CAVITATION OPTIMIZATION FOR RESIDUAL HEAT REMOVAL PUMP USING ORTHOGONAL EXPERIMENTAL METHOD BASED ON PUMPLINX

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Long Abstract

Introduction

Cavitation is a difficult problem to the development of hydraulic machinery, causing vibration, and noise, and affecting operation reliability of the pump. Residual heat removal pump is one of the key equipment in the million-kilowatt nuclear power plant, and it plays a vital role in the safety of the entire plant. Therefore, as an important characteristic of residual heat removal pump, the cavitation performance is usually studied. In this study, computational fluid dynamics (CFD) technology was used to test three factors (impeller inlet diameter D_1、inlet incidence angle $\Delta\beta$、blade wrap angle φ) affecting cavitation performance of the residual heat removal pump by Orthogonal Experimental Method (OEM) to study the cavitation characteristics of pump, as well as internal flow instability induced, and to analyze the effects of three factors on the pump hydraulic performance. The mechanism of cavitation was further discussed to obtain the optimal parameters combination for pump design.

1. Methods

To improve the performance of the centrifugal pump with a vaned diffuser, the influence of impeller geometric parameters on cavitation of the pump was investigated by Orthogonal Experimental Method (OEM) based on PUMPLINX. Impeller inlet diameter D_1, inlet incidence angle $\Delta\beta$, blade wrap angle φ were selected as the main impeller geometric parameters and the orthogonal experiment of L_9（3*3）was done in this study. Three-dimensional steady simulations were conducted to predict the cavitation performance of pump using constant gas mass fraction model with 2nd order upwind. The experimental results were justified by the variance analysis method. The inner flow of the pump was also analyzed in order to obtain the flow behaviors that can affect the pump performance. Table 1 shows the different parameters of the impeller, and schematic map of optimization process as shown in Figure 1.

Table 1. Parameters of the impeller

Trail No.	impeller inlet diameter D_1(mm)	inlet incidence angle $\Delta\beta(^0)$	blade wrap angle $\varphi(^0)$
1	260	3	110
2	260	5.5	120
3	260	8	130
4	270	3	120
5	270	5.5	130
6	270	8	110
7	280	3	130
8	280	5.5	110
9	280	8	120

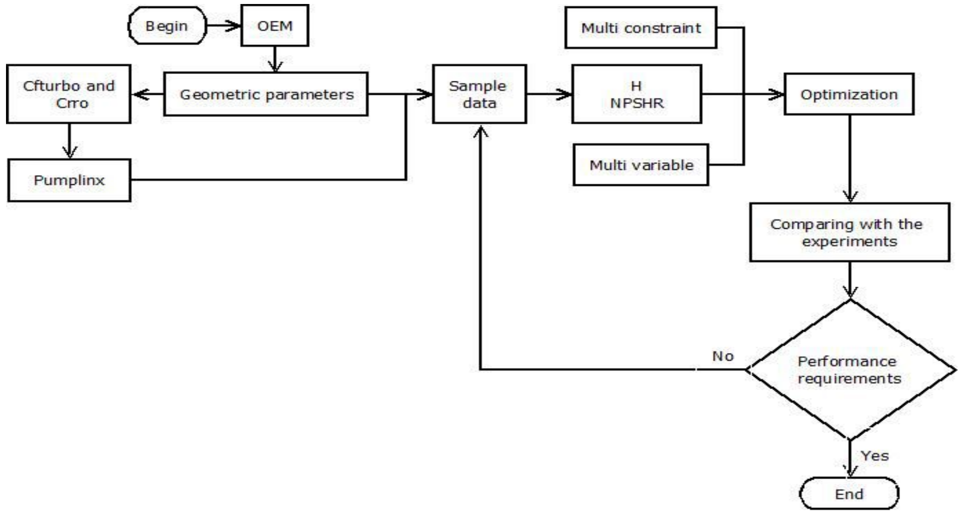

Figure 1. Schematic map of optimization process

The results show that the impeller inlet diameter D1 has the greatest influence on the cavitation performance. The final optimized impeller accomplished better cavitation performance, which can meet the design requirements and the velocity distribution in the optimized impeller is more regular, shown in Figure 2.

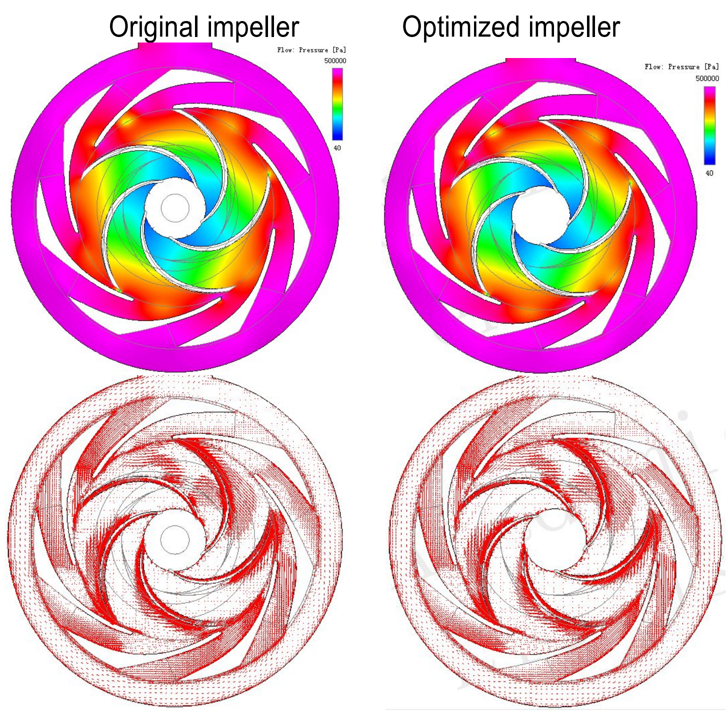

Figure 2. Total pressure and velocity

When the inlet pressure of pump dropped to 30kp, the vapor volume fraction of optimized impeller was better than the original impeller, in which serious cavitation occurred, and it is more intuitive to use total volume fraction to do comparison in Figure 3. Net positive suction head required of the optimized impeller dropped from 2.95m to 2.32m, comparing with the original one. And the efficiency of the optimized impeller increased by 0.6% based on the results of numerical simulation using PUMPLINX.

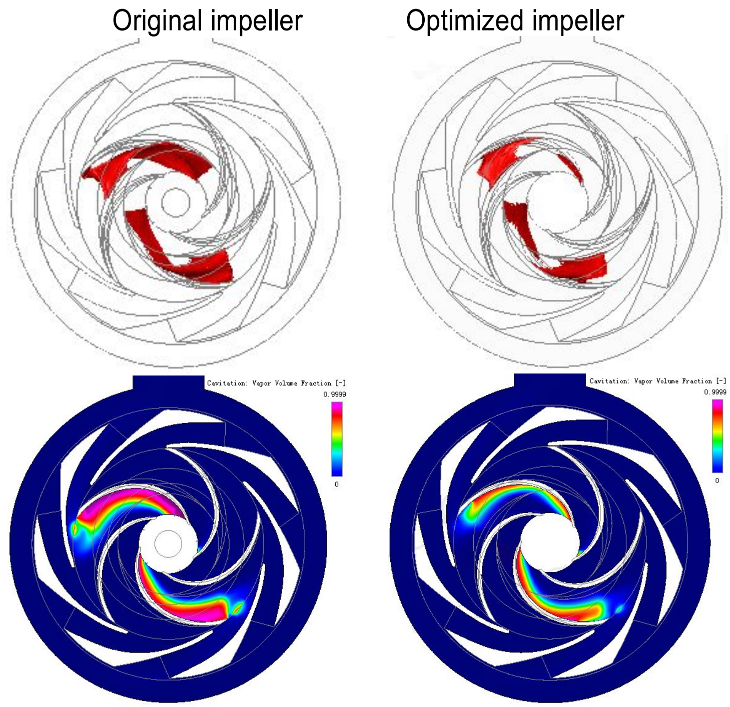

Figure 3. Total volume fraction and vapor volume fraction

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