How effective is your plate cooler?

1. Introduction

Pre-cooling milk with one or more plate coolers is the first stage of milk cooling undertaken on most Australian dairy farms. Plate coolers can be an extremely cost effective way to cool milk but are poorly utilised on many farms. This Quick Note gives some practical checks that can be made to make sure yours is working to its potential.

2. Interpretation and relevance to Australian conditions

Surveys show that milk cooling accounts for about 30% of the total energy costs of operating a dairy, so designing and operating an efficient milk cooling system can significantly reduce energy demand and shed operating costs. Plate coolers are very efficient at taking heat out of milk. They play an important part in ensuring milk is cooled quickly for storage, reducing the demand for electrical energy and are extremely cost effective if a source of naturally cool water is freely available.

3. Factors affecting performance of plate-coolers

There are several factors which can impact on the efficiency of plate coolers. These are:

The relative flow rates of cooling fluid and milk

The system should be designed based on the peak flow rate of milk expected from the milk pump. An even flow of milk from the milk pump (variable speed drive) will help make the plate cooler system easier to size and make more efficient use of the cooling water. Using a transfer (rather than pressure) pump to supply the cooling fluid is preferable. 'M-series' plate coolers work most efficiently with a water to milk flow ratio of 3:1, whilst 2:1 or even 1.5:1 is adequate for the newer industrial models.

Available surface area

The maximum flow rate of milk expected from the milk pump will determine the type of pre-cooler (size of the plates) and number of plates required.

Plate compression

Plates that are too tight will restrict flow. Allow about 3mm for each plate and gasket (certainly not less than 2.3mm).

Plate cleanliness

Contaminants in either the water or milk that adhere to the plates will affect their heat exchange capacity and reduce their performance. Blockages to the flow can restrict flow over the heat exchange surfaces.

Source water temperature

Most plate coolers use water that is sourced from the coldest water available on the farm. Although some fluctuation in source temperature can be expected over the year, this is an inexpensive way to initially reduce the temperature of the milk from around 35^{o}C to 18 - 20^{o}C, reducing the load on the refrigeration system significantly.

Correct plumbing

The cooling fluid should flow in the opposite direction to the milk. If not, the heat transfer is reduced. Some advisers insist that the milk be pumped into the bottom of the cooler so it fills all plates evenly (at low flow rates) as it rises to the top of the plates to exit.

4. Checks for your plate cooler

Testing the effectiveness of your plate cooler

The easiest way to check the effectiveness of your plate cooler is to compare the temperature that the milk leaves the plate cooler with the incoming temperature of the cooling water. A plate cooler that is working efficiently should cool milk to within 2^{o}C of the temperature of the incoming cooling fluid. For example, if the temperature of the incoming cooling water is 18^{o}C, the temperature of the milk exiting the plate cooler should be about 20^{o}C.

One simple way to check this is to use the PVC strip thermometer provided by CowTime. These thermometers have a paper backing on them, which you can peel off and stick directly onto clean dry metal pipe.

Step 1:

Locate the water inlet pipe and the milk outlet pipes as they enter and leave the plate cooler respectively.

Step 2:
Find a location for the thermometer that allows it to wrap around the outside of the water inlet pipe. You may need to move the rubber hose a little to get enough room to fit the thermometer on the metal pipe. A piece of electrician's tape or gaffer tape on each end of the strip can help you with initial positioning. Rotate the thermometer to ensure the temperature range you expect from the pipe is visible. Repeat the process by applying another thermometer strip to the milk outlet pipe.

Step 3:
You will see the temperature blocks light up with the brightest one being the temperature of the pipe. At the next milking check to see if the required temperature range is visible.

Step 4:
Remove the tape on thermometer strips and once the pipes are clean and dry, remove the paper backing and stick the strip thermometers permanently to their respective pipes.

Step 5:
Check the two temperatures during peak milk flow from the milk pump. If you get more than 3°C of difference – there is room for your plate cooler's performance to be improved.

A strip thermometer attached to the milk outlet pipe.

Checking the cooling fluid to milk flow rate ratio

Consider checking the water and milk flow rates through the plate cooler if the temperature difference measured above is greater than 3°C. Use a bucket of known volume (ie a 20kg detergent container = 23 litre bucket) and a stop watch. Flow rate (litres/second) is calculated by dividing the number of litres (L) by the time in seconds it takes to fill the bucket (secs).

Step 1:
Turn on the plate cooler (water) pump and record the time taken to fill the bucket at the plate cooler cooling water discharge point. You should measure at the discharge point to account for any flow rate restrictions in the pipe work downstream of the plate cooler. Calculate the cooling water flow rate. For example it may take 15 seconds to fill a 23L bucket (23 divided by 15 = 1.5L/sec)

Step 2:
At the next milking, if it is easy to do, record the time taken to fill the bucket with milk at the vat entry point. For example it may take 45 seconds to fill a 23L bucket (23 divided by 45 = 0.5L/sec). Aim to take this measurement while the milk pump is working at capacity (ie lots of clusters attached to cows at peak milk flow – just after cupping up a whole side). For larger dairies and bottom loading vats these measurements are best undertaken using water (instead of milk) at a simulated milking.

Step 3:
Divide the cooling fluid flow rate by the milk flow rate to determine the ratio. In our example this would be 1.5 divided by 0.5 = 3. Therefore the cooling fluid flow rate is 3 times the milk flow rate – a ratio of 3:1.

5. Potential issues with implementation

Improving the efficiency of plate cooling is likely to require the services of a skilled technician. Cleaning the plates is not an easy task – taking several hours and is best left to an expert. Inefficient systems may need resizing, extra pumping capacity, additional cooled water storage or a complete dismantle and service. The additional capital and service costs should be compared to the annual costs of using an inefficient plate cooler (Table 1). The costs of an inefficient plate cooler, as determined by the difference in temperature of the incoming cooling fluid and the out-going milk, increase in proportion to the annual milk production of the farm.

		Annual milk production (litres)								
		400,000	500,000	750,000	1 million	2 million	4 million	5 million	7 million	10 million
Temperature difference (°C) **	**1**	$24	$31	$46	$61	$122	$244	$305	$427	$611
	2	$49	$61	$92	$122	$244	$488	$611	$855	$1,221
	3	$73	$92	$137	$183	$366	$733	$916	$1,282	$1,832
	4	$98	$122	$183	$244	$488	$977	$1,221	$1,710	$2,442
	5	$122	$153	$229	$305	$611	$1,221	$1,527	$2,137	$3,053
	6	$147	$183	$275	$366	$733	$1,465	$1,832	$2,565	$3,664
	7	$171	$214	$321	$427	$855	$1,710	$2,137	$2,992	$4,274
	8	$195	$244	$366	$488	$977	$1,954	$2,442	$3,419	$4,885
	10	$244	$305	$458	$611	$1,221	$2,442	$3,053	$4,274	$6,106
	15	$366	$458	$687	$916	$1,832	$3,664	$4,580	$6,411	$9,159

Table 1: Annual costs ($) of inefficient pre-cooling.

Assumes refrigeration would be required to remove the extra heat at an electrical tariff of $0.15 per kWh (averaged from peak & off peak rates encountered over typical Australian milking times).

**The temperature difference used here is over and above the 2 degrees expected by from an efficient plate cooler.

Source: Barber, M. (2005)

6. Robustness of this information

This information has been confirmed by milk cooling specialists and milking machine technicians. It is also supported by economic modelling work undertaken by Sustainability Victoria.

7. References and further reading

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Hakim, G. and Schmidt, W. (1994), Cooling milk on dairy farms. Dairy Research and Development Corporation, Melbourne.

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