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The Effect of Self-Generated HHO on Diesel Engine Fuel Efficiency

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Abstract
The addition of HHO on the brake thermal efficiency and the specific fuel consumption was analyzed. The laminar flame speed for hydrogen is almost five times higher than that for most hydrocarbon fuels. Better homogeneity of the combustible mixture would provide better conditions for the complete combustion process. In addition, faster combustion becomes closer to constant volume causing an increase in the indicated efficiency. The analysis revealed that adding self-generated HHO affects the engine performance. The effect can be positive or negative depending on the operating condition of the engine. The reason for the high BTE is attributed to increase in heat release rate and improvement of the overall thermodynamic efficiency of the engine when mixed with hydrogen. A specific operating region of the engine where HHO could affect was identified.

Keywords Hydrogen energy · Brake thermal efficiency · Specific fuel consumption · Compression ignition

Abbreviations

HCCI	Homogeneous charged compression ignition
SI	Spark ignition
BTE	Brake thermal efficiency
ITE	Indicated thermal efficiency
Sfc	Specific fuel consumption

1 Introduction

With the scarcity of continuous fossil fuel supply and environmental concerns in the transport sector, scientists are in the extensive search for alternative fuels that have low impact on environmental pollution and emission of greenhouse gases. The current research trend for search of alternative energy sources for the transport sector is mainly on electricity, hydrogen and solar power (Azad 2019). Despite research trends, running vehicles with the aid of hydrogen generated as a result of electrolyzed water becomes a hot topic whenever the fuel price go up or when there is a fuel shortage in the local market. Further, there are many promotional publicity material and success stories shared on social media. In a nutshell, the process of running vehicles with water is to electrolyze water using electricity and to feed the hydrogen gas to the intake manifold to power the engine. A detailed review of theoretical background and results of experimental investigations on running an engine with hydrogen obtained by electrolyzing water is presented in the research paper.

Worldwide, around 50 million metric tons of hydrogen is consumed for various purposes such as production of ammonia, refining of petroleum products and refining of metals (Richards & Shenoy, 2007). The hydrogen required for such industrial applications are being produced mainly by a process called steam reforming using natural gas or coal with water in the presence of a nickel as a catalyst (Turner, 2004). Another way of producing hydrogen is by electrolysis of water. Extremely pure hydrogen can be produced by electrolysis of water. To produce 1 kg of hydrogen by means of electrolysis, 40.4 to 47.5 kWh of energy is required (Hodges et al., 2022). Accordingly, the cost of hydrogen production using grid electricity is 3–10 times expensive compared to steam reforming (Raissi and Block, 2004). Running internal combustion engines with hydrogen is not a new concept. It has been reported that "as early as the 1930s, over 1000 vehicles were converted to hydrogen and hydrogen/gasoline operation in England and Germany" (Das, 1990 and Santoso et al., 2013). Modern hydrogen powertrains utilize hydrogen in two different ways. The first method is to use hydrogen in a fuel cell where hydrogen is used to produce electricity and use the electricity on an electric motor for propulsion,

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