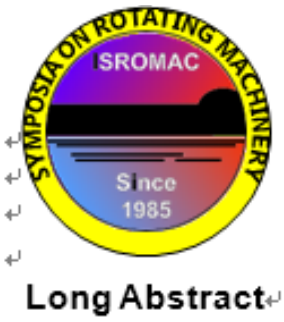
Optimization of Pump Hydraulic Performance Based on Response Surface Method



Long Abstract

Shengli Xu*, School of energy and power engineering, Dalian university of technology Dalian, Liaoning, China

Shaowei Zhong, School of energy and power engineering, Dalian university of technology Dalian, Liaoning, China

Xin Peng, School of energy and power engineering, Dalian university of technology Dalian, Liaoning, China

Haixin Zhao, Department of engineering mechanics, Dalian university of technology Dalian, Liaoning, China

Abstract

In recent years, with the development of computational fluid dynamics (CFD) method and numerical optimization algorithms. The method of pump design based on parameterization method, simulation calculation solver and optimization algorithm is becoming more and more widely used [1]. But in previous work, because of the complex geometry of pump and the limitation of computing capability the performance optimization of pump is generally limited to a single component and ignores the interaction between the impeller and the diffuser, and the diffuser and the volute [2].

In this paper, a method of automatic optimization of hydraulic performance of pump based on surrogate model is proposed. The whole pump including impeller, diffuser and volute is simulated using CFD. The influence of some key design parameters on the performance of pump is analyzed. The concerned performance function is the hydraulic efficiency. The specified head is selected as a constraint function to meet the requirement of input power. In addition, the distribution of pressure and velocity in the flow field has an important effect on the total efficiency of pump, so we investigate the impeller reaction factor which is the ratio of potential head and theoretical head on the optimal result of impeller. The reaction factor is selected as the objective function to study the influence of the distribution of static pressure and dynamic pressure at impeller exit on the external characteristics of the pump. The surrogate model is established by radial basis function (RBF), and the CORS-RBF algorithm are used to analyze the parameters and select the optimal points. The optimization results of whole pump and single impeller are compared.

The parameterization of component shape is prerequisite for the process of automatic optimization. This paper proposed a parametric method of impeller and diffuser based on Berizer curve. A one-dimensional code of performance design is implemented using MATLAB to provide the initial value of pump geometry parameters. The sample points are generated by design of experiment (DOE) method. After the response values of the sample points are obtained using ANSYS CFX and the sampling process is driven by a Matlab code, the surrogate model is constructed by radial basis function and the optimization problem is solved using CORS constraint optimization

algorithm which is suitable for the optimization problem with nonlinear constraints [3]. At last the influences of some geometry parameters are also discussed and the results of examples show that the proposed optimization strategies are effective.

References

[1] Van den Braembussche R A, Alsalihi Z, Verstraete T, Matsuo A, Ibaraki S, Sugimoto K and Tomita I 2012 Multidisciplinary Multipoint Optimization of a Transonic Turbocharger Compressor ASME-GT 695645.

[2] Huang R F, Luo X W, Ji B, et al. Multi-objective optimization of a mixed-flow pump impeller using modified NSGA-II algorithm. Sci China Tech Sci, 2015, 58: 2122-2130

[3] Hardy, RL. Multiquadratic Equations of Topography and Other Irregular Surfaces, J.Geophus. Res, 1971, 76: 1905-1915.