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# Hydrogen enriched waste oil biodiesel usage in compression ignition engine

Mustafa Atakan Akar [a], Emine Kekilli [b], Oguz Bas [a,*], Safak Yildizhan [a], Hasan Serin [a], Mustafa Ozcanli [a]

[a] Cukurova University, The Faculty of Engineerıng, Automotive Engineering, Adana, Turkey
[b] Cukurova University, Institute of Natural and Applied Sciences, Automotive Engineering, Adana, Turkey

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ABSTRACT

In the present study, hydrogen enrichment for biodiesel-diesel blends was evaluated to investigate the performance and emission characteristics of a compression ignition engine. Biodiesel was obtained from waste oil and blended to pure diesel fuel by volume fraction of 0%, 10% and 20%. After that, pure hydrogen was introduced through the intake air at different flow rates. Effects of pure hydrogen on performance and emission characteristics were investigated by evaluating power, torque, specific fuel consumption, CO, $CO_2$ and $NO_x$ emissions. Experimental study revealed that waste oil biodiesel usage deteriorated performance and emission parameters except CO emissions. However, the enrichment test fuels with hydrogen fuel can improve performance characteristics and emission parameters, whereas it increased $NO_x$ emissions. Brake thermal efficiency and specific fuel consumption were improved when the test fuels enriched with hydrogen gas. Because of absence of carbon atoms in the chemical structure of the hydrogen fuel, hydrogen addition dropped CO and $CO_2$ emissions but increment in cylinder temperature caused rising in $NO_x$ emissions.



## Introduction

Within last decades, there have been many advances in alternative fuel technology due to strict emission regulations and increasing energy demand [1,2]. Scientists searched for new alternatives to petroleum fuels. Biodiesel and hydrogen usage in internal combustions engines are two important alternatives to decrease fossil fuel consumptions.

Hydrogen is very promising because of their low ignition energy, high diffusivity, lower heating value, small quenching distance, high flame speed and wide flammability range [3]. Their carbonless atomic structure is also quite feasible from the point of obtaining lower carbon based emissions [4,5]. Nevertheless, hydrogen cannot be used solely in a compression ignition engine without any spark plug or glow plug because it has a very high self-ignition temperature which is 585 °C [6]. This makes hydrogen unsuitable as a sole fuel for compression ignition engines. In this regard, blending a fuel with hydrogen gas can improve the combustions quality and completeness. In terms of high diffusivity function, small amount of hydrogen induction into the cylinders provides a better premixed fuel [7]. Due to higher heating value of $H_2$ higher power output can be achieved without comprising from lower emission values. Besides,

* Corresponding author.
E-mail address: oguzbas06@gmail.com (O. Bas).
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high speed of flame propagation of hydrogen can reduce the combustion duration [8].

Hamdan et al. [9] reported increment in brake thermal efficiency while boosting hydrogen through intake manifold of diesel fuelled engine. Their results indicated that effect of hydrogen enrichment on engine efficiency is more remarkable at low engine speed and partial loading. Yet, hydrogen supplement increased $NO_x$ emissions caused by rising combustion temperature. Yang et al. [10] studied a method to show the hydrogen addition on the performance of diesel engine and how to determine best ratio of $H_2$ addition. They expressed hydrogen enrichment decreased PM emissions and gave the best results for maximum heat release at 17% $H_2$ by volume fraction. Uludamar et al. [11] tested different biodiesels and hydrogen addition to analyze noise and vibration of engine. Their results have shown that dominant frequency and peak values of pressure level of sound and vibration acceleration of the engine were regardless of fuel type and $H_2$ addition and strongly affected by engine speed. However, both biodiesel and hydrogen supplement in combustion decreased vibration and sound level slightly. Aldhaidhawi et al. [12] carried out experimental and numerical study of hydrogen enriched biodiesel-diesel blends and determined that hydrogen addition to Diesel and B20 fuels has not a significant effect on ignition delay because of its high ignition temperature.

Biodiesel is a clean renewable fuel which its usage in internal combustion engines can decrease the dependence on liquid fossil fuels, reduce emissions and boost the rural economy [3]. However, there are some minor drawbacks about biodiesel utilizing in a compression ignition engine. For instance, its high viscosity value deteriorates atomization of liquid fuel. Moreover, most biodiesels have lower calorific values, so their usage results in lower power output from the engine. Generally, higher $NO_x$ is emitted as a result of biodiesel combustion [13]. On the other hand, biodiesel can be produced from vegetable oils [14], animal fats [15–23] or waste oil [24–29]. Among them, biodiesel from waste oil brings advantages of cutting down production costs and as well as eliminating negative environmental effects of non-edible waste oil [30].

From this viewpoint, we motivated to utilize waste oil for biodiesel and improve its performance and emission characteristics with hydrogen enrichment. Experimental study was performed in compression ignition engine to evaluate these parameters.

## Materials and methods

### *Materials*

Schematic diagram of experimental set-up is shown in Fig. 1 and materials used in these experiments are listed below:

**Engine:** Performance tests were carried out naturally aspirated, water cooled, four stroke and single cylinder Kirloskar Oil Engine (CI Engine). Technical specifications of the engine are shown in Table 1.

**Dynamometer:** System was connected to AG10 Eddy current dynamometer.

**Gas Analyzer:** MRU Delta 1600 V gas analyzer was used to measure the exhaust gas emission values. This equipment was connected to host computer and using software of MRU.

**Performance measuring system:** Performance data were obtained with specific software of MRU via host computer.

**Air Filter:** Air filter was used to enhance air quality of the engine.

**Flow meter:** Gas flows were measured and set by Alicat volumetric flow meters which are located to sections before mixing chamber and after in-cylinder.

**Hydrogen Regulator**: was used to set flow motion of gas. Hydrogen fuel supplying to engine was adjusted to test results in order to obtain more effective results.

**Hydrogen Tank:** (170 bar pressurized) was filled out with 99.99% Hydrogen.

**Data Logger:** Outputs were transferred to computer system by data logger.

All properties of test fuels; heating value, kinematic viscosity, flash point, cetane number, density and copper strip corrosion was investigated at the Fuel Research Laboratory of Department of Automotive Engineering of Cukurova

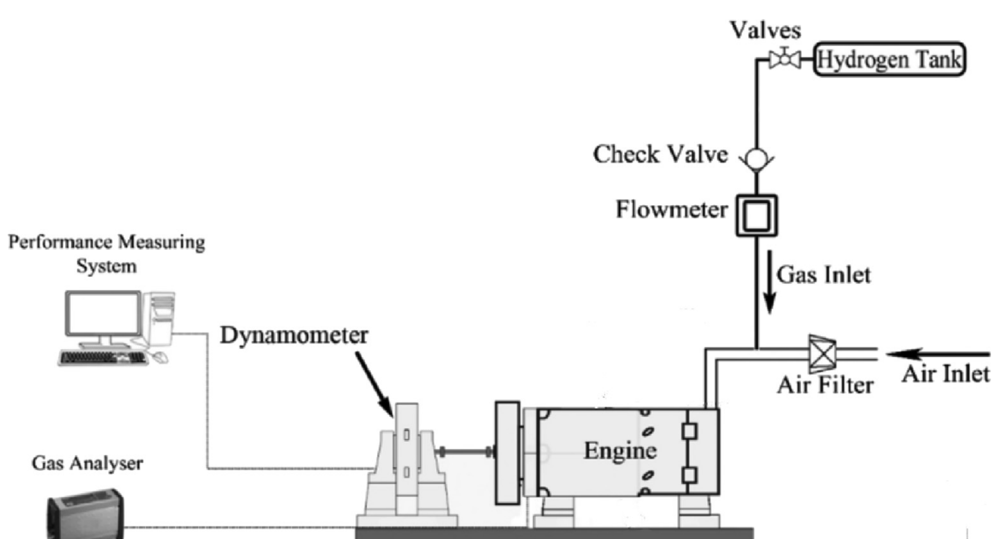


**Fig. 1 – Schematic diagram of experimental set-up.**

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