Summary of Deliverable D4.1: Assessment of Previously Derived Surface Erosion Model
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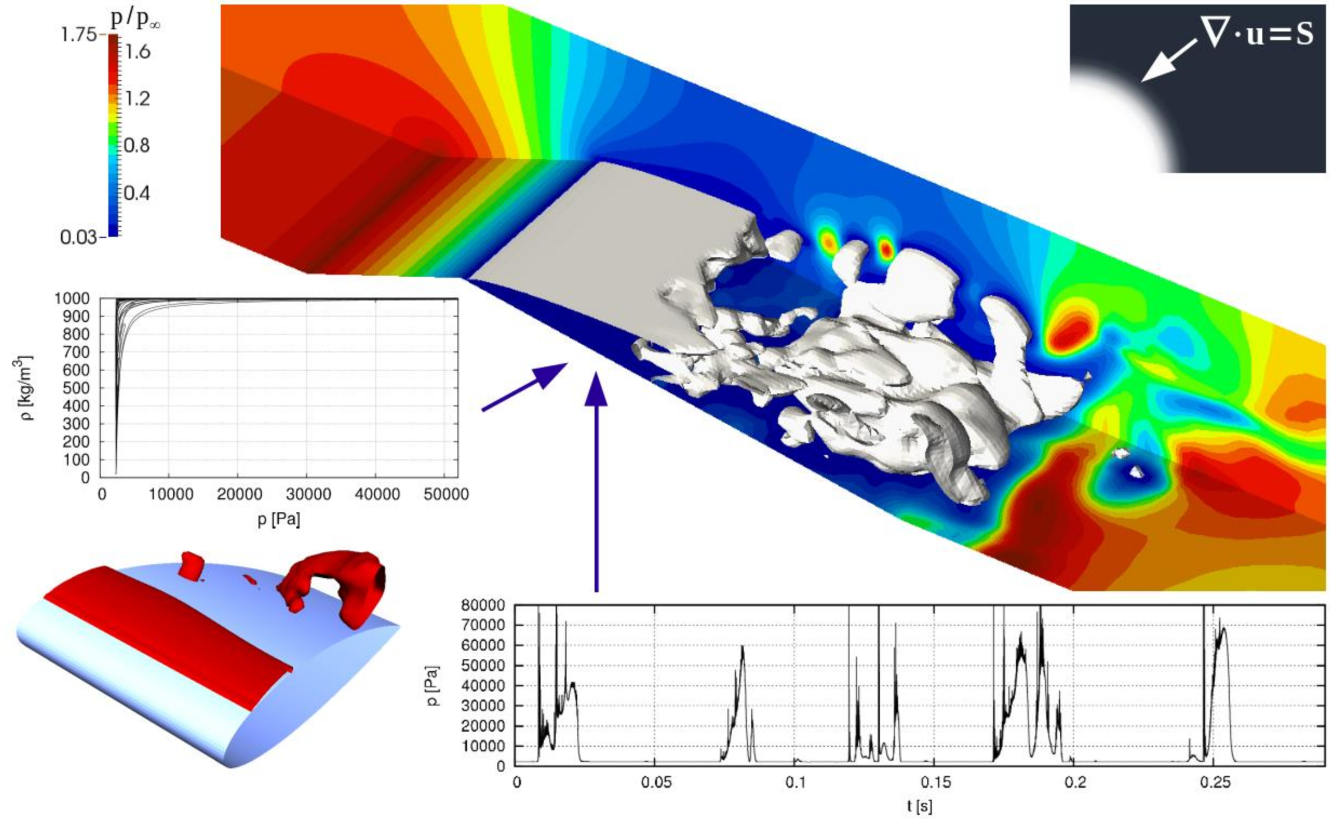

A surface erosion indicator function developed by Li (2012) is based on the idea that the erosive aggressiveness of cavitating flows is the result of power release during cavity collapse. The indicator function had been implemented as a post-processing tool in an incompressible RaNS solver, employing the mass transfer approach to model cavitation. Its applicability relies on the correct computation of local pressure time derivatives, at least on a level that is assumed to be the erosive threshold level.

Apart from the difficulty to define the erosive threshold level, the question whether the first pressure time derivative can be predicted by such flow solvers with sufficient accuracy, is not fully answered yet. The model parameters of mass transfer models are typically considered as empirical. However, recent attempts to set the model constants in a more consistent way, irrespective of which cavitation model is applied, are based on the assumption that the mass transfer model might eventually mimic an equilibrium-like flow, given that the mass transfer rates are sufficiently large (Koukouvinis and Gavaises 2015). The equilibrium flow condition is defined by the time scale of any internal process, e.g. phase transition, being negligibly small compared to the convective time scale of the flow (Sezal 2009).

In this study, the effect of mass transfer rate on the dynamics of cavitating flows has been studied. The open source CFD package OpenFOAM has been employed. To isolate the effect of mass transfer rate on density-pressure coupling, only the Euler equations have been solved. Studies on isolated bubble collapses as well as on the widely investigated cavitating wedge flow have been carried out.

It has been confirmed that sufficiently large mass transfer rates are required to obtain converged solutions for flow quantities such as shedding frequencies and pressure fluctuations. Sufficiently large temporal resolution has been identified as a second crucial requirement to satisfy the equilibrium flow condition. In fact, mass transfer rate and temporal resolution have been shown to go hand in hand. The interpretation of this is as follows:

1. Large mass transfer rates focus the evolution of peak pressures to densities close to liquid density. In the low density regime, pressure remains close to vapour pressure. The evolution of local density-pressure trajectories appears to be a useful indicator of the closeness to this condition.
2. The time step size of the simulation must be small with respect to the collapse time of characteristic cavities. Only by this means, the local phase transition can be effectively focused to small time intervals, given that the mass transfer rate is sufficiently large.

In summary, large mass transfer rates are required in combination with sufficiently small time steps to focus the local phase transition process to time intervals which are small with respect to both the convective time scale of the flow and the characteristic cavity collapse time. Only by this means, global flow quantities like vapour volume in the computational domain and cavity shedding frequencies exhibit convergent behaviour with respect to mass transfer rate and temporal resolution. Local peak quantities like peak pressures due to cavity collapses are more time step size dependent. However, they do not seem to affect the global flow dynamics as long as the equilibrium flow condition is met. This gives confidence that at least the dynamics in the erosive threshold regime are computed with sufficient accuracy. As such, this study further supports the idea that the parameters of mass transfer models are not as empirical as often assumed. The equilibrium flow approach will be further applied to viscid flows. With the density-pressure coupling being correct, the effect of viscosity on the vorticity of cavitating flows can be isolated. This will be a step towards identifying the origin of erosive cavitating vortices.