



Refrigeration efficiency ignored at slaughterhouse in pursuit of a heat recovery system.

During a survey at a leading independent slaughterhouse, it was found that the refrigeration system was operating at a higher-than-expected fixed condensing temperature.

It is best practice to float condensing temperature down as low as possible against the ambient temperature this is probably the biggest potential area of energy saving in refrigeration.

Depending on the load, condenser design and condition a typical refrigeration system should be condensing at 12-15°C above the ambient temperature.

As condensing temperature (discharge pressure) increases two things happen, cooling capacity reduces and absorbed power from the compressor increases.

The rule of thumb is for each 1°C increase in condensing temperature refrigeration efficiency reduces by 2-4%.

Refrigeration efficiency is expressed as a coefficient of performance (COP) and is the cooling capacity (kW) divided by the absorbed power (kW from the compressor).

A COP of 4.1 means for each 1 kW of input power you get 4.1 kW of cooling.

During the survey of the slaughterhouse it was found that a heat recovery system had been retrofitted to provide hot water for part of the production process.

When the new heat recovery system had been installed it was only achieving water temperatures of 25-30°C, this was not hot enough for the process and created a potential issue with ¹legionella.

To heat the water to the required temperature, the condensing temperature had been increased to 50°C much to the detriment of refrigeration efficiency.

As part of the installation, a heat exchanger had been installed in the pipework between the compressor and condenser. This is where the high-pressure superheated vapour (aka discharge gas) is at its hottest.

Discharge gas temperatures can range from 60 °C to 100°C the largest part of the energy available for heat recovery is lower grade heat as the refrigerant changes phase and condenses into a liquid.

Small amounts of high-grade heat is available from removing the discharge superheat required before the condensing process can begin.

As condensing temperature increases the harder the compressor works, the more heat is generated, and heat is transferred to the vapour leaving the compressor and the oil.



The table below is Bitzer's the manufactures performance figures at full load for a screw compressor, the model is CSH 8563-125Y operating on R407c at an evaporating temperature of -8°C.

Condensing Temp Dew Point °C	Cooling Capacity kW	Absorbed Power kW	Discharge Gas Temperature °C	COP
30	235	58.1	62.9	4.04
35	220	64.5	70.7	3.42
40	205	71.9	79.7	2.85
45	188.7	80.5	90.1	2.34
50	171.5	90.3	102.3	1.9

The table below is a performance comparison at 2 different condensing temperatures.

Condensing Temp Dew Point °C	Cooling Capacity kW	Absorbed Power kW	COP
35	220	64.5	3.42
50	171.5	90.3	1.9
Difference +/-	-48.5	+25.8	-44.44%

In this situation, the end-user was trying to raise the mains water temperature to 60°C, which in the UK can typically be between about 10°C and 20°C.

When considering heat recovery, it is possible to produce medium temperature water and then use a heat pump or heat pumps in a cascade system to raise water temperature. The advantage of this is that smaller heat pumps can be specified, which do not have to work as hard and can obtain very high COPs. This is because ²heat pumps work more efficiently the higher the source temperature and the lower the required delivery temperature.

In a race to reduce greenhouse gasses, there is a major push to reduce the burning of fossil fuels and heat recovery is a very important tool to help decarbonise.

Heat recovery can work very well, especially where both heating and cooling are required, in some cases, the waste cooling produced by the heat pumps can be used elsewhere for example subcooling of the liquid line.

³High-temperature ammonia heat pumps have also proven to be significantly more efficient than F-gas heat pumps and will play a major part in the future.

However, it can be extremely complex, and an issue to consider is the actual load as opposed to the design conditions or peak load which can vary considerably.

It would be nice if the load remained constant, but this is seldom the case.



This issue has been seen many times where combined heat and power (CHP) has been installed and the heat load has been incorrectly calculated and waste heat must be dumped.

¹A suitable and sufficient assessment must be carried out to identify and assess the risk of exposure to legionella bacteria from work activities and water systems and any precautionary measures needed. For more details <https://www.hse.gov.uk/pubns/priced/l8.pdf>

² Institute of refrigeration- Service Engineers Section Good Practice Guide 84.

³ Institute of refrigeration- Ammonia Heat Pumps Helping to De-Carbonise Food and Beverage Industries.