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RESEARCH ARTICLE

STRENGTH CHARACTERISTIC ANALYSIS OF KEY COMPONENTS OF HYDRAULIC-VISCOUS FRICTION COUPLER BASED ON ANSYS

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ABSTRACT

Teaching Friction coupler has an important application in the field of mechanical transmission. As typical wet friction transmission equipment, the strength characteristics of key components of the liquid-viscous friction coupler have a key impact on the reliability and service life of the whole friction coupler. Based on the finite element software ANSYS, the stress and deformation fields of the pump wheel and sector are calculated, and the response characteristics under different loads are obtained, which provides a basis for the optimal design of friction couplers.

INTRODUCTION

Friction coupler is a new type of mechanical transmission equipment, including dry friction and wet friction. As a typical wet friction device, the hydro-viscous friction coupler realizes friction transmission mainly through the viscous of liquid transmission medium. When the input speed is limited, its output characteristics can be controlled by the oil pressure of the inner chamber, such as speed, torque, etc. (Sun, 2013). The hydro-viscous friction coupler has the advantages of smooth transmission, step less speed change and no rigid impact, so it has a good application effect in the transmission of large equipment (Savitski and Lata, 2015). Because of the large transmission power, the internal components of the hydro-viscous friction coupler will bear a huge load, and the key components will undergo a certain amount of deformation under the load. If the stress of the internal component exceeds the allowable range, it will cause some damage to the coupler. If it is in this working state for a long time, the service life of the equipment will be greatly reduced. With the development of modern industry, the popularization rate of large-scale machinery and equipment is getting higher and higher. It is necessary to know the strength of key components in the liquid-viscous friction coupler. Based on the finite element method (Voltr and Lata, 2015), the stress and deformation fields of the key components in the liquid-viscous coupler are calculated by ANSYS software, which provides an important basis for the optimization design of the friction coupler in the later stage.

Establishment of Finite Element Model Model building: The finite element model needs to match the real model when it is constructed, but the computational workload should also be considered. Generally, it is necessary to keep the precise shape and size of the key structures. Some chamfers which have little influence on the calculation results can be neglected and simplified to achieve the coordinated arrangement of calculation accuracy and efficiency. In mesh generation, the rationality of mesh size and type directly determines the reliability of the calculation results. In the finite element software ANSYS, the element types with different node characteristics are provided for selection. However, in order to ensure the mesh fineness and reduce the mesh distortion, the mesh division based on ICEM is carried out. Finally, the mesh division results of the pump body in the coupler are obtained as shown in Fig.1. ICEM has been integrated into ANSYS. It can import grid model by command call and get ideal hexahedral grid model according to block partition. Compared with the same number of tetrahedral grid, ICEM has higher computational efficiency.

Boundary conditions setting: According to the working principle of the liquid-viscous friction coupler, different friction loads will appear in different filling rates of the pump chamber. Therefore, the strength of the pump body under 35%, 75% and full load conditions is analyzed respectively. In the setting of boundary conditions, the centrifugal force of oil is fully considered, and the load value is applied according to the experience method in practical engineering. In terms of freedom constraint setting, since the pump wheel of the liquid-viscous friction coupler is connected with the pump shaft at the center of the impeller, it is necessary to set this time as a cylindrical type constraint, that is, the impeller in the pump body can rotate around the Z axis. In order to set up conveniently, it is necessary to establish cylindrical coordinate system, complete the application of radial and circumferential constraints (Wang, 2012) and simulate interference fit state.

RESULTS

35% oil load condition: Under this load condition, the overall stress field of the pump body under steady-state condition can

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be obtained as shown in Fig. 2 (a). At the same time, in order to view the details, the single blade sector model is taken out, and its stress field is shown in Fig. 2 (b). As can be seen from Fig.2, when the input shaft runs at rated speed, the whole pump wheel is stretched along the radial direction. With the maximum stress located at the root of the outer diameter and the center of the blade, there is no obvious phenomenon of stress concentration. The whole deformation field of the pump body under steady state condition is shown in Fig. 3 (a) and that of the single blade sector is shown in Fig. 3 (b). In Fig.3, it can be seen that the maximum deformation is located at the outer edge of the pump body, which shows a significant linear increase under the action of centrifugal force.

75% oil load condition: When the oil load is 75%, the whole stress field of the pump body is shown in Fig.4 (a), and the stress field of the single blade sector is shown in Fig.4 (b). In Fig.4, it can be seen that compared with 35% load condition, the maximum stress under this condition reaches 355 Mpa, which significantly increases; there is a certain phenomenon of stress concentration, and it is located at the root of the blade inner diameter. There is also a certain uneven stress distribution at the end of the outer diameter. This is due to the fact that the blade, as the main bearing surface, bears a large pressure load under the action of larger liquid-viscous friction, but the non-working face bears a tensile load.

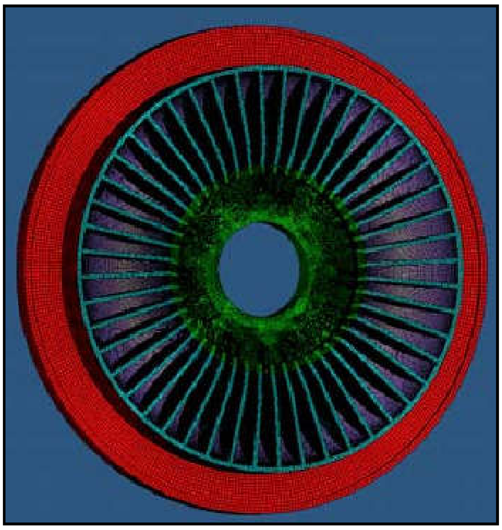
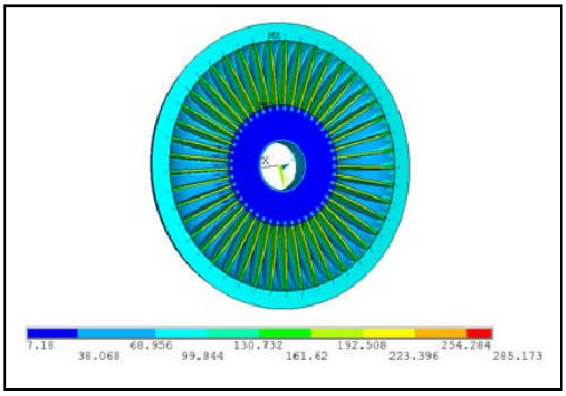
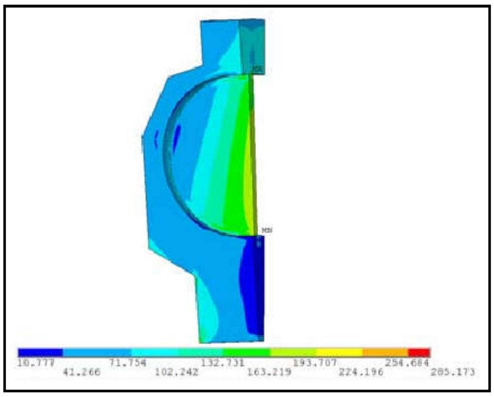


Fig. 1. Three-dimensional mesh model of pump body

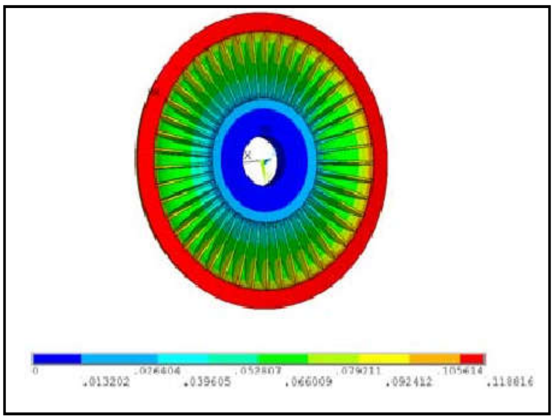


(a) Stress nephogram of pump body

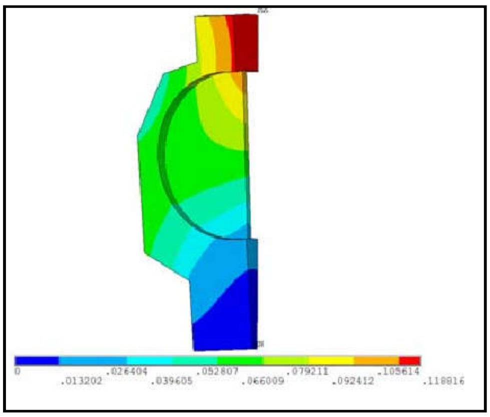


(b) Stress nephogram of single blade sector

Fig. 2. Stress calculation results (35% oil load conditions)



(a) Deformation nephogram of pump body



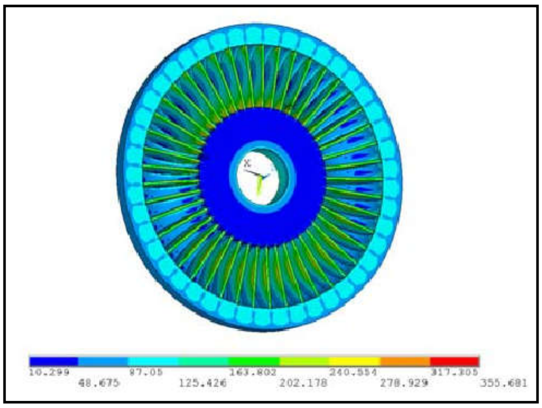
(b) Deformation nephogram of single blade sector

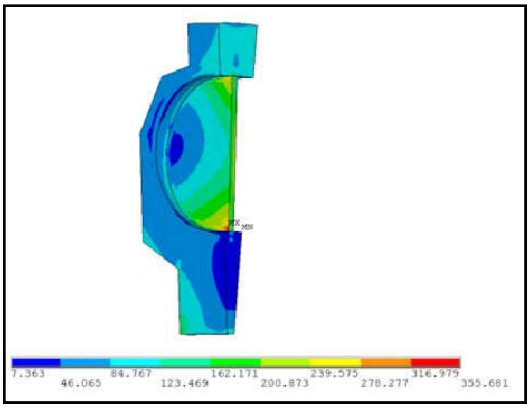
Fig. 3. Deformation calculation results (35% oil load conditions)

The whole deformation field of the pump body under this load is shown in Fig.5 (a) and the deformation field of the single blade sector is shown in Fig.5 (b). As can be seen in Fig.5, the deformation characteristics of the pump wheel are also significantly different from those under 35% load conditions. The maximum deformation position appears at the center of the blade, not at the end of the outer diameter under small load conditions. The maximum deformation is 0.17mm. According to the working principle of the liquid-viscous friction coupler, in order to reduce the deformation of the end face of the pump wheel, the pump body is usually fixed directly by opening bolt holes. When the pump wheel rotates at high speed, the hydro-viscous centrifugal force transforms the friction force of the blade, which makes the deformation field of the blade appear equivalent deformation ring state.

It can be seen that the oil pressure plays a major role in the deformation of the blade from the analysis of the main factors affecting the deformation.

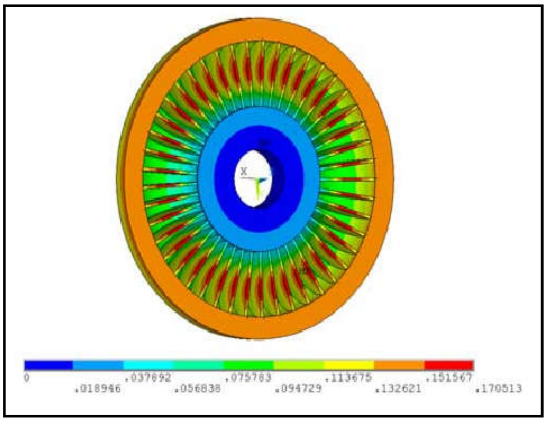
100% oil load condition: Under the limit load condition, i.e. the state of complete oil load, the whole stress field of the pump body can be obtained as shown in Fig. 6 (a) and the stress field of the single blade sector as shown in Fig. 6 (b). As can be seen in Fig. 6, under this condition, there is also a phenomenon of stress concentration. Under the action of huge oil shock, the maximum stress value reaches 1710 MPa at the root of the outer diameter and inner diameter of the blade. For the non-working plane, the eddy phenomenon appears in the stress nephogram, which is due to the centrifugal force of the oil fluid, so that the larger stress appears in a small part of the area away from the center of the blade.



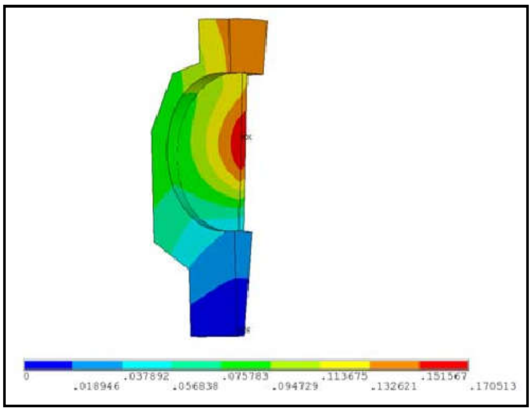


(a) Stress nephogram of pump body (b) Stress nephogram of single blade sector

Fig. 4. Stress calculation results (75% oil load conditions)

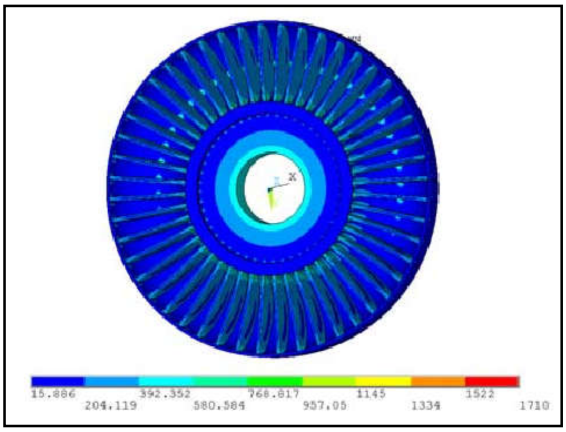


(a) Deformation nephogram of pump body

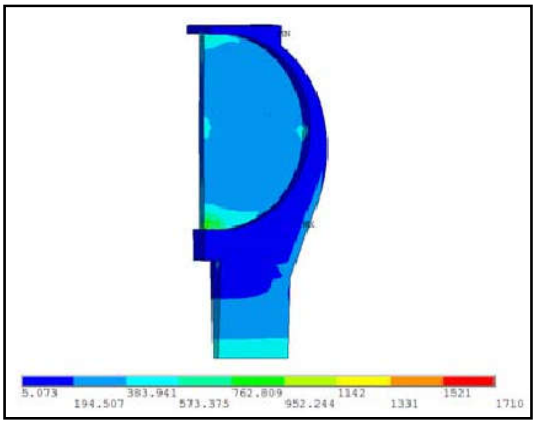


(b) Deformation nephogram of single blade sector

Fig. 5. Deformation calculation results (75% oil load conditions)

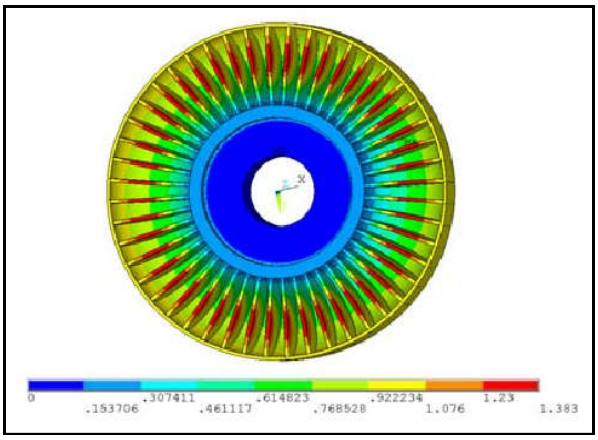


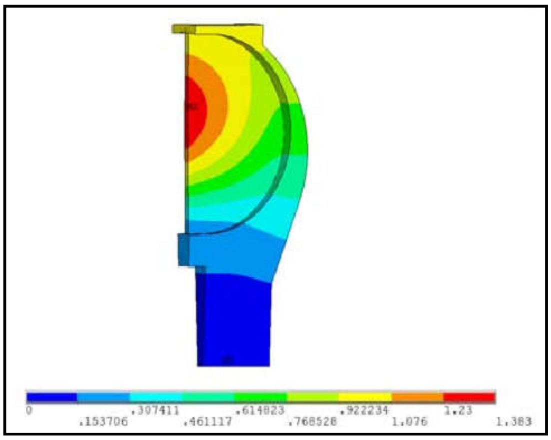
(a) Stress nephogram of pump body



(b) Stress nephogram of single blade sector

Fig. 6. Stress calculation results (100% oil load conditions)





(a) Deformation nephogram of pump body (b) Deformation nephogram of single blade sector

Fig.7. Deformation calculation results (100% oil load conditions)

The whole deformation field of the pump body under this load condition is shown in Fig.7 (a) and that of the single blade sector is shown in Fig.7 (b). In Fig.7, it can be seen that the maximum deformation of the blade is 1.38 mm due to the large load. On the whole, as the oil fills the whole cavity, the boundary conditions of the pump body are similar to those of the simply supported beam with the rotation of the spindle. Under the action of bending moment, the maximum deformation position is located at the center of the blade.

Conclusion

In the strength analysis scheme of the key components of the liquid-viscous friction coupler studied in this paper, the strength calculation under different working conditions is mainly based on the finite element method. The characteristics of stress field and deformation field under different load conditions are significantly different, which can provide an important basis for the optimal control of working conditions, and provide ideas and methods for the design of the air structure of the liquid-viscous friction coupler.

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