The solution of oil leakage on the joint surface of the combustion chamber casing and the rear jacket

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Abstract: In order to solve the problem of oil leakage at the flange bolted connection of the casing of combustion chamber, an implementation solution was proposed in this paper. Firstly, a simplified flange bolted connection finite element model was established in ANSYS based on the actual size of the casing. Then, the deformation of the flange joint surface under two different forms of load was analyzed. Finally, according to calculation results, the suggestion of adding gasket was proposed to improve sealing performance of casing, and the sealing effect of gaskets of different thicknesses is also studied. This article provided a reference for improving the oil leakage problem of the casing flange bolted connection.

1. Introduction

The oil leakage at the junction of the engine combustion chamber casing and the rear jacket not only affects the service life and working performance of the engine, but also pollutes the environment, wastes oil, and causes greater economic losses to the enterprise. Therefore, improving the sealing performance between the casing flanges is an urgent problem to be solved.

There are many possible factors that cause oil leakage of casing\cite{1,2}. Generally speaking, the main ones are as follows: (1) the effects of structure and performance of the bolt and nut material itself; (2) the matching clearance between the combustor casing and the rear outer cover is too large; (3) uneven joint surface; (4) the load causes the connection structure to deform. Since the fourth is the most frequently encountered in practical engineering applications, and in order to find an effective method to prevent oil leakage from the bolted connection surface of the casing, the displacement and stress of the joint surface under different loads must be analyzed\cite{3, 9}. This article finds that adding asbestos washer on the outer side of the flange joint surface bolted connection can effectively fill the outer edge of the flange clearance and reduce the deformation of the flange joint surface, especially when the flange was under axial force\cite{6, 12}. Asbestos washer was used to seal almost all common applications, and usually gave reasonable performance. The model of flange bolted connection with gasket was implemented in finite element analysis and the sealing effect of gaskets of different thicknesses is also studied\cite{11}.

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2. Methodology
Our objective is to prove that using asbestos gaskets to the flange bolted connection surface can improve the sealing performance of the flange connection. Therefore, this paper needs to compare the stress and deformation of the flange connection surface between no gasket and using gaskets. To carry out the comparative analysis of displacement between the joint by without gasket and by using gasket in FEM [6], the following are the steps to be followed out:

Step 1. The detailed FEM model of the single bolt joint was built, completely reflecting geometry of the bolt and fragment of the flange. For the computationally efficient, building uncomplicated flange bolted connection model instead of complex casing flange model.

Step 2. Contact set up, the friction coefficient of the flange joint surface is 0.2, and the friction contact between the screw and the flange is ignored, as well as the friction between the nut and the flange.

Step 3. Mesh generation, since the geometries of the flange and bolt models are complex, the hexahedral-dominant technique was used to mesh, and the size is 2mm.

Step 4. Parameters like loads, pressure of the equivalent bolt joint model are defined.

Step 5. Solutions including the maximum displacement and the Von-mises stress.

3. Finite Element Model
The finite element model of bolted connection of casing is shown in Figure 1. Because of symmetry with respect to the plane that passed through the gasket mid-thickness and evenly repeated loading in the angular direction, it is possible to model only an angular portion (Fig 2) that includes half of the bolt and half of the gasket thickness[6,12].

4. Result and Discussions

4.1. Without gasket
Figure 3 shows that when the flange internal pressure is 70Mpa, the maximum deformation of the flange occurs in the inner edge of the middle part of the adjacent bolted connection, and the maximum deformation of flange connection surface is $5.37 \times 10^{-2}$mm. Whereas when the bolted flange is subjected to axial tension which is 4000N, the position of maximum deformation of the bolted connection surface is at the outer edge of the flange, the value is $7.72 \times 10^{-2}$mm.
4.2. Adding gasket

Apparently, after adding gasket (5mm) in the flange bolt connection surface, the maximum deformation change of the joint surface is different under two different forms of load. From figure 5, it is not difficult to find that the maximum deformation is $5.46 \times 10^{-2}$mm when the pressure is 70MPa. However, when the axial tension is 4000N, the maximum deformation is $7.2 \times 10^{-2}$mm which is much smaller than before using the gasket.

4.3. Discussions

Changing the pressure value to obtain the deformation and stress of the flange which is using gasket, and compared with no gasket, the results are shown in Fig7 and Fig8. When the internal pressure of the flange exceeds 70MPa, the gasket increases the maximum deformation of the flange connection surface, but decreases the maximum Von-Mises stress. Therefore, when the internal pressure is lower than 70MPa, the effect of the gasket is the best.

Obviously, the gasket in joints plays an important role in the sealing performance of bolted flange joints when the axial force is loaded on the flange. Figure 9 shows that gasket can greatly reduce the flange axial deformation, as well as the maximum Von-Mises stress on the joint surface.
4.4. Maximum stress and Displacements in the gasket for three cases

The thickness of the gasket also affects the sealing performance of the bolt connection, so it is necessary to find a suitable gasket thickness while ensuring that the gasket is in the safe range. Figures 10 to 11 show the relationship between the maximum stress and the maximum displacement on the gaskets when the flanges are under the same external load and bolt pretension. The maximum displacement of the gasket observed due to compressive load of the flange upper and lower housing. The gasket shows displacement up to 0.4 mm for 5 mm thickness.

It can be seen from Figure 10 that the maximum stress on the surface of the gasket with a thickness of 5 mm is 73.3 MPa, which is under the limit of maximum allowable stress of 80 MPa, and the maximum deformation is 0.41mm. The 4 mm gasket shows maximum von-Mises stress up to 84.8 MPa which is slightly greater than yield strength of the material. The last one which is 3 mm gasket shows maximum von-mises stress more than 93.6 MPa, which is more than the yield strength of the material. Therefore, the first type of gasket thickness (5mm) is the most suitable for application.

5. Conclusion

A finite element analysis was performed to investigate the stress and displacement of the bolted flange joint surface under different internal pressure and axial force. At the same time, the displacement and stress change of the joint surface after the asbestos gasket was added to the flange connection surface.
were analyzed. Finally, the deformation of the gasket was studied when subjected to bolt preload and internal pressure 69 MPa. So, it is concluded that: (1) the position of the maximum displacement of the flange connection surface under internal pressure is exactly opposite to the position when it is subjected to axial force. (2) when the internal pressure of the flange exceeds 70 MPa, the gasket increases the maximum deformation of the flange connection surface, but decreases the maximum Von-Mises stress. While flange was subjected to axial force, the using of gasket greatly reduced the deformation and stress of the joint surface. (3) the thickness of 5 mm of the gasket is structurally safe to use in the flange and the bolt.

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