Performance and emission characteristics for petrol engine with H_2O_2 addition

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ABSTRACT – Alternative fuel has become an essential effort to fight against air pollution produced by automobiles. Some vehicles consumed gasoline as a burning fuel in spark ignition engine which discharged various harmful substances to the surrounding. Therefore, a blended gasoline with H_2O_2 is one of the alternative fuel to counter the problem. In the present research, experiments have been performed to study the effects of H_2O_2 on performance and emission characteristics when it is blended with gasoline at 5 %, 10 % and 15 % propositions. A single cylinder, four-strokes spark ignition engine fueled with gasoline and H_2O_2 has been used in this study. Various speeds and loads were applied in the experiments. This paper shows some increments in indicated thermal efficiency for 10% of H_2O_2-gasoline and decrements in indicated specific fuel consumption for 5% of H_2O_2-gasoline. Therefore, the H_2O_2-gasoline blends show better performance compared to gasoline alone. However, hydrocarbon and carbon dioxide emissions increased dramatically. Plus, exhaust gas temperature also increased slightly for H_2O_2-gasoline blends.

1. INTRODUCTION

Transportation has become the central attention to modern industrial society [1]. The worldwide use of automobiles is operating widely with estimation around 6 billion users [2]. Therefore, decreasing supplies of fossil fuels, steadily rising of atmospheric carbon dioxide concentrations and increments of atmospheric pollutants are some of major challenges to the modern society [3]. Harmful pollutants, namely nitrogen oxides (NO_x) and particulate matter, from engines are very difficult to reduce simultaneously [4]. Nitrogen oxide emissions from diesel engines cause unavoidable damage on environment and human health [5]. Besides that, higher number of smaller particles emerged from internal combustion engines are relatively more harmful to human health compared to smaller number of larger particles because smaller particles penetrated deeper into human lungs [6]. Due to stricter emissions standards for NOx and carbon dioxide (CO_2) emissions, the applicability of clean energy technologies is demanding crucially [7].

Furthermore, there has been a lot of study and research going on globally to improve the performance, fuel economy and combustion technologies for gasoline and diesel engines [8]. In addition, there is a strong initiative in looking for alternative fuels due to the stricter regulations on exhaust emissions [9]. Alternative fuels have become crucial for both spark ignition and compression ignition engines in order to protect environment, the need to reduce dependency on petroleum and even socioeconomic aspects. There is one experimental investigation that has been conducted by other researcher to study about reducing the fuel consumption by using alternative fuels and lowering the concentration of toxic components in combustion products [10]. Another paper added hydrogen as the alternative fuel to enhance the performance and emission of diesel engines [11]. Lastly, another alternative fuel that has been studied is a blended burning fuel between gasoline and ethanol [12].

2. RESEARCH METHODOLOGY

The experiments conducted were chemical properties determination and engine performance testing. In engine performance testing, percentage of H_2O_2 in the fuel blend were the only manipulating variable and other input such as fuel and air temperature, fuel-air ratio and engine specification were fixed. Meanwhile, performance analysis and emission characteristics are the responding variable. HV6000EXE is the model of the engine which has been used in this experiment. Moreover, this 4-stroke engine with single cylinder is equipped with overhead valve, carburetion system and air cooling system. In these engine testing, there are plenty of halogen bulb of spotlights that will act as load to the engine.

DEWESoft SIRIUS is the data acquisition system that has been used in this research. There are two types of sensor used in this engine testing which are pressure transducer and optical angle encoder. The experiment started by blending off the gasoline and hydrogen peroxide according to blend compositions which are 5%, 10% and 15% of hydrogen peroxide by volume. 20% fuel blend is not use for this project because the engine did not start for the first attempt. Polysaccharide as emulsifier was added in order to reduce the surface tension between the gasoline and hydrogen peroxide and stabilizes the blend for longer period. MRU-air gas analyser is used to measure the emission from the experiments.

3. RESULTS AND DISCUSSION

3.1 Peak pressure

Peak pressures for every engine speed and load can be obtained from P-θ diagrams. Peak pressures are obtained in order to determine the maximum force of engine piston and cylinder. Figure 3.1 shows the variation of in-cylinder peak pressure for all test fuels at engine speed of 3000 rpm. 10% H_2O_2-Gasoline test fuel showed the highest peak pressures at all engine speed compared to others. Furthermore, at all engine speeds, 5% H_2O_2-Gasoline test fuel showed the lowest peak pressures. The drop in peak pressure at higher engine speed due to incomplete combustion of richer mixture.

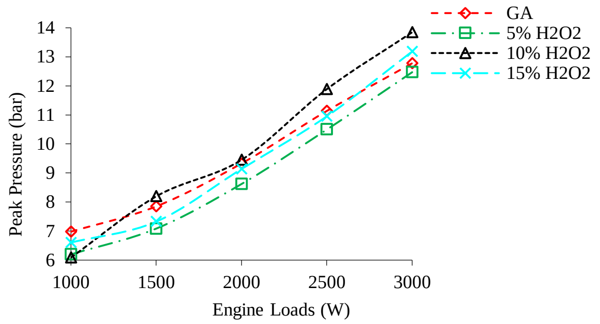

Figure 3.1 Variation of peak pressure at 3000 rpm

3.2 Indicated work

In order to get work per cycle, average cycle for each engine speed and load was exported and analysed. Figure 3.2 shows the variation of indicated work at 2500 at 3000 rpm. 10% H_2O_2-Gasoline test fuel showed the highest gross indicated work per cycle along the engine loads. Moreover, GA test fuel showed the lowest gross indicated work per cycle. As the percentage of hydrogen peroxide in the test fuel increased, the hydrogen content is increased too. Increase in hydrogen content will increase the indicated mean effective pressure which later will increase the indicated work per cycle.

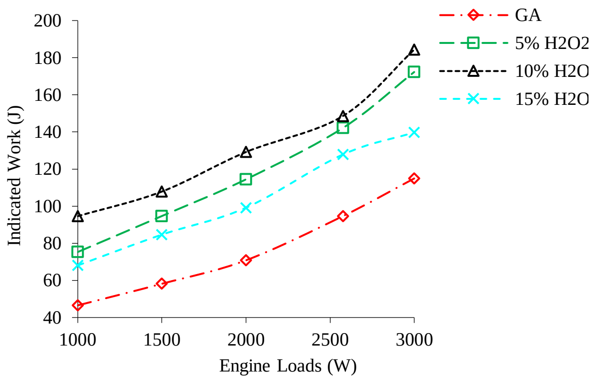

Figure 3.2 Variation of gross indicated work at 3000 rpm

3.3 Indicated power

Figure 3.3 shows the effects of H_2O_2-Gasoline blends on indicated power at 3500 rpm. 10% H_2O_2-Gasoline test fuel showed the highest indicated power along the engine loads. Furthermore, GA again showed the lowest indicated power. This due to the presence of H_2O_2 in the fuel, which starts decomposing and releasing a large amount of oxygen which assist to complete the combustion of fuel. It was noticed that indicated power of each fuel test increased as the engine loads increased. This is because friction loss is not considered so indicated power increases with engine speed while brake power increases to a maximum and then decreases at higher load.

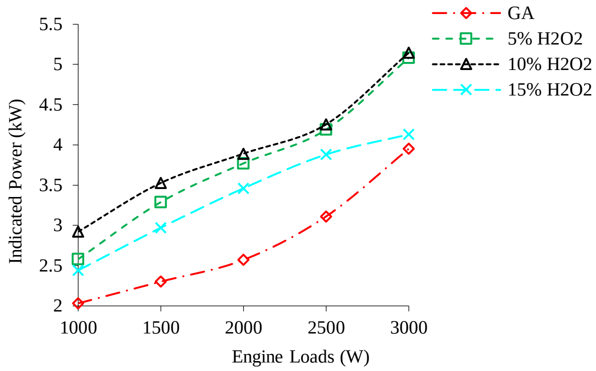

Figure 3.3 Variation of indicated power at 3500 rpm

3.4 Indicated thermal efficiency

Figure 3.4 represents the effect of H_2O_2-Gasoline blends on thermal efficiency at 3000 rpm. H_2O_2-Gasoline test fuels showed higher indicated thermal efficiency than gasoline alone at all engine speeds This is because indicated thermal efficiency is the ratio of indicated work per cycle to the energy or heat input to the engine. As the concentration of hydrogen peroxide increased, the thermal efficiency of the engine is increased too. H_2O_2-Gasoline blends displayed better thermal efficiency than gasoline alone to the engine.

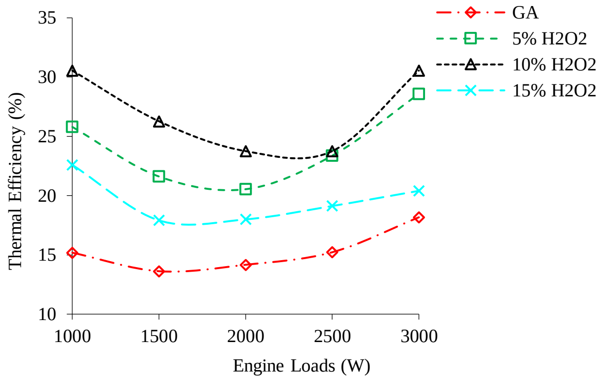

Figure 3.4 Variation of indicated thermal efficiency at 3000 rpm

3.5 Indicated specific fuel consumption

Specific fuel consumption (SFC) is measured to find the efficiency of an engine in using the fuel supplied to produce work. The effects of H_2O_2-Gasoline blends on indicated specific fuel consumption (ISFC) at 3500 rpm is illustrated in Figure 3.5. It is discovered that H_2O_2-gasoline fuel blends have lower ISFC than GA. 5% H_2O_2-Gasoline fuel blend shows the lowest SFC at each engine loads for both speed because of its low calorific value. Furthermore, its higher combustion efficiency owing to higher oxygen atom. Adnan et al. found that their 10% H_2O_2-Gasoline fuel blend has the best ISFC due to the small amount of fuel usage at highest engine speed of 3500 rpm [13].

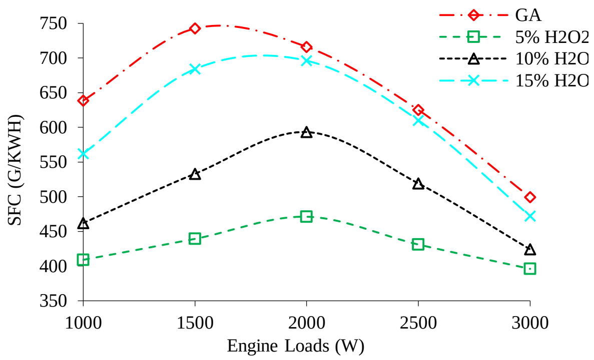

Figure 3.5 Variation of ISFC at 3500 rpm

3.6 Emissions of hydrocarbon

The variation of the hydrocarbon (HC) emission at 2500 rpm for various ratios of fuel blend is shown in Figure 3.6. 5% H_2O_2 fuel blend has the highest concentration of HC emission among all the fuel tests. Meanwhile, GA has the lowest HC emission compared with compared to other fuel tests. In this study, 5%,10% and 15% H_2O_2 fuel blend has higher HC emission compared to GA. At this point, it is noted that H_2O_2 has a lower flame speed compared to GA fuel operation. As a result, less mass fraction of the fuel is burnt in the case hydrogen peroxide-blended gasoline. Hence, higher amount of unburnt are left in each cycle. Plus, incomplete combustion can occur in the combustion chamber when an engine operates over a definite lean limit. It is because misfires can become more frequent with unburned fuel leading to the increased HC emission. Therefore, it can be concluded that, the higher the H_2O_2 ratios with gasoline, the lower the concentration of HC emission.

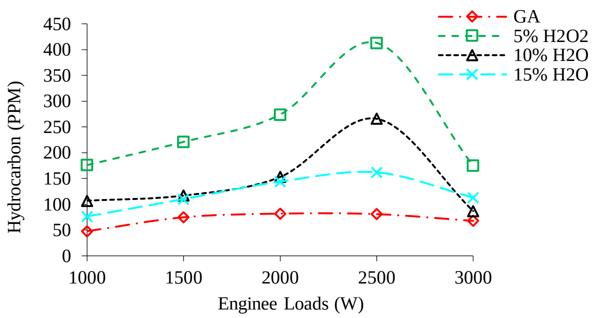

Figure 3.6 Hydrocarbon emissions at 2500 rpm

3.7 Emissions of carbon dioxide

Next, Figure 3.7 shows the variation of carbon dioxide (CO_2) emission at 2500 rpm with various ratios of fuel blends. The graph indicated that 5% H_2O_2 fuel blend shows the highest CO_2 emission compared to other fuel blends. Meanwhile, the lowest CO_2 emission is GA. The lowest CO2 emission can be associated with the highest carbon monoxide emission as discussed earlier. In this study, 15% H_2O_2 shows lower concentration of CO_2 emission. It is opposite from CO emission that has lower concentration. This is because the higher oxygen contents in the blended fuels improves the combustion process and cause increase the CO_2 emission.

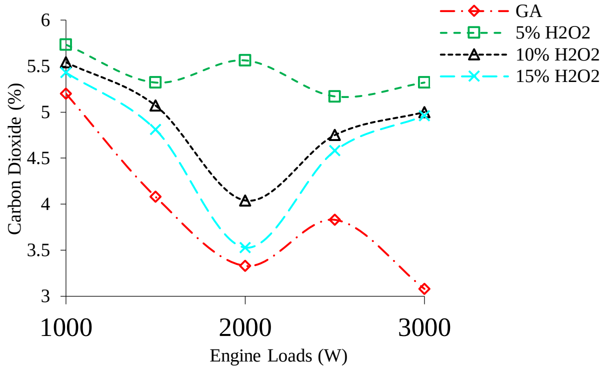

Figure 3.7 Variation of CO2 emissions at 2500 rpm

3.8 Exhaust gas temperature

Figure 3.8 shows the variation of exhaust gas temperature (EGT) at 2500 rpm for various ratios of fuel blend. It shows 5% H_2O_2 fuel blend produces the highest EGT at all load. All the fuel blends have increased the EG. Higher EGT for 10% H_2O_2 compared to 15% is due to the concentration of H_2O_2 that give an additional oxygen molecule that enhance the combustion process resulting high combustion temperature in the cylinder charge. Spark ignition engines are designed so that a flame front will propagate smoothly from the spark plug into the unburned mixture until all of the mixture has been ignited. As the flame front progresses, the temperature and pressure of the combustion gases behind it rise due to the release of the chemical energy of the fuel. As the front propagates, it compresses and heats the unburned mixture. In this study, by adding H_2O_2 will make the EGT to rise due to the wide range of flammability and effective combustion.

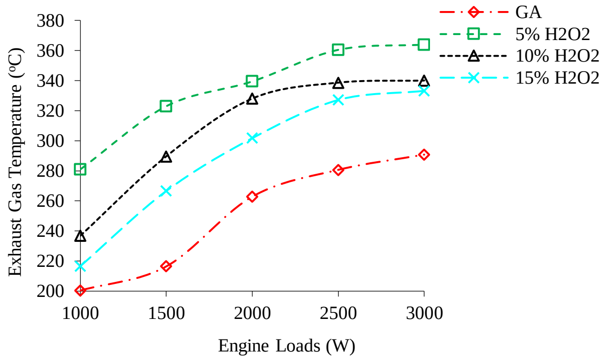

Figure 3.8 Variation of exhaust gas temperature at 2500 rpm

4. SUMMARY

Based on the results and discussion, test engine displayed the best performance characteristic with 10% H_2O_2-gasoline blend for free and full load tests at all engine speeds. Last objective of this study was to determine fuel blend that display optimum engine performance. According to analyzed results, since there was not too much differences in performance characteristics between 5% and 10% of hydrogen peroxide in fuel blend, 5% H_2O_2-gasoline blend is chosen. In conclusion, the engine performance had improved when blending off hydrogen peroxide with gasoline for petrol engine.

As for emissions, the aim of this study is to find the optimum blend of H_2O_2-gasoline fuel mixture to have less emissions. Experimental results indicated that using H_2O_2-gasoline blend, the HC and CO_2 emissions increased dramatically due to high boiling point and it causes the fuel to comprise fractions or components that may not be completely vaporized and burns. Therefore, it can be concluded that gasoline alone in SI engine is more practical as compared to H_2O_2-gasoline fuel mixture in term of emission.

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