Vibration Failure Analysis of Civil Aircraft Engine Blades Based on Virtual Reality

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Abstract. With the development of new aircraft, the flight speed of aircraft is faster and faster, and its requirements for engine performance are higher and higher. If the vibration accuracy of the blade is reduced, it will lead to its vibration failure. Therefore, this study designs a vibration failure analysis method of civil aircraft engine blades based on virtual reality. Firstly, the vibration state of single blade of civil aircraft engine is analyzed by finite element method, and then combined with the analysis results of virtual reality technology, the vibration failure analysis equation of blade is designed. The experimental results show that the analysis effect of this method is good, and can be used as a reference for subsequent aircraft engine research.

Keywords: Virtual reality · Aircraft engine · Blade vibration · Failure analysis

1 Introduction

Blade structure is widely used in various modern machinery and daily electrical appliances, such as gas turbine, steam turbine, water turbine, various booster pumps, electric fan, air conditioner, refrigerator and so on [1]. In the typical power plant, except the piston engine, most of them adopt the structural form of blade for design. Blades are one of the main components of various aviation engines, including turbojet engine, turbofan engine, turbine and turboplasma engine [2].

The research on Aeroengine Blades belongs to a multidisciplinary comprehensive field, involving vibration mechanics, fluid mechanics, material mechanics, solid mechanics, structural strength, mechanical design, manufacturing technology and so on [3]. These disciplines cooperate with each other, but restrict the research of engine blades, which makes the development of Aeroengine Blades a complex system engineering.

Since the birth and operation of turbojet engine in 1930s, blade failure has been one of the main factors hindering its development. In the late 1960s and early 1970s, turbofan engines began to develop. The turbofan engine looks similar to the double rotor turbojet engine. The main difference is that the blades of the low-pressure compressor of the turbofan engine are lengthened into a fan, and an outer culvert is added behind it [4].

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With the development of new aircraft, the requirements for engine driving force are higher and higher, the rotating speed of engine blades is faster and faster, and there are more and more compressor stages. The total boost ratio of the engine is the multiplication of boost ratios at all levels. When the boost ratio at all levels is certain, more compressor stages are required to improve the total boost ratio, and the weight of the engine is large, Therefore, only increasing the compressor stage cannot solve the problem of engine efficiency, but also improve the single-stage boost ratio [5]. The improvement of total boost ratio and average single-stage boost ratio, on the one hand, greatly improves the thrust of the engine, but on the other hand, it also brings a series of new problems, such as smaller surge margin, lower working efficiency, increased engine weight and so on. With the increase of the number of engine blades, the designed structure tends to be lighter and thinner in order to pursue high efficiency. In addition, turbine blades are often designed into complex cooling structures to meet the working needs in the environment of high temperature and high load. These factors cause a high probability of blade failure in the working process.

In fact, in order to meet the design requirements of the engine, the safety factor of blade design is close to “1” at present, and the potential of materials has been applied to the limit. In order to further develop the use value of blades, researchers put forward the method of adjusting the amount of blade cover [6]. The cover value of the blade, that is, the offset of the blade, is an important parameter to balance the aerodynamic bending stress. The blade is subjected to centrifugal force generated by rotating speed, bending moment generated by pneumatic pressure, resonance force generated by various excitation factors, etc. Under the action of aerodynamic pressure and centrifugal force, the blade root produces relatively large bending stress, which often exceeds the yield strength of the material after combined with tensile stress, which is not allowed for the design requirements of infinite life of the blade.

Based on the above analysis, this study designed a method for vibration failure analysis of civil aircraft engine blade based on virtual reality. On the basis of analyzing the vibration state of single blade of civil aircraft engine by using finite element method, this study combined virtual reality technology and finite element software to design the vibration failure analysis equation of blade, providing reference for the subsequent research of aircraft engine.

2 Method Design

2.1 Finite Element Analysis of the Vibration State of a Single Blade of a Civil Aviation Aircraft Engine

The finite element method can be understood as dividing the structure to be solved into a series of elements connected by nodes. The shape of these elements is very simple, such as triangles, rectangles, etc., so for each element, it is easy to establish equations according to the balance relationship or energy relationship, and then combine the equations of each element to obtain the total equation system of the structure [7]. The basic idea of finite element analysis of real structural systems is to simulate complex continuous real structures with a simple finite number of interacting elements.

With the rapid development of computer technology, a large number of finite element calculation software have been developed. Now the application of finite element method can not only analyze plane problems, but also spatial problems, plate and shell problems, not only static analysis, but also stability analysis and dynamic analysis.

The three basic elements of the finite element system are nodes, elements and degrees of freedom [8]. The finer the units, the more accurate the results. The basic task of element analysis is to establish the relation between element joint force and node displacement, namely the element stiffness equation, so as to determine the element stiffness matrix and transform the external load into the element equivalent node load. The rectangular element shown in Fig. 1 is taken as an example to establish the finite element equilibrium equation.

For the blade, which is similar to a rectangular thin plate, it can be easily discretized by rectangular elements. If the four corners of the rectangle are taken as nodes, a simple rectangular plate element is obtained, and its structure is shown in Fig. 1.

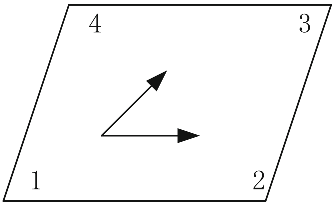

Fig. 1. Schematic diagram of finite element element

It can be seen from Fig. 1 that when the plate is bent, there is moment transmission between the elements, and the nodes are rigidly connected. A point on the element surface actually represents a normal line segment with the length of the plate thickness. According to the hypothesis, the length of the normal line segment is constant, and the points on the midplane of the thin plate do not produce displacements in the x and y directions. Therefore, the possible displacements of the thin plate nodes are only the deflection in the z direction and the rotation angle of the normal around the x and y axes. Taking the vector marked according to the right-hand spiral rule to be positive along the positive direction of the coordinate axis, the two corners θ_x, θ_y at this time are as follows:

$$\theta_x = \frac{\partial w}{\partial y} \tag{1}$$

$$\theta_y = \frac{\partial w}{\partial x} \tag{2}$$

In formulas (1) and (2), w represents deflection, and the element displacement vector at this time is as follows:

$$\{\theta_x, \theta_y\} \tag{3}$$

Substituting the nodal displacement component and nodal coordinates into the above formula, the expression of the undetermined coefficient can be obtained as follows:

$$g = Na \tag{4}$$

In formula (4), N represents the shape function, and a represents the displacement component. In the finite element analysis of the plate, since the deflection and rotation angle have been used as nodal parameters, the known deflection and rotation angle on the boundary can be used as mandatory boundary conditions. Considering the equivalent load caused by the surface force, assuming that there is a lateral distributed load q acting on the surface of the thin plate, the virtual work of the external force generated in the case of the lateral shear force V and the upper bending moment M is as follows:

$$V = \int g \frac{N}{VM} \tag{5}$$

Set the element balance equations according to degrees of freedom to obtain the overall balance equation of blade finite element analysis as follows:

$$Ka = P \tag{6}$$

In formula (6), K is the overall stiffness matrix of the structure according to the node group, a is the overall node displacement of the structure, and P is the overall node load of the structure.

Any deformed body has natural frequency and vibration mode. When there is external excitation, it will produce a series of responses. In addition to structural static analysis, structural vibration analysis is also an important aspect of structural evaluation, which is of great significance to the working state and functional control of the structure [9]. The structure in the vibration problem is also a deformed body, which also needs three kinds of mechanical variables to describe. The time-dependent inertial force and damping force can be considered in a static way by using the darumbel principle.

In the solution domain Q, if the field function u is an exact solution, then any point in the domain Q satisfies the control differential equation, and at the same time any point on the boundary I satisfies the boundary conditions, then the equivalent integral form must be strictly satisfied. But for complex practical problems, such exact solutions are often difficult to find, so people need to try to find approximate solutions with a certain degree of accuracy.

Assuming that in an engineering problem, the general forms of the governing equations and boundary conditions of the system are shown in Eqs. (7) and (8) respectively:

$$A(u) - f = 0 \tag{7}$$

$$B(u) - g = 0 \tag{8}$$

In the formula, u represents the function to be solved, A and B represent the differential operator of the boundary, and g represents the known function. By selecting the parameters to be determined, the approximate residual value is considered to be zero. The system of equations obtained in this way can be solved to obtain the undetermined parameters, and then the approximate solution of the problem can be obtained by solving. Properly choose the trial function w so that it satisfies all the conditions on the boundary, so that the boundary residual value R is zero, and the approximate solution has a high precision. The more approximate functions should be selected, as the number tends to At infinity, the approximate solution is infinitely close to the exact solution.

The method of using the weighted integral of the residual value to zero to obtain the approximate solution of the differential equation is called the weighted residual value method, which was first proposed by Crandall. Weighted residual method is an effective method to find approximate solutions of differential equations. Obviously, any independent complete function set can be used as a weight function [10].

The residual equation is orthogonal to each basis function of the trial function, which ensures the convergence of Galerkin method. In many cases, the coefficient matrix obtained by Galerkin method is symmetrical. Therefore, Galerkin finite element method is used almost without exception when using weighted residual method to establish finite element scheme. At the same time, it should be pointed out that Galerkin method and variational method are often equivalent when there are corresponding functionals for differential equations and their boundary conditions.

2.2 Design Failure Analysis Equation Based on Virtual Reality

Based on the above finite element analysis of the vibration state of a single blade of a civil aircraft engine, this study then combined virtual reality technology and finite element software to design a blade vibration failure analysis equation.

In theory, virtual reality technology is a computer simulation system that can create and experience the virtual world. It uses the computer to generate a simulation environment and immerse users in the environment. Virtual reality technology is to use the data in real life and the electronic signals generated by computer technology to combine them with various output devices to transform them into phenomena that people can feel. These phenomena can be real objects in reality or substances that can not be seen by our naked eyes, which are expressed through three-dimensional models [11]. Because these phenomena are not what we can see directly, but the real world simulated by computer technology, they are called virtual reality. Therefore, we can use virtual reality technology combined with finite element software to design vibration failure analysis equations.

ANSYS software is a large-scale general-purpose finite element analysis software that integrates structural mechanics, fluid mechanics, electromagnetics, acoustics, and thermodynamics. ANSYS provides a complete modeling and analysis module, capable of pre- and post-processing. The analysis that ANSYS can carry out includes: structural linear static analysis, structural dynamic analysis, structural nonlinear analysis, fatigue and fracture analysis, and structural optimization design. ANSYS itself contains modeling functions, which can build structural solid models. There are mainly top-down and bottom-up modeling schemes. The former is to directly build the structure of the body, and then operate on the body through Boolean operations to obtain the structure. The model is suitable for simple and regular structures; the latter is a solid model for building structures in the order of points, lines, areas, and bodies, and is suitable for building more complex structures [12]. You can also build a model in a specialized modeling software, and then import it into ANSYS. ANSYS has powerful meshing functions, including free meshing and mapped meshing. The quality of the grid determines the accuracy of the finite element calculation results. Calculation and analysis ability is the most powerful function of ANSYS. For each analysis type, ANSYS provides a variety of solution methods, which can be selected for different structures. The general post-processing program and the event-history post-processing program can separately view the results of structural analysis such as deformation displacement, stress, and time-varying curve.

The plate member in the structure has a remarkable geometric feature, that is, the size in one direction is much smaller than that in the other two directions [13]. Flat plates are usually divided into thin plates and medium plates. Quantitatively speaking, when the thickness is less than one fifteenth of the minimum size in the other two directions, it can be called thin plate. The bending deformation of thin plate is very small compared with its thickness. According to the particularity of thin plate, there are some reasonable thin plate theoretical assumptions. First, the extrusion deformation in the thickness direction of thin plate can be ignored. Transverse fibers similar to beams are assumed to have no extrusion. Second, in the plate bending deformation, the normal of the middle plane remains a straight line and still the normal of the elastic surface, which is the famous Kirchhoff straight normal hypothesis, which is similar to the plane section hypothesis in the beam bending theory. At this time, the vibration failure analysis equation of the aircraft engine blade is designed as follows:

$$G = \{M\}\{\delta\} \tag{9}$$

$$D = [C]\{\delta\} + [K]\{\delta\} \tag{10}$$

In the formula, $\{M\}$ represents the matrix at this time, $\{\delta\}$ represents the nodal matrix, $[C]$ represents the vibration set, $[K]$ represents the blade stiffness, and $\{p\}$ represents the engine load.

2.3 Achieve Vibration Failure Analysis of Aircraft Engine Blades

Rotating stall is another aerodynamic excitation source that produces high frequency response. Stall is caused by the limited ability of the boundary layer to bear the inverse pressure gradient. Experiments have confirmed that there are two types of stall in the compressor. One is simple blade stall, that is, the boundary layer separation on the blade surface; The other is rotating stall, which is a unique phenomenon in compressor. If all blades in the blade row are identical and feel the same stall inlet angle at the same time, the blades in the whole annular channel shall stall at the same time, that is, simple blade stall, such as local separation of blade surface of compressor under normal working condition. When some blades reach the stall condition before other blades in the blade row, a stall mass is formed. The stall mass rotates at a speed less than the rotor speed. When the blade rotates, it will alternately pass through the stall area and non stall area and be periodically excited, which is called rotating stall.

When a cascade works in its critical stall state and the air flow attack angle at the blade increases due to some local disturbance, resulting in air flow separation. Due to the blocking effect of stall on the cascade channel, the inlet air deflects to the channels on both sides of the blade, reducing the inlet attack angle of the front blade and the rear blade (in the opposite direction of rotor rotation) the inlet attack angle of the blade increases, so the air flow also separates and becomes the next stall blade. In the case of blade air flow separation, as above, the air flow flows to the front blade at a smaller attack angle, so that the separation phenomenon of blade air flow disappears and exits the stall state. Such a continuous reaction forms a stall mass continuously moving towards the blade back, i.e. It is transmitted in the direction opposite to the rotor rotation, but because its transmission speed is less than the rotor rotation speed, it is observed in the absolute coordinate system that the stall mass still moves along the rotor rotation direction, but the speed is much lower [14].

The characteristic parameters that usually represent the rotating stall phenomenon include the rotation speed of the stall group, the number of the stall group, the width of the stall group, the strength of the stall group, and the type of the rotating stall. Most of the content about the rotating stall comes from the axial compressor test; the stall group observed in the experiment generally has a changing geometric shape and is rarely stable, but it is generally considered that the fully developed rotating stall group is stable and no longer changes with time; The rotation speed of the stall group is generally 10%–70% of the rotor speed; the number can be as high as 9 or as low as 1; the width can only occupy part of the blade height, or occupy the entire blade height, all of which are progressive stalls with the rotating stall type, it's still related to the sudden stall.

The type of rotating stall is divided into progressive stall and sudden stall according to the characteristics of the characteristic line change after the compressor enters the stall state: For progressive stall, the pressure ratio characteristic of the compressor is gradually reduced during the change from the stable working state to the rotating stall state; and the pressure ratio of an abrupt stall has obvious discontinuity or a sudden decrease. In the results presented in the experiment, progressive stalls generally have multiple stall clusters, and abrupt stalls seem to always produce only a single rotating stall cluster; full-leaf high-rotating stalls are usually abrupt stalls, but in some cases it can also be a gradual stall.

The magnitude and direction of the load exerted on the blade surface by rotating stall are affected by time and space changes, so it is difficult to obtain an accurate load model. In order to simplify the model, this paper only considers the sudden rotating stall with single stall group of whole blade height, and sets up a simplified load calculation model to simulate the load applied to the blade surface during the rotating stall. The dynamic pressure of rotating stall with or without distortion was measured by placing a dynamic pressure measuring sensor on the pneumatic interface near the compressor inlet.

Compressor inlet distortion is an important factor for stall boundary degradation and steady-state characteristic attenuation of aviation fan/compressor. Geometric asymmetry of inlet, gust, strong crosswind, change of yaw angle and pitch angle caused by high angle of attack flight, change of inlet flow field during hovering take-off and landing, airborne weapon Factors such as transient flow field changes during launch (such as missiles) will lead to uneven compressor inlet velocity field, temperature field and pressure field, resulting in degradation of aircraft stall boundary and reduction of stability margin, which is usually called compressor inlet distortion.

The influence of inlet distortion on the engine includes aerodynamic response and mechanical response. It not only affects the performance and stability of the engine and causes the compressor to surge, but also the non-uniform inlet conditions will produce exciting force on the rotating blade, produce a variety of complex harmonic exciting components, and increase the vibration level of the blade (for example, in most compressor blades, high-intensity and small angle inlet distortion can produce high-intensity high-order modal response), cause blade flutter, forced vibration and resonance, and may lead to blade vibration fatigue failure.

There are many examples of blade vibration fatigue and fracture damage caused by distortion and therefore modifying the design of relevant parts. Serious blade vibration occurred during the modification of a jet engine. According to the analysis, it is known that the blade resonance is caused by the flow field distortion caused by the inlet support plate. The failure of the first stage compressor blade of a certain engine is also due to the flow field mismatch between the inlet and the engine It is caused by serious inlet distortion.

No matter how complex the aerodynamic pressure and excitation factors borne by the compressor blades are, these different excitation factors form excitation force through one channel and act on the rotor blades. Therefore, the above aerodynamic excitation factors will also affect each other. There is interaction between wake, distortion and rotating stall.

Wake and intake distortion have an impact on the stall. Under certain circumstances, the interaction between the upstream stator wake and the unsteady flow inside the rotor channel may improve the aerodynamic performance near the stall point, thereby increasing the stable operating range of the rotor; but At the current row of blades where the downstream wake is generated, if the wake area is sharply expanded to cause severe separation, it will cause a rotating stall. Therefore, the change of wake can be used as a way to predict rotating stall. Intake distortion will reduce the duration of the stall prelude wave and induce the generation of rotating stall, which will lead to the reduction of compressor stall margin, and the influence of circumferential inlet distortion on the decline of stall margin is stronger than radial distortion. When the total intake pressure is distorted, after the system enters the rotating stall state, its flow value is less than the flow when the intake is uniform. However, intake distortion does not affect the propagation frequency of the rotating stall.

Intake distortion will change the original design flow conditions of the compressor, make the intake angle of attack of the compressor cascade deviate from the design value, increase the intensity of vortex disturbance, flow loss and the separation of the rotor blade exhaust flow, thereby affecting the blade wake speed and direction Influence. Rotating stall will result in increased turbulence in the wake area. And when it is close to rotating stall, it will cause a significant change in the wake waveform behind the rotor.

The rotor structure includes not only the rotor blades and the disc, but also the blades and disc connections such as tenons and collars, as well as the connections between the disc and disc, such as connecting rods and radial pins. Due to the influence of stiffness, the analysis model of the rotor is not just a simple solid model of the rotor and blisk, but a three-dimensional coupled model including connecting rods, radial pins, tenons and collars. Since the focus of this article is the study of the dynamic response of the blade under aerodynamic loading, if the rotor structure is accurately modeled and the friction of the connected parts is considered, the mathematical solution will be extremely complicated and the solution time will be increased. Therefore, this article grasps the main contradiction and simplifies the rotor model.

When modeling, only the first-level roulette is considered, and the connection between the roulette and the roulette is ignored, and the axial and radial displacements of the roulette are constrained to simulate the constraints between the roulettes. There are fixed parts such as tenon and clamp ring between the blade and the wheel. The model does not consider its function, but uses the bonding of the blade and the wheel to simulate. Ignore some rounded corners and bosses on the roulette. Because if there are rounded corners and bosses in the solid model, it will make the meshing complicated, reduce the speed of simulation, and make it difficult for the accuracy of the analysis to reach the expected results.

Since the rotor is a rotationally symmetric structure, the ANSYS rotationally symmetrical entity modeling function is used when modeling, and the rotor disc is regarded as a rotationally symmetric entity for analysis, which reduces the amount of calculation for analysis. ANSYS program provides two solid modeling methods: top-down and bottom-up. When performing solid modeling from top to bottom, first define the most advanced volume primitives of the model. The program will automatically define the relevant surfaces, lines and key points, and use these advanced primitives to directly construct the geometric model. Bottom-up is to construct the model from the lowest-level primitives upwards, first define key points, and then use these key points to define high-level primitives, namely line, area, and volume primitives, until the entire model.

In order to facilitate structural improvement, this paper adopts a bottom-up solid modeling method, using the coordinate data of 70 points of the axial section of the rotor blade parallel to the y-axis as the key points, and inputting it into the ANSYS preprocessor to establish More advanced primitive lines, due to the complex characteristics of the leaf shape, especially the large curvature of the leaf shape at the leading and trailing edges of the leaf, the polyline fitted by cubic spline fitting is used to fit the leaf shape, and then pass through the boundary The line generates a leaf-shaped section, and then stretches in the y direction to form a solid model of the leaf.

Twenty-node hexahedral element SOLID95 is used to mesh the blade, because this is a high-precision element with intermediate nodes, and to adapt to boundary conditions, it can be degenerated into a pentahedral or tetrahedral element. However, there are many problems in the actual division, and there are many failure units, and even the mesh cannot be divided. After many times of analysis, it is believed that because the thickness of the rotor blade is thin and the edge angle is too small, the lines and surfaces generated by the hexahedral element cannot be recognized in ANSYS. Therefore, SOLID95's degenerate element-ten-node tetrahedral element SOLID92 was used for meshing in the later stage, and denser meshes were used for parts with large data gradients, such as the leading edge and trailing edge of rotor blades., And in the parts where the data change gradient is small, such as the wheel and the middle of the blade, in order to reduce the scale of the model, a relatively sparse grid is divided, and finally the finite element grid of the model is free of failure elements.

3 Experiment and Analysis

In order to test the analysis effect of the engine blade vibration failure analysis method designed in this paper, it is compared with the traditional blade vibration analysis method, and the following experiments are carried out.

3.1 Experiment Preparation

The data source used in this paper is that the front stator of the compressor rotor in the experiment has 30 blades. Although the change of the pressure in the front half of the suction with time is chaotic, which shows that there are multiple oscillations in one wake cycle, the pressure pulsation at the rear of the whole pressure surface and the suction surface shows good periodicity, which can be approximated as a high-frequency large amplitude sine wave whose mean value is not at zero, Moreover, the mean pressure on the pressure surface and suction surface first decreases and then increases along the leading edge and rear edge of the blade, while the amplitude of sinusoidal pulsation gradually decreases. The standard table of pulsation values at this time is shown in Table 1.

Table 1. Standard table of pulsation value

Measuring point	Standard value/Pa
1	712.55
2	590.54
3	585.16
4	535.16
5	370.46

It can be seen from Table 1 that the blade pulsation value at this time is the standard blade vibration pulsation. Based on this value, the subsequent vibration failure analysis can be carried out.

3.2 Experimental Results and Discussion

The engine blade vibration failure analysis method designed in this paper and the traditional blade vibration failure analysis method were used to analyze the blade pulsation value, and compared with the standard value in Table 1. The comparison results are shown in Table 2.

It can be seen from Table 2 that the numerical value of the engine blade vibration failure analysis method designed in this paper is the closest to the standard value, which proves that its analysis effect is good and has certain application value. The reason for this result is that the vibration state of a single blade of a civil aircraft engine is analyzed by the method in the finite element environment. Based on this, in the virtual reality environment, the engine blade is meshed by SOLID92, which is the degradation unit

Table 2. Experimental results

Measuring point	The analysis value of the vibration analysis method designed in this paper/Pa	The traditional vibration analysis method analyzes the value/Pa
1	712.54	711.54
2	590.44	589.24
3	585.26	584.46
4	535.18	536.49
5	370.49	371.46

of SOLID95, so that it can better adapt to the gradient of data change and obtain more accurate analysis effect.

In order to further verify the effectiveness of the proposed method, the accuracy of the analysis results is taken as an indicator to validate the application performance of the proposed method and the traditional method. The results are shown in Table 3.

Table 3. Comparison of accuracy of analysis results

Test times	The vibration analysis method is designed in this paper	Traditional vibration analysis method
10	95.2%	88.1%
20	92.6%	86.9%
30	97.7%	83.5%
40	93.8%	84.4%
50	94.7%	85.0%

As can be seen from Table 3, in many experiments, the accuracy of analysis results of the vibration analysis method designed in this paper has always been above 90%, while the accuracy of analysis results of the traditional vibration analysis method is between 80% and 90%. By contrast, the method presented in this paper can more accurately analyze the vibration failure state of civil aircraft engine blades.

4 Conclusion

With people's attention and investment in aviation technology, various high and new technologies have been applied to the development of aero-engine blades. At present, engine blade research has become a multidisciplinary technical field, involving theoretical mechanics, vibration mechanics, material mechanics, thermodynamics, casting technology, coating technology, finite element analysis theory and so on. On the one hand, these disciplines promote each other and make the engine blade technology more and more perfect, on the other hand, they restrict each other, and the optimal scheme of each discipline cannot be realized on the blade at the same time. After decades of development, engine blade research is not only to meet the performance requirements of the engine, but also to the comprehensive pursuit of reliability, usability, durability and maintainability.

Engine failure caused by engine blade fracture has always been one of the main causes of aero-engine failure, and blade surge and flutter are the main factors of blade crack and even fracture. Research on blade vibration has a very important role in preventing blade flutter and other phenomena. Therefore, in this study, the vibration failure analysis method of civil aircraft engine blade was designed, and the vibration failure analysis equation of blade was designed after the vibration state of a single blade of civil aircraft engine was analyzed by making full use of the advantages of virtual reality, so as to provide reference for subsequent aircraft engine research.

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