Markus Mayer and Hartmut Grimm, Hohenheim

Liner Movement

Influence of Milk Flow and Milking Unit Parameters

Even though pressure difference in the milking unit, which increases due to the milk flow level and/or high line installation, causes radial extension of the liner shaft, it does not manifest itself as accelerated liner movement in the a- and c-phase. Instead, the closing movement is slowed down with increasing milk flow. Since the folding-in pressure difference is reached sooner, opening begins earlier. The velocity of movement does not change. The opening velocities are always lower than the corresponding closing velocities. Maximum speeds of 49 cm/s (closing) and 29 cm/s (opening) were measured.

Markus Mayer (e-mail: *markus@uni-hohenheim.de*) is studying at Hohenheim University and working on this topic as a „diplom“ thesis. Lecturer Dr. Hartmut Grimm (e-mail: *grimm@uni-hohenheim.de*) is a scientist working at the Institute of Agricultural Engineering, Department of Process Engineering in Animal Production and Farm Building (director: Prof. Dr. Th. Jungbluth).

Keywords

Milking machine, liner movement

In the first part of this publication (Landtechnik 3/2003), measuring technology and pulsation were discussed. In the present part, the influence of flowing milk (or water) and the position of the milk line on liner movement are explained in more detail. The phases of movement and liner velocity are given particular attention.

The Influence of Low/High Milk Line Installation

If the milk is transported through a high milk line, this high milk transport leads to even heavier vacuum reductions in addition to the vacuum fluctuations caused by the milk flow and the reduction of the mean vacuum under the teat tip. Therefore, positive pressure differences arise in the milking cup.

Milk Flow and Ballooning

With growing milk flow, the closing velocity of the liner diminishes (and, hence, the length of the c_v and c_s phases increases). This is mainly caused by the partial blockage of the short milk line by milk plugs towards the end of the suction phase. The quick collapse thus causes sudden volume reduction below the teat. Due to the milk plug, the arising pressure cannot be compensated for immediately, and the diminishing pressure difference (despite the ventilation of the pulse chamber) „slows down“ the closing movement (*fig. 1*). For the consideration of liner velocity, the maximum velocity reached by the liner is of greater importance than the average velocity in the a- or c-phase because maximum velocity in particular could cause the main strain on the teat and the cow.

Due to these pressure differences between the interior of the liner and the pulse chamber, the liner is blown up during the b-phase - so-called ballooning. Despite this ballooning during the b-phase, the liner does not move faster at the beginning of the c-phase and does not begin its movement sooner. The reason for this behaviour is that the pressure differences decrease towards the end of the b-phase so that only slight or no ballooning occurs under dynamic conditions at the beginning of the closing movement of the liner.

With increasing milk flow, the opening velocities exhibit virtually no alteration because the opening movement of the liner is mainly determined by its own return force while the pulse curve remains unchanged. In addition, the short milk line is largely free of milk plugs at this time. Therefore, the volume change under the teat tip which occurs when the liner is opened can be compensated for. However, the growing pressure difference in relation to the pulse chamber (lower vacuum under the teat tip!) in conjunc-

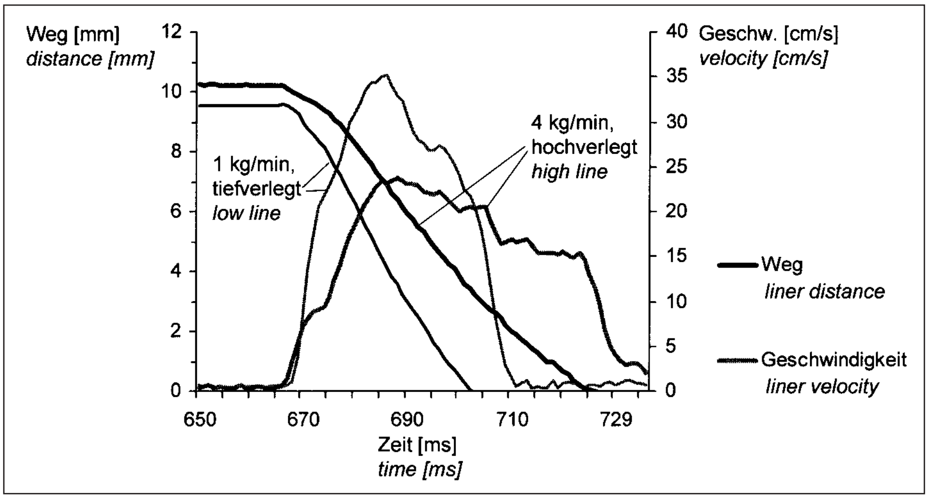

Fig. 1: Distance and velocity of the closing liner with different milk flow levels and high/low line installation, electrical pulsation (EP)

tion with an increase in the milk flow level causes the pressure difference to fall below the folding-in pressure difference of the liner sooner and thus the opening movement to begin earlier (*fig. 2*). The pulse curve remains uninfluenced by this process (!). Hence, the course of the pulse curve is virtually independent of the milk flow.

This earlier opening of the liner can acquire particular importance if it leads to interaction with the closing movement of the liners on the other side of the milking unit during alternating pulsation. This would cause crossflow, which might lead to the transmission of udder pathogens. However, this question requires further studies.

Table 1 shows the maximum measured liner velocities as a function of milk flow and pulse line length. The opening velocities are always lower than the corresponding closing velocities.

If one considers the entire pulse cycle, the ($a_{v,s}$ + $b_{v,s}$) phases must be expected to exhibit a tendency towards extension while milk flow is growing without any change in the percentage of (a_d + b_d) in the entire pulse cycle.

The Influence of Pulse Line Length

In addition to the above-mentioned decrease in the percentage of the ($a_{v,s}$ + $b_{v,s}$) phases in the entire cycle of movements, the opening- and closing velocities of the liner decrease with increasing length and, hence, growing buffer volume of the long pulse line. Therefore, the length of the phases of movement increases. In this process, the a_s and a_v phases are subject to stronger influence than the corresponding c-phases. Especially the later beginning of the opening phase may constitute a reason for the reduction in the liner pulse ratio as a function of the length of the pulse line.

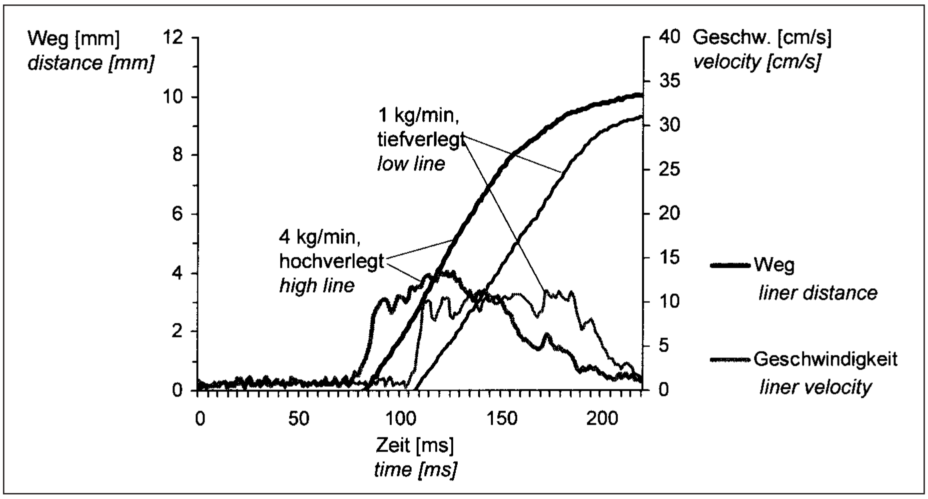

Fig. 2: Distance and velocity of the opening liner with different milk flow levels and high/low line installation, electrical pulsation (EP)

Literature

Books are identified by •

[1] • *Hermann, A.*: Entwicklung eines digitalen Messsystems zur simultanen Erfassung der Pulsierung, der Zitzengummibewegung und des Druckes auf die Zitze im Melkzeug. Dissertation, Universität Hohenheim, 1990

[2] N. N.: ISO 3918. Milking Machine Installations - Terms and Definitions., 1998

[3] *Reitsma, S. Y. und D. K. Breckman*: Measurement and analysis of milking machine teat cup operation. Can. Agri. Eng., 27 (1985), no. 2, pp. 91 - 97

[4] *Schuiling, H. J., F. Neijenhuis and M. C. Beek-van Maanen*: Liner monitoring. Dairy Systems for the 21st Century. Proceedings of the 3rd International Dairy Housing Conference, American Society of Agricultural Engineers (ASAE), 1994, pp. 36 - 39

[5] *Spencer, S. B. and L. R. Jones*: Liner Wall Movement and Vacuum Measured by Data Acquisition. J. Dairy Sci., 83 (2000), pp. 1110 - 1114

[6] *Uhmann, F. und C. Thalheim*: Variation der Dauer von Übergangsphasen und deren Einfluss auf das Bewegungsverhalten von Zitzengummis. Agrartechnik, 30 (1980), H. 12, S. 561 - 564

Pulse line [mm]	Milk-flow [kg/min]	High/low installation	Opening velocity- [cm/s]	Closing velocity [cm/s]	Length of a_v-Phase [ms]	Percentage of (a_v+b_v) in the pulse cycle [%]
	0	-	18,4	44,1	69	59
	1	t	16,8*	35,4*	71	59
200+	1	h	18,1*	33,6*	70	60
	4	t	17,6*	31,8	70	59
	4	h	22,6*	29,7	62	60
	0	-	14,0	38,5	89	56
	1	t	12,6	36,1*	93	56
2400+	1	h	13,5	33,1*	97	57
	4	t	14,0	30,4*	107	57
	4	h	14,5	25,9*	90	58

Table 1: Velocities of the liner in high/low line installation with different milk flow

*Significant difference ($\alpha \leq 0.05$) between high and low in the individual milk flow
+Significant difference between the pulse line lengths over all three milk flows ($\alpha \leq 0.01$)