The Application and Development of Intelligent Speed-Dependent Variable Control Technology in Agriculture

Wu Liying， Wang Jiang*, Shi Weiliang

School of Automotive Engineering

Zibo Vocational Institute, 255100, Zi Bo, China

Abstract : Intelligent speed-dependent variable control technology, as an important module for the intelligentization of agricultural machinery equipment, this paper reviews the current research status of intelligent speed-dependent variable control technology at home and abroad. By using motor drive to improve the insufficiency of mechanical transmission mainly based on ground wheel drive, the intelligent transformation of domestic agricultural machinery is achieved. Domestic scholars have conducted research in speed-dependent control, which has improved the seed scheduling accuracy of agricultural machinery. This paper mainly discusses the development and application of domestic intelligent speed-dependent variable control technology and looks forward to its future development.

1. INTRODUCTION

At present, with the acceleration of agricultural modernization and the tightening of resource and environmental constraints, the development of intelligent speed-dependent variable control technology has become an inevitable trend. On the one hand, under mechanically driven operation conditions, it will lead to uneven operation quality in links such as sowing, fertilizing and spraying, serious waste of resources, and affect crop yields. The widely used agricultural operation machinery nowadays often adopts ground wheels as the driving force for the device in links such as sowing and fertilizing. However, the ground wheels are prone to slipping due to changes in operation speed and ground environment, especially when operating at high speed, the slipping phenomenon is particularly serious, which will lead to a decline in operation quality [1, 2]. According to statistics, in the case of ground wheel-driven sowing, the seed waste rate can reach 8%-12%, and the fertilization error can reach 20%-30%[3, 4]. On the other hand, with the intensive development of agriculture, efficient and precise operations have become the demand for industrial upgrading, which makes the traditional pure mechanical and extensive operations with low efficiency unsustainable. Meanwhile, the global competition in agricultural science and technology is fierce. The United States, Japan and other countries have widely applied speed-sensitive intelligent control technology to high-end agricultural machinery equipment. China urgently needs technological breakthroughs to enhance its agricultural competitiveness.

To solve the problem of the loss of mobility of the working device caused by the slippage of the ground wheels in agricultural production and meet the demand for precise and convenient setting of different operation volumes, this paper develops an intelligent speed-dependent variable control technology based on the GNSS module speed measurement method. This technology is modularized and can be corrected and adapted according to the operation device and environment. In recent years, China's sensor technology, automatic control technology, Internet of Things technology and artificial intelligence technology have developed rapidly, providing solid technical support for intelligent speed-dependent variable control technology in agricultural production. From the perspective of software and hardware design, with the support of existing technologies, precise matching of "speed - workload" can be achieved. From an industrial perspective, intelligent speed-dependent variable control technology can promote the intelligent upgrade of agricultural machinery equipment, give rise to new business forms such as precise operation services, and help domestic agricultural machinery enhance its global competitiveness.

2. Research Status of Intelligent Speed-Dependent Variable Control Technology

2.1 Overview of the Development of Intelligent Speed-Dependent Variable Control Technology Abroad

Intelligent speed-dependent variable control technology, as a

component of precision agriculture, has been developed for a relatively long time in Europe and America and has been widely applied in the field of agricultural production. The related products have developed relatively maturely. At present, many well-known enterprises in Europe and America such as John Deere, Case, Hoshi, and Maschi Ogilan have already developed mature products related to this. These products have been applied in various types of seeders and solid-liquid fertilizer applicators/devices. At the design stage, they all abandoned the

traditional wheel-driven operation mode for seed discharge or fertilization, and chose to drive the working components with motors. Moreover, the drive modules and working components are highly integrated. The modular design is reasonable and has strong system portability [5]. As shown in Figure 1, these are the related products of foreign enterprises equipped with intelligent speed-following control systems. It is learned from the official website that the speed measurement modules of the products mostly adopt GPS or encoders.

(a) John Deere intelligent seeding unit

(b) Haoshi no-till seeder

(c) John Deere granular fertilizer applicator

(d) Case liquid fertilizer applicator

Figure 1-1 shows the related products of foreign enterprises equipped with intelligent speed-following control systems

Relevant foreign scholars have conducted research on the driving sources and speed measurement methods in intelligent speed-dependent variable control technology. Jafari et al. designed a DC motor variable speed controller, which acquires speed information based on GPS signals and regulates the motor rotation. Two encoders are used as output signals and feedback signals. The design structure is shown in Figure 1-2a. During the field experiment when converting from low seeding rate to high

seeding rate, the seeding rate was stable and the seeding rate deviation did not exceed 5.3%[6]. The corn precision seed scheduling control system designed by Mangus has a structure shown in Figure 1-2b. It adopts a seed scheduling scheme of "DC motor control + tooth top seed pushing + seed tube detection". This system can be applied to large-scale field operations [7], and the motor drive is shown in Figure 1-1 (b).
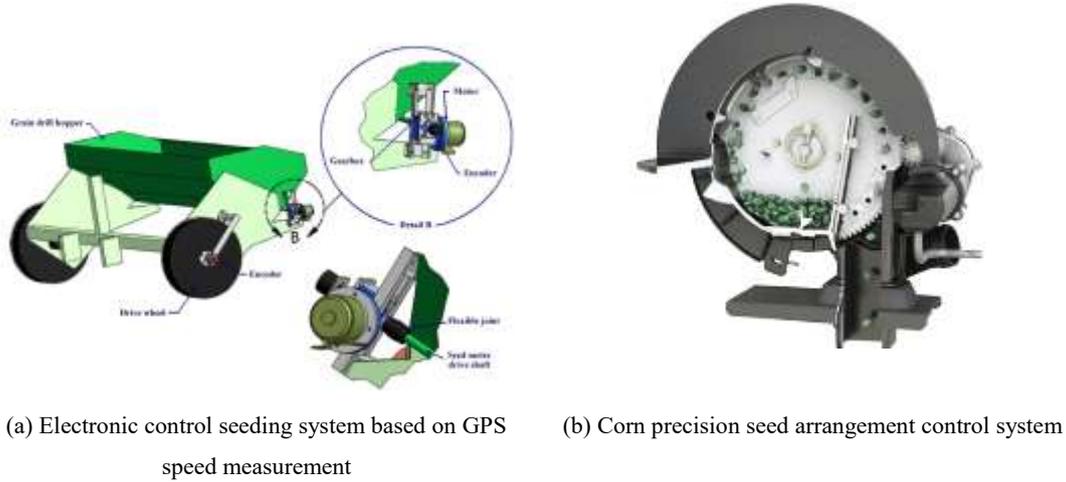
(a) Electronic control seeding system based on GPS
speed measurement

(b) Corn precision seed arrangement control system

Figure 1-2 Schematic diagram of the control system

2.2 Overview of the Development of Domestic Intelligent Speed-Dependent Variable Control Technology

A survey of domestic agricultural machinery enterprises with large scale and market share found that domestic related sowing and fertilizing devices are still in the mechanical transmission stage mainly driven by ground wheels, and motor-driven is still in the research stage without mass-produced products. Figure 1-3a shows the Nonghaha 2BYFSF-6C corn no-tillage fertilizing precision seeder. The power for both the sowing and fertilization stages is driven by the ground wheels at the rear of the entire machine. Figure 1-3b shows the Wode Xiaolong high-speed transplanter. When purchasing, you can choose a side-row fertilization device. The power of this device is obtained through belt transmission, and the power is prone to fluctuation and instability. It can be found that in terms of intelligent control and human-computer interaction, there is still a considerable gap between domestic products and those of developed countries in Europe and America. The analysis of the reasons is not only that the domestic planting model is different from that of Europe and America, but mainly due to the short development time and low profit of the domestic agricultural machinery industry. The No. 1 National Document of 2025 proposed to lead the aggregation of industrial elements with scientific and technological innovation, increase subsidies and support for new technologies and new products [8], and focus on promoting the modern development of agriculture. This has also injected a strong impetus into the large-scale development of the domestic agricultural machinery industry. Facing the national policy orientation and high-quality competition from foreign agricultural machinery, domestic agricultural machinery enterprises have also reached a stage where they have no choice but to undergo intelligent transformation.

(a) Nonghaha 2BYFSF-6C Corn no-till fertilizing Precision
planter

(b) WodeXiaolong high-speed transplanter

Figure 1-3 Representative models of domestic agricultural machinery enterprises

To achieve efficient and high-precision operations, domestic scholars have carried out research in the field of speed-dependent control technology. Yin Xiang et al. designed an intelligent control system for corn precision planters based on photoelectric encoder speed measurement. The structure is shown in Figure 1-4, achieving the dynamic matching of sowing grain spacing and the operating speed of the planter [9]; Zhang Chunling et al. used a radar speedometer to detect the real-time speed of the seeder and collected the real-time rotational speed of the seed scheduler through an encoder for feedback control. The physical installation diagram is shown in Figure 1-5, which improved the seed scheduling accuracy [10, 11]; HE et al. proposed a driving scheme that uses a motor to drive the seed disperser, measures the speed with an encoder, and adds the slip ratio parameter for speed correction, which improves the sowing quality [12]. However, the encoder speed measurement is still affected by the slipping of the ground wheels, and different plots and soil conditions have different slip rates. This cannot guarantee the universality of the correction parameters and cannot fundamentally solve the problem of ground wheel slippin

Figure 1-4 Precision seeder based on photoelectric encoder speed measurement

Figure 1-5 Physical installation diagram of the radar speed detector and encoder

By comparing and analyzing the current research status of speed-dependent control technology at home and abroad, and considering the differences in planting and operation models at home and abroad, it has become an inevitable path to develop an intelligent speed-dependent variable control technology that is applicable to China's national conditions and can be used in different working links.

3. References

[1] Zhang Xirui, He Jin, Li Hongwen, et al. Design and Experiment of Horizontal Weeding Wheeled Corn No-till Seeder [J]. Transactions of the Chinese Society for Agricultural Machinery, 2010,41(12):39-43.

[2] Fu Qiankun, Jian Shichun, Jia Honglei, et al. Design and Experiment of Corn Stubble Killing, Ridging, Fertilization and Seeding Machine [J]. Transactions of the Chinese Society of Agricultural Engineering, 2016,32(04):9-16.

[3] Li Tao, Liu Jiangtao, Sang Yongying, et al. Design and Experiment of Monitoring System for Electrically Driven Wheat Planter Based on Beidou Speed Measurement [J]. Journal of Agricultural Mechanization Research, 2025,47(04):116-121.

[4] Su Ning. Research on Variable Fertilization Control Technology in Precision Agriculture [D]. University of Science and Technology of China, 2016.

[5] Liao Qingxi, Luo Zhancheng, Yang Heng, et al. Research on the Speed-Adjustable and Controllable Seed Scheduling Control System of Rapeseed Direct Seeding Machine Based on RTK Speed Measurement [J] Transactions of the Chinese Society for Agricultural Machinery, 2024,55(09):65-74.

[6] Jafari M H A S M. Development and performance assessment of a DC electric variable-rate controller for use on grain drills[J]. Computers and Electronics in Agriculture, 2010,73(1):56-65.

[7] Mangus D L S A F D. Development of high-speed camera hardware and software package to evaluate real-time electric seed meter accuracy of a variable rate planter[J].

Computers and Electronics in Agriculture, 2017,142(1):314-325.

[8] Song Hongyuan, Su Yutong. Focusing on Promoting Rural Construction: Key Issues and Practical Approaches [J]. Journal of China Agricultural University (Social Sciences Edition):1-13.

[9] Yin Xiang, Yang Tengxiang, Jin Chengqian, et al. Development of Intelligent Control System for Precision Corn Sowing [J]. Journal of Agricultural Mechanization Research, 2018,40(09):125-128.

[10] Zhang Chunling. Design and Experiment of Electric Control Corn Seed Disperser [D]. Anhui Agricultural University, 2016

[11] Zhang Chunling, Wu Rong, Chen Liqing. Design and Experiment of Electric Control Corn Seed Arrangement System [J]. Transactions of the Chinese Society for Agricultural Machinery, 2017,48(02):51-59.

[12] HE X D C T. Development of an electric-driven control system for a precision planter based on a closed-loop PID algorithm[J]. Computers and Electronics in Agriculture, 2017(136):184-192.