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The animals radio-frequency identification systems for stall milking machines

Abstract

The paper considered the implementation of radio frequency identification system of animals for stall milking machines. The proposed system is a part of the information-measuring system of animal zootechnical parameters and process parameters to obtain milk that is used in milking dairy cattle farms departments. A new method for automatic radio frequency identification was developed in realization of which the transponders are not on animals but are mounted in the installation place of the portable milking process control units.

Keywords: transponder, animal radioidentification, reader, milking machines, inductive antenna, inductive coupling.

1. Introduction

The modern automatic control systems of technological processes in milking - dairy departments of cattle farms provide the ability to track the development of each animal and manage the process its keeping. The solution of these problems is provided by the relevant information-measuring systems of animal zootechnical parameters that are the part of the systems of automatic control.

The composition of information-measuring systems of zootechnical parameters includes the specialized means of animal identification by which it's established individual number in the herd. Then the measurement of zootechnical parameters occurs. Currently subjective means of identification, identification tools based on the scan of the retina, a means of identification using active transponders with an infrared interface, a radio frequency identification devices using active and passive transponders are used. The means of identification on the basis of scanning the eye retina are not widely known due to its complexity, high cost and low reliability. While using the means of identification which are designed to work with active transponders with an infrared interface, there is a need for periodic replacement of the batteries. Besides, there are technical difficulties in ensuring the relative orientation in space of the transponder's transmitter and reader's receiver, which reduces the reliability of the identification of animal. Due to the above circumstances, such means of identification are not widely spread.

According to the need of periodic replacement of batteries the means of radio frequency identification with active transponders aren't widely used. Subjective means of identification are used in different ways of animals keeping. In this case the number of animal in the herd is visually identified by the operator and then is introduced into the control unit of the milking process by using the keyboard. As a result, the probability of subjective error and the complexity of the operator work significantly increases. The means of radio-frequency identification with passive transponders that don't require own power source are the most common in our days. The actual task is to develop the means of radio-frequency identification with passive transponders for milking stall. Current milking stalls in most cases use subjective means of identification. The research conducted refers to the theory and practice of designing the means of animal identification and information-measuring systems of zootechnical parameters.

2. The analysis of references

Currently, there are the most common means of radio-frequency identification of animals with passive transponders. The action principle which is based on reading the unique transponder's digital code, that is installed on the animal in anyway [1 - 3]. Reading this digital code is performed using a special reader. The interaction between reader and transponder is occurred contactless using radio communication [4]. Radio frequency identification, due to redeposit structural elements of the milking system, the skin and tissues of the animal can be carried out during the preparation of the animal for milking, during the milking or during the movement of animals. Parameters and transponders design that are installed on animals are regulated by international standards [5]. The transponders are used in animal husbandry, divided into active and passive. The composition of the active transponder includes an autonomous power source that provides a large reading distance and the possibility of integration the measuring means of the animal activity with transponder. The disadvantages of active transponders are relatively high cost and the necessity of periodic replacement of the batteries. Due to that the operation of the milking system is greatly complicated [6]. The passive transponders function is performed due to the energy of the electromagnetic field. This energy is created by the means of the reader via inductive antenna. The passive transponder for the radio frequency identification of animals structurally represent a monolithic sealed articles that are fixed on the ear, leg, under the skin or in the stomach of the animal [4 - 6]. Passive transponder consists of an inductor, that performs the function of the inductive antenna, a transceiver, a microprocessor, a number of passive and active components. If the transponder is in the induction zone, its oscillatory system accumulates energy that is enough for actuating the microprocessor and transceiver during transmission the electromagnetic package of a certain frequency and duration by reader. The microprocessor reacting the reader request generates its own data packet with a digital code of transponder. The package was said about above is broadcast by the radio transceiver to the transponder via an inductive antenna. The reader using synchronous detection decrypts the transponder code [7,] after that the code is transmitted to the server of the information - measuring system. The server on the base of received transponder code determines the number of animal in the herd. The result of the loss of information about the transponder code is the loss of zootechnical measurement information that concerned with a certain animal [8].

3. Statement of the problem

Tethered keeping of animals when stall milking machines are used in which radio frequency identification is applied is relatively rare. These machines use subjective identification or not carry out the identification of animals in general. There is a technical solution, when each control block of milking process is equipped with a reader. Then the operator manually brings it closer to the transponder that is located on the hind leg of the animal before animal preparation for milking [9]. Such solution increases the complexity of the operator work.

The variant of realization of the subjective identification of animal numbers in the herd and the corresponding numbers of their stall places are kept in specialized database that resides on the information-measuring system server, is described in [10]. In this case, the number of the animal is visualized on the display of control block. The operator has to check the number and confirm or correct it. There is a need to adjust the corresponding database with the change of the animals stall place, the excretion in deadwood or the transfer animals to another group. It's not head-wait time to provide in practice. In addition, the adequacy of the

animal number and its correction also increases the complexity of the operator work.

The operator has to follow the established rules of the algorithm, i.e. animals milking has to occur in sequence and accordance with the numbers of stall places for providing the maximum productivity of stall milking machines. In practice the staff of dairy-milking very often not follow the rules. As a result, the milking machines productivity and farm efficiency is reduced.

Based on this, there is a need to develop the system of animal radio frequency identification for stall milking machines. Using such system the identification is performed automatically with minimal participation of the operator, the execution of operator algorithm is ensured and there is no need to adjust the database of animals. The result of implementation such system will increase the productivity and efficiency of the milking machine.

4. The solution of problem

The modern milking machine can't function effectively without automatic control systems and information-measuring systems of technological process parameters to obtain milk. On this basis, the modernization of stall milking machines by integration of the above systems is an important task. The composition of the above systems often includes the radio frequency identification systems of animals that greatly increase the efficiency of their work. According to [5], the means of radio frequency identification for cattle have to operate at the carrier frequency of 134 kHz that corresponds to the wavelength of 2.2 km. The geometrical dimensions of the reader inductive antenna and the transponder and the distance between them is much smaller than the wavelength of the electromagnetic oscillations carrier. So, the energy of interaction between reader and transponder can be presented as two oscillatory systems with inductive coupling between the antennas (Fig. 1.)

An important parameter is the coefficient of inductive coupling between the antennas of the reader and transponder that significantly affects on the reliability of the system operation identification.

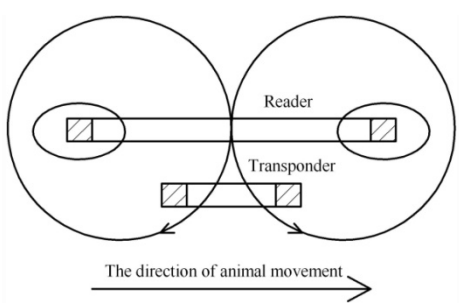

Fig. 1. The oscillatory system with inductive coupling between antennas

This coefficient depends on the distance between the antennas, the geometric dimensions of the antennas and the angle between their planes. In most cases the reader and transponders, which are used for radio frequency identification at a small distance, use a circular loop antenna. For a circular loop antenna the inductive coupling coefficient is determined by the expression

$$k(x) = \frac{M_{RT}}{\sqrt{L_R L_T}} = \frac{r_R^{\,2} \cdot r_T^{\,2} \cdot \cos(\theta)}{\sqrt{r_R \cdot r_T} \cdot (r_R^{\,2} + x^2)^{\frac{3}{2}}}, \quad (1)$$

where: M_{RT} - the mutual induction between the antennas of the reader and transponder; L_R - the inductance of the reader antenna; L_T - the inductance of the transponder antenna; Θ - the angle between the planes of the reader and transponder circular loop antenna; r_T - the radius of the transponder circular loop antenna; r_R - the radius of the reader circular loop antenna; x - the distance between the antennas.

From the expression (1) it follows that at the perpendicular location of the reader and transponder antennas the identification is impossible. It's necessary to reduce the distance between the transponder and reader and to minimize the angle between the planes of their antennas for increase the functioning reliability of the identification system.

So, the control unit of the milking process is proposed to be equipped with the reader and with fixed the transponder in the mounting location of the control unit as shown in Fig. 2.

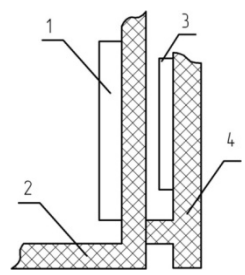

Fig. 2. The mutual location of the control unit of the milking machine and transponder: 1) the reader; 2) the housing of the control unit of the milking machine, 3) the transponder; 4) the housing of transponder mounting

The housing of the control unit of the milking and the housing of the transponder mounting are made of plastic for ensuring the redeposit. The transponder is still installed on the mount, the reader is inside the control unit of the milking process. The minimum distance between the reader and the transponder and parallel orientation of their inductive antennas are ensured when the above method of the control unit installation of the milking process is used. Due to, the transponder code is automatically read with the maximum reliability.

To service a group of animals on stall milking machine can be used from two to four control units of the milking process. The operator algorithm on stall milking machine is as follow [11]. The machine is equipped by vacuum valves for connecting the control units of milking process. The valves are placed sequentially on vacuum line. One valve is located on each serial animal pair in the stall. The operator prepares the first animal with the first pair to milking process and then puts on the teat cups and prepares for milking the first animal from another pair, puts on the teat cups and goes to the preparation of the first animal from the next pair. These actions continue until all the control units of the milking process are involved. Next, the operator watches the milking process. When the milking of the first animals with first pair ends then the operator begins to prepare for milking the second animal of this pair. After milking the first animal on the pair the operator starts the milking of the second animal. Thereafter, the operator goes to the next animal pair and performs similar actions. After milking all involved pairs the operator goes to the next one. The described action occur to that time while the milking in all stall milk line is not finished. As a rule, the stall milking machines have four or eight lines. Each line has about fifty animals. The separate line is served by the operator. The deviations from above milking regulations cause the reduction of its performance. The Figure 3 shows the transponder location on milking machine with a different number of the control units of milking process. On stall milking machine the animals are kept in stalls that are marked by C1, C2,..., Cn and the transponders that respond to a specific animal marked by T1, T2...Tn. As mentioned above, it's possible to use two (Fig. 3a), three (Fig. 3b) or four (Fig. 3c) control units of the milking process. The operator can freely move these units along the milk line by special guides. Each of these units has its own guide and the setting of these units for the implementation the milking process is possible only in those places where the transponders are installed. The vacuum valve is combined with the connector through that the control unit of the milking process

provides the supply voltage. The bi-directional communication between the control unit of the milking process and the information-measuring system server of animal zootechnical parameters is occurred also through the pins of this connector. The transponders on the milking machine are located opposite to animal pairs in such way to enforce the operator to perfume the sequence actions with the rules of the milking machine in accordance with the Fig. 3.

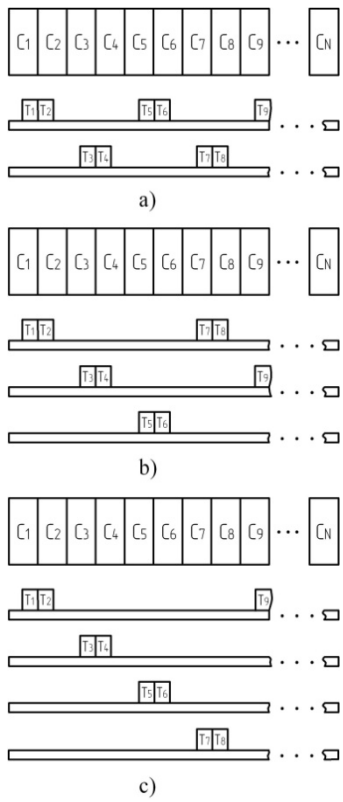

Fig. 3. The transponder location on the stall milking machines for a different number of control units of the milking process, a) two control units of the milking process b) three control units of the milking process, c) four control units of the milking process

The algorithm of the milking process control unit is as follows. After the unit is mounted on a curtain place, the operator connects the vacuum valve with electrical connector. Then the supply voltage is given to the unit and as a result the inbuilt reader is activated. At that time, the transponder is in reader induction zone (Fig. 2). As a result, the transponder code is read and transmitted to the information-measuring system server. The stall animal number is set on the server that corresponds to the given transponder number then this number is transmitted in the opposite direction and is visualized by means of the unit indicator. The operator has to check the number and in the case of necessity to perform its correction by means of the keyboard. If animal identification wasn't happened in some reasons (e.g. the reader or transponder were broken), the animal milking would be blocked by means of software. To start the milking process in this case the operator has to enter the animal number by hand. After the animal identification took place the operator prepares the animal to milking, puts on teat cups and starts the control unit of the milking process that performed the udder stimulation during determined time. The transition to the milking uncontrolled phase takes place after finishing the stimulation phase. The milk intensity isn't measured during this phase. After that, the transition to the milking contact phase occurs. During this process the milk intensity is measured and in according to its meaning the frequency of vacuum pulses is set in teat cups. After milk intensity reduction below some mean (typically, a 200 g/min), there is a transition to full milking phase, during that occur the udder massage and then the teat cups are removed by the operator manually or automatically. The transition to the milking process of another animal in accordance with the milking machine rules is after removal of the teat cups.

During the milking process the control unit performs a number measurements of animal zootechnical parameters, that include milk yield, average milk electrical conductivity, the conductivity in each quarter of the udder, the milk transparency, the milk intensity, milking duration, the duration of the latent period, the intensity of milk flow in the interval from the milking beginning to 30 seconds after the start of milking, in the interval from 30 to 60 seconds after the start of milking, in the interval from 60 to 90 seconds after the start of milking, the instant value of the milk flow intensity. All the measurement results after the end of the milking process are transmitted to the information-measuring system server of the animal zootechnical parameters.

The experimental investigation of developed information-measuring system of animal zootechnical parameters that includes the proposed radio frequency identification system, was implemented in PJSC "Dream", Chukiv, Vinnitsa region, Ukraine. The researches were conducted using two and three control units of the milking process with manual removal of the milking cups and forty-eight animals in stall milk line. The operating experience of the developed radio frequency identification system proves its high reliability and efficiency. The milking machine performance was increased by 6.5% due to the strict execution of milking regulations by farm staff after implementation of the above system. During three months from the start of the system operation the failures amounted 0.2% of the total number of control unit with readers. All failures were caused by the pollution of the connector's contact groups that ensure the exchange of data between the control unit of the milking process and the information-measuring system server of animal zootechnical parameters.

5. Conclusion

The article suggested and considered the implementation variant of the animal radio frequency identification system for stall milking machine that is used while animal's tethering keeping. The identification system is a part of the information-measuring system of animal zootechnical parameters and technological process parameters of obtaining milk. A new method for automatic radio frequency identification was developed in realization of which the transponders are not on animals but are mounted on the installation place of the portable milking process control units. As a result of such technical solution the operator participation in the radio frequency identification process is minimized and supplied with strict enforcing rules on the milking machine. In addition, the change of the milking group structure or composition doesn't cause the animal database adjustment. The transponder location is changed only. The implementation of the proposed radio frequency identification system increases the efficiency and productivity of milking machine.

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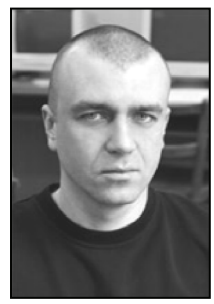

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