gas collection header. Following a hydrostatic test, the water side of the BLQ is pressurised with nitrogen for protection during transport and installation. The BLQ is shipped on a wooden skid with hoisting lugs. A

Fig. 56: Installation of BLQ
Fig. 57: Upper end of BLQ with gas collection head and riser head
Fig. 58: BLQ system with 8 straight upflow modules serving one common steam drum
Fig. 59: Repair of BLQ

Fig. 57

removable lifting device is used for convenient transport and installation.

INSTALLATION

The module can easily be removed from its transport skid and hoisted into vertical position with two cranes and the lifting device.
Once the BLQ with its integral supports has been installed in the furnace structure, the coil outlets can be welded to the BLQ gas inlet heads. Once the steam drum has been set up, the interconnected piping between BLQ and steam drum can be installed.
The pipework is bent and prefabricated as much as possible in the workshop and only requires a few circumferential welds during the installation process.
Spring hangers are supplied if necessary.

SUPERVISION AT SITE

Experienced BORSIG supervisory engineers accompany the on-site construction and commissioning. An instruction manual covering installation, activation and maintenance is provided for each job. The water side of the entire quench system including upstream units have to be cleaned carefully prior to activation to guarantee the build-up of a homogeneous protective layer of magnetite on all water side surfaces.

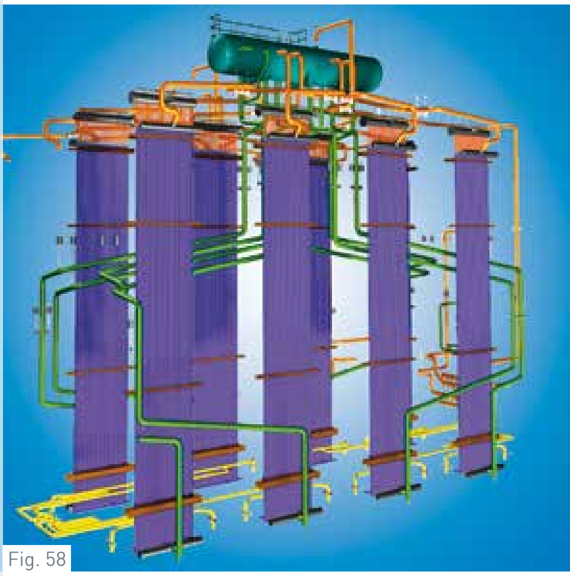


Fig. 58

Cutting process / water side connections lifting upwards

Removing of BLQ double pipe of the module

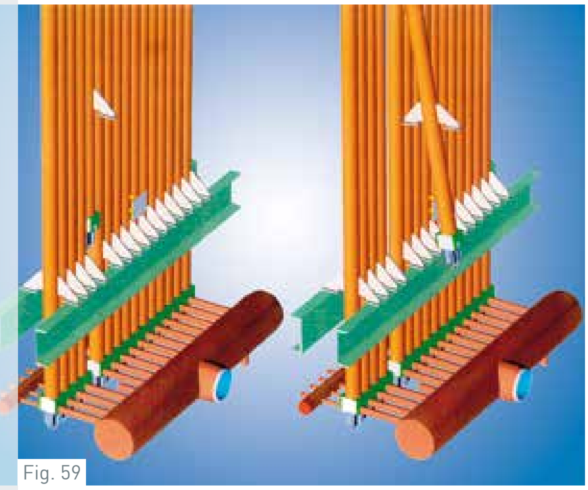


Fig. 59

„LINEAR“ TRANSFER LINE EXCHANGERS

Fig. 60

KEY FEATURES

BORSIG Process Heat Exchanger GmbH has more than 55 years of experience in the design and manufacture of transfer line exchangers.

- The close and direct coupling of a quench exchanger to each radiant coil outlet
- The elimination of wye, tri or tetra fittings in the cracking furnace
- No hot tube sheet: no fouling, no erosion
- Low volume of BLQ gas side: low residence time
- Low overall pressure drop
- Online instead of off-line decoking
- Upflow or downflow arrangement
- Single or twin leg designs
- Compact, modular design
- Individual exchangers
- No restriction in quench pipe diameter
- Three refractory gas inlet heads: no steam purge required
- “Turboflow” chamber design
- One common water and one common water/ steam header per BLQ module
- Ease of maintenance

BORSIG has supplied its “Linear“ transfer line exchangers to virtually all contractors and companies active in the construction of ethylene plants worldwide.

Fig. 60: BLQs during shipment
Fig. 61: Cracking furnace
Fig. 62: Steam drum ready for shipment
Fig. 63: Secondary transfer line exchanger / steam drum unit
Fig. 64: Installed BLQs

Fig. 61

Fig. 62

Fig. 63

Fig. 64

BORSIG

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