GEA PHE Systems plate heat exchangers in the sugar industry

Heat exchangers are used in many areas of a sugar factory, from the raw-juice through to sugar drying and from flume water to the oil cooler. Plate heat exchangers (PHE) are used in most cases nowadays.

1. Shell-and-tube, spiral-, or plate heat exchangers for unfiltered media.

Up to 20 years ago the sugar industry used almost exclusively shell-and-tube type heat exchangers that were good for heating with vapours, but less suited for heating with condensate or falling water. Spiral heat exchangers were therefore more suited due to the precise counterflow. The plate heat exchangers (PHEs, Fig. 1) used in the first applications in the sugar industry were the classic version with very narrow gaps between the plates and with many supporting points. The later generation of PHEs, the so-called free flow heat exchangers, have wider gaps between the plates and are therefore less susceptible to scaling and deposits (Fig. 2). In 1984 the first large-size Free Flow plate heat exchanger, the FA 184, was developed by GEA Ecoflex for the sugar industry, and in 1992 the well established FA 192 model followed that was finished just in time for the new sugar factories in Könnern, Zeitz and Klein Wanzleben.

The main advantage of PHEs was that plates with different design features (e.g. corrugations) were developed so that with the relevant experience the suitable plate can be selected for just about every heating and evaporation process. Optimum plate profiling and plate gaps tailored to suit the specific application and the correct design resulted in the highest heat transfer coefficients (K-values) with plate heat exchangers and plate evaporators and therefore in the smallest specific heating areas with resulting reduction in investment costs. This is also due to the compact design with low operating weight, i.e. lower installation costs and lower juice volume.

Thanks to the compact design with small external surfaces made up only of the frame plate and the gaskets, there is generally no need for any thermal insulation. The low juice volume is also of advantage in emptying and chemical cleaning of the unit, as only a correspondingly smaller amount of flushing and cleaning solution is needed. Furthermore heating surfaces of the PHEs can be increased easily by installing a greater number of plates, so that changes can be made to suit just about any operating conditions.

Heat exchangers K-values also depend on flow velocity, turbulence and self-cleaning effect. Increasing K-values also naturally cause increasing pressure drop. This is why it is of great advantage that the PHE can be adapted to suit the changed conditions not only in respect of the heating surface but also with regard to pressure drop and K-value. All other heat exchanger types are less flexible and allow optimum design for only one specific application and flow rate.

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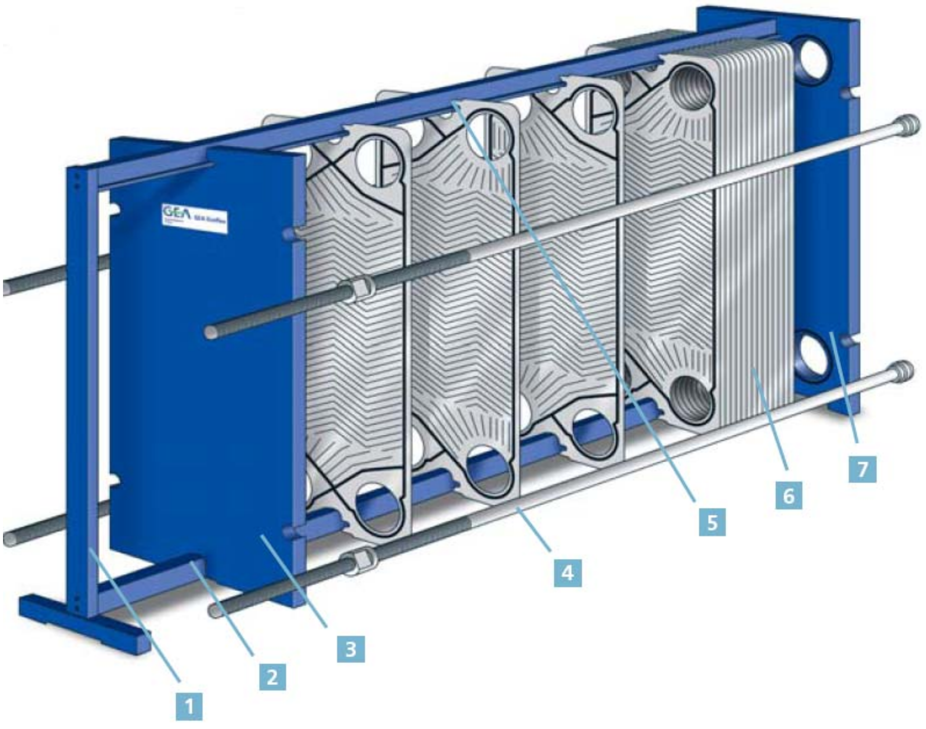

Fig. 1: Elements of a GEA PHE Systems plate heat exchanger:

1 Support beam
2 Guiding bar
3 Loose plate
4 Tightening bolt
5 Carrying beam
6 Heat exchanger plates
7 Fixed plate

When heating using vapours from evaporation crystallization however, Free Flow heat exchangers with their maximum steam connection of DN 350 reach their limits. Factories with a high daily capacity, where you don't want to have two or more free flow heat exchangers installed in parallel, they need a specially designed shell-and-tube heat exchanger for raw juice. But this type is however very large and very expensive. The heat exchanger heated with the vapours from evaporation crystallization for heating the raw juice also has the disadvantage that it is installed at the height level of the evaporation crystallization and the raw juice has to be pumped to that level. The length of the juice line is also unfavourable from a microbiological viewpoint especially with its low temperature level. This is why for raw juice heating the heat exchanger is heated using falling water instead of the vapours from evaporation crystallization and this has proved to be a good solution as there is then no need to pump the raw juice up to a heat exchanger at the height level of the vacuum pans. The falling water temperature can be increased using spray nozzles or with a two-stage condenser. Either two condensers arranged in series (Fig. 4) or a vertically arranged condenser tower can be used for this.

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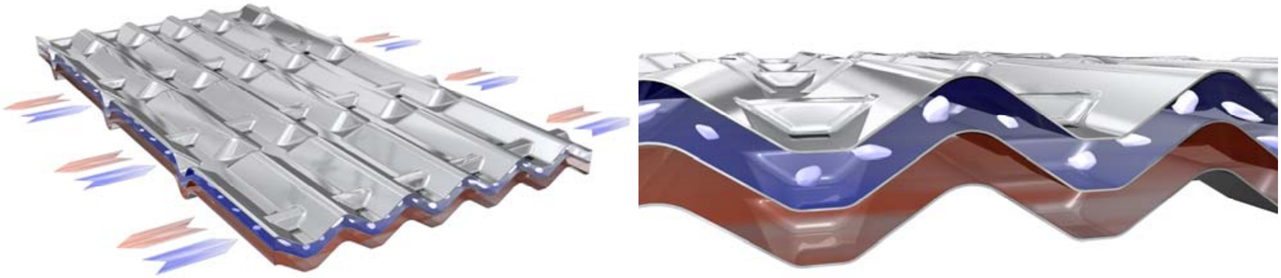

Fig. 2: Flow gap – Free flow principle of a GEA PHE Systems Free Flow PHE

Like raw juice, or juices and waste liquids containing solids cannot be heated up in the classic PHE version, but Free Flow heat exchangers have to be used as the solids block up the more effective narrower plate gaps more or less quickly. This also applies to filtrate or thin juice 1 after the 1st filtration stage: Firstly this juice is mostly not as clearly filtrated as the thin juice before the evaporation plant. Secondly the formation of deposits is often quite considerable especially in this PHE. However free flow heat exchangers are considerably more expensive than the PHEs described above due to their greater plate thickness and the lower K-value caused by the wider free flow gap. This is what makes the decision with thin juice 1 particularly difficult – depending on the quality of the 1st filtration stage and the deposit thickness – whether you should install a free flow heat exchanger or a classic plate heat exchanger with a second stand-by heat exchanger (for cleaning).

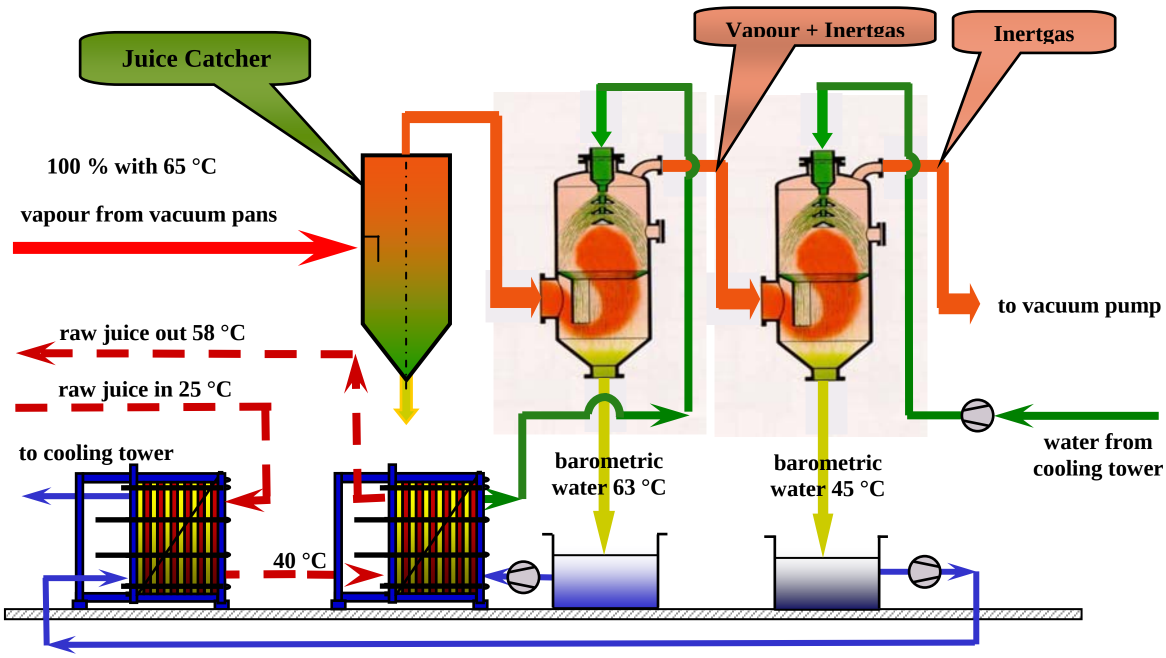

Fig. 4: Two-stage condensation

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2. The NT series for clear filtrated media

The thin juice before the evaporation plant is clearly filtrated and should not contain any rust or other solids. So the NT series of GEA PHE Systems are the right solution for its heating. The heating medium can be either normal vapours or calandria vapours. When using calandria vapours the evaporation units are best degassed and the heat of the degassing vapours is best used exergetically step-by-step. On the other hand the condensation temperature of the calandria vapours is somewhat lower so that the temperature difference between juice and vapours is around 2 K lower. Therefore the realistic and economic difference is not 1–2 K, but 3–4 K. The same applies for the heat exchanger where the heat from all degassed vapours is utilised in one unit. However in this case the condensation temperature of the mixture corresponds to that of the coldest vapour.

If the water evaporation rate in the evaporation unit is not adequate, or the waste steam pressure is too high, then the obvious choice is a low temperature difference in the heat exchangers and a waste-steam-heated thin-juice heat exchanger as the most cost-favourable option to improve the evaporation performance. This waste-steam-heated heat exchanger can also be used as a pre-evaporation unit to improve downstream evaporator performance and therefore increase the corresponding vapour temperature. To extend the life time of the gaskets in the turbine exhaust steam heated thin-juice heater the turbine exhaust steam should always be used as vapours from the 1st calandria . This is the only way to ensure that the steam is no longer overheated and the 1st effect is degassed in an optimum way.

"Normal" PHEs are generally used In the sugar house with the exception of the heat exchangers for remelt, because the run-offs have already passed through the centrifugal screen. However, crystals and other solids caused by overfilling the centrifuge or by "bottom run-offs" or so-called "sweepings" in the run-off can therefore reach the heat exchanger. In this case to be on the safe side you should always use a free flow heat exchanger (e.g. with a 5 mm free flow gap). This type has also proved its value as a heat exchanger for remelt and to improve the performance of the sugar melting station as a circulation heater. If there is no guarantee that the fine crystals have all been dissolved in the run-off, then two heat exchangers are used for run-off, with the second heat exchanger heating up the run-off using vapours to around 90° C, and the first heat exchanger setting the desired temperature using run-off against run-off.

3. Cleaning the GEA PHE Systems heat exchangers

It is still often the case, especially with Free Flow heat exchangers, that these are opened up and cleaned using high-pressure cleaners, although there are experienced companies that can examine the deposits and recommend relevant cleaning chemicals. It is often sufficient to add a small amount of Kebosol or Lithsolvent to the alkaline or acidic solution to achieve the desired cleaning effect with adequate circulation and reverse flushing, as with the juice, even if the unit has to be opened later for emptying. With clarified juice or thin juice 1 and thin juice 2 on the other hand hard deposits are formed similar to those in the evaporation plant. As in the evaporator unit these often have to be firstly disintegrated using an alkaline solution so that they can then be removed using formic acid or amidosulfonic acid. It is often sufficient for the corresponding cleaning solvent to be pumped through the heat exchangers into the evaporator units just as the thin juice.

In selecting the suitable heat exchanger attention should be paid not only to the performance data alone. Often environmental conditions and legal regulations are also of importance. This is why all boundary conditions should be considered in designing and selecting the right heat exchanger.

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