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Design and Experiment on Self-propelled Precise Feeding Equipment for Dairy Cow

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Abstract

Designed a kind of self-propelled precise feeding machine for single dairy cow based on the technology of RFID, to achieve the automation, fine and intelligent of dairy farming. The computer was used as the information management platform, MCU was used as control platform, even using wireless transmission, RFID recognition, infrared detection technology and so on,which achievement the information data of wireless transmission, precise recognition and detection cattle position. It is applied to equal-diameter and variable-pitch screw feeding structure to realize the precise concentrated feed supply, equipment performance test shown that the system speed 60rpm is the most stable when feeding, feeding accuracy not less than 97.5%, to meet the feeding requirements, equipped with the best traveling speed is 0.6m/s, the response time of the system is 0.4s, the recognition rate is 96%; through one-month feeding experiment in the dairy cow farm showed that the milk production was increased, the average daily milk yield of individual cows improve 0.8kg than artificial feeding.

***Key words**: dairy cow, precise feeding, RFID, dual-mode moving, wireless transmission, experiment*

1. Introduction:

With the quickly development of animal husbandry and international trade liberalization process, more and more attention is paid to precision feeding of dairy cattle. Implementation cows precise feeding has important implications for reducing the occurrence of animal diseases in the process of intensive farming as well as to improve production and product quality, etc [1, 2]. Data shows that reasonable precise feeding technology for dairy cows is simultaneously on dairy cattle forage and feeding, and ensures accurate dairy feed supply [3-5]. For this reason, we designed the self-propelled cows accurate feeding machine based on radio frequency identification and infrared identification technology. The precise feeding machine of self-propelled cows is according to accurate feeding cows individual physiological characteristics information. This equipment that comprehensive utilization of machinery, electronics and modern control technology takes the cows as the feed unit. It also solved the only wireless transmission of information and data of individual cattle, the automation accurate identification of individual cows, the location detection of the cattle where caught in the middle of the railings, the dual-mode traveling and precise feeding problems and so on. It realizes the cows fed mechanization, automation, refined and intelligent.

2. Equipment Structures and Working Principle

2.1. Equipment Structures

As shown in Figure 1, the self-propelled dairy cows accurate feeding equipment mainly components are mechanical system and control system. Mechanical systems including silos, equal diameter variable pitch screw feeder device, traveling device and rack [6], etc. The control system is composed of a radio frequency identification system, a wireless transmission system [7], bovine bits on the detection system and the information management system, etc. Equipment technology parameters are shown in Table 1.

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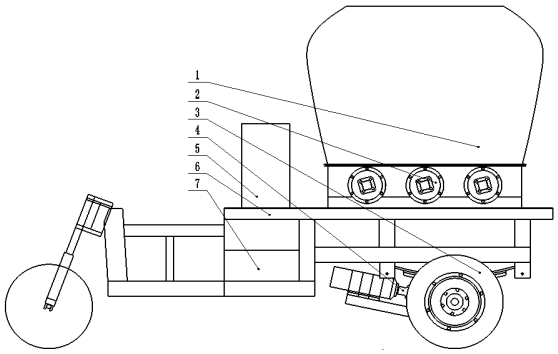

1. bunker, 2. feeder device, 3. traveling device, 4. power system, 5. control box ; 6. Frame, 7. power supply

Figure 1. The Precise Feeding Equipment

Table 1. Component Model/Technical Parameters

Components	parameters
stepper motor	type:130ZYT48V rated speed:3000r/min power:1200W volt:48V Output speed:375r/min
Feed motor	type:110BYG250-115 type:48V static torque:12.7NM
stepper motor driver	type:2HD8080
recognition system	type:ID-240
power supply	storage battery:12V, 120Ah 4block

2.2. Working Principle

Before feeding, parlor computer called the data of cows physiological characteristics, to calculate the data of cows on the previous day through the precise feeding software. Through a wireless transmission system the calculated feeding data and cow tag number is transmitted to memory of the precise feeding equipment control system.

Before the dairy cattle feeding, first toggle the precision feeding equipment running motor control switch. And adjust the feeding equipment to the artificial control state under which feeding equipment and common battery car can autonomous walk in the cattle farm. Feeding, the equipment must be in feeding mode. Equipment travels along the road under the control of single-chip microcomputer automatic. When the equipment travels to the feeding area, the wearer in milk cow ear tags is identified by radio frequency card reader, and the identification of the tag number is sent to the MCU control system. It control equipment to stop and to travel, compare the recognized label number with memory ID number. After the corresponding ID number is made sure, MCU control system call the cows fed data, initiate the spiral feeding system, delivers concentrate. After feeding, equipment continues to move forward, then the next cow identify, local, invest concentrate. After the whole cows' feeding in the barn, the equipment is adjusted to the artificial control state, the staff move the equipment in the Park Inn.

2.3. Mechanical Systems

Mechanical system is composed of a hopper, frame, feeding systems and travelling device. Feeding equipment that is designed as triple helix feeding device based on equal variable pitch system for the traditional screw feeder device exists a "dead zone" and discharge instability phenomenon [8]. It solved the problem of pitch auger material blocking and discharge instability. Control spiral auger revolutions precisely with stepper motor; improve the accuracy of the feed, as shown in Figure 2. The well designed 3 paragraph pitches are 25, 35 and 40mm, respectively. The model of Feeding system stepper motor is 110byg250-115 type, and its static torque is 12.7N•m. as the stepper motor is two-phase four-wire system, type 2HD8080A/B drive is selected as stepper motor driver.

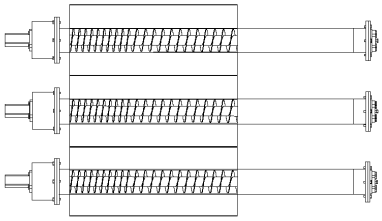

Figure 2. Transporting Device Made by Three Sections of Spiral

The dual-mode traveling mode is used as the equipment travelling system. That is, during the non-feeding time use the non-feeding mode, under which, equipment works like ordinary electric tricycle. The equipment can realizes automatically travels, automatic positioning and automatic precision feeding under feeding mode. The dual-mode traveling mode simplifies workflow, improves the stability and reliability of the equipment. The test results show that under the working conditions of feeding mode, the equipment optimum traveling speed is 0.6m/s, the system response time is 0.4s, the recognition rate is 97.5%.

To avoid the impact of noise on cows, and to reduce pollution of the environment, equipment forward momentum uses 48V battery, DC motor power is 700W. Equipment braking system uses brake mechanism the auxiliary DC motor brake, improves positioning accuracy and feeding effects.

3. Control System and Software Design

The control system consists of a single-chip control system, radio frequency identification system, wireless transmission devices, information management systems, dual-mode of travel agencies, infrared detection system, infrared material level monitoring system and accurate feeding device.

3.1. SCM Control System

The control system is one of the core technologies to achieve a precise individual cows feeding. MCU control system consists of the main program and subprogram. The watchdog in the control system is to avoid the program into an infinite loop. Once crashes and other issues occur, program will pop up within the specified time, to ensure the reliability of the equipment. SCM control system flow chart is shown in Figure 3.

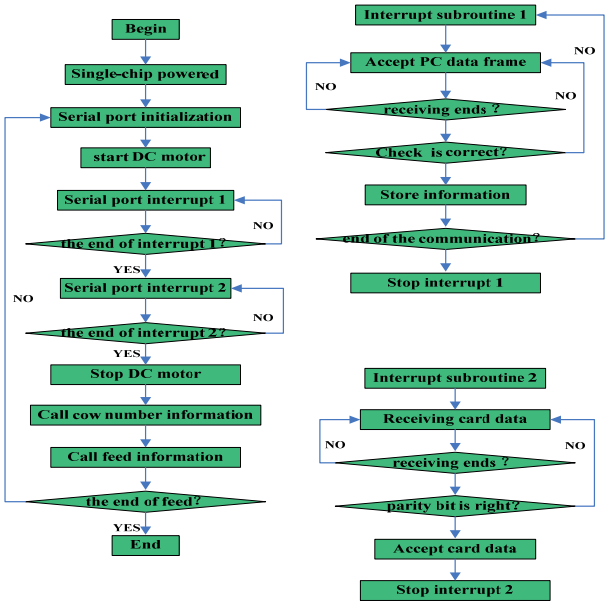

Figure 3. Flow Chart of MCU Program

3.2. Design of Management System on Cattle Farm

Management system of cattle farm used function-oriented, prototyping method of process-oriented to design, utilized the object-oriented VB.NET2008 to program develop, accessed 2007 to create a back-end database, Crystal Report10.0 to design the report. The system achieved a series of function, such as the related storage information of cattle, management, herd warning, statistical analysis, report printing. It also realized the data send for the Hypogenous machine (lower computer).

3.2.1. System Development

Established a unified data platform by means of data directly abstract and functional decomposition, combined the actual situation of the cattle, from a global perspective of the system, based on comprehensive analysis of user needs and information flow. At the same time the system is divided into multiple functional modules. System uses the prototype method as system develops. The system design and development process is shown in Figure 4.

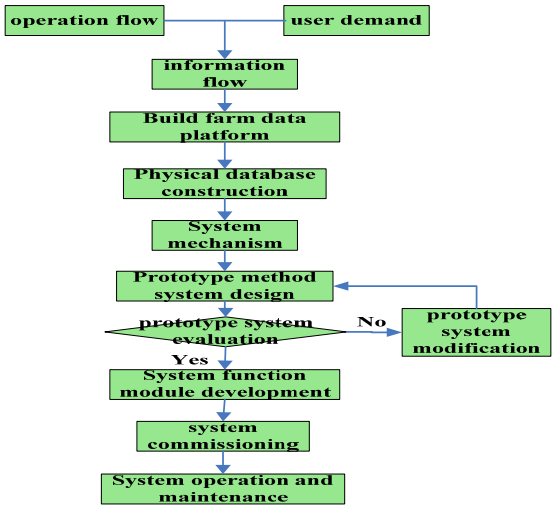

Figure 4. Flow Chart of System Development

3.2.2. System Structure and Function

The development of information management system aims to unified management of the cattle farm, integrated various types of data, provided a convenient users interface to management data, found information, printed reports and so on. A functional structure of the cattle information management system is shown in Figure 5.

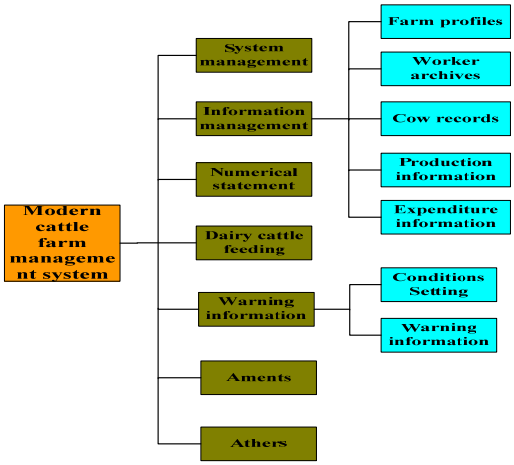

Figure 5. System Function Structure

3.2.3. Communication between the System and SCM

Feeding data is transferred from computer and stored in the microcontroller before feeding. First, we must declare a communication port object “Dim RS232 As Serial Port”. RS232 is used as communications port for operation between the microcontroller and computer. Communication protocol between PC and MCU is that synchronously send data, the transfer rate of transmission data is 9600bit/s, no parity, data bits is 8, the end bit is 1. We establish a communication port during the “Click" event in the button of “send” commanding. System transfer data by RS232.Write (Data,0, Count) . The type of transmission data is Byte, and the length of the data is count.

3.3. Radio Frequency Identification (RFID) System

RFID technology is used to achieve the identification of individual cows in the feeding process; the RFID system mainly included four parts that is microcontroller, card reader, antenna and ear tag. The RFID equipment is ID-240 that produced by Jishi electronic identification technology Co., Ltd. in Shanghai. The frequency of reader transmitter is 134.2 kHz,ear tag is hitter the cows’ ear by ear tag pliers which is no power supply, passive ID card. Anti-interference technology is introduced in order to improve the distance recognition [9, 10]. It uses the non-metallic materials as holder. The use of shielded cable connection between the controller and the reader increased the recognition distance and rate of reader to movement labels. Identification distance in normal working environment is 75±10%cm, recognition rate is 100%.

3.4. The Cattle Positioning System based on Infrared Detection Technology

Designed the system that infrared detection of the cattle location where caught in the middle of the railings for improving cow identified and feeding effects, executed the precise location through the identification of bovine neck, reducing the process of cows were fed snatch effectively, avoided leakage feeding phenomenon what ear tag shedding caused during the cattle feeding.

4. Experimental Investigations

4.1 Performance Test

After debugging, device feeding performance test under different levels was carried out in the laboratory. Feed weight was measured with an electronic balance (Shanghai Okawa Electronic Weighing Apparatus Co., XC-A 30kg); time was record by the used of the stopwatch (Wan PENGDA Technology Co., Ltd. in Shenzheng CSD9060 three rows of 20 memory stopwatch); Measurement error was computed by the contrast between following practical and quantity theory; Test concentrated feeding was mixture with 2 portion Purina lactation cows feed supplement 1919 and 1 portion owned material. Determination carried out that spiral feeding device in 60rpm works more stability.

4.1.1. The Feeding Model's Fitting

Feeding amount was a linear relationship with the number of pulses screw speed of 60rpm in screw speed of 60rpm, a linear regression equation derived by the least squares method

$$Y=3686.505X-30.639$$

X—Feeding amount

Y—Number of pulses

4.1.2. Feeding Accuracy Test

Used above equation for accuracy test, the range of actual feeding equipment was 2-4Kg, so set the device target of feeding amount were 2.0kg, 2.5kg, 3.0kg, 3.5kg, 4.0kg, The data obtained as shown in Table 2, feeding error shown in Table 3, the mean relative error of the target value in the different range conditions were less than 2.5%, that is feeding more than 97.5% accuracy to meet the feeding requirements.

Table 2. The Weight Value under Different Measure Range

Target volume	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	average value
2	1.98	2.01	1.972	1.972	1.992	1.986	2.022	1.976	1.998	1.972	1.988
2.5	2.47	2.478	2.482	2.488	2.478	2.468	2.5	2.5	2.476	2.46	2.48
3	2.976	2.978	2.998	3.004	2.994	2.988	2.96	2.998	3.000	3.002	2.990
3.5	3.48	3.486	3.478	3.484	3.466	3.446	3.44	3.426	3.432	3.456	3.459
4	3.95	3.96	4.000	3.976	3.978	4.016	4.004	4.012	3.98	3.952	3.983

Table 3. Relative Error between Measured Value and Target Value

target value	Average relative error	Max error bound	Min error bound
2	-0.6	1.1	-1.4
2.5	-0.8	0	-1.28
3	-0.33	0.133	-1.33
3.5	-1.16	-0.4	-2.11
4	-0.43	0.4	-1.25

4.2. Feeding Verification Tests

To test feeding methods for the impaction on the performance in dairy cattle and reliability of the equipment, verification tested in 121 Mission of eighth corps on July 15, 2012 to 23, 2012.

4.2.1. Feeding Conditions

Choose the 2nd barn 80 high-yielding dairy cows in experimental group,which was 1.2m spacing of bovine jugular folder,choose 80 cattle consistent with milk yield in the same period in 2011, feeding program for the control group cattle average daily per cow artificial supplementary concentrate feed 3kg, experimental group using precise feeding equipment for concentrate feed demanding precise supplement at noon, feeding once a day, the production of concentrated feed with experiment was feed supplement that purina lactation cows 1919 mixed 2:1 of own material.

4.2.2. Experiment Result

According to the data of the milk yield obtained the test milk yield variation curve shown in Figure 6. The figure shows that: the same period in 2012, the lowest yield and the highest yields were higher than 2011 levels over the same period, and fluctuations in the same period in 2012, milk yields slightly less than the same period in 2011, during the experiment calculated average per cow per day and increase the yield per unit 0.8kg Xinjiang milk average price of 3.8 yuan/kg calculated, can improve the economic benefits of a daily average of 3.04 yuan per cow, the economic benefits, the stability and reliability of the equipment work well during the test, the system runs stable.

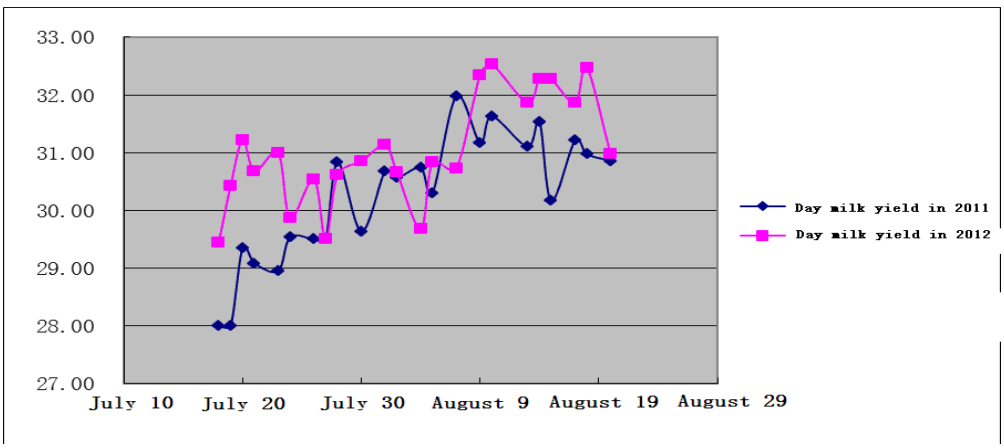

Figure 6. Milk Production Variations during Testing Period

5.Conclusion

The computer of feeding equipment as information management platform, the integrated used single-chip technology, wireless RF technology, wireless transmission technology, to achieve the automation, fine and intelligent of dairy farming. Equipment performance test shown that the system speed 60rpm is the most stable when feeding, feeding accuracy not less than 97.5%, to meet the feeding requirements, equipped with the best traveling speed is 0.6m/s, the response time of the system is 0.4s, the recognition rate is 96%. Through a one-month feeding trial showed that the technology and equipment can improve the performance of the milk, the average daily milk yield of individual cows improve 0.8kg than artificial feeding.

References

[1] Juan-Du, Jinhua-Bao.The adjustment of dairy cows microbe. *Animal Husbandy and Feed Science, Animal Husband*. 2008; (4): 73.
[2] Chunlin-Tan, Za-Kan, Mingjun-Zeng, et al. Analysis of the situation about cow-feeding technique and equipment. *Journal of Agricultural Mechanization Research*. 2007; (12): 240-245.
[3] Zhijiang-Ni, Zhenjiang-Gao, Hewei-Meng. Design and experiment on intelligent precising feeding machine for single dairy cow. *Transactions of the Chinese Society for Agricultural Machinery*. 2009, 40(12): 205-209.
[4] Xiaoming-Fang. *Design and experimental investigation on the movable intelligent feeding machine for dairy cow*. Beijing: China Agricultural University. 2008.
[5] Xue-Gao. *Study on an auto-control system of dairy cows recision-feeding*. Beijing: China Agricultural University. 2008.
[6] Zhanqi-Hu, Xiaowen-Qi, Bingli-Fan, Wei-Li. Research on Service Life Prediction Model of Thrust Needle Bearing. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012;10(7): 1621-1628.
[7] Hanshan-Li, Zhiyong-Lei. An Research on Infrared Special Facula View Measurement Method Based on Image Processing Technology. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012; 10(6): 1422-1429.
[8] Jicheng-Li, Zhenjiang-Gao, Hongwei-Xiao. Design and experiment on dairy cow precise feeding equipment based on MCU. *Transactions of the Chinese Society for Agricultural Machinery*. 2011; 42(1): 101-105.
[9] Y*ongcun-Fan, Changli-Zhang, Shoutia-Dong, etal.Research on precise feeding system of dairy cattle. Transactions of the Chinese Society for Agricultural Machinery.* 2009; 40(S1): 65-68.
[10] Tao-Guo, Jinguo-Zhang, Xiajing-Huo, et. al. Studies of the Testing System for Cow's Accurate Feeding Intake. *Journal of Agricultural Mechanization Research*. 2012; (2): 47-50.