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Impact of Using Ethanol with Diesel in Compression Ignition Engine

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Abstract

The depletion of fossil fuels and global warming alarms to find and use an alternative fuel such as biofuels. Ethanol is considered as a renewable fuel in different countries, which is produced from plant, sugary and starchy biomass. Biomass resources are the bio-degradable fraction of product, waste and residues from agriculture, forestry and related industries as well as the bio-degradable fractions of industrial and municipal wastes. In fact, ethanol is an important additive to gasoline and diesel fuel which can improve the engine performances and reduce emissions. The behavior of diesel-ethanol mixtures directly related to the engine performance parameters such as torque, brake power, brake specific fuel consumption, brake thermal efficiency, heat releasing pattern and also related to emission characteristics, such as Carbon-dioxide (CO_2), Carbon-monoxide (CO), Nitrogen oxide (NO_x), Total Hydrocarbons (THC), Particulate matter (PM) etc. the addition of ethanol with diesel have a significant impact on the performance parameters and emission characteristics in compression ignition engines.

1. Introduction:

Compression ignition engines are widely employed in industrial and agriculture field and in most efficient propulsion plant for both inboard and outboard engines. This is due to their reliability, durability and high fuel efficiency and agreeing to use alternative fuel with diesel in different ratios without any large moderation in the compression ignition engines Uyumaz (2018). Many researchers are consistently applying effort to use biomass-based fuels (renewable fuels) derived from biodegradable fraction of industries and municipal waste. Since the use of these fuels reduces greenhouse gases, air pollution, dependence on fuel imports, cost of energy and these fuels cover a part of energy demand. These fuels can be used in pure or blended forms with fossil fuels in transport systems, heating homes, buildings and industrial processes. Bio-ethanol is one of the important renewable fuels which is used in different countries as an alternative fuel for internal combustion engines. The advantage of ethanol has oxygen for combustion as compare with diesel and gasoline fuel and result in creating lower pollutants.

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2. Blend properties:

The fuel properties play an important role in the operation of an internal combustion engine. The properties of the diesel and petrol suits to the proper working of an internal combustion engine but due to scarcity and environment concern it is the high time to find an alternative fuel such as biodiesels, ethanol etc. In fact, since 19th century, the ethanol has started to use in an internal combustion engine. The blend properties of ethanol with fossil fuels should have the consistency in the important key properties such as stability, volatility, viscosity, lubricity, flash point, cloud point, cetane number, energy content, safety and biodegradability.

2.1. Blend stability:

Ethanol solubility in diesel is mostly affected by two factors such as temperature and water content of the blend. Dry ethanol (ethanol with a very low water content) mixes easily with diesel fuel at warm temperatures. However, the two fuels separate below around 10°C, a temperature that is readily exceeded for a significant amount of the year in many places of the world. Prevention of this separation can be accomplished by certain additives, such as emulsifiers or surfactants, are added to help produce a stable combination and avoid phase separation in order to increase the stability of ethanol-diesel blends. These chemicals help to decreases the polarity differences between ethanol and diesel, improving their ability to combine. Water-absorbing additives (isopropanol) improves the blend stability by reducing ethanol's water absorption properties and reducing its ability for absorbing moisture.

2.2. Viscosity and Lubricity:

Viscosity and lubricity properties of fuel plays important role because they influence how the fuel flows through the components like injectors, pumps, and the combustion chamber. Ethanol has a low viscosity as compared to diesel. Higher viscosity can result to poor atomization or spraying of fuel which affects the efficiency of combustion. Lower fuel viscosities lead to greater pump and injector leakage reducing maximum fuel eventually, power output. Lower viscosities typically result in increasing the surface area of droplets and significantly influencing the evaporation characteristic time. Ethanol also offers less lubricity than diesel due to its higher oxygen content, meaning ethanol-diesel blends have reduced lubrication (Letcher, 1983).

2.3. Energy Content:

The low heating value of a fuel has a directly influence on the power output of the engine. Blending ethanol with diesel lowers the volumetric energy density of the fuel in proportion to the ethanol content. For every 5% increase in ethanol content, the energy value

of the blend drops by around 2% (Hansen *et al*., 2005).

2.4. Cetane Number:

The cetane number is an important fuel property for diesel engines as it affects start-ability, emissions, peak cylinder pressure and combustion noise. Ethanol has a notably low cetane number, the cetane number of the ethanol with diesel blend fuel reduces significantly. A lower cetane number leads to longer ignition delays, allowing more time for fuel to vaporize before combustion starts. Hardenberg and Ehnert (1981).

2.5. Safety and Biodegradability:

When using ethanol with diesel, there are several factors to consider, especially regarding safety and biodegradability. Ethanol is highly flammable as compared diesel, it ignites at a lower temperature. Using ethanol with diesel may results to changes in the fuel's properties such as its volatility and combustion characteristics. Ethanol is generally considered as biodegradable and has a very low environmental impact as compared to other petroleum-based fuels. Diesel is less biodegradable it can persist in the environment for a longer time. However, the ethanol blended with diesel the biodegradability increased as the ethanol accelerates the microbial breakdown of hydrocarbons in the diesel fuel.

2.6. Flash Point:

The lowest temperature at which a fuel will ignite when it comes into contact with an ignition source is known as the flash point. The flashpoint of the fuel affects the shipping and storage classification of fuels and the precautions that should be used in handling and transporting the fuel. Ethanol has lower flash point than diesel. When ethanol is added with diesel, the flash point of the mixture will depend on the ratio of ethanol mixed (Li *et al.,* 2005).

2.7. Boiling Point:

The boiling point of ethanol is around 78°C. The boiling point of diesel ranges between 180°C to 360°C (Rakopoulos *et al.,* 2007). When ethanol is added with diesel, the boiling point of the mixture will depend on the relative concentration of ethanol and diesel. Ethanol has a very low boiling point as compared to diesel, so even small concentration of ethanol will decrease the overall boiling point of the mixture.

3. Engine Performance:

Comparisons of engine performance between using ethanol with diesel and pure diesel in unmodified engines generally show decrease in power that are approximately same as the reductions in energy content of the blends relative to diesel fuel. The engine performance at different loads at different speeds using ethanol with diesel was measured in terms of Brake

Power (BP), Brake Specific Fuel Consumption (BSFC), Brake Thermal Efficiency (BTE)

3.1. Brake Power (BP):

Brake power is directly proportionally dependent on the brake torque for a specified speed of the engine. Brake power increases with increase in ethanol percentage at different engine speed and its maximum improvement (Kumar and Chaurasia, 2019). It occurred because of the improvement in the combustion efficiencies due to oxygenated fuel. Additionally, engine power is influenced by the compression ratio, which is enhanced by ethanol blending. Brake torque also depends on volumetric efficiency which enhanced with added ethanol concentration.

3.2 Brake Specific Fuel Consumption (BSFC):

Brake Specific Fuel Consumption is a measure of the fuel efficiency of an engine in relation to the power it produces. It is found that the BSFC decreases with the increases of load. The maximum BSFC of diesel engine resulted when using pure diesel as a fuel. This condition is different according to some researchers using ethanol with diesel increased the BSFC value as the percentage of ethanol increased this is due to the low energy content in ethanol (Rakopoulos *et al.,*2008).

3.3 Brake Thermal Efficiency (BTE):

It shows the ability of conversion of fuel energy into mechanical form. BTE of using ethanol with diesel increases as the load increases as compared to the using pure diesel. In spite of higher BSFC of using ethanol with diesel fuel blends, the BTE of blended fuel is found higher. The reason for increase of BTE is the increment in compression ratio due to its higher octane number in case of using ethanol blended fuel. Cetane value of using ethanol with diesel blended fuel is less as compared to using pure diesel in engine. In this increased time period, more amount of fuel will convert into vapour causing higher heat release which shows better efficient conversion of heat into work. Due to this reason BTE of using ethanol with diesel blended fuel elevates. Also, it has more oxygen present in the ethanol provides better combustion efficiency causes improvement in BTE of using ethanol blended fuel (Tutak *et al.,* 2015).

4. Engine Emissions:

Exhaust emissions such as nitrogen oxides (NOx), carbon dioxide (CO2), carbon monoxide (CO), total hydrocarbon (THC) and particulate matter (PM) considerably depends on oxygen content and burning condition of fuel. Many factors affect emissions, which are different from those emitted by fuels. Some of these factors are engine age, fuel metering

method, engine maintenance, emission control technology, and engine test etc.

4.1. NOx Emissions:

NOx emissions are the most concerning emission in compression ignition engines. The formation of NOx often depends on the temperature and oxygen concentration in the cylinder (Ajav *et al.,* 1998). NOx emissions are lower for ethanol blended fuel as that of pure diesel. This reduction in NOx emissions is due to the temperature-reducing effect of ethanol's low calorific value, and it gradually decreases with increase in ethanol concentration. This effect is compensating by the presence of oxygen using ethanol with diesel blends. Furthermore, since using ethanol with diesel blended fuel has a lower cetane value, its ignition delay period is longer. Therefore, ethanol leads to higher temperatures during premixed combustion and NOx production.

4.2.CO2 Emissions:

CO2 is another important factor after NOx emission. Diesel fuel is made from petroleum, which has maximum carbon intensity at the time of extraction, refining, and combustion. When pure diesel is burned, a large amount of CO2 is released. Using ethanol with diesel can reduce CO2 emission because ethanol has a lower carbon intensity as compared to diesel especially if the ethanol comes from low-carbon or renewable feed stocks (He *et al.,* 2003).

4.3.CO Emissions:

CO is a toxic engine emission and it must be controlled. It forms due to incomplete combustion of the hydrocarbon fuel. Increasing the amount of alcohol (ethanol) in the diesel, fuel mixture will leaner. Thus, full combustion takes place and CO is converted into CO2 more effectively than pure diesel fuel. Some researcher also found that CO emissions decreased significantly with the increase of load by using the ethanol diesel blended fuels (Putrasari *et al.,* 2013)

4.4.THC Emission:

THC emissions when using ethanol in diesel fuel is an important consideration. As THC represents the consists of the fuel which incompletely burned or partially burned that released into the atmosphere. Compared to pure diesel, THC emissions are greater for fuel with ethanol content and they were higher for fuel with a higher ethanol percentage in the blend (Parthasarathi *et al.,* 2012). Also, it was observed that THC emission increases with increasing engine speed (Banugopan *et al.,* 2013).

4.5 PM Emissions:

Using of ethanol with diesel is an important aspect of understanding how ethanol affects engine performance and air quality. Unburned fuel, soot, and other combustion byproducts are examples of particulate matter, which are tiny particles or droplets in the air that can come from engine exhaust. Both the environment and human health are at risk from these particles. Particulate matter can be reduced by ethanol in small amounts. Especially during low-load operations, when particulate matter is typically high in pure diesel combustion, ethanol helps reduce the formation of soot and black carbon particles by promoting complete combustion.

5.Conclusions:

The idea of using ethanol has started since 18th century and the use of blending of ethanol in diesel engine was first investigated in late 1970s in South Africa. Seeing the importance of ethanol as one of the alternative fuels for fossil fuel in an internal combustion engines researchers have started to conduct research work for different engines using blending of ethanol with fossil fuels in different ratios as well as using ethanol with different biodiesels in different ratios. The ultimate goal of the research is to optimize the important performance parameters such as torque, brake power, brake specific fuel consumption, brake thermal efficiency and as well to reduce the emission parameters such as NO_x, CO_2, CO, THC, PM. Under these circumstances the ethanol is considered as an attractive alternative fuel which is widely used as an octane enhancer in spark ignition engines as well as one of the most important components of biodiesels fuel in compression ignition engines. So, knowing the future petroleum-based energy availability and to control the emission of greenhouse gases is concern and government have passed the policies on use of biofuels as an alternative fuel in an internal combustion engine.

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