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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;

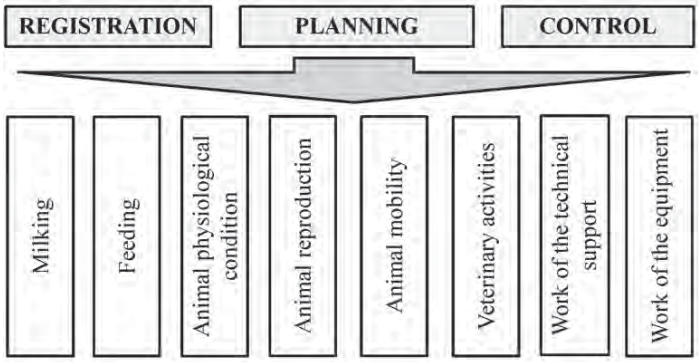

FIGURE 1. The tasks of the automated control systems for dairy farming

– 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 improvement of work culture.

For today different companies offer variable equipment of the automated control systems for dairy farming (Tab. 1).

These automated control systems for dairy farming can't give the full production evaluation according to the physiological 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 monitoring, can be realized with the executive commands of the control system based on the biological objects functioning evaluation parameters (Tab. 2).

Analysis of the Table 2 shows that the level of the animal biological potential realization is defined by the technological 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 technical processes, based on the precision technologies and technical means using, is the important reserve for the increasing of the milk production effectiveness.

Automated control system for technical milking process defines the effectiveness of the cow milking (Fig. 2). This system is based on the monitoring of technical and technological parameters 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 developed device (Fig. 3) controls technical 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

System name, maker (country)	Equipment	Automated functions	Additional abilities
1	2	3	4
ALPRO, DeLaval (Sweden)	– ALPRO processor; – transponders; – antennas; – controllers; – activity sensors; – software	– milk yields measurement; – registration of the food eating; – control of the animal biological condition	– control of animals, registration of animals; – calendar of the veterinary activities; – group forming; – separated registration of the calves' growing up
Dairy Plan 5, GEA Group (Germany)	– 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	– 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	– milk cost calculation; – calendar of the veterinary activities; – making work plans; – weight measurement; – animal moving control; – separated registration of the calves' growing up
Cattle Code, SAC (Denmark)	– 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	– 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	– individual animal calendar; – feeding in the milking parlor; – weight measurement; – separated registration of the calves' growing up; – ration calculation for calves feeding
DataFlow, SCR (Israel)	– computer; – HR Tag transponders; – ID antennas; – controllers; – DataFlow milking control system; – software	– activity monitoring; – chewing activity (rumination) monitoring; – milk yields and milk quality monitoring	– individual animal calendar and history; – herd selection
System for the identification and normalized cow feeding (prototype), STC "Fermmash" (Russia)	– controllers; – central computer; – sensor collars; – antennas; – milk meter; – automated feed station; – software	– measurement of individual milk yields; – individual concentrate feed dosing; – control of the biological animal condition	– monitoring of the milk yield flow; – individual animal calendar; – group forming according to the lactation stage; – ration optimization; – herd selection

Table 1. (continued)

1	2	3	4
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

Technological processes; operations	Control and monitoring tasks	Controlled parameters	Evaluated parameters and formed control commands
1	2	3	4
Animal identification	Animal identifiers database management	Number of the animal	Identification of the animal inside the herd
Milking	Milk yields database management	Milk yield, milking duration, after-milking, after-milking duration	Individual animal parameters
	Monitoring of the milking process	Milk flow intensity	Forming the commands for the milking control, the breaches in the milking process
	Control of the milking mode	Technical and technological parameters of the milking equipment	Forming of the technical service plan
	Operator control	Duration of the cow milking preparing, timely putting the sockets on	Breaches of the preparing operations
	Milk quality control	Milk quality parameters	Animal disease identification, forming of the veterinary activities calendar, ration optimization
Feeding	Ration database management	The feed quantity, the duration of the eating, the uneaten feed quantity	The quantity of eaten feed, forming and issuance of the individual rations
	Detection of the animals with illness symptoms	The rate of the food eating, deviation from the average rate of the food eating, rumination monitoring	Animal disease identification, forming of the veterinary activities calendar
	Control of the technical means functionality	Technical and technological parameters of the technical means	Forming of the technical service plan

Table 2. (continued)

1	2	3	4
Insemination	Insemination and estrus database management	Insemination calendar, animal mobile activity	Timely animal insemination, control of the selective herd reproduction, estrus identification
Weighing	Animal weight-changing database management	Animal weight	Weight gain
Animal location identification	Animal location database management	Three-dimensional coordinates of the animal, behavior parameters	Identification and definition of the animal location in the maintenance zone, estrus, group forming, exercises control
Animal mobility definition	Animal mobility database management	Autovaluation, identification of the limbs disease	Control of the selective herd reproduction, forming of the veterinary activities calendar

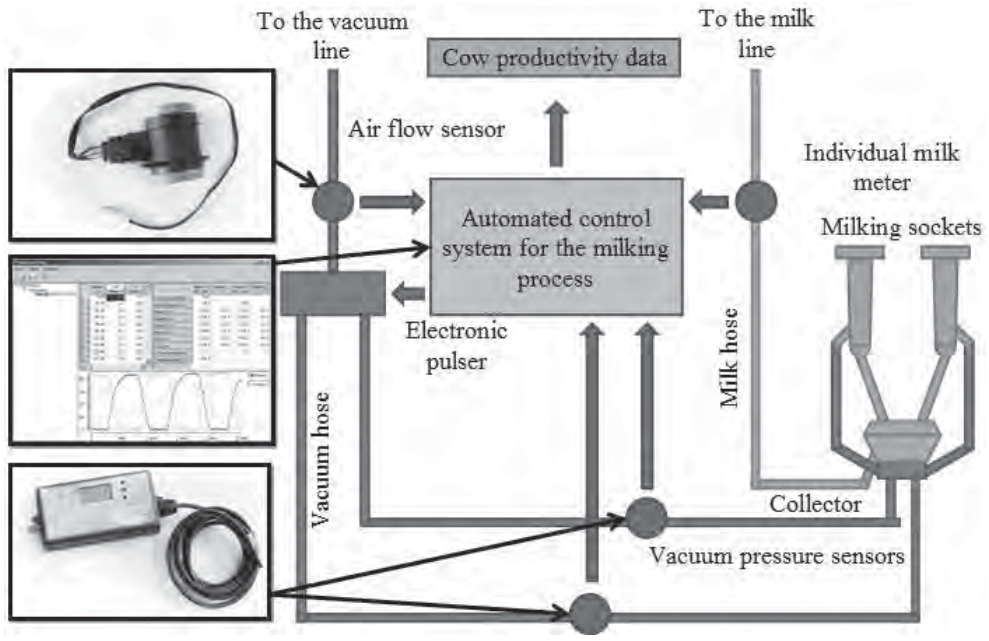

FIGURE 2. Automated control system for technical milking process

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

FIGURE 3. The controlling device for the vacuum and pulse parameters of the milking machine

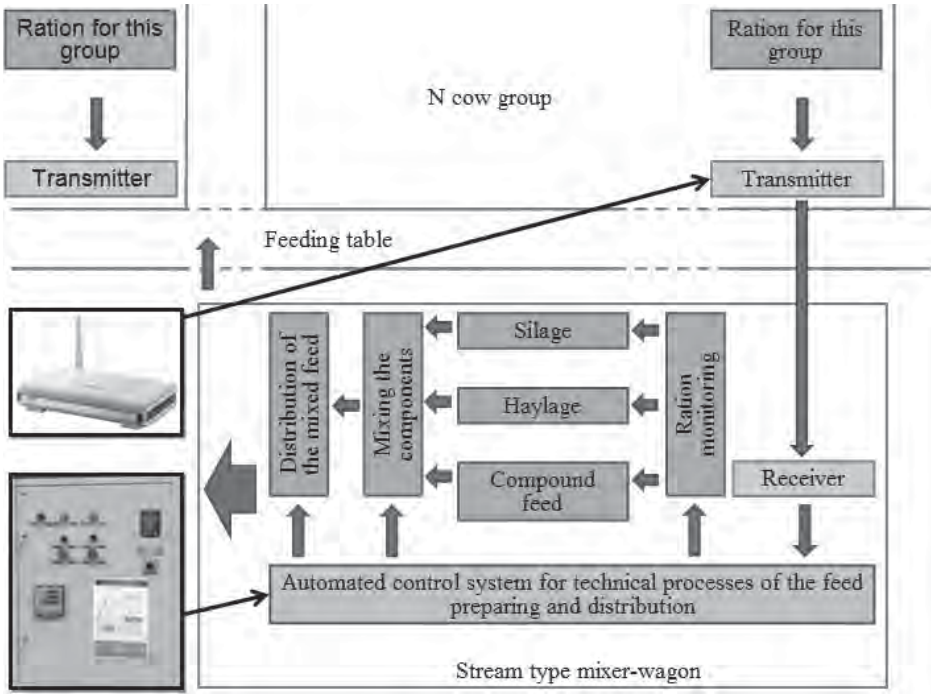

FIGURE 4. Automated control system for technical processes of the feed preparing and distribution

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-

FIGURE 5. Automated system based on the motor control unit Danfoss Micro Drive

ation of cow geometrical parameters, its kinematic and dynamic moving characteristics to determine the physiological condition and to valuate 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).

Existent 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.

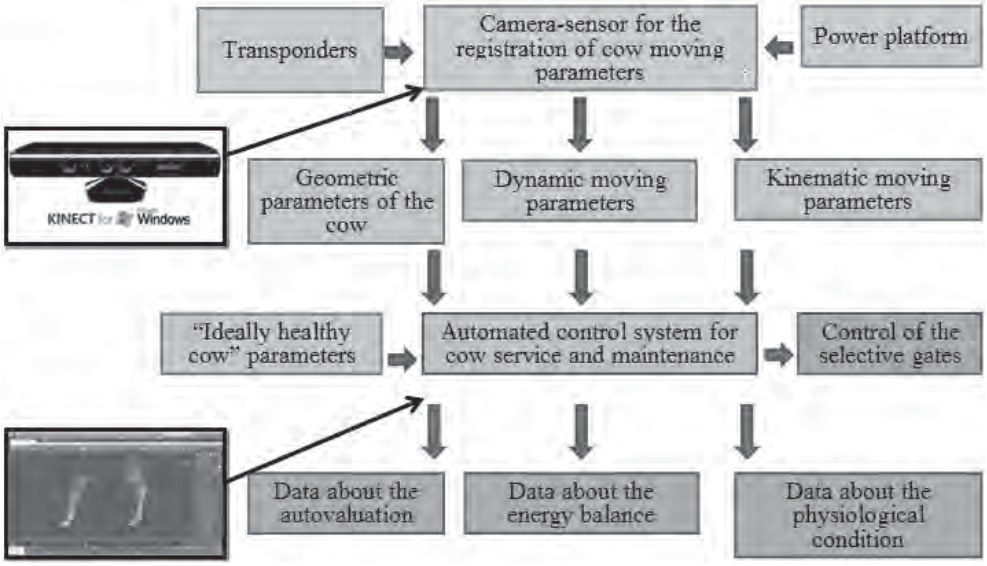

FIGURE 6. The automated control system for cow service and maintenance

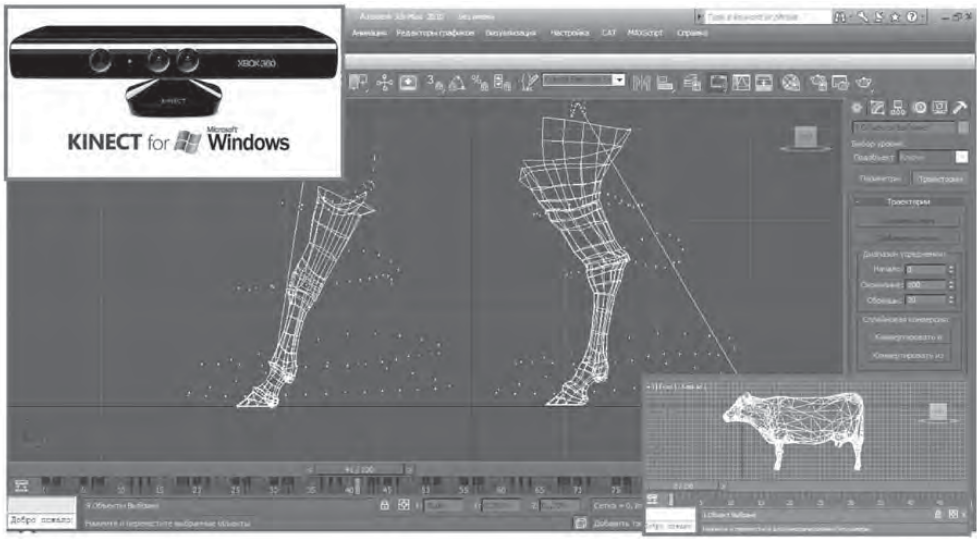

FIGURE 7. Software for the automated control system for cow service and maintenance based on the Kinect camera-sensor

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.

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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 technologicz-

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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