Use of Biodiesel as Vehicle Fuel: A Review

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ABSTRACT: This paper provides a review of the literature on biodiesel as a fuel for compression ignition engines. This review is based on accounts from scientists who published their findings prior to 2015. Many tests were carried out by scientists and researchers utilizing several kinds of raw and refined oils. These trials using raw biodiesel as a fuel did not provide acceptable results when the raw biodiesel was utilized. Injector coking and piston ring sticking were seen in the fuel. Some of the researchers used methanol or ethanol in the presence of KOH or NaOH, then filtered and washed the mixture. Transeterfication is a technique for degumming, dewaxing, and removing triglycerides from vegetable oils. The viscosity, density, and flash point of the gasoline are all reduced during transeterfication. The results achieved by utilizing such oils as fuel in compression ignition engines were only acceptable for a limited time. The overwhelming majority of scientists used various ratios of transesterified biodiesel oil to fuel. The researchers' primary conclusion is that coking is a potentially severe issue when using unmodified vegetable biodiesel. The refined, chemically treated, and degumed vegetable oil combined with diesel, on the other hand, may be utilized to operate a compression ignition engine for extended periods of time.

KEYWORDS: Biodiesel, Biofuel, Flower oil, Transeterfication, Vehicle fuel.

1. INTRODUCTION

Petroleum fuel is a God-given gift. It is critical to the growth of industry, transportation, agriculture, and many other fundamental human necessities. However, because of finite reservoirs, the world's energy demand is quickly rising due to excessive usage of fossil fuels. As a result, researchers are searching for alternative fuels. Another major issue connected with the usage of petroleum fuel is the increased emissions of pollutants. In Lahore, for example, tons of diesel are burned every day, resulting in a rise in CO2, HC, NOx, SOx, and a variety of other harmful gases. These contaminated fumes are wreaking havoc on people's respiratory systems and neurological systems, as well as causing a slew of skin disorders. These gases also harm animals' health and have an impact on plants and trees. These pollution exhaust gasses also contribute to acid rain. As a result, the demand for alternate fuels is unavoidable.

One of the greatest options is biodiesel. It's produced from sunflower, palm, cottonseed, rapeseed, soybean, and peanut oils, among other oilseed crops. Biodiesel is almost as ancient as the diesel engine itself. In 1892, Rodulf Diesel patented his engine, which was the first diesel engine designed to operate on vegetable oil [1]. He successfully operated the engine on peanut oil for many hours in 1900. In 1912, he prophesied that vegetable oil will one day be used as a fuel similar to diesel.

For a long period, dual-fuel engines were in use. Huge petroleum reserves were discovered in 1940, and extraction and refining were made simple and inexpensive. The monopoly of certain countries, along with political conditions, created a new scenario in the 1970s, forcing engineers and researchers to find an alternative, environmentally benign fuel. For a variety of reasons, including political considerations, environmental concerns, and economic factors, there has been increased interest in utilizing vegetable oils in diesel engines since then.

To decrease viscosity and enhance combustion and flow characteristics, the seed oil is filtered and chemically processed. It may then be used either as pure vegetable oil (B100) or mixed with diesel in any proportion. The greatest results were achieved by utilizing a mix of diesel and vegetable oil in an engine with an 80:20 (B20) ratio. Compared to diesel, biodiesel offers a lot of benefits. It's a renewable resource that's also non-toxic and biodegradable. Biodiesel fuel (vegetable oils processed with methanol or ethanol) is non-toxic and does not raise CO2 levels in the atmosphere at a global level since it is a renewable fuel. The fuel's exhaust output contains no SOx and produces much less NOx.

Sunflower oil, cotton oil, rapeseed oil, soybean oil, and palm oil were among the raw and processed vegetable oils evaluated by the scientists. The findings of a few scientists/researchers are compared and summarized in this paper.

2. DISCUSSION

2.1. Sunflower

Crude sunflower oil has a considerably higher viscosity than diesel oil, approximately 15 times more. When it is transesterified, however, it becomes extremely similar to diesel. The viscosity of methyl ester, which is made from methanol, is 3.2, whereas diesel has a viscosity of 2.8. Methyl ester has a density that is just 4.5 percent greater than diesel. When sunflower oil is utilized in the form of B20, a mix of 20% vegetable oil and 80% diesel, these characteristics are virtually identical.

2.1.1. Use of raw sunflower

Sunflower seed oil was investigated as a renewable energy source by Bruwer et al [2]. He operated the tractors on 100 percent sunflower oil instead of diesel, and after 1000 hours of operation, he recorded an 8 percent power decrease. The fuel injectors and injector pump were replaced to restore power. Except for the injector tips, which had significant carbon build-up after 1300 hours of operation, the carbon deposits in the engine were found to be comparable to an engine fuelled entirely with diesel.

Jakub et al. investigated the use of sunflower oil as a diesel substitute in agricultural tractors [2]. Engine performance using sunflower oil was found to be comparable to that of diesel fuel, however since sunflower oil has a lower heating value than diesel, more fuel was used and the engine generated somewhat less power.

Three mixes of sunflower oil and diesel fuel were used in other studies at International Harvest Company. Sunflower oil caused early engine failure owing to carbon buildup, according to the findings [3]. It was discovered that cold weather operation resulted in fuel system failures. German et al. conducted an on-farm research with six John Deere and Case tractors that were used for an average of 1300 hours. Carbon deposits on internal engine components were higher in tractors that ran on a 50/50 sunflower oil/diesel fuel mix than in tractors that ran on a 25/75 sunflower oil/diesel fuel blend. All of the test engines had greater carbon build-up than a diesel engine would usually have.

2.1.2. Use of processed sunflower

Engler et al. investigated the engine performance of sunflower and cottonseed oil as a substitute for diesel in 1983 [4]. They claimed that utilizing these oils instead of diesel resulted in poor engine performance. When refined and degummed oils are utilized, however, the performance is somewhat improved. These oils were found to have carbon deposits and lubricating oil contamination issues, suggesting that they were only suitable for short-term usage.

Sunflower oil, according to Biofuel Industries' study titled "Sunflower Biodiesel," is an ecologically beneficial alternative fuel. It drastically lowers hazardous exhaust emissions. CO2, HC, particles, and air toxics had all decreased by 12.6 percent, 11 percent, 18 percent, and 15 percent, respectively.

2.2. Cottonseed oil

India produces a large amount of cottonseed oil. Methyl ester has characteristics that are extremely comparable to diesel, especially when it is employed in the form of B20. Cottonseed oil has a viscosity of 3.2 and a density of 0.9. These characteristics are similar to those of diesel. However, since the oil's iodine value (IV) is greater than diesel's, it is less stable and more prone to oxidation.

2.2.1. Use of raw cottonseed oil

Goering et al. looked examined the characteristics of 11 different vegetable oils to see which ones would work best as an alternative fuel source [5]. Corn, rapeseed, sesame, cottonseed, and soybean oils have the best fuel characteristics, according to him.

In short-term performance and emissions testing, cottonseed oil and diesel fuel mixes performed similarly to petroleum-based fuels, according to the International Harvester Company. When power, fuel consumption, emissions, and other criteria were used, the experimental fuels performed well. However, due to carbon deposits and fuelling system issues, engine durability was a concern with prolonged usage of these fuel mixes.

2.2.2. Use of processed cottonseed oil

Tests were also performed at the International Harvester Science and Technology Laboratory using a mix of processed cottonseed oil and diesel. By utilizing a low-cost commercial process, the cottonseed oil was refined nearly to food grade in order to eliminate the gummed particles and decrease viscosity. Cottonseed

oil was blended with diesel in percentages of 30%, 50%, 65 percent, and 80 percent cottonseed oil. The tests were repeated four times for a total of 15 hours each time. With a 50 percent mix, the results were excellent. As a result, the mixed gasoline was put through a 200-hour endurance test. The engine exhibited scoring on two of the cylinders after the endurance test, and the matching pistons were likewise deeply scored with the surfaces ripped. The top rings of all the engines were severely packed with a very hard carbonaceous deposit, blocking the rings' functions.

2.3. Rapeseed oil

Rapeseed oil has a flash point of 220°C, which is considerably higher than diesel. Although it makes ignition more difficult, it makes transportation and handling considerably safer. Although the calorific value is 10–15 percent lower than diesel, the volumetric content of heat value is almost identical to diesel due to greater density.

2.3.1. Use of raw rapeseed oil

In Germany, a scholar experimented with using rapeseed oil as a diesel fuel, with mixed results. Rapeseed oil showed similar energy outputs to diesel fuel in short-term engine testing. The studies revealed that deposits on piston rings, valves, and injectors caused problems with engine functioning after 100 hours. He said that further research is needed to produce gasoline that is appropriate for continuous engine operation, as well as the engine changes that are necessary.

He et al.'s research in New Zealand found that vegetable oils, especially rapeseed oil, may be utilized to substitute diesel fuel [6]. Initial short-term engine testing revealed that a 50 percent vegetable oil fuel mix had no negative consequences, according to his findings. In long-term testing, they found injector pump failure as well as cold starting issues. Carbon deposits on combustion chamber components were discovered to be similar to those seen in engines running on 100 percent diesel fuel. They came to the conclusion that rapeseed oil had a lot of promise as a fuel replacement, but that further research was needed.

Wagner and Peterson investigated the long-term consequences of utilizing vegetable oil as a fuel by using rapeseed oil as a diesel fuel extender [7]. They successfully operated a tiny single cylinder engine for 850 hours using a mix of 70% rapeseed oil and 30% diesel fuel, with good results. He also said that using pure sunflower oil resulted in significant piston ring gumming and engine failure. For short-term performance testing, however, no detrimental operating circumstances were found.

2.3.2. Use of processed rapeseed oil

When utilizing rapeseed oil as a replacement fuel, Wagner and Peterson found mixed results. Attempts to heat the oil fuel combination before combustion resulted in no discernible increase in fuel injection. During short-term engine testing, severe engine damage was discovered owing to the usage of rapeseed oil. A long-term test utilizing a 70% rapeseed, 30% diesel fuel mix was successful for 850 hours with no visible indications of wear, lubricating oil contamination, or power reduction.

Rapeseed oil has a significantly greater kinematic viscosity, which influences the flow qualities and spray characteristics. It also causes the injector nozzle to corrode. The advantage of this alternative fuel is that it contains less sulfur, which means that the generation of SOx, ash, and residuals is minimal. When used untreated, the experimental findings also revealed that it causes difficulties. It should also be used in a mixed form at all times.

2.4. Miscellaneous/unknown

Sevim had excellent success using various vegetable oils in dual fuel mode in a diesel engine [8]. Under normal operating circumstances, he said, vegetable oils may be utilized as an alternative fuel in compression ignition engine cars.

Nikolaos and colleagues investigated a variety of vegetable oils as possible fuel sources [9]. They claimed that early engine performance testing using vegetable oils were determined to be satisfactory, despite the fact that these oils produced carbon buildup in the combustion chamber. Continuous part-load and mid-speed operation of a diesel engine resulted in high carbon deposition rates on the injector tips. The effects of utilizing various vegetable oils in lieu of diesel fuel were visually compared in two-hour testing. The engine's performance was determined to be acceptable, and there were no irregularities discovered.

The injection and combustion characteristics of various vegetable oils were studied by Ryan et al [10]. They claimed that owing to the greater viscosity of vegetable oils, their atomization and injection properties differed considerably from those of diesel fuel. Engine performance studies revealed that utilizing vegetable

oil fuel mixes reduced power output somewhat. For oil-based fuels with greater viscosities, injector coking and lubricating oil contamination seemed to be a more prevalent issue.

3. CONCLUSION

Although nearly any kind of vegetable oil may be used to substitute diesel oil, the most appropriate oils for use as a diesel fuel extender are rapeseed and palm oil. Vegetable oils may only be utilized for tiny engines for a limited time. A mix of diesel and vegetable oils is suggested for long-term usage and for heavy/big engines. These vegetable oils should only be used after they have been properly filtered, degummed, and dewaxed. To deacidify and reduce viscosity, appropriate amounts of additional chemicals, such as methanol, should be added. Indirect fuel injection is more effective than direct injection when vegetable oils are used instead of diesel oil. Only diesel should be used to start the engine. It should be switched to a vegetable oil mix once it has warmed up. The engine has to be maintained and serviced with more care and regularity. Because biodiesel produces much less harmful gases than diesel, it is preferable to use B100 in urban settings.

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