Development of a Prototype of an Automated Dog Feeding System

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Abstract: - In large kennels, canine services have difficulties in feeding dogs. Known dog feeding systems are studied and the development of an automated system using Omron PLC is described. The developed technological scheme is given. For simplification of installation, the equipment is divided into modules. A table of signal addresses used in Omron series industrial controllers is given. The system of logical equations for controlling the main modules of the equipment device drive is given. *Purpose of the research*: development of the project of the automated system of dog feeding in kennels. *Materials and methods*: the theory of finite automata, the theory of synthesis of logical equations and ladder diagram technique were used. The software was developed using Software CX-One. *Results*: a laboratory bench prototype of the automated feeding system was developed. Practical significance: implementation of this system in departmental organizations will reduce the time spent on food dosing, reduce the probability of error associated with the human factor, as well as provide the process of feeding dogs while reducing the labor input of service personnel.

Key-Words: - automated system, dog feeding process, cynology, PLC.

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1 Introduction

The issues of automation of animal feeding systems were raised at the dawn of computer development. At present, the development of automated animal feeding systems is given much attention [1–3]. The greatest progress has been made in the livestock industry on farms: cattle, pig farms and poultry farms. Articles on farm animal feeding systems are mainly of a review nature [4,5]. Feeding control systems mainly consist of a microcomputer, ration management software, a weighing kit for portion distribution and a module for remote data transmission (GPRS or Wi-Fi) [6]. Also the industry produces feeders for dogs and cats for home use, but at the same time the automated systems for feeding service dogs are not given enough attention. The problem of the relevance of creating automated systems for feeding service dogs for departmental organizations was raised in [7,8]. This issue became especially acute during the pandemic, when the on-duty staff of canine services was significantly reduced. At present, automated systems for feeding service dogs have not been developed, in connection with which, cynologists have difficulties with accurate dosage of food and feeding of food in enclosures to aggressive dogs in the absence of the dog's "master".

Many computer programs have been created for the formation of skills in the use of feeding systems for animals [9,10]. When implementing an automated monitoring system, it is easier to monitor the condition of dogs from the feeding ration, as well as to issue the right amount of food from the weight of the dog. The experimental sites will facilitate the ability to calculate and plan the optimal diet of animals [11,12].

The article deals with the construction of the project of an automated system for feeding service dogs, in order to further develop the elements of the system and create a prototype of the industrial sample.

Due to the fact that the food for service dogs can be diverse, the designed system should take into account the peculiarities of the daily ration from the type of food and weight of dogs. The developed automated dog feeding system will be based on industrial controllers and is designed to reduce the use of human resources.

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2 Materials and Methods

The methodology of automating the process of feeding service dogs is coordinated with the regulatory documents that govern the work of the canine service, in particular: with the Order of May 13, 2008 N 330 "On approval of the norms of providing feed (products) and the norms of replacing feed (products) in the provision of regular animals of institutions and bodies of the penal system in peacetime"; Order of the Federal Penitentiary Service of Russia from July 4, 2018 N 570 "On approval of the norms and procedure for providing institutions of the penal system with equipment, products of general economic For the development of the automated feeding system the theory of finite automata, the theory of synthesis of logical equations and the methodology of construction of ladder diagrams were used. The canine operator screen was developed using the CX-Designer module of the CX-One Software. The relay contact circuits are programmed using the CX-Programmer module [13–16]. Dry peleted dog food is proposed to be used as the food.

3 Results of the study

3.1 Development of technological scheme of feeding

When developing an automated feeding system, it is necessary to take into account the necessary technological regulations of food preparation and feeding, it can be the preparation of special feed mass or the use of primary ingredients (meat, fish). The analysis of feeding dry and wet dog food has been studied in a number of papers [17,18]. In this work it is proposed to use dry granular feed soaked in a reactor, just before the feeding cycle.

The process of food preparation and feeding will be described by the following operations: granulated feed is put into the reactor and water is supplied. In winter time, heating of the mixture is carried out. Feed is distributed to feeders through a system of pipelines with the help of pneumatic conveying (Figure 1). Water is supplied to the drinkers using a system of pipelines. As the drinkers are emptied, water is supplied up to the upper level (the water bowls have sensors for controlling the minimum and maximum liquid levels).

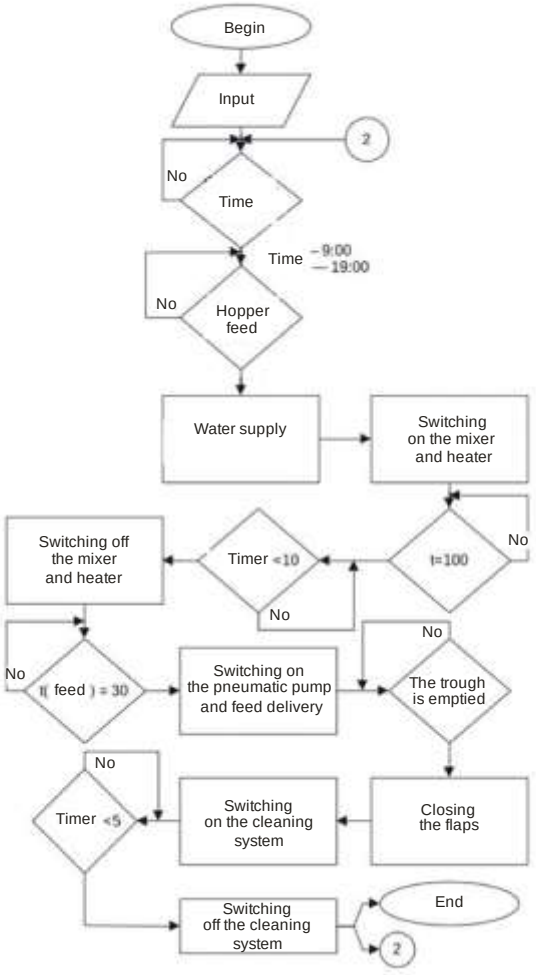

Fig. 1: Algorithm of feed mixture preparation

3.2 Synthesis of analytical solution

To develop the project of the automated system it is necessary to select the drives of devices, actuators, sensors and other technological equipment. The main technological elements of the designed system are presented in Table 1.

To create a relay-contact circuit, logic equations of the main modules of the automated feeding system: feed preparation and water supply were made.

Development of a block of logical equations for feed preparation (1)-(7):

The start of the feeding cycle is initiated with a signal from the real time clock (1):

$$FS \ \& \ D14 \ \& \ D15 \ \& \ SS = Q100.00, \quad (1)$$

where FS is the signal from the real time clock, D14 is the signal from the feed sensor in the reactor, D15 is the water sensor in the hopper, SS is the start of feeding, Q100.00 is the water supply to the reactor.

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Table 1. Designation of the main technological elements of the system automated dog feeding system

Name of elements	Model	Module
PLC	CP1L-M30DR-D OMRON	Automatic
Programmable terminal	NB5Q-TW00B OMRON	Automatic
Diaphragm air pump	DF50 50 *l*/min Samoa 552021	Feeding
Turning hopper for mixed fodder	BV-4	Feeding
Pumping station / water pump	MATEUS MS05101	Water supply
Heating element for boiler	RCA 2 kW	Water supply
Food waste tank	240 *l*	Utilization
Water tank	ECOPROM 500 *l*	Water supply
Water (liquid) level sensor	With electronic control	Water supply
Pressure (weight) sensor	Load cell 50 kg	Feeding
Temperature sensor	Electronically controlled 63 mm	Water supply
PVC pipe	Dkc 63963	Water supply
PVC pipe	¾", 3 м	Water supply
Electric water valve	Universal	Feed / water supply
Dog bowl	Metal	

To develop the system of logical equations and PLC programming, the address system of sensor and equipment drive signals was specified (Table 2).

After the reactor is filled with water, it is necessary to turn on the heater (to work in winter period) and mixer, the equations for their inclusion will look as follows (2)-(3):

FS & SS & D15 = Q100.01 & Q100.02 V PS (2)

where FS - signal from the real time clock, SS - start of feed, Q100.01, Q100.02 - PLC memory settings, PS - signal from the timer on completion of feed mixture preparation.

In order to turn off the heater and mixer, as well as for the feed to cool down and it can be fed to the feeders, it is necessary to set the delay timer:

Q100.01 & SS V T0 = TIM & 1.00 & PS, (3)

where Q100.01 - PLC memory setting, SS - feed start, T0 - feed preparation time, TIM - timer, 1.00 - temperature relay, PS - feed preparation.

At this stage feed preparation is completed.

Table 2. Address system for sensor and actuator signals

Equipment	Receiver	Mnemonic/ address
Lower level in bowls 1-5	PLC	D0 (0.00) D0 (0.04)
Upper level in bowls 1-5	PLC	D5 (0.05) D9 (0.09)
Manual feeding of feed into the feeders	PLC	D10 (0.10)
Manual feeding of water into bowls	PLC	D11 (0.11)
Manual flushing of the system	PLC	D12 (0.12)
Reset (shutdown)	PLC	D13 (0.13
system reset	PLC	D14 (0.14)
Feed in the hopper	PLC	D15 (0.15)
Water in the hopper	PLC	D16 (1.0)
Weight (net) of animals 1-5		WR10- WR14
Weight (net) of feeders 1-5		WR15-WR19
Water supply to the hopper		O0 (100.00)
Switching on the heater		O1 (100.01)
Switching on the mixer		O2 (100.02)
Pneumatic pump		O3 (100.03)
Hydraulic pump		O4 (100.04)
Hopper flaps		O5 (100.05)
Feeder flaps 1-5		O6 (100.06) O10 (100.10)
Drinker valves 1-5		O11 (100.11) O15 (100.15)
Weight (net) portions 1-5		WR20 - WR24

Next, it is necessary to make the distribution of the feed mixture. Operation of the pneumatic pump for feed supply and opening of the hopper flap is described by the formula:

1.00 & PP=Q100.05 V Q100.03, (4)

where 1.00 – temperature relay, PP - signal of feed preparation completion, Q100.05 - signal for hopper flap, Q100.03 - signal for pneumatic pump.

Then opening of valves on feeders (5) takes place:

1.00 & CF & PS, (5)

where CF – signal about filling of the feeder, PS - signal about completion of feed preparation, 1.00 - signal from the temperature relay.

Calculation of the portion size is made with the help of the program flashed in the PLC.

After filling the troughs with the required portion, a signal is given to close the valve (6):

$$CS\&CF01\&CF02\&CF03\& \\ \&CF04\&CF05 = FE\&SM, \quad (6)$$

where CS is the flag to close the first feeder, CF is to stop feeding the feeders, FE is the flag to end the feeding cycle, SM is the manual stop.

After these operations (1)–(6), all variables and I/O are reset. At the end of the feeding cycle, the system for flushing the pipelines of food mass residues is activated (7):

$$SF \ \& \ SM=TIM \ \& \ (T0 \ V0.12) \ \& \ Q100.04, \quad (7)$$

where SF - start of cleaning system operation, SM - manual stop of the system, TIM - timer of system operation, T0 - timer of cleaning start, 0.12 - manual cleaning button, Q100.04 - signal to drive the hydraulic pump and valve.

Development of a command system for monitoring the filling of drinkers

Monitoring the condition of dog drinkers is to maintain the necessary level of drinking water. The process of automatic refilling of water bowls is defined by means of a system of logical equations:

$$\begin{cases} (D0 \vee D11) \cdot \overline{D5} = Set(100.11) \\ D5 = Rset(100.11) \end{cases}, \quad (8)$$

where the upper equation is water supply, the lower equation is water supply pump shutdown.

Based on the synthesis of logic equations (1–8), ladder diagrams were developed for Omron PLC programming.

The next operation was the development of the kinolog operator screen.

3.3 Development of the screen-operator of the cynologist

During the design of the screen operator-cynologist were formed fields with bunkers-reactors, a field with aviaries, which shows the state of feeders and drinkers. Level sensors are monitored at each site. The operator's screen displays load cell readings to measure the weight of the feed. The weight of the dog is entered by the operator based on their pre-weighing. The circuit has feeder gate control actuators and reactor control actuators. On the screen there are windows for writing to the memory registers, the current weight of the dogs in the enclosures. Figure 2 shows the operator panel, which monitors the feeding system, as well as its control elements. The feeding cycle is started automatically at the programmed time (morning and evening), 2 times a day in accordance with the dog feeding schedule.

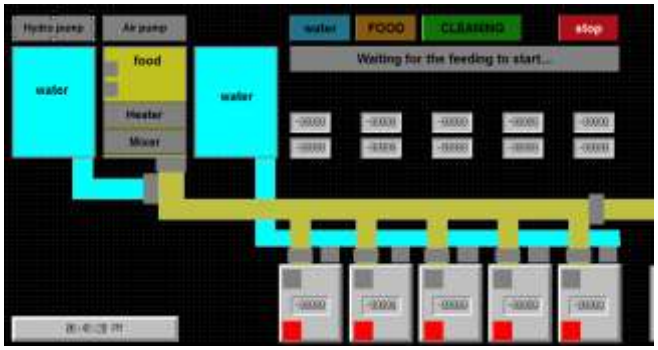

Fig. 2: Development of the design of the operator panel

3.4 Simulation of the circuit operation

The feeding system was tested in software simulation mode, all modules worked according to the planned technological mode. Figure 3 shows the drinking water supply mode. Water availability in dogs is monitored by level sensors. Water heating is provided for the system operation in winter conditions.

Fig. 3: The water supply process takes place

Figure 4 shows a simulation of the feeding cycle operation.

Fig. 4: Simulation of PLC relay contact circuit operation. The process of filling feed troughs with fodder is taking place

4 Conclusion

Nowadays not enough time is given to the development of industrial systems for feeding dogs, which are designed for a large number of animals, there are only automatic feeders for home use.

In the article the project of the automated system for feeding of service dogs is developed, that within the limits of import substitution by the Russian software is the decision of the important applied problem. Practical significance of the work consists in the possibility of implementation of the developed project in departmental organizations when feeding service dogs, due to which it is possible to solve the problems of dog care at the limited composition of cynological services and to improve the rationing and dosage of food in accordance with the Orders of departmental organizations.

According to the system requirements, operation algorithm and technological scheme, relay contact circuits were constructed to control the feeding process. As a hardware and software programmable logic controller PLC Omron. Development of relay-contact circuit programmable logic controller CP1L was carried out using CX-Programmer. An operator screen was developed to monitor the system status and manual control. Simulation of the circuit operation was carried out. Simulation of the device circuit operation showed positive results in controlling the process of dog feeding. As a result of the introduction of the proposed computer system in kennels it is possible to achieve reduction of the operative on-duty staff of cynologists up to five-six times, one on-duty cynologist will be enough to manage the technological process of dog feeding. Due to the introduction of the automated information system the system of accuracy of feed dosing will be improved by 15–20% and also feeding will be carried out at the exact scheduled time and will not depend on the human factor. The introduction of an automated feeding system will also help to solve the problem of infection transfer on the clothes of dog handlers and prevent the development of an epidemiological situation in kennels intended for keeping service dogs.

Currently, the project has attracted interest in designing a kennel for stray dogs in the Yaroslavl region of the Russian Federation. The capacity of the shelter will be up to 1000 animals per year. It will fully comply with all requirements of the federal law "On Responsible Treatment of Animals and on Amendments to Certain Legislative Acts of the Russian Federation". During the 25-day animal confinement in the shelter, the animals will be quarantined, vaccinated, sterilized, and treated if necessary. A feasibility study is currently underway to implement an automated feeding system in the kennel.

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The authors have no conflicts of interest to declare that are relevant to the content of this article.