EVALUATION OF THE OPERATIONAL CHARACTERISTICS OF SHEEP MILKING INSTALLATION

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Abstract

An operational study of sheep milking installation DIO-24 has been carried out. The values of “Labour productivity per hour net milking time, \( W_1 \)” and “Labour productivity per hour operational milking time, \( W_{02} \)” were found:

- At high level of productivity:
  \[
  W_1 = 80.17 \text{ ewes/man-hour;}
  \]
  \[
  W_{02} = 55.28 \text{ ewes/man-hour;}
  \]
- At low level of productivity:
  \[
  W_1 = 114.53 \text{ ewes/man-hour;}
  \]
  \[
  W_{02} = 70.87 \text{ ewes/man-hour.}
  \]

The relative values of the time for performing: technological operations during the actual milking \( T_1 \), preparatory \( T_2 \) and terminative \( T_3 \) technological operations have been established. Significant influence on the duration of the technological operations cause the level of productivity and the stage of lactation period, as the increase of \( T_1 \) is proportional to the increase of the productivity and the increase of both \( T_2 \) and \( T_3 \) is inversely proportional to the increase of productivity. The relative value of \( T_1 \) varies from 61.88 % to 68.95 % and the total relative value of auxiliary technological times \( T_2 + T_3 \) - from 31.05 to 38.11 %.

The study of the relationship between the duration of the auxiliary technological operations \( T_2 + T_3 \) and the design of DIO-24 gives grounds to conclude that the relatively high values of the auxiliary technological operations are caused by the design of fixation system, based on “The principle of arbitrary fixation”.

A possible approach to overcome these disadvantages is to implement a fixation system, based on the “principle of arranged fixation”. Such an approach helps for improving of the organization of animals movement on the milking platform, reducing the time for performing of auxiliary technological operations and improving the operational characteristics of milking installation.

Key words: sheep breeding; milking; milking installation; operational characteristics

Introduction

Operational studies in the field of milking equipment and milking technologies are research approach for adequate description and obtaining of useful information about the properties of the studied object and related processes. These studies help to collect objective data about the operational conditions of milking equipment, characteristics and parameters of the working environment and the organization of working process.

The obtained information allows doing an operational evaluation of the milking technique. This evaluation is the base of the decision-making process about the effectiveness and appropriateness of application of a specific technical and technological solution. And also, about the possibilities for optimization of some technical parameters and the improvement of milking equipment, labour organization and milking process (Kardashevski, 1979; RS 3527-72.G99).

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The aim of the study was to carry out an operational evaluation of sheep milking installation DIO-24.

Materials and Methods

The study was conducted in the Experimental sheep farm of the Institute of Animal Science in Kostinbrod town. 110 ewes of the “Synthetic Population Bulgarian Milk” breed are bred in the farm.

The basic parameters of the farm are shown in Table 1 (Ivanova, 2013).

The herd milking is done by milking installation DIO-24, mounted in a milking parlour. DIO-24 is a 24-places, single-row, “side-by-side” type installation, operated by two milkmen. The applied milking technology includes feeding of the ewes with concentrate feed during the milking process.

The installation is equipped with a movable fixation system, with manually-driven fixation. The design of the fixation system applies “The principle of arbitrary fixation”. According to this principle, any ewe, when enters the milking platform, can occupy any unoccupied place (“arbitrary place”) at the concentrate feeder.

A general view of the milking parlour with milking installation DIO-24 is shown at Figure 1.

In the course of research, the technological operations, carried out during the implementation of milking process were explored. The names of the technological operations are presented in Table 2.

Table 1
Main parameters of the flock at the experimental sheep farm in IAS-Kostinbrod

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measure</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm capacity (number of ewes)</td>
<td>Number</td>
<td>110</td>
</tr>
<tr>
<td>Average milk production per 120 days milking period</td>
<td>l</td>
<td>110</td>
</tr>
<tr>
<td>Live weight of the ewes</td>
<td>kg</td>
<td>65.00</td>
</tr>
<tr>
<td>Prolificacy</td>
<td>%</td>
<td>155</td>
</tr>
<tr>
<td>Sheared wool per ewe</td>
<td>kg</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Fig. 1. General view of the milking parlour and milking installation DIO-24
With the purpose of higher representativeness of the obtained results and authenticity of completed operational evaluation, the study was conducted during different stages of the lactation period – in April and July. The resulting levels of milk productivity are conditionally named “a high level of productivity” (with average milking productivity of the flock $X = 1.21 \text{ l/day}$) and “a low level of productivity” (with average milking productivity of the flock $X = 0.79 \text{ l/day}$).

The assessment of technological operations was made by the application of methods of “Control Working Shifts” and “Timing Monitoring” (RS 3527-72.G99). For the observation and exploration of technological processes a specialized video system was used (Sabkov and Ivanov, 2009).

The preparation and the conduct of experimental research, as well as the processing of obtained results, was carried out with the help of priori known methods (Mitkov and Minkov, 1989; RS 3527-72.G99).

In the process of timing the observations it was determined the duration of each technological operation, carried out within one milking cycle. The duration of the operations is measured to an accuracy of 0.01 s.

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On the basis of the obtained results for the duration of the technological operations the following operational characteristics are determined:
- labour productivity per hour of net milking time, $W_1$;
- labour productivity per hour of operational milking time, $W_{02}$.

Labour productivity per hour of net milking time, $W_1$, is presented with the expression:

$$W_1 = \frac{3600Q}{T_1N}, \text{ ewes/man-hour}, \quad (1)$$

where $Q$ is the number of simultaneously milked ewes (i.e., the capacity of milking platform);
- $T_1$ – net milking time, s;
- $N$ – number of milkmen, simultaneously milking with the installation.

The net milking time, $T_1$, is the sum of all times, involved in the process of actual milking, or

$$T_1 = \sum_{i=1}^{3} T_{1;i}, \text{ s}. \quad (2)$$

In this equation with $T_{1;i}$ are indicated the times for:
- $T_{11}$ – machine milking, s;
- $T_{12}$ – machine stripping, s;
- $T_{13}$ – waiting for the end of milking the group.

Labour productivity per hour of operational milking time, $W_{02}$, is expressed with:

$$W_{02} = \frac{3600Q}{T_{02}N}, \text{ ewes/man-hour}. \quad (3)$$

The operational milking time, $T_{02}$, is the sum of the:
- net milking time, $T_1$;
- time for preparatory technological operations, $T_2$; and
- time for terminative technological operations, $T_3$, i.e.:

$$T_{02} = T_1 + T_2 + T_3, \text{ s}. \quad (4)$$

<table>
<thead>
<tr>
<th>№</th>
<th>Name of the technological operation</th>
<th>Duration symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Technological operations during the actual milking</td>
<td>$T_1$</td>
</tr>
<tr>
<td>1.</td>
<td>Machine milking.</td>
<td>$T_{11}$</td>
</tr>
<tr>
<td>2.</td>
<td>Machine stripping.</td>
<td>$T_{12}$</td>
</tr>
<tr>
<td>3.</td>
<td>Waiting for the end of milking the group.</td>
<td>$T_{13}$</td>
</tr>
<tr>
<td>II.</td>
<td>Preparatory technological operations</td>
<td>$T_2$</td>
</tr>
<tr>
<td>1.</td>
<td>Loading the feeder with concentrate feed</td>
<td>$T_{21}$</td>
</tr>
<tr>
<td>2.</td>
<td>Routing the ewes onto the milking platform</td>
<td>$T_{22}$</td>
</tr>
<tr>
<td>3.</td>
<td>Arrangement of the ewes on milking platform and fixation</td>
<td>$T_{23}$</td>
</tr>
<tr>
<td>4.</td>
<td>Attaching of teat cups</td>
<td>$T_{24}$</td>
</tr>
<tr>
<td>III.</td>
<td>Terminative technological operations</td>
<td>$T_3$</td>
</tr>
<tr>
<td>1.</td>
<td>Detaching of the milking clusters</td>
<td>$T_{31}$</td>
</tr>
<tr>
<td>2.</td>
<td>Waiting for release of the group</td>
<td>$T_{32}$</td>
</tr>
<tr>
<td>3.</td>
<td>Routing the ewes out of milking parlour</td>
<td>$T_{33}$</td>
</tr>
</tbody>
</table>
The time for preparatory technological operations, $T_2$, is the sum of all times for performing of preparatory technological operations, necessary for starting the “Actual milking” process:

$$T_2 = \sum_{i=1}^{4} T_{2,i}, \text{ s.} \tag{5}$$

In this equation $T_{2,i}$ is the time for:
- $T_{2,1}$ – time for loading the feeder with concentrated feed;
- $T_{2,2}$ – time for routing the ewes onto the milking platform;
- $T_{2,3}$ – time for arrangement and fixation the ewes on the milking platform and bringing the fixation system in position “For milking”;
- $T_{2,4}$ – time for attaching of the teat cups.

The auxiliary time, $T_3$, is the sum of times for performing of terminative technological operations:

$$T_3 = \sum_{i=1}^{3} T_{3,i}, \text{ s.} \tag{6}$$

Here with $T_{3,i}$ are presented the times for:
- $T_{3,1}$ – detaching of milking apparatus;
- $T_{3,2}$ – waiting for release of the group;
- $T_{3,3}$ – routing the ewes out of milking parlour.

The operational time for milking with the installation, $T_0$, equals to the necessary time for performing of one milking cycle, $T_c$.

$$T_0 = T_c = T_1 + T_2 + T_3, \text{ s.} \tag{7}$$

For evaluation of the working effectiveness of milking installation it was determined the relative value of net milking time, $T_1$, and the auxiliary times, $T_2$ and $T_3$, within one milking cycle $T_0$.

**Results and Discussion**

The obtained statistical evaluations of numerical characteristics for the technological operations during milking with DIO-24 are presented in Table 3.

On the basis of these results were calculated:

**Labour productivity.**

Labour productivity per hour of net milking time, $W_1$, of:
- At high level of productivity: $W_1 = 80.17$ ewes/man-hour;
- At low level of productivity: $W_1 = 114.53$ ewes/man-hour.

Labour productivity per hour of operational milking time, $W_0$:
- At high level of productivity: $W_0 = 55.28$ ewes/man-hour;
- At low level of productivity: $W_0 = 70.87$ ewes/man-hour.

**Percentage distribution of the time per milking cycle**

The obtained results show, that the level of productivity (respectively, the stage of lactation period) significantly affects the duration of technological operations. That influence is most expressed for the net milking time, $T_1$. The relative value of $T_1$ in one milking cycle varies from 61.88% to 68.95%, as the increase is proportional to increase of the level of ewes’ productivity.

The time for preparatory technological operations, $T_2$, varies from 22.21% to 26.67%, and the time for terminative technological operations, $T_3$, - from 8.84% to 11.44%. The relative value both of $T_2$ and $T_3$ in one milking cycle is inversely proportional to the increase of productivity.

**Table 3**

Evaluation of the numerical characteristics of technological operations during ewes machine milking with DIO-24

<table>
<thead>
<tr>
<th>Name of the technological operation</th>
<th>Duration symbol</th>
<th>At high level of productivity</th>
<th>At low level of productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\overline{X}$, s</td>
<td>$S$, s</td>
<td>$V$, %</td>
</tr>
<tr>
<td>Loading the feeder with concentrate feed</td>
<td>$T_{2,1}$</td>
<td>47.56</td>
<td>2.63</td>
</tr>
<tr>
<td>Routing the ewes onto the milking platform</td>
<td>$T_{2,2}$</td>
<td>35.60</td>
<td>2.48</td>
</tr>
<tr>
<td>Arrangement the ewes on milking platform and fixation</td>
<td>$T_{2,3}$</td>
<td>80.16</td>
<td>5.53</td>
</tr>
<tr>
<td>Attachment the teat cups</td>
<td>$T_{2,4}$</td>
<td>10.28</td>
<td>0.95</td>
</tr>
<tr>
<td>Machine milking</td>
<td>$T_{1,1}$</td>
<td>73.88</td>
<td>5.07</td>
</tr>
<tr>
<td>Machine stripping</td>
<td>$T_{1,2}$</td>
<td>9.90</td>
<td>0.93</td>
</tr>
<tr>
<td>Waiting for the end of milking the group</td>
<td>$T_{1,1}$</td>
<td>455.05</td>
<td>33.28</td>
</tr>
<tr>
<td>Detaching the milking clusters</td>
<td>$T_{3,1}$</td>
<td>5.77</td>
<td>0.61</td>
</tr>
<tr>
<td>Waiting for the release of group</td>
<td>$T_{3,2}$</td>
<td>11.52</td>
<td>0.82</td>
</tr>
<tr>
<td>Routing the ewes out of milking platform</td>
<td>$T_{3,3}$</td>
<td>51.78</td>
<td>3.43</td>
</tr>
</tbody>
</table>
The total relative value of auxiliary technological operations (i.e., $T_2$ and $T_3$) within one milking cycle varies between 31.05% and 38.11%. In fact this is “idle” for the working process of milking installation. To increase the efficiency it is necessary to increase the relative value of net milking time ($T_1$), i.e. to reduce the relative value of auxiliary technological operations.

The study of relationship between the duration of auxiliary technological operations and the design of milking installation DIO-24 gives grounds to conclude that in this case significant impact on the relatively high values of $T_2$ and $T_3$ induces the design of fixation system (based on “The principle of arbitrary fixation”).

A possible approach to reduce the duration of auxiliary technological operations is to implement a fixation system, designed on “The principle of arranged fixation”. Under this principle, when the animals enter on the milking platform, each animal can occupy an exactly specified, unoccupied place at the concentrate feeder, next to preceding animal. Thus each successive animal “is arranged” next to the animal, fixated before him. And as whole the animals can occupy successively and tidy their places at the concentrate feeder.

The study results show that the operational characteristics “Labour productivity per hour of net milking time, $W_p$” and “Labour productivity per hour of operational milking time, $W_{op}$” of the sheep milking installation DIO-24 are functions of the current productivity and stage of lactation period of the ewes.

The duration and the relative value of technological operations within a milking cycle vary depending on the current productivity. The relative value of the time for technological operations during the actual milking ($T_1$) is proportional to the increase of ewes’ productivity. The relative value of time for auxiliary technological operations ($T_2$ and $T_3$) is inversely proportional to the increase of productivity.

The study of relationship between the duration of auxiliary technological operations and the design of sheep milking installation DIO-24 gives grounds to conclude that the design of the fixation system and the application of the principle of “The arbitrary fixation” induce significant impact on the auxiliary technological times. A possible way to overcome these disadvantages of DIO-24 is to implement a fixation system, based on “The principle of arranged fixation”.

**Conclusion**

The study results show that the operational characteristics “Labour productivity per hour of net milking time, $W_p$” and “Labour productivity per hour of operational milking time, $W_{op}$” of the sheep milking installation DIO-24 are functions of the current productivity and stage of lactation period of the ewes.

The duration and the relative value of technological operations within a milking cycle vary depending on the current productivity. The relative value of the time for technological operations during the actual milking ($T_1$) is proportional to the increase of ewes’ productivity. The relative value of times for auxiliary technological operations ($T_2$ and $T_3$) is inversely proportional to the increase of productivity.

The study of relationship between the duration of auxiliary technological operations and the design of sheep milking installation DIO-24 gives grounds to conclude that the design of the fixation system and the application of the principle of “The arbitrary fixation” induce significant impact on the auxiliary technological times. A possible way to overcome these disadvantages of DIO-24 is to implement a fixation system, based on “The principle of arranged fixation”.

**References**


