Design of an automatic weighing check system for small material feed

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Abstract. Small material is an important part in feed production, and it is one of the keys to guarantee product quality. Nowadays, small materials are putting into small batches artificially in many feed enterprises, and the small materials are weighing manually before putting. In order to improve the automation of the weighing and putting process of small materials, this study designs an automatic weighing check system for small materials. The system is composed of Arduino electronic development platform equipped with weighing sensor, liquid crystal display module (LCD), and relay module. The results show that the relative error of the weighing check measure is less than 0.2%, and it demonstrates that the system has realized the precise control of the weighing check of small materials, which is beneficial to reduce the work intensity of workers, and improve the automation degree of the feed production industry.

1. Introduction

Feed ingredients are a very important part in the production process of compound feed enterprises, which directly affect the quality and safety of finished feed products. Feed ingredients are the process of accurately weighing and uniformly mixing feed ingredients of different ingredients using specific ingredients and equipment according to the requirements of the formula. The small feed is the core material of the feed product, which refers to the intermediate product obtained by pre-ingredient or mixing the ingredients in the feed production process, and used to supplement essential nutrients lacking in feed. There are two kinds of batching methods for small materials. The first method is micro batching method. The small material directly enters the main mixer after batching. The second method is to use artificial ingredients. The prepared small materials are directly put into the main mixing machine to participate in the production through the weighing and checking artificially. At present, most feed production enterprises adopt manual weighing and checking, which not only increases the work intensity of workers, but also reduces the efficiency of feed production.

The Arduino control system is an open software with the advantages of flexible and convenient, strong scalability, etc., which can be used to design a variety of programs to achieve the desired functions. The researchers have studied many machines based on Arduino system, such as adaptive packaging machine and Unmanned forklift, this demonstrated that Arduino system can be used in many fields. In order to increase the degree of automation of the small feed section in the feed production process and reduce the work intensity of the workers, this subject combines the actual production and designs a device that can automatically perform the weighing and repetition of the small feed and the automatic placement based on the premise of manual bag opening. The designed device could realize the automation of the repetitive verification and delivery process of the small material scale, and reduce the work intensity of the workers.
2. Automatic weighing check system of small materials

2.1. Composition of automatic weighing check system
In the feed production process, the amount of small feed needs to be strictly controlled, so the accuracy of the weighing part is very high. According to the requirements of small material weighing, this paper designs an automatic weighing check system based on Arduino electronic development platform. The load cell is connected with the frame to form a platform scale installed on the instrument, equipped with a LCD module, a relay module and a solenoid valve.

2.2. The principle of automatic weighing check system
The main function of the automatic weighing check system is to realize the automatic weighing and recheck of small materials, when system begins to work, the weight information of the target small materials is first measured by load cell and displayed on the LCD screen. If the result is within the range, perform the weighing, piece counting and blanking operations, and display the weight and quantity information on the liquid crystal display; if it is not in the range, the warning light will be on and no operation will be performed until it is unqualified. The small pieces were taken away, the alarm light goes out and the system waits for the next cycle of weighing review and automatic feeding. The flow chart of the system is shown in Figure 1.

![Flow chart of automatic weighing check system for small material feed](image)

3. Hardware design of weighing check system for small materials

3.1. Arduino development board
The Arduino development board can be used for circuit connection and programming, the development environment is Arduino IDE, its purpose is to write the program that needs to be burned into the development board in the computer. The Arduino development board is flexible and easy to use and master. Arduino uses serial communication, which is suitable for low-speed transmission. Long-distance transmission can be achieved through RS485 level conversion, which can meet working requirements,
so the control system of this device chooses to use the Arduino UNO development board as the control core which is shown in the Figure 2.

![Arduino UNO development board](image)

**Figure 2 Arduino UNO development board**

### 3.2. Load cell selection

Load cell is the core component of electronic scale, which is used to measure the weight of the object. Compared with the traditional mechanical weighing tools, it has the advantages of small size, high precision and simple operation. The load cell converts the gravity signal into an analog electrical signal. In this paper, ILF single point sensor is selected due to the wide measuring range and easy installation. The measuring range of the sensor is 0-75kg, and the measuring accuracy is 0.001kg. The main parameters of load cell are shown in Table 1.

| Parameters                   | Values                      |
|------------------------------|-----------------------------|
| Rated Load                   | 75 kg                       |
| Sensitivity                  | 2.4±0.2 mV/V                |
| Total Error                  | ±0.03% F.S                  |
| Creep (30 min)               | ±0.02% F.S                  |
| Input Resistance             | 400±20 Ω                    |
| Output Resistance            | 352±3 Ω                     |
| Insulation Resistance        | ≥5000 MΩ                    |
| Operating Temperature Range  | -30~70%                     |
| Safe Load Limit              | 150% F.S                    |
| Over Load Limit              | 200% F.S                    |
| Recommend Excitation         | 10~12 V DC                  |
| Maximum Excitation           | 15 V DC                     |
| Construction                 | Alloy Steel                 |

### 3.3. A/D conversion module selection

The load cell is a device that converts the gravity signal into the electrical signal, and the output voltage signal is very small, and therefore need to connect an A/D conversion module between weighing module and Arduino development board. The output voltage signal of load cell is amplified and filtered by conversion module, then converted into a digital signal and input to Arduino development board through digital input serial port.

The load cell is a 4-wire sensor, the white and red wire are the positive and negative poles of the signal output, and the blue and black wires are the positive and negative poles of the power respectively. Therefore, the HX711 conversion chip is selected, the maximum output of the chip is 5V. The signal conversion and amplification function can be realized after the load cell is connected with the conversion module and Arduino development board. The connection wiring diagram is shown in Figure 3.
3.4. LCD screen selection
In order to facilitate the workers to observe the actual weight of the current small materials and the total weight statistics of the small materials after the launch, LCD12864 dot matrix LCD module is selected, with the resolution of 128 × 64 and the clock frequency of 2MHz. It can display 8 × 4 lines of 16 × 16 dot matrix Chinese characters or graphics, which has the advantages of simple wiring, strong display scheme, easy programming and low power consumption.

3.5. Selection of electromagnetic relay module and power switch
In order to ensure that the solenoid valve of small material feeding has enough power, SRD-05VDC-SL-C 4-way DC electromagnetic relay module is selected to control 4 solenoid valves in turn with low-level trigger switch mode, and the rated power is 24 v. NES-100-24 switching power supply is selected as the external switching power supply to reduce the 220 V AC voltage to the rated working voltage of the solenoid valve, so as to drive the solenoid valve to work.

3.6. Hardware connection
According to the wiring diagram, the load cell is connected to the A/D conversion module firstly. Then, the conversion module and the LCD display are connected to Arduino development board. The power module is connected to the 5V output port on the development board. The connect mode between the power port and the development board is as follows, the ground terminal is connected to the GND port, the signal port is connected to the signal output port corresponding to the program on the development board, and the red and green LED indicator lights and switches are connected with the 5V-power supply output port, GND port and the corresponding signal output and input port in the program respectively.

4. Experiment on weighing accuracy of small material weighing check system
4.1. System debugging
After the circuit is connected, the weight reading can be displayed on the display screen, and the weight value read by the load cell can be judged by comparing the displayed value with the standard weight. If not, the sensor can be calibrated by modifying the parameters in the header file.
4.2. Experiment on weighing accuracy of system
A certain amount of small sample is weighed with electronic scale (W1), and then the sample is put in the weighing part of the equipment to measure its weight (W2). The sample is measured for three times, and the average value is taken as the weight read by the system. The measurement results are shown in Table 2. It can be seen that the relative error of sample weighing accuracy is within 0.2%, which indicates that the weighing accuracy of the system is good. There is no obvious regularity in the relative error of the system measurement, which indicates that these errors are random errors. A possible reason is that the different conversion coefficient between the voltage and gravity caused by the different position of small material.

Table 2 Weighing accuracy experiment

| Number | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    |
|--------|------|------|------|------|------|------|------|------|
| W1/kg  | 17.000 | 18.000 | 19.000 | 20.000 | 21.000 | 22.000 | 23.000 | 24.000 |
| W2/kg  | 17.013 | 18.014 | 19.019 | 20.002 | 20.992 | 21.970 | 22.990 | 23.997 |
| Average/kg | 16.986 | 17.982 | 19.002 | 19.998 | 20.978 | 21.955 | 22.960 | 23.972 |
| Relative error/% | -0.08 | -0.10 | 0.01 | -0.01 | -0.10 | -0.20 | -0.17 | -0.11 |

5. Conclusion
Small material is an indispensable part of formula feed processing. It’s necessary to strictly control the amount of small material in the process of feed production. Aiming at the problem that small feed needs to be manually weighed and rechecked, this paper designs an automatic weighing and rechecking system for small material. The system consists of Arduino development platform, the weighing sensor, A/D conversion module and liquid crystal display. The weight of small material is measured by sensor system and transmitted to the control module. If the weight is within the required range, the green indicator light will be on, and the control module will start to control the solenoid valve on and off in sequence for the next step. If the target small material is not within the weight range, the red indicator light will be on and no operation will be performed. The experimental results show that the system realizes the weighing and rechecking of small materials in the production process of formula feed by machine instead of manual work, which can reduce the work intensity of workers and improve the mechanization and intelligent degree in the feed production process.

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References
[1] Hanafy M. Omar. (2018) Enhancing automatic control learning through Arduino-based projects. European Journal of Engineering Education, 43(5):6-8.
[2] Ma X. W. (2014) The advantages and formulating principles of compound feed. China Animal Husbandry and Veterinary Digest, 30(4):184.
[3] Li B. (2018) Analysis on the working principle and use method of feed machinery. China Plant Engineering,24:224-225
[4] He W. F., Liu Y. (2018) Research on smart control switch based on Arduino. China Computer & Communication,16:87-88.
[5] Lv B. (2018) Design of adaptive packaging machine based on Arduino electronic platform. Technology and market,25(12):92-93.
[6] Yan W. (2018) Design of unmanned forklift based on Arduino. Internal combustion engine & parts,23:187-189.