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A Comparative Study of Transport Equation Models for Prediction of Cloud Cavitation in a Venturi

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Extended Abstract

Cavitation is a phenomenon of the formation of vapor bubbles when the flow pressure drops below the saturation vapor pressure of the liquid. The collapse of these vapor bubbles in high pressure regions usually have negative impact in many applications. While experiments will give some insights into the flow dynamics, it is economical to conduct numerical simulations to obtain preliminary designs. It is of importance to understand the phenomenon in more detail so that the numerical models are better at predicting the cavitation phenomenon. One of the numerical approaches is the use of homogeneous transport equation model along with RANS equation. The majority of cavitation models used in homogenous approach are mainly based on local pressure with other physical and empirical parameters attached to it[1]. There are new class of models which are based on velocity divergence term and one such model was proposed by Goncalves[2]. It is important to study the performance of this new class of models. Usually, cavitating flows have coupling between cavitation and turbulence and hence it is important to also focus on how turbulence properties vary with various cavitation models. The cavitation models are coupled with the $k - \omega$ Shear Stress Transport Scale-Adaptive Simulation (SST-SAS) model[3] as the RANS model to simulate cloud cavitating flow inside a venturi using interPhaseChangeFoam, an incompressible multi-phase flow solver in OpenFOAM[4]. An opensource solver is chosen in the view that it accessible to more people. In this study, the results obtained from Goncalves model[2] is compared with a standard model, Merkle model[5] to see the effectiveness of cavitation models made with velocity divergence terms. Also, comparisons between simulations and high-fidelity data obtained from X-ray Particle Image-Velocimetry (PIV) experiments are made for the mean flow and turbulence properties on global and local scale, with the help of statistical tools like SPOD[6] and DMD[7].

The results obtained from Merkle model show good agreement with the experimental data. In Fig. 1, the mean streamwise velocity has been compared between the Merkle model and experimental data, at different streamwise locations. In Fig. 2, a cavity evolution plot is generated for the Merkle model and the cavitation length obtained from experiments is indicated to show that the required cavitation length is generated from simulations. Cavity evolution plot is obtained by taking minimum density along cross stream direction at each streamwise location for each time step and it represents the unsteady cloud cavitation behaviour.

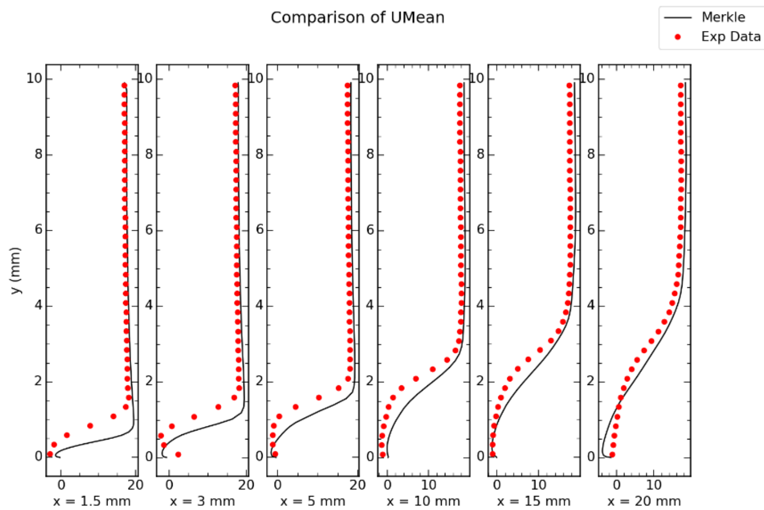

Fig. 1: Comparison of streamwise mean velocity between Merkle model and experiment.

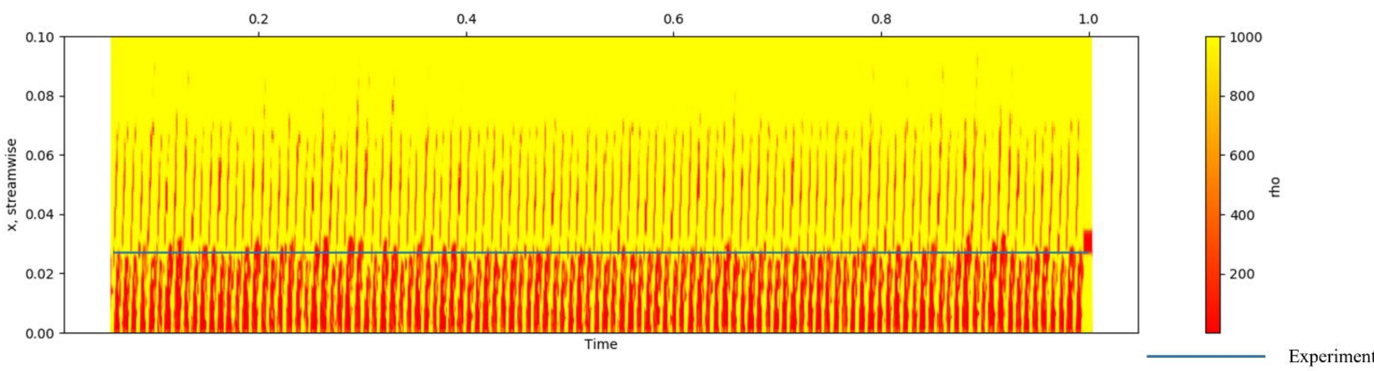

Fig. 2: Cavity evolution plot obtained from Merkle model.

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