Comparative Analysis for Fluid Cooler Application:
Corrugated Plate vs Tube/Fin Heat Exchangers

Thermo-Pur engineers conducted a two phase comparison of the performance parameters of three fluid coolers for a major HVAC equipment manufacturer. The objective was to compare various parameters of the standard tube/fin heat exchanger core with a Thermo-Pur corrugated plate stainless steel heat exchanger core. The initial evaluation (**Phase 1)** compared the core size and resulting unit footprint of the existing products (**Product 1 & Product 2**). The **Phase 1** goals of the evaluation were the reduction of the **core footprint**. The results are given in Table 1.

Table 1 (Phase 1)

Core	**Product 1**	**Product 2**
Existing footprint, m^2	1200 x 1080 = 1.296	4500 x 1080 = 4.86
TPT footprint	800 x 1080 = **.864**	3800 x 980 = **3.72**
Ratio TPT/Existing footprint	**.66**	**.77**

Phase 2 was a request that we evaluate keeping the footprint the same and maximize performance. The company gave us the performance data of a 3rd product, a 2 fan unit with the company's largest heat exchanger:

Existing Parameters;

Pressure: 10 bar
Heat carrier: 35% ethylene glycol
Entering Fluid Temperature: 54 Deg C
Entering Air Temperature: 35 Deg C
Air flow: 46,870 m3/hr
Air side Resistance: 10.9 mmCE
Heat Exchanger length: 2,000 mm
Heat Exchanger width: 2,160 mm
Heat Exchanger depth: 138 mm

Fluid Flow m3/hr	**Capacity kW**	**Fluid Pressure Drop mWG**
25	196.2	0.41
45	216.0	1.15
65	224.1	2.18
85	228.5	3.48

Phase 2

In the initial estimation of this Fluid Cooler (**Variant 0**) we offered a one path cross flow core with the **same heat rejection capacity**, temperatures, air flow and air side losses. As a result, we received the core with a significantly smaller length along the air flow, mass and reduced water side losses.

Our engineers developed three alternative designs to increase heat rejection capacity:

1. **Variant 1** – to increase the heat exchanging surface by 40%. This will insure a capacity growth of 4% for minimal fluid flow and 5% for maximal fluid flow. The core length along the air flow will increase to 138 mm (equal to existing Product 3 core) and core mass will increase by 40%.

2. **Variant 2** – to apply the 3 path scheme of the core. In this variant the capacity growth will be 3% for minimal fluid flow and 4% for maximal fluid flow. The core length along the air flow will increase to 138 mm (equal to existing Product 3 core), pressure losses on the water side will increase, but the core mass will not increase relative to Variant 0.

3. **Variant 3** – to increase the air flow. Only 1.4 kW of power is necessary to move 13 m^3/sec of air through the core with fixed pressure losses of 10.9 mmCE. In our practice, we usually design heat exchangers for pressure losses on the air side of 40-60 mmCE. Product 3 has two 2.35 kW fan drives. Assuming drive and fan efficiencies are .9 and .85, we determined that the power required to moving air through the core is 3.6 kW. Using that fan power factor, in the Thermo-Pur design, the air flow will be increased 1.4 times (the air pressure losses will be 21 mmCE). The capacity growth will be 32 % for the core designed for Variant 0. If more powerful drives are installed in this fluid cooler (two drives 5 kW each) the air flow may be increased 1.8 times, and the capacity will increase 50% and air pressure losses will be 35 mmCE. All these variants are given in the following table. All cores have 2000 mm x 2169 mm front surface, 54°C entering fluid temperature and 35°C entering air temperature.

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Comparative Data

Fluid Cooler #3

Fluid Flow m3/hr	**Variant 0** Same Heat Rejection: **FC PU 06D P02 D4**		**Variant 1**		**Variant 2**		**Variant 3** N =2x2,35 кВт		**Variant 3** N = 2x5 кВт	
	Capacity **kW**	Pressure Drop mWG	Capacity **kW**	Pressure Drop mWG	Capacity **kW**	Pressure Drop mWG	Capacity **kW**	Pressure Drop mWG	Capacity **kW**	Pressure Drop mWG
25	196.2	0.21	205	0.21	205	0.41	259	0.21	294	0.21
45	216.0	0.6	225	0.6	224	1.15	285	0.6	324	0.6
65	224.1	1.17	235	1.17	233	2.18	296	1.17	336	1.17
85	228.5	1.9	240	1.9	235	3.48	302	1.9	343	1.9
Air flow, m^3/hour	46,870		46,870		46,870		65,618		84,336	
Air side pressure losses, mmCE	10.9		10.9		10.9		21		35	
Core length along air flow, mm	60		138		138		60		60	
Width	2000		2000		2000		2000		2000	
Length	2169		2169		2169		2169		2169	
Weight, kg	116		170		116		116		116	

Comparison of typical tube/fin and TPT heat exchanging surfaces:

Tube/fin surface is designed specially for heat exchange between two heat carriers with significantly different heat transfer properties – usually water with excellent properties and air with bad properties. To balance the heat resistance for both sides a plain tube (bad surface) is used from the water side and a highly developed fin surface (excellent surface) is used from the air side. In other words, the heat flow is limited from both sides (air and water) – they are in balance.

This allows us to build a very efficient heat exchanger even with a one path cross flow scheme – we see that the typical fluid cooler has an efficiency of up to 80%. This means that almost all cooling capacity of the air flow is already used and the further growth of heat rejection capacity does not depend on the heat transfer properties of the surface.

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You can see this on examples of Variants 1 and 2. Our excellent TPT surface (one of the best heat transfer surfaces) allows us to increase the heat rejection capacity under the same operating conditions and volume only in the 3-5% range.

At the same time this “balanced” heat transfer surface evidently has some disadvantages. The heat transfer properties on the water side depend on water velocity, therefore, NYSE Company should change the tube arrangement (schemes A,B, so on) and the space between the fins in order to change the water flow in a wide range. This is called “flexibility”. Also the increase of air flow (and air side losses) would demand the increase of heat flow from the water side and water velocity growth.

The TPT cross corrugated surface is universal - it has excellent heat transfer properties from both sides. The heat transfer on the water side is “over-sized,” therefore, water velocity may be changed in a wide range without reducing the heat rejection capacity. In other words, the heat rejection is always limited by the air side in the TPT core. This will insure “flexibility”.

In the typical core the air pressure losses are balanced with the heat supplied by water in the plain tubes. Therefore, these air side losses are small. In the case of the increase of air flow and air side losses NYSE Company should increase the heat flow from the water side also – this means that they would increase the water velocity, which is already too high. Therefore, the tube/fin scheme would most probably not allow increased air flow.

The TPT scheme has reserves for increasing heat flow on the water side due to the excellent heat transfer properties of the cross corrugated surface without the significant growth of water velocity. Therefore, the TPT core allows us to increase the air flow and air side losses (and total heat rejection capacity) versus the NYSE Company core that would most probably not allow increased air flow.