

A Comprehensive Overview of Recent Advancements in Alternate Fuels for Internal Combustion Engine

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ABSTRACT: Ever since the industrial revolution fossil fuels have been used as the world's main energy source as they have proven to being a relatively cheap fuel with a high energy density. They have especially been important in the transport sector where the amount of fuel that is possible to carry is limited. The invention of internal combustion engine is one of the greatest inventions of mankind. For heavy-duty, aviation and Commercial Ocean applications IC engines are used extensively. The highest efficient engine ever developed has efficiency not even 50 percent. Nevertheless there is still tremendous amount of scope in improving the efficiency of fossil fuel based engines, and thus reducing the greenhouse emissions. The problem of exhaust emissions from internal combustion engines has led to a scope in developments. This work deals with the compendious overview of alternate fuels and cost comparison that can be used instead of diesel in a conventional ICE vehicle

KEYWORDS: Internal Combustion Engine (ICE), Alternative Fuels, Hydrogen fuel, Bio-diesel, Ethanol, P-series, E-diesel.

I. INTRODUCTION

Rapid Urbanization has resulted in growth of the requirement of transport. First commercially successful internal combustion engine was created by Elenne Lenoire around 1859, where environment was not the major concern. Since the pollutants level were at the low level, the climate and pollution was not alarming. In present scenario, all health related issues are considered one of the major causes of pollution across the globe. As of year 2013 statistics more than 80 % of the world's vehicle fleet is dependent on liquid hydrocarbon fuels; these will remain a major part of the fuel infrastructure in the foreseeable future because even though there are few alternatives for ICE vehicles, such as battery electric vehicles, but then the maximum range, availability of charging infrastructure and other factors contribute to dissatisfaction of consumers, and they turn to the traditional ICE vehicle. When a hydrocarbon fuel is completely oxidized the exothermic reaction converts the carbon present in the fuel to carbon dioxide (CO₂) and the hydrogen to water (H₂O). This combustion results in a large heat release that can be used to move the piston and produce work. While the products are emitted as exhaust gases. As CO₂ is also a Greenhouse Gas (GHG) the large use of fossil fuels over the years has lead to a global temperature increase by 1 degree Celsius since the pre-industrial time, with negative impact on the environment figure 1 shows the emission breakdown by transport mode.

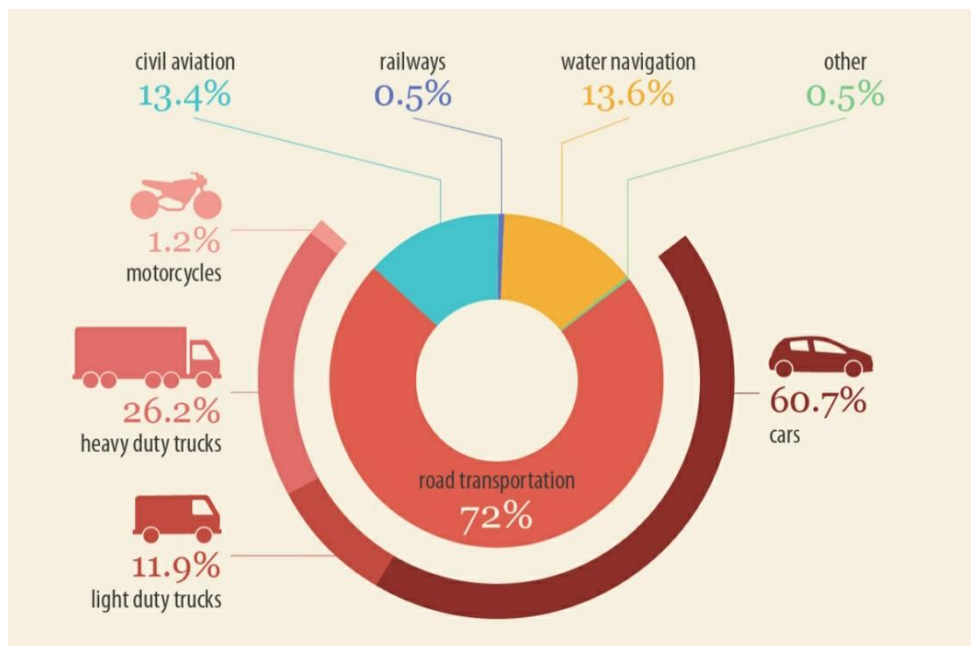


Fig 1. Emissions by different transport modes in EU

Fossil fuels are made up by hydrocarbon chains of different length and composition, from the simplest molecule methane to petrol, which can consist of up to 250 different hydrocarbons species. Considering the rising prices of the petrol and diesel, it is believed that petrol would soon reach the 100 rupees per litre mark by the end of 2030. It is believed that Alternate fuels will have expandable capacity in future of automobiles. The following are the two key factors that spur the use of these fuels.

- Most of the alternative fuels are sustainable because they do not come from fossil fuel sources.
- Alternative fuels generally have lower vehicle emissions that contribute to air pollution thereby causing global warming and ozone depletion.

The popular Alternative fuels are Bio-diesel, Ethanol, Hydrogen fuel, e-Diesel.

II. LITERATURE REVIEW

A. BIODIESEL

Biodiesel is more entirely from sources. It does not contain any sulphur, aromatic hydrocarbon metal or crude oil resources. Biodiesel is produced from renewable vegetable animal fats and hence improves fuel or energy security and economy independence. But the high viscosity and low volatility affected the atomization and spray pattern leading to incomplete combustion and severe carbon deposits, injection, choking etc. Various types of Fuels with different proportions are being tested as an alternative for conventional diesel; waste transformer oil was used as an alternate fuel in a single cylinder four stroke diesel engine. Blends up to B5 are the most commonly approved by vehicle manufacturers for use in diesel engines, while some manufacturers recommend blends up to B20. Transesterification process was actualized to produce pure and untested bio-diesel. Using this bio-diesel various blend were produced and tested. B10 (10% bio-diesel and 90% diesel) B20 (20% bio-diesel and 80% diesel) B30 (30% bio-diesel and 70% diesel) B40 (40% bio- diesel and 60% diesel). When the results were actualized, it was found that the B30 blend is the best blend as it produced emissions having minimum amount of CO, HC, smoke capacity and maximum amount of Carbon-dioxide and a consistent amount of nitrogen-oxide, when all load condition was considered. Table 1 shows the advantages and disadvantages of different Bio diesel production method.



Table 1 Advantages and disadvantages of different Bio-diesel production method

Bio-diesel production method	Advantages	Disadvantages
Dilution (direct blending or micro-emulsion)	<ul style="list-style-type: none"> • Simple process 	<ul style="list-style-type: none"> • High viscosity • Bad volatility • Bad stability
Pyrolysis	<ul style="list-style-type: none"> • Simple process • No-polluting 	<ul style="list-style-type: none"> • High temperature is required • Equipment is expensive • Low purity
Transesterification	<ul style="list-style-type: none"> • Fuel properties • is closer to diesel • High conversion • Efficiency • Low cost • It is suitable for industrialized production 	<ul style="list-style-type: none"> • Low free fatty acid and water content are required (for base catalyst) • Pollutants will be produced because products must be neutralized and washed • Accompanied by side reactions • Difficult reaction products separation
Supercritical methanol	<ul style="list-style-type: none"> • No catalyst • Short reaction Time • High conversion • Good adaptability 	<ul style="list-style-type: none"> • High temperature and pressure are required • Equipment cost is high • High energy consumption

B.ETHANOL AND METHANOL

Vehicle manufacturers have available vehicles that are capable of operating on gasoline plus ethanol or a mixture of gasoline and ethanol called E85. E85 consists of 85% ethanol and 15% gasoline. Pure ethanol has an octane number of about 113. E85 contains 35% oxygen by weight, has an octane rating of about 100 to 105. The fuel economy is reduced by 20% to 30% if E85 is employed rather than gasoline. Diesel-Ethanol blends also are utilized in CI engine with some modification and therefore the use of ethanol Cetane also improves. Bio-ethanol is manufactured through a bio reaction using hydrolysis to supply simple from sugar beet and wheat, corn and sugarcane. Sugars are then fermented to produce bio-ethanol. Currently, these processes are rather expensive and not yet competition for market place. General Motors, Ford, Chrysler, Mazda, and Honda are a few of the manufacturers offering E85 compatible vehicles.

A research on a 4 stroke, 4 cylinders, water cooled, port fuel injection, SI engine was carried out. Different blends of alcohols were mixed with gasoline in fixed proportions and the alternative fuels were tested in different operating conditions of the engine. Mixtures like ethanol/butanol gasoline were used. Gasoline was used as a base fuel. Butanol and methanol were mixed in the ratios of 2, 5, 10, 15 and 20. The alcohols were mixed in percentage range of 0-20%. By adding these alcohols helps in reduce the knocking due to the octane contents present in the alcohols. The alcohols also help in the complete and proper combustion of the fresh charge as the alcohols have oxygen content in it bonded with various bonds. A surge tank was used to regulate the air sucked into the combustion chamber during the combustion process and measure the flow rate of air into the engine. An air flow meter was installed in the tank. A fuel pump was submerged inside a container. It was on a weighing balance in order to measure the mass of fuel consumed by the engine during the combustion process. An exhaust gas analyser was used to measure the percentage of exhaust gases like CO, CO₂, HC and NO_x coming out of the exhaust pipe. Three thermocouples were used to determine the temperature of oil in the engine, the exhaust gas and the coolant during operation. In the experimental results it was observed that the 15% fuel blend EB15 gave the best results for both pollutants emissions and fuel consumption. In the experiment the observed results showed a clear decrease in pollutants or undesirable gases emitted from the engine. There was reduction of 13.7% for carbon monoxide and 25.2% of hydrocarbons as well as fuel consumption was reduced by 8.22%. Though there were benefits due to these alternate fuels the power of the engine was decreased and could only pile up to 11.1% for the fuel blends

C. HYDROGEN FUEL

The use of hydrogen as fuel within the combustion engine represents an alternate use to exchange the hydro carbon fuels, which produces polluting gases like CO, HC during combustion. Hydrogen may be a future renewable and fewer polluting fuel. Hydrogen is clean burning characteristics and better performance drives more interest in hydrogen as fuel. Hydrogen produces only water after combustion. It is non-toxic, non-odorant gaseous matter. When hydrogen is burned, hydrogen combustion doesn't produce toxic products like hydrocarbon, carbon monoxide gas etc. except only the formation of nitrogen monoxide. Since pure hydrogen doesn't occur naturally on earth. But the hydrogen found on earth is abundant within the sort of compound like water and other chemical like peroxide etc. Hydrogen is extracted from electrolysis and steam-methane reforming. In electrolysis, electricity is run through water to separate hydrogen and oxygen atom and obtaining hydrogen from this process is being suited as a viable thanks to produce it domestically at low cost. The energy is often delivered to fuel cells and generates electricity and warmth or burned to run a combustion engine. Hydrogen after burning emits water and warm air. Hydrogen has the highest energy content by weight of any fuel but its energy content by volume is low. This fuel property makes strong challenge because it requires high, coldness or chemical processes to be stored in small spaces.

An experiment was actualized by using a four stroke four cylinder spark ignition engine. Hydrogen was added to various blends of methanol and gasoline (G95M5, G90M10, G85M15). As the experiment proceeded it was observed that the amount of emission of HC, CO and Carbon-dioxide were reduced and efficiency of combustion was increased. As the efficiency of combustion was increased the emission of NO_x was also increased.

In a similar work, Madhuca longifolia oil was used to accomplish the experiment. Considering various cases in this experiment single cylinder diesel engine was made to run completely on diesel, then only on madhuca longifolia oil, then blend of madhuca longifolia oil as primary fuel and hydrogen as secondary fuel, then a blend of madhuca longifolia oil as primary fuel and hydrogen as secondary fuel with water injection, followed by a blend of madhuca longifolia oil as primary fuel and hydrogen mixed with ALPG as secondary fuel and when the experiment was actualized it was found that the blend of madhuca longifolia as primary fuel and hydrogen mixed with ALPG as secondary fuel gave high efficiency and low emission compared to other cases.

D. e-DIESEL

Ever since the invention of the Fischer-Tropsch synthesis the possibility to produce gasoline and diesel in a synthetic way have been available, but due to low oil prices it has very seldom been profitable. However, during times of low supply, which took place in Germany during World War II or in South Africa during the boycott years of the Apartheid era, the method has been used by reforming syngas to liquid fuels. Recently, Audi launched the opening of a pilot factory located in Dresden where e-diesel is produced. Using ambient air as CO₂ source and sustainable energy as energy input the test plant will be able to produce approximately 130 litres of synthetic diesel per day, stated to have a high cetane number and being able to blend in any ratio with fossil diesel. The factory use a reversible electrolyzer with the efficiency estimated to 90% and a power to liquid stated efficiency of 70%. With plans to soon launch a full-scale factory, this proves the increasing interest for electrofuels in the automotive industry as a way to cope with increasing emission legislation's. Both e-diesel and e-gasoline will therefore be a part of this study.

E. P-SERIES

P-series alternative fuel is patented by Princeton University and is a non-petroleum- or natural gas-based fuel suitable for use in flexible fuel vehicles (FFV) or any vehicle designed to operate on E85 (85% ethanol, 15% gasoline). They are inexpensive fuels generated from municipal and agricultural wastes. They are blends of the following components:

- 1) Ethanol (Ethly Alcohol).
- 2) Methyltetrahydrofuran (MTHF).
- 3) Butane (used in severe cold-weather conditions).
- 4) Natural gas liquids.

Ethanol and Methyltetrahydrofuran (MeTHF) are expected to be derived from renewable domestic feedstocks such as corn, waste paper, cellulosic biomass, agricultural waste, construction wood waste, and other wastes. These fuels produce 35% less hydrocarbons emissions, 40% less carbon monoxide emissions, 70% less carbon dioxide emissions, and have over 50% less ozone forming potential than reformulated gasoline. In conclusion, the emissions of P-series fuels are generally lower than those for the reformulated gasoline. In addition to this, they about 70% renewable and produced domestically as these could be 96% derived from domestic resources. More than 60% of the energy content

in P-series is generated from renewable sources. P-series fuels are recognized by the United States Department of Energy as being an alternative fuel. Numerous researches are also being carried out in order to explore and improve the production process.

III. CONCLUSION

Currently, much attention is focused on alternative fuels such as biodiesel, ethanol, hydrogen, methanol, natural gas (CNG/LNG) and P-series fuel. The pollution from motor vehicles can be minimized by using new as well as innovative technology, alternate fuels and government policies. These fuels for diesel engines are becoming increasingly important due to diminishing petroleum reserves, their increasing price and the environmental issues due to emissions of exhaust gases from petroleum fueled engines. Flexible Fuel vehicles are being manufactured for ICE attracted masses by many Automobile manufacturers. Since the performance of ICE vehicle is superior to that of Electric vehicle but lack of Battery charging infrastructures, and cost for development are way too much compared with conventional IC vehicles.

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