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IMPROVEMENT IN NUMERICAL PREDICTION OF CAVITATING FLOWS OVER VARIOUS 2D GEOMETRIES USING MODIFICATION TO THE TURBULENCE MODEL

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ABSTRACT

Cavitation often causes performance breakdown and damage. So, it is very essential to accurately predict and control this phenomenon. In the present study, the unsteady effects associated with cavitation are investigated for various geometries including a NACA 0015 hydrofoil, a convergent-divergent nozzle, and a wedge, using the flow solver FLUENT. The turbulent viscosity and/or the turbulence dissipation in the k-epsilon turbulence model are modified. The cavitation phenomenon is represented based on the full cavitation model developed by Singhal et al. (2002), and it considers the liquid-vapor mixture as a homogeneous fluid whose density varies with respect to the static pressure and whose mass fraction is known in advance. Also, this model takes into account the formation and collapse of the vapor bubbles. The k-epsilon model was originally developed for fully incompressible fluids, and does not account for highly compressible two-phase mixtures. Hence, it has been found to be unsatisfactory for predicting cavitating flow in presence of high compressibility in the vapor region. Coutier-Delgosha et al. (2001) attributed this to the over-prediction of eddy viscosity in regions of flow with high vapor concentration, and suggested a modification for the calculation of eddy viscosity. Though the modification works in capturing the dynamic behavior of the cavitation sheet, the accuracy of cavity length and frequency are not accurately predicted for high cavitation numbers. This is due to inability of Coutier-Delgosha's turbulence modification to completely account for all the complex flow features present in the cavity closure region. Thus, a further modification based on geometry and cavitation type is introduced in the turbulence modification of Coutier-Delgosha. Better results were obtained for moderate cavitation numbers, but this modification failed to accurately predict the frequency of vapor-cloud shedding at high cavitation numbers. This discrepancy is attributed to the large (40000:1) variation of density in the liquid-vapor region. Hence, a new modification is suggested in the present work where the closure coefficients of dissipation production (C1epsilon) and dissipation (C2epsilon) in the turbulent dissipation equation are dynamically varied in the liquid-vapor region. A User-Defined Function (UDF) is implemented in FLUENT to achieve this dynamic variation of the above mentioned closure coefficients.

This modification is being tested to predict the time-averaged cavity length and vapor-cloud shedding frequency of cavitating flow over a NACA 0015 airfoil. The poster will present comparisons of cavity length and vapor-cloud shedding frequency over a wide range of cavitation numbers as predicted by the present and previous turbulence modifications and those observed in experimental studies.