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Topic

Improving the Energy Efficiency of Cooling Systems

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Improving the Energy Efficiency of Cooling Systems

Crunching the Numbers

The efficiency of a refrigeration system has a direct effect on a business' environmental and financial performance. This should be in every end-user's mind when selecting and operating cooling equipment.

There are a various ways of reducing energy consumption through a number of approaches that require little to no monetary investment. The first one is a reduction in heat load. The more the load is reduced the lesser the cooling required both in terms of capacity and duration. Many refrigeration systems are running at lower temperatures than actually required which increases energy consumption. Selection of the most suitable components for a given application along with measuring and analysis of the system are important to ensure that over years of operation, a refrigeration system is running as efficiently as when it was first commissioned.

Approximately 80% of the energy used in an industrial refrigeration system is accounted for by the compressor. Most industrial cooling, HVAC and heating systems can typically make a 10% reduction in energy by making small changes and it could be paid back within a year. This short payback period should be palatable for any forward thinking business but surprisingly few chose to act.

Reducing Heat Load

Good dock seal and door management prevents air ingress into temperature controlled chambers from the ambient and adjacent, higher temperature rooms. Warm air entering into chill and cold rooms adds both heat load and moisture. The refrigeration plant draws extra electricity to maintain the room temperature and moisture can pool on floors causing a slip hazard. The example below demonstrates that for every cubic meter per second of air entering into a +2°C chill room, the extra energy consumption could be £10,000 per year just from having a small gap by the door.

Reducing the electrical load of components such as lighting and fans in a temperature controlled facility delivers a double benefit.

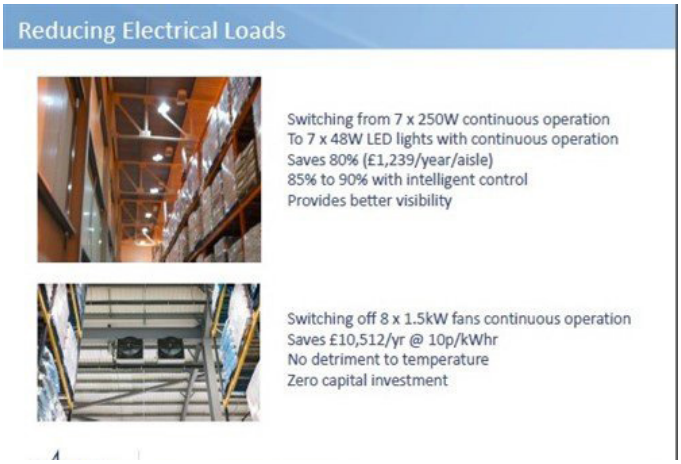
Lighting is a continuous load for many buildings including offices and warehouses. The heat emitted by lighting enters the room and it is then extracted by the cooling equipment. This is a double penalty as you are not only paying for the lighting electricity but also the refrigeration or air conditioning power to remove the heat. Switching to LED lights has a number of benefits, including intelligent control sensors which will result in significant energy savings.

The development of LED lighting and intelligent control began in offices, homes and other ambient temperature facilities, reducing lighting load through lower energy bulbs but also the use of intelligent lighting control which switches lights off when areas are unoccupied.

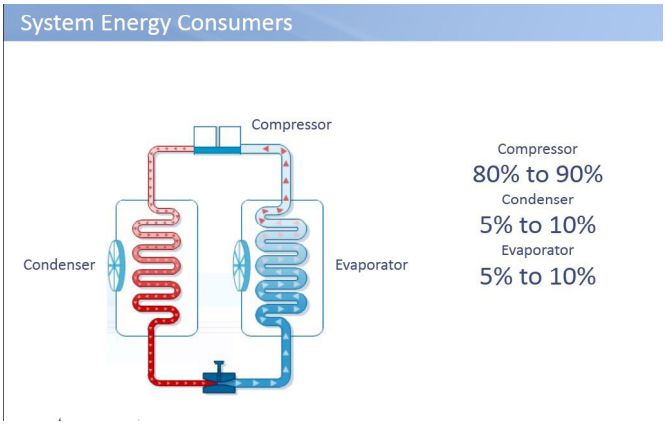
More recently, this technology has been implemented in temperature controlled warehouses, particularly cold storage facilities. Following below there is an early example of such a facility where a trial was undertaken to demonstrate the benefit of LED lighting. The seven existing sodium based lights consumed 250W each and had to be left on 24/7 due to the time taken to warm up again if switched off. They were replaced by 7 off 48W LEDs. This immediately reduced lighting power by more than 80% and with intelligent control, the annual saving is between 85% and 90% based on aisle usage. The reduction in energy has the added benefit of lowering load on the refrigeration plant. For a typical cold store, every 2kW saving in lighting energy reduces the refrigeration plant power consumption by 1kW.

Additionally, electrical usage can be reduced by experimenting with switching off booster fans. If you switch them off and there is no immediate effect on temperature control, you have an immediate saving. This action requires no capital investment and will result in lower energy consumption.

The compressor consumes around 80% to 90% of the electricity in a typical refrigeration system. Condenser and evaporator fans along with secondary pumps are examples of the other electrical users which make up the remaining 10% to 20%.



Improved compressor efficiency provides the greatest opportunity for energy reduction. Screw and reciprocating compressors are typically used for industrial applications.



Screw compressor

This type of compressor is at its optimum efficiency when operating at 100% capacity. The compressors slide valve or capacity steps to match the compressor's capacity to the cooling load requirement reduces efficiency. Varying capacity through speed control of the drive motor helps to reduce this deterioration in performance but part load efficiency is still lower than design. For systems where the load varies and there are multiple screw compressors, it is more efficiency to sequence operation so that one compressor operates with speed control and the other only runs at 100% capacity and speed.

Reciprocating compressor

The efficiency of a reciprocating compressor differs to that of a screw in that it can increase at lower speeds. This makes it more suited for variable cooling load applications. Where there are multiple compressors on a single system, optimum efficiency is achieved by operating all compressor with variable speed control and changing speed based on cooling requirements.

Fans and pumps

Fans and pumps are used to circulate air or liquids.

Controls have typically been on or off depending on cooling requirements but this isn't the most efficient way to operate them. The power consumption of a fan or pump varies with flow rate according to the power law. For example, having a fan run at 75% speed delivers a proportional air flow, yet only consumes around 42% of the power. Reducing the speed down to 50% only requires approximately 12.5% of the power. There is a huge opportunity for saving energy by reducing the speed of fans to match cooling loads. The same can be applied to pumps but care should be taken to consider the minimum speed necessary to overcome system pressure drop through pipes and valves.

The smooth control of condenser head pressure using variable speed fans has a positive effect on compressors. It avoids the spikes in discharge pressure associated with on/off control, resulting in more stable operation and less wear. Star's Aether controller bolts on to the condenser, and can optimise the condenser fan speed in relation to the heat rejection and compressor capacity.

Room Temperature

Adjusting the temperature required to cool an area, building or process can reduce energy consumption without affecting the output. In one case study, we raised the store temperature from +2˚C to +5˚C to deliver a significant saving to the end user. This and other simple changes resulted in up to 20% energy savings in the distribution centre, without a lot of investment. Half of this saving was made through the simple change in store temperature.

Performance Measurement and Monitoring

By monitoring and assessing refrigeration equipment and operation with energy management systems specifically design for refrigeration systems, you can improve overall energy efficiency. The readings of operating temperatures, pressures, etc. give real time data measurement and allow users to benchmark system performance. This can then be analysed and optimised to improve overall performance. Star's Ethos system makes it really easy to see what improvements could be made, how much capital investment is required and how much money will be saved.

Summary

Improve energy efficiency by:

• Minimise the heat loads going into the plant with better door control and reduced electrical loads

• Improve refrigeration plant performance by looking at compressor, fan and pump control.

• Continuously monitor and assess the performance, and compare with what the plant was doing last week, last month, last year.

For further information, contact **rlamb@star-ref.co.uk**

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