

Numerical Simulation of Internal Flow Field of Centrifugal Fan for Clearing and Selecting Grain Harvester

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Abstract: Aiming at the structure of the single air duct centrifugal fan in the existing full-feed grain combine harvester air sieve cleaning device, the flow channel model of the single air outlet single air duct centrifugal fan was established, and the mesh was partitioned using the MESHING software. And using CFD (Computational Fluid Dynamics) software to carry out three-dimensional numerical simulation of the internal flow field of the single-outlet single-channel centrifugal fan to determine the structure size of the fan. The improved internal flow field simulation results of the fan show that the airflow speed at the upper air outlet and the outer edge of the impeller of the single air outlet single air channel centrifugal fan is larger, and the air velocity attenuation distance is increased, which is beneficial to the airflow covering the entire screen surface; It is basically distributed in layers, and the lateral air flow at the air outlet is symmetrically distributed on the middle high side and low side, with obvious boundary effects. The influence of the fan speed, the distribution of the fan's internal flow field, the wind speed of the air outlet, and the air volume is analyzed: the wind speed and air volume of the air outlet gradually increase with the increase of the fan speed.

1. Introduction

The cleaning device of the combine harvester is an important working part for the screening and cleaning of the material after the grain is separated by threshing. At present, the most widely used grain combine harvester is the air sieve type cleaning device, which is composed of a fan and a cleaning sieve. Among them, the performance of the fan has a significant effect on the cleaning effect. In the air sieve type cleaning device commonly used in existing grain combine harvesters, most of the fans are single-outlet single-channel centrifugal fans [1]. With the development of large-scale, high-efficiency and multi-functional combine harvester, the harvesting area increases, the degree of mechanization increases, the feed volume continues to increase and the threshing ability continues to increase, which puts forward a higher performance for the cleaning performance of the combine harvester. Claim. The fan is an important working part in the air sieve type cleaning device. It can provide wind power for the cleaning room, blow away light debris directly, and make the mixture with different floating coefficients layered on the screen surface for easy screening. Increasing the research intensity of the centrifugal fan is of great significance for improving the

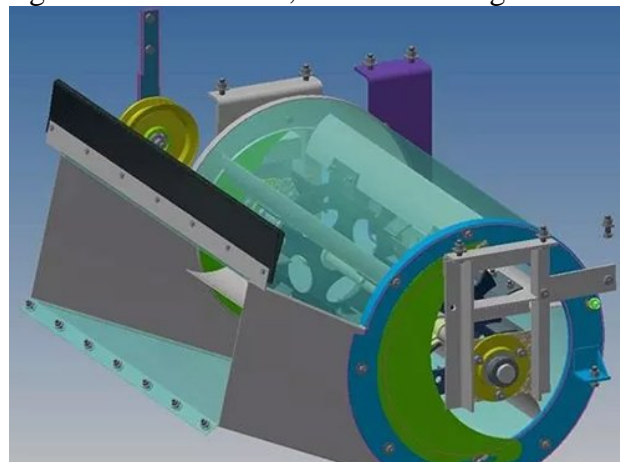
cleaning performance, reducing the impurity rate and loss rate, and improving the harvesting effect of the combine harvester [2]. In the current design method of wind turbines, the traditional experience-based structural design method cannot predict the internal flow field of the wind turbine. With the continuous development of CFD technology [3-5], calculating the flow field distribution by numerical simulation and analyzing the internal flow field of the fan is an effective means of structural design and improvement of the fan.

This paper intends to determine the structure of a single-outlet single-channel centrifugal fan, and numerically simulate its internal flow field to obtain the distribution of the fan's internal speed and pressure and other parameters, and to improve its internal flow field by changing the fan parameters [6]. Provide a basis for the design of multi-channel centrifugal fans.

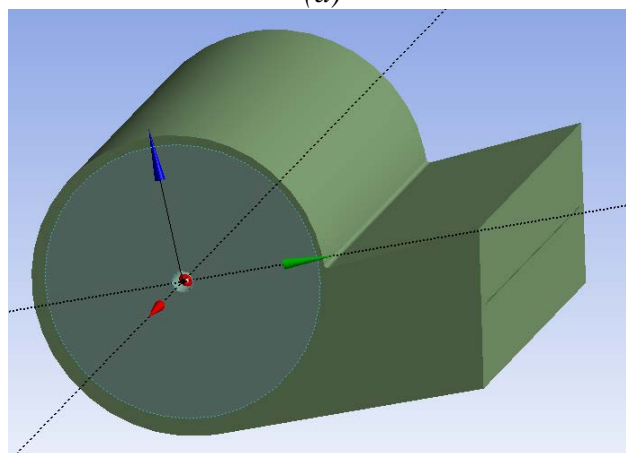
2. Numerical calculation model

2.1 Building a structural model

With reference to the structural characteristics of the single air outlet single air channel centrifugal fan, the designed single air outlet single air channel centrifugal fan is shown in Figure 1a. The centrifugal fan with a single air outlet and single air channel has a length of 770mm, an impeller diameter of 197mm, and a number of pages of 6 pieces. The full flow channel model of the fan is established with DesignModeler software, as shown in Figure 1b.



(a)



(b)

Figure. 1 Model of single outlet single-channel centrifugal fan

(a) Structural model (b) Full runner mode

2.2 Mesh

MESHING is used to divide the grid of single-outlet and single-channel centrifugal fan. Considering the complexity of its internal flow, in order to control the distortion rate of all grids below 0.1, the fan model is divided into 4 before grid division. The flow area is shown in Figure 2 (the left air inlet area has been hidden for clarity): the air inlet area (left and right), the volute area, and the impeller area. The element uses a tetrahedral unstructured grid. The contact area between the fan inlet and the impeller and the contact area between the impeller and the volute are set as interfaces respectively, and the grid at the interface is encrypted. After the division is completed, the total number of fan model grids is 6122454.

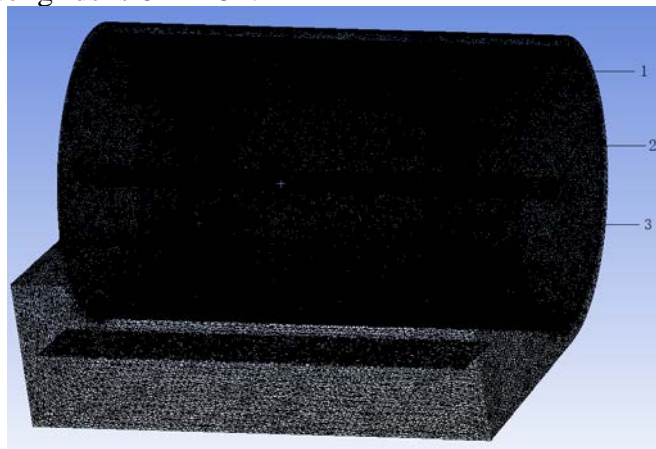


Figure. 2 Grid model of single outlet single channel centrifugal fan
1. volute area 2. air inlet area 3. impeller area

2.3 Overall structure design of the intelligent workshop product

According to the working environment of the fan, the air is assumed to be an incompressible Newtonian fluid, regardless of the changes in viscosity and temperature. The ke model is used for the turbulence model; the standard wall function and the separation implicit solver are used, and the SIMPLEC algorithm is applied to the air velocity and pressure inside the fan. Perform the coupling calculation and set the convergence residual to 0.001.

2.4 Boundary conditions

Set the volute and blade surface of the fan as a static wall surface, set the impeller area as a rotation area and give the corresponding speed (1200, 1300, 1400r/min), the inlet boundary adopts pressure inlet conditions and the given pressure 220Pa, outlet boundary Adopt pressure outlet and set pressure 0Pa. The description of the fluid flow in and around the impeller adopts a moving reference frame (MRF) model. Open the stored mesh grid file from CFX, set the inlet to 1 atm (101325Pa) through the setting of the fluid domain, the medium temperature (25 degrees Celsius) air, and the wind speed to 0m/s. In the impeller and the casing part, the exchange surface watershed is used for setting, and the other is the default wall. Set the outlet as the flow outlet, use steady state calculation, and then start the simulation. Figure 3 is the interface when the initial conditions are

set.

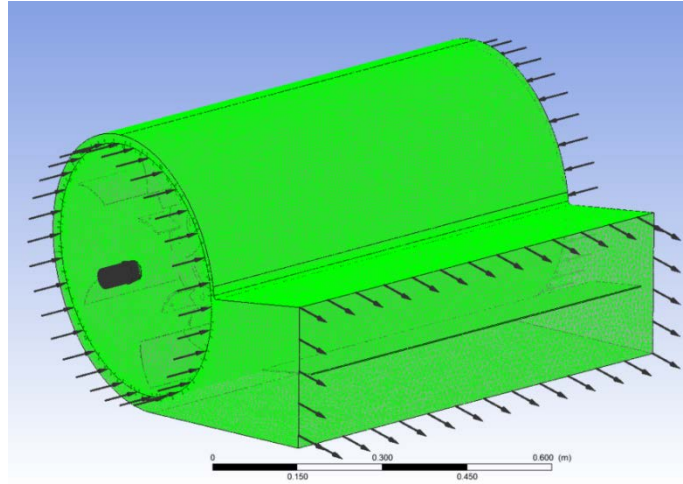


Figure. 3 Setting of boundary conditions

3. Analysis and structural improvement of internal flow field of fan

By simulating the fan, when the impeller speed is 1200r / min, the internal flow field distribution of the designed single air outlet single air channel centrifugal fan is shown in Figure 4.

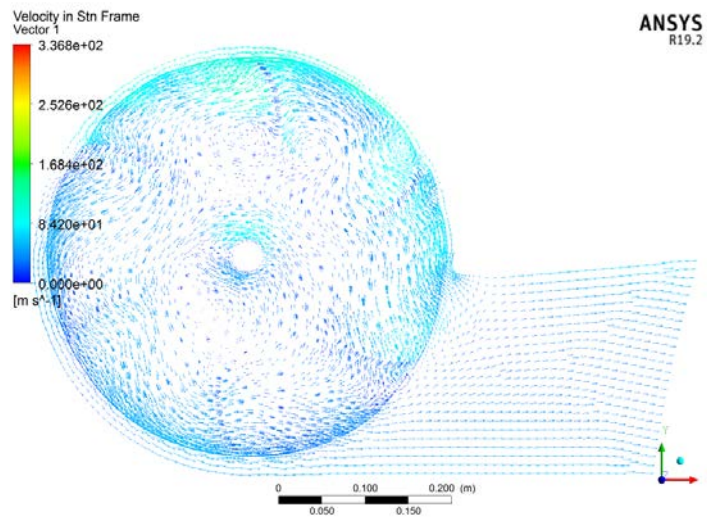


Figure. 4 Vector diagram of the velocity field inside the fan

It can be seen from Figure 4 that the airflow velocity distribution of the air outlet is relatively normal, but the airflow velocity is relatively low, the air output is only 0.2kg/s, the maximum wind speed is only 1.96m/s, and there is a secondary flow at the root of the upper fan And irregular flow phenomena such as eddies. The analysis found that the reason for this phenomenon is that the size of the upper air distribution plate of the single-outlet centrifugal fan configured on the combine harvester is longer and the installation position is unreasonable, which affects the gas flow at the outlet. With reference to the design theory of the centrifugal fan, by modifying the size and position of the upper fan plate and re-modeling, meshing and numerical simulation, a more reasonable

single-outlet single-channel centrifugal fan structure is obtained, as shown in Figure 5 As shown.

4. Simulation analysis of improved fan internal flow field

In order to improve the adaptability of the fan, the three main parameters of the centrifugal fan can usually be changed during actual harvest: adjusting the fan speed can change the airflow speed of the cleaning room; adjusting the diameter of the air inlet can change the airflow rate and pressure of the cleaning room; The angle can change the distribution of the airflow field in the cleaning room. This article refers to the adjustment factors and range of the upper fan of the 4LZ-8 combine harvester product, determines the three levels of fan speed, and analyzes the impact on the internal flow field of the single-outlet single-channel centrifugal fan. The experimental plan is shown in Table 1.

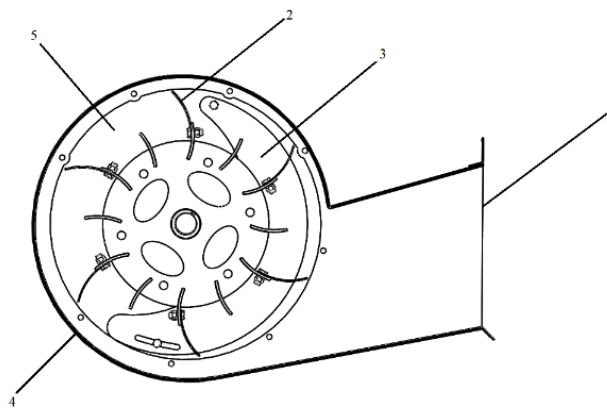


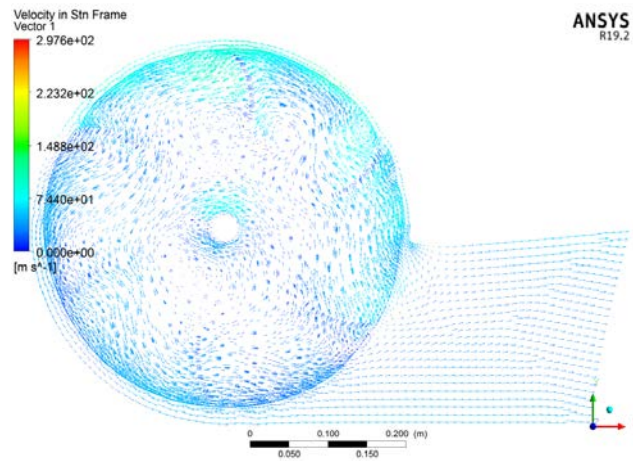
Figure. 5 System hardware platform

1. Air outlet 2. Impeller 3. Air adjusting plate 4. Volute 5. Air inlet

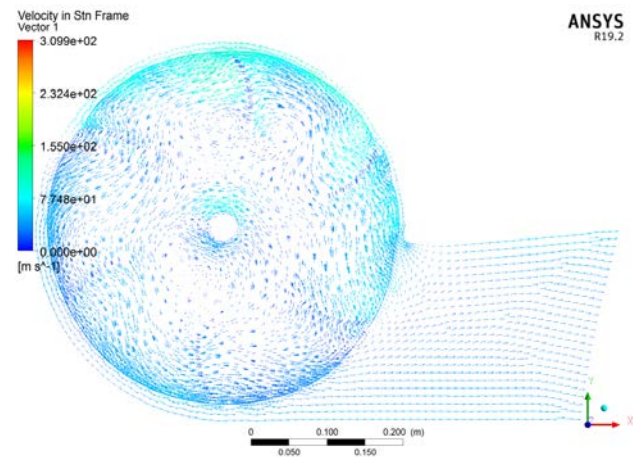
Table 1 Factors and levels

Level	Fan speed /(r/min)
1	1200
2	1300
3	1400

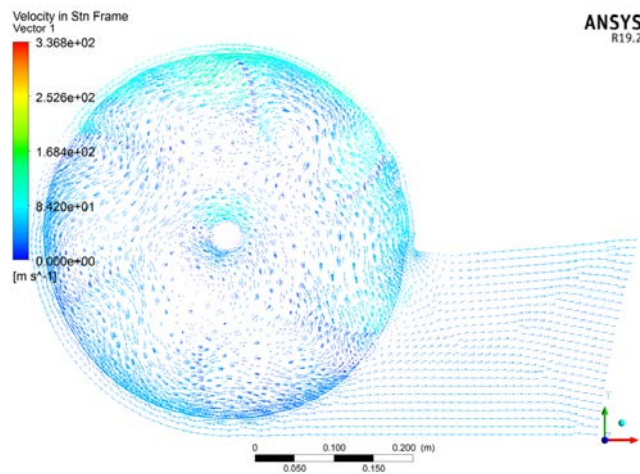
When the impeller speed is 1200, 1300, 1400r/min, the internal flow field distribution of the centrifugal fan with single air outlet and single air duct is shown in Figure 6.



(a)



(b)



(c)

Figure. 6 Vector illustration of internal speed at different speeds
 (a) 1200r/min (b) 1300r/min (c) 1400r/min

It can be obtained from Figure 6a that the air volume at the air outlet is 0.62 kg/s and the

distribution is relatively uniform; the flow velocity is between 8.20 and 22.6 m/s.

It can be obtained from Figure 6b that the air volume at the outlet is 0.62kg/s and the flow velocity is between 11.1~24.1m/s.

It can be obtained from Figure 6c that the air volume at the outlet is 0.61kg/s, the wind speed is between 9.46~19.7m/s; the flow velocity is between 12.6 26.8m/s.

At 3 rotation speeds, the distribution law of the fan's internal flow field is roughly the same: the air velocity at the air outlet and the outer edge of the impeller is larger; the air velocity at the air outlet gradually increases, and the wind speed attenuation distance increases, which is beneficial to the air flow covering the entire screen surface. The increase of the fan speed makes the wind speed of the air outlet continuously increase, and the air volume of the air outlet is relatively stable.

5. Conclusion

The distribution law of the internal flow field of the single air outlet single air channel centrifugal fan is roughly the same: the air velocity at the outer edge of the impeller is larger, the flow velocity of the impeller flow channel gradually increases in the radial direction, the air flow velocity of the air outlet gradually increases, and the wind speed attenuation distance increases. It is beneficial for the airflow to cover the entire screen surface; the lateral airflow at the upper air outlet is basically distributed in a layered manner, and the lateral airflow of the three air ducts at the lower air outlet is symmetrically distributed in the middle and low on both sides, with obvious boundary effects.

When the fan speed is increased from 1200r/min to 1400r/min, the wind speed of the air outlet continues to increase, the air volume of the air outlet is relatively stable, and the air volume of the air outlet changes from 0.62kg/s to 0.61kg/s. The flow velocity is increased from 8.20~22.6m/s to 12.6~26.8m/s.

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