An effective solution for a modern energy concern

Wasteful full fresh air systems should be discounted as an acceptable solution for indoor pools, argues Barry Littlemore, Product Manager. The additional latent load of a swimming pool needs a sophisticated solution that considers more than just the air heating. In these energy conscious times, ignoring the pool water heating is no longer an option.

Swimming pool environmental control

To be comfortable for swimmers, water temperatures are normally in the high twenties (°C). At this temperature the pool evaporation is substantial. To help minimise evaporation and heat losses to a manageable level, whilst giving some comfort for swimmers out of the water, the air temperature is set nominally 1-2°C above the water. This often results in a pool hall condition around 30°C, some 10°C above that of an office, hotel or sports facility that might use a traditional air handling unit (AHU). But the higher air temperature in a swimming pool hall is not the only difference.

A swimming pool is essentially a large, warm bath of water, and it will evaporate at a significant rate while uncovered. A typical 25m, six lane pool, with 325m^2 area, will lose an average of 65 litres of water per hour. Indeed, the majority of operational heat loss from an indoor swimming pool is as a result of this evaporation.

> The assumption of pool water heating being a continuous requirement for new heat is misleading, because recovery of the latent energy can return all of the evaporation heat loss back to the pool

Changing the state of water from liquid to vapour takes a significant amount of energy, called latent energy. The latent energy of evaporation for water is 2258 kJ per kg, or 0.627kWh per litre. Our average 65 L/h pool evaporation represents an average of 41kW lost to the pool hall air, which is a significant energy loss.

Pool water and air temperature

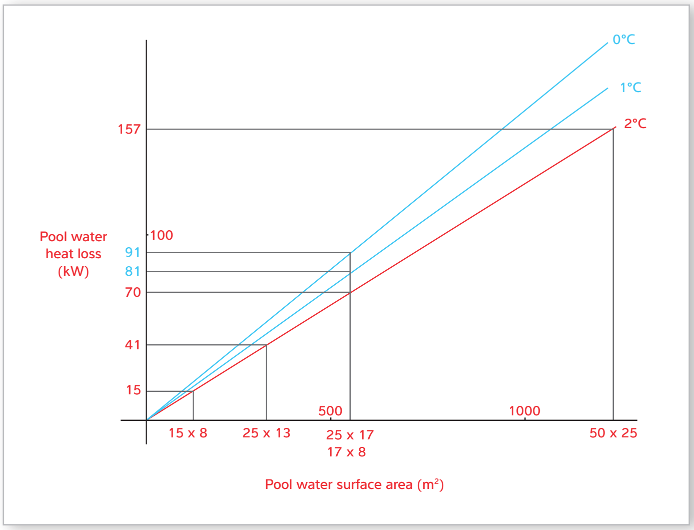
Recent trends for raising pool water temperatures only serve to increase the evaporation and heat loss from swimming pools, increasing energy usage. In the past it was straightforward to maintain the air temperature 1-2°C above the water temperature to help reduce evaporation and heat loss. Modern pools are often heated to 29-30°C and learner pools to 31-32°C. With the maximum comfort level for staff typically 30°C, a 1-2°C differential may not be achievable.

Whilst it is not necessary to maintain the air temperature higher than the water temperature, the evaporation and heat loss will increase, (see Figure 1). The 2°C line shows the average heat loss with the water temperature at 28°C and the air temperature at 30°C. The 1°C and 0°C lines show the effect of reducing the air temperature to 29°C and 28°C respectively. The additional heat loss of the 0°C differential is in the region of 30%.

It is important to recognise that any system must be sized for the intended operating conditions. A system sized for an air temperature 2°C above the water temperature will not cope with the extra evaporation and heat loss resulting from a reduced air temperature, leading to increased humidity, discomfort and the potential for condensation.

If designing swimming pools without the favourable differential, this should be carefully factored in at the AHU selection stage. The rules of thumb for air change rates that can be found in various guides are based solely on dehumidifying with fresh air, so do not take account of the variety of air and water temperatures found in modern pools, and base their recommendations on pool hall volumes rather than pool water areas. The evaporation from the pool water is a function of the interface between air and water, proportional to the area, and is largely independent of the pool hall volume.

Figure 1



Solutions

Regardless of operating conditions, the excess humidity must be removed and in less energy conscious times the solution was to exhaust the unwanted humid air from the pool hall and replace with drier fresh air. Unfortunately, not only does fresh air require heating, this solution also removes all the energy the exhausted moisture represents. The positive is that due to the large volume of the pool hall, the occupant density is relatively low, which enables a good atmosphere to be maintained with a lower rate of fresh air induction, provided the majority of the dehumidification is done by other means.

The basic solution for indoor swimming pools, fresh air with passive heat recovery using a cross-plate heat exchanger, recovers mainly the sensible energy available in the extract air and recovers little or none of the latent energy available. This can be illustrated with a simple graph, (see Figure 2).

The blue line represents the energy content of typical fresh air, the orange line represents the energy content of the same fresh air once heated to the target pool hall temperature. The heat recovery percentage of a cross-plate heat exchanger is defined only as the percentage of heat supplied to get from the blue line to the orange line. This definition, considering the energy required to raise the incoming fresh air temperature to the pool hall temperature, gives no consideration to the latent energy at all.

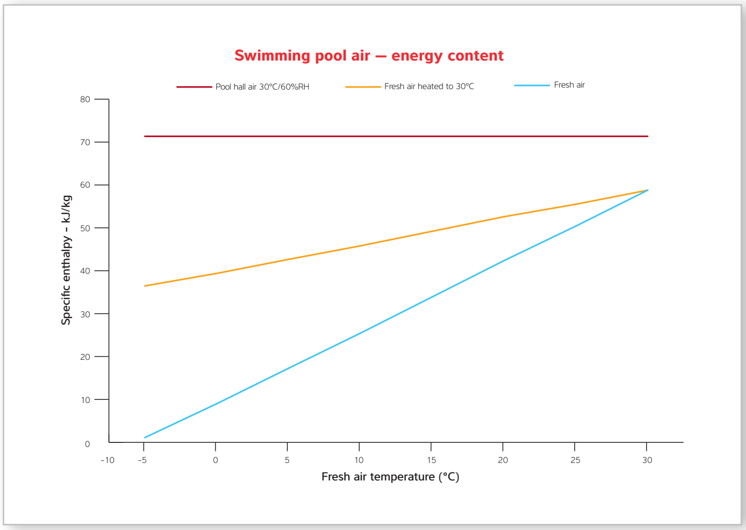
The red line is the energy content of the exhaust air, the energy that may be being thrown away. The difference between the orange line and the red line is the latent energy, the heat lost from the pool by evaporation. On cool days a percentage of the latent energy will be recovered, but of course it will only be recovered into the fresh air stream, with most going out to atmosphere and wasted. With realistic maximum efficiency claims of 70% (and this for sensible heat only, on large units with a low air velocity, given the maximum temperature difference between exhaust air and fresh air) the passive route to heat recovery leaves much to be desired.

The pool water will always require energy to replace the evaporation losses and no amount of effort with air recuperators will recover the lost latent heat back to the pool water. It follows that the assumption of pool water heating being a continuous requirement for new heat is misleading, because recovery of the latent energy can return all of the evaporation heat loss back to the pool far more efficiently than a system supplying new heat.

What is needed for swimming pool environmental control is an AHU that will recover all the latent heat given up by the pool in normal operation and return it back to the pool, thereby minimising pool heating requirements. Only a refrigerated heat pump system can provide efficient recovery of heat energy along with control over the potentially damaging humidity. By recirculating pool hall air and removing the humidity, the latent energy is automatically recovered by the heat pump and returned direct to the pool water, using a refrigerant-to-water condenser, creating a continuous cycle of energy recycling to minimise the new energy required to keep the pool heated.

Fresh air volumes recommended for fresh air dehumidification are significantly higher than those required for occupants and chemical dilution. A heat pump, with the addition of exhaust and fresh air inlet connections, needs only to introduce the much lower minimum fresh air volumes required by occupants and chemical dilution. This smaller volume also provides a boost during swimming periods to maintain the optimum conditions

Figure 2



for bathers and spectators alike while ensuring that the humidity levels are kept low enough to safeguard the building and fabric from moisture damage. The AHU will recover sensible heat from the outgoing exhaust air and put it into the incoming fresh air.

Benefits of using a heat pump

- Recovery of latent energy
- Reduced fresh air volumes
- Summer cooling
- Compact size

Swimming pool halls should be run at a slight negative pressure to overcome the evaporating moisture vapour pressure to prevent moisture laden air being driven into the building fabric, and in the case of leisure complexes, into the attached building. This should be accommodated at all levels of fresh air induction. On units with fresh air capability it is most easily arranged by a dedicated exhaust fan in conjunction with differential fresh and exhaust air damper operation controlled automatically by the control system.

In addition, a suitably sized heat pump system also offers the option of summer cooling. At times where the recovered energy is not required in either the pool water or the air, excess heat can be rejected to an exhaust air condenser (in the AHU) or a remote condensing unit (located externally). A heat pump system can not only remove latent energy, but also sensible energy, offering significant net cooling to the pool hall.

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Lower pool hall air temperatures also affect the AHU options. Fresh air systems rely on a difference in moisture content between inside and outside in order to dehumidify, so with a lower internal temperature, there will be times of year when the fresh air has more moisture than the pool hall air, leading to a compromise in conditions in summer, and increased fresh air usage at other times. Once again, heat pump based systems are a good solution, because with energy rich swimming pool air, the efficiency of a heat pump is only slightly reduced by the lower air temperature, and less affected by the reduced effect of fresh air. Sized correctly, they will comfortably handle the increased dehumidification load, and still maintain the similarly increased pool water heat loss with heat recovery.

The modern swimming pool and wet leisure centre heat recovery and dehumidification plant is a completely self-contained unit. No longer is it necessary to have discreet control panels for air control and for water control, no longer even to have temperature and humidity sensors wired back to their control panels. The modern AHU not only controls and coordinates all key parameters but internally senses them. Fit and forget, and keep running costs down.

In conclusion, considering the air and pool water heat losses separately is no longer good enough for modern energy concerns. An integrated approach, reducing fresh air to the minimum required, and recycling the energy lost by evaporation back into the pool water, is the way forward.

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