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Influence of Behaviour of Hydrogen Jet on Performance of Port Fuel Injection Hydrogen Engine for Heavy Duty Vehicles

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Extended Abstract

Research and development has begun on the conversion of existing diesel engines to port fuel injection hydrogen engines for medium and heavy-duty vehicles, in which use of electricity to achieve carbon neutrality is difficult due to the weight and volume of batteries that can be installed are insufficient to cover the cruising range [1]. Conversion refers to the removal of the injectors and common rail of a diesel engine and the installation of spark plugs and fuel injection devices [2]. An advantage of the conversion of an existing engine is that it has a lower introduction cost than zero-based development and production, and more rapid diffusion of heavy-duty vehicles equipped with hydrogen engines can be expected. However, a disadvantage of this conversion is that it requires limited modification of the engine geometry, including the intake manifold and intake port geometry. Therefore, whether the hydrogen jet injected through the nozzles is always properly delivered to the cylinder in a hydrogen engine to form an appropriate air–fuel mixture for the combustion phenomena there is unclear. Moreover, it is hard to determine whether the engine performance is maximized. To date, several studies have been conducted on port fuel injection hydrogen engines using computational fluid dynamics (CFD). Dhyani and Subramanian investigated the fundamental characterization of backfire in a port fuel injection hydrogen engine by conducting both CFD and experiments [3]. However, these studies have focused only on abnormal combustion, and there has been little discussion on improving the engine performance. In addition, few studies have been conducted on improving the engine performance of port fuel injection hydrogen engines using CFD.

In this study, the relationship between the internal flow field of a port fuel injection hydrogen engine and engine performance was investigated using CFD for a modified in-line four-cylinder 5L turbocharged diesel engine. Renormalization group k–ε model and SAGE detailed chemical kinetics solver were employed as the turbulence and combustion models, respectively. The flow field was assumed as a three-dimensional compressible viscous flow. The mesh was automatically subdivided using adaptive mesh refinement when the velocity and temperature gradients increased. Crank angle variation of in-cylinder pressure and equivalence ratio obtained from the engine tests of the port fuel injection hydrogen engine were compared with the CFD results to validate the CFD results. Subsequently, the influences of different nozzle mounting positions and angles on the behavior of the hydrogen jet and the flow field of the mixture in the cylinder were investigated. Consequently, the relationship between the behavior of the hydrogen jet as it passes through the intake port, combustion phenomena, and engine performance was clarified.

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