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Use of Hydrogen in compression ignition engines: techniques for reducing NOx Emissions

Abstract: The use of gaseous hydrogen (H2) in compression ignition (CI) engines is a viable option for simultaneously addressing the challenges of improving energy efficiency and reducing emissions, including greenhouse gases, as combustion produces only H2O. However, the use of H2 as a fuel in CI engines involves several issues such as combustion knock, high in-cylinder peak pressures and temperatures, and elevated NOx emissions. Additionally, the injection of H2 into the intake manifold leads to a reduction in volumetric efficiency because H2 displaces intake air during the intake stroke. On the other hand, the high diffusivity of hydrogen allows for a near-perfect mixture with air, achieving almost complete homogeneity when introduced into the combustion chamber. The high burning rate of H2 could also facilitate further optimization of the combustion process of diesel fuel, aiming to improve engine performance. Moreover, the use of H2 in dual-fuel diesel engines results in lower particulate matter (PM) emissions due to a more homogeneous charge, as well as a reduction in carbon dioxide (CO2), carbon monoxide (CO), hydrocarbons (HC), and PM emissions compared to fossil fuels. This work addresses key emission control strategies such as exhaust gas recirculation (EGR), water injection (WI), and reducing the compression ratio (CR). The impacts of these methods on NOx reduction, along with their effects on other performance metrics, have been analyzed in depth. The study shows that hydrogen can serve as an alternative fuel for CI engines when combined with proven techniques for reducing NOx emissions.

Keywords: hydrogen, diesel engine, emissions, clean combustion

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