Fault diagnosis and analysis of compressor fracture problem

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Abstract. Fault diagnosis of fracture problems has always been a difficult point in fatigue analysis, and there is no good solution at present. Aiming at the nonlinear problem of fracture problems, this paper studies the pre-critical technology. According to the compressor cover local cracking problem, respectively by finite element analysis software MSC. Patran and Nastran to cover components were nonlinear analysis, through the comparison and fault diagnosis method of the fatigue damage final cover cracking reasons, the improving measures are put forward in this paper, the solution is verified the effectiveness of the improved reliability calculation.

1. Introduction
Traditional compressors have the advantages of fewer moving parts, simple and compact structure, high efficiency, low energy consumption and low noise, etc. In recent years, they have been used more and more widely in refrigeration, air conditioning and gas compression fields [1]. Compressor often appears in the actual work of some faults, such as not timely elimination, or elimination is not thorough, will cause some unnecessary major accidents [2]. The upper cover is one of the main bearing parts of the refrigeration compressor, and its reliability is the basis to ensure the reliable and stable operation of the compressor [3].

2. Cracking analysis of top cover
In order to ensure that the reliability verification test of the upper cover is consistent with the actual operation process of the compressor, the reliability verification test of the upper cover is carried out in the form of compressor assembly. The test loading mode is cyclic high pressure pulse mode, and the upper cover is required to meet the requirement of 200,000 times without abnormality under the action of this cyclic high pressure. During the research and development process of compressor XW7, the reliability test of the top cover failed, and the suction port area of the top cover cracked locally.

2.1. Upper cover assembly structure
XW7 cover and traditional compressor cover structure form basic same, subject to the flat cover structure, and shell welding as a whole, the suction and covered by welding connection, the suction bottom deep into the compressor pump cover inspiratory mouth, suction pipe and pump cover for the clearance fit, between the suction pipe and pump cover sealing ring in order to ensure gas seals. The specific structure is shown in Figure 1.
2.2. **Top cover reliability test**

In the reliability verification test of the top cover of XW7 compressor, cracking occurred when the cyclic load did not reach 200,000 times, and the cracking location was all near the suction port area of the top cover. Since this model was in the initial stage of development, only five prototypes were tested in the reliability test. The crack location of the upper cover in this test is shown in Fig. 2.

2.3. **Cracking analysis of top cover**

Under the condition of ensuring the quality of parts processing, assembly and materials, from the perspective of structural design, the fundamental cause of cracking damage of parts is that under the action of cyclic load, the local stress at the cracking position is large, which eventually leads to fatigue failure of parts. Therefore, using the finite element analysis method, Patran was used to process the model before and after the cover components to ensure the mesh quality of the finite element model. Meanwhile, MSC Nastran's nonlinear solver was used to perform nonlinear calculation on the cover components to ensure the accuracy and accuracy of the solution. Constrained loading was carried out according to the experimental test conditions. In order to ensure the comprehensiveness of the analysis, two analysis schemes were adopted. The corresponding scheme cover stress and suction pipe deformation cloud diagram are shown in Fig. 3.
Fig 3. Stress and deformation nephogram.

From the results of the analysis, scheme a maximum equivalent stress in bending rounded corners on the cover, the maximum equivalent stress is 495 Mpa, less than the cover damage experiment adjusted strength standard, can meet the strength requirement, but the suction pipe into the pump cover end maximum radial deformation of 0.304 mm, is greater than the clearance between the suction pipe and pump cover design, make the suction bottom in compressor operation process controlled pump cover; The second scheme is that the suction pipe is constrained by the pump cover. The maximum equivalent stress of the upper cover is 765MPa, and the maximum stress occurs near the suction port, which is consistent with the reliability test results. At the same time, the maximum equivalent stress is greater than the strength standard corrected by the upper cover failure experiment, which means the failure will occur. Through the above analysis, it can be seen that the direct cause of cracking of the top cover is the constraint effect of the pump cover on the suction pipe, which makes the equivalent stress of the suction port area of the top cover too large during the operation of the compressor, and finally leads to the failure.

3. Structure optimization of top cover

According to the analysis results of cracking causes of the top cover of the refrigeration compressor XW7 the top cover optimization is mainly to increase the strength of the top cover body and reduce the deformation of the bottom of the suction pipe caused by the top cover deformation. Both increasing the strength of the upper cover body and reducing the deformation at the bottom of the suction pipe can be realized by increasing the wall thickness of the upper cover and changing the structure form of the bearring surface of the upper cover. The optimization scheme optimization point diagram is shown in Fig 4.

Fig 4. Schematic diagram of optimization point of optimization scheme.
Finite element analysis was carried out on the optimized scheme, and the loading mode of constraint in the analysis process was the same as that of the original crack analysis scheme. The equivalent stress on the top cover and the suction pipe deformation of each scheme were finally obtained. The specific stress and deformation cloud diagrams are shown in Figure 5 and 6.

![Equivalent stress nephogram of optimization scheme.](image)

**Fig 5.** Equivalent stress nephogram of optimization scheme.

![Deformation cloud image of suction pipe of optimized scheme.](image)

**Fig 6.** Deformation cloud image of suction pipe of optimized scheme.

Through the comparison and analysis of the optimization schemes, although the flat-cap thickening scheme has a higher strength, its suction pipe has a larger diameter deformation. Under the constraints of the pump cap, the maximum equivalent stress at the top of the scheme exceeds the calibration strength standard, and cracking will occur. The equivalent stress of ball cap R190 scheme and the diameter deformation of suction pipe are large, which cannot meet the design requirements. The equivalent stress of the ball cover R190 thickening scheme is less than the strength standard corrected by the failure test of the top cover. Meanwhile, the maximum radial deformation of the suction pipe is smaller, which is only 0.0827mm and less than the design clearance. It will not cause the large equivalent stress of the top cover due to the restriction of the pump cover on the suction pipe. Finally, the top cover of XW7 refrigeration compressor adopts the thickening scheme of ball cover R190, and the 5 reliability verification test prototypes all meet the requirement of 200,000 cycles of high pressure.

4. **Conclusions**

For XW7 refrigeration compressor upper cover cracking problem, research and development process through MSC Patran and Nastran finite element analysis software, were to cover cracking under different test conditions for the nonlinear analysis, determine the cover cracking reason, by increasing
the thickness cover, reduce cover spherical radius optimization analysis, the final determination by R190 thickening scheme on the cover, can solve the problem of cover cracking, improves the reliability XW7 compressor, for subsequent compressor cover to analyze the problem such as craze.

Acknowledgements
The research was financially supported by the National Natural Science Foundation of China (51275541).

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