Numerical Analysis on the Characteristics of Cavitation in the Variable Frequency Regulation of Centrifugal Pump

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Abstract. In this paper, for a certain type of horizontal single-stage single-suction centrifugal pump, a 3D model based on Pro/e is constructed and imported into Fluent, using moving reference frame model and two-phase mixture model to simulate the internal state of pump, then get the pressure distribution, vapor-liquid two-phase flow distribution, the vapor-phase volume fraction distribution within pump, when temperature remains constant and operating speed is changed by frequency control technology. Finally, compare and analyze these distributions. According to the main flow characteristics of the liquid-phase and the vapor-phase, reveals the intrinsic characteristics of cavitations in the two-phase flow field within pump. The results can provide a reference for the design optimization of centrifugal pumps and a theoretical basis to make the variable frequency regulation of pump get better and more rational application, and improve the effects of economic operation and energy conservation.

1 Introduction

Recently years, frequency control has developed rapidly in the water supply system, using of frequency conversion technology to change the operation of equipment speed to adjust the flow rate. It can’t only satisfy the production
operation condition requirement, also can achieve the purpose of saving energy. And we also should be clear that the variable frequency speed will definitely affect the pump’s working parameters and performance.

When pump is running, because the impeller blade inlet partial pressure drops, steam produces, bubbles appear and flow to the high-pressure place with the liquid. The pressure around bubble is greater than the vaporization pressure within bubble, bubbles rapid shrink, rupture and condenses, liquid particles will be high-speed filling the hole, mutual impact and water attack will happen. The cavitation phenomenon will show in hydraulic machinery [1]. Cavitation in centrifugal pump will make noise and vibration increase, even produce erosion on the material of flow channel.

In this paper, internal flow field in centrifugal pump are analyzed using CFD method to get the pressure, vapor-liquid two-phase flow and vapor volume fraction distribution within pump at the different speed when temperature remains constant. After comparative analysis, according to the flow characteristics of the liquid-phase and vapor-phase reveal the internal cavitation two-phase flow characteristics in pump.

2 Modeling and Calculation Methods

2.1 Pump Model

The type of this pump is the IS65-40-315 centrifugal pump, using Y200L1-2 type three-phase asynchronous motor with Senlan BT12S-37KWI frequency converter driven. The frequency setting range of Senlan BT12S-37KWI inverter is 0.10 ~ 120 Hz, and the minimum set volume is 0.01 Hz. This frequency converter applies to press square reduced torque of pumps load, with over-current, over-voltage, under-voltage, and electronic thermal relay overload protection.

The design rotary speed of centrifugal pump is 2900 r/min, design flow rate is 25 m³/h, design head is 125 m, specific speed is 23, and the number of blade using backward curved vane is 6. According to the IS65-40-315 centrifugal pump hydraulic model [1], construct model using "mixed boundary scan [2]" and "3d cylindrical shape of blade [3]" in Pro/e, shown in Fig. 1.

![Fig. 1 3d model of the design](image)