Case study – cooling in food industry

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Resource Efficiency of Refrigeration systems

Refrigeration systems often represent the largest electricity user in food and drink factories. Keeping refrigeration operating at best efficiency is very important but is often ignored because users are often unsure

how to set up an effective information system on their efficiency

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Monitoring Strategies

Stacit snap shot (audit) : Indirect Assessment of Plant Faults

Assesment of the performance of individual items of plant, such as condensers, to identify specific types of fault that need to be remedied. Collecting instantaneous data (e.g. temperatures and pressures) and comparing these data with “expected values” and diagnose different types of plant fault. Static audit approach can be very effective in identification of improvement options.

Information system: Direct Monitoring of Performance

This involves measuring the power input into the plant over fairly long periods of time (e.g. weekly) and estimating the amount of cooling done in the same period, either by direct measurement or through calculation. This strategy allows you to build a comprehensive picture of plant performance over time and discover additional potentials for improvement to the static audit approach.

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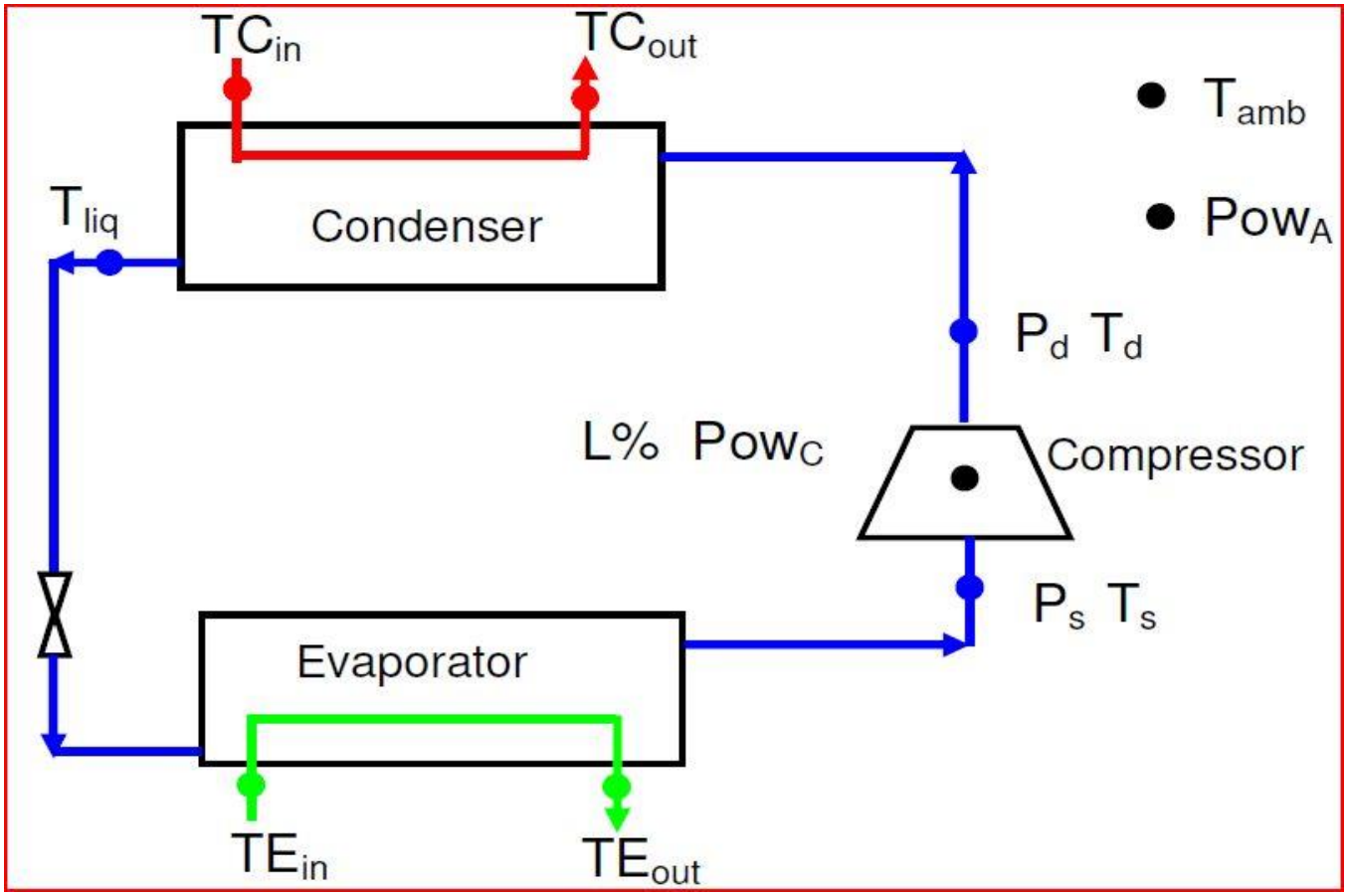
Indirect Assessment of Plant Faults

plant operating data to be collected within a snap shot

Source: Institute of Refrigeration, UK



Compare Data Snapshot with Expected Values

Expertise on given technology is needed, expected values for each snapshot parameter can vary with ambient temperature, cooling load and product temperature.

Fairly detailed plant design data is required to calculate expected values of temperature differences and pressures (most of the required design data should have been supplied when the plant was installed and during commissioning tests).

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Look for fault symptoms

Condensers: Inefficiencies linked to condenser problems always result in a compressor discharge pressure that is too high. A high discharge pressure reduces the system efficiency whilst at the same time it also reduces the amount of cooling being done. Most condenser faults are associated with a heat transfer problem that causes the condenser to operate inefficiently.

Evaporators: Evaporator faults are also common and easy to spot. Inefficiencies linked to evaporator problems always result in a compressor suction pressure that is too low. A low suction pressure reduces the system efficiency whilst at the same time it also reduces the amount of cooling being done (sometimes by a significant amount). Most evaporator faults are associated with a heat transfer problem that causes the evaporator to operate inefficiently.

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Look for fault symptoms

Compressors: Compressor faults can be more difficult to spot. Compressor problems can relate to mechanical damage inside the compressor or to undesirable pressure drops due to blockage.

Expansion valves: Expansion valve problems can be linked to the valve being open too much (leading to unwanted bypass of high pressure vapour through the valve) or being closed too much (leading to starvation of liquid feed to the evaporator).

Controls: There are numerous controls on refrigerant plants that could be set incorrectly or that could be operating badly.

Cooling load: The cooling loads themselves need to be checked to ensure they are not higher than necessary.

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Direct Monitoring of Performance

Use of “integrated data” measured over long periods of time e.g. kWh consumption of compressors. This data is used to estimate plant efficiency which can be compared to expected values.

Refrigeration Plant Performance cen be measured through

- The amount of cooling being carried out, Q, measured in kW.
- The amount of power consumed, P, also measured in kW.

Then we can calculate the plant efficiency in terms of the ratio of cooling carried out to power consumed (Q/P). This is known as the COP or Coefficient of Performance.

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Is specific COP good or bad?

Ideally we want the COP to be as high as possible, because that means we are getting more cooling for each kW of power input

We want:

- The evaporating temperature of the refrigerant to be as high as possible
- The condensing temperature of the refrigerant to be as low as possible

For one particular refrigerant plant many of the parameters that influence COP are fixed. In most situations the plant design is “fixed” and the product temperature is always approximately the same. However, if you measure a “snapshot” of the plant COP on two occasions it is normal that the COP could be significantly different. This is because

COP is very sensitive to:

- Ambient temperature
- Plant load

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You Need to Establish a Range of "Expected Values for COP"

Expected Compressor COPs
(for a plant chilling a room to +2° C)

Plant Cooling Load	Ambient Temperature [° C]	Expected Best COP
100 [%]	25	4.2
	15	5.9
	5	7.0
50 [%]	25	4.0
	15	5.5
	5	6.5
25 [%]	25	3.5
	15	4.8
	5	5.5

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Setting up a Monitoring Programme

For most food and drink sites a weekly monitoring interval is appropriate.

COP = Cooling carried out during period (kWh) / Electricity used during period (kWh)

COP should be compared with an expected value based on the plant design, the average plant load and the ambient temperature - the COP data (including both measured and expected values) can then be plotted on a week by week basis to try and spot adverse changes in performance – approach known from **Monitoring and Targeting**

If the measured COP is lower than the expected value then you should **carry out fault assessments** using the first „audit strategy“ **to identify the cause of the inefficiency**

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Options to Measure or Estimate the Cooling Load

- **Direct measurement.**
  In some cases you can measure a flow rate and a temperature difference to directly calculate the heat load utilising heat meter (expensive if an accurate measurement is to be obtained)
- **Estimate based on production throughput**
  If the load is dominated by process cooling then it is quite easy to relate the load to the tonnes of production
- **Estimate based on load modelling**

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