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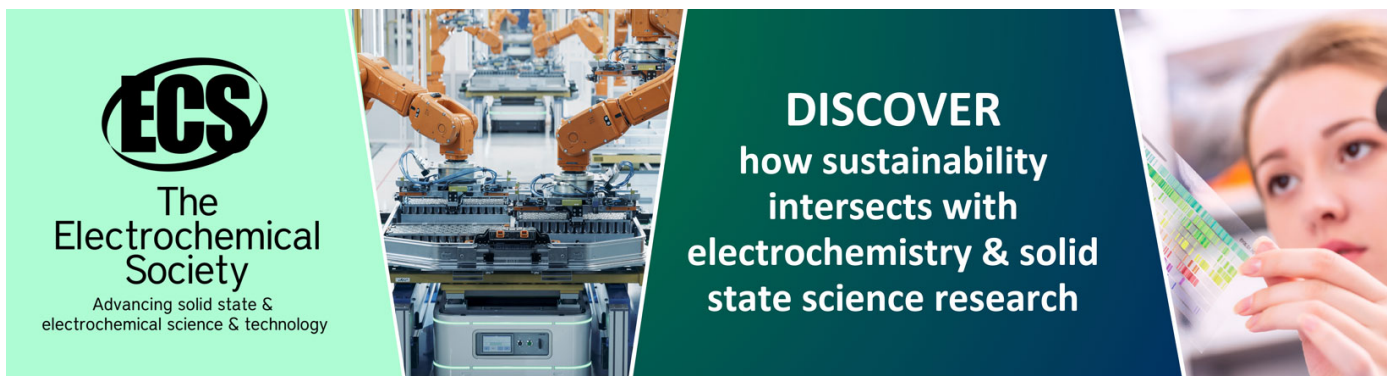
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Design of King Grass Crusher Based on SCM Control

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Abstract. King grass is rich in nutriment and palatable, and has soft and succulent leaves, with high digestibility. It is one of the best green fodders for herbivore livestock and poultry. In the process of breeding flocks and herds, the feed cost can be reduced largely by utilizing king grass rationally. King grass needs to be cut and ground for being used as feedingstuff. Conventional manual process consumes a large quantity of manpower and material resources, leads to the reduction of production efficiency, and brings about high labor intensity. In view of this, an automatic control king grass crusher high efficiency and practicability is designed, which integrates cutting and crushing. This machine is based on SCM, which realizes whole-process automatic control and rational coordination of pressure sensor with stepping motor for various movements, and can handle king grass crushing well.

1. Introduction

Currently, king grass is planted massively in the tropical and subtropical areas in south China as a kind of high-yield and high-quality tropical pasture and feed crop^[1]. It is rich in nutriment and palatable, and has soft and succulent leaves, with high digestibility, making it one of the best green fodders for herbivore livestock and poultry. King grass needs to be cut and ground for being used as feedingstuff. Conventional manual process consumes a large quantity of manpower and material resources, leads to the reduction of production efficiency, and brings about high labor intensity. In view of this, a king grass crushing machine integrating cutting and crushing is mainly introduced herein. By effectively combining pressure sensor detection and stepping motor control, the system achieves whole-process automatic control from feeding, cutting, crushing to discharging, which greatly improves the efficiency of king grass crushing.

2. Crushing Method and Principle

2.1. Crushing Method

Crushing is a process to break internal cohesive force of solid materials and fracture the materials by the aid of mechanical force^[2]. There are wide varieties of crushing machine invented for production, including jaw crusher, cone crusher, single tooth-roll crusher, vibrating crusher, vertical shaft crusher, rotary crusher, hammer crusher, and continuously developed multifunctional crusher. These machines have greatly facilitated industrial production^[3-6]. A king grass crushing machine integrating cutting and crushing is mainly introduced herein. For purpose of this system, whole-process automatic control is realized via SCM, and the movements in each step are realized via rational coordination of pressure



sensor with stepping motor.

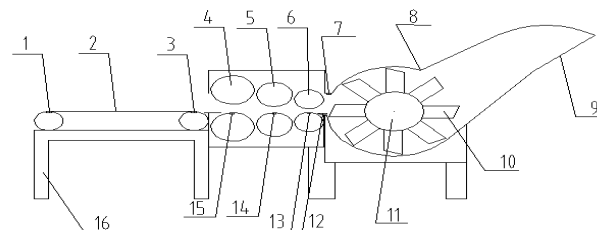
2.2. Crushing Principle

When the crusher starts to work, it sends signal to SCM via detection of Sensor 1; the SCM sends pulse after receiving signal, and the stepping motor rotates. The motor conveys king grass to the end of conveyor belt via the belt upon starting to rotate; the pressure roller system starts work after Sensor 2 detects king grass; king grass touches all pressure sensors of the three-stage pressure roller in the pressure roller system one by one after entering the pressure roller system (namely first-stage pressure roller sensor 3, second-stage pressure roller sensor 4 and third-stage pressure roller sensor 5). Sensor 6 sends out signal when the king grass that has passed through the pressure roller system and been crushed enters the crushing chamber. Then, the motor drives the roller cutter to rotate, and the cutter stator and cutter rotor work to crush king grass. Besides, the crushed king grass is discharged along tangential direction via the discharge hole with the roller cutter.

3. Basic Structure and Function

3.1. Basic Structure

The structural sketch of king grass crusher is shown in figure 1.



1. Sensor 1 2. Conveyor belt 3. Sensor 2 4. First-stage roller 5. Second-stage roller 6. Third-stage roller
7. Sensor 6 8. Cabinet 9. Discharge hole 10. Cutter rotor 11. Roller 12. Cutter stator 13. Sensor 5
14. Sensor 4 15. Sensor 3 16. Bracket

Figure 1. Structural sketch of king grass crusher.

3.2. Sensor System

Sensor 1 is installed in the position of initial conveyor belt, and is used to detect king grass and control the running of stepping motor. Sensor 2 is installed in the position of end conveyor belt, and is used to detect whether king grass is in the right place and control the running of stepping motor. Sensor 3, Sensor 4 and Sensor 5 are installed on the three stage rollers of the pressure roller system respectively, and are used to detect the presence of king grass in each stage pressure roller. Sensor 6 is installed at the feeding mouth of crushing chamber, and is used to detect the presence of king grass in the crushing chamber and control the running of motor. In this way, a sensor set is formed. If the sensor set does not receive the signal, the general power is cut out, and the crusher stops.

4. Automatic Crushing Process and Control System

4.1. Automatic Crushing Process

① Feeding: After the system starts to work, Sensor 1 detects king grass and controls stepping motor movement via signal to deliver the materials to the designated place by the conveyor belt. ② Material squeezing: After Sensor 2 senses the signal about the presence of king grass, the pressure roller system starts, squeezing king grass via the three-stage pressure roller system and delivering king grass to the next system. ③ Cutting and crushing: After Sensor 6 senses the signal of squeezed king grass, the cutting and crushing system starts, and the motor drives the roller cutter to rotate; the cutter rotor and cutter stator work to cut up king grass, and the cut king grass is discharged along tangential direction via the discharge hole with the roller cutter. ④ Automatic stop: If no sensor detects the signal, the crusher stops working. The automatic king grass crushing process can be completed by conducting

steps ① to ④ uninterruptedly. Based on the working process of the crusher, the program flow chart of the system is shown in figure 2.

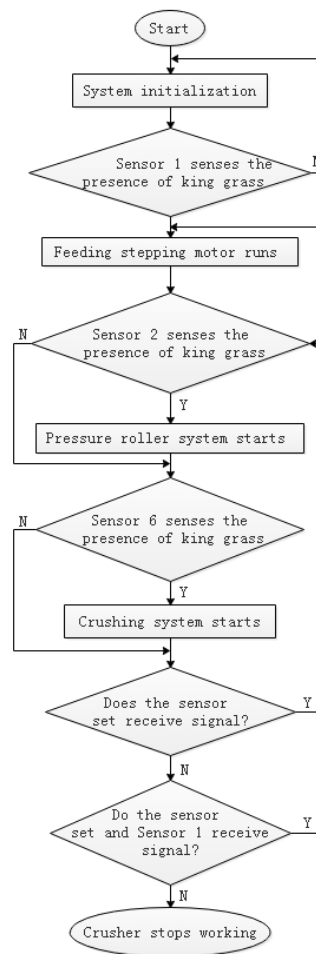


Figure 2. Program flow chart of system.

4.2. Control System

4.2.1. Control system of stepping motor. The stepping motor is an actuator which converts electric pulse signal into angular displacement or linear displacement according to the action principle of electromagnet. Under circumstance of non-overload, the stopping and speed regulation position of the motor depend on only pulse count and frequency of pulse signal, free from the impact of load. It controls angular displacement by controlling pulse count, or controls the accelerated speed and speed of motor by controlling pulse frequency, so as to realize speed regulation. The driver of the stepping motor is UDK5214NW -M5 phase stepping driver manufactured by HP, and ULN2003 chip is adopted for driver control. The three output ports of the chip are used to control commutation control relay of stepping motor, stop relay of stepping motor driver and alarming respectively. The motor driver is controlled via the relay. The stepping pulse of the driver is output via P1.4 port of SCM, so as to drive the stepping motor. The circuit of the control segment of stepping motor is shown in figure 3.

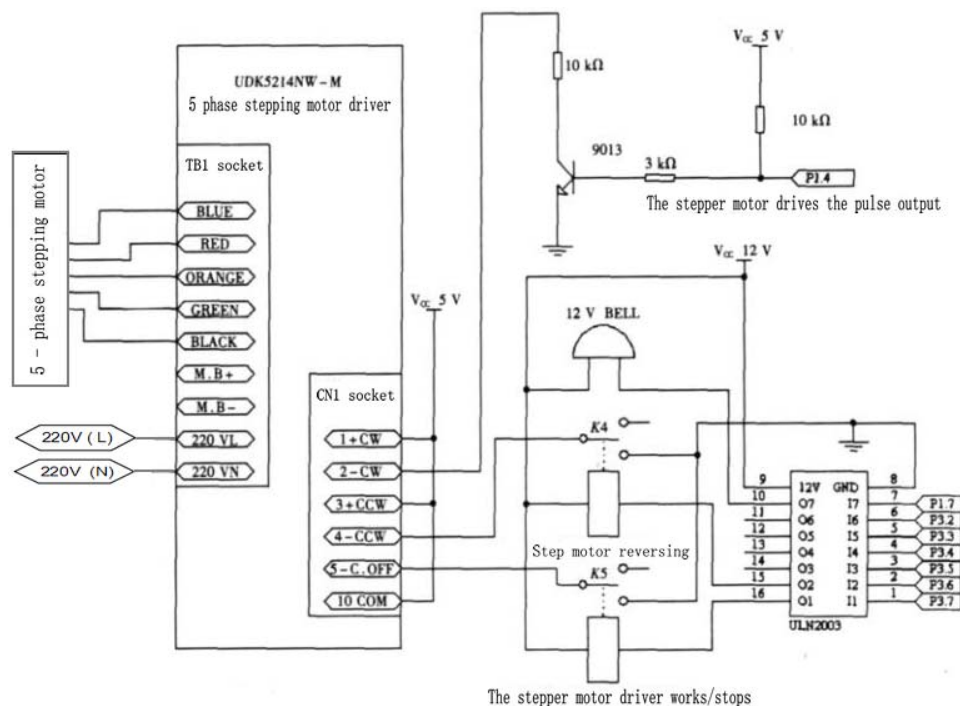


Figure 3. Control circuit of stepping motor.

4.2.2. SCM-based control system. The main control device of stepping motor is SCM. With high control performance and strong adaptability, SCM is a core control device from analogue control to digital control. Owing to its low cost and small size, SCM has become the best control mode of stepping motor^[7-10]. The control circuit of SCM consists of AT89C2051 chip and THB6064H chip. In the control process, SCM works as the control center, which receives the signal from the sensor and other chips, processes signals, and conducts logical operation, timing, arithmetic operation and sequential control by storing and executing instructions to complete operation control of king grass crusher. The whole-process automatic control of the whole machine is realized by the control circuit composed of SCM. The control circuit of SCM is shown in figure 4, and its I/O wiring diagram is shown in figure 5. The corresponding conversion conditions are as below:

X0: Start switch, for controlling the power of the whole circuit system;

X1: Photoelectric sensor 1, for detecting the presence of king grass and controlling the running of stepping motor;

X2: Photoelectric sensor 2, for controlling the running of pressure roller system motor;

X3: Photoelectric sensor 3, for detecting if king grass reaches the position of the first-stage roller;

X4: Photoelectric sensor 4, for detecting if king grass reaches the position of the second-stage roller;

X5: Photoelectric sensor 5, for detecting if king grass reaches the position of the third-stage roller;

X6: Photoelectric sensor 6, for detecting if king grass enters the crushing system and controlling the running of motor;

X10: Stop switch.

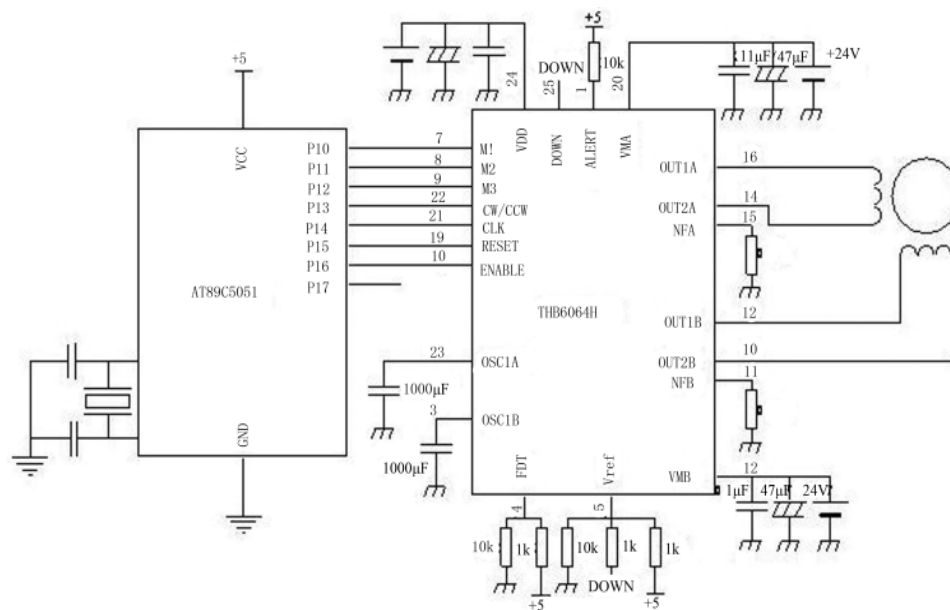


Figure 4. Control circuit of SCM.

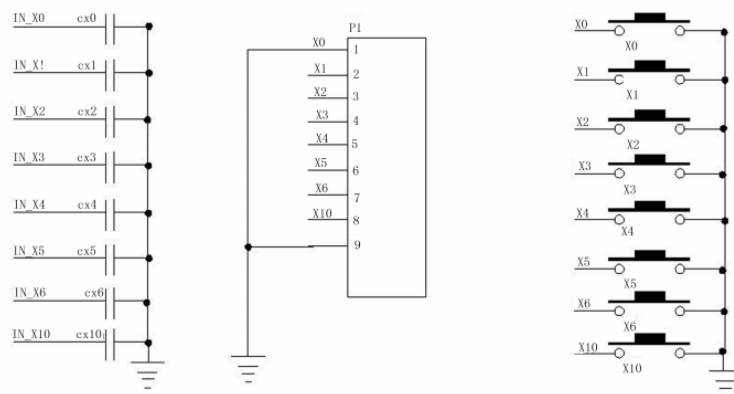


Figure 5. I/O sequential function wiring diagram.

5. Conclusion

With the development and change of the agricultural industry in an all-around way, good forage grass processing is particularly important to the industry chain of livestock breeding. The design of a king grass crusher based on SCM, stepping motor and pressure sensor can improve labor productivity and production safety, solve labor shortage, reduce labor intensity, resolve feed source problem for livestock farmers or farms and bring certain economic benefit to them, and promote the continuous development of feed processing industry and breeding industry.

Acknowledgments

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