

SCR 시스템에서 우레아 수용액 및 우레아 침전물 형성의

분무 벽면 충돌에 관한 연구

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A Study on the Spray Wall Impingement of Urea-water Solution and Urea Deposit Formation in SCR System

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Even though urea-SCR is the most felicitated automotive exhaust after-treatment solution for nitrogen oxides (NOx) emission reduction from diesel engines, it is not without problems. The residence time in the silencer is very short and it is, therefore, necessary to have a well designed and efficient urea injection where the urea-water solution can evaporate quickly. Moreover, solid deposit may form due to wall impingement and incomplete urea decomposition. Therefore, the most challenging things for the implementation of the urea-SCR system are urea decomposition and mitigation of deposit formation. Urea-water solution spray wall impingement is a key parameter affecting the performance factors, has not been researched well. The characteristics of the UWS spray and wall impingement has been identified by experimental investigation and numerical simulation that may affect the urea decomposition and deposit formation. In this study, the influence of certain spray and wall impingement characteristics on the droplet evaporation as well as urea decomposition and wall film formation has been investigated. Moreover, solid deposit formed due to incomplete urea decomposition has been analyzed by FTIR and TGA measurements to find the chemical composition and decomposition behavior of urea deposit products.

The experimental investigation has been carried out in the test rig that was designed to obtain the simulated exhaust flow condition. A commercial pressure driven SCR injector was mounted in the perpendicular direction to the exhaust flow into the optical chamber. The spray and wall impingement has been captured by high-speed shadowgraph imaging. The spray cooling due to wall impingement have been measured by using infrared thermography.

The numerical analysis of UWS spray wall impingement and urea decomposition has been conducted by using STAR CCM+ CFD code. The turbulence flow was modeled by realizable $k-\epsilon$ two-layer model together with standard wall function and all y^+ treatment along with two-layer approach. The Eulerian-Lagrangian approach was implemented for the modeling of multiphase flow and urea-water spray droplets. Specially developed user-defined functions (UDF) were implemented to simulate the desired conditions.

Relevant dimensions of spray and wall impingement images were estimated by digital image processing. The investigation reveals that higher injection pressure results longer spray penetration that may increase the risk of wall impingement and wall wetting which leads to deposit formation. Wall temperature has a great impact on spray development after impingement. High wall temperature causes longer spray front projection length, better droplet evaporation and smaller film area. Though injection pressure is dominant on droplet size, exhaust temperature has also significant effects on droplet size and evaporation. Spray injection causes local cooling that effects on urea decomposition and relatively high temperature is needed for the complete decomposition of urea.

The FTIR analysis shows that various chemical components present in the deposit sample relying on temperature. Undecomposed urea, biuret, cyanuric acid, melamine, ammeline etc. are the major components presents in deposit samples. The TGA measurement shows that majority of the urea deposits decompose around 400° C temperature, but it requires a long time for complete decomposition.

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