Possible use of vacuum controlled pulsators for sheep milking machines

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ABSTRACT: Comparison measurements and evaluation of the suitability of three pulsators for sheep milking machines were carried out, i.e. a prototype made by the manufacturer of the milking parlour of the pulsator ratio 50% (50:50) and two hydraulic pulsators of the Danish manufacturer S.A. Christensen (SAC), models Unipuls-2 of the pulsator ratios 50% (50:50) and 60% (60:40). The specified pulsation rate was 2.5/s (150/min). It was found that the pulsator prototype made by the milking parlour manufacturer slowly passed air, whereby the vacuum in pulsation chambers did not attain the maximum value. Fig. 2 illustrates the operation of this pulsator. Both SAC pulsators had better parameters and their pulsograms are plotted in Figs. 3 and 4. Also the measurements of a liner deformation in dependence on the vacuum in the teatcup pulsation chamber were made based on which the moment of a real liner opening, i.e. at the vacuum of 35 kPa was determined. The results obtained by the experiments carried out can be summed up as follows: As the change in pulsation rate does not affect the time of transition phases "a" and "c", the intervals "b" and "d" are shorter if the pulsation rate is increased. Interval "b", i.e. a full liner opening, shortens with the rising rate and extends with the increased value of the pulsator ratio. For this reason higher pulsator ratios should be used at very high pulsation rates. The teatcup operation depends on the physical-mechanical properties of the liner used. On the milking unit measured considerable differences in time take place between the interval "b" and the liner full opening due to a relatively high resistance power of the liner to deformation. The pulsator prototype designed by the milking parlour producer revealed as fully unsuitable based on its pulsogram. As far as the time of the liner opening is concerned, its parameters were worse than on both SAC pulsators, however, we cannot indicate it as unsuitable.

Keywords: milking machine; sheep milking; pulsator; pulsation rate; pulsator ratio

The problems of sheep milking are mostly a little neglected in particular due to the fact that the numbers of sheep are relatively very low. In the Czech Republic sheep numbers dropped from the original 400,000 down to about 100,000 pcs. The changes in the agricultural production method, in particular in the submontane regions, can again result, under certain conditions, in an extended sheep breeding (OPLT 1998). Basic parameters of sheep milking machines can be characterized by the following values (DUCHO 1990): Vacuum is used within 40 to 50 kPa. Pulsation rate is higher than in cows, mostly ranging from 1.17 to 1.67/s (70–100/min), pulsator ratio of the pulsators used being within 50% (50:50) and 67% (67:33).

Small dimensions of teatcups along with the fact that the milking unit has two teatcups only lead to the assumption that the sheep milking machines are undemanding and have a low air consumption, however, it is not true. We started dealing with this problem more intensely when being asked for help in designing a suitable pulsator for a rotary milking parlour. The situation was rather complicated as the pulsation rate should be 2.5/s (150/min) or possibly even higher. Electronic pulsators attain this pulsation rate without any problem, however, they are very expensive and complicated for a standard and simple milking parlour. For this reason we endavoured to use pneumatic or hydraulic pulsators which do not need any electrical installation and are connected to a vacuum source only. It was, however, necessary to choose the models being able to operate at the required high pulsation rates and to keep stable parameters.

MATERIAL AND METHODS

With respect to a high pulsation rate applied, pulsator models of short transition phases and provided with hoses of an appropriate I.D. had to be used. The function of the pulsator and the milking unit are best proven by a pulsogram of the vacuum time behaviour in the teatcup pulsation chamber (ISO 5707). A pulsogram example is shown in Fig. 1. Vacuum in kPa is plotted on the vertical axis and time in seconds on the horizontal axis. Two vacuum levels are recorded. The first of them is of 4 kPa and the other, i.e. the value of the max. vacuum, is reduced by 4 kPa. The points of intersection of the curve with the above vacuum levels divide one pulsation interval into four time periods designated "a", "b", "c" and "d". Interval "a" is the time of vacuum growth, when air exhausts from the teatcup pulsation chamber and the liner opens. Interval "b" is the time of a max. vacuum,

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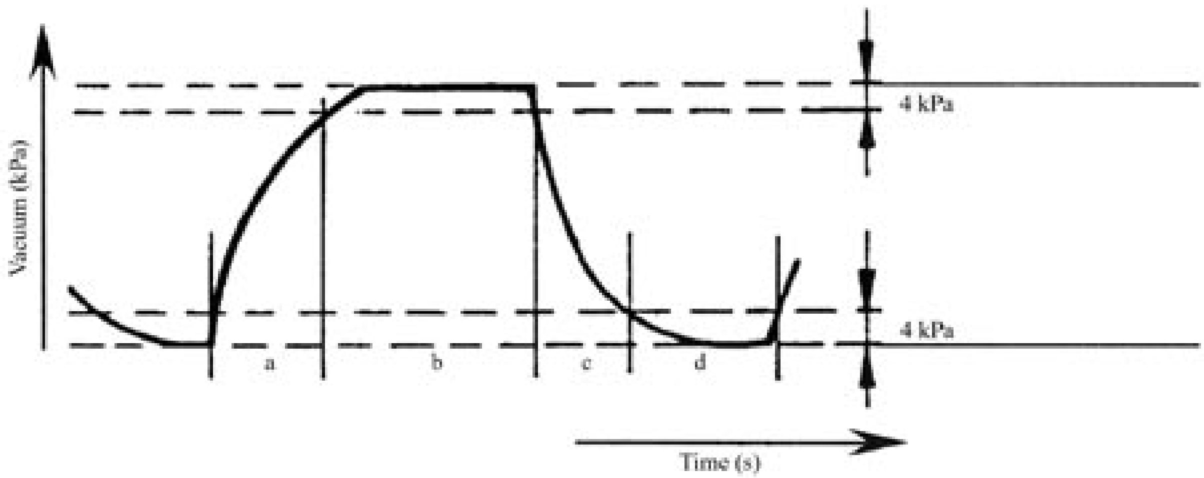


Fig. 1. Pulsogram – pulsation chamber vacuum record

i.e. the time of a full liner opening. Interval "c" is the time of vacuum drop, when atmospheric air closing the liner is admitted to the teatcup pulsation chambers. Interval "d" is the time of the atmospheric pressure. Almost all the time the vacuum is of a zero value and the atmospheric pressure in the teatcup pulsation chambers compresses the liner. The pulsation time is expressed by the sum:

$$T_p = a + b + c + d \qquad \text{(s)} \qquad (1)$$

Its reciprocal value is the pulsation rate:

$$f_p = \frac{1}{a + b + c + d} = \frac{1}{T_p} \qquad \text{(s)} \qquad (2)$$

Pulsation ratio is expressed by the relation:

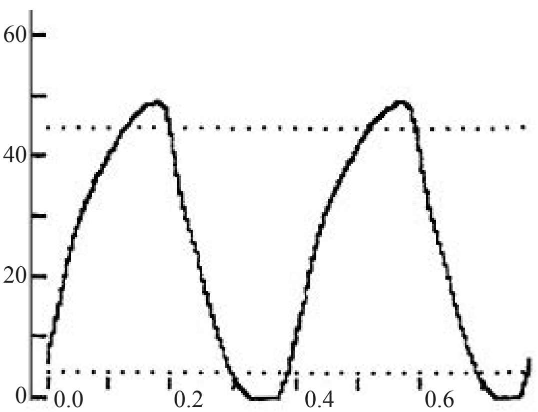
$$\delta = \frac{100\ (a + b)}{a + b + c + d} \qquad (\%) \qquad (3)$$

To plot a pulsogram the so-called pulsator tester is used, which is a device recording vacuum course. The device also evaluates the vacuum in addition to its course recording and determines the max. vacuum value, pulsation rate, the time of one pulsation in milliseconds and the time of the "a", "b", "c" and "d" intervals in milliseconds and per cent based on the time of one pulsation duration.

Three pulsators were compared, i.e. the prototype of a pneumatic pulsator made by the milking parlour manufacturer of the pulsator ratio 50% and two hydraulic pulsators of the Danish producer S.A. Christensen (SAC), models Unipuls-2 of 50% and 60% pulsator ratios. The operation of the pulsators was evaluated by means of the Pulsator tester PT-IV of the producer De Drie Electronic B.V. Niederlands.

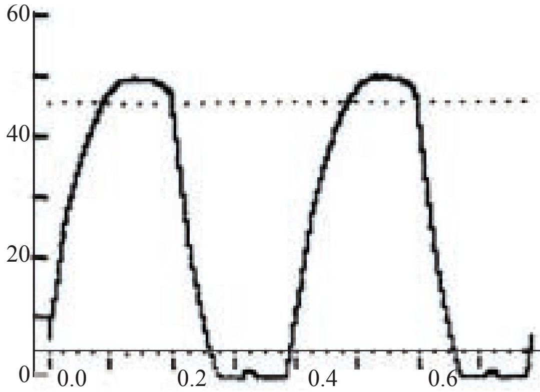
RESULTS

In the first measurements it was found that the pulsator prototype made by the milking parlour producer slowly passed the air, whereby the vacuum in pulsation chambers did not attain the maximum value at all. Fig. 2 depicts the operation of the pulsator. It was connected to a 50 kPa vacuum and set to the pulsation rate of 2.5/s (150/min), pulsator ratio being 50%. By a mere visual comparison we could see that horizontal sections representing a full opening or a full closing of the liner were almost missing in the pulsogram. The transition phases "a" and "c" did not nearly link up to each other.



Vacuum level	48.5 kPa	
Puls	152.3 min^{-1}	394 ms
a + b phase	52.0%	205 ms
c + d phase	48%	189 ms
a phase	33.0%	130 ms
b phase	19.0%	75 ms
c phase	24.1%	95 ms
d phase	23.9%	94 ms

Fig. 2. Pulsogram of the pulsator prototype made by the milking parlour producer of 50% pulsator ratio



Vacuum level	49.7 kPa	
Puls	151.5 min^{-1}	396 ms
a + b phase	52.0%	206 ms
c + d phase	48.0%	190 ms
a phase	23.7%	94 ms
b phase	28.3%	112 ms
c phase	15.2%	60 ms
d phase	32.8%	130 ms

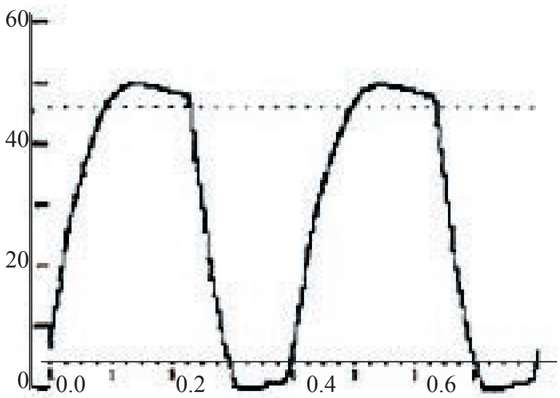
Fig. 3. Pulsogram of the SAC Unipuls-2 pulsator of 50% pulsator ratio

In a detailed analysis of the values measured we found out that the vacuum in the teatcup pulsation chambers attained the max. value of 48.5 kPa only. Interval "b", which is a full liner opening, lasted 75 ms only. The short time of liner opening also resulted in a short time of milk suction, i.e. in a slower milking.

Fig. 3 illustrates the pulsogram of the SAC Unipuls-2 pulsator of 50% pulsator ratio. The pulsator was also connected to a vacuum of 50 kPa and set to the pulsation rate of 2.5/s (150/min). By a visual assessment we can find that the pulsogram in Fig. 3 reveals distinct horizontal sections representing a full opening or closing of the liner. Interval "b" which is a full liner opening, lasts 112 ms on the SAC pulsator, which is a 1.5-multiple of the value obtained by the prototype.

Fig. 4 illustrates the pulsogram of the same SAC pulsator as in Fig. 3, its parameters remained unchanged, only pulsator ratio was modified from 50 to 60%. Unless the external conditions of pulsator connection are changed, the change in pulsation rate or pulsator ratio should not affect the course of the transition phases "a" and "c". By the above change in pulsator ratio the interval "b" should be extended and the interval "d" shortened. The values obtained confirm it. Interval "a" revealed a 5 ms and interval "c" a 1 ms difference only. On the other hand, interval "b" was extended from 112 ms to 143 ms, which is almost a 1.3-multiple and interval "d" reduced from 130 ms to 103 ms.

The pulsogram expresses the vacuum course in detail, however, the reaction of the liner on the changes depends on its shape, wall thickness, modulus of elasticity as well as on other physical-mechanical properties of the material it is made of. For this reason deformation measurements of the liner were carried out depending on the vacuum in pulsation chamber. The chamber under the teat was closed by a plug and connected to the vacuum of 50 kPa. The vacuum in the pulsation chamber was increased from 0 kPa up to 50 kPa by making use of the fact that the teatcups were made of a transparent plastic and that the liners used made of silicon rubber were also transparent. In this way the vacuum in the pulsation chamber at which the liner was fully opened could be easily determined. At the vacuum of 0 kP and with atmospheric pressure in pulsation chamber, liner walls are compressed to each other almost along the whole length (Fig. 5a). By a gradual increase of the vacuum, liner walls fall away from each other. This process starts at both ends and continues as far as the middle part. At the vacuum of 30 kPa the walls are still compressed at the middle part Fig. 5b. At the vacuum of 35 kPa the walls are separated from each other along the whole length and it can be presumed that



Vacuum level	50.0 kPa	
Puls	147.8 min^{-1}	406 ms
a + b phase	59.6%	242 ms
c + d phase	40.4%	164 ms
a phase	24.4%	99 ms
b phase	35.2%	143 ms
c phase	15.0%	61 ms
d phase	25.4%	103 ms

Fig. 4. Pulsogram of the SAC Unipuls-2 pulsator of 60% pulsator ratio

a – 0 kPa b – 30 kPa c – 35 kPa d – 40 kPa

Fig. 5. Deformation of the liner depending on the vacuum in pulsation chamber

a milk suction takes place at this vacuum although the liner is not fully opened yet (Fig. 5c). Its full opening takes place as late as at the vacuum of 40 kPa (Fig. 5d). With respect to the fact that the liner deformation depends on the vacuum, the vacuum of 35 kPa was found as the moment of a full opening. Based on it, time intervals at which the liner was opened were read from the pulsograms of individual pulsators tested. On the pulsator prototype this value amounted to 145 ms, which is 36.8% of the pulsation time. The SAC pulsator of a 50% pulsator ratio revealed the value of 165 ms, which is 41.7% of the pulsation time and at the pulsator ratio of 60% the time of the liner opening increased to 195 ms, which is 48.0% of the pulsation time.

DISCUSSION

The problems of sheep milking are a little neglected but the demands for a technical method due to the high pulsation rates applied are higher than in cow milking. The basic condition of a correct operation of a sheep milking machine is a vacuum pump of a sufficient efficiency. As late as then it is possible to carry out the diagnostics of other parts, to assess their function and possibly to suggest a measure to be taken to remove the drawbacks found. The results obtained by the experiments carried out can be summed up as follows:

1. As the change in pulsation rate does not affect the time of transition phases "a" and "c", the intervals "b" and "d" are shorter if the pulsation rate is increased. Interval "b", i.e. a full liner opening, shortens with the rising rate and extends with the increased value of the pulsator ratio. For this reason higher pulsator ratios should be used at very high pulsation rates.
2. The teatcup operation depends on the physical-mechanical properties of the liner used. On the milking unit measured considerable differences in time take place between the interval "b" and the liner full opening due to a relatively high resistance power of the liner to deformation. The pulsator prototype designed by the milking parlour producer revealed as fully unsuitable based on its pulsogram. As far as the time of the liner opening is concerned, its parameters were worse than on both SAC pulsators, however, we cannot indicate it as unsuitable.

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Možnost použití podtlakem řízených pulzátorů u dojicích strojů pro ovce

ABSTRAKT: Byla provedena srovnávací měření tří pulzátorů a hodnocena jejich vhodnost pro dojení ovcí. Byly hodnoceny tři následující pulzátory: prototyp pneumatického pulzátoru zhotovený výrobcem dojírny s pulzačním poměrem 50 % (50 : 50) a dva hydraulické pulzátory dánského výrobce S. A. Christensena (SAC) typu Unipuls-2 s pulzačním poměrem 50 % (50 : 50) a 60 % (60 : 40). Bylo požadováno, aby frekvence pulzace byla 2,5/s (150/min). Bylo zjištěno, že prototyp pulzátoru zhotovený výrobcem dojírny pomalu přepouští vzduch, a tím podtlak v mezistěnných komorách vůbec nedosáhne maximální hodnoty. Na obr. 2 je zobrazena činnost tohoto pulzátoru. Oba pulzátory SAC dosahovaly lepších parametrů a jejich pulzogramy jsou vidět na obr. 3 a 4. Dále byla provedena měření deformace strukové návlečky v závislosti na podtlaku v mezistěnné komoře. Na základě toho byl určeno, že okamžik skutečného otevření strukové návlečky je při podtlaku 35 kPa. Výsledky získané provedenými experimenty lze shrnout: protože změna frekvence pulzace neovlivňuje doby trvání přechodových fází „a“ a „c“, dochází při zvyšování frekvence pulzace ke zkracování intervalů „b“ a „d“. Tedy interval „b“ plného otevření strukové návlečky se s rostoucí frekvencí zkracuje a s rostoucím pulzačním poměrem se naopak prodlužuje. Proto by se při používání velmi vysokých frekvencí pulzace měly používat vyšší pulzační poměry. Skutečná činnost strukového násadce závisí na fyzikálně mechanických vlastnostech použité strukové návlečky. U měřené dojicí jednotky vlivem relativně velké odporové síly strukové návlečky proti deformaci dochází ke značným rozdílům mezi dobou intervalu „b“ a dobou skutečného otevření strukové návlečky. Prototyp pulzátoru navržený výrobcem dojírny se posouzením pulzogramu projevil jako zcela nevhodný. Posuzujeme-li však dobu otevření strukové návlečky, má tento pulzátor horší parametry než oba pulzátory SAC, ale nemůžeme ho označit za nevhodný.

Klíčová slova: dojicí stroj; dojení ovcí; pulzátor; frekvence pulzace; pulzační poměr

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