Multiphase Injector Modeling for Automotive SCR Systems

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Abstract

Advances in emission control technologies have seen the introduction of Selective Catalyst Reduction (SCR) systems as a method for NOx decontamination in light and heavy duty vehicles. SCR systems make use of a urea-water solution (UWS) injected directly into the exhaust gas stream for the reduction of NOx contaminants to Nitrogen (N2) over a base metals catalyst (Boorse & Dieterle, 2012). The effectiveness of an SCR system depends on many factors including the type of catalysts, the injection and mixing pattern of the UWS, temperature and more (Skalska et. al. 2010). Spray analysis involves multiphase flow phenomena and requires the numerical solution of the conservation and transport equations for the gas and the liquid phase simultaneously. Spray-wall interactions mechanisms such as droplet splash, spread, rebound or stick are complex to model and directly affected by the injector parameters (Abu-Ramadan et. al. 2012). The accurate modelling of the UWS injector can help in the prediction of phenomena such as wall film formation, droplet evaporation and urea crystallisation (Birkhold et. al. 2006). This study presents a series of multiphase numerical analyses, computed with the commercial software AVL Fire 2014 v, to measure the impact of injection velocity, visualisation angle and droplet size, in the overall performance of an SCR system. The analysis consisted of a completely mixed turbulent flow, solved using a two equations turbulence model (k-z). The interaction of the injected particles were solved with an Euler/Lagrange approach, the liquid phase calculation was based on the statistical Discrete Droplet Method interacting with the numerical solution of the conservation equations of the flow pattern. It was found that the injector parameters had an impact on the final results of the ammonia uniformity index and the back pressure behaviour of various components within the SCR system. The method applied in this work successfully predicted the performance of an SCR system and allows for its further optimization.

References

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