Journal of Engineering Mechanics and Machinery (2021) Vol. 6: 94-97
Clausius Scientific Press, Canada
DOI: 10.23977/jemm.2021.060111
ISSN 2371-9133

Design of condenser air filter integrated device for self-cleaning agricultural air conditioning

Wei Sun, Junjie Liu, Liuyue Zhao, He Li, Baolong Liu, Yuanyue Zhang*, Xiang Han

XuZhou University of Technology, School of Mechanical & Electrical Engineering, Xuzhou, Jiangsu, 221000

*Corresponding author

Keywords: air conditioning, finite element analysis, fluid dynamics

Abstract: The goal of this project is focus on developing suitable for air cooling of farm machinery air conditioning condenser, concrete is a kind of self-cleaning air filter of air conditioner condenser of agricultural machinery integration device, can effectively solve the due to poor working conditions of agricultural machinery, air conditioning condenser vulnerable to dust, insects, weeds, such as congestion, caused by poor heat dissipation, leading to frequent failure of a series of problems[1].It is of great significance to save resources, improve economic benefits, adapt to the adjustment of agricultural structure and improve the technical level of agricultural environmental protection equipment[2].

1. Background

As people's requirements for quality of life and working environment improve day by day, many agricultural machines are equipped with air conditioning. However, due to the poor working environment of agricultural machinery, the condenser on the air conditioner is easily blocked by dust and insects, resulting in failures such as timely heat dissipation, which greatly reduces the service life of the air conditioner. Therefore, this project designs the parts and the whole assembly, analyzes and simulates the heat transfer problems between the temperature sensor, the condenser and the air, and the working conditions of the rotating impeller in the air filter to solve this problem.

2. Overall design of device

Self-cleaning air conditioner condenser air filter integrated device, including shell 1, screen 2, swirl impeller fastener 3, motor mounting support 4, motor 5, pin 6, motor shaft 7, nut 8, swirl impeller 9, isolation pipe 10, air conditioner condenser 11, temperature sensor 12 and so on.

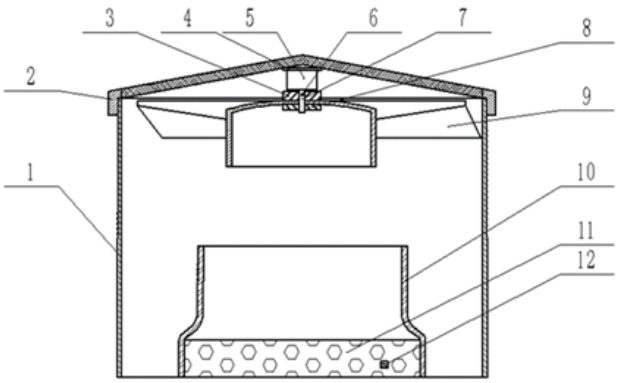


Figure 1: Condenser air filter integrated device drawing

Among them, the screen 2 is conical and assembled with the outer shell 1 by welding, the motor mounting support 4 is fixed on the screen 2 by screws, and the motor 5 is installed on the motor mounting support 4. Pin 6 passes through motor shaft 7 in a radial way, fastener 3 of swirl impeller is fixedly mounted on motor shaft 7 through pin 6, and swirl impeller 9 is fixedly mounted on motor shaft 7 through nut 8. The isolation tube 10 is installed on the air conditioner condenser 11, and the contact part of the two is well sealed.

3. Analysis of heat transfer problems

3.1 Summary of the heat transfer

The transfer of heat energy of a substance occupying a given volume from one place to another is called heat transfer. There are three causes of heat transfer: heat conduction, convective heat transfer, radiation heat transfer. Depending on the problem, Fluent solves different energy equations to take into account the user-set heat transfer model. Fluent can also predict the periodic heat transfer corresponding to the geometric structure with periodic symmetry, thus greatly reducing the amount of calculation[3].

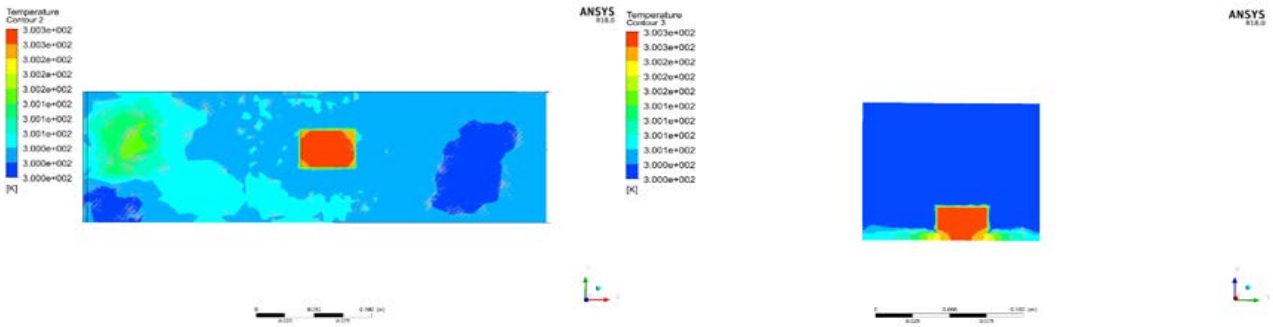
3.2 The instance simulation

The overall model is modeled in Solidworks, and the 3D model is imported into Ansys Workbench for mesh division. The first step is to rename each part of the entity as temperature sensor, condenser and air. The second step is to name the boundary, including outlet, inlet, solid wall and fluid wall, and then define the coupling boundary. The five surfaces of the sensor in contact with the air are defined as coupling with the air, and the bottom surface is defined as coupling with the condenser surface. Finally, the grid is divided, a grid control is inserted into the sensor, 12 edges of the sensor are selected, the grid type is changed to the number of copies, the number of copies is set to 8, and the Behavior option is set to Hard.

The steady-state model is selected, with gravity being 9.8m/s2, the energy equation is opened, and the turbulent laminar model is selected, with standard K-Epsion (2EQN). The default fluid material is air and the default solid material is aluminum. Calculate the area allocation, set the external air as air material, set the temperature sensor and condenser as aluminum material, and set the heat source, edit the thermal efficiency as 90000W /m3. Set the boundary conditions, the inlet condensation wind speed is 0.5m/s, the temperature is 300K, the air convection wall temperature is also set to 300K, the convective heat transfer coefficient is set to 1.5, the outlet temperature is set to 300K, and the

convective heat transfer coefficient of aluminum is set to 2, the temperature is 300K. The sensor and the air, the underside of the sensor and the surface of the condenser can be coupled.

When fluid thermal and temperature coupling occurs, select the coupling solver and leave the rest as default. The number of iterations was set to 50, and the residual iteration diagram and two temperature sensing cloud images of different cross-section angles were obtained respectively. In the following figure: (a) is the temperature sensing cloud image of XY section; (b) is the YZ cross section temperature sensor cloud picture.



(a) (b)

Figure 2: Simulation results of fluent heat transfer

4. Fluid dynamics analysis of rotating impeller in air filter

4.1 Overview of the turbulence

Turbulence is unsteady, irregular movement, transport volume fluctuates in time and space, can produce turbulent vortex, enhance the mixing effect. Flow properties and speed appears random changes, including a wide range of turbulent vortex size, the size of the large eddy simulation and rate and average flow in an order of magnitude, large eddy kinetic energy from the average flow of energy, on the contrary, the energy can also shift from large to small vortex vortex, vortex at the smallest scales, turbulent energy transfer for internal energy as the viscous dissipation.

4.2 The instance simulation

In Solidworks to complete the three-dimensional modeling of rotating impeller. Import the 3D model into Ansys Workbench for meshing. The first step is to compress the 3D model into planes, extract and generate two planes respectively, perform Boolean operation on the two planes, divide the rotating wind wheel and the inner wall into two entities, and artificially define the area as the air around the impeller and the impeller. The second step is to name each boundary, namely the wall body, inner surface and outer surface. Finally, the grid was divided into triangles for the fluid area around the rotating impeller, and the boundary conditions of the grid were set. The thickness of the first layer was set as 2mm, and a total of five boundary layers were set. Then add the external fluid region mesh method, the external region mesh is all divided into quadrilateral. In order to prevent rough mesh, the overall mesh size correlation degree was set to 100 for encryption, and the transition smoothness was set to high.

The internal medium is set as air, and the external medium is set as particles with different sizes and densities. The problem is set as an unsteady problem, and the model is set as a turbulent laminar model. The method is standard K-Epsion (2EQN). The boundary conditions are not modified. Enter the action grid setting, check Dynamic Mesh, and select Mesh smoothing and Mesh reconstruction. Mesh reconstruction is an excellent Mesh update method. No matter how big the boundary motion

amplitude is, the Mesh reconstruction method can be used to solve the Mesh update problem. The idea of mesh reconstruction is relatively simple, that is, in the process of boundary movement, the program constantly detects the mesh quality in the computational domain and marks the low-quality mesh. In the process of dynamic mesh updating, the marked mesh is redivided. The Settings we need to do here are: The spring coefficient is set to constant 0.5, and the node relaxation factor is also set to 0.5. The reconstruction method is Local Cell and Local Face, mainly to reconstruct the mesh on the deformed interface in 3D. The Skewness is set to 0.4, that is, when the skew coefficient is greater than 0.4, the mesh reconstruction starts, and all the elements are set to be used. Import a custom profile file to specify the motion of the parts. Instead of using the UDF macro method, the profile file defines the contour of the time and speed in the field. For example, when the time is 0 to 1 seconds, the rotating impeller achieves an acceleration from 0 to 4 radians. The rotating impeller is in a state of stable speed. Create a network area as the wall of an empty filter, of type rigid, with the center of gravity set at the center of the circle.

Initialization is performed using Hybrid Initialization. The rotation is set to anticlockwise (anticlockwise is positive and anticlockwise is negative). The rotation time step is 2. The global time step is set to 0.03 and the number of time steps is 50. The static pressure cloud, velocity cloud, molecular viscosity cloud and density cloud of rotating impeller under multi-component condition were obtained respectively:

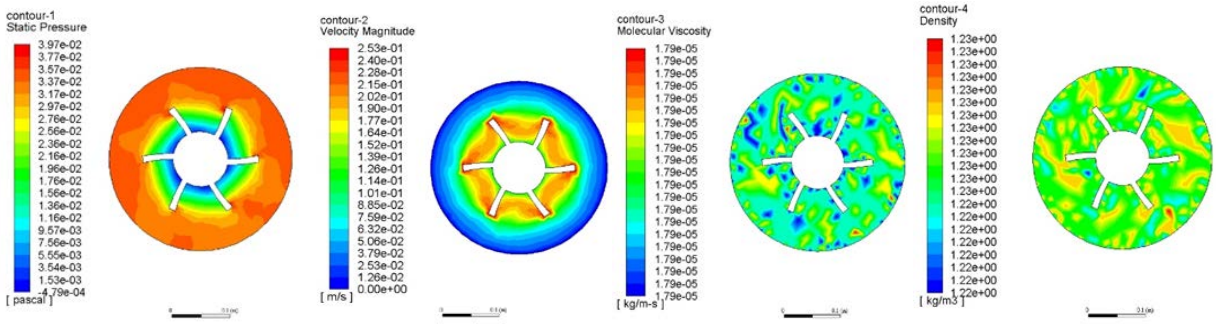


Figure 3: Simulation results of fluent turbulence

5. Conclusion

Through the above analysis and simulation verification, the device solves the problem of poor heat dissipation caused by dirt, insects, weeds and so on, and realizes the self-cleaning function under the bad working environment. The device has the advantages of simple structure, good reliability, small space occupied by agricultural machinery, and good adaptability with agricultural machinery.

References

[1] HU Qiong, Chen Jun, DENG Liwen, et al. CFD-DEM coupling Simulation and Experimental study of deep-sea mine lift Pump under extreme working conditions [J]. Chinese Journal of Nonferrous Metals: 1-16.

[2] Li Junjie. Simulation of Pneumatic Conveying of Charged Particles in Pipeline Based on CFD-DEM Method [D]. Lanzhou University, 2021.

[3] Qu Caihong, Liu Tao, Ren Yun. Mechanical Design, 2021, 38(S1): 53-55.