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Study of production optimization and effect of hydroxyl gas on a CI engine performance and emission fueled with biodiesel blends

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ABSTRACT

Depletion and environmental impacts of the fossil fuel are the major concerns to think about the alternative energy sources to reduce the load on petroleum fuel. Researchers worldwide are working years to improve the biodiesel fuel economy and emission characteristic. At the same time, they are working on fuel development so that can be used in the IC engine without significant modification in vehicle design. Among different alternative fuels biodiesel as well as hydroxyl gas (HHO, also known as Oxyhydrogen gas) are renewable, recyclable and non-polluting fuel. In this study, HHO gas has been introduced with ordinary diesel (OD) and 20% (v/v) palm biodiesel blended with OD (PB20) for evaluating the engine performance and emission characteristics. Optimum yield of HHO was found using single anode and two cathodes from a solution containing 1% KOH and 100 ml of water producing 2150 cc of HHO gas when electrolysis was carried out for 15 min. Using the HHO generator, about 2% more power and 5% less consumption was observed for biodiesel blended fuel in a single cylinder CI engine at full load variable speed operating conditions. Besides, on an average 20% and 10% reduction of CO and HC emission were observed respectively.

Introduction

In modern days, the growing energy demands are being satisfied mainly from fossil fuels sources, like coal, natural gas and petroleum oils etc. Energy obtained from fossil resources are less expensive and in concentrated forms. However, the burning of the fossil fuels emits harmful pollutants which have negative impacts both on the environment and lives. Global warming is one of the key harms that scientific

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Nomenclature and abbreviations

CI	Compression Ignition
DC	Direct Current
AC	Alternating Current
3E	Three Electrodes (cathode-anode-cathode)
2E	Two Electrodes (cathode–anode)
1% KOH	1 wt. % KOH solution
0.5% KOH	0.5 wt. % KOH solution
OECD	The Organization for Economic Co-operation and Development
HRG	Hydrogen Rich Gas
HHO	Mixture of H_2 and O_2 gas or Hydroxyl or Oxyhydrogen gas
OD	Petroleum Diesel or Ordinary diesel
PB20	20% (v/v) Palm biodiesel + 80% (v/v) OD
BP	Brake Power
BSFC	Brake Specific Fuel Consumption
BTE	Brake Thermal Efficiency
CO	Carbon Monoxide
HC	Unburned Hydrocarbon
NO	Nitrogen Monoxide

community is facing today. Many researchers point out the rise of exhaust gases gathering in the atmosphere as one of the serious reasons of the global warming [1,2]. Engineering plants, manufacturing plants and vehicles are the main source of the exhaust gases [3]. Fossil fuel uses in the transportation sector, in particular, is of great concern for the age as the transportation division increases by an average 1.10% per year of world total energy consumptions [4]. Transportation activity is estimated to raise significantly worldwide of the next ages, with most of the increase occurring in non-OECD countries [5,6].

The combination of issues – the increasing prices of petroleum fuels, the rise in awareness of environmental issues, concerns over energy security, stricter regulations on engine or vehicle emissions, and high growth rate of their consumptions – has spurred interest in moving the world away from petroleum fuels to alternative fuels and advanced vehicle technologies. This promotes scientists to look for alternative solutions to provide engines without modification in the vehicle structure. With those choosing hydrogen (H_2) as a substitute fuel which boosts the engine efficiency and can run with the close to absolutely no pollution, the outcome has become tested basically in the last several years [7]. The combination associated with the molecular composition of H_2 and a number of its remarkable properties (such as high laminar flame speed, wide flammability range, etc.) shows hydrogen as a desirable resource for internal combustion engines [8]. Other than that, compared with standard energy sources, H_2 is a carbonless fuel, combustion of which does not bring in emissions similar to combustion of hydrocarbon fuels e.g. HC, CO and CO_2. However, there are concerns regarding the viable solutions both for the generation and storage of H_2 from the commercial point of views. Other researchers have used biogas [9,10], syngas [11] producer gas [12] either solely or with H_2 blends successfully in gasoline engines. The use of HHO gas in gasoline engines is comparatively new. HHO gas is the combination of H_2 and O_2 within a ratio 2:1 by volume produced from water electrolysis, which was invented by Yull Brown in 1978 [13]. Hence, electrolytic gas often called as "Brown gas" or Hydrogen Rich Gas (HRG).

In recent years, there are some investigations present on the existing literature on the effects of HHO gas addition on the performance of spark ignition (SI) [14] and compression ignition (CI) engine [15]. Studies indicated that the addition of HHO gas seemed to affect engine performance in the same way as if the hydrogen had been used. Fuel consumption reduced [16], the torque and indicate mean effective pressure (IMEP) increased, the combustion time and cycle-to-cycle difference also reduced. However, the NO_X emissions were found to be increased [17].

Over the year, many researchers separately investigated the application of HHO and biofuel blends on IC engine fueled with fossil fuel [14,16,18,19]. However, there is no studies available to find out the effect of HHO on IC engine fueled with a blend of biodiesel. In this study, the effect of HHO on a single cylinder diesel engine fueled with palm biodiesel blend has been investigated.

Yilmaz et al. [15] studied the HHO production using KOH, NaOH & NaCl electrolyte with hydroxyl electronic control unit to control the production. Musmar et al. [14] studied the HHO production using Na_2CO_3 electrolyte and stainless steel electrode. However, none of the studies dealt with the effect of different parameters on the optimization of HHO production.

The purpose of this effort is to design and fabricate a compact unit of HHO fuel cell for HHO gas production optimization by varying different parameter for a specific electrolyte (KOH) and electrode (stainless steel plate) and test the gas in an unmodified CI engine fueled with biodiesel blend. The electrolyzer used for this study was easy to construct by using locally available materials and are cheap. Electrodes were chosen to bear into mind that they should withstand high temperatures as well as high current flows. Also, an automobile battery was used as power source. The construction procedure is simple and requires less maintenance time. Afterward, the produced HHO was applied on a single cylinder diesel engine fueled with 20% palm biodiesel blend and the performance and emission were compared with petroleum diesel and also the blend of palm biodiesel.

Material and methodology

This section consists of three subsections which explain the required materials selection for biodiesel production from crude palm oil and the theory behind the production of HHO gas from the water electrolysis.

Biodiesel production from crude palm oil

Crude palm oil was collected from the local market and considered as the biodiesel feedstock. Other chemical and equipment that are associated with the biodiesel production process are purchased from the supplier. Biodiesel was produced in the laboratory by conventional process i.e.