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# Numerical Investigation of Combustion Chamber Geometry on Combustion Performance and Pollutant Emissions in an Ammonia-Diesel Common Rail Dual-Fuel Engine

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**Abstract :** As emissions regulations grow more stringent and traditional fuel sources become increasingly scarce, incorporating carbon-free fuels in the transportation sector emerges as a key strategy for mitigating the impact of greenhouse gas emissions. While the utilization of hydrogen (H2) presents significant technological challenges, as evident in the engine limitation known as knocking, ammonia (NH3) provides a viable alternative that overcomes this obstacle and offers convenient transportation, storage, and distribution. Moreover, the implementation of a dual-fuel engine using ammonia as the primary gas is promising, delivering both ecological and economic benefits. However, when employing this combustion mode, the substitution of ammonia at high rates adversely affects combustion performance and leads to elevated emissions of unburnt NH3, especially under high loads, which requires special treatment of this mode of combustion. This study aims to simulate combustion in a common rail direct injection (CRDI) dual-fuel engine, considering the fundamental geometry of the combustion chamber as well as fifteen (15) alternative proposed geometries to determine the configuration that exhibits superior engine performance during high-load conditions. The research presented here focuses on improving the understanding of the equations and mechanisms involved in the combustion of finely atomized jets of liquid fuel and on mastering the CONVERGETM code, which facilitates the simulation of this combustion process. By analyzing the effect of piston bowl shape on the performance and emissions of a diesel engine operating in dual fuel mode, this work combines knowledge of combustion phenomena with proficiency in the calculation code. To select the optimal geometry, an evaluation of the Swirl, Tumble, and Squish flow patterns was conducted for the fifteen (15) studied geometries. Variations in-cylinder pressure, heat release rate, turbulence kinetic energy, turbulence dissipation rate, and emission rates were observed, while thermal efficiency and specific fuel consumption were estimated as functions of crankshaft angle. To maximize thermal efficiency, a synergistic approach involving the enrichment of intake air with oxygen (O2) and the enrichment of primary fuel with hydrogen (H2) was implemented. Based on the results obtained, it is worth noting that the proposed geometry (T8_b8_d0.6/SW_8.0) outperformed the others in terms of flow quality, reduction of pollutants emitted with a reduction of more than 90% in unburnt NH3, and an impressive improvement in engine efficiency of more than 11%.

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