ABSTRACT

NUMERICAL SIMULATION OF CAVITATING FLOWS BY THE SPACE-TIME CONSERVATION ELEMENT AND SOLUTION ELEMENT METHOD

by

JIANRONG QIN

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Advisors: Prof. Sheng-Tao Yu

Prof. Ming-Chia Lai

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Cavitation is a common phenomenon for many engineering devices. The inception, development, and collapse of cavitation produce noise, vibration, and even damage to solid wall surfaces. We developed a model for cavitating flows based on the Space-Time Conservation Element and Solution Element method in conjugation with a homogeneous equilibrium cavitation model.

Commercial codes were used to preliminarily predict internal flows through VCO and mini-sac nozzles and subsequent spray behavior. The numerical results show that nozzle design has strong influences on the exit flow and its subsequent spray atomization. Cavitation may occur at the orifice entrance under high injection pressure. Due to the lack of cavitation model, the predicted discharge coefficients are larger than experimental observations.

A one-dimensional model was developed to simulate cavitating flows through pipeline systems. The numerical simulation captured the acoustic waves and shocks in excellent agreement with our theoretical analysis. The predicted pressure histories at

upstream and downstream valves agree well with existing experimental data in terms of amplitude and period.

A two-dimensional model was developed to simulate cavitating flows over hydrofoils and through fuel injectors. The flow field and cavitation over hydrofoils were favorably predicted, as compared with experimental observations. Under different conditions, cavitating flows through fuel injectors generated hydraulic flip, supercavitation, and cyclical cavitation, which are commonly observed in experiments. Cavitation inside the nozzle explains the spray angle oscillation in experiments. Numerical simulation also demonstrated different inception mechanisms of cavitation: boundary layer separation, strong large-scale vortex, and suction force produced over curvy surfaces.