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Performance of Four Stroke One Cylinder IC Engine with Dual Spark Plugs Using 94-100% Ethanol

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Abstract
Problems related to depleted fossil fuel reserve and worsened air quality in the earth needs to be solved. One of the solutions is using ethanol, an alternative fuel produced from the plants. A research was conducted to identify the feasibility of ethanol 94-100% as fuel for one cylinder IC engine of 110cc Yamaha LM-5. In the research, the combustion condition was set to stoichiometric ethanol combustion. Engine rotational speed was 1500 – 4000 rpm. The change made into the engine is adding one more spark plug to become dual spark plugs configurations. The results showed that dual spark plugs gives more efficient combustion compared with single spark plug for combustion of ethanol 94-100%. The emission of exhaust gas, fuel consumption, torque and power were analyzed.
Keywords: Ethanol, Four Stroke Engine, Dual Spark Plugs

1. Introduction

In accordance with the growth of automotive industries which most of them still rely on fossil fuel (gasoline), and the increasing level of gasoline fuelled vehicle, such as automobiles, motorcycles, and other mass transport vehicles, has an impact on increasing of air pollution level caused by exhaust emission from the vehicle. Some of the gas emissions are Carbon Monoxide (CO), Hydrocarbon (HC), Nitrogen Dioxide (NO_x) dan Sulphur Dioxide (SO_2), which has bad effect on human body health and destroy ozone layer in the atmosphere. In efforts to deal with this problems, some alternatives has been proposed and one of them are modification of gasoline fuelled Internal Combustion (IC) engine to use more environmental friendly fuel so that emission of carbon monoxide, and other toxic gases such as NO, HC, SOx and others could be lowered.

One of the environmental friendly fuels is ethanol which is produced from agricultural products. Ethanol as fuel has become long term national policy in renewable energy especially in Indonesia. Ethanol may be used as additive to gasoline or solely used as fuel for IC engine. In the market, ethanol and gasoline mixture started to be marketed as E-10, E-15, and E-20. This type of fuel has advantages because this mixture can produce greener exhaust. Beside used as additive, the dedicated ethanol also can be used as fuel, eventough rarely available IC engine dedicated to ethanol. Therefore, it usually applied on gasoline fuell engine with some modification. The advantage offered by ethanol in greener gas exhaust and availability (renewable one) makes ethanol become good choice to substitute gasoline for vehicle. Other researcher conducted the research on twin spark plugs on gasoline fuelled IC engine which has results in lower emission of exhaust gas. The combination of two methods, i.e. using ethanol and twin sparks in lowering exhaust emission then need to be pursued. Another way to lower the emission level are by using catalytic converter to filter toxic exhaust from exhaust manifold so that safer exhaust to the environment could be produced.

1.1 Ethanol

Ethanol or etil alcohol, a single substance with chemical C_2H_5OH, is a liquid substance produced by fermentation and distillation of carbohydrate which mainly come from agricultural product, such cassava, sugar cane, corn etc. Ethanol is a liquid which is colorless, easy to evaporate (volatile) and highly combustible. Ethanol usually makes ingredients of liquor and chemical solvent and also use as fuel. Octane number is most important parameter in specification on the fuel for Otto cycle engine, because octane number is directly correlated to quality of fuel of Otto cycle engine which influence combustion processes in combustion chamber and also thermal efficiency level of engine. Calorie value is main parameter and demand of fuel choice in order to be able to use in transportation sector because storage consideration in vehicle. One of the advantages of hydrocarbon fuel is its higher energy density. Calorie value of ethanol is varied depend on its quality and composition / specification. The calorie value spread from 30 – 33.6 MJ/liter, while *anhydrous ethanol* around 21MJ/liter or nearly 2/3 of gasoline calorie value, and *hydrated alcohol* less than half of calorie value of gasoline, in which 13.3 MJ/liters. There are two types of ethanol available in the market according to its water content. The difference is a result of purity process of ethanol by *hydrated (hydrous) alcohol* produced from direct fermentation and distillation of biomass (sugar cane, corn, rice etc) with purity above 94% (± 6,8% water) and *anhydrous alcohol* as results of post distillation process and drying of *hydrated (hydrous) alcohol* so that has purity above 99,3% (<0.7% water)

1.2. Principle of Otto Cycle's 4 Stroke IC Engine

There are four stages, as showed in Figure 1. Intake stage, in this stage, intake valve is open and exhaust valve is closed, cylinder head moves from (TMA) to (TMB) so the mixture of fuel and air is sucked into cylinder. Compression stage is when piston in Below Dead (BDC), intake valve is closed and cylinder head move back to Top Dead (TDC) and then intake and exhaust valve are closed. Compression on the mixture of fuel and air caused temperature and pressure increase in the cylinder. Shortly before the end of compression stage, spark plug discharge electrical current and starting the combustion. Combustion stage, when the mixing of compressed fuel and air were combusted by electric sparking system. Exhaust stage, combusted gas has very high pressure and temperature enabling to push the cylinder to move down. In this moment, exhaust valve will be opened to exhaust combusted gas. For four stroke IC engine, working process of engine is completed in four cylinder head stroke as followed: First stroke, cylinder head moves from TDC to BDC, called intake stage. Second stage, cylinder head moves from BDC to TDC and called compression stage.Third stage, cylinder head move from TDC to BDC and called work stage. In this stage, combustion process of fuel and air mixture take place in cylinder/combustion chamber producing pressure to push cylinder head from TDC to BDC. Fourth stage, cylinder head moves from BDC to TDC and called exhaust stage. Gas of combustion product is push out by cylinder head to move out from combustion chamber.

1.3.Twin Sparks Ignition

Twin spark ignition engine has two spark plugs located in the very end of combustion chamber and produce fast and efficient combustion. The advantages of efficient combustion process are better fuel efficiency and low emission. Ignition of twin spark plugs is an alternative solution to slow combustion process on single spark plug usage. Head of cylinder was equipped with two spark plugs in contrast to standard one spark plug. By introducing two spark in one edge of combustion chamber, (about 90º of polar axis) the mixture of fuel and air was ignited by two spark, therefore decreasing flame flows as much as 40 percent could be achieved. Faster level of combustion will in turn produced faster increased pressure. The prominent results were increasing of torque, fuel efficiency and lowering emission. The Programmable CDI (Capacitive Discharge Ignition) apparatus controlled the sequence of sparking of the plugs. Mixture of fuel – air went inside cylinder during suction stroke then compressed during compression stroke. After that, spark from one plug ignited the mixtures and flame started to widening like inflating balloon. The other spark then ignited according to control sequence by Programmable CDI. Again the flame ignited was widening. Therefore, the area was not covered by first flame front will be ignited by second spark and perfect and fast combustion could be achieved

1.4.Research Methods

The research methods employed in this research was experimental one. Treatment variation in the research was by employing single spark plug in first treatment, and twin spark plugs in second treatment. The main spark plug was positioned 45° (as standard) and secondary spark plug was positioned on 20°. Variation of engine speed in this research were in range of 1500 rpm to 4000 rpm, which step increase of 500 rpm each test run. Before conducting research, the spark plugs were installed on block head in accordance with designed schematic diagram of electrical installation of ignition, see Figure 2. Then checked of all test apparatus such as buret, stopwatch, scale, tachometer, IC engine condition and condition of gas analyzer to make sure all set and ready. And the research flowchart described in Figure 3.

1.5. Result and Discussion

1.5.1.Exhaust Emission

Comparation of application single and twin spark plugs on their contents of CO_2, CO dan O_2 were explained in Figure 4. CO gases is a product of imperfect combustion. The very dangerous gas for human health, the high content of CO shows the combustion process in the cylinder is not good. It can be shown that the content of CO was lowering when twin spark was applied. The lowest content of CO was on twin spark plugs obtained on 3000 rpm and the highest CO content was on single spark plug on 1500 and 2500 rpm. CO_2 gas is a product of perfect combustion process. The process will produces high content of CO_2 therefore the higher content of CO_2 on exhaust emission, better combustion occurred in cylinder. The content of CO_2 on twin spark plugs system was more efficient that single spark plug for rotational speed more than 3000 rpm. The result of CO_2 gas emission was in contrary with CO gas emission. O_2 gas is excess air which not reacted on combustion. The good combustion always produce low amount of O_2 content since much of O_2 will react with fuel. From the Figure 4, it was shown that better combustion occurred in twin spark plugs for rotational speed above 2000 rpm. O_2 which is product of combustion process, reacted better with fuel and the excess O_2 is lower than single spark counterpart. Also, good combustion has low HC content. The lower HC content, means better combustion process and even close to perfect combustion one. Twin spark plugs able to lower HC content on exhaust emission on rotational speed of 3000 rpm and above. This showed that twin spark plugs able to improve

combustion process in cylinder on high rpm.

1.5.2.Fuel Consumption, Torque and Power

As showed on Figure 5, the specific fuel consumption for each treatment of single and twin spark plugs with rotational speed variation give the significance effect, for rotational speed between 1000 until 2500 rpm the single spark plug seem more efficient. Contrarily for rotational speed above 3000 rpm, the twin spark plugs give more efficient combustion than single spark plug. While the torque produced from single and twin spark plugs combustion was differs constantly from low rpm until high speed rpm. For single spark plug, the maximum torque was 3.55255 N.m on 4000 rpm. While for twin spark plugs, the maximum torque was 4.044271 N.m on 4000 rpm. For the engine power as described on Figure 6, the maximum power for single spark plugs was 1.488088664 kW on 4000 rpm and the maximum one for twin spark plugs was 1.692544152 kW on 4000 rpm. It was always on higher rotational speed to produce maximum power because the interval time of combustion becomes faster.

1.6. Cloncusion

From the research analysis and discussion, it can be concluded that the influence of single and twin spark plugs on ethanol fuelled Otto's cycle IC engine were:

1) Ethanol is feasible to be used as alternative fuel for four stroke engine using.
2) In general, twin spark plugs improved performance of four stroke IC engine fuelled by ethanol as seen from lower emission of exhaust of CO and HC.
3) Performance of four stroke IC engine was increased when using twin spark plugs compared to single spark plug on fuel consumption, torque and maximum power produced.

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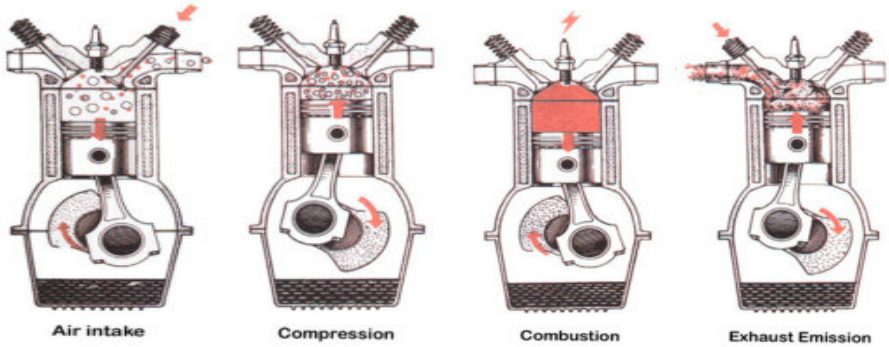

Figure 1. The Four Stages

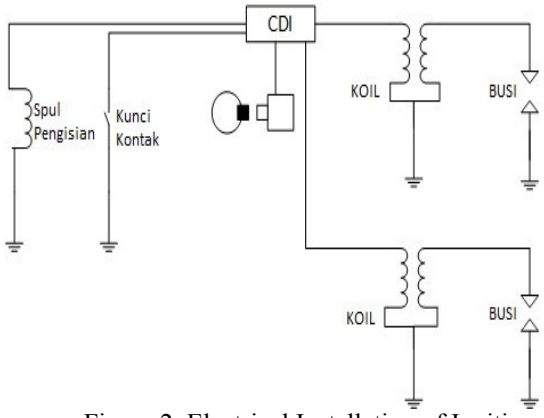

Figure 2. Electrical Installation of Ignition

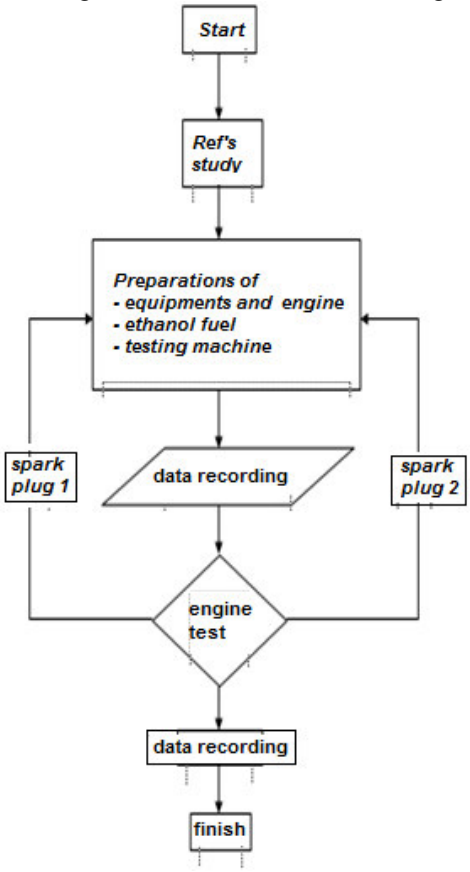

Figure 3. Flow Chart of Research

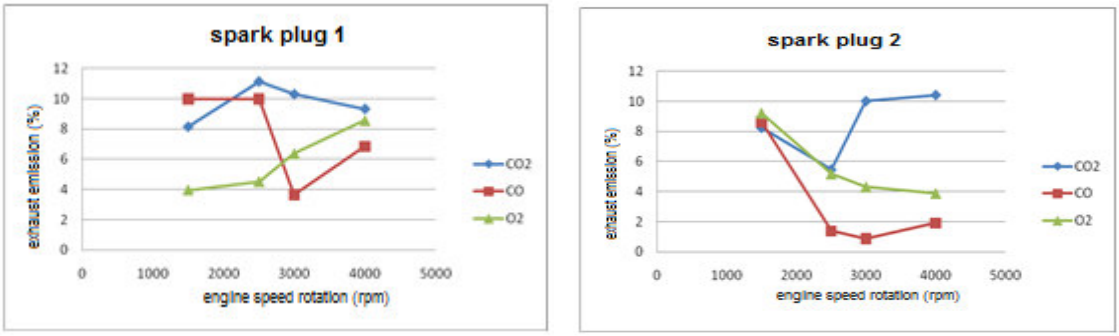

Figure 4 Relations between Engine Speed Rotation and Exhaust Emission on Single and Dual Spark Plug

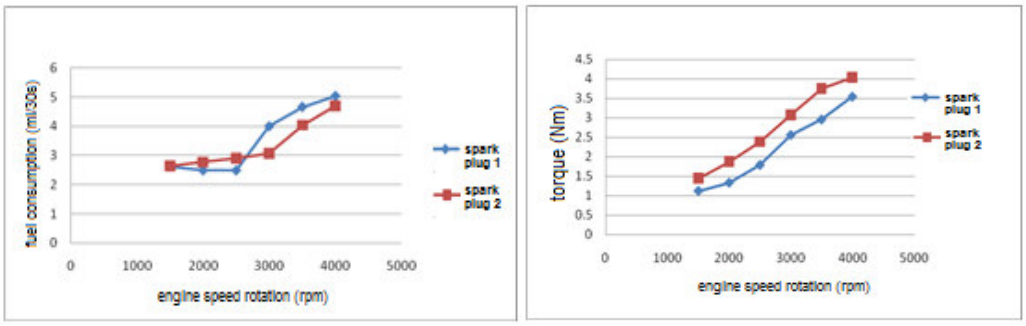

Figure 5 Relations between Engine Speed Rotation, Fuel Consumption and Torque on Single and Twin Spark Plugs

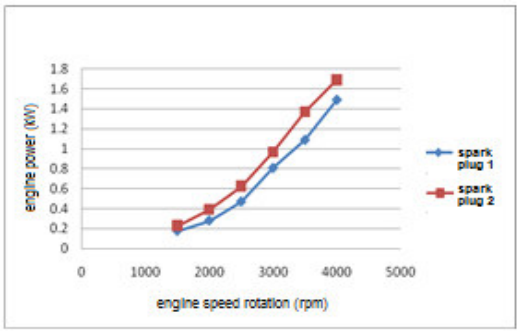

Figure 6 Relations between Engine Speed Rotation and Engine Power on Single and Twin Spark Plugs