A Method for the Coupling of Compressible 3D Flow Simulations with a Cavitation Erosion Model for Ductile Materials and Assessment of the Incubation Time

Felix Schreiner*, Stephan Mottyll and Romuald Skoda

Chair of Hydraulic Fluid Machinery
Ruhr University Bochum
Universitätsstraße 150, 44801 Bochum, Germany
e-mail: felix.schreiner@ruhr-uni-bochum.de, web page: www.hsm.rub.de

* Corresponding author

ABSTRACT

It is assumed that cavitation erosion is associated with pressure wave dynamics and shock waves in the fluid. For the prediction of cavitation erosion, 3D compressible volume-of-fluid CFD methods with a Riemann solver and barotropic cavitation model are therefore utilized. The void collapses and the peak pressure are determined by a mass flux divergence criterion [1]. Time steps in the range of nano seconds ensure an adequate resolution of the peak pressures. Due to this extensively fine temporal resolution, an explicit time scheme is applied. It has been demonstrated that an accurate assessment of erosion sensitive wall zones is achieved by the statistical evaluation of the wall load – i.e. wall load collectives – induced by void collapses and the subsequent shock waves [2,3]. Beyond the qualitative assessment of cavitation erosion by erosion sensitive wall zones, for a quantitative evaluation of the incubation time, an erosion model taking into account material parameters is included in the computational method. In the present study, a compressible 3D flow solver in terms of an in-house extension to OpenFOAM is coupled to a simple erosion model for ductile materials [4]. Load collectives are evaluated and serve as input for the erosion model. Grid dependence is carefully assessed. To capture realistic time scales where the material is exposed to the void-collapse induced load, a method for the time extrapolation of the simulation wall load collectives is presented. The simulation method is applied on an impinging water jet test case as well as on an ultrasonic horn case. The incubation time is assessed with a reasonable accuracy for both test cases.

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