Technical Presentation

Optimum Design of a Plate & Frame Heat Exchanger

Diversified Engineered Solutions Company

Parameters for Plate & Frame Heat Exchanger Design

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Topics of Discussion

- Parameters that define the heat transfer, pressure drop and pressure retention characteristics
- Parameters that effect the cost
- Discussions on fouling factor…a self fulfilling prophecy
- Summary of design specifications for Heat Exchangers

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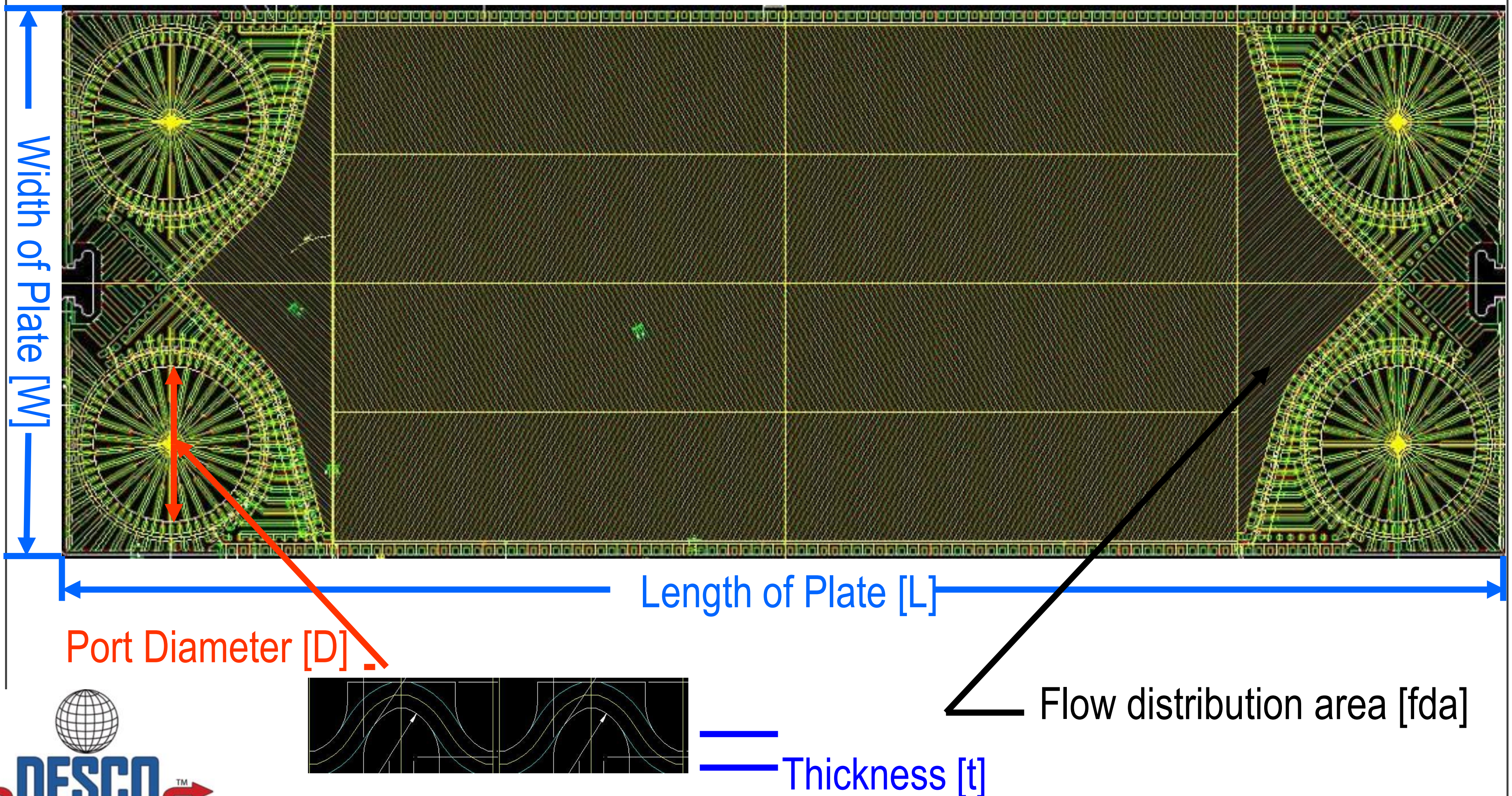
Parameters that define the pressure drop, pressure retention and heat transfer characteristics



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Parameters that effect the pressure drop, pressure retention and heat transfer characteristics *for a given flow rate*

Effect of Width [W]			
	Heat transfer coeff.	Pressure drop	Pressure retention
Larger	Lower	Lower	Lower

Effect of Port Diameter [D]			
	Heat transfer coeff.	Pressure drop	Pressure retention
Larger	No Change	Min.Lower	No Change

Effect of thickness [t]			
	Heat transfer coeff.	Pressure drop	Pressure retention
Larger	Min Lower	No Change	Higher

Effect of Length [L]			
	Heat transfer coeff.	Pressure drop	Pressure retention
Larger	No change	Higher	Lower

Effect of Flow distribution area [fda]			
	Heat transfer coeff.	Pressure drop	Pressure retention
Chevron	No change	Higher	Higher
Chocolate	No change	Lower	Lower

Heat transfer coefficient is α 1/[W] [t]

Pressure drop is α [L] / [W] [D]

Pressure retention is α [t] /[W] [L]

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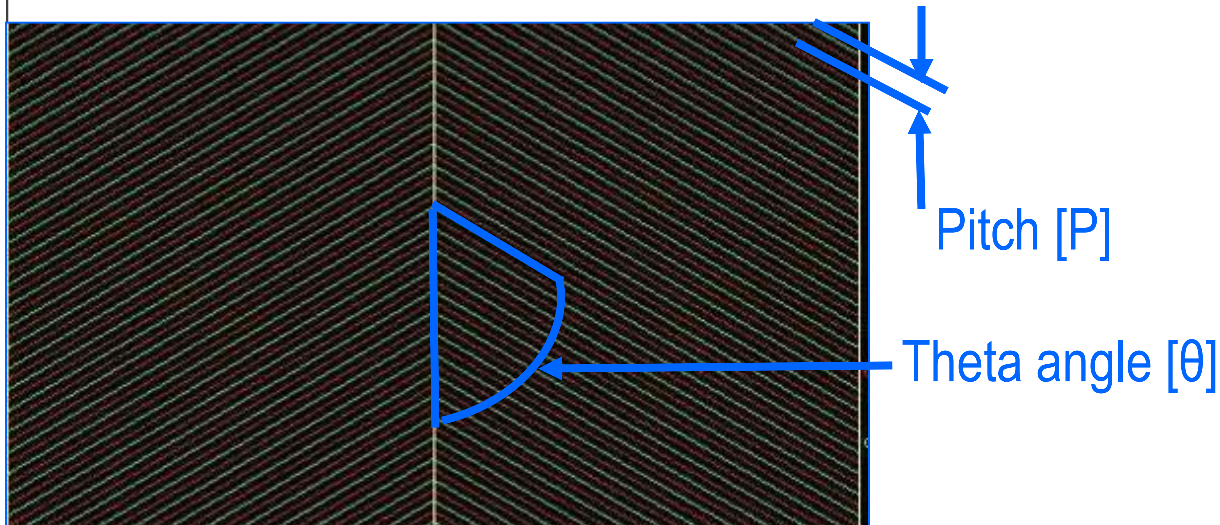
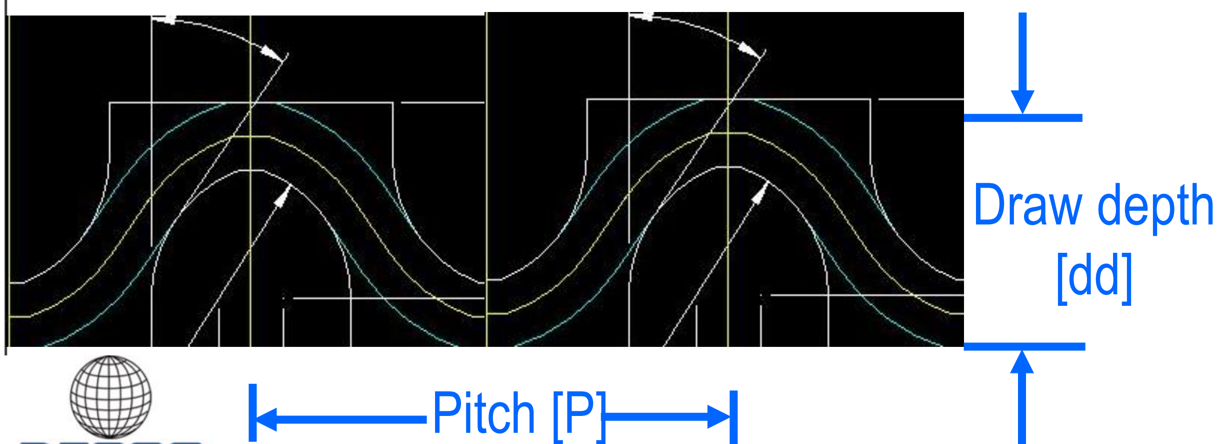
Parameters that effect the pressure drop, pressure retention and heat transfer characteristics *for a given flow rate*



Effect of Pitch [P]			
	H.T	P.D.	P.R.
Larger	Lower	Lower	Lower

Effect of Theta angle [θ]			
	H.T.	P.D.	P.R.
Larger	Higher	Higher	N.E.



Effect of Draw depth [dd]			
	H.T.	P.D.	P.R.
Larger	Lower	Lower	Lower

Heat transfer is α $\theta/[P]\ [dd]$

Pressure drop is α $[\theta]/[P]\ [dd]$

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Summary:

Parameters that define the pressure drop, pressure retention and heat transfer characteristics *for a given flow rate*

- ❑ Pressure retention is α [t] / [W] [L][P] [dd]...*also the flow distribution area design, operating temperatures and material of construction*
- ❑ Pressure drop is α [θ] [L]/ [W] [D] [P] [dd] …*also the flow distribution area design*
- ❑ Heat transfer is α [θ] / [P] [D] [W] [t] [dd]

Parameters effecting the cost of a Plate & Frame Heat Exchanger

<u>Design pressure and temperature:</u>

- Higher the pressure and temperature…..***higher the cost***
- May require thicker materials & frames, larger bolts, and more expensive gaskets

<u>Allowable Pressure drop:</u>

- Lower the allowable pressure drop…..***higher the cost***
- This will have to be balanced with operating costs

<u>Flow rates</u>: Too high of a cooling or heating flow rate, with limited pressure drop (even though helpful with the LMTD), might increase the unit size due to pressure drop limitation.

Parameters effecting the cost of a Plate & Frame Heat Exchanger

Materials of construction: Higher the material alloy, higher the cost.

Temperature approach: Closer the temperature approach, larger the unit & higher the cost.

Fouling factor: Adding a "fouling factor" will become a **"self fulfilling prophecy"** and only adds costs while increasing the possibility of fouling
(More discussions later in presentation)

Manufacturing to particular codes when it may not be necessary:

- This adds cost because special material may have to be procured.
- Could increase deliveries and limit the number of suppliers.

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Parameters effecting the cost of a Plate & Frame Heat Exchanger

<u>Utilizing a specification that has been developed by a particular vendor:</u>

The specification will be biased towards that vendor forcing the rest of the vendors not be able to give you the most cost effective units.

<u>Specifying single pass design</u>:

- required when vapor breakout is an issue.
- A multi pass design **may** be the most optimum solution, with a possible reduction in the size of the exchanger and increased velocities to minimize the fouling.

<u>Specifying parallel or diagonal flow design</u>:

Depending on the supplier, for a given set of conditions, they may have a plate that may is parallel or diagonal flow. Limiting the design may eliminate the best solution.

Parameters effecting the cost of a Plate & Frame Heat Exchanger

Specifying Glue-less gaskets:

- This type of gasket is primarily designed for the food and dairy industry where there are requirements to replace gaskets between production batches.
- Even if the PHE is opened, it should **not** be necessary to replace gaskets.
- A glued gasket can be most probably be re-used several times after opening and cleaning, whereas a glue-less gasket is more likely to have to be replaced.

Performance test requirements…especially with zero tolerances:

- Vendor's will guarantee the performance of their products, therefore performance testing is an over-kill.
- If zero tolerance testing is required, vendors will have to oversize units which will result in higher unit cost.

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Parameters effecting the cost of a Plate & Frame Heat Exchanger

Unreasonable guarantee clauses and penalties for late deliveries:

- All vendor's want to ship their units out as fast as possible so that they can invoice.
- If penalties are included as part of the project, vendors will add cost to give themselves a "safety" factor.

Manufacturing in a particular location:

- This potentially could add cost.
- This may also add freight costs and add to the lead time.

Discussions on fouling factor…”*a self fulfilling prophecy*”

- To minimize fouling in ANY heat exchanger, the highest possible turbulence should be achieved, given the constraints of pressure drop and flow rates.

- High flow rates, increase turbulence, and the “scrubbing” action will minimizes fouling.

- In a shell & tube heat exchanger, the flows achieve turbulence **only** due to velocity. Heat transfer film coefficients tend to be low and the application of a fouling factor will not lower the overall heat transfer coefficients significantly. Therefore, the result is longer tube lengths.

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Discussions on fouling factor…"*a self fulfilling prophecy*"

- Turbulent flow in a PHE is achieved by continuous change in flow direction over a very short distance resulting in very high film coefficients. By adding a fouling factor, overall heat transfer coefficients could be lowered significantly, increasing the heat transfer area required, as discussed below.

- Increased area is generally achieved by adding plates to the heat exchanger.

- Additional plates will reduce the flow rate per channel, increasing the fouling possibility. In a new and clean condition, the additional area will cause the unit to over perform. If flow control valves are used to monitor performance, they will start to close reducing flow to correct for the over performance and *further increase the possibility of fouling.*

Discussions on fouling factor…"*a self fulfilling prophecy*"

- One possibility is to increase the length of plate. This will maintain the velocity and eliminate the over performance issues of added plates. However, this will increase the pressure drop but will not eliminate the issue of potential fouling.

<u>Bottom Line:</u> ***Do not add a fouling factor.***

If you have to, it should be kept to a minimum and achieved by increasing the plate length.

Summary of Design Specifications for Plate & Frame Heat Exchangers

1) Be sure not to OVER SPECIFY the design pressures and temperatures.

2) Allow the greatest temperature approach possible.

3) Specify the maximum allowable pressure drop

4) Materials of construction should be chosen with care.

5) Flow rates for heating or cooling fluids should be stated as “maximum” and the designer should be allowed to select the correct flow rate to correspond with the allowable pressure drop. An excessively high cooling or heating flow rate, with limited pressure drop (even though helpful with the LMTD) might increase unit size due to pressure drop limitations.

Summary of Design Specifications for Plate & Frame Heat Exchangers

6) Avoid specify fouling factor. Add 10% surface area if absolutely necessary.

7) Do not ask for a specific type of gasket, e.g. glue-less or snap-in, unless you plan to replace the gaskets frequently,

8) Do not specify unit design as a single pass. Let the supplier offer the best design.

9) Do not set the type of flow pattern…parallel or diagonal. Let the heat exchanger supplier work out the best design.

10) Avoid specifying unnecessary codes.

11) Make the specification as generic are possible.