The role Air Source Heat Exchangers play is vital in the cooling of Data Centres

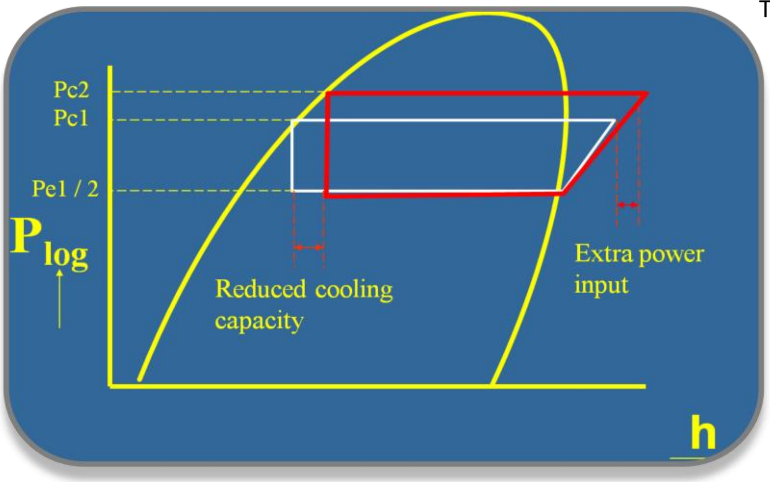
Since several years we are experiencing an increasing interest in the energy consumption of data centres. The increasing power hungry servers produce more heat. More powerful and advanced cooling technology is required to remove the heat and allow the servers to operate at optimal conditions.

Next to the direct power consumption of the servers the indirect power consumption of the cooling installation plays a key role in energy efficient data centres. This has initiated research and the market introduction of new technologies. Some of these developments focus on the process inside the data centre from which the heat must be removed , others focus on the equipment outside the data centres that is essential for releasing the heat to the environment. Together these developments should result in a well designed and easy to maintain cooling system that will only constitute a small part of the energy consumption of the total data centre.

It is clear that operational costs will exceed the initial investments by far on the long term. Yet a big part of the operational costs are fixed by choices made in the initial investment process. The choices made in the design phase of data centre cooling equipment, will not only affect the initial efficiency and power consumption but it may have a major impact on these parameters in the future.

A good example of this is the choice of the type and material of the heat exchangers that are used in most installations. In the process industry or power plants heat exchangers are considered key elements for optimal process efficiency. Loss of heat transfer in these elements affects the efficiency of the whole installation and is therefore carefully monitored and corrected if necessary. In data centre design and operation the focus on these heat exchangers seems to be less than in other industries.

To understand how corrosion and pollution in HX can have such an impact on cooling installations efficiency we can look at the basics of the cooling process. In all cooling installations the refrigeration cycle uses the evaporation of a liquid to absorb heat. The absorbed heat is then released at a higher pressure/temperature to the environment. The cycle of evaporation, compression, condensing and expansion is shown simply in figure 1



1- simplified refrigeration cycle

The white lines show the normal cycle where the system works in optimal condition. The red lines show the cycle when the condensing temperature raises. This can be due to higher outside temperatures or due to a less efficient heat exchanger. The higher condensing temperature results in a extra power input while the effective cooling capacity is reduced. Because an increased condensing temperature has this double effect, the efficiency of the cooling equipment is reduced significantly.

For an acceptable energy consumption of the cooling installation it is essential to keep the condensing temperature as low as possible. **Every degree counts!** This is the point where a close look at the heat exchangers in the system becomes vital. These heat exchangers must be kept clean and free of corrosion. The right choices in the design phase determine the performance in the long term.

Heat exchangers are designed to exchange heat between media without direct contact between those media. Aluminium and copper are good materials for this purpose as they have high heat conductivity. Standard liquid-to-air heat exchangers are made with copper tubes and aluminium fins.

A weakness in this design is the joint between the copper and aluminium. As long as the fins are tightly joined to the copper tube, without gaps or interference of organic layers or corrosive products, the heat transfer will be optimal. Pollution on the fin surface will also influence the heat transfer of a heat exchanger and the airflow through it.

The joint between the copper tubes and aluminium fins is one of the more corrosion sensitive parts of an air-conditioning unit. With aluminium being less noble than copper it will be sacrificed in the presence of electrical conducting fluids. These fluids will always be present due to pollution and moisture from the environment . The accelerated corrosion due to the presence of different metals is called galvanic corrosion and is one of the main problems in copper-aluminium heat exchangers. An example of this galvanic corrosion is given in figure 2.

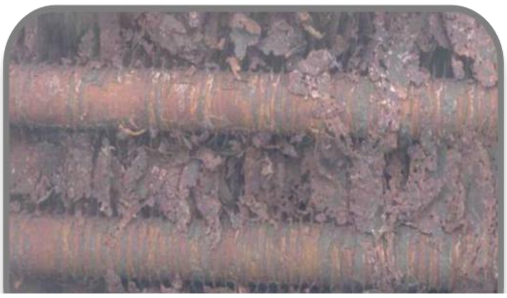
The joint that existed between copper and aluminium is now replaced by a copper aluminium oxide joint. The heat conductivity of aluminium oxide is much lower than that of aluminium. Therefore, the heat transfer between copper tubes and aluminium fins is significantly decreased.

2- galvanic corrosion in cu-al heat exchanger

If pollution on the fins limits the airflow through the heat exchanger, the temperature of the air that is passing over the aluminium fins will increase (the same kW in less kg of air). This will cause the temperature difference between the liquid/gas in the copper tube and the air passing over the fins to decrease. A smaller temperature difference will result in reduced heat transfer. The only way the system can cope with this loss of heat transfer is the undesirable increase of the condensing pressure and temperature .

In the design phase engineers must take into account the effect corrosion and pollution will have during the lifetime of a cooling installation. Corrosion can of course be controlled by selecting the right materials but also the type of heat exchangers is important. The use of indirect adiabatic cooling on heat exchangers will create massive galvanic corrosion due to the amount of moisture that is brought into the heat exchanger.

Protecting heat exchangers from corrosion and accumulating pollution is essential for cooling installation capacity and energy consumption. The options available in the market to realize this can be divided into three parts; metal optimization, pre-coated metals and post-coated metals.



3- copper coil, 4 years in industrial environment

Metal optimization consists of looking into different metals or alloys to reduce the risk of corrosion. Using copper fins instead of aluminium is a good example of this. The resulting copper tube-copper fin heat exchangers will not suffer from extreme galvanic corrosion anymore. Apart from the price and the weight the disadvantage is that in industrial environments sulphurous and nitrogen contamination will create high amounts of metal loss. Heat transfer will not directly be affected but the lifetime of the heat exchangers will significantly decrease.

4- precoated coil with corrosion from cutting edge

Precoated aluminium is often offered as a "better than nothing" solution against corrosion in heat exchangers. The ease of application makes this a cheap and tempting solution . In this case the aluminium fin material receives a thin coating layer before being cut and stamped to fit. The result is that during cutting and stamping the fins, the protective layer is damaged creating hundreds or even thousands of meters of unprotected cutting edges in every single coil. Next to this one must take into account the fact that the protective layer will be between the copper tube and alu fin which reduces the heat transfer already without any corrosion being present.

5- Blygold PoluAl XT coated coil

Post coating is a technique where corrosion protective coatings are applied to heat exchangers after full assembly. If the right coating and the right procedures are applied the metals will be sealed off from the environment without reducing heat transfer. Disadvantage is that it requires special coatings and application can only be done by specialized companies. Applying these special heat conducting coatings on the complete heat exchanging surface of coil is difficult and time consuming. This creates extra challenges with respect to pricing and delivery times compared to other solutions that can often be produced/supplied by heat exchanger manufactures themselves. Even though post coatings are preferably applied as a preventive measure before installation, it is possible to use them as corrective measure if choices made in the design phase turn out to be insufficient.

Selecting the right solution for heat exchanger design and corrosion prevention will affect the costs of maintenance, replacement and energy consumption. Investments made in the design phase will show significantly reduced operational costs in the long term. Data centres engineering has a big focus on electronic equipment that can handle higher temperatures because increasing the operational temperature can significantly reduce the operational costs, every degree counts! With this awareness it is only a small step to look at the heat exchangers of cooling equipment the same way.

Every degree counts; Protect, monitor and maintain these key elements of the cooling process!

How choices in the design phase affect long term performance ; example from the field

Aluminium –copper air-cooled heat exchangers with indirect adiabatic cooling system might seem to be a cost effective method to lower the initial investment but will significantly increase corrosion problems. Within 3-4 years the heat exchanger efficiency is significantly reduced as the hidden corrosion process is accelerated due to the water atomization during hot days (design days). With a less efficient heat exchanger the installation efficiency is negatively affected the whole year long . Once efficiency drops below critical point early replacements of HX is inevitable even though the front of the coil might look in good condition.

galvanic corrosion at heat exchanger with adiabatic cooling (water spray)

Blygold on-site coating intervention