Experimental Comparison of Cavitation in Water and Refrigerant R113

Long Abstract

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Introduction

Cavitation is a common phenomenon in high speed liquid flow, which is characterized by vapor generation and condensation. It usually occurs in rotating machinery, especially in high-speed pumps, which results in an efficiency reduction. With variable liquids used in industry, cavitation research on different liquids in pumps is more significant.

Cavity grows in the liquid, and liquid surrounding the cavity supplies latent heat to the cavity interface. The consequence is the local reduction of the liquid temperature, which results in a slight drop of the vapor pressure. The local vapor drop delays the development of the cavity. The phenomenon is defined as “thermal delay” by Brennen [1]. Thermodynamic effects are rarely taken into account in water in room temperature, because the critical point temperature of water is much higher than the working temperature (room temperature). As for refrigerant R113, the effects can’t be neglected, because the critical point temperature is close to the working temperature. In that case, it results in large variation of vapor pressure, even if there is a small local decrease of liquid temperature. In other words, the effects are significant in hot water.

Sarosdy and Acosta [2] conducted an experiment in water and refrigerant R113 using a cavitating disk, and they compared the differences of cavitation appearances in two liquids under the same B-factor. They described the cavity in water is “glassy” while that in refrigerant R113 is “forthy”. Franc et al. [3,4] used a cavitating inducer to discuss the relationship between cavitation performance/instabilities and the thermodynamic effects using water and refrigerant R114 as working fluid. They found the thermodynamic effects play an important role in delay of cavitation. The cavity length in refrigerant R114 is shorter than that in water in the same cavitation number, and when temperature get higher, the cavity length becomes shorter in the same working fluid. A similar research is conducted by Cervone et al. [5] using hot water as working fluid in a NACA0015 hydrofoil, respectively. From past studies, some parameters is used to estimate the thermodynamic effects, such as B-factor [6], Σ [1], Σ^* [7]. Most parameters are from single bubble equation which can’t represent all information of relationship between the thermodynamic effects and cavitation exactly. Most studies concern about the consequences of the thermodynamic effects on cavitation performance/instabilities, rather than the mechanism of the thermodynamic effects. Lots of studies still need to be carried on to understand the thermodynamic effects of cavitation better.

The present cavitation research is conducted in hydrofoil with water and refrigerant R113. Different cavitation aspects are found in the experiment and influence of the thermodynamic effects on cavity is discussed.

1.Methods

Experiments were conducted in a small scale water tunnel with a hydrofoil. The working fluids were cold water and refrigerant R113. The flow velocity was measured, and the pressure and temperature on the surface of hydrofoil were also measured. A high-speed camera was used to record the cavitating flows.

2. Results

to be added

References

[1] Brennen C E. Hydrodynamics of pumps. *Cambridge University Press*, 2011.

[2] Sarosdy L R, Acosta A J. Note on observations of cavitation in different fluids. *Transactions of the ASME*, 83(3): 399-400, 1961.

[3] Franc J P, Rebattet C, Coulon A. An experimental investigation of thermal effects in a cavitating inducer. *Journal of Fluids Engineering*, 126(5): 716-723, 2004.

[4] Franc J P, Boitel G, Riondet M, et al. Thermodynamic Effect on a Cavitating Inducer—Part I: Geometrical Similarity of Leading Edge Cavities and Cavitation Instabilities. *Journal of Fluids Engineering*, 132(2): 021303, 2010.

[5] Cervone A, Bramanti C, Rapposelli E, et al. Thermal cavitation experiments on a NACA 0015 hydrofoil. *Journal of fluids engineering*, 128(2): 326-331, 2006.

[6] Stahl H A, Stepanoff A J, Phillipsburg N J. Thermodynamic aspects of cavitation in centrifugal pumps. *ASME J. Basic Eng*, 78: 1691-1693, 1956.

[7] Watanabe S, Hidaka T, Horiguchi H, et al. Analysis of Thermodynamic Effects on Cavitation Instabilities. *Journal of Fluids Engineering*, 129(9): 1123-1130, 2007.