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Research and Design for a New Type Stepless Speed Wheat Precision Seeder

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Abstract: The study puts aside the purely mechanical seeding mode which is driven by traditional wheel. It uses a self-designed and developed double suction seed plate, a semi-open seed container, CVT governor, corresponding accessories of sowing machine and so on. The perfect combination of CVT technology and feedback control technology is applied to the wheat double precision seeder. In this technique, the force of seed shaft is from the power output of the tractor tail. It uses wireless transfer mode of SCM to establish a set of control algorithm between forward speed, wheat sowing quantity and sowing spacing. The seeding shaft speed tracks the forward speed in order to ensure the constant distance when trans-miss the progress status. Prototype tests indicate that the wheat double precision seeder developed by air suction stepless regulation can reach the expected target precisely about the fall for each particle. Meanwhile, it has steady performance, small errors and spacing constant.

Key words: Stepless regulation, precision seeding, wireless transmission, control algorithm, real-time tracking

INTRODUCTION

After the 1980s, people started to focus on the design and manufacture of more advanced and practical wheat seeder in some Chinese universities and research institutions. Summary for many years, people with no ground-breaking thinking mode (Zhang and Zhao, 2008) mainly research the Chinese seeding monitoring and control technology under the traditional wheel actuation seeding. By contrast, foreign people study earlier in crop precision sowing control and the related technology is more mature and perfect. Just for wheat precision seeding technology, these shortages are widespread in China: (1) To-wheel drive sowing, slipping inevitably, (2) Unit forward speed and sowing shaft speed with the poor, poor stability spacing., (3) When adjusting seed amount, people must stop manually adjustable sprocket. This way has low adjustment precision and time consuming, (4) Between tractor and seeder control system with wire connection will it be a problem. It makes inconvenience to a complete set of machines, dismantling and planting process. So under the support of the development of science and technology plan projects in the province of Shandong, we abandoned the seeding of traditional wheel actuation and started trying to use stepper motor drive device. We successfully produced double line precision intelligence control system of wheat in 2011. The system uses MCU as the control core, in real time to adjust the stepping motor speed, in order to drive the seeding shaft on-demand seeding (Li *et al*., 2012). Compared with the traditional wheel actuation drive, when the stepper motor drive seeder seeding, it increases energy consumption and people need timely, repeatedly charging battery. As mentioned in this study, through the design of our further research, we developed another wheat double line precision seeder-air-suction stepless variable speed for wheat double line precision seeder (Sun *et al*., 2009; Chen *et al*., 2006). Through the stepless speed regulation technology and the integration of PID control technology, the seeder uses power output of the tractor rear axle as seeding power source, realizes the unobstructed docking between the tractor rear axle power in high speed and the seed shaft in low speed, ensures constant spacing in a machine speed forward condition.

DESIGN SCHEME OF THE PRECISION SEEDING MACHINE

The suction-type metering which has the highest precision is now known as the most mature sowing method. This design chooses a precision seeding way of air-suction stepless regulation and uses a self-designed double suction seed plate, a semi-open seed container, Continuously Variable Transmission (CVT) governor, planter frame and so on. Based on MCU, it combines CVT and PID perfectly and uses PTO of tractor rear as the

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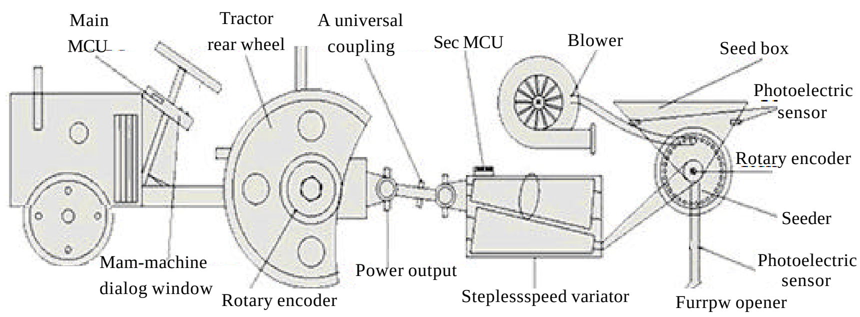

Fig. 1: Structure schematic drawing of the precision seed drill

driving source of sowing (the motor with the same power output replaces the tractor rear power in the experiment temporarily). In order to ensure the plant spacing of wheat constant when seeder changes speed, we establish the control algorithm between forward speed, sowing shaft speed and sowing spacing to get the forward speed in real time.

When the spacing is constant, precision sowing machine will automatically calculate and display the relevant parameters: Spacing, quantity, speed, the state of the operation and so on. The reasonable size design and uniformly distributed state of the suction plate edge planting hole make it accurate to every seed. By using the seeding way of non-synchronous operation of double air sucker, the intelligent control precision sowing machine can achieve cruciform sowing of double-line and the constant single line spacing. Fig. 1 is the schematic diagram and physical prototype of the double precision wheat seeder developed by air-suction stepless regulation.

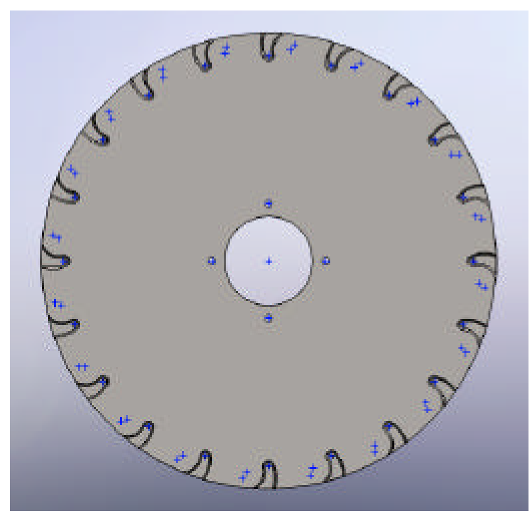

Fig. 2: Design of sowing disc

DESIGN OF THE KEY PARTS OF MACHINERY

The seeding tray is the most critical part of the seeder. We choose the suction-type metering way to achieve single-channel and double sowing to every seed accurately. The technical indicators of suction-type seeding tray mainly include surface roughness, size of the suction hole, depth and slope of the arc groove and so on. These factors decide that whether it can absorb seeds. It ensures only one seed for a hole. The surface roughness of the seeding tray is 3.2. The diameter of the air-suction hole is 3 mm (Li *et al*., 2008; Liu *et al*., 2010). Fig. 2 and Fig. 3 are respectivelythe plan of the seed tray and assembly drawing of the seeder.

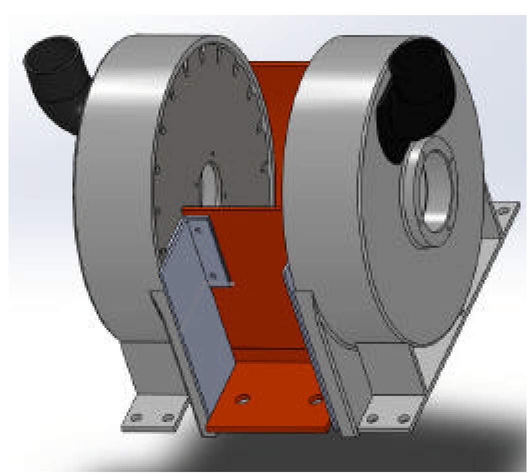

Fig. 3: Sowing device assembly drawing

KEY TECHNOLOGY OF CONTROL SYSTEM

Speed information acquisition: The internal parts of encoder consists of light sources, code disc, photoelectric apparatus, signal conversion circuit and so on. The rotary encoder is the device which is used to measure the speed. It's the most applied digital sensor in automatic measurement. By optoelectronic conversion, the photoelectric encoder is able to convertangular displacement and velocity of output shaft, the volume of machinery into corresponding digital value. The precision seeding device select E6B2 as the rotary encoder (600P/R). One encoder is installed on the front wheel and one on sowing shaft.

Stepless speed regulation control circuit: To achieve the required precision sowing, we introduce a stepless speed regulation control technology in wheat precision sowing control system. We track the machine forward speed and adjust the transmission ratio in the PID control mode. Thereby adjusting the seed shaft speed can achieve constant spacing. The stepless control process: Firstly, master MCU transfers speed signal to slave MCU via bluetooth. Secondly, after receiving commands from MCU, master MCU controls speed regulating motor and achieves transmission's forward, reverse and stop three actions by opening and closing the four relays. Four relays are numbered relay 0-relay 3, respectively. The pipe legs are defined the P1.0-P1.3. The relay 0 and relay 1 are as the power switch and with the same action. The relay 2 and relay 3 as reversing switch and with the reverse action. When the relays 0 and 1 for the high potential, relays 2 and 3 for the low potential, speed regulating motor is forward. When the four relays were the same as the low potential and high respectively, speed motor reversed respectively and no action. Stepless speed regulation control circuit is as shown in Fig. 4.

Fig. 4: Stepless speed regulating circuit

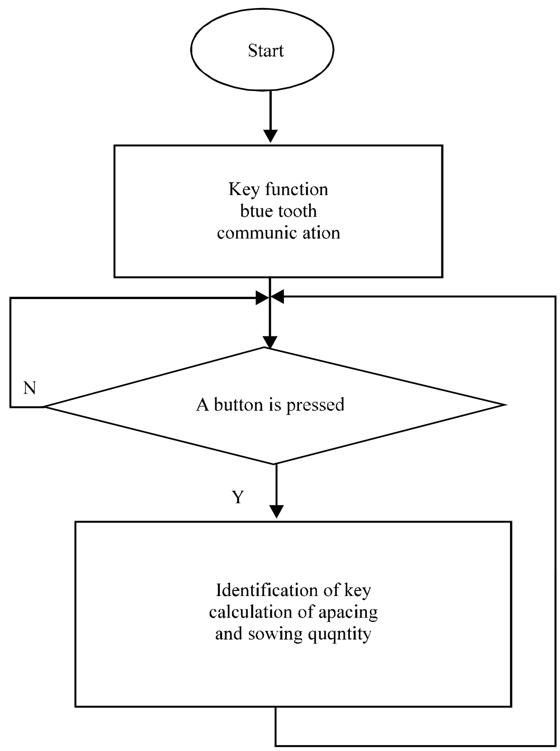

Fig.5 Main program flow diagram of SCU

Planting status display: The display part uses LCD screen 12864. The main contents of the lcd display include spacing, quantity, speed, the state of the operation and so on. The control panel has three control buttons which are for function control, increasing and reducing. These three key-presses, respectively correspond to the vehicle type, sow type and quantity. The corresponding key-presses can change corresponding parameters among various functions.

SCM control process: Considering that we need to decide and handle the output pulse of encoder frequently, the user has a strong request to the stability of the MCU. It's for the reason that the traditional 51 Series MCU is far from perfect. The design chooses the STC12C5A60S2 SCM and uses the master and slave systems. It sends and receives dates by the bluetooth wireless transmission module. The control process: Firstly, the rotary encoder collects speed information of the front wheel and then sends it to the master MCU. Secondly, after the process of decoding, computing and coding, the master transmits the high frequency signal to the slave MCU which is installed on the planter frame in wireless way. Last but not

Table 1: Uniform performance test when seed on even running surface

Serial number	Seed spacing qualified interval [0.5Xr 1.5Xr](cm)	Seed spacing qualified index (%)	The replay index (%)	Loss index (%)
1	[1.5 4.5]	72.8	19.8	7.4
2		74.2	19.6	6.2
3		70.6	22.4	7.0
4		72.5	20.3	7.2
5		71.1	21.3	7.6

Table. 2: Uniform performance test when seed on sandrunning surface

Serial number	Seed spacing qualified interval [0.5Xr,1.5Xr](cm)	Seed spacing qualified index (%)	The replay index (%)	Loss index (%)
1	[1.5 4.5]	69.9	21.4	8.7
2		72.7	20.2	7.1
3		70.2	23.1	6.7
4		71.3	20.9	7.8
5		73.5	18.2	8.3

least, comparing with the real-time speed information of the sowing shaft speed which is collected by encoder, we can control the movement of the stepless speed regulator of conical ring style after receiving the information for slave MCU. In addition, SCM also has control and monitoring alarm functions. Once there are cases of the insufficient amount of seeds in seed box or blockage conditions in seed tube, it makes sound and light alarm timely to draw operators' attention(Ding, 2002; Shi and Gao, 2002; Wang and He, 2011) .Fig. 5 shows the Main program flow diagram of SCU.

RESULTS AND ANALYSIS FOR EXPERIMENTAL

The test results of spacing measurement are clearly defined in the GB/T6973-2005 "Single grain (precision) seeder test method ". The sample which was Xr interval (Xr is design seed spacing) is divided into section. The sections are as follows.

$$n1 = \sum n_i \{X_i \in [0\ 05x_i]\}$$

$$n_2 = \sum n_i \{X_i \in [0-05x_i\ 1-5X_i]\}$$

$$n_3 = \sum n_i \{X_i \in [1-5X_i\ \ 2-5X_i]\}$$

$$n_4 = \sum n_i \{X_i \in [2-5X_i\ \ 3-5X_i]\}$$

$$n_5 = \sum n_i \{X_i \in [3-5X_i + 00]\}$$

$$N = n_1 + n_2 + n_3 + n_4 + n_5$$

And established the following equation:
Reseeding amount:

$$n_2 = n_1$$

Acceptable amount:

$$n_1 = N - 2n_2$$

Miss-seeding amount:

$$n_0 = n_3 + 2n_4 + 3n_5$$

Intervals:

$$N = n_2 + 2n_3 + 3n_4 + 4n_5$$

There are three important indicators in the evaluation of the test results sowing description and they are registered spacing index, reseeding index, miss-seeding index.

Registered spacing index:

$$A = \frac{n_1}{N} \times 100$$

Reseeding index:

$$D = \frac{n_2}{N} \times 100$$

Miss-seeding index:

$$M = \frac{n_0}{N} \times 100$$

Considering from the accuracy and the reliability of the test results, the number of spacing samples can not be less than 250. Therefore, we took 400 test samples and setted theoretical spacing Xr that equals to 3 cm. In order to research the flatness of the road for planting quality impact, we respectively did the test on the road and covered with gravel pavement and repeated 5 times, counted seed spacing and calculated the relevant parameter. Statistical test results are shown in Table 1 and Table 2.

Based on "JB/T 10293-2001 single grain (precision) seeder technical conditions " specified: When the seed spacing X is not greater 10 cm, what precision seeder operation performance indicators shall conform to is that the registered spacing index is not below 60%, reseeding index not greater 30%, miss-seeding index not greater 15%. The data of Table 1, 2 shows that each index all conforms to the relevant provisions and miss-seeding, reseeding index is smaller. Compared to two table data can be seen, in addition, for the wheat seeding prototype under control of air-suction stepless speed regulation system, road roughness on evenness of seeding affected smaller. This kind of wheat seeder can completely meet the demand of field planting.

CONCLUSION

The research makes up for the shortage of the skip and miss-seeding phenomenon which is easily appeared in traditional seed of Land-wheel Driven. It overcomes the obstacles on the technologies of the intelligent control precision sowing machines in China these years. At the same time, it realizes single-channel and double sowing to every seed. So reducing the further seeding rate per unit area and costs comes true.

Wheat double line precision seeder which has self-design seeder and parts, uses MCU as the control core, controls the stepless speed regulation system in PID way, realizes the unobstructed docking between the tractor rear axle power output in high speed and the seed shaft in low speed, replaces the traditional sowing wheel drive.

Reasonable design of CVT and the control of fan delivery can make the suction hole of the seed plate adsorb single seed without damage as required.

Seeding performance test and prototype seeding test show that stepless speed wheat precision seeder has stability, small error, constant spacing and good practical popularize value.

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