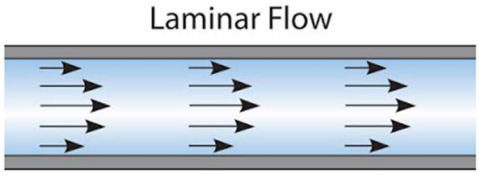
Hello,

Happy belated Chinese New Year! 2020 is the year of Metal Rat. People born on this year tend to be more reliable and live a stable life, they may hold some power and are able to turn unlucky events into fortune. This is the snack sized Chinese zodiac horoscope for you. To be honest, the main reason me and my friends throw down an annual party for this day is to just to have a party in the middle of a long drought of holidays between New Year and Easter.

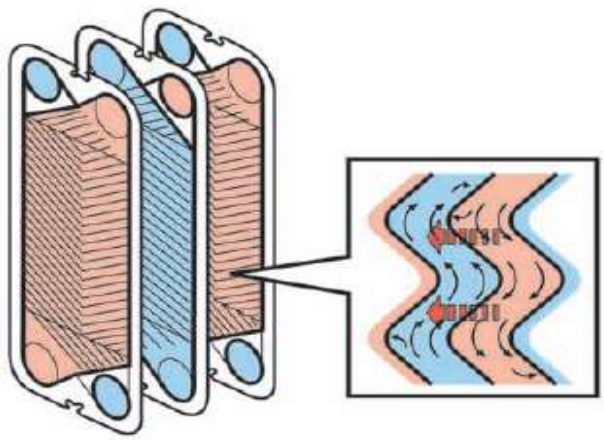
I know the title of these emails is “Learning Vacuum”, but as I’m getting more and more involved in various projects, I’m finding the heat transfer side of our expertise has a whole different world of scientific knowledge and engineering challenges that are worth sharing and learning. Maybe I’m biased, but I have say, heat exchanger knowledge has a lot more nuances than vacuum knowledge. I’ll be adding topics on various types of Alfa Laval heat exchangers to my future emails.

Besides shell-and-tube heat exchangers, plate-and-frame (PHE) units are probably the next most common heat exchangers. They would look like these below:

Just like a shell-and-tube, PHE utilizes indirect heat transfer, where the two fluids are separated by a wall. Unlike a shell-and-tube, PHE can create significantly more turbulent flow to make heat transfer more efficient. Inside the tubes of a shell-and-tube unit, flow would look like image below. This laminar flow will have low pressure drop, little mixing between inner and outer layers of fluid, therefore more heat transfer at the wall of the tube, but less efficient at the center of the flow.



The surface geometry of a PHE's plate would force the fluid to take a much more turbulent flow path, creating random mixing motion, allowing for more uniform and efficient transfer of heat between plates.



The exact sizing of a PHE, or any other heat exchanger, is governed by the same heat transfer equation:

$$\mathbf{Q = A * k * LMTD}$$

k = overall heat transfer coefficient, W / m^2,°C

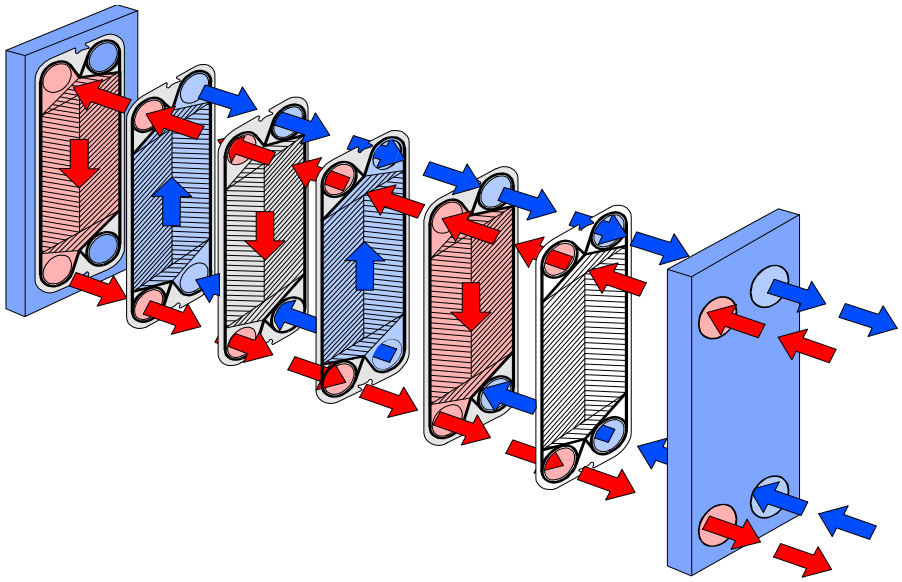
A = heat transfer surface area, m^2

LMTD = Log Mean Temperature Difference, °C

The actual calculation of this can get complex very quickly. Fluid properties, flow directions, flow turbulence, flow rate, plate thickness, material of construction, temperature profile can have significant effect on PHE design outcome. Luckily, Alfa Laval has a software program that does a lot of the heavy math for us, leaving us to focus on designing a solution to fit specific application. Below are a few quick key concepts to grasp regarding a PHE.

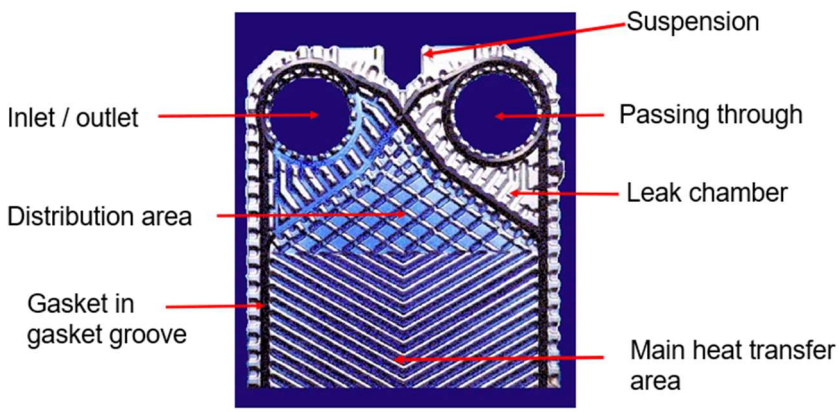
How it works.

In below illustration, hot fluid enters the top left port, flows down every other plate, then returns and exists at the bottom left port. The cold fluid enters the bottom right port, flows up every other plate as well, but offset from the plate the hot fluid flows down in, then returns and exists at the top right port. The metal plates facilitate the heat transfer between the hot and cold fluids without them mixing with each other.



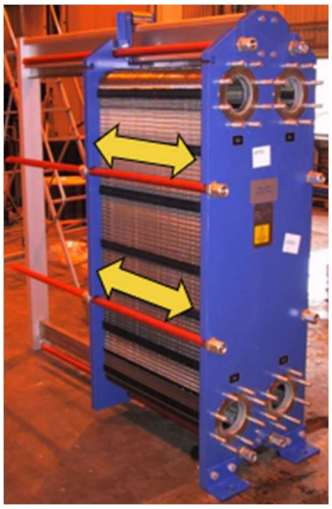
Number of plates, size of plates, pressure drop, and shear

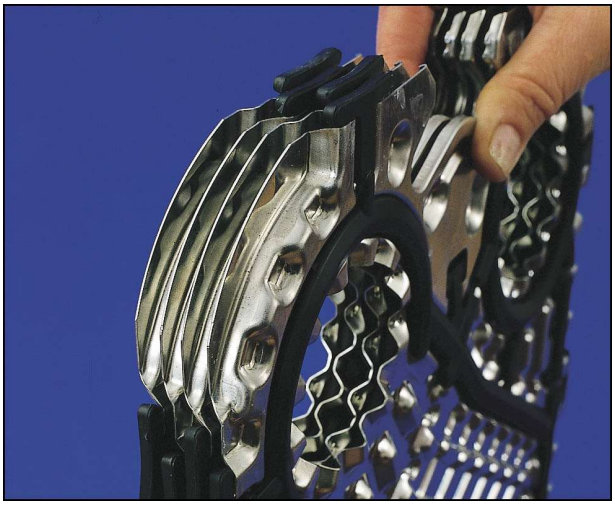
Imagine the hot side, or the cold side of a PHE as a pipe. More plates would be like large diameter of pipe, causing less pressure drop, but slower flow, therefore less shear: more potential for build-up of debris, fouling. Too few plates would result in higher pressure drop, less likelihood of fouling, but potentially not enough time for effective heat transfer. This is a very simplified way of looking at this system. Thickness of the plate, pressing depth of the plate, geometric patterns on the plate, size of the plate can all effect this balance. Below is a typical plate surface and functional zones:



The A Dimension

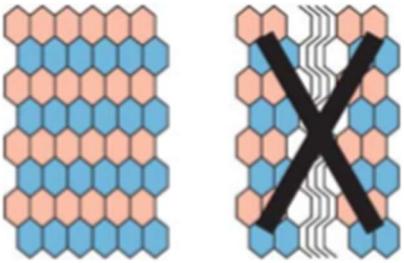
When servicing a PHE, it is crucial to not closing the unit back together via a torque value on the tightening bolts, but by the A dimension: the distance between the inside of the frame and pressure plate. See below on the left. This is because the plates are designed to be pressed together just enough to make contact to create the flow channels, the gaskets around the edge of the plate closes these channels in. See image on the right. The A dimension is set to allow just enough contact without crushing the plate.



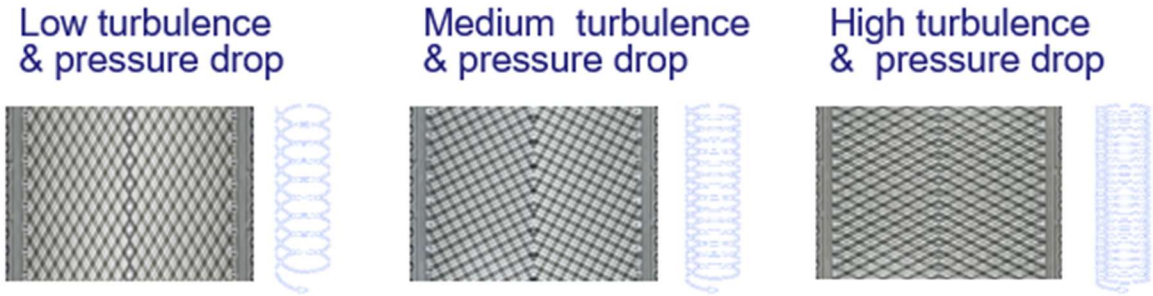


Honeycomb Pattern

PHE units can easily have over 100 plates for certain applications. Servicing these units can be a meticulous task. Especially the task of re-hanging all the plates in the correct order. One quick way to visually inspect this is checking whether the edge of the plate pack forms a “honeycomb” pattern, see picture below:



However, this does not guarantee all the plates are put back in the correct order, only that flow channels would form without leaking. Plates are designed to create low, medium, and high turbulence flows, using different surface patterns. See below.



When designing a solution, we try to take serviceability into consideration, and present options with uniform plate patterns, to make maintenance guys’ job a little easier.

I’ve been getting a lot of feedbacks on these emails, and I really appreciate folks taking the time to send me a note back, chat with me when I visit them, and even calling me. I even got invited for a couple of presentations and training sessions. I truly believe that, as a vendor it should be part of my job to educate and empower our customers by giving away value without the expectation of anything in return.

Take care!