Pulsation systems

1. Introduction

Pulsation is defined as "cyclic opening and closing of a teatcup liner". The development of pulsation was a major turning point in the adoption of mechanical milk harvesting systems. All pulsation systems are made up of a pulsator (an air switching device), a source of vacuum, connecting pipelines and flexible pulse tubes that connect the pulsator to the annular chamber formed between the teatcup shell and liner.

2. Interpretation and relevance to Australian conditions

The pulsation system impacts on both cow health and milk harvesting time, both of which are important factors in farm productivity and profit. All aspects of the pulsation system must be functional, free from defects & damage and wear & tear. Components must be properly matched and the system regularly tested and adjusted to ensure the pulsation works in harmony with the cows.

3. Relationship to CowTime goals

The main purpose of pulsation is to limit the development of congestion and oedema in the teat tissues during machine milking. In addition to, or as a consequence of, this primary function, pulsation helps to:

- maintain a high rate of milk flow from the teat within each pulsation cycle;
- reduce the rate of new mastitis infections;
- counter the possible ill-effects of teat congestion on the level of discomfort or pain experienced by the cows; and
- stimulate good milk let-down.

A well-adjusted pulsation system helps to improve milking productivity, cow comfort and reduces the time spent on handling problem cows.

4. Features of pulsation systems

Although many different brands and designs of pulsators are used to milk cows, all pulsators are simple valve mechanisms that alternatively connect the pulsation chamber of each teatcup to vacuum or to air (usually, at atmospheric pressure). These cyclic pressure changes cause the liners in the teatcup to open and close around the teat-end, thereby providing massage to the lower part of the teat.

Pulsation characteristics

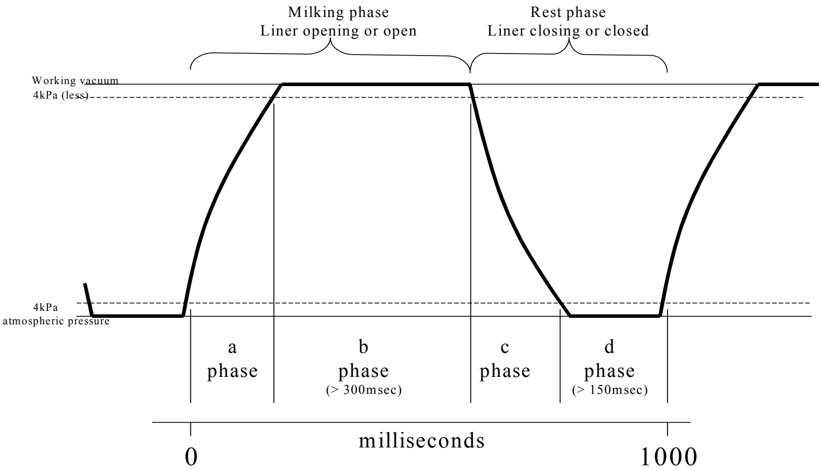
Both field experience and research have shown that a relatively narrow range of pulsation rates and ratios is required to ensure good teat-end health, good udder health and also to optimise milking speed. The preferred range for pulsation rate is about 55 to 65 cycles per minute. The preferred range for pulsator ratio is about 55:45 to 65:35. Although a wider ratio such as 70:30 will milk cows faster than a ratio of 65:35, first-class preventive maintenance programs must be conducted regularly because there is less margin for error, especially in Australian milking systems where prolonged over milking is a common problem. At a pulsator ratio of 80:20, peak milk flow rate is often lower than at 65:35 or 70:30, probably because there is insufficient time for an adequate compressive load to be applied to the teat-end at such a wide ratio.

The gradual evolution (mainly by trial and error) of such a narrow range of rates and ratios implies that the liner should be fully open for about 0.5 to 0.6 sec in each pulsation cycle. Research at the old Milking Research Centre at Werribee ot in the 1980s provided the scientific confirmation for this field experience. That research also showed that pulsation settings which allow the pulsation chamber to return to full atmospheric pressure for at least 15% of each cycle, or at least 150ms of each cycle, help to overcome teat congestion induced by the milking vacuum. This is the scientific basis for the current recommendations for the minimum D-phase of pulsation.

A fairly common pulsation system for Australia is alternating pulsation (also known as 2 x 2 pulsation), applied at a rate of 60 cycles per minute (one per second) with 60:40 ratios for both front and rear teatcups. This combination seems to have provided a good compromise for both udder health and speed of milking. As milk yields per cow continue to increase and, therefore, milking times per cow become longer, it is possible that the optimum combination of pulsator settings might change to a rate of about 55 cpm and a ratio of 65:35. Theoretically, this combination is more likely to maintain better teat condition in high-producing cows because the liner would squeeze and compress the teat less often per milking. The installation of automatic cluster removers would allow pulsator ratios at the faster end of the acceptable range to be used with more confidence and with a greater margin of safety.

An example pulsation cycle (at a pulsation rate of 60 cpm) is shown in the diagram below. Milk starts to flow from the teat during the A-phase (or opening phase) of pulsation. Typically, milk will start flowing at a time corresponding to a point about 25 - 50% up the A-phase curve. The exact time at which milk flow starts depends mainly on the mounting tension and wall thickness of the liner. Milk flow continues throughout the B-phase (the open phase) and into the first part of the C-phase (the closing phase). Milk stops flowing at a time corresponding to a point about 50 - 75% down the C-phase curve and the teat canal remains closed throughout the D-phase and into the first part of the opening phase.

Figure 1: Example of a typical pulsation cycle.



When analysing the results of pulsation chamber vacuum recordings, it is helpful to go through the data systematically with a biro or highlighter, marking any values that are outside the pulsation specifications given by the manufacturer on guidelines given on the report form. As a general guide:

- start with the most important columns (D% and D ms)
- then check the next most important column (Pulsator ratio A + B %)

Pulsation rate (CPM) and B% seldom exceed the specified limits in modern milking systems.
C% is a useful indicator of common problems such as air leaks into pulse tubes (causing an unusually short C-phase) or partially blocked air ports (causing an unusually long C-phase).

'Limping' is defined in international standards as "a number, in percentage units, indicating the unintentional difference between two pulsator ratios of an alternating pulsator". If one side of an alternating pulsator had a pulsator ratio of 63:37 and the other side had a ratio of 57:43, for example, then limping would be recorded as 6% or 6 units of percentage. Although limping should not exceed 3% according to current AMMTA specifications, it is clear that other characteristics of pulsation are much more important than limping (notably, the D-phase of pulsation).

As a further guide when diagnosing pulsator faults, keep the following points in mind:

- An unusually slow A-phase combined with a rapid C-phase indicates the likelihood of an air leak from atmosphere. Therefore, check for air leaks in the short pulse tubes or long pulse tubes.
- The combination of a normal A-phase, an unusually long C-phase and a short D-phase often means there is a partial blockage in the pulsator air port.
- A D-phase that does not reach atmospheric pressure even though the graph is more or less horizontal during the D-phase usually indicates foreign matter stuck between the pulsator valve and the valve seat.
- The combination of a slow A-phase and a slow C-phase usually indicates a restriction to air flow in both directions. Therefore, look for partial blockage or kinking of tubes or excessive length of the long pulse tubes. A length in excess of 2m imposes a substantial restriction to air flow.
- A transient jump in vacuum during the D-phase may indicate dirty filters or insufficient capacity of the filters in the fresh airline supplying atmospheric air to the pulsators.

Pulsation Tubing

Both the bore of tubing and the number of clusters connected to a pulsator will affect pulsation characteristics. Typical bores of long pulse tubes are 6-8mm for clusters with alternating pulsation, and 8-9mm for clusters with simultaneous pulsation. Generally, there is no improvement in pulsation characteristics if the bore is made greater than 9mm.

Pulsators

Pulsators can be electronic, pneumatic or mechanical. Pneumatic pulsation and mechanical pulsation systems still exist, but are not as reliable or easy to maintain as electrically controlled systems. In practice, electrically controlled pulsators tend to produce more consistent pulsation from stall-to-stall and from day-to-day.

Pulsation systems also vary from where all quarters experience the same thing simultaneously ('simultaneous' or 4 x 0 pulsation) or 2 quarters resting while the other 2 are milking and are alternating back and forth. ('alternating' or 2 x 2 pulsation). Athough millions of cows are milked successfully on both systems, research and field experience appears to be slightly in favour of alternating pulsation.

Some electronic pulsation systems have an option to vary the ratio between front and rear quarters.

5. Potential challenges with implementation

The main problems that are likely to be encountered arise during upgrades to existing systems. Fitters need to ensure that if one component of the pulsation system is upgraded, the remaining components are compatible with the new component. Testing by qualified testers and systematic observation of cows' teat-ends are both essential after such an upgrade.

6. Robustness of this information

Pulsation has been extensively researched and the principles have been well established for decades.

7. References and further reading

Mein, G.A. (1992) Chapter 4 - Action of the cluster during milking. In "Machine Milking and Lactation", edited by AJ Bramley, FH Dodd, GA Mein and JA Bramley, Insight Books, Burlington, VT, USA.

Akam, D.N. & Spencer. S.B. (1992) Chapter 5 - Design and operation of milking machine components. In "Machine Milking and Lactation" edited by AJ Bramley, FH Dodd, GA Mein and JA Bramley, Insight Books, Burlington, VT, USA

CowTime Guidelines for milk harvesting - Chapter 5, edited by Klindworth, D. et al (2003). Available on the CowTime website www.cowtime.com.au

Quick Note 3.2: Checklist for making changes to milk harvesting infrastructure