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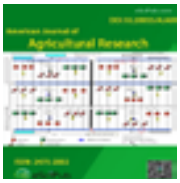

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Development status and trend of high efficiency grain air-and-screen cleaning device

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ABSTRACT

The cleaning device in modern agricultural equipment is an important part of the reference of the grain combine harvester. The loss rate of the grain and other factors are directly affected by the cleaning device. In this paper, the development status of the current cleaning equipment and the research and analysis are described in three aspects: the distribution of the airflow field in the cleaning device, the movement law of the exudate, and the research on the centrifugal fan. The loss rate and the impurity ratio of the grain harvest are reduced. Objectives, reviewed the research status and trends of domestic and foreign grain combine harvester cleaning equipment, and put forward new ideas for the future development prospects and prospects of grain combine harvester, and provide reference for improving the research and design of grain harvester cleaning equipment. experiments.

Keywords: grain harvester; cleaning device; airflow field; decanted state; fan

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Introduction

The air screen type cleaning device plays an important role in the whole plant harvesting efficiency by separating and clearing the grain after the grain is separated by the threshing system. At the same time, the cleaning device plays an important role in the efficiency of the whole machine in terms of exhausting and improving cleanliness. Judging from the current domestic agricultural mechanization harvesting effect,domestic agricultural machinery equipment and manufacturing process technology still have imperfect performance, quality and harvesting effect can not meet the current agricultural mechanization production demand, and it is necessary to study the problems existing in the grain cleaning device. perfect.

According to the national machinery industry standard "General technical conditions for grain combine harvesters" the total loss rate and content of the whole machine are: soybean ≤ 2%, wheat ≤ 1.2%, rice ≤ 3.0%; soybean impurity rate ≤ 5%, the impurity rate of wheat and rice are ≤ 2%. As the threshing system and the harvester header technology continue to improve, the grain loss rate continues to decrease. However, the overall performance of the grain harvester in the cleaning device limits these parameters. At the same time: the loss rate and the inclusion rate are important indicators for evaluating the performance of the grain harvester, and the efficiency and quality of the grain harvester will be directly affected.

In order to improve the quality and efficiency of the grain harvester, it is necessary to study the distribution of the airflow field in the cleaning device, the movement law of the exudate, and the structural design of the centrifugal fan combined with the finite element, kinematics test and various influencing factors. Grain harvest quality, mechanization and high efficiency.

Introduction to the basic principle of harvester cleaning device

The air screen cleaning device consists of a shaking plate, an upper screen, a lower screen, a tail screen, a transmission mechanism and a fan. The dither plate transports the layered crops, kernels, and short stems to the screen surface, and reciprocates along with the screen to deliver the material separated from the threshing drum gravure screen and the drafter to the front end of the screening screen. The finger screen is located at the tail end of the dither plate, so that the exudate is loose and loose, and first contact with the screen surface, the short stem is on the surface of the valley layer, and the long short stem is raised by the finger screen to improve the cleaning effect. . At the same time, the airflow generated by the fan fan in the cleaning device is blown to the entire cleaning chamber where the sieve is located, and the lighter debris is first blown out of the machine. The effect of the tail sieve is to further separate the uncutted grain head from the extract and send it to a heterogeneous auger for secondary degranulation. Eventually, the transport of the grain auger will transport the grain to the grain bin for grain harvesting.

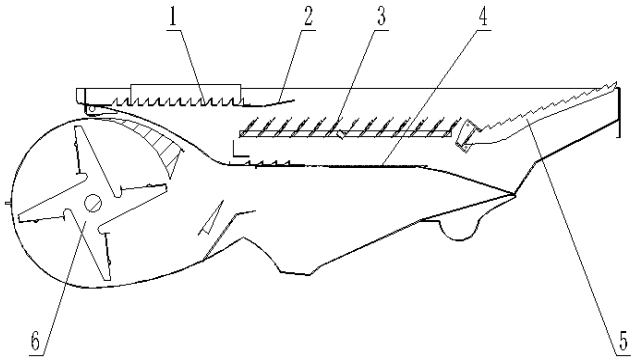

Figure 1: Air screen sieve type cleaning device. 1 Dithering plate; 2 finger screen; 3 upper screen; 4Lower screen; 5 tail screen; 6 fan

Research on the status quo of cleaning equipment

Regarding the research on the cleaning device, domestic and foreign scholars mainly study the distribution of the indoor airflow field, the movement of the exudate, and the influence of the centrifugal fan of the cleaning system on the airflow field of the entire cleaning chamber, through the cleansing test research and parameters. Test optimization plays a constructive role in the field of cleaning.

Airflow field distribution research

The distribution of the airflow field directly affects the cleaning effect of the cleaning room. In the clearing chamber, the separation effect of the exudates is greatly affected by the wind speed distribution of the airflow field. When the airflow in the cleaning chamber is large, the loss rate of cleaning is increased and the impurity content is reduced. When the airflow in the cleaning chamber is small, the loss rate of cleaning is reduced and the impurity content is increased. A large number of research and simulation experiments have confirmed that the distribution of the surface gas field in the screening has a great influence on the quality correlation of the cleaning.

Advanced airflow field technology and research at home and abroad are worth learning and learning. Tsuji was the first to use the combination of ANSYS-FLUENT and DEM software to simulate the current situation of agriculture. The research on the plug flow problem of non-sticky particles and two-dimensional fluidized bed in the pipeline was studied. The test was obtained through a large number of experiments. The data is consistent with the simulation results . The research on gas-solid two-phase flow with CFD-DEM coupling technology has been widely applied and developed. Watano considered the effects of electrostatic properties in the numerical simulation of the pneumatic transport of powder particles.

Zhang Jianzong and others studied the single-channel centrifugal fan, especially the influence of the airflow field on the cleaning performance caused by the inclination angle of the left and right side plates and the length of the fan outlet. Du Xiaoqiang et al used ANSYS FLUENT to study the variation law of the airflow field, and carried out the experimental simulation calculation of the cross-flow grain cleaning room after meshing. The separation effect of the grain in the clearing room is obvious, and the numerical simulation results of the gas-solid two-phase flow are further verified. Shen Dechao conducts an airflow field test on a cleaning device consisting of a layer of sieve and a double air duct. Using the knowledge of optimal design regression equation to calculate the optimal parameter combination when the minimum cleaning loss rate is used, it serves as a reference for the development of the dual air duct cleaning device. Tang Zhong used digital wind speed equipment to measure the wind speed at multiple points in the interior of the cleaning room, and then used the method of drawing the constant velocity line to obtain the position of the center of the vortex. And analyzed that the vortex position is affected by different outlet vent angles and different centrifugal fan speeds.

Ning Xiaobo et al used ANSYS-FLUENT to build a mesh model, numerically simulate the airflow field inside the cleaning chamber, and used the fan speed, the number of blades, and the exit angle as test factors, and obtained the pressure through the orthogonal test of the response surface. With the parameter distribution map such as speed, the cleaning system achieves high efficiency and high quality. In 2003, Chen Xiuhuai et al. used three-dimensional numerical simulation method to study and analyze the turbulent airflow field in the cleaning chamber, and to import and export the fan blades. Width ratio, inlet angle of centrifugal fan blades, number of blades, etc. Through a large number of experiments to study the factors affecting the

performance of the fan, it is concluded that the traditional empirical data is very different from the optimized value achieved by the three-dimensional simulation, which has a great impact on the fan.

Li Fang et al used the ANSYS CFD software to numerically simulate the airflow field in the cleaning chamber in order to find the shortcomings in the distribution of the indoor airflow field in the longitudinal flow, and studied the streamlined structure of the jitter plate compared to the original The flow velocity of the airflow field of the dither plate of the structure is compared and analyzed. The research shows that the streamlined arc plate type jitter plate has a prominent effect on improving the airflow velocity in the front part of the cleaning chamber.

From the perspective of clearing the indoor airflow field, the study of the formation of the cut-off flow clearing cavity is conducive to the efficiency of the removal of the airflow field. According to the research results of Chengfang and Dong Guohua, In order to complete the removal of various impurities in the grain mixture, the distribution of the airflow field on the sieve surface was studied by using the concept that the different airflow speeds of the sieve surface and the airflow velocity of the sieve surface decrease linearly with height. The test shows that the airflow sieve type The cleaning device can better remove large and small impurities, and only the air flow can not achieve the purpose of removing large impurities.

Gao Chunyan et al used CFD Fluent to carry out three-dimensional numerical simulation of centrifugal fan, wind speed and centrifugal fan inclination. According to the simulation test results, the distribution of pressure, velocity and vector in the selected airflow field was obtained. According to the experimental simulation, the strong swirling flow generated in the cleaning separation cylinder appears in the cylinder (the high pressure and high pressure region at the center, the high pressure and low velocity region near the wall), and the formation of the low pressure region and the high pressure region is mainly affected by the diameter of the suction duct. With the influence of the diameter of the grain outlet, this distribution of velocity pressure has an important influence on the impact of grain cleaning. Tang Qianwen et al.used the FLUENT software to use the RNG K-ε model to carry out a three-dimensional numerical simulation of the velocity and pressure of the gas flow field in the separation cylinder. Through a large number of experimental simulations, it was concluded that the pressure field is about axisymmetric distribution. The cylinder is divided into a central vertical DC speed and a swirling speed, and an extension line with the suction tube wall facing downward is used as its interface. The Lagrangian discrete model is used to track the trajectory of the effluent. The experiment shows that the pressure is from -900 to 600pa.

Status of research on exudate movement

The movement of the indoor exudates on the sieve surface, especially the movement of the grain, will directly affect the screening performance, reduce the cleaning loss and impurities, and it is necessary to study the movement law of the exudates.

JT Macaulay studied the effect of the movement state of the extract in the cleaning device on the effect of the cleaning test. Tbatabaifar Aet al. studied the gas flow and pressure of the blown screen and described the movement of the Introduced the screen during continuous feeding. K. Maertens et al. introduced a probability distribution function and a corresponding conservation law by establishing a global analysis model to further study the different flow patterns of different components.

Lu Lin used ADAMS simulation software to carry out virtual simulation test for the cleaning device suitable for grain production. Based on the study of various characteristics of grain extracts, the movement of the extracts under

the combined action of airflow and screen surface was Isolated reasonably.

Li Hongchang used the CFD-DEM coupling test to study the physical model of rice grain and short stalk, and adjusted the wind speed of the fan outlet to 5. 0, 7.5, 10. 0 and 12. 5 m / s Using FLUENT fluid dynamics and EDEM to simulate the coupling test, it is concluded that the vertical velocity of the short stem and the grain are affected by the wind speed. When the indoor airflow is increased, the material will fall back and the material will Be cleaned. The time has been significantly improved, and the grain cleaning rate has also increased.

Li Yaoming took the material movement law as an important factor affecting the sieving rate of the cleaning device, and used the vibration frequency as the control parameter to calculate the eigenvalue curve through the mapping method to obtain the collision motion. Process of the turbidity of the turbidity is tested to obtain the nonlinear motion law of the grain on the sieve surface. Wang Zhihua constructed a motion model of material particles on the sieve surface under the assumption of particle collision theory. The main influencing Factors affecting the movement state of rapeseed kernels were analyzed, and the motion law of the particles under different ejection strength conditions was obtained through the analysis of motion stability. It laid the foundation for the harvesting of materials and other agricultural machinery. Chen Cuiying Used ADAMS motion simulation software to study the effects of different airflow parameters on the motion law of The exudates. Four kinds of oily rapeseed extracts with four components were used to create four small balls for experimental research. It is concluded that the suspension speed of grain kernels and short stems is approximately equal. It is not enough to analyze the motion state of The rapeseed grains on the sieve surface by studying the effect of airflow. The influence of vibrating screen is also considered.

Li Ge uses the VB platform to compile material trajectory and drop position, flow velocity, direction, and material velocity. It is convenient to simulate the motion trajectory of the airflow material and optimize and adjust the cleaning according to the actual situation. The parameters of the airflow in the device. The exudate is simplified into particles and rods, or simply classified as a particle, but this simplification does not reflect the true condition of the material. Since the moisture content of different exudates is different, there will be adhesion between different components. A lot of difficulties have come. Especially for rapeseed extracts with small kernels and relatively high water content, self-care adhesions are likely to occur on short stems. Therefore, a more in-depth study of the moisture content of the exudates is needed.

Frarran, Macmillan et al. studied the movement of rice hulls under the action of vertical airflow. It is pointed out that the main factors affecting the grain cleaning effect are the air flow speed, the feeding amount and the feeding angle, etc., and the influence of the material state on the cleaning effect in the cleaning device. Jing Zhichen et al used FLUENT to construct a DPM model to simulate the movement of wheat granules, stems and hulls in the separation cylinder. Through the study of the extracts in the cleaning device, the velocity and pressure distribution of the airflow field inside the cyclone separation cylinder are basically axisymmetric and divided into inner and outer layers. Finally, the analysis results verified by the bench test are consistent with the simulation.

Through the research on the exudates at home and abroad, most of them use the discrete element method such as EDEM to establish the structure model of the exudates of grains, hulls and short stems. However, the simulated results are different from the experimental authenticity, and they are prolapsed. Between the objects, there is adhesion between the exudates due to different water content, and the EDEM discrete element software can not

be simulated. Therefore, more in-depth research and analysis of the separated extracts is needed.

Research status of centrifugal fan in cleaning device

Since the 1980s, many experts and scholars have devoted themselves to the structural improvement and experimental research of wind turbines, and have studied the performance of wind screen grain harvesters as the main content of improvement. To this end, many experts and scholars at home and abroad have conducted a large number of experimental studies to make centrifugal fans play a greater role in the operation.

At present, the main types of fans in air-screen cleaning equipment: centrifugal, axial, and cross-flow fans are generally low-pressure medium-speed fans for centrifugal fans. The principle is based on the difference in floating speed of materials in the cleaning chamber. Separate. In order to complete the cleaning and separation of indoor grain and short stalk, pod shell and miscellaneous waiting for cleaning materials. Through the centrifugal fan, the cleaning loss rate and the impurity content are in line with the national standard value. The cleaning device is an important part of the combine harvester. According to the structure, the fan and the sieve are usually divided into a fan and a cylinder screen cleaning device and a fan plus a reciprocating vibrating screen cleaning device. 1) Fan and cylinder screening cleaning devices mainly include: single air duct and double air duct fan cylinder screen cleaning device, double fan cylinder screen cleaning device. 2) The fan and vibrating screen cleaning device mainly includes: single air duct fan single layer and single air duct double layer vibrating screen cleaning device, double air duct fan double layer vibrating screen and double fan double vibrating screen cleaning device.

By changing the form of the centrifugal fan casing to meet the needs of the cleaning device: Giannattasio conducted a test on the cross-flow double outlet fan, and the research shows that when the fan is working, the cleaning center will generate eddy currents. The unique role of eddy currents can reduce noise and cleaning capabilities. Shandong Futian Heavy Industry Jiao Zhongyuan and other experimental research on the air intake of centrifugal fan, adding multiple air inlets at the front end of the centrifugal fan volute, so that the air volume and wind pressure are more evenly distributed within the fan air duct range, and can also be increased The air volume at the air inlet of the fan increases the aerodynamic performance of the centrifugal fan.

By changing the form of the centrifugal fan impeller to meet the needs of the cleaning device: Hunan University of Agriculture Tang Chuzhou and so on studied the centrifugal-axial flow fan, this centrifugal-axial flow fan can change the wind speed at the air outlet at both ends Disadvantages, its axial flow vanes are mounted at the corners of the blades at both ends of the conventional centrifugal fan, so that the centrifugal-axial flow mixing fan greatly improves the need for the cleaning device. Han Bin and so on through a test to study a roll-type centrifugal fan applied on the John Deere combine harvester. Airfoil blades developed according to the principles of fluid mechanics have the advantage of being able to draw in a large amount of airflow, which is not only large but also uniformly distributed in the cleaning chamber, so that the cleaning effect is enhanced.

Through the research on multi-duct centrifugal fan: Jin Chenglie of China Agricultural Machinery Research Institute and others conducted experimental research on the double-airway cleaning components of centrifugal fan. Studies have shown that the double air duct cleaning device has significantly improved the cleaning capacity and is of great significance for improving the feeding and cleaning ability of the grain harvester. Shen Dechao et al. studied the

double-air duct cleaning components of centrifugal fan for wheat and rice through the multi-channel clearing bench test of centrifugal fan. Both calculations and tests have shown that within the scope of the test, the minimum parameters for the loss rate of grain winnowing can be found.

Through the analysis of the numerical simulation of the internal airflow field of the centrifugal fan, Chen Xiuhuai adopts the three-dimensional numerical simulation method, namely: the numerical simulation software of the three-dimensional turbulent flow field plus the design theory of the modern wind turbine, the inlet angle of the centrifugal fan The number of blades, and the inlet/outlet width ratio of the blades are optimized. Through experiments, these optimization values have great influence on the difference between traditional empirical data and the performance of the fan. Research shows that the use of three-dimensional turbulent numerical simulation is essential for improving the aerodynamic design of centrifugal universal fans. Zhao Lifeng used CFD-FLUENT software to simulate the centrifugal fan to meet the mechanical strength with impeller radius, blade installation angle size, blade shape and size as experimental design variables, numerical simulation of three-dimensional viscous airflow field under airflow velocity . Improve the aerodynamic design of the fan, the efficiency of the fan, the total efficiency of the fluid machine and the compression ratio to achieve functional optimization.

Improved cleaning performance through the use of multiple centrifugal fans: H.A. Lee studied two centrifugal fan dual duct cleaning devices. The performance of the dual centrifugal fan is similar to that of the single fan. Through research and pointed out that the appropriate height of the upper air duct between the dither plate and the cleaning upper screen is combined with the mechanical and wind power, the grain loss rate on the upper part of the screen decreases with the increase of the material moving speed, which improves the cleaning efficiency.

Japan's Kubota full feed combine harvester provides two air deflectors at the air outlet of the centrifugal fan to provide air volume to the upper, middle and lower directions of the cleaning chamber. This method uses a three-stage centrifugal fan. The main features are that the straw and residue in the cleaning chamber can be easily discharged outside the machine and improve the cleaning performance. The Japanese Yanmar AG600 series combine harvester uses a triple fan consisting of a front fan, a main fan, and a suction fan. Compared with a single air duct, the air duct has a better cleaning ability and a higher cleaning rate than the one.

Summary of research status

The cleaning device is an important part of the whole combine harvester, and its role in the whole machine is very important. In recent years, some researches have been made on the harvester cleaning system at home and abroad. For example, most of the airflow field research The ANSYS-FLUENT CFD software was used to conduct a large number of experimental studies on the multi-air duct cleaning test bench. The reasonable distribution of the airflow field in the cleaning device has a reference significance for improving the quality and structural study of the cleaning. In addition to the structure of the cleaning device: adjusting the fan speed, the fan damper opening, the air deflector angle adjustment, the vibrating screen opening, the vibrating screen amplitude and frequency, etc., through a large number of tests using ADAMAS, CFD-DEM, etc. The coupling simulation test is carried out by the Design-Expert response surface test to optimize the parameters.

In the research and analysis of the decanted material in the cleaning chamber, the CFD-DEM coupling technique is usually used to numerically simulate the movement state of the grain on the sieve of the cleaning system.

The ADAMS motion simulation software was used to establish the motion model of the effluent, and the motion state of the effluent in the airflow was analyzed. The motion analysis in the airflow was mainly the influence of the airflow parameter change on the motion law of the effluent, which provided a reference for the selection of the airflow parameters.

Development trend outlook

1) Intelligent intelligent screening device: In order to adapt to the maturity of different crops, water content, and adhesion between seeds, a particle loss sensor is installed at the tail of the vibrating screen. When the moisture content of the material is too high, the cleaning effect will be poor, the loss rate and The impurity content is improved; in order to improve the cleaning performance, reduce the cleaning loss and impurities, the particle loss sensor can automatically adjust the fan speed, fan inlet size, vibrating screen frequency and cleaning screen inclination angle, and use smart technology to better Improve the performance of grain clearing.

2) At present, the research on cleaning equipment mostly uses FIUENT CFD-ADAMS EDEM and other finite element, kinematics simulation, discrete element and other software to carry out simulation test analysis. These test conclusions often deviate from the field test values, therefore: should be conventional The simulation test is an in-depth study of intelligent and remote terminal control. In addition, the multi-air duct cleaning device is highly efficient and intelligent: the intelligent height and the air deflector angle are automatically adjusted on the upper and lower air ducts, which has a good prospect for the research of the cleaning device.

3) In order to improve the efficiency of air-screen cleaning, we have developed an automatic detection of grain yield, humidity and residual detection sensors. This sensor can detect grain yield, grain moisture, and residual flow on-line, and display the detected results in driving. On the touch screen of the room, it provides the basis for the driving manipulator to control the quality of the harvester in real time.

4) Clearing the intelligent control system: During the operation of the harvester, through the parameters such as collecting fan speed, cleaning the screen tilt angle, crop loss rate, and the flow and distribution of the material, the real-time control of the cleaning device operation parameters is ensured to ensure the cleaning device. Has been in the best working range, reducing cleaning losses and impurities, to ensure the best work.

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