High Pressure Fuel Injector Valve Simulation using OpenFOAM

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Abstract:

A fuel injector is a device used to control fuel admission into an internal combustion(IC) engine. The injectors and their technology are continuously gaining interest among the manufacturers because of the stringent emission norms along with customer demands for smaller engines and advances in turbocharger. Hence the knowledge of the injector mass flow rate and the flow conditions at the nozzle exit are key parameters for all the subsequent processes of mixture formation, combustion and pollutant formation. The key parameters are thoroughly investigated and optimized for a particular set of operating conditions. As experiments can be difficult to manage for injection conditions (small-scaled, high-speed flow), a numerical simulation seems to be the appropriate tool to get a better understanding of the flow features inside and at the exit of the injector nozzle.

In this paper, high pressure fuel injector valve has been simulated using OpenFOAM. The physics of the problem is considered as transient, incompressible, turbulent and two-phase, hence interFOAM solver is used. The inlet pressure is at 200bar and outlet is at ambient pressure. Due to high pressure difference down the stream, velocity fluctuations are too high at injector nozzle which makes interFOAM solver unstable. Hence velocity field is initialized with results obtained from simpleFOAM to make it stabilize. The variables like mass flow rate at nozzle planes, beam and cone angles are evaluated using Ensight post-processing tool. The results obtained are compared with commercial code results and validated. interFOAM results are pretty acceptable.

Further investigation on fuel injector is carried out to evaluate cavitation phenomenon at the injector hole using interPhaseChangeFOAM. As the solver can handle only two phases, fuel and fuel vapor are considered. Entire domain is initiated by fuel and the resulting fuel vapor generated is observed as per expectations.