Multi-Scale Euler-Lagrange Approach to Assess Cavitation Erosion in Hydrodynamic Flows
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ABSTRACT

Cavitation occurs in flows around different ship appendages such as propellers and rudders. Except for naval or special purpose ships, all propellers face cavitation under certain conditions because of inevitable inhomogeneous inflow conditions. Different types of cavitation can cause a loss in propeller efficiency, vibrations in the ship's structure, radiation of noise, and erosion of material surfaces. Erosion of ship appendages leads to additional repair and maintenance times and generates additional costs for ship owners. The prediction of cavitation erosion from model tests of propellers is only qualitative and afflicted with scale effects. Seizing on these ideas, numerical approaches to predict cavitation erosion have acquired increased importance. As soon as microscopic cavitation nuclei reach regions of low pressures evaporation processes start on their outer walls leading to the growth of larger cavitation bubbles. In regions of higher pressures, cavitation bubbles collapse aggressively and may damage material surfaces if located in their vicinity. Numerical models for cavitation in technical flows, mostly assume a continuous vapour phase while neglecting the behaviour of single cavitation bubbles. To gain more information about cavitation behaviour, a Lagrangian approach enables the simulation of motions and dynamics of single bubbles. Although Lagrangian approaches reveal more details about single bubble behaviour the computational costs are significantly higher compared to Eulerian approaches. In the present work, we used a hybrid multi-scale method to treat larger vapour structures on a Eulerian grid while smaller vapour volumes were tracked using a Lagrangian approach [1,2]. We used a Navier-Stokes based solver to simulate the cavitating flow in an axisymmetric nozzle and over a NACA 0015 hydrofoil. The liquid phase was treated as a continua in the Eulerian framework. Larger vapour structures were also treated in the Eulerian framework using the volume of fluid method together with the cavitation model of Sauer and Schnerr [3] to account for processes of vaporization and condensation. Small, isolated vapour structures were treated as spherical bubbles whose motions were obtained by solving a Lagrangian equation and whose dynamics were obtained by solving a Rayleigh-Plesset type equation. Information from bubble collapses close to solid surfaces were used to assess the potential of cavitation erosion.

REFERENCES

[1] A. Peters and O. el Moctar, "Numerical assessment of cavitation-induced erosion using a multi-scale Euler–Lagrange method", *Journal of Fluid Mechanics,* 894, A19. doi:10.1017/jfm.2020.273 (2020).

[2] A. Peters, "Numerical Modelling and Prediction of Cavitation Erosion Using Euler-Euler and Multi-Scale Euler-Lagrange Methods", PhD Thesis, University of Duisburg-Essen, Duisburg, Germany (2020).

[3] J. Sauer and G. H. Schnerr, „Unsteady Cavitating Flow - a New Cavitation Model Based on Modified Front Capturing Method and Bubble Dynamics", *Proceedings of the 6th International Symposium on Cavitation,* CAV2006, Wageningen, Netherlands (2006).