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Design and Numerical Simulation of Symmetric Multistage Canned Motor Pump

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ABSTRACT

Due to the advantages of high head, no leakage, multistage canned motor pump is widely used in the national economic construction department. At present, in the premise of guarantee reliability, saving energy efficient become an important development direction of canned motor pump. In order to research and improve the performance of the pump, this paper designed and used symmetric multistage canned motor pump DBP15-50x8 as the research object. Three-dimensional model of the main flow passage components is built and the mesh is generated respectively by using Pro/E and ICEM software, and we calculated the whole internal flow field of the pump that was selected by using ANSYS CFX software, achieving the pressure and velocity distribution rule in the pump and the internal details of flow in impeller and other main flow components. It is found that there is pre-whirl flow in the front of inlet in the first stage impeller under the conditions of 0.5 Q and Q flux, obtained the unstableness in inlet when this pump works under the low flux conditions. The post-processing showed the internal flow of bearing section and volute is chaotic, etc. The results provide theoretical basis for the design optimization of multistage canned motor pump.

KEY WORDS: *Symmetrical Type; Multistage; Three-Dimensional Modeling; Structural Design; Numerical Simulation*

1.0 INTRODUCTION

Canned motor pump belongs to no seal pump, the pump and drive motor is enclosed in a pressure contain full of pumped media. Due to the characteristics of multistage canned motor pump can increase the head conveniently, the demand is widely in the water supply and drainage and agricultural engineering, organic chemical industry, aerospace and marine engineering, energy engineering [1-2], however, the development and research of such small flow and high head no leakage pump have a late start, and to this end we have developed a symmetric multistage canned motor pump, then simulated and analyzed it based on CFD software.

2.0 DESIGN

2.1 Hydraulic design

Design performance parameters: Capacity Q=15m3/h, Head H=50m, Rotate speed n = 2900 r/min, Series I = 8. Have hydraulic design according to the parameters. Considering the small inlet pressure and the media easy vaporization, increase imports appropriately to improve the cavitation performance of the first stage impeller, and the design of secondary impeller take the improvement of efficiency as the main consideration. The first stage impeller inlet is 8mm larger than the secondary impellers inlet, and impeller outlet is 0.6mm wider than the secondary impellers. The secondary impeller form drawing is shown in figure 1.

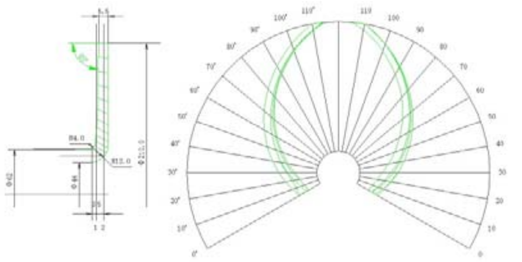


Figure 1: Secondary impellers form drawing.

2.2 Structural design

Multistage canned motor pump adopts symmetrical arrangement structure of four impellers on each side in order to balance axial force mainly. Increase inlet diameter of the first stage impeller to improve cavitation performance, and the other seven impellers have the same basic parameters. Eight impellers symmetrically arranged on both sides of the volute, the first four impellers are counterclockwise rotation from the pump inlet, after four impellers are clockwise rotation. The residual axial force due to other factors at running of pump can be balanced by the thrust plate before and after the canned motor. Symmetric multistage canned motor pump structure shown in figure 2: media inflow after first four impeller, from the water outlet section into the outer cylinder, and then through the water inlet section reverse after four impeller, and finally into the volute and outflow from the outlet.

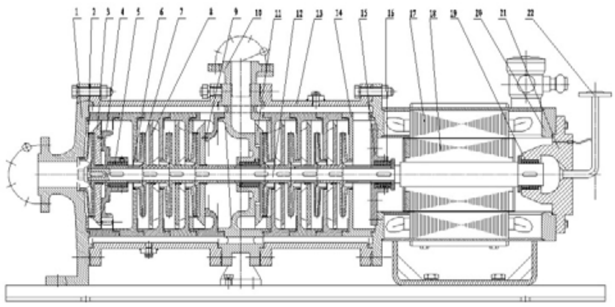


Figure 2: Symmetric multistage canned motor pump structure.
1.Casing cover, 2.The first stage impeller, 3.The first stage guide vanes, 4.Sliding bearing section, 5.Sliding bearing, 6.Shaft sleeve, 7.The secondary stage impeller, 8.Middle section, 9. Water outlet section, 10.Volute, 11.Final stage guide vanes, 12.Shaft, 13.Outer cylinder, 14.Water inlet section, 15.Front bearing housing, 16.Front sliding bearing, 17.Stator, 18.Rotor, 19.Behind sliding bearing, 20.Behind casing cover, 21.Behind bearing housing, 22.The circular tube.

3.0 MODEL OF COMPUTATIONAL MODEL

After the design, Three-dimensional model of the main flow passage components in multistage canned motor pump is built by using Pro/E. We calculated the whole internal flow field of the pump that was selected by using ANSYS CFX software, and analyze the results.

The object of study is the whole internal flow field of multistage canned motor pump, reference to the two-dimensional map of the main flow passage components in multistage canned motor pump, built three-dimensional model of internal flow field by using Pro/E. In the modeling process, in order to prevent the small parts of pump model to affect the quality of the mesh in the mesh generation, leading to inaccurate of numerical calculation, we simplify the model by omitting small gap portion between parts. The three-dimensional model of the internal flow field is shown in figure 3 [3].

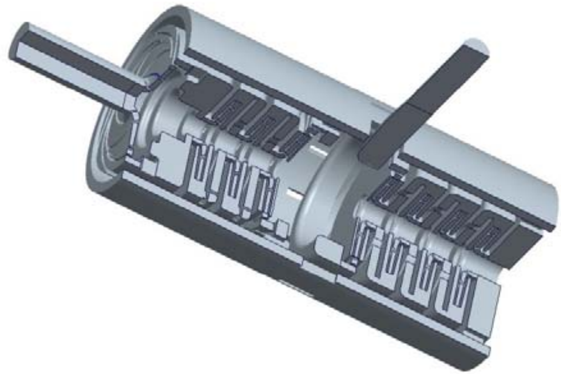


Figure 3: Three-dimensional model of the internal flow field.

4.0 NUMERICAL SIMULATION

In this paper, the internal flow field of multistage canned motor pump is numerical simulated by using ICEM and CFX software.

The entire flow field simulation model including: inlet pipe, the impeller water, the guide vane water, Sliding bearing section water, Middle section water, Water outlet section water, Water inlet section water, volute water and the pipe between outer cylinder and middle section.

4.1 Mesh generation

The reasonable design and high quality of the computational mesh generation is the prerequisite for simulation, also the key factors that affect the simulation. The quality of mesh directly affects the accuracy of the numerical calculation, and even the success or failure of computational problems. This paper used the ICEM to generate mesh. Considering the complexity of the model, we used unstructured mesh for mesh generation. Due to the whole flow field simulation involves many models, the mesh size depends on the size of every model, and the number of mesh after assembly in calculation reached more than 5 million.

4.2 Calculation method

Importing assembled mesh to the flow field calculation of CFX. K-ε turbulence model was selected for the standard model. The mass flow rate outlet and the total pressure inlet were selected for the boundary conditions. The mass flow rate outlet of the whole internal flow field is 15/3.6kg s^-1, the pressure of inlet set at 1 atm. Wall settings according to the domain Settings, the face contact with the rotor parts set to the rotating wall surface, The interface adopts the GGI mesh connection, and the simulation is the unsteady flow situation, the relative motion of the wall set to “Frozen Rotor” option [4-5].

5.0 RESULTS AND ANALYSIS

Figure 4 shows the pressure distribution of the internal flow field in multistage canned motor pump. As can be seen from the figure 4, the pressure increased along the direction of media flow which from the inlet to the outlet.

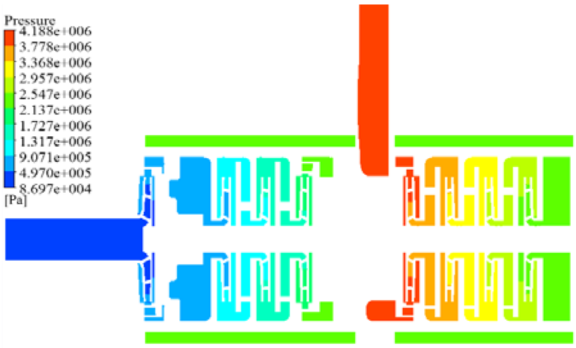
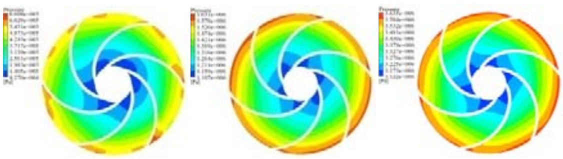


Figure 4: Pressure distribution of the internal flow field.

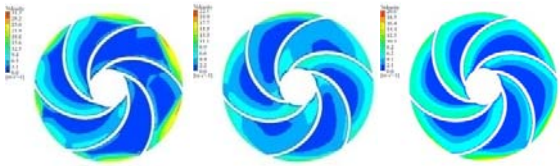
Figure 5 shows the pressure contours of the level 1, 3 and 7 impeller center plane in multistage canned motor pump. It can be seen from the figure that the pressure from the blade inlet to the outlet increases linearly in three impellers, the pressure near the blade face larger than the pressure near the blade back. From pressure distribution of level 3 and 7 impellers, the pressure in seven secondary impellers are relatively uniform. The pressure near the first stage impeller the pressure face outlet increases faster, showing a high-pressure zone.



1th stage impeller 3th stage impeller 7th stage impeller

Figure 5: Pressure contours of the level 1, 3 and 7 impeller center plane.

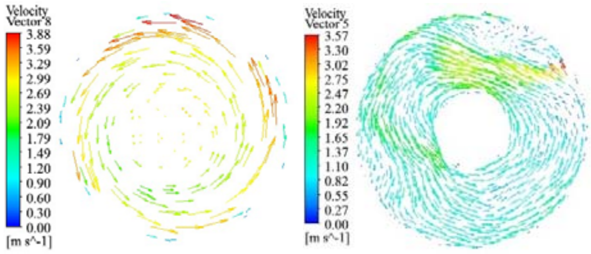
Figure 6 shows the relative velocity contours of the level 1, 3 and 7 impeller center plane in multistage canned motor pump. As can be seen from the figure, the relative velocity increased from the blade inlet to the outlet; the relative velocity in blade back is relatively stable, and increased near the outlet; In the blade face, the relative velocity gradually decreased from blade inlet to the middle of blade, and then gradually increased near the outlet, until closed to the relative velocity in blade back. The relative velocity distribution of secondary impeller is relatively steady, and the work situation of first stage impeller is different from the other seven impellers. There is irregular flow in local areas, the design can be considered separately.



1th stage impeller 3th stage impeller 7th stage impeller

Figure 6: Relative velocity contours of the level 1, 3 and 7 impeller center planes.

Take more planes as the reference surface in multistage canned motor pump, achieving the velocity vector in the flow field by post-processing, and it is shown that the velocity field is uniform in the pump. It proved that the design is reasonable, but there are some places need to improve: Figure 7.a shows the velocity distribution of inlet pipe, It is found that there is pre-whirl flow at the back of inlet pipe obviously under the conditions of 0.5 Q and Q capacity, obtained the unstableness in inlet when this pump works under the low capacity conditions. Figure 7.b shows the velocity distribution in sliding bearing section. The fluid in sliding bearing section rotates around the shaft, but the local flow is chaotic. The existence of the bearing structure leads to a long axial cavity, the media out of the guide vane directly into the bearing cavity. The media have large circumferential velocity, resulting in a movement of rotation around the shaft. The lack of return guide vane lead to irregular flow.



a. inlet pipe b. sliding bearing section

Figure 7: Velocity distribution.

Figure 8 shows the velocity distribution of the volute cross section. The volute as last flow passage components, it can be seen from figure 9 that its flow in some local areas of cavity is chaotic, such as the velocity of 4^{th} cross section is larger than other area around, may cause a large shock loss. It obtained that the volute design is not reasonable. We can further to analyze the results as reference to optimize [6-10].

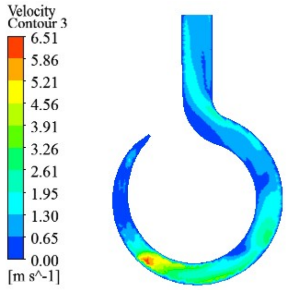


Figure 9: Velocity distribution of volute cross section.

6.0 CONCLUSION

Symmetric multistage canned motor pump is developed to meet the needs of the market for low flow, high head no leakage pump. Impeller arranged symmetrically balances the axial force and reduces the additional balance institutions. Reliability is also improved.

After model and assemble the main flow passage components of pump, this paper simulate the whole internal flow field, more realistic.

Achieving the velocity and the pressure distribution in the flow field by post-processing, the analysis shows that the velocity and the pressure distribution in the flow field are reasonable. The flow of first stage impeller differs from the other seven impellers. It is found that there is pre-whirl flow in the front of inlet in the first stage impeller, the internal flow of bearing section and volute is chaotic, etc. The results provide theoretical basis for the design optimization.

ACKNOWLEDGEMENTS

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