Automated control systems for technical processes in dairy farming

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Abstract: Automated control systems for technical processes in dairy farming. Monitored parameters, evaluated data and formed control and operating commands for technical processes of individual animal service are presented. Perspective directions for the development of automated control systems for technical processes of machinery milking, feeding, livestock and maintenance in dairy farming based on precision (highly accurate) technologies and technical means are substantiated.

Key words: dairy farming, automation, control system, milking, feeding, maintenance, physiological condition.

INTRODUCTION

During last ten years in daily farming the priority scientific problem was formed and based on four main directions: intensive technologies, mechanization, automation and physiological aspects. At the same time, it’s impossible to actualize intensive technologies without any control system for technical processes. According to the facts [Gasteiner 2005], the introduction of automated control systems for technical processes in dairy farming allows to increase the work productivity by 1.2–2 times, reduce energy costs by 30–40%, raise the animal productivity to 20% and improve working conditions for stockbreeders significantly.

MATERIALS AND METHODS

Usually automated control systems for dairy farming are attached to the milking equipment, because it’s the key part of the milk production technology – this is where the information about productivity, milk quality parameters, reproduction and physiological condition of the animal is collecting, updating and recording. This huge data set is processed on the computer, so that specialists can use all the necessary information for making decisions either about one animal, or about the whole herd.

Automated control systems for dairy farming are solving next tasks (Fig. 1).

Using the automated systems provides:
- getting the current information about animals;
- fast access to the animal history;
- increasing the milk yield because of the preclinical disease diagnosis;
- structure analysis of the herd and the animal physiological condition;
- reducing veterinary medicine costs;
detection of the breaches in the herd
reproduction technology;
reducing the number of unpregnant
animals and increasing the calves
productivity;
increasing the feeding effectiveness;
reducing work costs and the improve-
ment of work culture.

For today different companies offer
variable equipment of the automated con-
trol systems for dairy farming (Tab. 1).
These automated control systems for
dairy farming can’t give the full produc-
tion evaluation according to the physio-
logical animal parameters.

RESULTS OF INVESTIGATIONS
AND DISCUSSION

To substantiate the perspective directions
for the development of automated control
systems for dairy farming and to continue
the ways of its realization.

Technological process of the individual
animal maintenance, its control and moni-
toring, can be realized with the executive
commands of the control system based on
the biological objects functioning evalua-
tion parameters (Tab. 2).

Analysis of the Table 2 shows that the
level of the animal biological potential
realization is defined by the technologi-
cal milking and feeding processes, the
animal location control, the mobility
function, the detection of the estrus and
the insemination time.

So the individual animal maintenance
and improving of the animal milking,
feeding, maintenance and service tech-
nical processes, based on the precision
technologies and technical means using,
is the important reserve for the increas-
ing of the milk production effectiveness.

Automated control system for tech-
nical milking process defines the effec-
tiveness of the cow milking (Fig. 2).
This system is based on the monitoring
of technical and technological param-
eters of the milking machine electronic
pulser through the measurement of its air
flow and the rate of the cow milk flow
[Shevchenko 2012]. The special deve-
loped device (Fig. 3) controls techni-
cal and technological parameters of the
milking machine electronic pulser. This
device is used for the measurement of
the vacuum pressure in the range from
0 to 99.9 kPa, pulsation frequency in the
TABLE 1. Comparative characteristics of the automated control systems for dairy farming

<table>
<thead>
<tr>
<th>System name, maker (country)</th>
<th>Equipment</th>
<th>Automated functions</th>
<th>Additional abilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPRO, DeLaval (Sweden)</td>
<td>– ALPRO processor; – transponders; – antennas; – controllers; – activity sensors; – software</td>
<td>– milk yields measurement; – registration of the food eating; – control of the animal biological condition</td>
<td>– control of animals; registration of animals; – calendar of the veterinary activities; – group forming; – separated registration of the calves’ growing up</td>
</tr>
<tr>
<td>Dairy Plan 5, GEA Group (Germany)</td>
<td>– computer circuit boards; – Responder sensors; – antennas; – Metatron system; – Finilactor system; – electronic pulser; – feed distribution system; – activity Rescounter sensors; – checkpoint scales; – selection gates; – Dairy Plan software</td>
<td>– measurement and control of the milk yields; – mastitis indication and ban milking ill cows; – after-milking and taking the device off; – registration of the food eating; – food dosing; – indication of the condition in heat</td>
<td>– milk cost calculation; – calendar of the veterinary activities; – making work plans; – weight measurement; – animal moving control; – separated registration of the calves’ growing up</td>
</tr>
<tr>
<td>Cattle Code, SAC (Denmark)</td>
<td>– portable ID-Logger computer; – responders; – portal antennas; – UNI–LAC Memolac / 2 Milk Meter milk yields control system; – Unitlow 3 Milk Claw milk conductivity sensors; – Respactor activity sensors; – Herd Management software</td>
<td>– measurement and control of the milk yields; – registration of the rate of milk yield flow; – mastitis indication; – concentrate feed dosing; – registration of the food eating; – measurement of the cow motility and temperature</td>
<td>– individual animal calendar; – feeding in the milking parlor; – weight measurement; – separated registration of the calves’ growing up; – ration calculation for calves feeding</td>
</tr>
<tr>
<td>DataFlow, SCR (Israel)</td>
<td>– computer; – HR Tag transponders; – ID antennas; – controllers; – DataFlow milking control system; – software</td>
<td>– activity monitoring; – chewing activity (rumination) monitoring; – milk yields and milk quality monitoring</td>
<td>– individual animal calendar and history; – herd selection</td>
</tr>
<tr>
<td>System for the identification and normalized cow feeding (prototype), STC “Fermash” (Russia)</td>
<td>– controllers; – central computer; – sensor collars; – antennas; – milk meter; – automated feed station; – software</td>
<td>– measurement of individual milk yields; – individual concentrate feed dosing; – control of the biological animal condition</td>
<td>– monitoring of the milk yield flow; – individual animal calendar; – group forming according to the lactation stage; – ration optimization; – herd selection</td>
</tr>
</tbody>
</table>
Table 1. (continued)

| Automated herd control system, AIAE&AIM (Russia) | – computer; – responders; – antennas; – identification systems; – automated feed station | – measurement of individual milk yields; – concentrate feed dosing; – temperature measurement in udder parts | – individual animal calendar and history; – weight measurement |
| AFIFARM, Bratslav Ltd. (Ukraine) | – controllers; – central computer; – sensor collars; – antennas; – milk meter; – software | – measurement and control of the milk yields; – registration of the rate of milk yield flow; – control of the biological animal condition | – cow health analysis; – reproduction; – individual animal calendar and history |

TABLE 2. Control and monitoring parameters for technological processes of the individual animal maintenance

<table>
<thead>
<tr>
<th>Technological processes; operations</th>
<th>Control and monitoring tasks</th>
<th>Controlled parameters</th>
<th>Evaluated parameters and formed control commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal identification</td>
<td>Animal identifiers database management</td>
<td>Number of the animal</td>
<td>Identification of the animal inside the herd</td>
</tr>
<tr>
<td>Milking</td>
<td>Milk yields database management</td>
<td>Milk yield, milking duration, after-milking duration</td>
<td>Individual animal parameters</td>
</tr>
<tr>
<td>Monitoring of the milking process</td>
<td>Milk flow intensity</td>
<td>Forming the commands for the milking control, the breaches in the milking process</td>
<td></td>
</tr>
<tr>
<td>Control of the milking mode</td>
<td>Technical and technological parameters of the milking equipment</td>
<td>Forming of the technical service plan</td>
<td></td>
</tr>
<tr>
<td>Operator control</td>
<td>Duration of the cow milking preparing, timely putting the sockets on</td>
<td>Breaches of the preparing operations</td>
<td></td>
</tr>
<tr>
<td>Milk quality control</td>
<td>Milk quality parameters</td>
<td>Animal disease identification, forming of the veterinary activities calendar, ration optimization</td>
<td></td>
</tr>
<tr>
<td>Feeding</td>
<td>Ration database management</td>
<td>The feed quantity, the duration of the eating, the uneaten feed quantity</td>
<td>The quantity of eaten feed, forming and issuance of the individual rations</td>
</tr>
<tr>
<td>Detection of the animals with illness symptoms</td>
<td>The rate of the food eating, deviation from the average rate of the food eating, rumination monitoring</td>
<td>Animal disease identification, forming of the veterinary activities calendar</td>
<td></td>
</tr>
<tr>
<td>Control of the technical means functionality</td>
<td>Technical and technological parameters of the technical means</td>
<td>Forming of the technical service plan</td>
<td></td>
</tr>
</tbody>
</table>
range from 40 to 200 pulses/min and pulsation phases A + B in the range from 0 to 99.9% [Aliev 2012].

Using of the automated control system for technical processes of the feed preparing and distribution, which can be based on the stream type mixer-wagon (Fig. 4), is expedient for the animal feed distribution by groups. Each group has the transmitter, which transfer the information about the group ration to the mixer-wagon. Automated control system, receiving data
from the receiver, operates technological processes of the components mixing and feed distribution to the feed table. Nowadays this system, which is based on the motor control unit Danfoss Micro Drive (Fig. 5), is being developed.

The automated control system for cow service and maintenance (Fig. 6) is offered as a way to control the selective herd reproduction and the cow selection from the groups of physiological condition. This system is based on the evalu-
Automated control systems for technical processes in dairy farming

Determination of cow geometrical parameters, its kinematic and dynamic moving characteristics to determine the physiological condition and to evaluate the cow automatically. This method gives the chance to evaluate tribal animal properties comprehensively and to make a forecast about the potential productivity for each cow. Kinematic and dynamic cow moving characteristics are determined with the developing software, which uses the Kinect camera-sensor (Fig. 7).

Existant automated systems are based on the monitoring of the operated technological processes and the animal physiological condition. This monitoring allows collecting information in the dynamic mode that provides the adapted controlling and increasing of the technological process effectiveness as a result.
CONCLUSIONS

- Improving the automated control systems for the technological processes of milking, differential feeding and service in the dairy farming, based on the precision technologies and technological means, is the most perspective way of the technical development in the dairy farming.
- It’s established that the adaptive analytic information control system for the milking technological process, based on the animal physiological condition analysis, using the permanent mobile monitoring, determines the effectiveness of the machine milking.

REFERENCES


Streszczenie: Automatyczne systemy sterowania procesami technologicznymi w gospodarstwie mlecznym. Przedstawiono monitorowane parametry, analizowane dane i formułowane, sterujące i robocze polecenia w procesach technologicznych indywidualnej obsługi zwierząt. Określono przyszłościowe kierunki rozwoju systemów automatycznego sterowania procesami technologicznymi.
nymi mechanicznego doju, żywienia i utrzymania zwierząt w gospodarstwie mlecznym, opartym na zastosowaniu precyzyjnych (o wysokiej dokładności) technologii i środków technicznych.

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