Comparison of Various Models for Transient Nozzle Flow Simulations Including Time-Resolved Needle Lift

S. Jollet*, T. Willeke, F. Dinkelacker
Institute of Technical Combustion (ITV)
Leibniz University of Hanover
Welfengarten 1a, 30167 Hannover, Germany

Injection systems of modern diesel engines are one of the key components to increase the fuel efficiency and to lower pollutant emissions. Therefore, a detailed understanding of the spray generated by the injector nozzle is crucial to optimize the process of the mixture formation, ignition, combustion, and emission. In diesel injection systems the spray formation is significantly influenced by the internal flow of the injector and often influenced by cavitation [1]. Increasingly important is the transient flow behavior during the needle lift. The aim of this study is the time dependent numerical simulation of the internal flow processes including the multiphase processes with special emphasis to the time dependent variation of the needle. The injector consists of a needle with an adapted needle cone geometry and a nozzle body, which is a 8-hole blind hole nozzle. The holes have a diameter of $d = 247\ \mu m$ with cylindrical geometry and sharp inlet. Experimental test data from a cold injection chamber provide boundary conditions and serve as a plausibility check. The injector needle movement is realized by a dynamic mesh. Several models have been evaluated. These were the combinations of two multiphase models (Eulerian and Mixture model) [2], two cavitation models (Schnerr-und-Sauer, Zwart-Gerber-Belamri) [3] [4]. A suitable combination is found from subsequent studies. Also the influence of vapour pressure was investigated. First results show strongly asymmetric two phase regions inside the nozzle for the transient initial and final part of the injection.

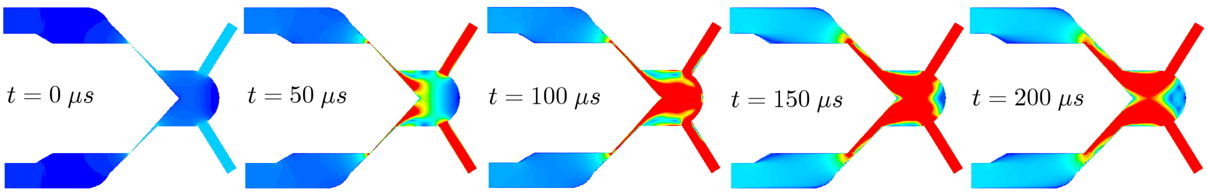

Figure 1. Time-dependent velocity inside the injector during the opening of the needle ($t = 0;\ 50;\ 100;\ 150;\ 200\ \mu s$)

During the opening process (Figure 1) of the needle the cavitation area increases, while in the steady open state it reduces. The influence of details of geometry between needle and needle seat is clearly visible, as here the momentum wave of the fluid is starting. It is found that the multiphase models have a bigger influence on the nozzle flow compared to the cavitation and the vapour phase models. In accordance with literature, a cavitation area was observed for all of the mentioned models at the flow-induced orifice of nozzle hole inlet. In the nozzle appears a cavitation zone at the opposite side of the inflow.

As a conclusion, the multiphase models have a bigger influence on the nozzle flow compared to the cavitation and the vapour phase models. In accordance with literature, a cavitation area was observed for all of the mentioned models at the flow-induced orifice of nozzle hole inlet.

For further work, the comparison of the macroscopic spray simulation with measured data obtained from an injection chamber is planned.

[1] Walther, J. *Quantitative Untersuchung der Innenströmung in kavitierenden Dieseleinspritzdüsen*, Dissertation, TU Darmstadt, Deutschland(2002).
[2] Brennen, C.E. *Fundamentals of Multiphase Flow*, Cambridge University Press, (2009).
[3] Schnerr, G.H., Sauer, J. *Physical and Numerical Modeling of Unsteady Cavitation Dynamics*, In Fourth International Conference on Multiphase Flow, New Orleans, USA, 2001.
[4] Zwart, P.J., Gerber, A.G., Belamri, T. *A Two-Phase Flow Model for Predicting Cavitation Dynamics*, In Fifth International Conference on Multiphase Flow, Yokohama, Japan, 2004.

*Corresponding author: jollet@itv.uni-hannover.de