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Liner Movement

Measuring Technology and Pulsation

Liner movement (distance and velocity) was measured using a newly developed unit. In the first part of the study, the measuring technique (laser sensor) and the temporal position of liner movement within the phases of the pulse cycle (DIN ISO 3918) are described. It is shown that the movement of the liner begins at the end of the a-phase of the pulse cycle and is completed in the b-phase. The closing of the liner commences at the beginning of the c-phase and is finished during its first half. The percentage of the „real" suction phase (based on liner movement) is usually 10 to 20% less than the percentage of the suction phase according to DIN ISO.

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Keywords

Milking machine, liner movement

During milk withdrawal, the liner and in particular its movement play a significant role. It establishes the direct connection between the biological (teat) and the mechanical (milking unit) side of milk withdrawal. On the one hand, the movement of the liner stimulates the cow and massages the teat. On the other hand, this movement causes volume alterations in the milking unit, which result in substantial, undesirable vacuum fluctuations under the teat tip while the milk is flowing. Therefore, milk withdrawal is slowed down, and pathogenic germs can be transmitted.

Since only a few reliable data regarding liner movement are available, a measuring unit is intended to be developed in order to determine the movement of the liner (distance and velocity) and thus to obtain information for the optimization of milking. The present first part of the study describes the measuring unit and the temporal position of the liner movement (phase position) within the phases of the pulse cycle (DIN ISO 3918). The second part discusses the influence of the milk flow and the position of the milk tube on liner movement.

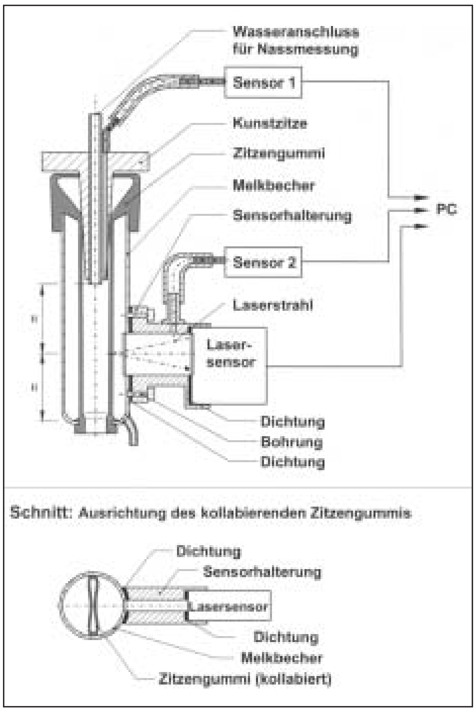

Fig. 1: Measuring unit: teat cup with sensors

Measuring Technology and Data Collection

Liner movement is measured with the aid of an opto-electronic position sensor (Wenglor YP 06MGV80); initial tension: 0 to 10 V (200 mA); response time: 0.5 ms; resolution: <20 µm; diameter of the measuring patch: 0.5 mm). For the measurement of the vacuum conditions, pre-calibrated pressure sensors (Keller Druckmesstechnik, type: PAA-21S/80427.3-2,0) are used. The selected measurement location is the point where the liner walls touch for the first time during folding. The exact measurement location is shown in *figure 1*. A measuring orifice is cut into the teat cup which matches the liner used, and the sensor holder is mounted above this orifice. For the measurement of the vacuum conditions under the teat tip, the pressure sensor is attached to the measuring teat (sensor 1). The vacuum conditions in the pulse room (= pulse curve) are measured by a pressure sensor at the holder of the laser sensor (sensor 2).

The data are collected in a completely installed measuring unit. All analogue values of the measuring instruments are bundled at an interface, digitalized in the measuring computer, and processed further with the aid of measuring and registration software (Visual Designer®). The velocity of the movement is calculated based on the distance covered by the liner within 2 ms. For graphic display, the determined velocities are given in cm/s.

Results and Discussion

In addition to the phase classification of the pulse curve according to DIN ISO 3918, whose phases contain a „d" as an index, two different techniques were used in order to

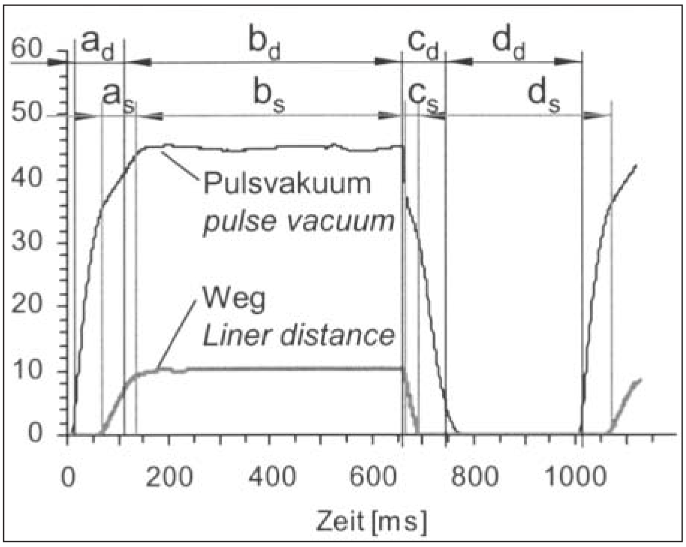

Fig. 2: Pulsation and liner movement (distance from sensor)

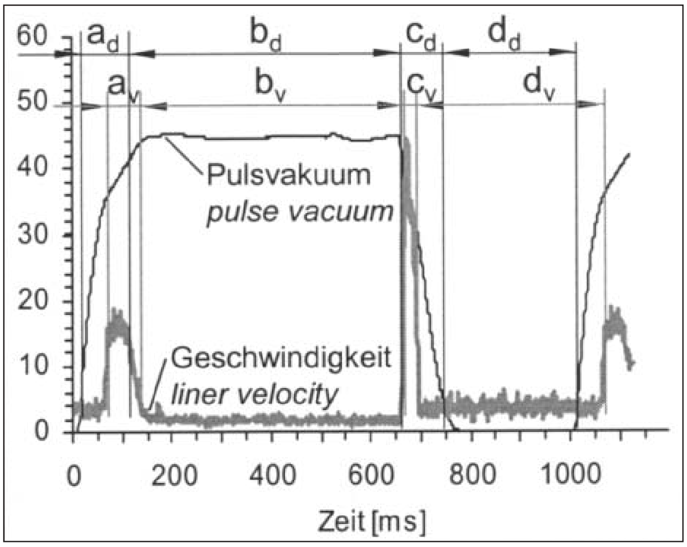

Fig. 3:Pulsation and liner velocity

classify the phases of liner movement in the present study. The individual phases are calculated in a manner analogue to the calculation method according to DIN ISO 3918. However, they contain different indices.

The phases of liner movement, which are calculated based on the *distance* travelled, are classified similar to [1]. The determined point of phase transition (*fig. 2*) is situated one millimetre above the position of the collapsed liner and one millimetre below the position of the opened liner. For this phase classification, an „s“ is used as an index. In addition to the pulse curve, the figure shows the distance of liner movement and phase classification.

For phase classification based on the calculation of *velocity*, the index „v“ is used. Here, 5 cm/s is set as a limit. As long as the liner moves at greater velocity, it is in the a_v phase (opening phase) or in the c_v phase (closing phase). If the liner moves more slowly, it is considered opened or collapsed (*fig. 3*).

No matter whether they are calculated based on distance or liner velocity, the *opening phases* of the liner are always situated at the end of the a_d phase of the pulse curve and only terminate in the vacuum phase (b_d) according to DIN ISO 3918. The closing phases of the liner are always situated at the beginning of the c_d phases. The closing phases are significantly shorter so that the liner has completed its movement far before the end of the ventilation phase.

The a_s (a_v) and c_s (c_v) phases of liner movement are not identical with the a_d and c_d phases of the pulse curve. The opening phase of the liner is significantly shorter than the corresponding a_d phase of the pulse curve (evacuation phase). This also applies to the closing phase in comparison with the ventilation phase [2]. In addition, the beginning of the opening phase (a_s, a_v) is considerably delayed in relation to the evacuation phase (a_d). Even at the beginning of the vacuum phase (b_d), the opening phase is not yet completed. The closing phases generally commence at the same time as the ventilation phase. Due to their different lengths, however, the closing phases terminate significantly sooner than the ventilation phase. Therefore it is only possible to infer the liner movement directly from the pulse curve with reservations.

The deviation of the pulse curve from a typical „log“ function is striking (figures 2 and 3). The gradient of the pulse curve in the areas of liner movement is flatter than would be expected. The flatter course of the pulse curve (a_d phase) exactly coincides with the opening phase of liner movement. Here, the liner causes fast volume reduction in the pulse room, which leads to a vacuum reduction. In the c_d phase, the influence of the liner's closing movement on the pulse rate is visible as well. The sudden volume increase in the pulse room due to the quickly collapsing liner results in slower vacuum reduction because a greater air volume per time unit must be supplied by the pulsator. Thus, the pulse vacuum not only influences liner movement, but, conversely, the vacuum conditions in the pulse room are also influenced by the quick volume alteration during liner movement (opening and closing).

Influences on the Pulse Curve

must generally be attributed to the pulsator (electric / pneumatic; pulse ratio) and the pulse tubes (length; diameter). In order to gain insights into the range of these alterations, six pulse cycles with combinations of either an electric or a pneumatic pulsator with one short (200 mm) and one long pulse tube (2,400 mm) each were evaluated. The effects on liner movement are listed in *table 1*.

According to DIN ISO, both pulsators have a pulse ratio of 65:35, while the liner itself pulsates at approximately 60:40 with a short pulse tube and at 55:45 with a long pulse tube. Once again, this shows that liner movement can actually only be measured directly, whereas it is impossible to derive it indirectly from the pulse curve.

Table 1: Influence of pulsator type and length of tube on pulsation

Pulsator	Pulse			relative [%]			
	tube	a	b	c	d	(a+b)	(c+d)
[Type]	[mm]	d/s/v	d/s/v	d/s/v	d/s/v	d/s/v	d/s/v
Elektric	200	10/6/7	55/53/52	9/2/4	26/39/37	65/59/59	35/41/41
	2400	15/7/9	50/48/47	11/3/4	24/42/40	65/55/56	35/45/44
Pneum.	200	10/5/6	55/53/52	7/2/4	28/40/38	65/58/58	35/42/42
	2400	15/7/8	49/48/47	10/3/5	26/42/40	64/55/55	36/45/45