Regenerative Heat Exchangers

Air Preheaters & Gas-Gas Heaters
HEAT EXCHANGERS FOR A WORLD
OF ENERGY
Burmeister & Wain Energy A/S is a Danish company with many years of experience as a supplier of high-tech solutions for the power generation industry.

The company dates back to a period when Denmark’s industrial development had not yet gained momentum. The history of the company began in 1843 when a young and enterprising engineer, Hans Heinrich Baumgarten, was awarded a royal license to establish a machine shop in Copenhagen.

In 1846 he went into partnership with Carl Christian Burmeister. Baumgarten retired in 1861 and was succeeded in 1865 by William Wain, and the company Burmeister & Wain was finally founded in 1872 soon becoming the largest and most important enterprise in the iron industry of Denmark.

In 1980 Burmeister & Wain Energy A/S (BWE) was established as an independent company, and in 2002 it was acquired by the Italian company STF SpA.

The history of the regenerative heat exchangers in BWE started in 1958 when the company acquired a licence for Ljungström heaters. Fredrik Ljungström was a Swedish engineer who invented the process in 1920.

The licence agreement was in force until 1984 and when it came to an end BWE continued to develop and design the heaters as own technology and today these heaters are marketed as BWE regenerative heaters.

BWE supplied the first Air Preheater in 1961 for a 195 MWe power plant in Denmark and the first Gas-Gas Heater was supplied in 1987 for an FGD plant in Holland.

Up to now BWE has supplied more than 135 units successfully and has an extensive experience with the technology.
Vision

- To remain a leading supplier of boiler and environmental technology through technology supply and engineering services to national and international clients.

- To be a significant international player in the upgrading of existing boilers for higher efficiencies, lower emissions or for conversion to alternative fuels.

- To be a significant European player providing services and maintenance to utilities directly or through alliances.

……... this to ensure and enjoy a better future

BWE benefits from being part of the history of power generation in Denmark

Since the energy crisis of the early 70’s, Danish power industry has been focusing on the environment, fuel flexibility and efficiency.

The collaboration of BWE with local utilities has allowed our company to acquire direct experience with different fuels, biomass combustion, co-combustion, high efficiency and load flexibility.

BWE exports the Danish example in power generation to the worldwide market.

Advanced Clean Technology in Boiler Design

- Fossil fuels and especially coal will be the main energy source to cover the increased demand for power generation for many years to come in a growing world.

- The BWE Advanced Clean Technology in boiler design is an important factor in meeting the world’s CO₂ reduction target.

- By introducing the best available technology both in new power plants and when retrofitting existing, the plant efficiency is increased and consequently the CO₂ emissions are reduced.

- The BWE Ultra Super Critical Flex Boiler is a solution to utilize fossil and biomass fuels in USC boilers maximizing efficiency, fuel flexibility and use of renewables.

- The first step to make Carbon Capture and Storage (CCS) viable is to maximize efficiency.

- The BWE USC Flex boiler and its high efficiency makes the subsequent implementation of the CCS technology feasible.
Regenerative heat exchangers of own design

The regenerative heat exchanger was first used as an Air Preheater in steam boiler plants, where combustion air was heated up by the hot flue gases.

Since 1976 this type of heaters has also been applied in Flue Gas Desulphurization (FGD) and Tail-end Selective Catalytic Reduction (SCR) plants as Gas-Gas Heaters for exchange of heat between untreated and treated flue gases.

The working principle of a regenerative heat exchanger is a slowly rotating rotor filled with heating elements which transfer heat between two or more gas flows. The hot gas flow to be cooled down has to be in counter flow with the cold gas flow to be heated up.

Rotor diameters range from 5 to 25 meters and the heaviest rotor weighs more than 1600 tons.

Typical temperature profiles for an Air Preheater (APH) and a Gas-Gas Heater (GGH) for a FGD application are shown in the figure.
for new plants and for rehabilitation of existing plants

BWE has developed and designed both Air Preheaters and Gas-Gas Heaters as a proprietary technology since 1984.

- BWE designs and builds Air Preheaters and Gas-Gas Heaters to minimize the leakage and maximize the thermal efficiency.
- BWE’s design calculations for Air Preheaters and Gas-Gas Heaters are impressively precise. BWE is able to design the machines in such a way that the performance corresponds exactly to the calculations.
- BWE’s proven measures regarding improved efficiencies can almost always be built into existing Air Preheaters & Gas-Gas Heaters.
- BWE’s Air Preheaters and Gas-Gas Heaters are simple in their structures and therefore extremely easy to service.
- BWE’s Gas-Gas Heaters are easy to protect against corrosion due to their simple structure and due to corrosion protection being incorporated in the design.
Air Preheaters

Air Preheaters (APH) are important components in modern power stations. By preheating the combustion air with the hot flue gases leaving the boiler, a considerable increase in efficiency is obtained.

The type of Air Preheater totally dominating the market is the regenerative type, first and foremost because it is extremely efficient which results in reduced space requirements and a favourable price.

Furthermore, the design of the BWE APH satisfies the requirements of:

- a reduced need of maintenance
- longer operational periods between major overhauls
- the need of operating in connection with flue gas cleaning equipment such as high dust SCR (Selective Catalytic Reduction) plants
- high heat transfer rates
- small pressure drop
- reduced fouling
- ease of cleaning
The regenerative Air Preheaters are designed in three different types depending on whether both primary air and secondary air are preheated in the same heater or in secondary heaters.

**Bi-Sector Type**
Used in gas and oil fired boilers, and in coal fired boilers as separate preheaters for the primary and the secondary air.

**Tri-Sector Type**
Divided into three sections, one for the flue gas, one for the primary air and one for the secondary air.

**Quad-Sector Type**
A further development of the Tri-sector type. The secondary air section is divided into two sections embracing the primary air section. The advantages of the quad-sector type compared to the other types:

- Reduced leakage: increased boiler efficiency
- Simpler duct design
- Reduced need of space
- Less maintenance due to fewer components
- Increased operating reliability
Gas-Gas Heaters

Today power generation with fossil fuels requires installation of flue gas cleaning systems such as electrostatic precipitators for removal of dust, desulphurisation plants (FGD) for removal of SO₂ and deNOx plants (SCR) for removal of NOx.

In these processes the most energy economical way to create the heat transfer is to let the two flue gas flows exchange heat directly from the hot flow to the cold one. The most efficient equipment in terms of the heat transfer area required and hence also cost-wise the most favourable solution is the rotating regenerative type of Gas-Gas Heater (GGH).

The BWE Gas-Gas Heater

The BWE Gas-Gas Heater type operates on the counter flow principle and is similar to the well known rotating regenerative Air Preheater type, but is designed with special consideration to the conditions prevailing in a gas cleaning plant.

Corrosion Resistance

In most GGH applications, the risk of condensation and corrosion is much greater than in a typical Air Preheater. The GGH operates at lower temperatures than the Air Preheater. This means that the GGH is exposed to fly ash and acid condensing on the untreated side and to a combination of water droplets (often with a high chlorine content), unreacted limestone and the remaining SO₂/SO₃ on the clean gas side.

To withstand corrosion, the BWE Gas-Gas Heater is designed with the application of many special materials:
- the rotor is manufactured of Corten-steel
- the heating elements are made of enamelled steel
- the housing, cold ducts and sealing plates are lined with flake-glass coating or high-alloy wall papering.
BWE can offer to modernize and improve the performance of existing heaters regardless of make.

The work can comprise:

- installation of new improved sealing systems
- modification of existing air heaters for SCR application
- new cleaning systems
- delivery of new heating surface in mild or corten steel or with vitreous enamel coating
- general repair and maintenance work

Advantages:

- Higher Efficiency
- Lower maintenance costs
- Larger ROI
- Implementation of improved sealing system
- Renovation of rotor grate and casing
- Improvement of design and supply of new heating elements
- Modernization of soot blowers
- Performance tests
- Service at site
The APH and GGH can be equipped with various sealing systems in order to minimize the leakage of air to the flue gas in an APH or untreated flue gas to treated flue gas in a GGH:

- Radial Sealing System
- Axial Sealing System
- Circumferential Sealing System
- Shaft Sealing System
- Leakage Minimizing System (GGH)

The Radial Sealing System is the primary sealing system in regenerative heaters. It prevents the direct leakage from the gas side at highest pressure to the gas side at lowest gas pressure. BWE has developed a highly efficient sealing system for the radial sector seal plates to minimize the leakage between the gas flows.

In GGH’s the direct leakage can almost be eliminated by installing a special leakage minimizing system which comprises a small fan supplying pressurized treated gas to the space between the rotor and the radial seal plates. In this way the untreated gas is prevented from passing to the untreated gas side. In addition the untreated gas contained within the rotor sections between the radial seal plates is purged out of the rotor into the untreated gas duct. With such a system it is possible to obtain leakage levels of less than 0.5%.
Active leakage control

The shape of the rotor changes from cold to hot condition due to the temperature difference between the hot upper part of the rotor and the cold bottom part. In order to retain a fixed minimum gap between the sector seal plate and the rotor, the sector seal plates must be adjusted according to the actual shape of the rotor.

The purpose of BWE’s sensor controlled sealing system is to perform the adjustment automatically and continuously.

Being insensitive to fly ash, water, gypsum etc, a major advantage of the inductive position principle is the ability to operate in dirty environments

Measuring Sensor

Measuring sensor devices measure the distance between the sector plate and the rotor flange continuously. The sensor uses three magnetic inductive coils installed in a sensor unit. The sensing coil is an open core coil which produces a magnetic flux according to the distance between the coil and the rotor flange. The reference coil is a closed core coil for temperature compensation. The drive coil generates the magnetic field. The coils are able to work continuously at temperatures up to 420 °C.

Control Panel

The signal from the sensor is amplified and linearized in a transmitter placed inside the local control panel. The actual distance, as well as the status of the system, is shown on the screen of the panel and on the DCS of the plant. The control panel also includes a PLC which compares the gap information to a set value and if necessary an actuator will move the sealing plate in order to maintain the correct gap distance.

Installation of Active Leakage Control in existing units

By installing Active Leakage Control System in existing Air Preheaters and Gas-Gas Heaters instead of a fixed sealing system or a manually adjustable system it is possible to:

- reduce the leakage to an absolute minimum
- save power consumption for the fans
- increase the overall plant efficiency
The BWE soot blower is a multi cleaning media type with a fully retractable lance. The cleaning media are air (pressure range 6-20 bars) and water (pressure range 80-100 bars).

**Advantage of a BWE soot blower:**

- No shut down periods of main boiler unit due to soot blower malfunctions
- The lance and nozzles can be serviced/repaired/changed while the Gas Gas Heater is still in operation
- The lance and nozzles are not in contact with the aggressive and abrasive flue gas when the soot blower is in standby-mode
- No need for internal lance support structures
Equipment:

• All elements in flue gas contact are made of resistant materials, such as Hastelloy and Teflon.

• High pressure nozzles provide solid stream (0 degree spread) to secure an optimal penetration of the narrow space between the heating elements.

• The seal box is equipped with a labyrinth seal giving the lance a large freedom of movement.

• Air knife for lance deposit removal (optional).

Seal air is applied to the seal box and, to avoid clogging of nozzles, to the high pressure nozzles during low pressure cleaning and to the low pressure nozzles during high pressure cleaning.

The soot blower operates in a Go-Stop-Go mode which secures a full coverage of the rotor surface.
Heating elements

The performance of a regenerative Air Preheater or Gas-Gas heater is primarily determined by the type of heating elements installed in the rotor matrix.

**Element Types**

Various types of element surface profiles have been developed each with special properties for the many different types of applications and operational conditions.

The types of elements most commonly used are the following three types:

<table>
<thead>
<tr>
<th>Element Type</th>
<th>Properties</th>
</tr>
</thead>
</table>
| DU-Element  | - High efficiency  
              - High heat transfer coefficient  
              - Relatively small pressure drop factor  
              - Parallel notches making the element very suitable for soot blowing |
| CU-Element  | - Very efficient in relation to heat transfer, but with a relatively high pressure drop factor  
              - The Air Preheater will be lower with more surface area  
              - Specially suited for gas and oil-fired boilers |
| UNF-Element | - Easy-to-clean element  
              - Used in the cold end of the Air Preheater and in Gas-Gas heaters |

**Baskets**

The element plates are packed in baskets for easy handling. The baskets can be:

- All-wall baskets
- Frame baskets in mild steel or Corten.

For GGHs a special basket with thick end plates has been developed.
In order to optimize the function of the sealing systems and reduce the amount of steel in the structures, BWE makes use of the most advanced design tools such as 3D parametric CAD design and finite element analysis.