BIODIESEL: THE SUITABLE ALTERNATIVE FUEL FOR DIESEL ENGINES

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Abstract: Primary fuels like petrol, diesel, coal, natural gas etcare unfortunately exhaustible energy sources and due to huge global energy demand and heavy escalation and extraction of these sources from the crust of the earth, there reserves are draining at alarming rate. The global scientists must urgently identify some alternative energy options to move the world. Presently many alternative fuels like methanol, ethanol, vegetable oils, biodiesel, hydrogen, wind energy, solar energy etc are available which can run the existing engines and can be used as suitable energy source. Among all alternative energy sources Biodiesel is fond most suitable to run existing engines. In the present paper attempt is made to identify, analyze and explore some of the techno economic feasible, cost effective, environmental friendly renewable fuels which can be used as substitute fuels for existing I C engines. Moreover in the present study emphasis is given on biodiesel as it is emerged as most suitable fuel for diesel engines.
Keywords: I C Engine, Diesel Engine, Biodiesel, Transesterification.

I. INTRODUCTION

Demand of Energy became the most essential feature of humanism and in every activity.An important role is play by energy in the growth of any developing country like India where rapidly increasing consumption is seen in recent years. In current scenario, the world petroleum reserves are depleting very rapidly which gave lot of eye to produce fuels from renewable resources which are enormous and environmentally acceptable such as. Methanol, Ethanol, Natural Gas (NG), compressed natural gas (CNG), Liquefied Petroleum Gas (LPG), biogas, biodiesel, hydrogen etc, all have taken into consideration as an alternative fuels. Properties of some of the alternative fuels are discussed and analyzed.

II. ALTERNATIVE FUELS

2.1 Alcohol Fuel

Generally, the term alcohol refers to ethanol, the first organic chemical produced by humans, but any alcohol can be burned as a fuel. Ethanol and methanol is the most common, being sufficiently inexpensive to be useful. Methanol and ethanol can both be derived from fossil fuels or from biomass. Ethanol is produced through fermentation of sugars and methanol from synthesis gas. Methanol (CH3OH) is a clear liquid alcohol that can be produced from natural gas, coal, crude oil and biomass crops such as wood and wood residues as well as directly from catalytic synthesis.Under combustion, methanol produces neither soot particles nor sulphur oxides. It also yields less nitrogen oxides than any other fuel. Methanol is the lightest and simplest alcohol, produced from the natural gas component methane. Its application is limited primarily due to its toxicity (similar to gasoline), but also due to its high corrosivity and miscibility with water. Methanol is also called methyl alcohol or wood alcohol, the latter because it was formerly produced from the distillation of wood. It is also known by the name methyl hydrate.Ethanol, also known as grain alcohol or ethyl alcohol, is most commonly used in alcoholic beverages. However, it may also be used as a fuel, most often in combination with gasoline. For the most part, it is used in a 9:1 ratio of gasoline to ethanol to reduce the negative environmental effects of gasoline. There is increasing interest in the use of a blend of 85% fuel ethanol blended with 15% gasoline. This fuel blend called E85, has a higher fuel octane than most premium gasoline.

2.2 Compressed Natural Gas and Liquefied Natural Gas

Natural gas is comprised of a mixture of gases, mainly hydrocarbons, found in geological formations. Methane is the principal component, generally comprising from 87 percent to 97 percent by volume of the hydrocarbons depending on the source of the gas.The interest in natural gas as an alternative transportation fuel stems mainly from its clean-burning qualities, domestic resource base and commercial availability. Because of the gaseous nature of this fuel, it must be stored onboard a vehicle in either a compressed gaseous (compressed natural gas, CNG) or liquefied (liquefied natural gas, LNG) state. Liquefied Petroleum Gas (LPG) is a mixture of light hydrocarbons which are gaseous at normal temperatures and pressures, and which liquefy readily at moderate pressures or reduced temperature. The main component gases of LPG include Propane (C3H8), Propylene (C3H6) and Butane (C4H10). Their main claims to fame are that they produce much less tailpipe pollution.

2.3 Biogas

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Organic waste such as dead plant and animal material, animal feces, and kitchen waste can be converted into a gaseous fuel called biogas. Biogas originates from biogenic material and is a type of fuel. Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal waste, green waste, plant material, and crops. Biogas comprises primarily methane (CH4) and carbon dioxide (CO2) and may have small amounts of hydrogen sulphide , moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel. Biogas can be used as a fuel in any country for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat.Biogas can be compressed, much like CNG and used to power motor vehicles. In the UK, for example, biogas is estimated to have the potential to replace around 17% of vehicle fuel Biogas is a renewable fuel, so it qualifies for renewable energy subsidies in some parts of the world. Biogas can also be cleaned and upgraded to natural gas standards when it becomes bio methane.

2.4Hydrogen

Hydrogen has the potential to revolutionize transportation and, possibly, our entire energy system. Because hydrogen burns nearly pollution-free, it has been looked at as the ultimate clean fuel. The interest in hydrogen as an alternative transportation fuel stems from its clean-burning qualities, its potential for domestic production and the fuel cell vehicle's potential for high efficiency. Producing hydrogen with renewable energy and using it in fuel cell vehicles holds the promise of virtually pollution-free transportation and independence from imported petroleum.The main technical difficulty with hydrogen is storage. Developing safe, reliable, compact, and cost-effective hydrogen storage technology is one of the most technically challenging barriers to the widespread use of hydrogen as a form of energy.Liquefied hydrogen is the liquid state of the element hydrogen. It is a common liquid rocket fuel for rocket applications and can be used as a fuel in an internal combustion engine or fuel cell. Various concept hydrogen vehicles have been lower volumetric energy, the hydrogen volumes needed for combustion are large. Hydrogen was liquefied for the first time by James Dewar in 1898

2.5 Biodiesel

Biodiesel is a domestic, renewable fuel for diesel engines derived from natural oils like soybean oil, coconut oil that can be used in a fossil fuels concentration with petroleum based diesel fuel. Among liquid fuels, biodiesel is considered to be one of the prominent alternative fuels which can be obtained from different types of plant seeds. The idea of using vegetable oils instead of fossil diesel fuels has resurfaced as a way to minimize the net carbon footprint from compression ignition engines. Straight Vegetable Oils (SVOs) have some operational problems in unmodified CI engines. These problems include: cold-weather starting; chocking and gumming of filters, injectors; engine knocking; coking of injectors etc. Vegetable oils decrease power output and thermal efficiency while leaving carbon deposits inside the cylinder. Most of these problems with vegetable oil are due to high viscosity, low cetane number, and low flash point resulting incomplete combustion. The process, called transesterification, forces vegetable oil or animal fat to react with a catalyst (usually sodium hydroxide) and methanol or ethanol to produce glycerol and fatty acid esters, the latter being the actual chemical name for biodiesel.Transesterification originally was used to obtain glycerol for soap; what we now call biodiesel was a byproduct of the soap-making process. The use of biodiesel can decrease the solid carbon fraction of particulate matter (since the oxygen in biodiesel enables more complete combustion to CO2), eliminates the sulphur fraction (as there is no sulphur in the fuel), while the soluble or hydrogen fraction stays almost same. Most of the studies on emission using biodiesel have reported lower emissions of un-burnt hydrocarbons, carbon monoxide, smoke andparticulate matter with some increase of NOx.

2.5.1 Biodiesel Production

The transesterification reaction between a typical triglyceride and methanol is shown in Figure [1.1]. Three moles of methanol are required to react with each mole of triglyceride in the oil or fat. The reaction is carried out in the presence of a catalyst to improve the reaction rate . The catalyst, alcohol, and vegetable oil are combined in a batch reactor at approximately 650C and stirred continuously. The duration of the reaction can range from 1-6 hours, depending on the desired yield. Two immiscible layers are formed once the reversible reaction reaches equilibrium. The lower layer is glycerol and the upper layer contains and unreacted feedstock. Many processes separate the glycerol and conduct a second transesterification reaction to increase the yield. If the biodiesel is to meet ASTM D6751 specifications, it must undergo a series of separation processes for the removal of alcohol, catalyst, water, soaps, glycerol, and unreacted triglycerides and free fatty acids. The separated crude glycerol can be further purified and used in other applications (e.g., cosmetics, pharmaceuticals, etc.).

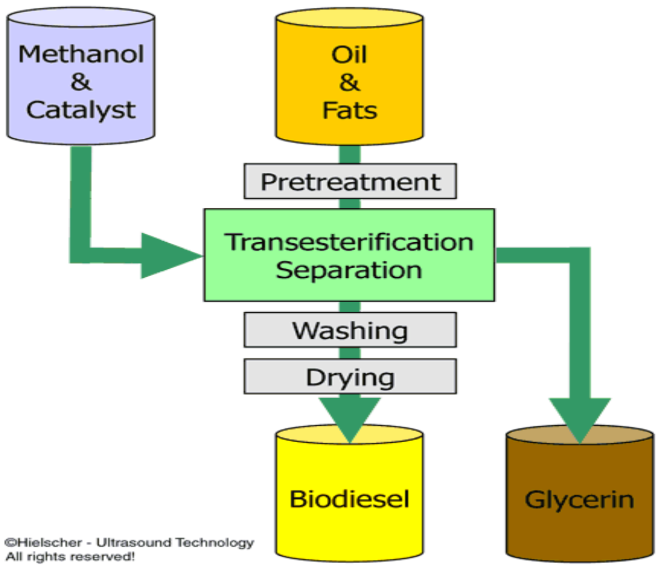

Figure [1.1] Layout of biodiesel production

2.5.2 Biodiesel Applications

Present diesel engines are more efficient and produce lower emissions than gasoline engines. Diesel engines may play a significant role in the future small engine market as well.

The adoption of biodiesel/diesel blends is very promising since proper blends have proven to have better combustion efficiency and lower emissions than even with neat diesel fuel. However, some properties of biodiesel and engine durability problems limit the maximum substitution of diesel by biodiesel. Biodiesel can also be used as the engine lubricants, primarily because of some inherent properties such as high lubrication and lower cost.

2.5.3Advantages of Biodiesel

The exceptional advantages of using biodiesel/biodiesel blends as engine fuel are the adaptability to a diesel engine without any major engine modification, especially when a very small amount of biodiesel is added to the blend. The maximum amount of biodiesel blended with regular diesel depends on type of engine used and engine operating parameters. Dedicated engine models from large engine manufacturers can sustain as high as 20% biodiesel in the blend. However, use of B20 or even higher fractions of biodiesel requires some minor precautions on fuel degradability, fuel filters choking, cold weather starting, and maintenance.Additional oxygen in biodiesels improves fuel oxidation leading to more spontaneous combustion and hence better combustion efficiency. At the same time, it reduces the total energy content1 of the fuel by ~10% (on a mass basis) primarily because oxygen carries less energy than heavy hydrocarbon molecules. This is the primary reason for reduction of engine power output when using 100% biodiesel. At lower biodiesel fractions, there is some inconsistency in the literature about the effect on power output – some studies show higher power output whilst others report a reduction. This is possibly due to the combined effects of better combustion efficiency and lower heating value of biodiesel. Furthermore, engine power output can be affected by engine operating parameters. More complete combustion of biodiesel can substantially reduce Unburned Hydrocarbon (UBHC) and Carbon Monoxide (CO) emissions. However, biodiesel can increase NOx emissions as the combustion temperature is observed to be higher. However, for an engine with a catalytic converter, inherently low sulphur in biodiesel leads to a better NOx catalytic conversion efficiency and as a result, after-treatment from a biodiesel engine most likely emits less NOx.Fuel lubrication property helps in reducing engine wear and extends engine life. In ordinary diesel fuel, the natural sulphur content enhances lubrication property. However, tight sulphur regulations have caused lubrication related problems in diesel engines. Unexpectedly, biodiesels derived from vegetables oils2 have an ultra low sulphur level yet also have high lubricity. The better lubrication property of biodiesel extends the lifespan of fuel injection system as well as metallic components that have sliding contacts between each other. The low sulphur content in biodiesel reduces emission of SO2 and sulphate particulate matter. Finally, it is safer to handle and store biodiesel at high temperatures as biodiesel has a high flash point due to its composition of non-volatile fatty acid methyl esters.

2.5.4 Disadvantages of Biodiesel

Engine life is the real confront of using biodiesel blends as an engine fuel. First is elastomeric seal degradability, including swelling, shrinkage, embrittlement and changes in physical properties such as hardness and tensile strength. Second, high solubility of biodiesel could cause fuel system nuisance especially when used in an engine by and large operated with regular diesel fuels. During the use of the regular diesel fuels, deposits accumulate in the fuel tank. Addition of biodiesel loosens these additives and re-introduces them into the fuel stream. High cloud point and pour point temperatures of biodiesel reduce thermal stability and bound the cold weather operability of biodiesels and its blends. The cloud point and pour point temperatures of biodiesels depend on the fraction of biodiesel present in the blends and the type of fatty acid methyl esters. High cloud point causes filter clogging. In addition to engine operation, high cloud point temperature of pure biodiesels could lead to “shock crystallization” during the blending process of two fuels and therefore controlled conditions in operation is compulsory. Another major problem caused by biodiesels’ high viscosity, surface tension and molecular weight,which lead to poor atomization and generally larger drop size. This adversely affects engineperformance. In addition, the bigger droplets tend to impinge on the engine cylinder wall. These impinged fuels on the cylinder wall and piston can form deposits in the ring grooves and escape through the piston rings to the crank case during the compression stroke. This escaping oil finally dissolved in the engine lubricating oil, causing engine oil degradability very fast. Therefore, engine oil needs to be replaced more frequently. Problems at the injector tip might occur when using biodiesel. In addition to this, it is difficult to store biodiesel over a long period of time due to fuel degradability. Biodiesel is very sensitive to water, surrounding temperature, microbial action and oxygen resulting in unpleasant changes of biodiesel properties rapidly. The changing properties include acidic value, viscosity, growing microbial creatures and the presence of other substances such as peroxides, acids, aldehydes and highly viscous polymers.

III. CONCLUSIONS

A major apprehension for majority of people these days is the availability of energy in abundance as well as ensuring safety of life by reducing exhaust emissions. People use a large fraction of their income on gas and oil. These fossil fuels are being continuously used to a large extent. Because these forms of energy are non-renewable, their availability will continue to decrease and costs will continue to go up. This has led to a search for new energy sources. Among all alternative fuels,biodiesel obtain from vegetable oils like jatropha oil, karanja oil, castor oil, jojoba oil, cotton seed oil, neem oil, mahua oil, thumba oil, palm oil, soybean oil, sunflower oil etc are being investigated as potential substitute for current high polluting fuels obtained from conventional sources to meet fuel crises. Biodiesel has high-energy content, comparable calorific values, nontoxic and non-flammable in nature facilitates easier and safe handling.

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