farm energy centre

Milk Cooling Costs Final Analysis

Technical Note 53

A jointly funded project between the Farm Energy Centre and the Milk Development Council has been investigating the cost of cooling milk with different types of cooling equipment. Twelve farm installations have been monitored over a 12-month period and results are now available.

Results

Due to the normal variation in standard practice on farms, several adjustments have been applied to enable direct comparisons to be made between the different cooling systems.
These are as follows:

- The milking time has been adjusted so that they all start at the same time. This is important as it determines the amount of night rate electricity that can be utilised.
- The amount of cooling that can be achieved by a plate cooler varies and this was confirmed by the trial results. It has been assumed that the plate cooler removes 10°C from the milk temperature.
- Water costs have not been added to the running costs as this can vary considerably depending on:
  a) the water source
  b) reuse of the water after it has passed through the plate cooler
  c) The quantity of water passing through the cooler.
  If the water to milk ratio is 1:1 and the water is not reused the cost would typically be 6.4p/100litres of milk cooled. It can be seen by this that the water must be reused otherwise any electricity cost savings are offset by the cost of the water.
- The addition of a plate cooler will reduce the compressor operating time towards the end of each milking. As the end of the morning milking normally extends into the day rate period, most of the reduction in electricity consumption comes from the day rate leaving the E7 consumption almost unaffected. If all the compressor running time is during the E7 period, the potential running cost savings are less because E7 electricity costs less than day time electricity.
- All the farms are on an Economy 7 type tariff and the times are not adjusted for BST. The hours for the cheap rate economy 7 tariff are 12.30am to 7.30am GMT and 1.30am to 8.30am BST
- Electricity is charged at E7 type tariff - 8.5 p/kWh day rate 2.7 p/kWh night rate
- An Economy 7 controller when fitted arranges to build as much ice as possible during the Economy 7 night period.
- The size of the ice storage for an ice bank tank - it was assumed that the ice storage capacity was capable of cooling 60% of the volume of milk stored in the tank.

Table 1 overleaf shows the actual running costs adjusted to take into account the previously described factors. The annual running cost is based upon an annual yield of 455,000 litres (70 cows each yielding 6,500 litres p.a.).

Annual Running Costs

The illustration of annual running costs in table 1 shows that the addition of a plate cooler and an Economy 7 controller can produce reasonable running costs for an old ice bank tank. Once low running costs have been achieved such as £243 for a DX with plate cooler and an ice bank tank with plate cooler and E7 control - £193, the running costs do not become such an issue. The difference of £50 indicated above could quite easily be reversed by the variables that were discussed earlier. ***It is worth noting that a reduction of 1p/100 litres would only give a saving of £100 p.a. even when producing 1,000,000 litres.***

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Table 1

A Comparison of Milk Cooling Costs #

Type of Cooling System	Cost - p/100 litres of milk cooled	Annual running cost £
DX (using E7 where possible)	8.43	384
DX with mains water plate cooler (using E7 where possible)	5.34	243
old ice bank tank without an E7 controller	16.31	742
old ice bank tank without an E7 controller and with a mains water plate cooler	10.22	465
old ice bank tank with an E7 controller	12.44	566
old ice bank tank with an E7 controller and with a mains water plate cooler	6.35	289
new ice bank tank with an E7 controller	8.01 (5.98)*	364 (272)
new ice bank tank with an E7 controller and a mains water plate cooler	4.24*	193
DX and ice builder	5.98**	272
DX and ice builder with a mains water plate cooler	4.24**	193

 # Under the specified conditions laid out earlier
** All the ice is produced during the E7 period (large ice storage capacity or every day tank used for EODC)*
*** All the ice is produced during the E7 period and all the milk cooling is done by the ice builder*

A New Installation

With an efficient new installation running costs become less of an issue than other factors such as capital cost, compressor size, building alterations and speed of milk cooling. The key points worth consideration when purchasing new equipment are detailed below:

Every other day collection (EODC)

In most cases the running cost of a new every day collection (EDC) tank will be very close to that of an EODC tank because most of the cost of running a tank is cooling the milk, not keeping it cool.

Although, for a given milk production, the energy consumptions of every day and EODC systems are similar, an every day ice bank tank used as an EODC tank can be cheaper to run than an EODC tank used for EODC because it has bigger ice reserves that can all be produced during the E7 period. This is because most ice bank tanks have an ice storage capacity sized to be able to cool 60% of the daily milk production, all of which can be produced during the E7 period. For example, the ice reserves in a 2000 l every day tank can cool 1200 l compared to 600 l for a 2000 l EODC tank. A farm producing 1000 l/day with a 2000 l every day tank would be able to cool all the milk using ice produced during the E7 period with a bit to spare, a 2000 l EODC would only be able to cool 600 l and the compressors would have to run during the day rate to cool the remaining 400 l. This is especially relevant when considering the purchase of a reconditioned every day tank for use as an EODC tank.

Physical size of the tank

In some cases an EODC DX tank will fit into the same building as an old every day ice bank tank. This is less likely to be the case for an EODC ice bank tank, although new ice bank tanks tend to be higher with a smaller footprint.

Ice builders can be situated some distance from the bulk tank giving added flexibility in installation.

Electricity supply

The compressors for a DX tank alone will typically be at least twice the size of those for an equivalent ice bank tank. This can 'eat into' the farms electricity supply. In a limited number of situations supply reinforcement may be required which can be expensive.

Future electricity supply requirements should also be considered. Larger compressors are more likely to be three phase than single phase.

Integration with an existing parlour

This relates specifically to the installation of plate coolers (mains or chilled).

The performance of any plate cooler is reduced by high capacity milk pumps. The installation of a balancing tank, milk pump speed control or a simple valve to reduce the milk flow rate through the plate cooler will all improve the performance by varying amounts. The added installation costs may however be prohibitive.

DX / ice builders - at high milk flow rates it is more difficult to cool the milk to 4°C before it reaches the tank. This will mean that the DX part will be required to remove the last 2-6°C, resulting in increased use of day rate electricity and increased cooling costs. The use of a larger plate cooler and/or reducing the milk flow rate as above will help to solve this problem.

Speed of cooling

A DX tank with an appropriately sized compressor will cool milk at the same speed as an ice bank tank. The addition of a mains water plate cooler will reduce the milk cooling time by the same amount in both cases.

The addition of a plate cooler supplied with chilled water can give almost instant milk cooling. The chilled water supply can be from a separate ice builder or, in the case of ice bank tanks from the existing chilled water supply.

Effect of a power cut

A DX tank will need a larger standby generator than an ice bank tank due to its larger compressor size.

Once power is restored a DX tank will cool the milk just as quickly as it would normally. In the event of low ice reserves remaining in an ice bank tank the speed of cooling will be significantly reduced until the ice reserves are rebuilt.

Reliability

DX tanks are much simpler than ice bank tanks hence increased reliability/reduced maintenance costs would be expected. In practice ice bank tanks are extremely reliable and there is little difference between the two. An experienced local dealer with good manufacturer backup is very important.

Compressor

Type

Hermetic - the least efficient and normally the cheapest. The compressor itself (not the condensing unit) is 'sealed for life' and cannot be taken apart therefore repairs are limited to a replacement unit.

Semi hermetic - most widely used, most bulk tanks over 10 years old will have this type. They are more expensive, but more efficient than a hermetic compressor. The compressor can be taken apart and repaired but anything other than very simple faults need a 'factory rebuild'. Reconditioned/rebuilt units are widely used as replacements rather than trying to repair a compressor on the farm.

Scroll - relatively new to the agricultural market but with a rapidly increasing market share. They have been widely used in other industries for several years. They are the most efficient type, up to 10% better than a hermetic compressor, but they tend to be the most expensive. However prices are falling and the more popular sizes can be the cheapest of the three types available. The

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compressor itself is 'sealed for life' as with the hermetic. It is however a rotary rather than a piston compressor, this results in fewer moving parts, quieter operation and lower starting currents.

Size (kW)

This is normally quoted as the power drawn by the compressor motor. For a DX tank the compressor should be big enough to ensure that the milk is cooled to 4°C within 2.5 hours of starting milking. For an ice bank tank the compressor should be at least big enough to build the ice to its maximum level during the E7 period.

The sizes of different compressor types for the same tank should be similar, the difference in performance between them is minimal and should have little effect. Any differences usually result from selecting the model closest to the actual requirement, different types will not necessarily have models of exactly the same size.

Installation

Ensure good airflow to and from the condensing unit. Anything that restricts the supply of fresh air and/or causes the recirculation of warm air will increase running costs and reduce compressor life.

Easy access to the front of the cooling fins on the condensing unit will help to ensure that they are cleaned regularly.

Insulation of refrigerant pipes - the pipe supplying liquid refrigerant to the tank/ice builder should not be insulated, the pipe returning the gaseous refrigerant to the compressor should be insulated.

Refrigerants

Most new systems are fitted with R22. This is a HCFC (less ozone unfriendly than CFCs) and its production, but not use, will be phased out by the year 2015. The most likely replacement for R22 will be R407c. This is a HFC and it is totally ozone benign (friendly).

R407c is currently more expensive than R22. It is expected that as 2015 approaches the cost of R22 will increase to that of R407c as its production is reduced.

Plate cooler

The bigger the better within reason. Water to milk ratio. Manufacturers recommend a ratio of 2:1, in practice 1:1 is more typical. This should form the basis of more realistic energy savings. Ensure that the water supply is capable of giving a realistic water:milk ratio otherwise a header tank and pump may need to be installed to give a reasonable performance. Mains water should be supplied via a type 'B' air gap or be fitted with a double check valve (Water Byelaws).

A time delay solenoid valve should be fitted to the water supply so that the water flow starts at the same time as the milk pump and continues to flow for a short time after the pump has stopped. This will improve the performance of the plate cooler whilst efficiently using the water. The time delay should be no longer than 20-30 seconds.

All the water should be reused, if mains water is going to waste the economics of plate cooling are questionable. This does not apply to bore hole or spring water as it costs very little, however if it is disposed of via the slurry / dirty water system additional 'hidden' costs can be incurred.

For a new installation and if the plate cooler can be used all year round without wasting the water it is possible to reduce the size of the compressor on a DX tank by up to 33% whilst keeping cooling speeds within acceptable limits; this is not common practice. It is worth noting that mains water is normally warmer during the summer months hence the plate cooler will be less effective. The compressor will also be working harder as a result of higher ambient temperatures. The size of an ice bank tank compressor is normally unaffected because it is dictated by its ability to build maximum ice during the E7 period and not by the speed of cooling.

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