EXPERIMENTAL INVESTIGATION ON VIBRATION CHARACTERISTICS OF A CENTRIFUGAL PUMP IN CAVITATING CONDITIONS

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Long Abstract

Introduction

Cavitation, one of the unexpected flow instabilities inside the centrifugal pumps, is detrimental to the stable operation of the pump. With absolute static pressure at the impeller suction decreasing, cavitation may easily occur at blade leading edge. Furthermore, with static pressure decreasing continuously, cavitation region inside blade channels expands towards blade trailing edge, and cavitation bubbles travel with the main flow collapsing at high static pressure region. During the collapse process, unsteady impact forces acting on blade surfaces, shock waves would be generated resulting in vibration energy of the pump increasing rapidly. Besides, due to the continuously impingement effect of the burst cavitation bubbles, cavitation erosion would develop on the blade surface. So it is essential to detect cavitation during pump operating to avoid the adverse influence.

To detect cavitation inside the centrifugal pump, determination of 3% head drop is the most common method in industrial application. But many researches have proved that cavitation develops much earlier than that reflected in head drop. Visualization of cavitation inside the blade channels could observe cavitation inception effectively, but it is not a convenient means in industrial application. Along with cavitation occurring, emitted acoustic noise and high amplitude vibration would be easily identified. So cavitation induced vibration signals could be applied to detect cavitation considering its convenient for application. Many researches have been done to investigate vibration characteristics induced by cavitation in the pump, but most of them lay emphasis upon high frequency vibration signals. Besides, a synthetic analysis of cavitation visualization and cavitation induced vibration is rarely conducted leading to a lack of comprehensive understanding of the influence of cavitation process on vibration characteristics.

1. Methods

In this paper, to have a comprehensive understanding of the vibration characteristics induced by cavitation flow, several accelerometers are mounted on the surface of the spiral volute casing as seen in Figure 1. The PCB series accelerometers used in the experiment have a flat frequency response from 0.5Hz to 5 kHz. Meanwhile the typical resonant frequency is about 50 kHz, which is adequate to capture the high frequency vibration signals excited by cavitation phenomenon.

A transparent model pump made of plexiglass is investigated to visualize cavitation flow inside the blade channels. To capture the complex cavitation flow, high speed camera OLYMPUS I-SPEED 3 is used, and the exposure time is set as 5×10-4 s. Image size of each figure is 1072×800 pixels. The high energy light and LED light sources are applied to illuminate the optical view. And the visualization system of cavitation flow is shown in Figure 2.

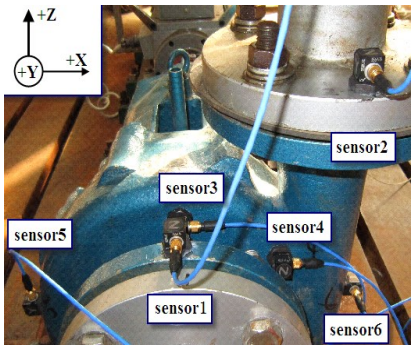

Figure1

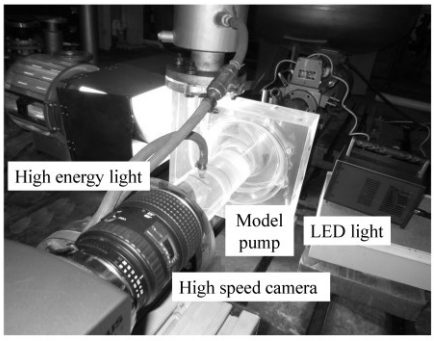

Figure2

Conclusions

Vibration energy of the model pump is significantly affected by the onset of cavitation. Vibration signals in low frequency band are affected as well, and vibration energy increases with cavitation developing. High frequency vibration signals are more sensitive to cavitation inception, and vibration energy starts to increase much earlier than the usual critical point inferred from 3% head drop. The increment of vibration energy is enough to detect full-cavitation in the model pump. With cavitation number decreasing, vibration level first rises to a local maximum, then it drops to a local minimum, and finally it rises again. The varying trend of vibration energy is closely associated with the developing process of cavitation. Based on the visualization results of cavitation, it is easy to relate vibration characteristics to cavitation morphology inside the model pump. According to the visualization results, it is found that cavitation morphology experiences several stages with cavitation number decreasing, and vibration energy of the model pump is closely related to cavitation status inside the blade channels.

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