CPD Programme

The *CIBSE Journal* CPD Programme

Members of the Chartered Institution of Building Services Engineers (CIBSE) and other professional bodies are required to maintain their professional competence throughout their careers. Continuing professional development (CPD) means the systematic maintenance, improvement and broadening of your knowledge and skills, and is therefore a long-term commitment to enhancing your competence. CPD is a requirement of both CIBSE and the Register of the Engineering Council (UK).

CIBSE Journal is pleased to offer this module in its CPD programme. The programme is free and can be used by any reader. It is organised jointly by *CIBSE Journal* and London South Bank University, and will help you to meet CIBSE's requirement for CPD. It will equally assist members of other institutions, who should record CPD activities in accordance with their institution's guidance.

Simply study the module and complete the questionnaire on the final page, following the instructions for its submission. Modules will remain available online at **www.cibsejournal.com/cpd** while the information they contain remains current. You can also undertake the questionnaire online, and receive your results by return email.

CIBSE CPD

LONDON SOUTH BANK UNIVERSITY

LOGO TO COME

Evaporative cooling enhancement on air cooled chillers

How can evaporative cooling deliver improved performance, and what are the cost implications? These are some of the issues examined in this month's article, which follows up a previous CPD on chillers.

This month's article features a further improvement to the performance of air cooled chillers in the form of evaporatively cooling the fresh air intake to the condensers. The theory of evaporative cooling will be presented, together with the improved performance data and an application into modular data centre air conditioning packages.

This follows on from the CPD article in the July 2009 *Journal*, which introduced several innovative improvements to the performance of centrifugal compressor water chillers. These included:

- Magnetic bearings within the compressor;
- Oil free compressor;
- Floating head pressure;
- Micro-channel aluminium condensers, that reduce refrigerant charge while increasing the effectiveness of heat exchange;
- Flooded evaporators that ensure optimum energy transfer between refrigerant and water;
- Inverter-controlled compressors whose output can be matched to the load; and
- Use of a liquid refrigerant pump system that significantly increases thermodynamic efficiency across the chiller's operating range.

Evaporative cooling systems

Evaporative cooling is achieved with a cassette made from inorganic, non-combustible packing material, which is a resin coated board – one that is fireproof and will not support bacterial growth. Figure 1 shows the typical air cooled chiller arrangement. The cassettes are set in front of the V bank epoxy coated condenser coils and can be slid out for replacement or winter operation to reduce fan pressure drop.

The system incorporates a once-through water system with micro jet spray nozzles, which means that only the minimum amount of water is used with the water being pumped by a variable speed drive pump, through a UV filter to kill all bacteria.

The sprayed water flows onto the corrugated surface of the cassette material and saturates the material, but without passing through and coming into contact with the condenser coils.

As the warm, dry ambient air passes through the cassette it evaporates a proportion of the water, lowering the air dry bulb temperature and raising the humidity. The fans are variable speed drive with electronically controlled motors to reduce energy usage. Approach temperatures between refrigerant condensing temperature and air onto the coils are reduced by up to 8K at peak design conditions (35C ambient). Condensing temperatures are reduced and condenser fan volumes also lowered, so energy savings can be very significant. Utilising the flow/power cube law, savings of up to 30% are possible.

The evaporative unit can be automatically switched off at lower ambient conditions, when water cost equals or is greater than potential energy savings. Excess water assists in washing the media, and is drained back >

from the cassettes. It also allows the use of water straight from the tap with no need for water treatment (i.e. demineralisation plants). Minerals and pollutants stay behind in the cassette material to be washed away with the discharge water, keeping the total humidification process pure.

The theory of evaporative cooling

Figure 2[1] shows air passing through a water spray chamber, which could also be the corrugated packing medium saturated and sprayed from the micro jet nozzles in our application. Text books refer to air passing over or through a wetted surface.

This process results in heat and mass transfer and can be represented by the 'straight line law'. This law states that when air is transferring heat and mass (water) to or from a wetted surface, the condition of the air at point A, shown on the psychrometric chart, drives towards the saturation line at the temperature of the wetted surface. The condition of the air leaving the spray chamber or wetted surface at point B has dropped in dry bulb temperature and increased in humidity or moisture content. The straight line law states that point B lies on a straight line drawn between point A and the saturation curve at the wetted surface temperature at point C. The warm air at point A dry bulb temperature drops when in contact with the water at temperature tC. This application of heat and mass transfer is one of the most complex encountered in heat exchange theory, but this article will consider the underlying application of the basic principles. Further reading on this is given at the end of the article.

The process that is taking place is known as *adiabatic saturation* and as such occurs without any external exchange of heat into or out of the system. Air at the start of the process is at a dry bulb temperature tA and moisture content gA and as it passes through the saturated cassette, water is evaporated from the surface of the cassette material so that the air leaving the cassette and entering the condenser coil, in our case, has a dry bulb temperature tB and moisture content gB. For water to evaporate, heat must be supplied and, in an adiabatic process, this heat can only come from the air itself. The latent heat of evaporation gained by the air must equal the sensible heat loss by the air, which means there will be a drop in air dry bulb temperature to compensate for the increase in moisture content:

i.e. $(g_B - g_A)h_{fg} = C_{pair}(t_A - t_B)$

The theoretical process line follows the adiabatic saturation temperature (which may be assumed to follow the wet bulb temperature lines that are printed on the psychrometric chart). But a close approximation, which usually assists psychrometric calculations, is to consider the process as a constant enthalpy one.

The main factors that affect the performance of the cassette in reducing the ambient dry bulb temperature entering the condenser coil are:

- **Ambient air wet bulb temperature:** At summer ambient conditions of say 30C dry bulb, 20C wet bulb, air leaves the cassette and enters the condenser coil at approximately 23C. The lower the actual ambient wet bulb, the more the potential for the dry bulb to be reduced, but of course, the opposite is also true. The more humid, and hence the higher the wet bulb temperature of, the ambient air, the less dry bulb reduction will occur.
- **Cassette contact factor:** Looking at the psychrometric chart, if the saturation were 100%, the air entering the condenser coil would have a dry bulb temperature equal to the wet bulb temperature.

In reality the efficiency, or contact factor will be 85% to 90% so the dry bulb temperature of the air leaving the cassette will practically 'approach' but not get as low as the wet bulb temperature.

Figure 1: Typical air cooled chiller arrangement

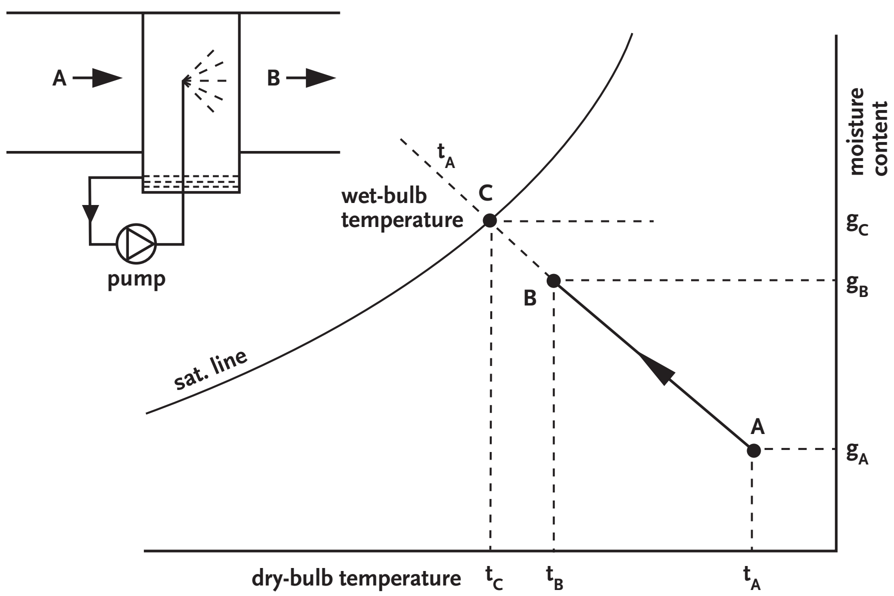

Figure 2: Psychrometric chart for evaporative cooling process

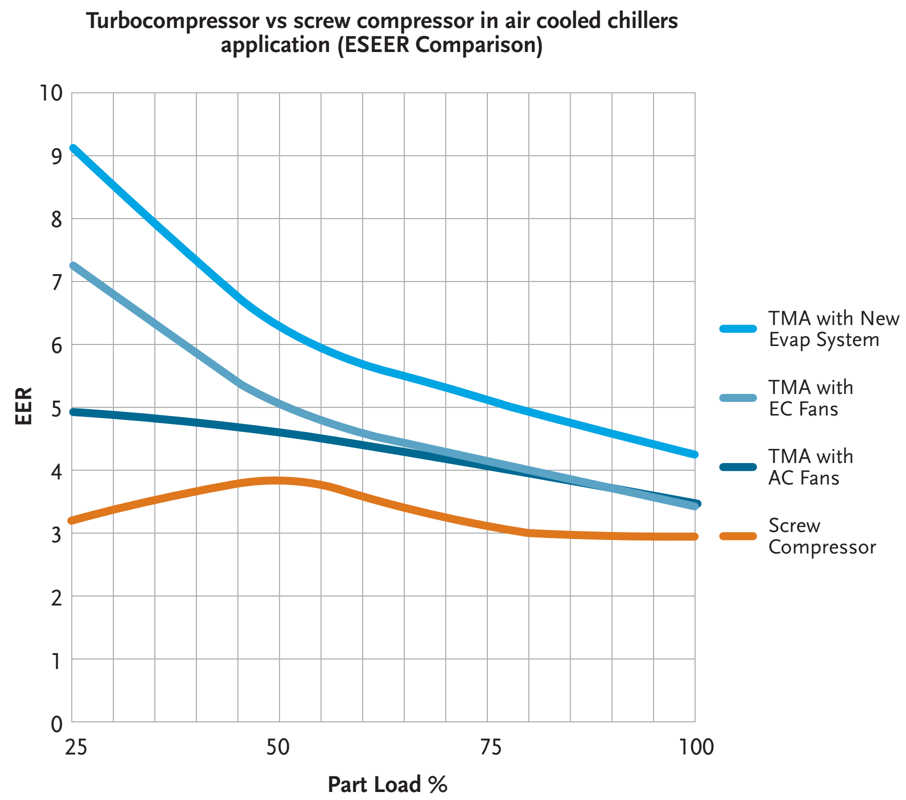

Figure 3: Efficiency comparison between turbo and screw compressor

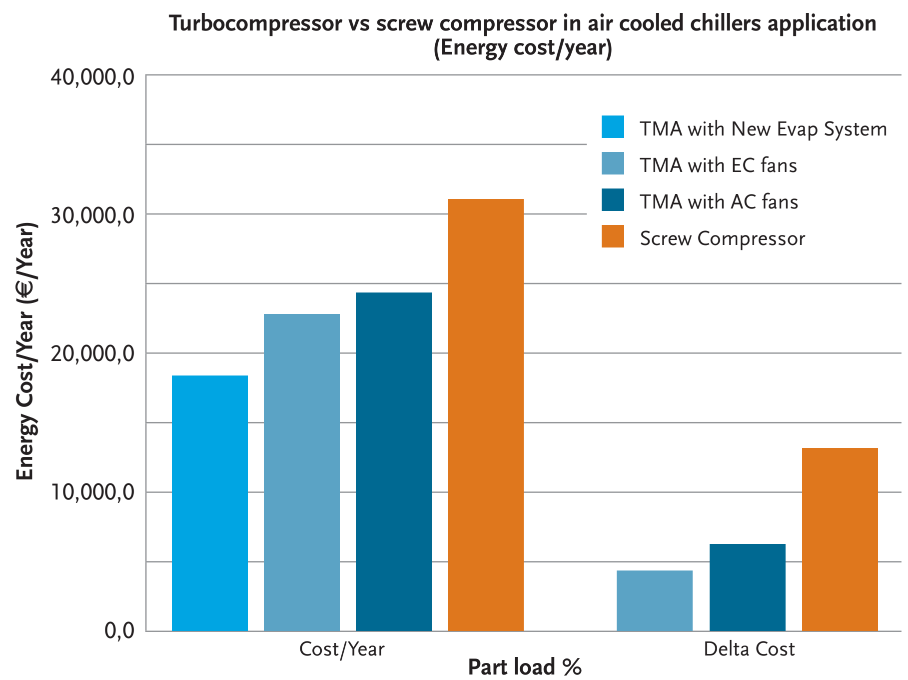

Figure 4: Annual energy cost comparison

Enhanced performance data

Figures 3 and 4 illustrate operating efficiencies in terms of the EER(Energy Efficiency Ratio) and Energy costs between the new centrifugal air cooled chiller with evaporative cooling and a typical air cooled screw chiller. Data from a 500kW air cooled centrifugal chiller with evaporative cooling indicate a 26kW saving in power consumption compared to the same chiller without the evaporative cooling, and a saving of 52kW over a screw compressor chiller. There is a requirement for between 360 and 490 l/h of make up water for the evaporative cooling system.

The overall annual running cost for the enhanced chiller is £16,000, a reduction of £3,200 over the non enhanced centrifugal chiller and a reduction of £10,600 over a screw compressor chiller.

Application to data centre air conditioning

Data centres are an application of building services where it is being proposed that the whole project be built from pre-manufactured, pre-assembled components (in fact, not just the services, but the complete building). Known as ITPACs (IT pre-assembled components) the modules are not containers in the traditional sense, but are pre-configured, manufactured components, pre-assembled and delivered to any site around the world. As part of this scheme, modular cooling plant in 300kW packages is being developed and produced.

The air cooled chiller section can include the evaporative cooling cassettes for improved performance. Conditioned air is ducted from the air handling unit section to discharge under-floor in the data centre sections and ducted from high level back to the air handling unit/fresh air intake. Further enhancements to the air handling package include an adiabatic heat exchange unit in the return air section, with sensible heat transfer to the fresh air supply providing initially free cooling from the outside ambient, then adiabatic cooling, then liquid pressure amplification(LPA) free cooling and finally mechanical cooling from the centrifugal compressor.

© Terry Welch, Steve Chaplin

References:

1. *Air Conditioning Systems – Design, Commissioning and Maintenance*, Legg RC, Batsford, 1991
2. *Refrigeration and Air Conditioning*, McGraw Hill, Stoecker and Jones
3. Geoclima: Evaporative systems
4. Geoclima: Turbomiser performance data
5. DataCentreDynamics *Focus*, April/May 2010 'The new future of data centres'

Module 18

July 2010

1. Which document is specifically relevant to the installation of gas fired appliances in catering establishments?

☐ A BS 6173 ☐ B GSIUR ☐ C DW172
☐ D EH40 ☐ E IGE/UP/1A

2. Why do the Gas Safety regulations specifically require gas supply to Type B commercial kitchen appliances with a canopy extract system to be interlocked with the ventilation system?

☐ A Because they use gas
☐ B To maintain comfort levels
☐ C Because they are all treated as deep fat fryers
☐ D Because the canopy extract system is deemed as a power-operated flue
☐ E Because they are designed to be operated with high fresh air supply rates

3. Which document will provide explicit guidance on the air flowrates required for kitchen ventilation systems?

☐ A BS 6173 ☐ B GSIUR ☐ C DW172
☐ D EH40 ☐ E IGE/UP/1A

4. Which one of these is most unlikely to be true for dynamic gas proving systems employing differential pressure sensing?

☐ A It provides a means of ensuring that all gas appliances are switched off before allowing gas into the kitchen
☐ B It is unlikely to close the solenoid valve with transient changes of gas pressure
☐ C As it is dynamic in operation, it can miss small gas leaks
☐ D It typically monitors the pressure across the electronic control valve
☐ E The gas supply will be isolated if the gas drops to a dangerously low pressure during use.

5. When monitoring CO_2 in a kitchen, what is the approximate maximum increase above typical outdoor CO_2 levels that is deemed acceptable before the gas should be switched off?

☐ A 400ppm ☐ B 1000ppm ☐ C 1400ppm
☐ D 2400ppm ☐ E 2800ppm

Name (please print) ....

Job title ....

Organisation ....

Address ....

....

....

Postcode ....

Email ....

Are you a member of:

☐ CIBSE

If so, please state your membership number

(if available) ....

☐ Other institution

(please state) ....

To help us develop future CPD modules, please indicate your primary job activity:

☐ Building services engineer
☐ Mechanical engineer
☐ Electrical engineer
☐ Commissioning engineer
☐ Energy manager
☐ Facilities manager
☐ Other (please give details) ....

If you do NOT wish to receive information about Geoclima, the sponsor of this CPD, please tick here: ☐

By entering your details above, you agree that CIBSE may contact you from time to time with information about CPD and other training or professional development programmes, and about membership of CIBSE if you are not currently a member.

Please go to **www.cibsejournal.com/cpd** to complete this questionnaire online. You will receive notification by email of successful completion, which can then be used to validate your CPD records in accordance with your institution's guidance.

Alternatively, you can fill in this page and post to:
N Hurley, CIBSE, 222 Balham High Road, London, SW12 9BS