Analysis of Oversize of Engine Compressor Disk

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Abstract. In order to solve the problem of the extreme axial position of the engine compressor during the process of machining, three kinds of calculation States were selected according to the extreme difference, and the influence of the excess on the stress and deformation of the compressor was determined.

1. Introduction
Modern aero engine compressor discs typically use a welded disc drum hybrid rotor. The drums of different grades are connected by drums, which reduces the number of parts of the joint structure, and improves the structural safety and reduces the weight. However, for the sake of weight reduction, the drum is usually designed to be thinner. Deformation is easy to occur during processing, welding, and post-weld heat treatment, causing the axial position of the disk core of the compressor to deviate from the design position.

For different oversize cases, the strength of the design state and different oversize states were calculated, and the influence of oversize on the strength of the compressor disk was analyzed.

2. Calculation method and software
This calculation uses the internationally accepted finite element analysis software ANSYS, and uses the two-dimensional axisymmetric algorithm to calculate according to the structural characteristics and calculation purposes of the compressor disk.

3. Raw data

3.1. Material data
The material data of the engine compressor disc is shown in Table 1.

Table 1. Material Data Sheet

| Density (kg/m³) | Modulus of elasticity (Gpa) | Poisson's ratio | Yield strength (Mpa) | Tensile strength (Mpa) |
|----------------|-----------------------------|-----------------|----------------------|------------------------|
| 8240           | 204                         | 0.3             | 1030                 | 1280                   |
3.2. Load data
Speed \( n = 14675 \text{r/min} \). The centrifugal force of the blade is equivalent to the radial force \( F = 942679 \text{N} \) at the bottom of the wheel groove.

4. Calculation status
According to the condition of the parts and the document, the following three calculation states are selected for comparison calculation:
- State 1: Design Status;
- State 2: the axial position of the hub is 0.4 mm ahead, that is, the tolerance is 0.4 mm;
- State 3: The axial position of the hub is 0.8 mm ahead, that is, the deviation is 0.8 mm.

5. Calculation model and boundary conditions
The respective finite element models are established for different computing states. The two-dimensional axisymmetric unit (PLANE182) is used to mesh the compressor disk model. Apply axial restraint at the compressor plate attachment bolts, as shown in Figure 1.

![Figure 1. Finite element model of compressor disk](image)

6. Analysis of calculation results
See Table 2 and Figure 2 for comparison of static calculation results for each calculated state. It can be seen from the calculation results that the circumferential stress in the compressive stress of the compressor disk is the largest. And as the amount of oversize increases, the circumferential stress tends to increase. As the amount of oversize increases, the radial and axial stresses of the compressor disk increase. Among them, the radial stress increases linearly, and the axial stress decreases in deceleration, but the stress level is not high.

| Calculation status   | Design status | Oversize 0.4mm | Oversize 0.8mm |
|----------------------|---------------|----------------|----------------|
|                      |               | Stress | Increment | Stress | Increment |
| Circumferential stress | 774           | 784    | 10        | 812    | 38        |
| Radial stress         | 532           | 555    | 23        | 579    | 47        |
| Axial stress          | 186           | 222    | 36        | 232    | 46        |
See Table 3 for a comparison of axial displacement values of the hub. The calculation results show that under the action of centrifugal force, the axial displacement of the disk core of the design state is 0.27 mm forward. As the amount of oversize increases, the axial displacement value of the hub gradually decreases. When the amount of oversize is 0.8 mm, the axial displacement of the hub has changed to the opposite direction (-0.186 mm).

### Table 3. Table of axial displacement values of different calculation states (mm)

| Calculation status | Design status | Oversize 0.4mm | Oversize 0.8mm |
|--------------------|---------------|----------------|----------------|
| Axial displacement of the hub | 0.27 | -0.045 | -0.186 |

The stress and displacement clouds for different calculation states are shown in Figure 3-6. It can be seen from the figure that the circumferential stress level of the compressor disk is greatly affected by the circumferential position error of the disk core. And the core is a large stress zone. The axial displacement distribution is greatly affected by the tolerance. When the deviation is large (>0.8mm), the axial displacement direction of the core of the engine is opposite to the direction of the overrun, and there is partial compensation.

![Figure 3. Cloud stress distribution of each calculated state](image)

![Figure 4. Radial stress distribution cloud map of each calculation state](image)
7. Conclusion
1. As the axial position of the disk core of the compressor is out of tolerance, the circumferential stress tends to increase.
2. The axial displacement distribution is greatly affected by the tolerance. When the deviation is large (>0.8mm), the axial displacement direction of the core of the engine is opposite to the direction of the overshoot, and there is partial compensation.

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