EMbaffle® Technology – A Major Advance in Heat Exchanger Technology

a report by
Stuart D Oakley[1] *and* **Eric van der Zijden**[2]
1. Chief Executive; 2. Technical Manager, EMbaffle BV

Of all shell and tube heat exchangers used throughout industry, the vast majority are still of the segmental baffled type – a design that has stood the test of time over the decades, but that is now being gradually superseded by a new tube support method that offers considerable advantages over the old ways. Over the years, alternative designs have been introduced to overcome some of the shortcomings of the segmental design, most of which were brought onto the market some 25 years ago. These included the development of twisted-tube, helix and rod-baffle heat exchangers, but each addressed only some of the limitations of the segmental design. With the recent introduction of EMbaffle® technology, things are now about to change.

Process industries in all market sectors are under pressure to reduce energy use, limit greenhouse gas emissions and cut costs. An innovative heat-exchanger technology developed in The Netherlands by Shell Global Solutions International BV is now available on the market that addresses these issues, as well as offering significant improvements in unit operating performance and efficiency. Known as EMbaffle, this new heat-transfer-enhancing technology is an expanded metal baffle that is now being marketed worldwide through EMbaffle BV, a company established in The Netherlands in 2007, with its head office in Amsterdam and regional offices in Houston and Calgary. EMbaffle BV promotes its technology through an international network of manufacturing licensees, as well as offering heat transfer enhancement solutions directly to the market itself.

A significant population of shell and tube heat exchangers incorporating EMbaffle technology already exists, with units operating on refineries and petrochemical plants in Europe, the US and South-East Asia across a range of applications. A really exciting development for EMbaffle BV is the recent securing of two contracts to provide oil/molten salt heat exchangers for the new generation of concentrated solar power stations being built in Spain as part of that country's major initiative in renewable energy. It is the ambition of the company for EMbaffle to become the technology of choice among end-users and engineering contractors as they seek to reduce capital and operating costs, as well as to derive material benefits from saving on energy and emissions.

Heat Transfer Performance Enhancement

So, what exactly is an expanded metal baffle and how does it deliver such a significant heat transfer performance enhancement over conventional designs? This new shell and tube heat exchanger technology is based on supporting the tubes in the shell with baffles with an open structure, allowing the shell-side fluid to flow through the baffles parallel to the tubes. Although longitudinal flow as such is not new, this type of baffle, together with its shape and engineered profile, results in specific flow characteristics that in many applications lead to optimised heat transfer efficiency.

With this new EMbaffle technology, the shell-side fluid flows axially along the tubes, but in the vicinity of the baffles the flow area is reduced. This creates local turbulence in the flow while breaking up the boundary layer over the tubes. The shape of the grid induces a local cross-flow component on top of the longitudinal flow pattern, which together improve the heat transfer characteristics at the surface of the tubes. The break-up of the boundary layer occurs repeatedly at each expanded metal baffle along the length of the heat exchanger, resulting in lower hydraulic resistance while maintaining higher heat transfer. Pressure loss is effectively converted into improved heat transfer and, compared with the segmental baffle, heat transfer at the same fluid velocity is significantly higher.

As a direct consequence of the longitudinal flow on the shell side, tube vibration in an EMbaffle heat exchanger is effectively eliminated, significantly reducing the risk of mechanical damage. This absence of cross-flow-induced vibration enables considerable flexibility in EMbaffle heat exchanger design. For instance, if the particular application demands a low pressure loss, the baffle spacing can simply be increased without the risk of introducing tube vibration, although in general EMbaffle spacing is shorter than in a conventional exchanger.

The longitudinal direction of the shell-side liquid in EMbaffle heat exchangers approaches pure counter-current flow; as a result, they can handle lower approach temperatures between the shell-side and tube-side fluid, or deliver higher duty at the same approach temperature.

Application of EMbaffle Technology

Initially developed as a potential solution for fouling services, EMbaffle technology has been proved in a wide range in applications from liquid/liquid and gas/gas to condensing and boiling. In fouling services, for instance in crude pre-heat trains, the dead zones typically found with conventional segmental designs reduce the performance of the heat exchanger with an increasing pressure drop during operation. However, with EMbaffle, due to the longitudinal flow no dead zones are created behind the EMbaffle, and in-service thermal performance has been shown to improve by more than 50%. This performance enhancement can be translated directly into elevated approach temperatures to the furnace, resulting in significant energy savings, a reduction in CO_2 and NO_X emissions and a payback period of less than six months for new heat exchanger or retrofit bundle deployment. In addition, by significantly extending operational run times of production units between cleaning as a direct result of reduced fouling, maintenance schedules can be optimised, reducing downtime, increasing throughput and

reducing operating costs. EMbaffle BV already has a number of references in Europe and South-East Asia for this application, with more retrofit bundles currently under fabrication.

EMbaffle technology also offers considerable benefits in gas/gas applications where minimising pressure loss is essential to avoid large designs. Often the segmental design demands the more expensive no-tubes-in-window solution to avoid a potential tube vibration problem. In contrast, using an EMbaffle solution significantly reduces pressure loss while still allowing a close approach temperature by increasing the baffle spacing. It eliminates vibration by virtue of all tubes being fully supported on every baffle and significantly reduces surface area and thereby weight, footprint and, of course, capital cost as a result of more efficient heat transfer. A number of EMbaffle heat exchangers in gas/gas service are already installed and in operation in The Netherlands and Syria, with more under construction for installation during 2010.

A seawater-cooled gas application is a typical example of where conventional segmental baffle design does not lend itself to achieving pure counter-current flow, as multiple tube passes are often required to achieve sufficient tube-side water velocity and the low shell-side pressure drop becomes the governing design parameter. The characteristics of EMbaffle technology allow a multipass shell design that facilitates pure counter-current flow, which offers distinct advantages in this type of cooling application, particularly as very low approach temperatures are involved, which cannot always be achieved with other technology.

In comparing EMbaffle technology against conventional designs for applications on, for example, floating production, storage and offloading vessels – in particular in the gas compression modules where these water-cooled gas coolers are typically used – it has been shown that weight savings of up to 35% can be achieved, with a commensurate reduction in plot space. Coupled with this are further reductions in capital investment costs, which could be as much as 2% on the complete gas compression module, together with lower power consumption in the compressor due to the lower shell-side pressure drop. In certain cases, this could even result in smaller compressors being used. Other applications where EMbaffle technology offers clear advantages are in overhead condensers, where high shell-side velocities enable the condensing fluid to remain in shear flow for longer, feed effluent exchangers and diluted bitumen and other heavy fouling services in the oilsands sector.

In the renewables sector, specifically in concentrated solar power applications using solar trough technology, EMbaffle BV has already achieved a number of major successes, in particular for the thermal energy storage systems (TESS) where the number of oil/molten salt heat exchangers required has been halved from six to three on a typical 50MWe power plant. Although individually larger than the conventional units they replaced, the use of EMbaffle heat exchangers dramatically lowers the installed capital cost of a TESS by dramatically reducing loadings, support structures and foundations as well as piping, valves and associated insulation and heat tracing systems. In addition, the smaller volumes of the

more efficient heat exchangers offer further cost savings from the use of less heat transfer fluid (thermal oil) and molten salt.

Thermal Design

For several years, the thermal design parameters for EMbaffle technology have been embedded in the industry standard HTRI XChanger™ software suite, enabling licensees and users to carry out their own thermal engineering designs. Single-phase and condensing methods have been available in the current Xist 5 package for a number of years and will shortly be completed with the addition of boiling methods in the upcoming Xist 6 release. A complete range of standard and customised grid designs is available for all conventional tube sizes and most applications. Baffles are available in most sizes and materials from carbon steel, stainless, duplex and super-duplex steels, high-nickel alloys and copper alloys, including bronze, brass and cupro-nickels. EMbaffle utilises TEMA tolerances and, being a tube support system only, has the same pressure parts as conventional segmental designs. It is compliant with all relevant international standards.

Business Model

EMbaffle BV was established in March 2007 in The Netherlands and now has offices in Amsterdam, Houston and Calgary. It promotes its technology through a growing list of licensed international fabricators around the world including the UK and Europe, the US, India and South-East Asia. In addition, EMbaffle BV and its subsidiaries offer enhanced heat transfer solutions for small and large specialist applications, where their experience and specialist knowledge will complement that of their end-user clients and intermediary engineering contractors.

Conclusion

After many years of incremental design changes, an innovative shell and tube heat exchanger technology is now available, offering a quantum step forward in thermal performance. This patented EMbaffle technology has opened the way to achieving cost-effective, high-performance enhanced heat transfer solutions that offer significant benefits for many applications compared with conventional designs, including:

- lower shell-side pressure drop;
- no flow-induced vibration;
- reduced fouling rates;
- improved heat transfer;
- hybrid solutions for particular applications and services;
- reduced weight of heat exchanger unit;
- compact heat exchanger design;
- significant unit and installed cost savings;
- energy savings;
- CO_2 and NO_X emissions reduction; and
- tax benefits (in The Netherlands only at this time). ■

Additional information is available at www.embaffle.com