

Research and Experiment on Hot Air Cleaning Device of Combine Harvester

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Abstract: The harvest season in southern rice producing areas is often rainy and wet. The rice extruded material is squeezed and rubbed by the threshing nails so that the stem's water with higher moisture content penetrates the surface of the extruded material. During the contact process, the water film is formed, and the pressure difference inside and outside the water film forms the capillary force. Due to the influence of capillary force, the extractives easily adhere to the vibrating screen and the shaking plate, which leads to problems such as the reduction of the effective working area of the cleaning device, the blockage of the screen hole, and the obstruction of the material flow, resulting in generally high impurity and loss rate of the cleaning device. Aiming at the problem of high impurity and loss rate of wet crop cleaning, a kind of cleaning fan with variable temperature was developed, so that the cleaning device could not only adjust the air temperature of the fan in real-time, but also ensure that the wind speed of the whole cleaning device was not affected, and improve the cleaning efficiency.

Keywords: Cleaning fan, Simulation, CFD.

1. Research Status at Home and Abroad

1.1. Domestic research status

Xu Lizhang et al. [1] put forward a kind of centrifugal fan with double outlet and multiple air channels, and designed the structure of the fan. CFD simulation software numerical simulation analysis and experimental research were carried out to optimize the fan, determine the best position of the upper outlet, and get the best combination of fan speed, fish scale screening degree, and the inclination angle of the air distribution plate I and II. The optimization of cleaning loss rate and impurity rate is considered comprehensively.

Liu Shiduo et al. [2] designed a double-fan cylinder screen cleaning device. The centrifugal fan is at the front and the cross-flow fan is at the back. The direction of the wind speed and the airflow field in the cleaning room are studied. The results show that this method has an obvious effect on improving the cleaning performance.

1.2. Foreign research status

In another study, Gebrehiwot et al. [3] carried out air velocity measurements and analysis using a hot wire anemometer and found that increasing cross-flow openings across the width of the fan played a vital role in providing uniform airflow along the width of the fan outlet. Craessaerts et al. [4] showed that the cleaning section settings, like lower and upper sieve openings, had a minor effect on the MOG content in the grain bin in comparison to the fan speed and the loadings by chaff, straw, and grain on the upper sieve.

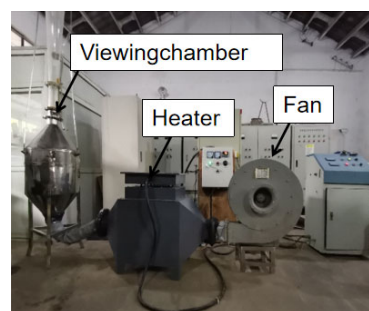
At present, most cleaning fans at home and abroad are simulated from the parameter and improved from the structure. Only the influence of wind speed and air volume on the cleaning effect was studied. During cleaning, there were still more residues on the vibrating screen and shaking plate, which caused the screen to plug. There is no further improvement of the fan, the cleaning effect is not greatly improved, and the hot air technology is also mostly used for drying wet crops, without considering the combination with

cleaning. At present, there are no products of hot air fans at home and abroad, so this topic is the first time to propose research and development of hot air fans, which can greatly improve the cleaning efficiency of fans.

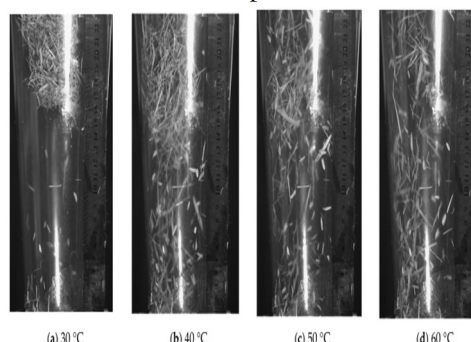
2. Research Method

2.1. Hot air suspension test

Hot gas suspension test, as shown in Figure 1. It can be concluded from the hot-air suspension test that the hot-air flow has obvious improvement and enhancement in the separation of wet rice. Under the same wind speed and air volume, the higher the temperature, the better the separation effect of wet rice.



1a. Hot air suspension device



1b. The suspended state of wet particles at different wind temperatures

1. Hot gas suspension test

According to hydrodynamics and thermodynamics, the adhesion and accumulation of wet crop in cleaning chamber and sieve surface were studied. The introduction of hot gas flow cleaning can effectively improve this situation. Simulation of hot gas flow with different parameters is carried out, and the relationship between various parameters of hot gas flow and cleaning capacity is obtained.

Airflow volume design of hot air flow:

$$V = \beta q / \rho \mu$$

Where; V is the rate of airflow volume, m^3/s ; q - is the machine feeding rate, kg/s ; ρ is the density of air $1.20kg/m^3$; μ is the mixing concentration ratio of the air stream carrying impurities, and the general value range from $0.2\sim 0.3$; β is the proportion of impurities in the cleaning materials to the machine feeding rate, and when fully fed, the value for the crop is generally taken $0.15\sim 0.2$, and $0.1\sim 0.15$ for wheat and rice respectively .

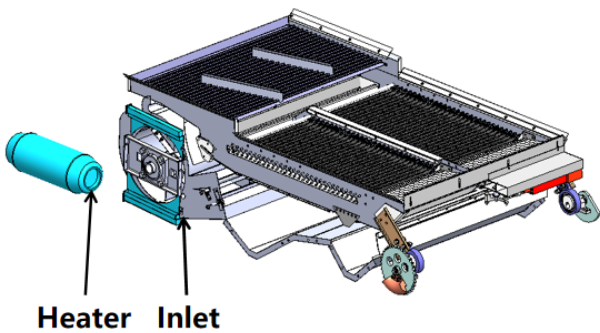
The air flow that is heated by the heater will undergo a heat exchange, enter the fan interior and take place with the volute. The heat exchange equation is as follows:

$$Q = G \times C_p \times (T_2 - T_1)$$

Where; Q is the Heat absorption by airflow, KW ; G - is the air mass flow rate, kg/s ; C_p is the Air specific heat capacity, $J/(kg \cdot ^\circ C)$; T_2 is the Heated air temperature, $^\circ C$; T_1 is the Ambient air temperature, $^\circ C$.

2.2. Hot air fan overall scheme and working principle

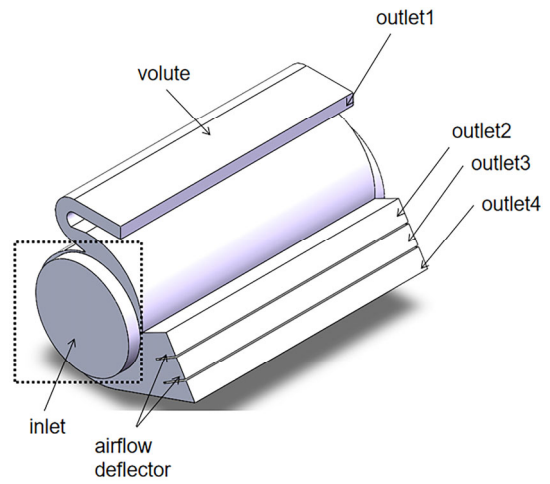
The hot-air fan device is shown in Figure 2. The left heating device is a diesel heater that inhales normal temperature air into the interior, carries out heat exchange in the interior to increase the temperature, and then flows out from the outlet of the heating device and is transported by the insulation pipe to the air intake device. The right air flows directly through the heating resistance wire into the fan.



2. hot-air fan device

3. Simulation Analysis

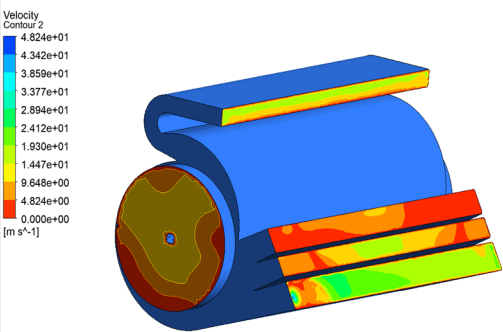
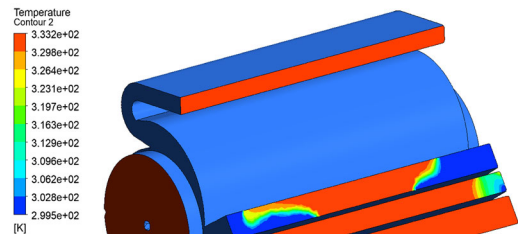
Fan flow channel model, as shown in Figure 3. Air comes in from both sides, with four outlets. The first outlet mainly cleans the front end of the screen, the second and third outlet mainly cleans the middle end of the screen, and the fourth outlet cleans the tail of the screen.



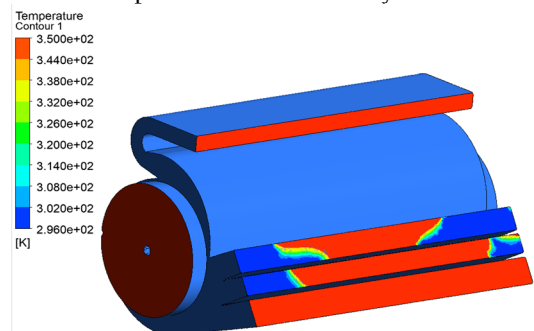
3. Fan flow channel model

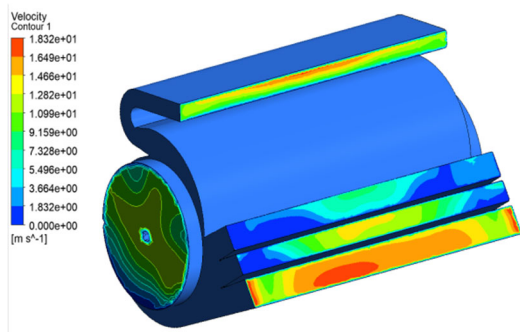
Through the previous parameter design and structural design, the FLUENT software is used to simulate it, and the changes of wind speed and wind temperature of hot gas flow under different rotational speeds are observed.

The simulation results are shown in Figure 4.



4a. Air temperature and air velocity at 1500r/min





4b. Air temperature and air velocity at 1300r/min

1. simulation test

Through two simulation tests, when the air inlet temperature is 80°C, it can be seen that with the increase of fan speed, the temperature of the outlet decreases, the air velocity increases, and the temperature of the outlet decreases greatly and the distribution is uneven. The first outlet has the most uniform distribution of air flow, and the highest air temperature and velocity. The air distribution of the second and third outlet is not uniform, and the air temperature and velocity fluctuate greatly. The fourth outlet fluctuates less than the second and third outlet.

4. Conclusion

In this paper, through the analysis of the previous domestic

and foreign fan research found that are improved from the structure. The research and design of hot air fan is proposed for the first time. Through the calculation of the hot air suspension experiment, the design and simulation analysis of the hot air fan are carried out. Through simulation analysis, it is found that when the inlet air temperature is 80°C, the air temperature and air velocity of the outlet will change with the increase of the fan speed.

References

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