Numerical assessment of cavitation erosion in a high-pressure fuel injector

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Numerical cavitation erosion assessment of industrial high-pressure fuel injectors is still challenging as it requires computationally expensive simulation of flows with a wide range of time and length scales. This study aims to provide a numerical methodology for experimentally available high-pressure (2200 bar) Woodward L'Orange fuel injector. The experiment had been carried out with two separate, fixed, high and low lift needle positions. Same conditions are numerically investigated to provide comparison to that experiment.

A periodic single hole geometry is simulated with a pressure-based finite volume solver in the commercial Ansys Fluent software. Cavitation erosion assessment is examined with the collapse detector algorithm method, previously applied by Mouvanal [1].

Unsteady Reynolds-averaged Navier-Stokes (URANS) turbulence modelling is employed with k-Omega SST [2]. Here, the turbulence viscosity is retreated with Reboud's correction [3]. Besides the URANS approach, scale-resolving simulations are also carried out. Assuming a homogeneous mixture, cavitation is modelled via the mass transfer approach. Hence, the Zwart-Gerber-Belamri cavitation modelling is used with altered model coefficients.

Below, the figure on the left, shows the photograph taken at the end of experiment. Here, the geometry is filled with an epoxy material, which fills gaps of the eroded material. On the right, numerical result from the URANS solution is presented. Here, the maximum collapse pressure on the injector nozzle wall during the simulation period is recorded and presented with a contour plot.

References

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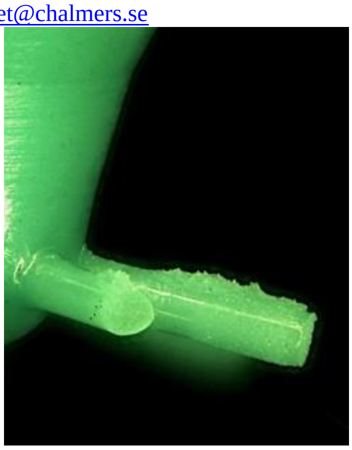

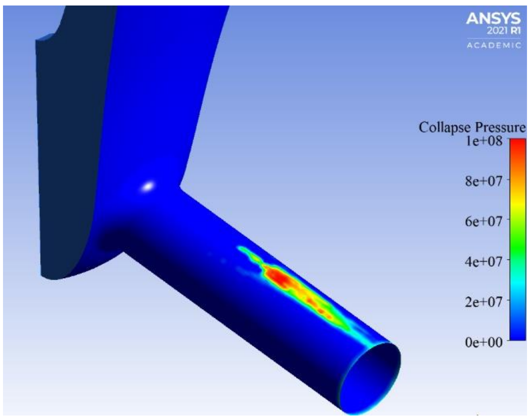

Figure 1: Comparison of the experimental (left) and numerical result (right) for high lift condition