COMPUTATIONS OF UNSTEADY CAVITATING FLOW OVER A HYDROFOIL USING UNSTEADY RANS AND DETACHED EDDY SIMULATIONS

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ABSTRACT

An unsteady turbulent cavitation flow over a hydrofoil at angle of attack is numerically simulated using three-dimensional incompressible, homogeneous multiphase Reynolds Averaged Navier-Stokes (RANS) method. To simulate cavitating flows, we adopt multi-phase single-fluid model including mass fraction transport equation. Two mass transfer models, also called cavitation models, are incorporated as source terms to model the transfer of mass from liquid to vapour and back [1]. In two-phase flows, the turbulence models might affect the cavity structure and cavitation dynamics. In the present work Unsteady Reynolds Averaged Navier-Stokes and Detached Eddy Simulation (DES) modeling are examined with the intent of elucidating the differences that these modeling approaches have in the prediction of flow structures and integrated quantities. The DES formulation in this study is based on a modification of the RANS SST model of Menter [2], such that it reduces to RANS close to solid walls and to LES away from the wall.

One of the main computational difficulties for cavitation is the large density ratio between the liquid and the vapor phases. The SIMPLE-like pressure-based method developed by Senocak and Shyy [3] is used for time-dependant computations. This modification of SIMPLE procedures is achieved through the inclusion of a pressure-density coupling scheme into the pressure correction equation.

Two test cases are used for the validation of the mass transfer models, a two dimensional (2D) NACA6602 hydrofoil and a three dimensional (3D) NACA0015 hydrofoil. The 2D NACA6602 case is primarily used for analysis of the influence of model parameters, such as the grid resolution, the mass transfer models and the numerical interpolation schemes, on the simulation results. The unsteady cavitation flow field including transient cavity shedding is reproduced. The cavitation patterns, such as leading edge cavitation inception and reentrant jets, are reproduced well and show good comparison with the well-known experimental data. A fully three-dimensional DES simulation was performed for attack angle 6° and cavitation numbers of 1.5, 1.0, 0.8 and 0.6. Visualizations of 3D flow structures and time evolution of flow structures are presented.

References

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