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NUMERICAL SIMULATION OF CAVITATION FLOW UNDER HIGH PRESSURE AND TEMPERATURE*

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Abstract: The numerical simulation of cavitation flow on a 2D NACA0015 hydrofoil under high pressure and temperature is performed. The Singhal's cavitation model is adopted combined with an improved RNG $k-\varepsilon$ turbulence model to study the cavitation flow. The thermal effect in the cavitation flow is taken into account by introducing the energy equation with a source term based on the latent heat transfer. The code is validated by a case of a hydrofoil under two different temperatures in a comparison between the simulation and the experiment. Computational results show that the latent heat of vaporization has a significant impact on the cavitation process in the high temperature state, and the cavity in the high temperature state is thinner and shorter than that in a normal state with the same cavitation number, due to the fact that the heat absorption in the cavitation area reduces the local temperature and the saturated vapor pressure. This numerical study provides some guidance for the design of machineries in the High Pressure and Temperature (HPT) state.

Key words: cavitation, NACA0015, thermodynamic, CFD, high pressure and temperature

Introduction

Cavitation is a kind of phase transformation, which often occurs in liquid flows. It is recognized that when the local pressure drops below the saturation pressure, cavities start to occur, and then develop with the variable pressure, finally collapse when the pressure is large enough[1]. In hydraulic machines, cavitation may lead to problems like vibration, hydrodynamic drag, pressure pulsation, noise and erosion on solid surfaces. Cavitation exists widely in pumps, turbines, marine current turbines and other fluid machineries. In the design process of these machines, the cavitation and cavitation damage must be considered.

In a nuclear power plant, the pump is one of the most important and widely used machineries, particularly, the nuclear reactor coolant pump is a key equipment. The operation of the reactor coolant pump is closely related to the safe operation of nuclear power plants, therefore, the cavitation must be avoided entirely in the reactor coolant pump design. Its working medium is high temperature and pressure water, so the cavitation in the High Pressure and Temperature (HPT) state is an important issue.

The cavitation model is the key for numerical simulations of cavitation flows. Existing cavitation models fall into two classes: the VOF method based on the interface tracking and the homogeneous equilibrium flow method[2,3]. The latter is popular due to its computationally inexpensive nature as compared with the interface tracking method. Many cavitation models based on the homogeneous flow theroy were put forward in recent years, such as Singhal et al.[4], Schnerr and Sauer[5] and Kunz et al.[6]. For numerical simulations of cavitation flows, the major challenge arises from the large density jump between the liquid and vapor phases, where many algorithms were deve-

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