Compensation of Axial Force Gap Between Induction Wheel and Impeller Combined With Impeller for Centrifugal Pump

Jing Shi

Chengdu Aeronautic Polytechnic, The Innovation Base of School-Enterprise Cooperation Aviation Electronic Technology in Sichuan, Chengdu, 610100, Sichuan, China

SJ13688324739@163.com

Keywords: Aviation Fuel, Centrifugal Pump, Centripetal Force Compensation

Abstract: At present, the effect of induction wheel and impeller on the performance of aviation fuel centrifugal pump is not clear. to solve this problem, two induction wheels and impeller with equal pitch and variable pitch are designed and studied. under five working conditions q 0.6 q、0.8q、1.0q、1.2q and 1.4, respectively, three models of fixed pitch induction wheel and impeller, variable pitch induction wheel and impeller and no guide wheel and impeller are numerically simulated, and the velocity and pressure distribution of flow field in pump are obtained. The analysis results show that the pump head can be slightly increased by adding the induction wheel and impeller before the main impeller of the fuel pump. Compared with the equal pitch induction wheel and impeller, the effect of variable pitch induction wheel and impeller is better. After adding the induction wheel and impeller, the flow condition of the inlet of the main impeller is improved, especially in the case of large flow rate, the distribution of the low pressure zone is reduced, and the influence of the induction wheel and impeller on the flow rate of the pump is mainly concentrated in the inlet of the impeller.

1. Numerical Simulation

Aviation fuel centrifugal pumps operate in high altitude environment most of the time [1]. Compared with the ground state, the temperature is low at high altitude and the environmental pressure is small. In this case, the pump will have the problems of insufficient pressurization and low efficiency, which has a great influence on its stable and efficient operation. improving the cavitation resistance of fuel pump is one of the effective methods to improve the above phenomenon [2]. At present, the method of adding induction wheel and impeller before the main impeller of centrifugal pump is usually used to improve its cavitation resistance. The induction wheel and impeller is an axial flow impeller, which is widely used in the turbine pump of aero-rocket engine as well as in the aircraft fuel pump [3]. In order to improve the speed and speed of aero-engine fuel pump, the optimization design of aero-engine fuel pump is updated, and the requirements are analyzed and emphasized. According to the performance of aero-fuel booster centrifugal pump under the condition of large booster, the design method of aero-pressurized centrifugal pump is given. The flow-critical cavitation margin curve of centrifugal pump is predicted, and compared with the theoretical calculation value and test data, the numerical simulation is consistent with the experimental data, which can meet the demand of high cavitation characteristics. Gao Xiang et al .[6] proposed a two-objective optimization design method of efficiency and cavitation for cavitation problem of air centrifugal pump, and compared the flow-head and flow-cavitation characteristics of the pump before and after optimization. The results show that the pump efficiency is improved and the necessary cavitation allowance is reduced after optimization. Wu Yuzhen [7], Ji Fenglai et al .[8] have carried on the numerical simulation study to the internal flow and the performance of the high-speed centrifugal pump with and without the induction wheel and impeller, and found that the induction wheel and impeller will increase the inlet fluid pressure of the high-speed pump and enhance the cavitation resistance of the impeller. Guo Xiaomei et al .[9] carried out the external characteristic performance test under the condition of

  DOI: 10.25236/iccemm.2021.030

the front variable pitch induction wheel and impeller, and pointed out that the main significance of the front induction wheel and impeller is to improve the head in front of the main impeller of the centrifugal pump, but it does not contribute much to the head of the whole high speed centrifugal pump. Cui Baoling et al .[10] carried out three-dimensional turbulent numerical calculation of the flow inside the equal pitch induced wheel and impeller to obtain the distribution law of velocity field and pressure field in the flow path between the induced wheel and impeller. It can be seen that most of the related studies focus on the design and optimization of aviation fuel pump and the influence of induction wheel and impeller on the performance of high speed centrifugal pump, but the combination of the two is less. Therefore, it is necessary to carry out the research on the matching between induction wheel and impeller and aviation fuel centrifugal pump. The internal and external characteristics of centrifugal pump in three cases were analyzed by using three models: induction wheel and impeller (model 1) and variable pitch induction wheel and impeller (model 2).

The research object of the calculation model is a certain type of aviation fuel centrifugal pump. The main geometric dimensions and design parameters of the model are as follows: design flow rate Q=1550 l/h, rotational speed nQ=7400 r/min, rated boost value 80 kPa.. impeller inlet diameter D1=25 mm, impeller outer diameter D2D1=45 blade number ZD1=7; outlet width 4 blade wrap angle ΨD1=110°. The main parameters of the induction wheel and impeller are shown in Table 1. the original model and 3d model of the induction wheel and impeller are shown in figure 1.

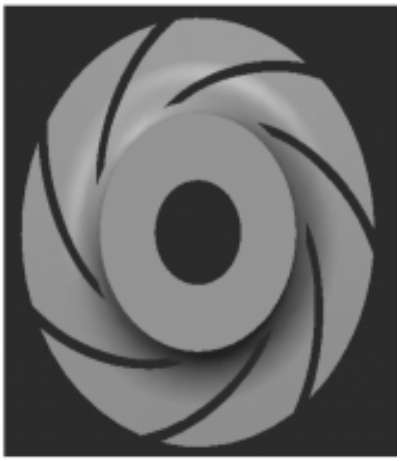

Figure 1 3D model

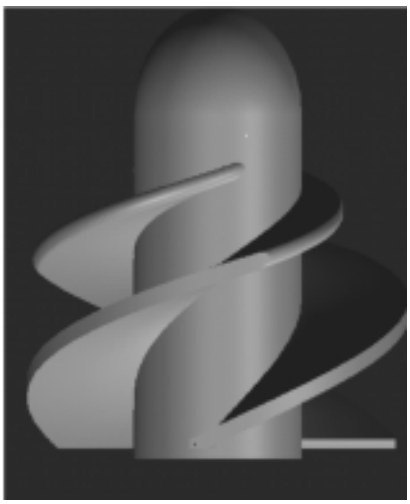

Figure 2 3D model

The numerical calculation part is carried out in the FLUENT14.5, using the standard k-epsilon turbulence model, the basic situation and regulation of this kind of model are analyzed in the picture, this figure is aero-engine rotor model, this model is often more regular graphics, its machining accuracy is often higher, the standard method of this kind of high-altitude model is analyzed to a

certain extent, the pressure-speed coupling solution uses SIMPLE algorithm. kerosene (Kerosene-liquid) was selected as the medium, and the pump inlet boundary condition was set as the velocity inlet (VelocityIn-let) and the outlet as the free outflow (Outflow).

2. Numerical Simulation Results and Analysis

The flow-head and flow-efficiency curves corresponding to the three models of aviation fuel centrifugal pump are obtained by numerical calculation, as shown in figure 2.

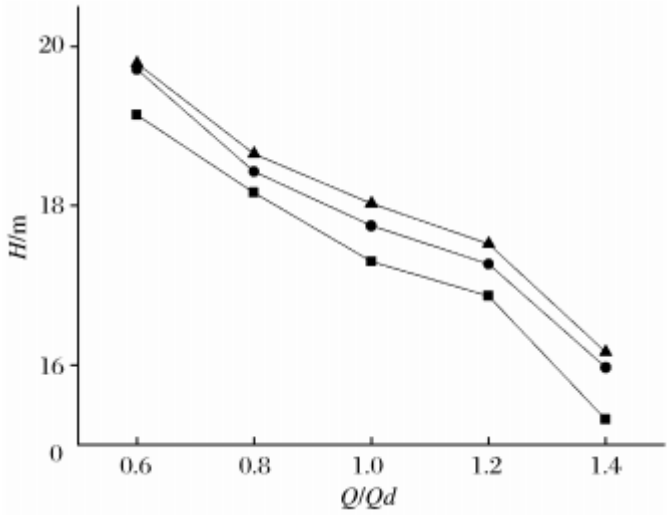

Figure 3 Lift and flow-efficiency curves

As shown in figure 2, the head of the original model, model 1 and model 2 shows a downward trend as the flow rate increases. Compared with the original model, the head of model 1 and model 2 increases slightly, and the head of model 2 is better than that of model 1. according to the inlet speed triangle, the relative inflow angle of the blade also changes with the increase of the induction wheel and impeller. in addition, the absolute speed and absolute speed components. according to the theoretical principal ratio, the head of the model comes. because of the axial flow structure of the induction wheel and impeller, the range of variation is very small. another difference from the mainstream flow curve is that the flow efficiency curve of type 1 and 2 is obviously different from the original flow efficiency curve. The efficiency of fuel pump is improved after adding induction wheel and defect, especially after adding lighter and compressor. thus avoiding the impact loss of the fluid from axial to radial, the mounting angle of the varactor and fuel outlet is similar to the blade inlet. compared with the same ignition induction wheel and ignition threat, the impact loss of liquid flow at the inlet of the blade is further reduced.

The internal flow analysis selected three typical working conditions: small flow rate (0.6 q), design flow rate (1.0 q) and large flow rate (1.4 q). the internal flow of the original model and model 2(shock absorber and defect) were analyzed and the internal velocity and pressure distribution of the emperor were calculated respectively. the results showed that the distribution of internal flow field was different when using induction wheel and pulse under different flow conditions. When the original fuel pump model is in a low flow state, the velocity distribution in the impeller is not uniform, and there is a lot of eddy current in the channel. The presence of eddy current in the emperor will affect the energy exchange with the liquid and increase the flow loss in the emperor, which is one of the reasons for the low efficiency of the original fuel pump. In some parts of the emperor, eddy currents still exist, indicating that the induction wheel and the emperor have little effect on the flow in the borehole, and the main function is to improve the flow at the entrance of the emperor.

Compared with centrifugal pumps without induction wheel and compressor, the distribution of induction wheel and impeller centrifugal pump in the inlet low pressure zone of each flow sensor is relatively uniform, especially in this case, the flow rate is obviously low. When the absolute

pressure is lower than the phosgene pressure, there will be cavitation phenomenon, and the performance of centrifugal pump will decrease.

3. New Material Blade

3.1. Carbon Fibre/Titanium Alloy Composite Blades

the GE90-115B engine produced by us general motors, the blade body is carbon fiber polymer material, the blade edge is titanium alloy material, a total of 22 turbofan blades, a single weight of 30~50 pounds, a total weight of 2000 pounds. Can provide the best push-weight ratio, is currently the largest aircraft jet engine blade for the Boeing 777 aircraft, in September 2010 in the United States New York Museum of Modern Art exhibition.

3.2. Intermetallic Compound Blade

Although superalloys have been used in aircraft engine blades for more than 50 years, these materials have excellent mechanical properties, and material researchers are still improving their properties to enable design engineers to develop more efficient jet engines that can work at higher temperatures. However, a new type of intermetallic compound material is emerging, which has the potential to replace superalloys completely.

Because the superalloy will form a γ phase when it works at high temperature, it is the main reason that makes the material have high temperature strength, creep resistance and high temperature oxidation resistance. Therefore, the study of intermetallic compound materials has been started, and the intermetallic compound, with a density of only half of the superalloy, can be used at least for low pressure subsections to replace superalloys.

U.S. General Motors, Precision Casting and others applied for an aviation industry technology project (AITP) supported by NASA in 2010 to be put into industrial production by validating and evaluating titanium-aluminum intermetallic compounds (TiAl,Ti-47Al-2Nb-2Cr, atomic fractions) and superalloys now used in low-pressure turbine blades. compared with nickel-based superalloys, the impact resistance of TiAl intermetallic compounds is poor; the technical risk will be reduced to the minimum through fatigue tests, etc.

4. Conclusions

(1) By adding the induction wheel and impeller in front of the main impeller of the air fuel centrifugal pump, the pump head can be increased slightly and the efficiency can be improved to a certain extent ;(2) the increase effect of variable pitch induction wheel and impeller is more obvious than that of equal pitch induction wheel and impeller ;(3) the flow at the inlet of the air fuel centrifugal pump is improved.

References

[1] Liu, Weiwei. Advances in Key Manufacturing Technology of Aeroengine Blade. Aviation Manufacturing Technology, no. 21, pp. 50-56, 2016.

[2] Li, Haining., Zhao, Yun., Shi, Yaoyao., Yao, Chuanfeng. Tan Liang. Aeroengine fan / compressor blade manufacturing key technology. Aviation Manufacturing Technology, no. 16, pp. 34-37, 2013.

[3] Li, Lin., Liu, Jianping. Aluminum-based core agent and its application in aero-engine blade manufacture. Journal of Aeronautical Materials, no. S1, pp. 282, 2003.