Analysis of vacuum fluctuation in milking units

J. Vegricht, A. Machalek & P. Ambroz

Research Institute of Agricultural Engineering Prague, Drnovska 507, 161 01 Prague, Czech Republic
E-mail: jiri.vegricht@vuzt.cz, antonin.machalek@vuzt.cz

For the vacuum conditions measurement of the clusters the vacuum sensors, placed on 4 points of this clusters were used. Evaluated was the vacuum course particularly in the liner chamber and in the claw within total pulse time in both maximum and minimum phase according to ISO 6690. The measurement was carried out under laboratory conditions and measured values were recorded. Evaluated were 5 different serial produced clusters with the claw volume of 150, 200, 300, 420, 450 and 500 cm³.

By the flow-rate of 5 l.min⁻¹ the vacuum decrease in the liner chamber of the clusters was 1.4 – 3.3 kPa and in the claw 1.7 – 5.3 kPa depended the claw type. By the flow rate of 12 l.min⁻¹ vacuum decrease in the liner chamber of the clusters was 4.1 – 11.2 kPa and in the claw 3.9 – 11.6 kPa.

In evaluation of the vacuum fluctuation within total pulse time no evidential difference was found in comparison with the vacuum fluctuation evaluated only for maximum phase. The measurements will continue by measuring in the milking parlour during the real milking.

Key words: Measurement, vacuum fluctuation, milking units, milking

The vacuum courses recognition in different points of the milking set and various milking intensity is one of possible ways how to obtain information on milking machine impact on the teat milk gland and to find suitable parameters for technical parameters effect assessment of variant design of the milking units.

The goal of the realised work was to specify the measuring methodology and comparison of selected milking units from the vacuum fluctuation aspect in different points of the milking system in dependence on milk flow rate. For this purpose the milk is replaced by water.
The measuring was carried-out in laboratory for the milking device testing at the VUZT Prague. The tested milking sets were set up from 10 various milk claw and 5 sets of teatcups. The claws technical parameters are presented in Table 1 and teatcups in Table 2.

The identification code of the tested milking set consists of 2 letters of which the first letter identifies the used claw by Tab. 1 and the second letter identifies the tested teatcups. The measuring was carried-out at the working vacuum of 42 and 50 kPa and at flow rates 1–14 l/min. The rate of pulsation was adjusted for all measurements to 50 pulses/min at pulsation ratio 60:40 and alternate pulsation. For each measuring was chosen 30 s time period for assessment, always after the situation stabilization in the milking set. The vacuum course was recorded in the under teat chamber, pulsation chamber, in claw and in the milking line situated 700 mm under the mountpice lip. The medium flow was evaluated during measuring for each teatcup individually. By this method the affect of eventual irregular media flow through the individual teatcups was excluded. The vacuum levels in particular points of the milking device were scanned by the tensometric sensors with accuracy of 0.3 kPa. The sampling velocity was adjusted to find out 300 values per second in each measured point.

The vacuum course within all time of pulse was evaluated in the time of bouth maximum and minimum phase at nominal vacuum of 50 kPa. The specification of the pulsation curve parameters is based on the pulsation curve definition according to the CSN ISO 3918. Part of the main obtained results is summarized in the graphs in Fig. 1–2.

By the flow-rate of 5 l/min the vacuum decrease in the liner chamber of the clusters was 1.4–3.3 kPa and in the claw 1.7–5.3 kPa depending on the claw type. By the flow rate of 12 l/min vacuum decrease in the liner chamber of the clusters was 4.1–11.2 kPa and in the claw 3.9–11.6 kPa. In evaluation of the vacuum fluctuation within total pulse time no significant difference was found in comparison with the vacuum fluctuation evaluated only for maximum phase.

The more significant vacuum decrease was recorded for claws C and I caused by their different construction. From aspect of the vacuum course in dependence on the flow-rate the best evaluation is evident at the claw A with original teatcup A. Other claws tend more to the vacuum decrease with growing flow-rate, but the differences are not too high.

Similarly was carried-out evaluation of identical milking units at vacuum nominal value of 42 kPa. The vacuum decrease character in dependence on the flow-rate is in fact equal as presented by the graph in Fig. 3 where the vacuum decrease is expressed percentually (nominal vacuum is 100%).

Method

Results
The results have confirmed the original hypothesis that construction and design of the milking unit are influencing the vacuum level during milking and thus also quality of milking process. The differences are evident mainly at high milking intensity. For this reason the attention will be paid to the following research with goal to optimise the milking parameters.

The research will also be focused to measuring of the vacuum course during milking under real conditions and comparison with laboratory measuring results.

One of the first operation measurement of the vacuum course in the under teat chamber, claw and milk line with contemporary measuring of milk flow-rate intensity is presented in graph in Fig. 4.

This article was prepared in connection with solution of the research project of the Ministry of Agricultural of the Czech Republic MZE 0002703101.

Table 1.

<table>
<thead>
<tr>
<th>Code of claw</th>
<th>Shape ground plan</th>
<th>Volume (cm³)</th>
<th>Weight (kg)</th>
<th>Diameter of inlet (mm)</th>
<th>Diameter of outlet (mm)</th>
<th>Air admission (l/min by 50 kPa)</th>
<th>Automatic shut-off valve</th>
<th>Notice</th>
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<tbody>
<tr>
<td>A orbicular</td>
<td>half-ball</td>
<td>420</td>
<td>0.412</td>
<td>11</td>
<td>15.5</td>
<td>6</td>
<td>Yes</td>
<td></td>
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<tr>
<td>B orbicular</td>
<td>with slope cylinder</td>
<td>195</td>
<td>0.153</td>
<td>8</td>
<td>13.5</td>
<td>6</td>
<td>Yes</td>
<td></td>
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<tr>
<td>C trapezoid</td>
<td>trapezoid</td>
<td>450</td>
<td>0.614</td>
<td>14</td>
<td>15</td>
<td>8</td>
<td>Yes upper outlet</td>
<td></td>
</tr>
<tr>
<td>D orbicular</td>
<td>sideline cylinder</td>
<td>200</td>
<td>0.295</td>
<td>9</td>
<td>16</td>
<td>6.2</td>
<td>Yes</td>
<td></td>
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<tr>
<td>E orbicular</td>
<td>sideline cylinder</td>
<td>300</td>
<td>0.512</td>
<td>10</td>
<td>18</td>
<td>6</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>F orbicular</td>
<td>sideline cylinder</td>
<td>300</td>
<td>0.506</td>
<td>10</td>
<td>18</td>
<td>7.1</td>
<td>No</td>
<td></td>
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<tr>
<td>G orbicular</td>
<td>sideline cylinder</td>
<td>450</td>
<td>0.566</td>
<td>12</td>
<td>17</td>
<td>6</td>
<td>Yes</td>
<td>faint tangential inlets</td>
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<tr>
<td>H orbicular</td>
<td>two half-ball</td>
<td>350</td>
<td>0.462</td>
<td>10</td>
<td>14</td>
<td>6.1</td>
<td>Yes</td>
<td>tangent inlets</td>
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<tr>
<td>I orbicular</td>
<td>half-ball with cone</td>
<td>500</td>
<td>0.809</td>
<td>14</td>
<td>16</td>
<td>5.8</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>J orbicular</td>
<td>truncated cone</td>
<td>300</td>
<td>0.418</td>
<td>10</td>
<td>16</td>
<td>6.1</td>
<td>No</td>
<td>tangent inlets</td>
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Table 2.

Parameters of teatcups used for measuring

<table>
<thead>
<tr>
<th>Teatcup code</th>
<th>Weight of one teatcup (g)</th>
<th>Pulsation chamber volume (ml)</th>
<th>Diameter of mouthpiece lip (mm)</th>
<th>Lenght of liner (mm)</th>
<th>Lenght of short milk tube (mm)</th>
<th>Diameter of short milk tube (mm)</th>
<th>Internal volume of liner (ml)</th>
<th>Volume under teat (ml)</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>316</td>
<td>95</td>
<td>26</td>
<td>315</td>
<td>150</td>
<td>12</td>
<td>90</td>
<td>50</td>
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<tr>
<td>B</td>
<td>290</td>
<td>90</td>
<td>23</td>
<td>310</td>
<td>170</td>
<td>11</td>
<td>95</td>
<td>56</td>
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<tr>
<td>C</td>
<td>263</td>
<td>90</td>
<td>21</td>
<td>325</td>
<td>160</td>
<td>13</td>
<td>110</td>
<td>66</td>
</tr>
<tr>
<td>D</td>
<td>413</td>
<td>130</td>
<td>23</td>
<td>320</td>
<td>150</td>
<td>14</td>
<td>110</td>
<td>64</td>
</tr>
<tr>
<td>E</td>
<td>539</td>
<td>90</td>
<td>23</td>
<td>350</td>
<td>135</td>
<td>11</td>
<td>120</td>
<td>84</td>
</tr>
</tbody>
</table>

Fig. 1 Average vacuum values within whole pulse time in the under-teat chamber of evaluated claws in dependence on flow-rate

Nominal vacuum 50 kPa
Pulsation rate 50 p/min
Pulsation ratio 60:40
Type of pulsation alternate
Fig. 2  Average vacuum values in the under-teat chamber of evaluated claws in dependence on flow-rate in the time of suction (B)

Nominal vacuum  50 kPa
Pulsation rate   50 p/min
Pulsation ratio  60 : 40
Type of pulsation alternate
Fig. 3 - Average vacuum decrease in the under-teat chamber in dependence on the flow-rate at nominal vacuum 42 and 50 kPa

Fig. 4 - Course of vacuum in the measuring points of the milking unit and milk flow-rate during milking of the dairy cow No 216 on farm Trhovy Stepanov
Fig. 2  Average vacuum values in the under-teat chamber of evaluated claws in dependence on flow-rate in the time of suction (B)

Nominal vacuum 50 kPa
Pulsation rate 50 p/min
Pulsation ratio 60 : 40
Type of pulsation alternate
Analysis of vacuum fluctuation

Obr.3 - Average vacuum decrease in the under-teat chamber in dependence on the flow-rate at nominal vacuum 42 and 50 kPa

Claw A
Teatcup A
Pulsation rate 50 p/min
Pulsation ratio 60 : 40
Type of pulsation Alternate

Flow-rate, kg/min
- 50 kPa
- 42 kPa
- Polynomický (42 kPa)
- - Polynomický (50 kPa)