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Hot Water Generation Using Hybrid Tubular Plate Heat Exchangers for Heat Condensation

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Installed Hybrid tubular heat exchanger for hot water preparation in combined heat and power plants

Hot Water Generation Using Hybrid Tubular Plate Heat Exchangers for Heat Condensation

Heat exchangers are used in combined heat and power plants to prepare hot water for district heating. But which heat exchanger is best suited? The following article emphasises on a comparison of a Hybrid tubular plate heat exchanger and a tube bundle heat exchanger.

A daily newspaper recently published an article on the modernization of a North-Bavarian combined heat and power plant. It was reported that a tube bundle heat exchanger installed to function as a heat condenser for turbine exhaust steam and district heating hot water weighs 26 t, is 10 m long, measures 1.6 m in diameter and consists of 1,804 pipes. It transmits a heat output capacity of 51 MW through its heating surface of 800 m^2.

For comparison (figure 1 and table 1): A fully welded Hybrid tubular plate heat exchanger from VAU Thermotech installed in a Dutch waste incineration plant and used for generating district heating hot water has a heat output capacity of 52 MW. Its heating surface is only 382 m^2 by a weight of just 7.8 t. The question is: Why is a Hybrid tubular heat exchanger more efficient, requiring only 48% of the transfer area and 70% less material?

Tube and plate heat exchanger in one

The answer is the sandwich structure of the Hybrid tubular heat exchanger's fully welded and shaped sheet-metal elements. Consecutively placing these elements one on top of another produces a tube side and a corrugated side. This special plate geometry (figure 2) creates an optimal flow cross-section area for the condensing steam on one side (tube side) and a turbulent water flow cross section area on the other side (corrugated side). Compared to a tube bundle heat exchanger the Hybrid heat exchanger offers about three times higher specific heating surface density per cubic meter of space.

By varying the length, width and height of the stainless-steel heating-surface plate-pack different modular sizes of the Hybrid tubular plate heat exchanger can be achieved. As a result, the heat transfer area can be varied between 50 and 10,000 m^2 and the device can be designed and built based on the existing conditions (room size, pipelines, connections).

Based on design parameters the flow cross-sections of the hybrid tubular heat exchanger can be modified using the flexibly adjustable shaping depth of the shaping tools. The shaping depth has a direct influence on the pressure loss, the heat transfer and the geometry of the heat transfer surface. A choice of diameters between 5 and 10 mm on the tube side and gap widths between 4 and 8 mm on the corrugated side is available.

Although greater shaping depths reduce the heating surface density and specific heat transfer they have a beneficial effect on both cleaning and service life of the device. This is because with a sufficiently dimensioned cross-section the tube side can be easily rinsed with cleaning solutions – without dismantling the apparatus. The corrugated structure on the other hand creates turbulences that make it difficult for dissolved matter to settle.

However, the Hybrid tubular plate heat exchanger realizes higher performance and a more compact design, needs less material, reduces weight and manufacturing costs.

How the Hybrid tubular heat exchanger works as a heat condenser

Hot water generation in a Hybrid tubular plate heat exchanger occurs in crosscurrent flow (figure 3): Steam enters the inlet header from above, flows horizontally through the tube side, heats the water pumped over the corrugated side and condenses in the process.

On the tube side condensate collecting at the bottom of the vessel is forcibly guided by baffle plates to the condensate outlet nozzle via several passes. In this way a precise sub-cooling to a specific target temperature is achieved. The number of flow paths can be freely selected in the sub-cooling zone. Process condensate inlet at a higher level of pressure is likewise possible at this point.

In contrast to classic plate heat exchangers where connections are attached directly to the plate, the connections of the Hybrid are located at the welded-on inlet and outlet headers. This results in several advantages: Depending on the geometric size of the plate packs any nominal connection width can be attached, for example diameters up to DN 1,500 at the steam inlet. Special operating modes and functions also require additional connections. In vacuum operation for example,

Figure 1. True-to-scale comparison of a tube bundle heat exchanger (l.) with a Hybrid tubular plate heat exchanger (r.)

Tube bundle vs. Hybrid				Advantages of Hybrid tubular heat exchangers
Capacity	MW	51	52	1.9% more capacity
Surface	m^2	800	382	about half heating surface for the same capacity
Weight	t	26	7.8	weight savings of up to 75%
Length	m	10	2.3	approx. 1/5 of installation area
Width	m		1.3	
Height	m		3.57	
Diameter	m	1.6		
Set up area	m^2	16	2.99	
Set up space	m^3	25.6	10.67	more than 50% space savings
Set up		horizontal	vertical	more compact boiler or machine house

Table 1. Comparison of a tube bundle heat exchanger with a Hybrid tubular plate heat exchanger and its advantages

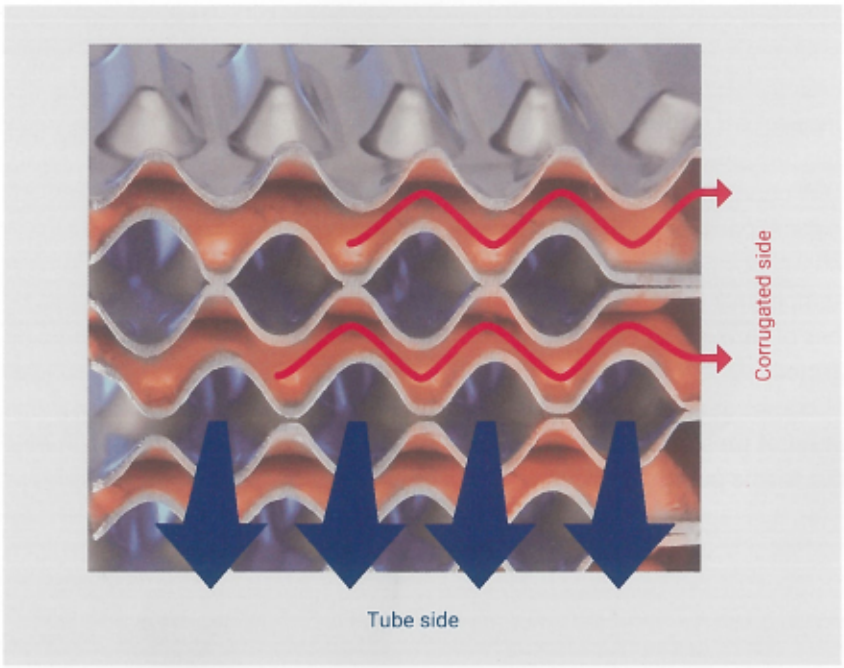
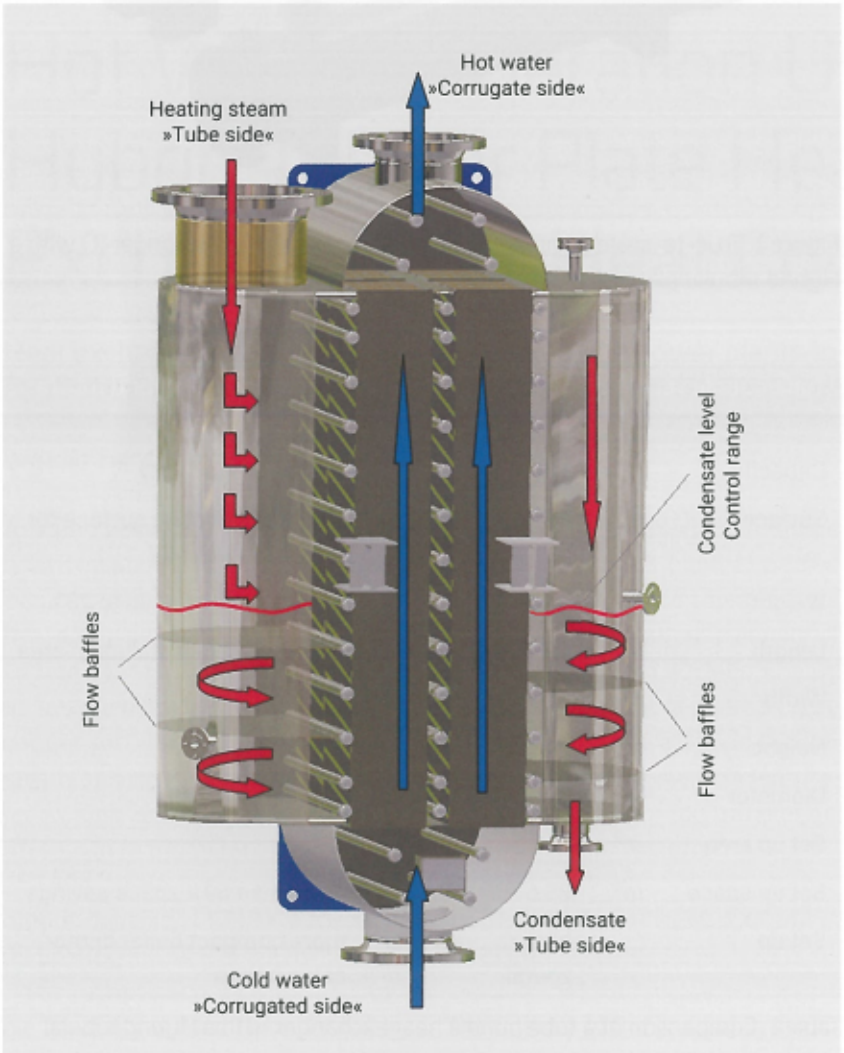


Figure 2. Special plate geometry of the Hybrid tubular heat exchanger for condensing steam on the tube side and turbulent water flow on the corrugated side



non-condensable gases have to be extracted at certain points in the apparatus. Such extraction is relatively easy to achieve with the design of the Hybrid tubular plate heat exchanger. Level indicator tubes and displays, measuring nozzles, vents, degassing or draining devices can also be flexibly installed to the vessel.

Since the Hybrid tubular plate heat exchanger can be adapted to all operating requirements – as well as the tube bundle heat exchanger – the Hybrid tubular plate heat exchanger's vessel design is much more similar to a tube bundle heat exchanger than to the usual plate heat exchanger.

Heat capacity is available as needed and infinitely variable between 0 and 100%

Hot water supply temperatures are weather-dependent. The heat capacity and hot water generation must take this into account. In contrast to a tube bundle heat exchanger heating surface usage in a Hybrid tubular heat exchanger can conveniently be controlled by minimizing or maximizing the area of the plate pack through which the steam flows. This is achieved using the "condensate level control" principle.

As the term suggests, the heating capacity is controlled via the condensate drain valve. The condensate drain valve regulates the amount of condensate drained. A reduction in the valve cross-section increases the condensate level on the tube side. This reduces the available condensation area and the transmitted capacity. If, on the other hand, a larger heating surface is required again, only the conden-

Figure 3. Section trough a Hybrid tubular plate heat exchanger as a heat condenser

sate drain valve needs to be opened and a higher heat transfer capacity is released. If the condenser has to be shut down the steam room needs to be completely flooded with condensate. Positive side effect: The condensate protects the device against corrosion (wet preservation). Incidentally, the capacity – as with all other steam-heated devices – can also be regulated via steam pressure. A corresponding steam pressure control valve carries out this function.

By the special condensate level control of VAU Hybrid tubular heat exchanger it is possible to adjust the heating capacity almost continuously between 0 and 100%. The prompt control capability come along with optimum heat transfer and high heat surface density opposite to a tube bundle heat exchanger.

A plate heat exchanger isn't just a plate heat exchanger

A steam-heated Hybrid tubular plate heat exchanger can have plate wall thicknesses starting from 0.8 mm. At first glance, the slightly higher material input when compared to a classic plate heat exchanger with a wall thickness of 0.4 mm, may appear too high. The same 0.8 mm thickness may appear too small when compared to a tube bundle heat exchanger's wall thickness of 1.2 mm.

Due to its thicker stainless-steel sheet the Hybrid tubular plate heat exchanger is more protected against abrasion caused by high velocity water drops – which arise when using moist steam under two-phase-physical-state conditions – as a regular plate heat exchanger would be. This is crucial in power plants that have to be highly fail-safe. A Hybrid guarantees a longer service life by less wear and tear.

The Hybrid tubular plate heat exchanger's fully welded plate pack is completely welded to its pressure-bearing housing (figure 4). The result: No gaskets are required, as gaskets become brittle and have to be replaced regularly.

Steam condition and steam quality must always be considered during thermal and mechanical design of a heat condenser. Non-condensable gases reduce condensation pressure. They should therefore be extracted during operation in order to prevent blockage and disfunction of the heating surface.

Both superheating of incoming steam and moist steam influence the amount of steam available as well as the mechanical strength of the processed materials. Competent design of a heat condenser therefore requires a careful recalculation of the various capacities and design values, minimum and maximum depending on operating pressures required. Thus, mechanical loads on all components are predictable, which occur as a result of flow velocities, pressure conditions, steam conditions, and thermal stresses.

Conclusion for modern power plants

For nearly 30 years fully welded Hybrid tubular heat exchangers have actively been working without malfunction as heat condensers. They are to be found in power plants, combined heat and power plants as well as waste incineration plants. Fully welded Hybrid tubular plate heat exchangers have achieved a service life same as the classic tube bundle heat exchanger.

Examples of Hybrid tubular plate heat exchangers successfully applied as heat condensers for several decades can be found in Germany in the combined heat and power plants of Wärme Hamburg and Stadtwerke Augsburg. Both companies are currently replacing their still operational Hybrid tubular plate heat exchangers with new ones just increasing the heat capacity.

Figure 4. Pressure test preparation of a Hybrid tubular heat condenser in the production hall

Hybrid tubular plate heat exchangers are economic, flexible in design, have low weight and offer high heat capacity at less space. They are characterized in operation by their ease of maintenance, fatigue resistance, efficiency, and flexible adaptation to different requirements.

Due to their long service life they ensure safe and continuous availability in district heating hot water generation. A power plant expansion or re-planning using a Hybrid tubular plate heat exchanger will increase overall efficiency, economy and variable utilization of the entire facility.

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