Fact Sheet

AUSTRALIAN MEAT INDUSTRY COUNCIL

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No. 2

VARIABLE HEAD PRESSURE CONTROL TO OPTIMISE ENERGY EFFICIENCY IN REFRIGERATION

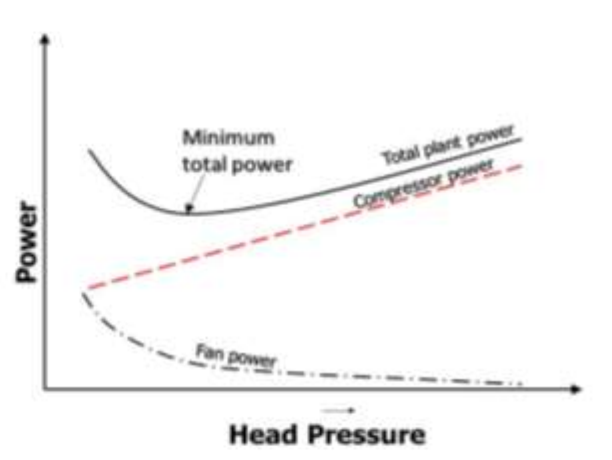

Figure 1: Relationship between compressor power consumption and pressure set point

The head pressure of a refrigeration plant is the pressure at which the high stage compressors discharge and the refrigerant condenses. In a conventional plant, the head pressure set point is fixed and the plant control system attempts to maintain it. If the head pressure set point is too low for a given ambient and plant load condition, the condensers will reach capacity and the head pressure will fluctuate with load, potentially causing plant instability issues. If the head pressure set point is too high, there is an increase in compressor power consumption.

If the condensing temperature can be reduced and the head pressure lowered without compromising the stability of the refrigeration plant, then energy savings may result. This can be achieved through Variable Head Pressure Control (VHPC) systems. VHPCs optimizes the head pressure of a refrigeration plant whilst considering operational factors such as minimum compression ratios, oil separation, ambient conditions and plant load. At an optimum head pressure, the combined high-stage compressor and condenser fan power consumption is minimized. VHPC represents a low-cost and highly effective energy savings opportunity for nearly all ammonia refrigeration systems, with the added advantage of increasing plant stability, reducing many operational issues at the same time.

VARIABLE HEAD PRESSURE CONTROL

Evaporative condensers are typically selected to match the highest cooling demands in summer. Therefore, for the greater part of the year, the plant condenser(s) are subject to lower cooling loads and wet bulb temperatures and as such, condensers are often oversized. Therefore, condensing pressures can be reduced to reduce the power consumption in high stage compressors. Furthermore, ambient wet bulb temperature is generally stable for long periods of the day and tends to fluctuate mainly with a change of weather, as shown in Figure 2. Because VHPC depends on wet bulb temperature and plant load, a well-defined VHPC logic can reduce head pressure fluctuations. The head pressure on an otherwise conventional plant configuration fluctuates with plant load.

Australian Government
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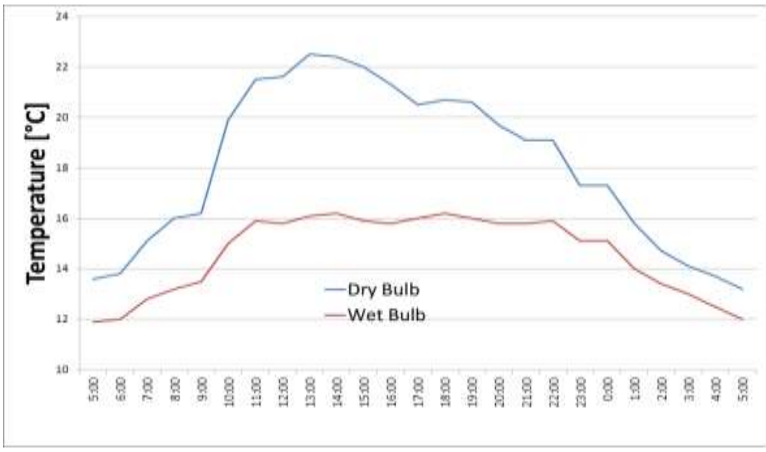

Figure 2: Fluctuation in wet bulb and dry bulb temperatures over a 24 hr period

Therefore VHPC, in addition to reducing head pressure where possible, also stabilizes the head pressure of the plant, resulting in more efficient and stable plant operation.

Plant head pressure may be deliberately raised to facilitate hot gas evaporator defrosts. This approach is inherently inefficient as the overall performance of the plant is penalized to facilitate a relatively infrequent and minor functional requirement of the plant. The alternative is to dedicate a single compressor in the facility as a “defrost compressor”. It would run at a higher discharge pressure to the remaining compressors and would equalize (in pressure) with these compressors via a pressure regulator mounted in the discharge line. This allows the plant to operate VHPC logic, whilst allowing a hot gas defrost line to be connected upstream of the pressure regulating valve and fed to the plant as required.

The average annual energy savings achievable with VHPC, compared to a system with fixed head pressure set-points are as follows:

- Fixed Head Pressure = 25°C → 9% to 12% of high stage compressor power consumption.
- Fixed Head Pressure = 30°C → 20% to 25% of high stage compressor power consumption.

The savings are greater with higher fixed head pressure, as the system is able to run on a lower head pressure for a greater portion of the year. However, note that VHPC cannot be implemented in refrigeration plants operating with synthetic refrigerants.

Implementing VHPC requires the following equipment and engineering:

- A PLC with sufficient programming capability;
- Variable speed drives (VSDs) on all condenser fans;
- An ambient humidity and temperature sensor;
- Load state for all high stage compressors;
- Site specific control algorithm.

FACT BOX: WET BULB TEMPERATURE

Wet bulb temperature refers to the temperature air would be if it reached 100% relative humidity. It is a specific measurement made for engineering purposes, NOT simply a temperature measurement!

During a rainfall event, the ambient temperature is equivalent to the wet bulb temperature. However if conditions are very dry, then the wet bulb temperature is significantly lower than the ambient temperature. Wet bulb temperatures are therefore much more stable than ambient temperatures, and also typically much lower.

FLOATING HEAD PRESSURE

Another method which can be implemented to improve the energy efficiency of the refrigerant plant is to “float” the head pressure, rather than applying VHPC. This technique involves running the condenser fans at full speed, which then allows the head pressure to float depending on the ambient conditions and the load profile of the plant. However, floating head pressure (FHP) does not achieve the same improvements in energy efficiency as VHPC and does not achieve the same level of plant stability. This can be explained by referring to Figure 1; the floating head pressure will achieve the minimum head pressure for a given condition (extreme left of graph), but not the minimum total power.

The advantages and disadvantages of VHPC and FHP are summarized in Table 2.

Technique	Advantages	Disadvantages
VHPC	• Significant energy efficiency gain • Stabilises the plant	• Not available for Freon plants
FHP	• Energy efficiency gain	• Can lead to plant instability • Constant running of condenser fans leads to additional energy use.

Table 2 - Advantages and disadvantages of VHPC and FHP techniques