Investigation on Hydrogen as Dual Fuel in Diesel & Gasoline Engines: A Review

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Abstract

This paper illustrates a comparative study of the effect of using hydrogen as a dual fuel in the intake mixture on exhaust emission characteristics of diesel and gasoline engines. There has been phenomenal technological advancements from the development of large external combustion engines to compact yet powerful internal combustion engines. With the advancement in technology and the stricter emission norms, there has been continuous effort to reduce the automobile exhaust emissions which are the major concern of the environment.

Fuel economy improvisation and reduction of greenhouse gases from vehicular sources are the important research topics now. Of the numerous ways available, alternative fuels can be used to fully or partially replace the conventional petroleum based fuels. By making such a change we can benefit from the alternative fuels using existing internal combustion engine technology. In this paper, there is a comparative study of the effect of using hydrogen as a dual fuel in the intake mixture on exhaust emission characteristics of diesel and gasoline engines.

Keywords: Diesel Engine, Gasoline Engine, Alternative Fuels, Hydrogen

1. Introduction

From the last few years, alternative fuels have become the center of attention for the automotive industry. Due to the uncertainty and interdependence of conventional fuel availability their and environmental impact. air pollution) a need to change to alternative sources of energy has been felt. The major polluting elements of the conventional fuels include Nitrogen oxides (NOx), Carbon Monoxide (CO),Unburned Hydrocarbons (UHC), smoke and particulate matter. Such pollutants are hazardous to the health of living beings of the planet. Automobile emissions are the leading source of air pollution constituting 41% of Nitrogen oxides (NOx), 70% of Carbon Monoxide, 38% of Hydrogen emissions globally. In addition to that 25% of the CO_2 emissions which are a result of human activities are added which cause global warming. [Sarvanan, N. et.al. 2001]

Fuel economy improvisation and reduction of greenhouse gases from vehicular sources are the important research topics now. Of the numerous ways available, alternative fuels can be used to fully or partially replace the conventional petroleum based fuels. By making such a change, we can benefit from the alternative fuels using the already-existing internal combustion engines.

It is known that alternative gaseous fuels such as hydrogen can be introduced into intake systems of IC engines. Pure Hydrogen used to enrich the diesel or gasoline fuel will improve the fuel economy and reduce emissions. It was found that, for diesel as the main fuel, increasing amount of hydrogen usually reduces NOx and smoke values and at the same time increases overall thermal efficiency. In gasoline engines, increasing amount of hydrogen tends to decrease cyclic-variability and reduces NOx exhaust emissions.[Samuel, S. et.al. 2010]

2. The Dual Fuel Concept

Internal Combustion Engines that operate on gaseous fuel have been used for a long time now. Usually large immobile engines use two types of fuels. Normally of these two; one is liquid fuel and the other fuel is gaseous. The fuels can be varied in a wide range; such an engine is called a DUAL FUEL ENGINE.

Dual fuel vehicles are multi-fuel engines that can run on two fuels simultaneously. These are the engines which have internal combustion where one fuel is diesel or petrol, and the other fuel is an alternative type of fuel i.e. natural gas (CNG), LPG or hydrogen natural gas (CNG). Two separate tanks are used to store these fuels and the engine can run on any on fuel sometimes, usually both the fuels are used together. Dual fuel vehicles are capable of switching back and forth from the conventional fuel to the other fuel. [Mathur, M et.al. 1996]

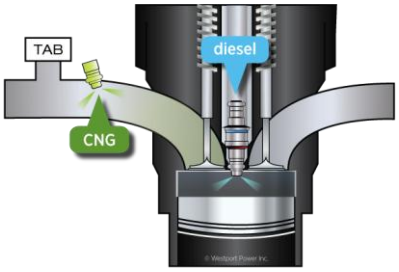

Fig.1 Illustration of the dual fuel concept

Ref: [CLH Systems]

3. Working Principle of Dual Fuel Engines

The concept of the Dual Fuel Engine is based on the Diesel Cycle. The gaseous (primary) fuel is added to the air inducted by the engine at a pressure slightly above the atmospheric pressure. The compression of this air fuel mixture and the added fuel occurs in the engine cylinder just the compression of air in a diesel engine. At a certain point in the compression stroke, a little amount of fuel in the liquid form also known as or the secondary fuel, is injected through a conventional diesel fuel injection system near the TDC. The source of ignition is this injection of fuel. Due to this, the gas-air mixture is ignited in the vicinity of the injected spray. Hence, the combustion starts smoothly and quickly. [Mathur, M,*et.al*. 1996]

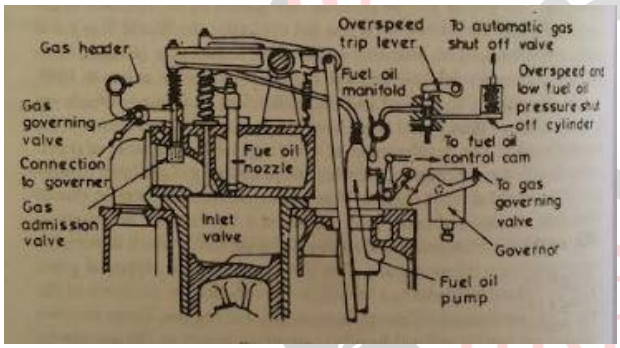

Fig.2. Dual Fuel Engine. [Mathur, M,*et.al*. 1996]

The process of combustion begins in a similar manner like that in a diesel engine and it propagates by the method of flame fronts like the combustion in a petrol engine. The gas is supplied in the intake manifold in the 4 stroke cycle engine where it mixes with the air.

By changing the amount of the primary fuel in the intake manifold, the output of the engine can be controlled. The pilot fuel quantity is usually kept constant for a given engine and is about 5% to 7% of the total heat of engine at full load. A wide range of temperature ratios can be used for the operation of a dual-fuel engine and it has the capability to run on gas or diesel or a combination of these two. Fig- 3 shows the p-Θ diagram for a dual-fuel engine working on different fuels. It can be seen that transition from one fuel to another is quite smooth. [Mathur, M et.al. 1996]

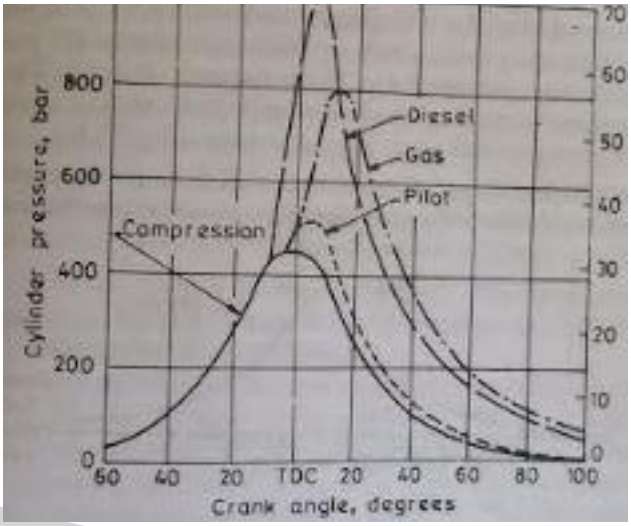

Fig.3. p-Θ diagram for a dual-fuel engine working on different fuels [Mathur, M et.al. 1996]

4. Hydrogen as a Dual Fuel

Hydrogen is the fuel of the future. There will be an important shift to a hydrogen based vehicles in the future. Internal combustion engines can run on hydrogen or fuel cells which virtually emit no greenhouse gases in the form of emissions when combusted with oxygen. Water vapor is the only major emission.

5. Working principle in I.C Engines

The process of combustion (i.e. burning) is the chemical process in which energy is released from the mixture of the fuel and air. It releases energy and it is converted into work in an internal combustion engine (ICE). The ignition and combustion processes occur within the engine cylinder, itself. The most popularly known types of IC engines are the spark ignition engines and the compression ignition engines. These are 4 stroke cycle engines.

The difference between the two lies in the actuation of the process. In a spark ignition engine, initially, the fuel and air are mixed to create a homogeneous mixture and then, inducted into the cylinder. After the piston compresses the fuel-air mixture, the spark ignites this mixture. This generates the required heat and energy required in the process. In case of diesel engines, initially, only air is inducted into the cylinder and compressed. After this, the fuel, in is sprayed on the pressurized air. As the air is highly pressurized and at a high temperature, the fuel ignites, instantly.

In the spark ignition engine, the hydrogen gas is inducted in the intake manifold before the carburetor and then it is sucked into the combustion chamber. It is, then, ignited to complete the combustion process. In a compression ignition engine the hydrogen gas is introduced in the intake manifold and is sucked in the combustion chamber along with the air. This is then compressed and when diesel is sprayed, the air-

hydrogen mixture ignites and subsequent combustion process takes place.

6. Effect on Engine Performance and Emissions

Data of following experiments on a single cylinder 100 cc, four stroke petrol engine, and a single cylinder 600cc, four stroke diesel engine is have been reviewed, analyzed. Following is review of experiments.

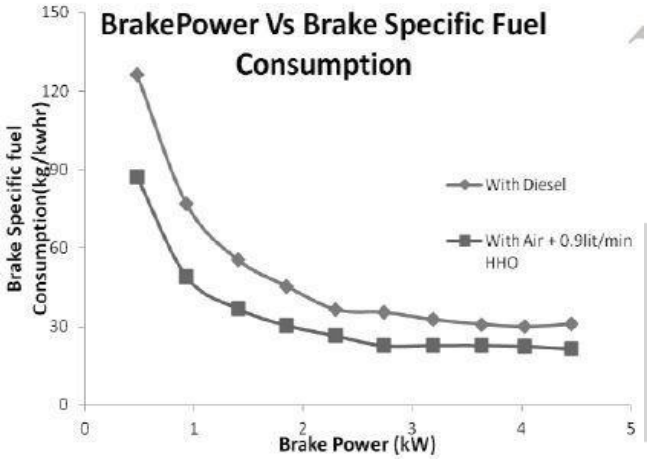

Fig.4 Brake Power vs. B.S.F.C for diesel engine
[T Sowba, et.al. 2013]

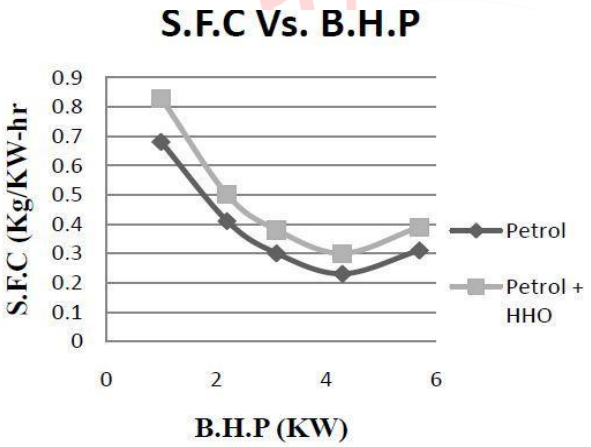

Fig.5 Brake Power vs. B.S.F.C for petrol engine
[Babaria D, et.al. 2015]

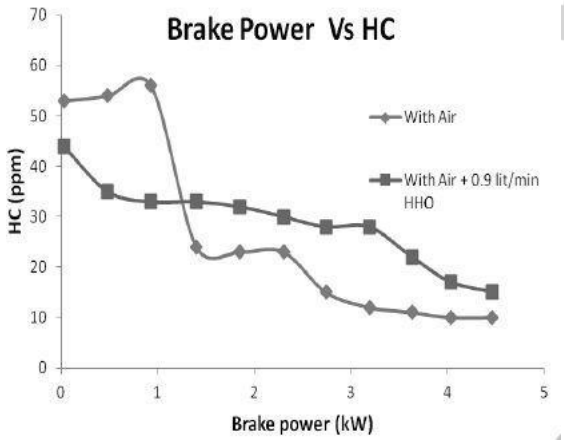

Fig.6 Brake Power vs. H.C emission for diesel engine
[T Sowba, et.al. 2013]

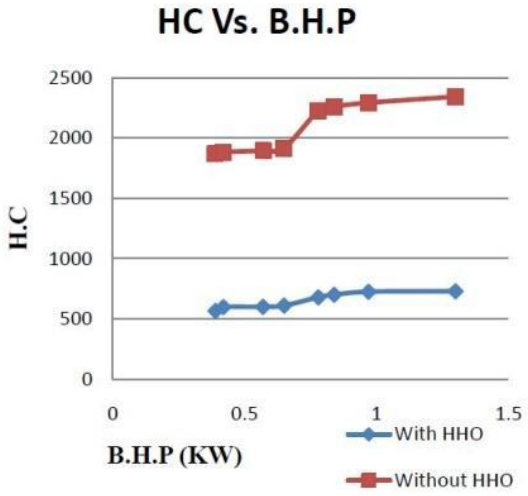

Fig.7 Brake Power vs. H.C emission for petrol engine
[Babaria D, et.al. 2015]

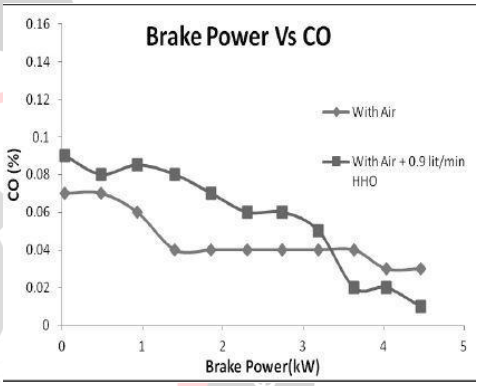

Fig.8 Brake Power vs. CO emission for diesel engine
[T Sowba, et.al. 2013]

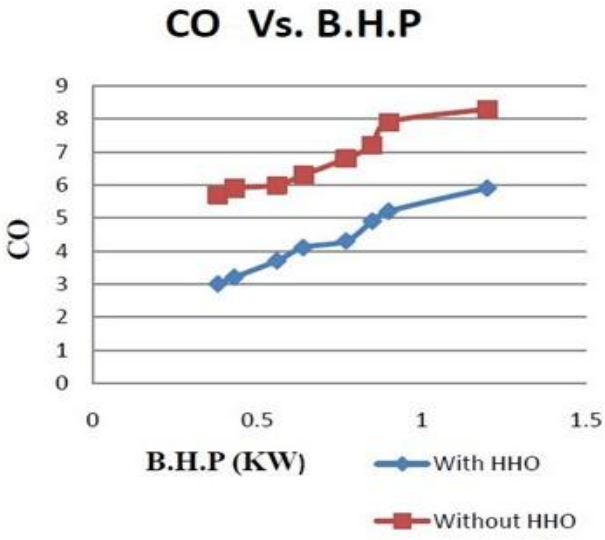

Fig.9 Brake Power vs. H.C emission for petrol engine
[Babaria D, et.al. 2015]

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7. Conclusions

1) The use of Hydrogen as a supplementary element in gasoline engines decreases the fuel consumption, and thus, combustion efficiencies increases by 20%.
2) The use of Hydrogen as a supplement in diesel engines fuel consumption, and thus, combustion efficiencies are reduced by almost by 30%.
3) The use of hydrogen fuel in compression ignition engines results in reduced emissions of pollutants such as carbon monoxide and unburnt hydrocarbons.

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