During the opening and closing process of a Diesel injector, the fuel characteristics at the nozzle exit change significantly as a consequence of the needle movement. This change of fluid properties at the exit of the discharge orifices strongly affects the spray pattern and the air-fuel mixing process, and therefore its subsequent combustion. However, despite its relevance, there are a lot of aspects about the injection process which still remain unclear due to the huge difficulties to perform experiments at partial needle lifts.

For that reason, the current Thesis is focused on the influence of the needle lift on the internal flow in Diesel injection nozzles. This study has been carried out with 3D simulations at cavitating and non cavitating conditions, using a homogeneous equilibrium model implemented in OpenFOAM.

Before analyzing in depth the influence of the needle position, the code has been tuned up and validated with experimental data in a calibrated orifice, a one-hole nozzle and a multi-hole nozzle at fully needle lift conditions. The cavitation model has shown a fairly good agreement with experimental results in terms of mass flow, momentum flux, effective velocity, flow coefficients and cavitation appearance. Nevertheless, the computational and experimental results have not been used only for the code validation, since they have been also used to analyze some phenomena related to cavitation, such as the mass flow collapse or the velocity and turbulence rise.

Once the code has been validated, it has been used to study the influence of the needle lift in a real microsac nozzle. Initially, this nozzle has been simulated at different fixed partial needle lifts applying RANS methods. In this study, focused on the fuel characteristics at the nozzle outlet and the cavitation development, it can be seen a significant shift of the cavitation pattern depending on the needle position: at high needle lifts, the vapour flows along the upper surface of the orifice, whereas for low needle lifts, cavitation appears in the needle seat, as well as in the lower part of the orifice for the lowest backpressures. This fact has a strong influence on the mass flow, momentum flux and effective velocity values, which barely change for needle positions higher than 75 μm.

The effects of the needle position at fixed partial needle lifts have been also studied with LES methods. The use of Large Eddy Simulation has provided relevant information about the internal flow, specially related to the turbulence development and its interaction with cavitation phenomenon. It has been proved that cavitation enhances turbulence, and therefore an important shift of the turbulence levels and the most turbulent region in the nozzle can be expected depending on the needle position. However, there is a certain interaction or interdependence between both phenomena, since turbulence has significant effects on the vapour phase’s appearance. Moreover, it has been demonstrated the increase of vortexes in the flow and the decrease of their sizes as the needle descends.

Finally, the effects of the needle lift have been analyzed with a moving mesh, which allows the reproduction of the needle motion during the injection process. This study has been performed thanks to the modification of the code and it has been used with boundary conditions obtained from a 1D model of the injector created in AMESim. On the one hand, the results obtained at stationary and transient simulations have been compared, showing negligible differences in the fuel characteristics at the nozzle outlet. Nevertheless, it has obtained less cavitation at transients simulations, specially at low needle lifts. On the other hand, the experimental injection rate has been compared against those obtained from OpenFOAM and AMESim. This comparison has demonstrated the great potential of AMESim and the good behaviour of OpenFOAM to predict the injection rate.