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The Design of The Space Engine Fan Blade Cooling System Based on Cooling Strategy

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Abstract*: The fan blades in the subsonic intake of jet aero engines have an important impact on the efficiency of the aircraft, whether the engine is working normally, and the size of the thrust. In view of the current problems in the design of jet aero engine blades, this paper carries out the design of the shape and number of engine blades. First of all, some of the current problems with heat dissipation in the engine blades are analyzed. Secondly, based on how to improve the cooling effect of the air intake fan blade of the jet aircraft engine, the design of the fan blade in the engine air intake was carried out. Finally, the 3D modeling software has been used to improve the engine air intake fan blades. The design results show that the desired effect is achieved for increasing the number of blades of the fan blade and improving its shape, and the cooling effect on the engine is improved.*

Keywords: jet engine; aircraft engine; subsonic intake; fan blade; shape design

1 Introduction

Aerospace engine is a thermodynamic machinery with strict aerodynamic loads and strong durability, it is a complex system composed of many parts and a series of accessories. At present, due to the large windward area caused by the defect of the fan blade during the flight of the space shuttle, the heat caused by the large resistance is too much, this paper mainly conducts a series of studies on the number of space engine blades [1] and the shape structure, and designs are carried out, so that the cooling effect of the blades of the space engine has been improved to a certain extent. The cooling of the air intake blades of the aerospace engine has an important role in the operating efficiency of the engine, for example, if the front temperature of the turbine is 1600K, and the withstand temperature of the turbine blade material is only 1200K, can such a material work? The answer is, it can hold it. But there must be advanced cooling technology. Taking the civil turbofan engine as an example, the difference between the front temperature of the turbine and the temperature of the blade material [2,3] has increased to more than 500K, which is the charm of cooling technology [4,5]. This makes the performance of the entire engine a great improvement.

In recent years, with the rapid development of science and technology, China's aerospace industry has also made great leaps [6-9]. Due to the demand for modern commercial aircraft to "fly higher and fly faster", there are also higher standards for engine power and efficiency. Turbofan engines [10,11] are widely used in the aerospace industry, so the engine must be moderately cooled at high temperatures to keep it working at the right temperature to meet the requirements of good working performance and durability of the engine. Engine cooling systems play a key role here. The control technology of the engine cooling system is mainly the control technology of the cooling fan. How to best complete the cooling task of the engine cooling system at the lowest cost, the lowest power consumption, the cooling fan control technology [12-14] deserves in-depth research and analysis.

At present, the most widely used cooling methods [15] are as follows: First: convection cooling. The way heat transfer by the flow of liquids or gases is called convection. According to the different cooling medium, it is divided into water cooling system and air-cooling system. This is the simplest way to cool, the coolant flows through the wall of the heated part, relying on convection heat transfer to take the heat away, such as spraying coolant on the heated wall to improve the effect of convection cooling. Convection cooling is widely used in various heated parts and components of the engine. The turbine blades of the aerospace engine are cooled by air convection, which can reduce the blade temperature by 200~250 °C. If the propellant flowing through the cooling sleeve is discharged directly from a small hole at the end of the nozzle, the discharge jet can also generate a portion of the thrust. Two: impact cooling. The cold air hits the inner wall of the blade at a very high speed through the small impact hole, and the inner wall surface is effectively cooled. Impact cooling is several times higher than the general convection cooling effect, because of its special way, mostly used to cool the most serious heating and poor cooling conditions. Three: air film cooling. Near the wall, it sprays air conditioners in a certain direction to the mainstream, which bends downstream under the pressure and friction of the mainstream. Adhere to the wall nearby, form a cold air film with a lower temperature, isolate the wall from the high temperature gas, and take away part of the radiant heat of the high temperature gas or bright flame to the wall, so as to play a good protective role on the wall, this cooling method is the air film cooling.

Various cooling methods improve the working environment of the turbine blades, but at the same time, they also make the turbine blade structure complex and the process complex. This time we mainly on a certain basis to change the number of engine fan blades and its external shape of the design, so that the blade cooling system is more perfect, specifically we have improved from three aspects, the first is to increase the number of blades of the aircraft engine air intake fan, the utilization rate of multiple blades for the wind is higher, and the cooling effect is increased, the second we are in the fan blade holes, punching holes can increase the convection of air, so that the heat dissipation effect is better, The third aspect is that we have made certain improvements to the shape of the fan blades, so that they have a certain bending angle, so that the speed of the fan in the entire engine air intake increases, while increasing the blast area, accelerating air flow, and finally achieving a better heat dissipation effect.

2 Design method of aerospace engine fan blade

The fan blade is one of the key parts of the aerospace engine, the design is very complex, through the collection of

information can understand the shape and operation of the fan blade, so it is necessary to design the approximate shape of the fan, and modify it according to the degree of cooperation with other parts. On the other hand, according to the cooling method of the fan-shaped cooling system commonly used in aerospace engines, that is, convection cooling, impact cooling, and air film cooling, the cooling characteristics of air film are studied, and then the fan is corrected.

In general, a small part solves the problem of excessive contact between the traditional air intake fan blade and the air, and proposes an improvement method for the fan blade.

The first step, since this was our first practical homework and the first time we came into contact with SolidWorks software, we didn't know much at first, so we looked at it at home through the explanation of the teacher in class and we looked at it at home Some of solidworks' instructional videos learn about the features involved in our design and how to use them.

In the second step, after learning SolidWorks software, use SolidWorks to create a part sketch, draw a moderately sized circle in the sketch, and use a convex. The table stretch function creates a column.

In the third step, create a sketch on the front view, use the tool to create a centerline and draw a flat fan blade. This is shown in Fig. 1.

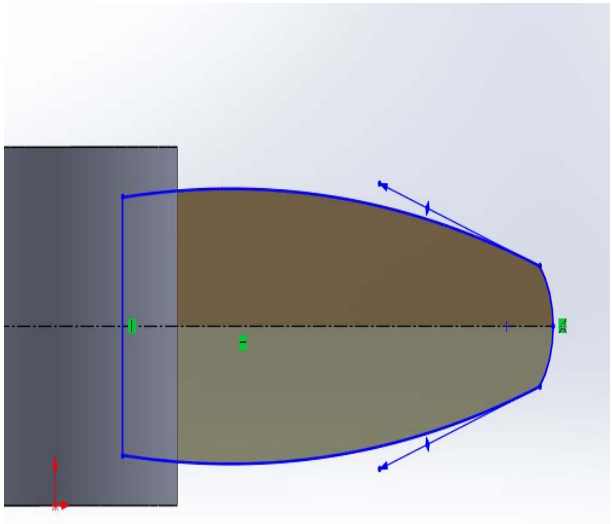

Fig. 1 A flat fan blade

In the fourth step, the fan blade model is made by using the stretching matrix function. This is shown in Fig. 2.

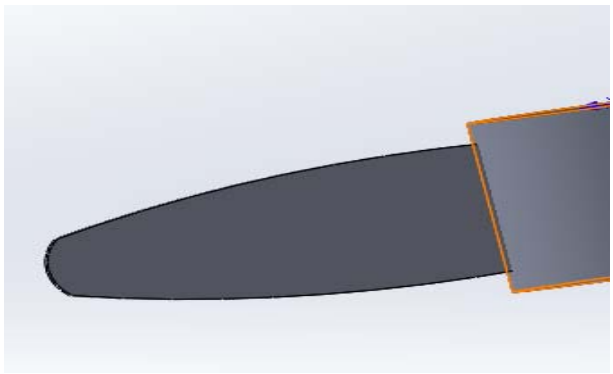

Fig. 2 Using the stretch matrix function to model the fan blades to make blades

In the fifth step, create a sketch on the leaf blade, draw a circle on the model of the created fan blade, control its size so that it is the size we want, and then use the linear array function to create a row of circles of the same size in the direction of the centerline. This is shown in Fig. 3.

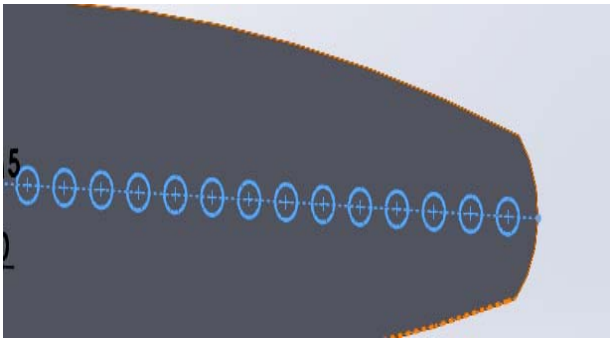

Fig. 3 Using the linear array function to create a circle

In the sixth step, on the basis of this flat fan blade, the drawn circle is set to run through using the function of stretching the base, and it is punched into a hole in the fan blade. The perforation is to increase the convection of air inside the fan blade, so that the blade has better heat dissipation. This is shown in Fig. 4.

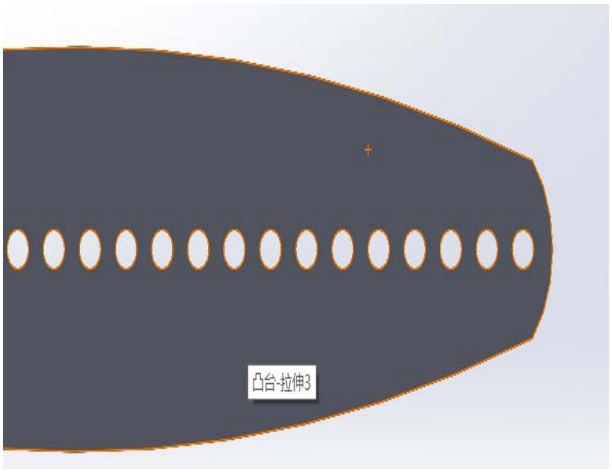

Fig. 4 Punch a hole in the fan blade

In the seventh step, the fan blade model selected by the circumferential array function is selected as a feature, and multiple fan blades are made in the direction of the cylinder face. This is shown in Fig. 5.

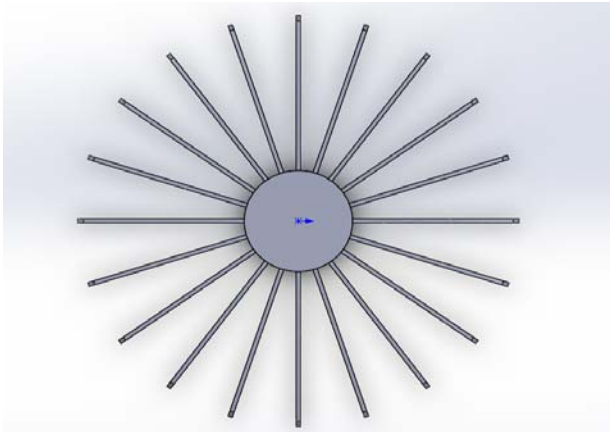

Fig. 5 Fan blade array

The eighth step is to bend on the prepared model with the bend function, and adjust the angle and direction at the bend

function interface so that it reaches the angle we want. This is shown in Fig. 6.

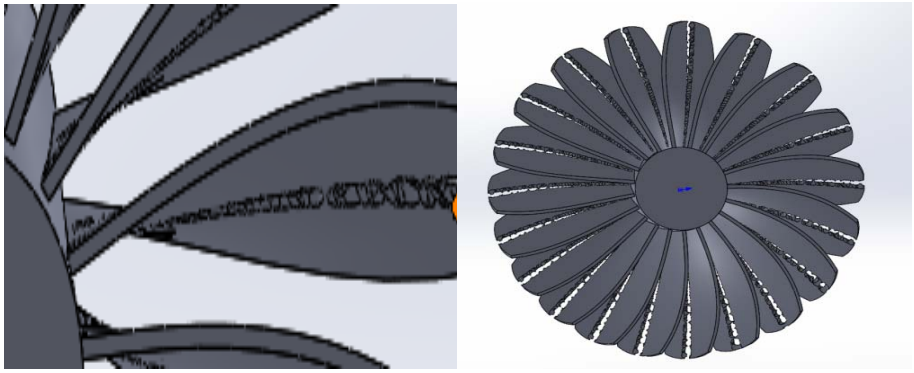

Fig. 6 Bending with the bend function

Finally, observe its overall effect and fine-tune it.

3 Design results and discussion

We successfully used SolidWorks software to design the shape of the fan blades in the air intake of this aircraft engine and the improvement of its fan blade number increase, and its final effect is exactly in line with what we envisioned, and the improved fan blade has greatly improved the cooling effect.

This time our design is very successful, the cooling effect of the fan blade is very good, for the method we use in this practice, it will be applied to other design aspects in the future, and at the same time, it will be more perfect on this basis in the future, so that some other performance will be improved.

4 Conclusion

The research of turbofan cooling technology has a history of more than 60 years of development abroad, and has also achieved remarkable results. For turbofan engines, the fan cooling system is of great significance for improving engine performance, such as increasing engine thrust, improving engine efficiency and engine thrust-to-weight ratio. The theme of our design is to improve the cooling system of the fan blade, which can effectively improve the efficiency of the engine. The blades are cooled by internal convection cooling, impact cooling and other heat exchange methods during engine operation, and a multi-layer air film cooling structure is formed based on this theory.

Based on the improved design of the air intake of the aircraft engine, we have carried out some fan blade shape structure based on the fan blade inside the air inlet

Improvement, specifically from the number of fan blades, increase it, as well as punching holes in the fan blades, but also let the fan blades have a certain bending arc, from these three aspects of the improved design, so that the overall heat dissipation effect of this aircraft engine increases.

Because most of the current aircraft can reach Mach 2 in high and low altitudes, this airflow for the air intake is very large and the pressure is also very large The high-pressure high-velocity air from the air intake here in addition to providing power to the turbine engine There is also a part used to cool the engine, but the high temperature generated by the combustion of the engine fuel is very large, it will be easy to melt the pipeline structure of the engine, which requires us to have a great requirement for the refrigeration effect, this time we have improved the fan blades inside the air inlet of the aircraft engine. So that the refrigeration effect has been greatly improved, so as to ensure that the engine of the aircraft in a long-term working state temperature can also be maintained at about 100 degrees Celsius, so that the aircraft is safer, while the design of the fan, the heat energy into mechanical work, the temperature and pressure of the air itself in the turbine outlet is greatly reduced, thereby obtaining cold air that meets the temperature and pressure requirements, and then mixed with the hot road air in a certain proportion can lead to the cabin to provide a comfortable environment and increase pressure.

Through the research on the development of turbofan blade cooling technology and related knowledge, it is believed that the new fan blade cooling effect we designed is better, which can improve the performance of turbofan engines and has a wide range of application prospects. I think that with the continuous development of the aerospace industry and the increasing demands on the engine, this new fan blade cooling system will be very popular.

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