Proceedings of the 11th World Congress on Mechanical, Chemical, and Material Engineering (MCM'25)
Paris, France - August, 2025
Paper No. HTFF 193
DOI: 10.11159/htff25.193

Design Modification Methodology for Diesel Injector Adaptation to DME Fuel Using 1D Simulation with AMESim

Jinwoo Lee[1]
[1]School of Mechanical Engineering, Ulsan College
57 Daehak-ro, Ulsan, South Korea
jwlee2@uc.ac.kr

Extended Abstract

As regulations on greenhouse gas emissions become increasingly strict, alternative fuels like dimethyl ether (DME) are drawing growing attention as potential substitutes for conventional diesel. DME offers many advantages, such as a high cetane number, high oxygen content, and the absence of carbon-carbon bonds, resulting in cleaner combustion characteristics [1]. However, its lower viscosity, density, and elasticity compared to diesel pose significant challenges for adapting conventional diesel fuel injection systems. Especially, DME requires a higher fuel mass flow for equivalent engine output, along with different internal flow behavior inside the injector.

This study investigates how DME application affects diesel injector performance by developing a one-dimensional (1D) injector model using AMESim. The injector geometry was reconstructed from 3D drawings, and the model was validated through experimental injection rate measurements [2]. By incorporating detailed descriptions of nozzle flow, control chamber dynamics, and needle motion, the model allowed systematic analysis of injection behavior under both diesel and DME conditions.

Traditionally, efforts to adapt DME fuel into diesel injection system have focused on increasing nozzle hole diameters to accommodate the higher volumetric fuel demand. However, this approach alone can induce undesirable phenomena, such as excessively early peak injection rates and delayed end-of-injection timing, as identified in this study. To address these issues, detailed injector internal redesigns were applied using the AMESim-based 1D model. In particular, increasing the discharge coefficient (Cd) of the OA orifice proved to be highly effective in balancing the injection dynamics without relying solely on nozzle diameter enlargement.

Simulation results showed that, compared to diesel under the same commanded injection duration, DME led to an earlier actual injection start, a slower initial injection rate slope, and a higher peak volumetric injection rate, mainly due to its lower viscosity and density [3]. During the closing phase, DME exhibited delayed sac pressure decay due to high Reynolds number effects. Through internal redesign strategies, a significant portion of these problematic behavior was mitigated, demonstrating the importance of multi-faceted design optimization rather than simple dimensional changes.

In summary, the 1D injector model provided clear insights into how injector behavior changes when using DME instead of diesel. The findings highlight that targeted nozzle and orifice design improvements—beyond simple nozzle diameter enlargement—can effectively address the challenges posed by DME's physical properties. This study emphasizes the important role of AMESim-based simulation in systematically guiding the design and optimization of injectors for future clean combustion technologies.

References

[1] H.K. Suh and C.S. Lee, "Experimental and analytical study on the spray characteristics of dimethyl ether (DME) and diesel fuels within a common-rail injection system in a diesel engine," *Fuel*, vol. 87, issue 6, pp. 925–932, 2008.
[2] M. Coppo and C. Dongiovanni, "Experimental Validation of a Common-Rail Injector Model in the Whole Operation Field," *Journal of Engineering for Gas Turbines and Power*, vol. 129(2), pp. 596-608, 2006.
[3] S. Xu, Y. Wang, X. Zhang, X. Zhen and C. Tao, "Development of a novel common-rail type Dimethyl ether (DME) injector," *Applied Energy*, vol. 94 pp.1-12, 2012.

ACKNOWLEDGEMENT

This work was supported by the Industry-Academia Collaboration Project "Development of Injector Analysis Technology for Eco-Friendly Fuel Engines" (202420342) and the Korea Institute for Advancement of Technology (KIAT) Project "Development and Demonstration of Core Components for Pressurization and Injection of Ammonia over 500 bar in Marine Internal Combustion Engines" (RS-2025-02702996).