Key elements of milking machinery:

Getting to grips with claws and clusters

Focal point of every milking parlour has to be the teat cups – and the claws into which those cups feed their milk. If these two items fail to work efficiently, the rest of the parlour's pipes and pumps count for little indeed. Andy Collings discusses the importance of these two elements with Green Oak's Roy Birchall

The milking machine as we know it today was not an overnight phenomenon or, for that matter, the brainchild of a single individual. Far from it. Its development continued to tax the minds of a large number of mechanical maestros for over 50 years before a satisfactory system finally emerged.
Not that the world's inventors were slow in devising new systems, many of which, it has to be said, were rather extreme and took little if any notice of the cow's well-being. Some of the earliest examples just used tubes (catheters) that were inserted into the teat to force the sphincter muscle open and allow the milk to flow from the udder. Inventors of this system developed it further by attaching tubes to the teats to encourage the milk to actually end up in a bucket and, in doing so, also ensured the risk of contamination was greatly, yet unwittingly, enhanced.

The earliest vacuum systems put in an appearance back in the 1850s and used a hand-operated pump to create a continuous vacuum that drew milk from the teats. Downside here was the vacuum caused damage to the mammary tissue.
Interesting to note that, while most of us will relate to these vacuum-type milking systems, there were, also at this time, pressure machines that tried to copy the action of the human hand as it pulled and squeezed the teat when milking. These types were not overtly successful due to their inability, it is reported, to adapt to different sizes of teat and their tendency to force some of the milk the wrong way.
It took until 1898 before the pulsator first debuted in a machine called the 'Thistle' milking machine. Powered by a steam-driven vacuum pump, the Thistle proved to be an efficient solution that overcame most of the problems encountered by the earlier machines, although those issues relating to efficient sanitation had still to be resolved.

Yet even while the pulsator system, which created a favourable intermittent flow of milk from the teats, was receiving official approval, kit inventors continued in their quest to come up with better mechanical devices that could mimic the action of the human hand when milking.
Today, most would consider such devices with their rollers and complicated drive systems as bordering on the bizarre and completely alien to the modern parlour – and probably totally unsuitable for the long-term welfare of the cow.
But to bring this section to a close, let's finish with a patent that was filed in 1910. This used a vacuum milking system, but had the addition of a wire connected to a battery. The cow was encouraged to let her milk down by giving her an electric shock; one can only hope it was a short-lived design that was never actually built or used.

High-yielding dairy cows won't be happy unless the farm's milking equipment, including those all-important cups and claws, is performing efficiently.

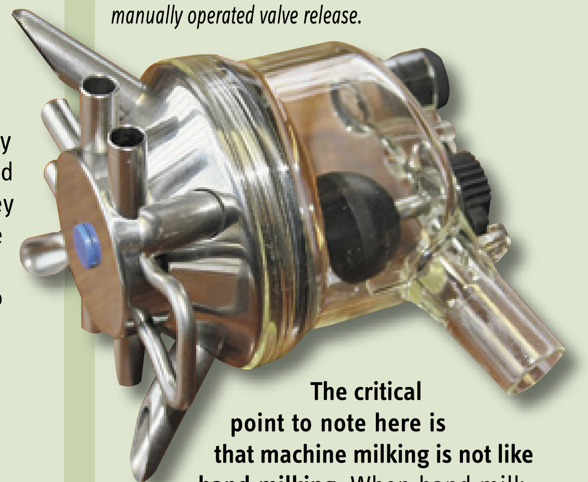
Anyway, sense prevailed and it was the pulsator system that became the industry standard. By the early 20th century most large farms were relying on it to milk their cows, and it was not long before smaller farms adopted the same system too. And, if cows could have a say on proceedings, they would probably all sigh with some relief that 50 years of experimentation had at last come to an end.
It would be laboured and, for the purpose of this feature, unnecessary to relate the changes that have occurred over the last 100 years to the milking machine. Suffice to comment that there is now a greater understanding of vacuum pressures, pulsation intervals and flow rates, and there have also been advances in plastics and synthetic rubber. These, along with much improved modern milking practices, have combined to improve the efficiency of the milking parlour.
But, the strange factor in all of this is that relatively few dairy farmers or herdsmen fully understand how a milking machine works or, for that matter, how the parlour can affect the performance of their cows.
According to Roy Birchall, of Crewe-based Green Oak, a firm that specialises in milking machine components, the lack of understanding by those who are involved in operating milking machinery is amazing.
"I am always truly astounded by just how little is understood about equipment they use every day of the year," he comments. "If you are going to get the best from any piece of machinery, it is really useful to know what's going on."
So, with the help of Mr Birchall, let's have a close look at what could be described as the 'engine' of the parlour – the teat cup, the claw and the pulsator – and how its elements work, how these items can be maintained and how their respective performances may even be improved.
The first port of call, however, is to have a look at the udder; this is not a biology lesson but it's worth at least considering where the milk comes from and what it is the milking machine is having to work with. Very briefly then, the udder contains small cell sacs called alveoli, a million of which would fit in a cu. inch. Surrounded by the blood vessels that provide the raw material, the milk collects in the alveoli. When it comes to milking time, the cow's key pituitary gland secretes the hormone oxytocin, which stimulates a contraction of the muscles that surround the alveoli to squeeze the milk out into the udder's duct system. Just for the record, pressure within the udder can rise at this time by as much as three inches of mercury above atmospheric pressure.
The patient cow is now ready to be milked – the oxytocin has been released, perhaps triggered as a result of the start of the milking routine – and she now waits for the attachment of the teat cups.

The critical point to note here is that machine milking is not like hand milking. When hand milking, the milk flows out of the teat because the hand increases the pressure inside the teat; in machine milking, the milk flows from the teat because the pressure outside of the teat is lowered by vacuum, the greater internal udder pressure forcing the milk out.
It would, of course, be very convenient if a constant vacuum could be used

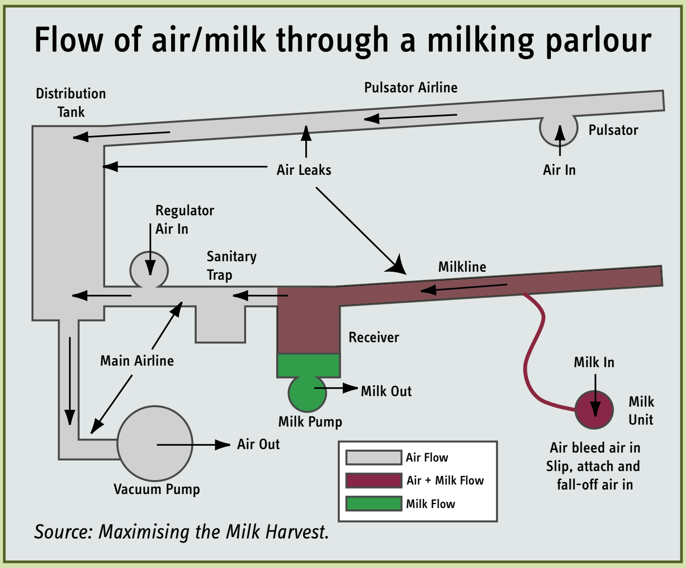
This cluster shows off its liner stem connection points – the angled pipes – and also its dual pulsation connectors – the straight metal pipes.

A high capacity claw, complete with a sight-glass, is recommended for use with high yielding cows to prevent 'flooding'. The air bleed hole is just behind the support loop.

And yet another cluster. This variant has a plastic collection reservoir and a manually operated valve release.



Choosing the right size of teat liner is important.



The system needs to be accurately sized and designed so that milk flows quickly without flooding the pipelines or, worse, backing up through the all-important cluster and the teat cups.

to simply extract all the milk. Sadly, this action is not possible because it would cause too much congestion within the teat of blood and other fluids, which need to be relieved if milk is to continue to flow.
Hence the magic of the double-chamber teat cup and the introduction of pulsation. When the vacuum pressure on either side of the liner is the same, the liner is open and milk flows from the teat. But when atmospheric pressure is allowed to enter the outer section, the liner collapses on to the teat end and helps blood to flow up the veins and reduce congestion.
While the main purpose of the pulsation is, as we've said, to reduce congestion at the teat end, the timing and action of the pulsation cycle can have a bearing not only on milking performance but also on the health of the udder, mastitis being the major concern.

The pulsation cycle comprises four main phases: The opening phase, open phase, closing phase and the closed phase. As we shall see, each performs an important role in the cycle. Check out the box to the right for a run-through of those pulsator cycle phases. All of which leads us on to the term 'pulsation ratio' – a comparison of the time spent opening and holding open the liner for milk flow, and the time spent closing and holding the liner in the closed (collapsed) position. A 60:40 ratio, for example, means 60% of the pulsation cycle is being used for the Opening and Open phases and 40% of the cycle for the Closing and Closed phases.
There is also the 'milk:rest' ratio, which relates to the ratio of time when the milk is allowed to flow and the time when the liner is collapsed and milk flow is stopped. This might be 65:35 for a pulsation ratio of 60:40, for example, depending on the liner being used.
There are a lot of variables to deal with in terms of the timing of each phase, but one of the key factors in all of this is the vacuum pressure variation that occurs during the pulsation cycle. While small fluctuations have little to no effect on the cycle, those that have variations from, say, -25kPa to -45kPa, will alter the characteristic of the cycle and, at the same time, reduce milking efficiency.

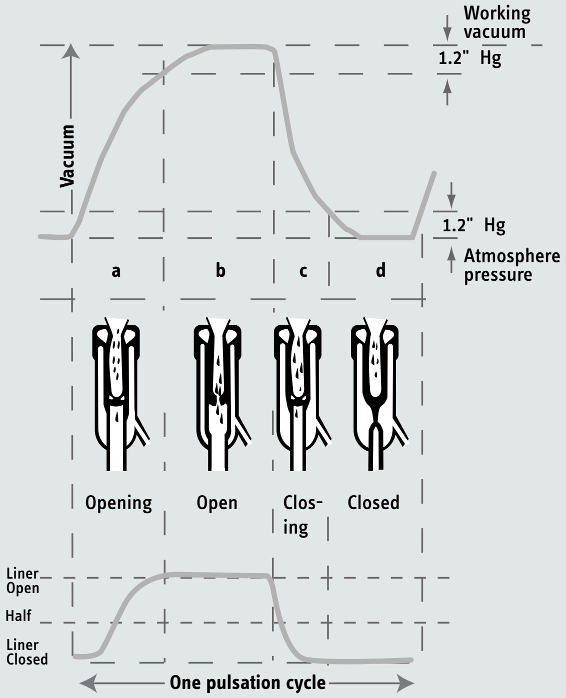
The pulsator cycle

■ The Opening Phase is when the pulsator causes the vacuum level to equal that of the machine vacuum level. Equal pressures on both sides of the liner means that it opens and the milk starts to flow from the teat.
■ The Open Phase, which lasts for about 0.5 seconds, is basically a measured hold of the opening phase, though the vacuum pressure in the pulsator-controlled side of the liner may be slightly higher than the machine vacuum level. At this point milk is flowing.
■ The Closing Phase is the point where the pulsator is allowing atmospheric air into the outer chamber of the teat cup. This causes the liner to collapse onto the teat end and milk flow to stop.
■ The Closed Phase is when the teat liner is collapsed and exerting maximum force on the teat end, massaging away the congestion and stimulating blood flow. It lasts for about 0.2 seconds – 20% of the pulsator cycle.

The complete cluster assembled. The small bore dark rubber piping carries the rinsing water for the clusters. About 300ml of water is air-blasted through the liners before the cluster is attached to another cow's udder.

A test to measure fluctuation in vacuum pressure is an essential part of discovering just what is going on within the teat cup at the time of milking. The test, called a Dynamic Test, is taken during milking at the teat cups and provides a printout of vacuum changes as they occur during the pulsation cycle.
Also worth noting here is that those who choose to employ alternating pulsation – two of the teat cups are milking while the other two are in the closed position – can usually benefit from a more even vacuum pressure during the pulsation cycle than those using simultaneous pulsation for all four teat cups.
Vacuum pressure changes can also occur during operation of the parlour – clusters being removed, vacuum gates opening, for example – and the greatest sin of all, says Mr Birchall, is to have dead-ended vacuum lines.
"Many people do not seem to realise that a closed end vacuum line, rather than one that loops back to the main vacuum tank, has a major impact on milking machine efficiency," he insists. "The fluctuation in vacuum pressure from one end of the line to the other is quite pronounced – as is the effect on the pulsator cycle – and the cows learn where to stand for the most comfortable milking."
Other factors that will have an effect on the pulsator cycle include the strength of liner. There are soft and hard liner types available. And contrary to popular belief, soft rubber liners, which collapse when only small pressure differences occur, do not apply a higher force to the teat. Teat compression rises with harder liners.
On the subject of liners, they should be changed, explains Mr Birchall, after about

Pulsation cycle explained



Source: Maximising the Milk Harvest.

Note how the vacuum pressure changes within the cycle and that, contrary to common belief, the collapsed liner in stage 'd' does not shut off the vacuum at the teat end. Fluctuations in vacuum pressure may affect pulsation cycle.

2,400 milkings, although this interval can be dependent on the type of detergent used to wash them. "They can lose their elasticity or become out of shape, both of which mean they won't work correctly."

So, you've got the pulsation cycle correct, the vacuum pressure is correct and the pressure fluctuation is minimal, the cows are milking well and all is right with the world. Well not quite. Before the milk is sent on its way to the tank, there is one more detail that can have a major effect on the whole milking job. The claw.

Aptly named because of its appearance, the claw is the point within the system where the milk delivered by those four cups comes together. It is the start of the transportation system that results in the milk arriving firstly at the air/milk separator before conveying it by pump at atmospheric pressure to the bulk tank.

"The main aim of this system is to provide an adequate flow of milk without flooding the pipes or causing any back-up through the system," he says. "For those who have yet to realise how the milk is moved from the cow to the separator, the answer is air. Air is allowed to enter the system to create a flow."

The air enters via a small hole at the claw, this hole having the effect of stabilising the vacuum pressure in the claw. Should this hole become blocked up or severely reduced in size, there is a chance that the claw will flood, vacuum pressure will fall – this affects the pulsator cycle – and there is then an opportunity for milk to back up within the teat cups and cause cross infection. All of which is bad news for both the parlour and the cow.

Clearly, it is important for the claw to have sufficient capacity to cope with the big volume of milk being delivered to it but, equally, there must also be a system that is capable of transporting the milk away. And that means having the pipework with adequate diameter that also allows for an air flow.

One of the issues that remains unresolved with machine milking is the subject of cross contamination between cows and, in particular, the spread of mastitis. It has been estimated that mastitis costs dairy farmers £200/cow/year.

While the object of this article is not to spell out measures that help to prevent the incidence of mastitis – dairy farmers should be well versed in these – the way milking plant is used and maintained can have a large influence on the spread of mastitis, both through the dairy herd and between quarters on individual cows. A recent development by a Dutch firm gets a mention here purely because it relates to the milking cluster. The Airwash is an auto liner rinsing system which, as its name suggests, sends a blast of water and compressed air through the liners 30 seconds after they have been removed from a cow. One to watch, perhaps.