Coupling 1D System AMESim and 3D CFD EOLE models for Diesel Injection Simulation

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Abstract

The paper describes an efficient way to couple 1D System AMESim and 3D CFD EOLE softwares together for the simulation of Diesel injection. The strong coupling model is based on a co-simulation approach. AMESim and EOLE are complementary tools with complementary approaches. From their combination, a very efficient tool is built able to model all the injection line from the Common Rail Injection up to the nozzle.

Introduction

In order to improve the simulation of Diesel injection, a coupling has been carried out between the 1D LMS Imagine.Lab AMESim software allowing the Common Rail Injection system modelling, and the 3D EOLE CFD code able to simulate the specific 2-phase flow in the nozzle including cavitation phenomena. Indeed, AMESim nozzle simple models are useful to predict in a first approach the global dynamic behaviour of the system but for more accurate results, 3D CFD local models are needed to go further for the injector nozzle. The paper describes the co-simulation 1D AMESim /3D EOLE model and shows validation results based on some comparisons with experiments.

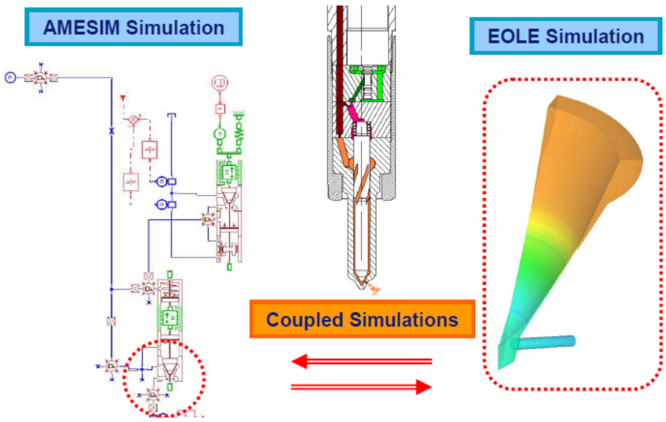

Figure 1. coupled AMESim / EOLE simulations of the injector nozzle

Methods

AMESim is a powerful software for 1D system approach based on a multiport representation of physical and technological components. Simulation of the complete system is issued using description of physical phenomena based on few macroscopic parameters. The model is an assembly of components which are described with analytical or tabulated models. Static and dynamic responses in time and frequency domains are issued. The AMESim model relates to the complete injector.

The 3D CFD code (EOLE) is used to simulate the cavitating flow around the nozzle. The code is based on a multiphase Navier-Stokes model using a VOF interface method allowing to compute the unsteady behaviour of the cavitation taking into account the mass tranfer process at the liquid/vapour interfaces. The dynamic motion of the needle in the injector is computed with a multi-blok grid deformation technique. Thus the EOLE model focusses on the local area around the nozzle.

The strong coupling between AMESim and EOLE is based on a co-simulation approach in which a direct local link is considered. The master is the 3D CFD code and the 1D system model is the slave, meaning that AMESim is called by EOLE at each time step in the same time loop. The variables exchanged are on one hand

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the flow rate and the needle force (EOLE to AMESim) and on the other hand the pressure (upstream and chamber) and the needle lift (AMESim to EOLE).

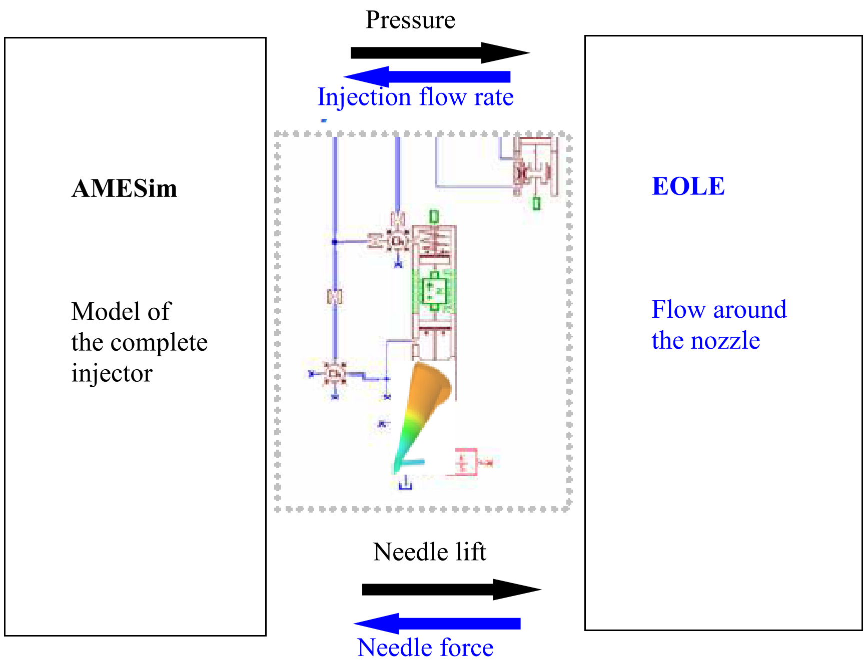

Figure 2. 1D_sytem / 3D_CFD interface in the complete injector model the nozzle component is computed with CFD

Results and Discussion

Quantitative validations have been carried out based on comparisons with measurements and with the uncoupled AMESim model (calibrated on experiments), for various operating points up to 160 MPa (injection pressure) into 5 MPa (chamber pressure). The needle lift, the pressure, the flow rate and the needle force are computed during a needle lift cycle.
Figure 3 shows an example of flow rate results for the operating point 47.5 MPa into 5 MPa.

The 1D AMESim / 3D EOLE co-simulation model is efficient. The results are consistent with what was expected for pressure, flow rate and needle force. This feasability demonstrates the added value of using both 1D System AMESim and 3D CFD EOLE softwares together to catch details in the physical phenomena (especially cavitation) occuring during this fast transient.

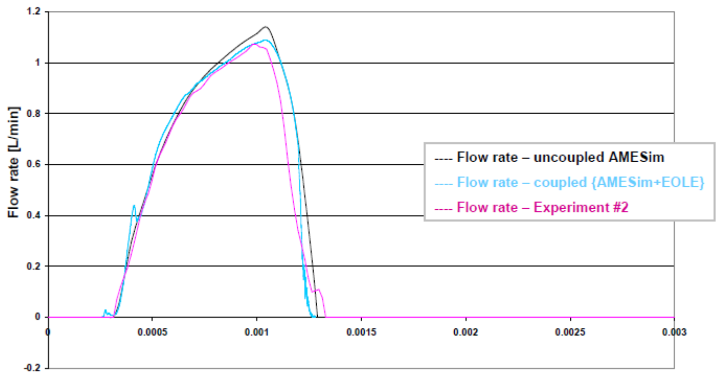

Figure 3. comparison of AMESim-EOLE coupled model and uncoupled AMESim model vs experiments

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