Effect of hydrogen injection on diesel engine performance intake: Preliminary result

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Keywords: Diesel hydrogen; fuel efficiency; diesel engine.

ABSTRACT – In automotive industry, diesel engine knows as a compression ignition engine plus was a better performance compared to gasoline engines. However, it contributes to environmental problem by causing global emission. In order to reduce the emission, hydrogen injection has been introduced on diesel performance intake. Thus, this research was about analyzed the effect of hydrogen gas inside the intake of a single cylinder diesel engine. Two conditions with and without hydrogen will be analyzed by comparing the diesel fuel consumption on different rotational speed of the crankshaft. Based on the preliminary result, hydrogen injection to the diesel engine can saved the fuel up to 16.82% from 200RPM until 2000RPM.

1. INTRODUCTION

The issue of large amounts of exhaust gas produced by diesel engine has received considerable critical attention. Exhaust gases contained hydrocarbons, nitrogen oxides and carbon monoxide, which are harmful to the environment and mankind [1]. Besides, the exhaust emission also released the carbon dioxide gas that can cause the greenhouse effect. Based on the studies by Jailani [2], the earth's temperature will rise by 2℃ if the content of carbon dioxide in the atmosphere doubled. The pollution effects of diesel engine will encourage researchers to find the proper solutions in solving this issue. Injected a small amount of hydrogen gas into diesel can be one of the alternative methods to improve fuel efficiency during the process of combustion in diesel engines. Compression ignition (CI) provides better thermal efficiency than spark ignition because of the higher compression ratio. Under optimum conditions, SI engine only uses 30% of heat liberated to turn the crankshaft, but with CI engines can attain more thermal efficiency which is above 40%. Compressing the air, rather than a mixing the air and fuel as the piston approach top dead centre (TDC), help in improving the engine thermal efficiency [3].

Although most of the research has been focused on hydrogen by modification the diesel engine, there is very little investigation on supplied hydrogen without changing the diesel engine. So, this paper examined the effects of non altered diesel engine consumption efficiency in the supply of hydrogen gas as an additive based on the different rotational speed of the crankshaft.

2. METHODOLOGY

The single cylinder, 4 stroke engine was used for this investigation. The specification of the diesel engine was given in Table 1, and Figure 1 shows the experimental set-up.

Table 1 Specification of diesel engine.

Engine type	**Single cylinder, 4-stroke, direct injection**
Maximum power (Hp)	5.5
Maximum engine speed (RPM)	3700
Bore (mm)	76
Stroke (mm)	62
Displacement (ml)	296
Compression ratio (CR)	20:1

Figure 1 Diesel engine set-up.

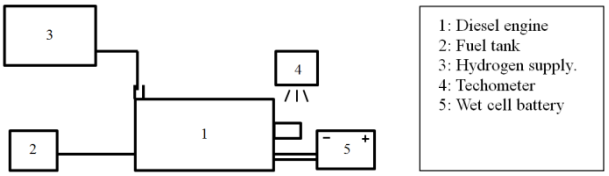

Figure 2 Schematic diagram of apparatus.

Figure 2 shows the general schematic diagram for this experiment. Other components required includes lubrication oil tachometer, hydrogen supply, syringe, wet cell battery and measuring beakers. The experiment was conducted to measure the required time for diesel engine with fuel capacity of 40 ml at different speed (RPM). The hydrogen was supplied at the intake air section of the engine. Measuring beakers were used to estimate the rate of hydrogen per minute before being supplied to the engine. The flow rate of hydrogen was 1.17×10^{-8} m^3/s. As the crankshaft rotates, the speed was measured by a tachometer.

3. RESULTS AND DISCUSSION

Further result is being compared by adding an additive with and without hydrogen gas inside diesel engine at different RPM towards fuel consumption. Table 2 and Table 3 shows the results for different engine speed (RPM) without and with hydrogen injection. Both tables consist of time duration with limited fuel capacity. Based on that data, the flow rate at each RPM will be calculated.

Table 2 Results without hydrogen injection.

Rotational Speed (RPM)	Volume (m^3)	Time Taken (s)	Diesel Fuel Flow Rate, D_0 (m^3/s)
1000	4×10^{-5}	741.9	5.316×10^{-8}
1500	4×10^{-5}	670.3	5.9675×10^{-8}
2000	4×10^{-5}	591.4	6.7636×10^{-8}
2500	4×10^{-5}	486.5	8.222×10^{-8}
3000	4×10^{-5}	398.8	1.003×10^{-7}
3500	4×10^{-5}	318.3	1.2567×10^{-7}

Table 3 Results with hydrogen injection.

Rotational Speed (RPM)	Volume (m^3)	Time Taken (s)	Diesel Fuel Flow Rate, D_H (m^3/s)
1000	4×10^{-5}	879	4.5506×10^{-8}
1500	4×10^{-5}	737.5	5.4237×10^{-8}
2000	4×10^{-5}	602.4	6.6401×10^{-8}
2500	4×10^{-5}	487.5	8.2051×10^{-8}
3000	4×10^{-5}	399.1	1.0023×10^{-7}
3500	4×10^{-5}	322.3	1.2411×10^{-7}

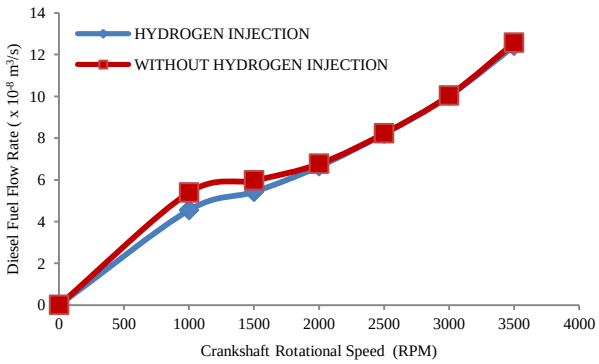

Figure 3 Graph of the diesel fuel consumption.

$$Efficiency = \frac{(D_0 - D_H)}{D_H} \times 100 \quad (1)$$

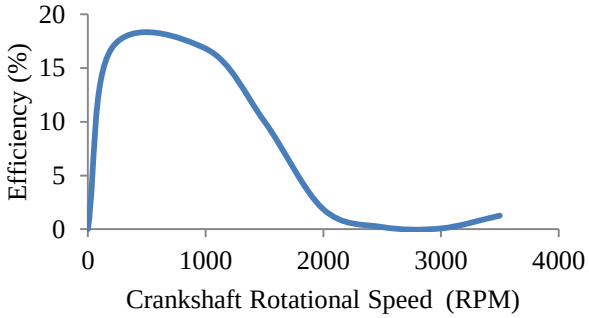

Figure 4 Efficiency diesel fuel

Figure 3 shows the graph of the diesel flow rate at different shaft rotational speed. Thus, the diesel flow rate increased correspondingly to the speed of the crankshaft. Equation (1) shows efficiency in Figure 4, at rotational speed 200RPM until 2000RPM, the diesel flow rate with hydrogen injection save approximately 16.82% compared to the one without hydrogen injection. This indicates that the hydrogen usage is being maximized at low speed. Young [1] proved that the suitable usage of hydrogen was only for lower load.

4. CONCLUSION

Hydrogen injection to the diesel engine can save the fuel up to 16.82% at lower load. The ideal engine combustion can be achieved by using hydrogen injection because the hydrogen auto-ignition is higher than other conventional fuel. Hydrogen can also decrease the excess fuel during combustion. When the ideal engine combustion occurred, the excess fuel will burn completely in the engine and contributing to high efficiency.

ACKNOWLEDGEMENT

The authors gratefully acknowledged contributions from the members of Efficient Energy and Thermal Management Research Group (EFFECTS) research group. This research is supported by the grants from the Ministry of Higher Education Malaysia (Grant Nos.: FRGS/2/2014/TK01/FKM/03/F00232).

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