STUDIES ON LINER VACUUM IN HIGH AND LOW LEVEL MILKING SYSTEMS

Edgars Andersons, Armins Laurs, Juris Priekulis
Latvia University of Agriculture
enedijs@inbox.lv, armins.laurs@promedia.lv, juris.priekulis@llu.lv

Abstract. For milking cows milking machines with high and low level milking systems are most often used. Milking in the milkline positioned underneath milk from the claw gets into the milkline by self-flow, but in the milkline above additional energy must be used to lift milk in the milkline, i.e., vacuum in the milkline must be higher than in the teatcup. The aim of the research is to state the influence of the position of the milkline in high and low level milking systems on liner vacuum. The experiments were performed in laboratory conditions on a special test bench using water instead of milk. The experiments were carried out in 4 series – with a high level milking system at working vacuum 49 kPa and with a low level milking system at working vacuum 49; 44 and 41 kPa. In every series 3 experiments were made at the water flow rate 0.6; 3.5 and 6.3 $kg \cdot min^{-1}$. In the research it was stated that milking with high level milking systems the working vacuum should be 50 kPa, but milking with low level milking systems the working vacuum – 43 kPa.

Keywords: high and low level milking systems, working vacuum, liner vacuum.

Introduction

The main parameter of the milking unit is liner vacuum, i.e., vacuum in the teatcup liner chamber. The higher the liner vacuum the higher the milking rate and shorter the milking length. But in practice it has been proven that the highest margin of the liner vacuum is 50 kPa [1; 2]. Milking with higher vacuum the teats are traumatized as well as pain can be caused in the udder. Besides, in veterinary medicine there is an opinion that the lower the vacuum in the teatcup liner chamber the lower its negative impact on the health of the udder. But also here there are limits. At too low vacuum the teatcups tend to slip off the teats and the length of milking considerably increases. Based on the results of many investigations it has been stated that the optimal mean liner vacuum during the peak flow rate period of milking is 32-40 kPa [3]. Such vacuum, observing correct milking regulations, does not leave negative influence on the health of the udder as well as ensures satisfactory milking rate and holding of teatcups on the teats.

In modern milking machines high and low level milking systems are used. High level milking system milkline is positioned about 1.8 m higher, but in low level milking systems – lower than the claw.

The most essential difference of both systems is the different procedure of milking. Milking in the milkline positioned underneath milk from the claw gets into the milkline by self-flow, but in the milkline above additional energy must be used to lift milk in the milkline, i.e., vacuum in the milkline must be higher than in the teatcup.

In long-term practice it has been proven that milking with high level milking systems the working vacuum, i.e., the vacuum in the milkline when the milk flow is 0 $kg \cdot min^{-1}$, should be 50 kPa. Then the mean liner vacuum during the peak flow rate period of milking is 32-40 kPa. The question remains open what the optimal working vacuum should be milking with low level milking systems?

Studying publications on this question and milking machine instructions we came to the conclusion that there are great differences in the recommendations. This influenced the choice of the theme of the present research.

The aim of the research – to state the influence of the position of the milkline in high and low level milkings systems on liner vacuum.

The tasks of the research:

- to state the changes of liner vacuum at the upper admissible working vacuum (50 kPa) with different milk flow rate in the high level milking system;
- to state the changes of liner vacuum at different working vacuum and milk flow rate in the low level milking system.

Materials and methods

The experiments were performed in laboratory conditions on a special test bench (Fig. 1) using water instead of milk.

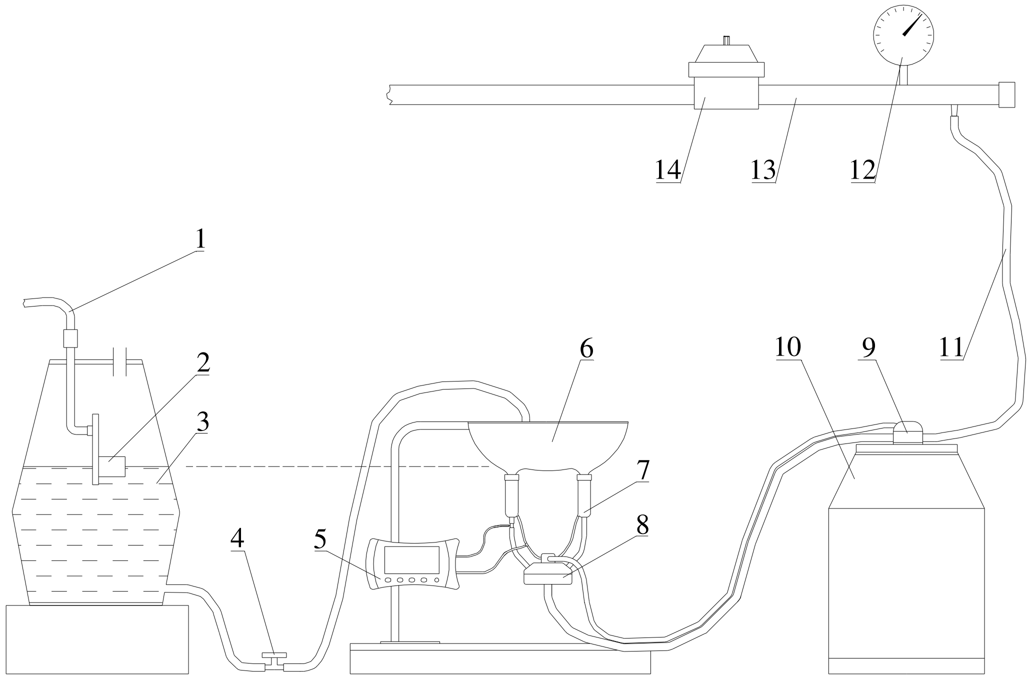

Fig. 1. **Scheme of test bench for imitation of milking systems:** 1 – water line; 2 – water level regulator; 3 – water reservoir; 4 – water tap; 5 – vakuum recorder; 6 – udder model; 7 – teatcup; 8 – claw; 9 – pulsator; 10 – bucket; 11 – vacuum tube; 12 – vacuum gauge; 13 – vacuum line; 14 – vacuum regulator

The necessary water flow rate was set by the water tap 4, but the working vacuum – with the vacuum regulator 14. Imitating the high level milking system, the bucket 10 was lifted 1.8 m higher, but imitating the low level milking system – positioned 0.7 m lower than the claw 8. The bucket was put on the scales. The water flow rate during the experiment was determined registering the amount of water through the milking unit and the length of the experiment. For vacuum registration in teatcup pulsation and liner chambers the DeLaval performance tester VPR100 was used [4].

During the experiment liner vacuum and vacuum in pulsation chamber were registered.

The experiments were performed in 4 series:

- with the high level milking system at the working vacuum 49 kPa;
- with the low level milking system at the working vacuum 49 kPa;
- with the low level milking system at the working vacuum 43 kPa;
- with the low level milking system at the working vacuum 41 kPa.

In every series three experiments were performed at the water flow rate 0.6, 3.5 and 6.3 kg·min^{-1}. The length of every experiment – 5 min. The flow rates 3.5 un 6.3 kg·min^{-1} were chosen based on long-term observations of the advisers of the Latvian Agricultural Advisory Center performing measurements on Latvian farms. According to their information on the best Latvian milk farms the mean milk flow rate uses to be in the range 3.0-6.0 kg·min^{-1}.

The graphs of the pulsation chamber vacuum changes recorded by the vacuum recorder were processed in compliance with ISO 5707 [3] and ISO 6690 [5]. The mean liner vacuum in the phase a+b is used as the criterion of the investigated process (Fig. 2). That is vacuum that operates on the teat tip during milk ejection.

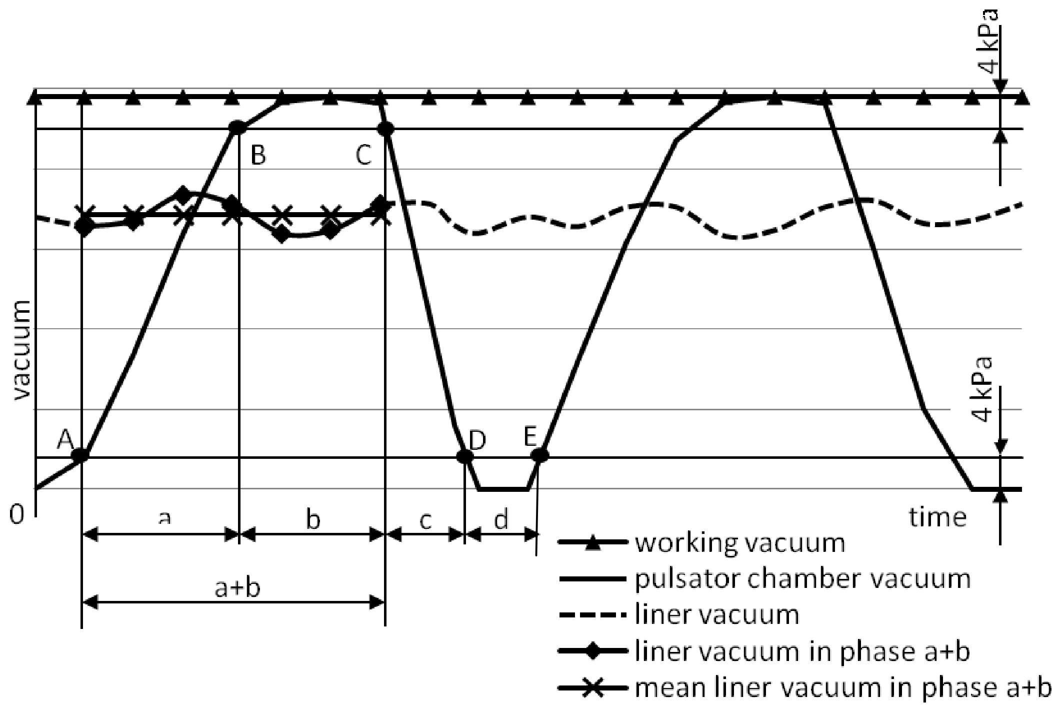

Fig. 2. **Pulsation and liner chamber vacuum record**

The data obtained in the research were processed with empiric material mathematical processing methods. In the publication the terms and their definitions are used in compliance with ISO 3918 [6].

Results and discussion

The results of the experiments are shown in Table 1. It presents that milking with the same working vacuum with high and low level milking systems in the low level milking systems the liner vacuum is higher. Reducing the working vacuum for one and the same milking system the liner vacuum reduces.

Table 1

Liner vacuum variability at different milking flow and working vacuum in high and low level milking systems

Type of milking systems	**Working vacuum, kPa**	**Mean liner vacuum in phase *a+b* ($x \pm \hat{s}$) at water flow, kPa**			**Recomended interval of mean liner vacuum in phase *a+b*, kPa [3]**
		0.6 $l \cdot min^{-1}$	3.3 $l \cdot min^{-1}$	6.3 $l \cdot min^{-1}$	
High-level	49.0	42.8±0.2	34.6±0.2	27.0±0.2	32.0-40.0
Low-level	49.0	43.2±0.6	34.7±1.2	31.5±1.3	
	43.0	39.9±0.4	31.6±1.0	27.9±1.2	
	41.0	37.7±0.3	30.8±0.9	28.0±1.0	

Remark: x – mean vacuum in phase $a+b$; $\hat{s}$ – standard error

Figure 3 presents the research results graphically. Analysing the research results it can be seen that milking cows in the high level milking system at the working vacuum 49 kPa, at the milk flow that is less than 1.33 $kg \cdot min^{-1}$, the liner vacuum is higher than the optimal 32-40 kPa. It means that at the beginning of milking, especially if the milk ejection reflection stimulation has not been effective enough, as well as at the end of milking the teats are subject to vacuum that is higher than optimal. In turn, at the milk flow higher than 4.1 $kg \cdot min^{-1}$, the liner vacuum is lower than optimal that could influence the length of milking.

Milking with the same vacuum with the low level milking system, the liner vacuum starts to exceed the optimal margin already at 1.57 kPa, what means that at the beginning and end of milking the teats will be subject to the negative influence of the vacuum even longer.

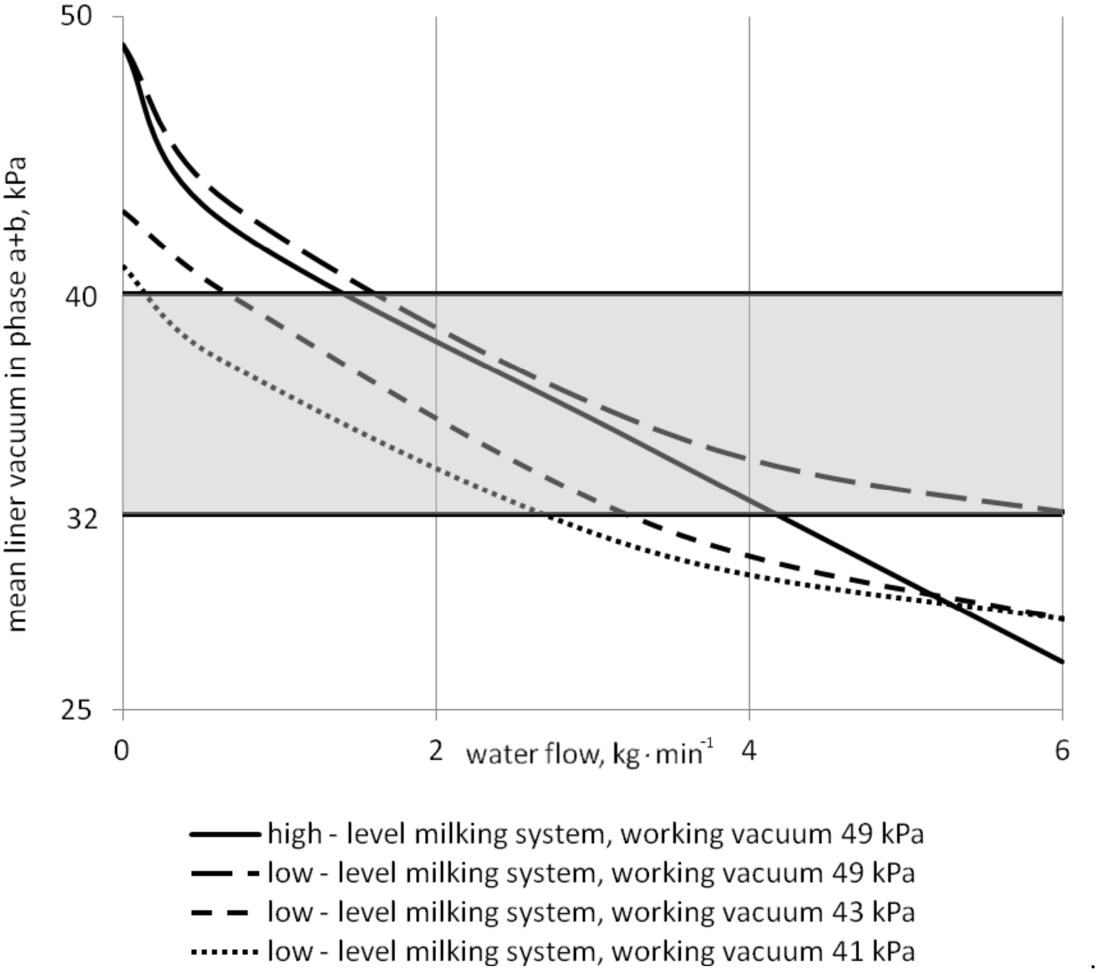

Fig. 3. **Vacuum variability in liner chamber in different types of milking systems at different milking flow and working vacuum (dark area – recommended interval)**

Lowering the low level milking system working vacuum to 43 kPa, the milk flow rate margin at which the liner vacuum is higher than optimal, lowers to 0.62 kg·min^{-1}, but to 3.14 kg·min^{-1} the milk flow rate reduces, at which the liner vacuum is lower than the lowest margin of the optimal vacuum range.

Further reduction of the working vacuum to 41 kPa reduces also the milk flow rate (0.14 kg·min^{-1}), at which the liner vacuum is the highest margin of the optimal vacuum range, but, unfortunately, with this the milk flow rate reduces to 2.67 kg·min^{-1} at which the liner vacuum is lower than the lowest margin of the optimal vacuum range.

From the above it can be concluded that using the low level milking system it is not advisable to milk the cows with the same working vacuum with which the cows are milked in the high level milking systems, i.e., 49-50 kPa. It would negatively influence the teats at the beginning and end of milking that could increase the risk of cows to get ill with mastitis.

The optimal working vacuum, milking cows with the low level milking system, could be 43-44 kPa. It would practically reduce the negative influence of vacuum at the beginning and end of milking as well as would ensure normal milk flow rate during the whole time of milking.

Further reduction of the working vacuum in the low level milking systems would not be advisable. Although the negative influence of vacuum would be essentially reduced at the beginning and end of milking, still, at the same time also the milk flow rate would be considerably reduced.

Conclusions

1. Reducing the working vacuum the milk flow rate, at which the optimal linear vacuum range higher margin is exceeded, reduces. It means that at the beginning and end of milking the teats are less subject to the negative influence of vacuum.
2. Reducing the working vacuum the milk flow rate, at which the optimal linear vacuum lower margin is exceeded, reduces. It means that the length of milking increases.
3. Milking with low level milking systems it would not be advisable to use the working vacuum 50 kPa. At such working vacuum the liner vacuum starts to exceed the optimal margin already at 1.57 $kg\cdot min^{-1}$, what means that at the beginning and end of milking the teats will be continuously subject to the negative influence of vacuum.
4. If the mean milk flow rate does not exceed 3.14 $kg\cdot min^{-1}$, the optimal working vacuum milking with low level milking systems could be 43 kPa. Then the mean liner vacuum at the milk flow rate 0.62-3.14 $kg\cdot min^{-1}$ would be in the liner vacuum optimal range (32-40 kPa).

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