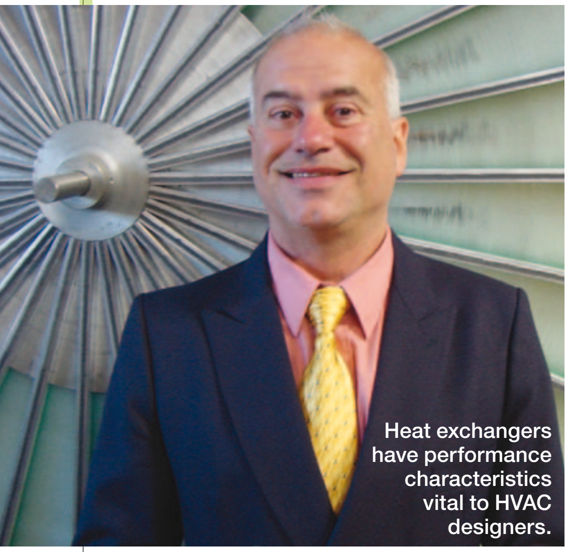
Performance characteristics explained in simple terms



Heat exchangers have performance characteristics vital to HVAC designers.

ROTARY HEAT EXCHANGERS CEO BILL ELLUL OUTLINES THE BASIC THEORY OF HEAT EXCHANGER PERFORMANCE.

THE BASIC THEORY of heat exchanger performance is applicable to all forms of heat exchangers such as plate, rotary, radiator coil or shell and tube heat exchangers.

Unlike fans, heat exchangers are regarded by many consultants as a bit of a mystery. In this article, my aim is to explain in simple terms some relatively complex heat exchanger concepts. Fan performance is generally characterised by flow and pressure. Fan characteristics are curves showing what pressure is produced by the fan for different air flows. This is most important to HVAC designers of air ducting systems and well understood throughout the industry.

Like fans, heat exchangers also have performance characteristics vital to HVAC designers. The complexity comes from the fact that they have two air flows, one for the cold and one for the hot path. They also have a third characteristic parameter -- efficiency.

Each of these flows will have an associated pressure drop and temperature efficiency. Heat exchanger performance characteristics are given for balanced air flow (i.e. equal flows through each side). It now becomes a flow versus pressure drop and efficiency characteristic.

The values are equivalent for either side of the heat exchanger.

UNBALANCED FLOW

This is where the analogy with fans breaks down. If you increase the flow in a fan, you are making it work harder and the pressure it can deliver decreases as depicted in its flow-pressure characteristic.

However, if we increase, for example, the hot flow rate of a heat exchanger, we are giving it a much better chance of heating the smaller cold flow and thermal efficiency will actually increase.

We have actually given the heat exchanger an unfair advantage and we must be mindful of what we are achieving and how we compare the performance of different heat exchangers.

Going back to our fan analogy, we can increase the flow of a fan if we ignore the fact that it will result in it developing a lower pressure duty. Both characteristic parameters are required when designing projects or comparing fans.

Increasing the size of the heat exchanger also gives it an efficiency advantage by providing more surface area for heat transfer but at a cost penalty.

THERMAL EFFICIENCY

Heat exchanger efficiency may mean different things to different people. Ultimately we are talking about how much cooling or heating we can achieve.

We can define thermal efficiency as the percentage proportion of energy transferred from the hot flow to the cold flow.

According to the law of energy conservation, i.e. energy can not be created or destroyed, the heat lost by the hot flow must equate to that gained by the cold flow – ignoring any losses to the surroundings, which will be insignificant.

This is true for both balanced and unbalanced flow conditions. Therefore, there is no difference in thermal efficiency between the two sides irrespective of air flow balance.

TEMPERATURE EFFICIENCY

For simplicity and to facilitate performance measurement, thermal performance can be deduced from simply calculating temperature difference ratios. We define the temperature efficiency, or sometimes described as temperature effectivity, as the temperature difference achieved on one side as a ratio of the two inlet flow temperatures.

There will be a difference in temperature efficiency on the hot and cold fluid sides if the flows are unbalanced. In this case, the thermal efficiency equates to the larger of these two values. As this is a little more difficult to explain simply, I will not attempt it here. For balanced flows, it can simply be shown that the temperature efficiency equates to thermal efficiency.

The advantage here is that, in a balanced flow situation, the thermal performance of a heat exchanger can simply be calculated by measuring three air temperatures – the two inlets and one outlet.

The efficiency is simply the ration of the temperature difference of one flow divided by the difference of the two inlets.

FLOW ORIENTATION

The most important factor affecting heat exchanger performance is flow orientation or arrangement of both hot and cold flows.

For example, coil heat exchanger design is critically dependent on inlet position and row orientation. In the case of plate and rotary heat exchangers, this critical air flow orientation are described as counterflow, cross-flow and parallel flow. This describes the path taken by adjacent flows which are exchanging heat with each other.

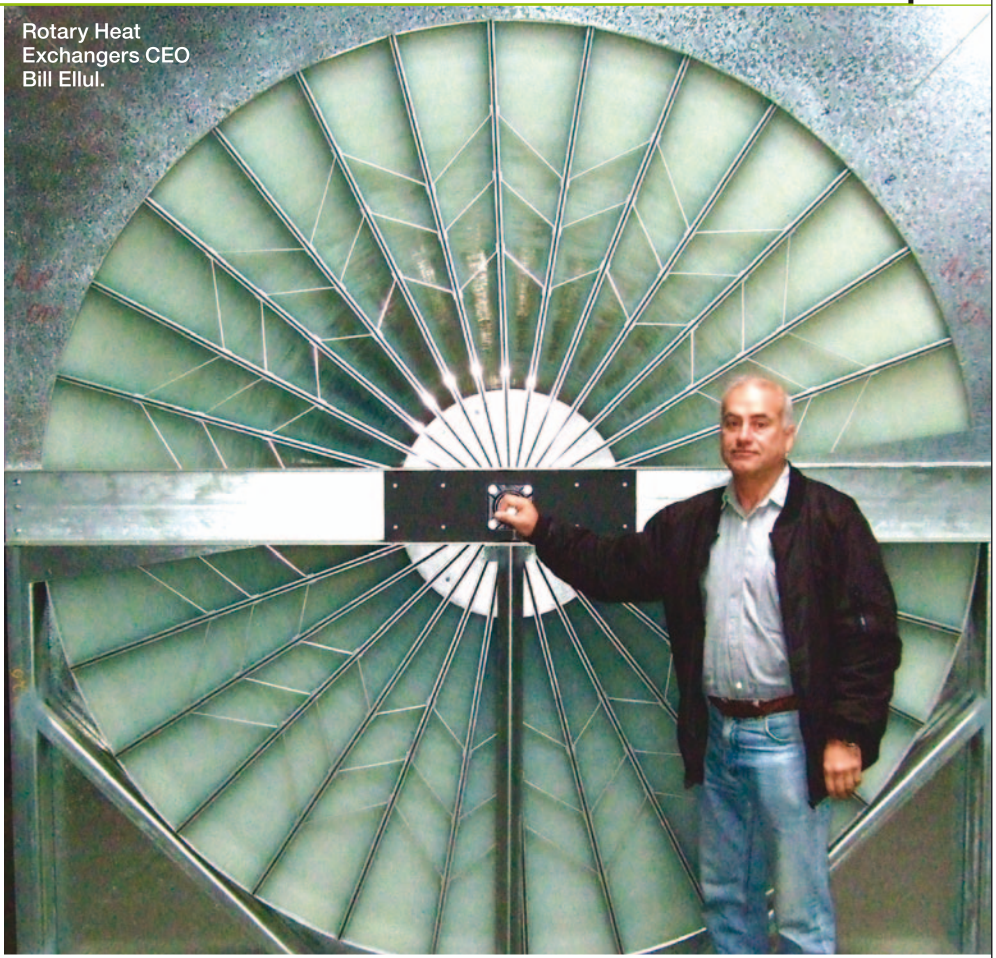
Plate heat exchangers may also have two or more of these arrangements within the same heat exchanger due to the generally long path lengths required and impracticality of attaining counterflow throughout the whole heat exchanger. Using a mathematical integration analysis, it can be shown that counterflow has a double efficiency advantage over parallel flow and cross-flow is a middle compromise. In the several decades of my involvement in this industry, it has taken such a long time for the industry to change from talking up the advantages of cross-flow to talking up counterflow.

HEAT EFFICIENCY

So far in this article we have only discussed heat exchangers where the only energy transfer taking place is that due to thermodynamic conduction and convection with no transfer of water or water vapour. We call this "sensible heat transfer" or "sensible heat exchangers".

Heat exchangers can transfer sensible heat or sensible and latent heat, meaning total heat. Sensible heat is where no moisture is transferred and so latent heat of water vapour is not involved.

In this case, the energy transfer can be simply calculated from the temperature differences and flow rates. A total heat exchanger transfers moisture and the energy of moisture from one stream to the next by using a moisture absorption compound that absorbs water in one stream and desorbs it into the next. The extra transfer of latent energy is added to the total transfer.



Rotary Heat Exchangers CEO Bill Ellul.

A gold winning performance in energy and heat recovery

ROTARY HEAT EXCHANGERS Pty Ltd has completed nine indoor aquatic centre upgrades supplying a total of 32 energy recovery Mylar heat wheels in the past 18 months.

Projects include the Australian Institute of Sport in Canberra, Hobart Aquatic Centre in Tasmania and the Broadmeadows Leisure Centre in Victoria.

The combination of the nine projects are making a real difference, according to company CEO Bill Ellul.

"Our energy recycling wheels for our nine recent aquatic projects heat a total of 220,000 l/s of fresh air using free exhaust air heat," he said.

"We estimate that this is saving approximately 108,000 GJ/annum of natural gas and delivering a total of $565,000 annual savings for our customers plus 4,600 tonnes CO2 reductions for the benefit of the environment for many decades to come."

The City of Hobart commissioned Rotary Heat Exchangers Pty Ltd to provide one of its largest R2750 heat wheels with 2750mm rotor diameter as a replacement for one of its existing imported heat wheels installed at the centre 12 years ago.

The fresh air flow through the wheel is 11,000 l/s. The existing Al wheel had a 3000mm diameter and 270mm deep aluminium honeycomb rotor.

The swimming centre at the Australian Institute of Sport (AIS), which houses a 50 metre and 25 metre heated pools in an indoor complex in Canberra, recently underwent a major refurbishment.

The centre is open to the public with both heated pools available when not in use by the AIS sport programs.

Rotary Heat Exchangers Pty Ltd was asked to supply four 2540mm diameter heat wheels to replace the existing three wheels supplied to the centre by Rotary over 30 years earlier.

"Our old three wheels provided decades of good energy savings after they were installed at the then National Sports Centre in 1982. Our four new wheels will give even better long term performance," Ellul said.