

Development and Application of the Intelligent Seed Processing Technology and Equipment



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Abstract. Seed processing is an important link in the seed industry chain. Crop seed industry is a national strategic and basic core of industry. Drying, cleaning, selecting, grading, coating, packaging and storage of crop seeds are the main measures to realize the precision sowing of crops and the increase of grain yield and income. Continuously improving the intelligence and fine level of seed processing equipment is of great significance to ensure the production and supply of excellent seeds and the stability of agricultural production. This paper describes the development status of modern seed processing equipment technology in China, introduces the establishment of seed processing equipment engineering technology research center, taking maize, rice, wheat and cotton seed processing technology and machinery as an example, describes the key technologies and technological process of the breakthrough in the major crop seed processing, analyzes the existing problems of seed processing equipment in China at this stage as well as the development trend in the future, provides a reference for government decision makers in resolving the problem of mechanical damage in the process of seed processing and further improving the intellectualization level of seed processing, promotes the common progress of the global seed processing equipment technology.

Keywords: seed, processing equipment, development and application.

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Разработка и применение интеллектуальных технологий и оборудования для обработки семян

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Реферат. Обработка семян – важное звено в цепочке семеноводства. Отрасль растениеводства – это национальная

стратегическая и базовая отрасль промышленности страны. Сушка, очистка, отбор, сортировка, дражирование, упаковка и хранение семян сельскохозяйственных культур являются основными мерами по обеспечению точного посева сельскохозяйственных культур и увеличения урожайности и доходов зерна. Постоянное повышение интеллектуального уровня оборудования для обработки семян имеет большое значение для получения и поставки отличных семян и обеспечения стабильности сельскохозяйственного производства. В этой работе описывается состояние разработки современного оборудования для обработки семян в Китае, рассказывается о создании центра инженерных технологий оборудования для обработки семян. На примере технологий и оборудования для обработки семян кукурузы, риса, пшеницы и хлопка описываются ключевые технологии и технологический процесс, лежащие в основе технологического прорыва в обработке семян основных сельскохозяйственных культур. Анализируются существующие проблемы, связанные с оборудованием для обработки семян в Китае на данном этапе, а также будущие тенденции развития обработки семян. Статья предоставляет рекомендации для лиц, принимающих правительственные решения в области проблем механических повреждений семян в процессе обработки и решения о дальнейшем повышении уровня интеллектуализации обработки семенного материала. Данная работа способствует дальнейшему развитию глобальных технологий в этой сфере.

Ключевые слова: семеноводческое оборудование, разработка и применение.

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President Jinping Xi put forward, “we must promote the mechanization and intelligence of agriculture vigorously, and add wings of science and technology for agricultural modernization”. “One seed can change the world, the bowls of the Chinese, in any situation, must be firmly held in our own hands, and it should be mainly filled with Chinese grain” [1].

Crop seed industry is a national strategic and basic core of industry. Seed processing equipment is an important link in its industrial chain, which is the main measure to realize precision sowing and the increase of grain yield. Seed processing mainly refers to the seed treatments before planting and the fine processing, drying and storage of the grain after harvest (Fig. 1).

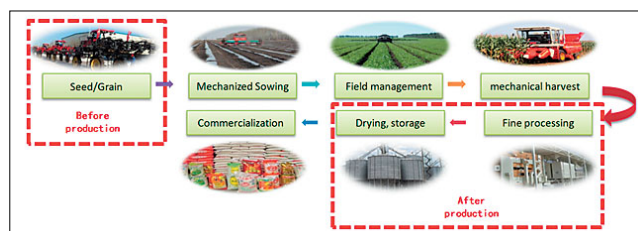


Fig. 1. Seed processing equipment in the crop seed industry chain

Seed processing refers to the process of drying, cleaning, grading, coating, packaging and storage of seeds from harvest to sowing depending on their different biological, physical and mechanical characteristics.

Seed processing equipment is the generic term of specialized processing technology and technical equipment which are designed and adopted for the different breeds of crop and processing requirements. Seed processing equipment is of special significance to ensure the production of fine seeds supply and the stability of agricultural production [2].

Development and application of intelligent seed processing technology and equipment

The National engineering technology research center of seed processing equipment was approved by the ministry of science and technology in 2012, established on Aokai Seed machinery Co., Ltd. Jiuquan, China (Fig. 2). It mainly engaged in the research of the principle of seed processing technology, the key technology of seed processing, the serialization, complete set, and intelligence for the seed processing equipment.



Fig. 2. National Engineering Technology Research Center of Seed Processing Equipment

Aokai Seed machinery Co., Ltd. is close to the core area of national corn seed production base, and it is the largest leading enterprise of seed industrial equipment development and manufacture, ranking first in the industry in China. The main products are seed fine processing, seed drying, metal storage, field seed production, environmental protection and dust removal, and other 10 series included more than 500 varieties.

The center has set up 4 research and development centers in Jiuquan, Lanzhou, Beijing and Chengdu, with 14 sub centers about seed processing, drying and complete engineering, including 128 technicians. In 2020, Aokai Seed machinery Co., Ltd. was rated as national green factory. Our goal is to build it into a garden mold of intelligent green manufacturing factory which manifests the type of brand effectiveness and viewing demonstration.

In the process of manufacture, the advance processing equipment such as laser cutting, numerical control cutting, numerical control machine, automatic welding, precision forging, precision casting has been widely adopted, and the precision of the manufacture of the seed processing equipment has been improved (Fig. 3, 4).



Fig. 3. Hydraulic gravity separation test detection platform



Fig. 4. Hydraulic testing platform

After the implementation of “seed law” in China, the number of seed enterprises in China has decreased from more than 8000 to less than 4000 now. The concentration of seed enterprises has been continuously improved, and the enterprises march toward the road of the large-scale management, which ensured the quality of seed processing and the safety of seed supply [3]. We have realized the industrialization, complete set, large-scale and intelligent of the seed processing in the standardizing, large-scale, mechanized and intensive environment. We pay attention to the seed health, preserve the seed vitality and ensure the processing quality [4].

The production line of the seed processing equipment is mainly divided into corn, rice, wheat, cotton, vegetable and flower seeds [5-7]. In China, corn seed production is a huge industry. In the field of the process of the corn seeds, we have built an intelligent mechanized operation in the whole process, and the mode of the large-scale production (Fig. 5). We developed the complete set of equipment for large-scale processing of corn seeds. We realized the information management, fine processing, mechanized operation and large-scale production of corn seeds. We provided the mechanized processing equipment

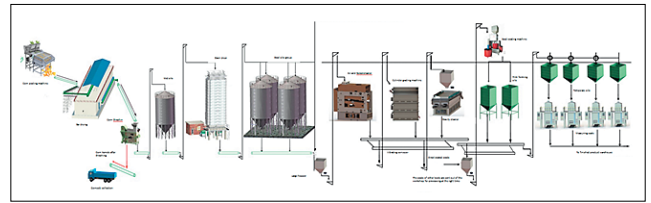


Fig. 5. Engineering processing technology flow of maize seed

of the corn seeds with high cost performance, intelligent, large-scale, engineering in the whole process for seed industry in China.

In terms of the product research and development, according to the processing characteristics of the corn seeds, we have successfully developed large modular corn ear drying equipment, variable temperature drying equipment, intelligent seed sorting and processing equipment, multi-channel corn peeling machine, kneading maize sheller, intelligent batch environmental coating machine and other equipment, forming an advanced and perfect corn seed processing technology and equipment system.

In the application of new technology, the automatic control and information management system of the corn ear drying were researched. Through tracking and analyzing the collected data and corresponding curves, the best drying process parameters for the certain corn seeds were defined (Fig. 6). The remote monitoring and intelligent control of corn ear drying were realized, which reduces the intensity of the operators, and realizes the information recording and administration of the whole process of drying.

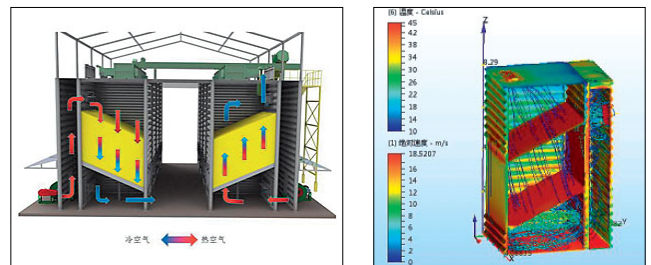


Fig. 6. Schematic diagram of hot air reversing in drying process of corn seed ear

In the aspect of intelligent batch seed coating machine, based on PLC, the units are controlled to operate automatically, orderly, and concordantly, which realize the intelligent and precise addition of the seed coating agent. The pre-mixing system of seed coating agent was developed to solve the problems of various kinds and complex formulations of the seed coating agent.

We have developed an integrated high-clearance self-propelled corn tasseling and spraying equipment, based on the Beidou navigation system, it achieve automatic navigational operation of the spraying machine, which solves the problem of the intelligent control of the mechanized tasseling, spraying, fertilization, reduces the production cost of the corn seed production, and improves

the competitiveness of the seed market. The layout of large-scale corn seed processing plant is constructed. We can develop one-stop solutions from plan, design, manufacture and install. We can complete the integrated turnkey project from the front unloading platform – ear dressing workshop – ear drying – threshing – temporary storage – cleaning processing – intelligent storage (Fig. 7).



Fig. 7. Layout of large-scale corn seed processing plant

In terms of popularization and application, the annual production of the seed production of hybrid maize in the base in Hexi corridor, Gansu, accounts for about 60% of the national demand. The purification rate of corn seeds reaches 99.5%, the damage rate is less than 0.5%, and the germination rate is more than 96%. At present, there are 150 corn ear drying production lines in China, which effectively guarantee the large-scale processing demand of corn seeds.

In the field of rice and wheat seed processing, we mainly solve the problems of processing equipment and intelligent control system, such as precleaning, grain drying, awning removal, gravity separation, pit-hole roller cleaning, specific gravity wind separation, coating and packaging (Fig. 8). In recent years, the demand of the mechanical drying of rice seeds is increasing by year. There are more than 1200 complete sets of wheat and rice seed processing lines in China, which basically meet the current processing requirements of rice seeds in China [8].

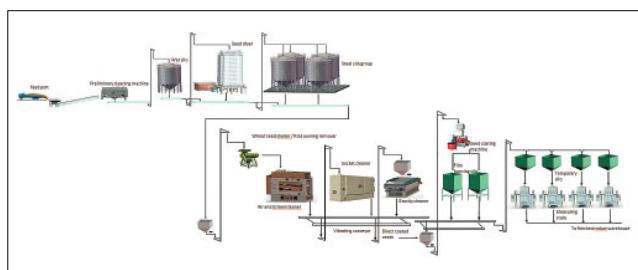


Fig. 8. Rice and wheat seed engineering processing process

The continuous intelligent drying technology of rice and wheat grain were mainly solved. According to the safety temperature of different materials tolerated, the variable temperature drying process was adopted to realize the slow and uniform precipitation of rice and wheat seeds, and reduce the rate of cracking and heat damage of seeds.

In terms of heat source, heat pump is used as clean heat

source to change the traditional drying mode which uses coal as heat source. Large rice dryers with 15 t/h, 30 t/h and even 100 t/h have been developed and produced. The drying temperature is accurately controlled, and energy saving, environmental protection and reduced seed drying cost are achieved.

In the aspect of cotton seed processing, the excessive dilute sulfuric acid depilation process was used to build a complete production line of intelligent de casing of cotton seeds. After processing, the purity of cotton seeds was more than 95%, the germination rate was more than 90%, and the crushing rate was less than 5%. China has built 120 complete sets of cotton seed production lines.

In recent years, color separation and magnetic separation technology have been continuously applied in processing production line of cotton seeds, which significantly improve the quality of cotton seeds. Color separation technology is also suitable for the processing production line of rice and corn seeds.

In the field of seed processing of vegetable, flower and forage seeds, a production line with a processing capacity of 150 kg/h has been developed, which has solved the key technologies of the fine processing single machine and complete set of production regarding polishing, drying, wind separation, specific gravity selection, coating of the vegetables, flowers and grasses seeds. It also provides key technical equipment for the fine processing of vegetable and flower seeds in China.

Seed processing technology in china originated in the 1970s and has a history of 50 years. The development of seed industry equipment has gone through a process from scratch less to much more, small to large, single to complete. The development of seed industry equipment has basically met the needs of China's seed processing equipment, and has been exported to many countries around the world. The technical level of seed industry equipment has reached the international advanced level, which can play an important role in solving the problem of the grain yield, farmers' income, and the eating problems of 1.4 billion people in China.

The future of seed processing

To solve the problem of mechanical seed damage during seed processing, the level of the intelligence in seed process should be further improved. The deep integration of 5G with cloud computing, big data, artificial intelligence, virtual reality and other technologies to establish seed processing parameter database and realize online remote intelligent control of seed process is the goal of the research and development of seed processing equipment in the future.

Quality traceability and on-line monitoring of seed production process should be solved. Machine vision technology, near infrared spectroscopy, hyper-spectral imaging technology, soft X-ray technology, laser speckle technology and other technical means should be applied to detect seed vitality and vigor.

We should adhere to the concept of “scientific and technological innovation lead the development”, build a seed industry equipment innovation system with the government as the leading factor, the market as the guide, enterprises and scientific research institutions as the main body, scientists and technicians as the main force, and the system as the guarantee. We should build a highland of scientific and technological innovation, and make greater contributions to the national food security and the new rural construction [9, 10].

We should further deepen the exchange and cooperation with international seed processing equipment enterprises, promote the common progress of the global seed processing equipment technology, and create a better future for human society.

CONCLUSIONS. With the continuous promotions of the national economic development in the period of “14th five

year plan”, the strategic core position of seed industry in the national economy will be more prominent. The mechanized technology system and equipment of seed industry in China face high-quality development. We should further grasp the development trend of seed industry in China, solve the problem regarding the supply-demand relationship between seed production and processing in the new period, continuously increase the investment in scientific research, strengthen the collaborative innovation and cooperative research, deepen the integration of agricultural machinery and agronomy, strengthen the integrated development of seed industry equipment with intelligence and information, establish the team of scientific talents, and promote the transformation and application of the achievements, which can make important contributions to ensure the food security in China.

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Conflict of interest.

The authors declare no conflict of interest.

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