SVU-International Journal of Engineering Sciences and Applications (2022) 3(2): 27-36
Print ISSN 2785-9967 | Online ISSN 2735-4571
DOI 10.21608/svusrc.2022.128381.1042

A Review on the Performance Analysis of C.I Engine with Biofuel Blends

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Abstract Recently, the interest in eco-friendly and renewable fuels has been highly developed to get rid of environmental pollution. The developed countries focus on renewable energy like wind energy, biofuels, and solar energy. Biodiesel is one of the most promising renewable energy sources because of its similar qualities to those of diesel fuel. The purpose of this article is to provide an overview of the most recent biofuel kinds and mixes, as well as examinations of how they function in various engines. The performance of several engine types when utilizing biodiesel and its mixes was also studied. In the event that fossil fuels run out, a biofuel blend with additives like alcohol may be the best option. Biofuel blends with additives like alcohol can be the appropriate solution for fossil fuel depletion. Many researchers tried to obtain the optimum blends through various experimental researches and used binary fuel blend with some modifications to the engine parameters. It is reported that biodiesel can be blended with several concentrations and supplied to engines for light duty and heavy-duty diesel cars and trucks, tractors, boats, and electrical generators.

Keywords Renewable energy, biofuels, biodiesel, and fuel additives.

Literature review

K. Pramanik (2003) used jatropha curcas oil and diesel fuel blends to test the performance of a single cylinder diesel engine at a fixed speed of 1500 rpm under varying loads. Different jatropha oil and diesel blends were tested, 20:80-30:70-40:60-50:50-60:40-70:30 J/D blends compared to pure diesel and pure jatropha oil. The results revealed that raising the brake load from 0.77 to 3.078 kw reduces specific fuel consumption while increasing the brake load above these levels increases it. Because of the higher density and viscosity of the mix, the fuel consumption rises with a high proportion of jatropha oil in the blend. On the other hand, the SFC of blends such as 30:70 and 40:60 J/D is quite matched to that of conventional diesel fuel. At 3.078 brake load, the SFC values were determined to be 0.338 and 0.365, respectively; the diesel value is 0.316. The results also indicated that the brake thermal efficiency (BTE) of the jataropha oil, diesel, and mixes rose initially with increasing brake load, with the highest BTE attained at 3.078 and then tending to drop with further rise in brake load. Diesel had the highest BTE of 27.11 percent, while jatropha curcas oil had the lowest BTE of 18.52 percent. The highest BTE of blends 30:70 J/D and 40:60 J/D is 26.09 percent and 24.36 percent, respectively, which is comparable to pure diesel's BTE.[1]

Kumar et al (2003), in their research a variety of procedures of combining jatropha biofuel and methanol, including blending, transesterification and dual oil. A single cylinder DI compression ignition prime mover at stable velocity of 1500 rpm at varied loads.

Received: 1 April 2022/ Accepted: 9 June 2022
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In double fuel operation the volume of fraction kept at 3:7. The proportion of methanol required for creating the ester with Jatropha oil in transesterification is the same as in dual fuel operation values. The total volume of the combination with jatropha oil was limited to 30% methanol throughout the blending phase. The maximum BTE with pure Jatropha oil is around 27.4 percent, while it is 30.3 percent with diesel at maximum power output, according to their findings. In comparison to the blend, BTE increased in the dual fuel operation and with the methyl ester of Jatropha oil. The methyl ester of jatropha oil had a 29 percent yield, while the dual fuel operation had a 28.7% yield.[2]

At 1500 RPM and 5.5 kW, A.S. Ramadhas and co-workers (2005) tested a rubber seed oil (R)/diesel oil (D) mixture in an engine that was fixed speed four-stroke DI water-cooled single-cylinder CI.

The 20:80-40:60-60:40-80:20 R/D mixes were compared against pure diesel and pure jatropha oil, as were various rubber seed oil and diesel blends. Different load settings (from zero to peak load) for all fuels were tested at 1500 rpm. Increasing load results in a drop in the SFC of all fuels, according to the results. Rubber seed oil blends having 20% to 40% rubber seed oil utilize a fuel similar to diesel. Despite this, the SFC of rubber seed oil was higher than that of diesel in the genset's loading range. Viscosity and calorific value of the blend are to blame for this. Blends' BTE grows until 81 percent loading, at which point it begins to decline. When rubber seed oil was used in combination with mixes, BTE increased considerably. The highest BTE was found in an 80:20 (R:D) combination. Diesel oil's BTE is quite consistent to a 60:20(R:D) blend.[3]

N. Vedaraman et al (2005), tested Mahua Oil Ethyl Ester (MOEE) in a 4-stroke direct injection natural aspirated diesel engine at constant speed of 1500 rpm at different brake mean effective pressures (BMEP). Results showed that BTE of MOEE was analogous with diesel, and it was 26.36% for diesel whereas 26.42% for MOEE at full load. BSFC decreases by increasing the BMEP for all oils. However, it has been found that the engine consumes a higher amount of MOEE than a pure diesel engine. MOEE has a higher density than diesel, hence the injection pump's plunger flows more MOEE than diesel.[4]

M. Pugazhvadivua and K. Jeyachandranb (2005) conducted an experimental study on the use of waste frying oil (WFO) as a CI engine alternative fuel. Apart from testing without preheating WFO, it was tested at different preheated temperatures of 75 ^{O}C and 135 ^{O}C. The evaluations were carried out using a single cylinder, constant-speed, compression-ignition (CI) engine that rotated at its rated speed of 1500 revolutions per minute and generated a maximum power output of 3.78 kilowatts. The results suggest that as brake power is increased, BSEC decreases for all fuels except WFO. However, when brake load reaches 85 percent of maximum load, BSEC increases. The minimum BSEC with WFO was 28% greater than with diesel (no preheating).WFO (75 ^{O}C) and WFO (135 ^{O}C) both improved BSEC by 17 and 1.9 percent, respectively, when compared to the minimal BSEC attained with WFO (at no preheating).The greatest thermal efficiency of the brakes while using WFO (without preheating) was 21.6 percent, compared to 30% for diesel, owing to WFO's lower heating value, greater density, higher viscosity, and less volatility. Maximum thermal efficiencies of 25.26 and 25.79 percent were attained with WFO (75 ^{O}C) and WFO (135 OC), respectively, compared to 21.6 percent with WFO (without preheating). [5]

N. Usta et al. (2005) examined engine performance using a methyl ester biodiesel made from hazelnut soap stock and waste sunflower oil. Three blends including 5%, 15%, and 25% biodiesel by volume were evaluated. Fully loaded as well as partially loaded, the performance of a four-cycle, four-cylinder turbocharged indirect injection (IDI) diesel engine was evaluated. The results shown that when biodiesel is added, the power first increases, maxes out, afterward falls when the biodiesel percentage is increased further. Because the highest power output may be attained with an addition of roughly 17.5 percent biodiesel, all tests were done with a volume ratio of 17.5 percent biodiesel to 82.5 percent diesel. All loads tested in the 1500-3000 rpm speed range, the blend (B17.5D82.5) produced slightly more power than the diesel. This is owing to the 10% oxygen content (by weight) of biodiesel, which results in full combustion of the mix, as well as the large volume of biodiesel injected to the engine due to biodiesel's higher density than diesel fuel. At fractional and full capacities, the blend's BSFC is greater than pure diesel oil due to the blend's less heating content and higher density relative to diesel fuel. At partial loads, the proportion of biodiesel was reduced in comparison to full loads, and the blend's BSFC values were comparable to those of diesel, particularly in the range of 2000 to 2500 rpm, at 50% of capacity. A diesel engine's BTE is inversely proportional to its BSFC and the fuel's heating value, the blend's thermal efficiency was lower at all loads than that of diesel fuel. [6]

L.M. Das et al. (2007) synthesised the polanga oil methyl ester (POME) by a three-step transesterification process and mixed it with diesel (D) at a ratio of 3:1. (20 percent ,40 percent ,60 percent ,80 percent and100 percent). On a single cylinder diesel engine, tests were done across the complete range of engine operation at varied loads. Their findings indicated that the brake specific energy consumption (BSEC) of POME 100 is a little higher when the load is low but stays the same when the load is high. Additionally, as compared to plain diesel fuel, the brake thermal efficiency of biodiesel for POME 100 has improved somewhat, particularly at lower loads, and remained constant with greater loads.[7]

In 2007, J. Porteiro et al. assessed the influence of waste cocking oil biodiesel (BD) on the implementation of a marine diesel engine. They established that biofuel, either alone or in combination with other fuels, may be utilised in compression ignition outboard motors. diesel diluted with a certain amount of biodiesel (10 percent, 30 percent, and 50 percent). According to their research, increasing the percentage of biodiesel in the gasoline reduces engine power. A small decrease in power of less than 5% has been observed for BD-10 and BD-30, but this decrease approaches 8% for BD-50 and BD-100. The BTE of a biodiesel-fuelled engine is greater than that of a diesel engine, while biodiesel blends are found to be less efficient than diesel.[8]

Metin Gürü et al. (2006) evaluated test fuels consisting of a mix include tall oil methyl ester (TOME) and diesel petrol (D). These mixes included 100% D, 50% TOME–50% D, 60% TOME–40% D, and 70% TOME–30% D. Tests were conducted on a single cylinder diesel engine. The results established that the greatest torque measured with all mixes occurred at a 2200 rpm engine speed. At low engine speeds, there were no discernible changes in the engine's recorded torque. However, at higher engine speeds, the mixed fuels produced a modest boost in torque. The largest torque differential was 6.1 percent at 3200 rpm while using a mix of (30 D–70 TOME). This is because mixed fuels have a greater cetane number, which results in enhanced combustion. At high engine speeds, the engine power output increased for all gasoline mixes compared to D. The increase in power output caused by mixed fuels varied between 3.2 and 5.9 percent, depending on the amount of TOME and engine speed. The specific fuel consumption rose by up to 10.4 percent when mixed fuels were used in place of D. However, at high engine speeds, the disparities in particular fuel usage were reduced.[9]

S. Rajaraman et al. (2009) demonstrated the feasibility of a biodiesel called Moringa Oil Methyl Esters [MOME]. The tests were done on a single cylinder four stroke diesel engine operating at its rated speed of 1500 rpm. MOME and conventional diesel were blended in the following proportions: 20%, 40%, 60%, 80%, and 100%. The discovery that the thermal efficiency of brakes rises as the load increases. As the amount of fuel consumed increases in proportion to the load, more heat energy is released, resulting in an improvement in thermal efficiency. Additionally, diesel has a little greater thermal efficiency than MOME blends for the majority of loads. Because blended oils have a lower heating value and a higher viscosity than diesel, they burn more slowly, reducing the thermal effectiveness of the brakes.[10]

M.A. Kalam et al. (2011) analysed the effectiveness of a multi-cylinder CI engine running on various blends, including 5% palm oil and 95% regular diesel fuel (P5), 5% coconut oil and 95% regular diesel fuel (C5), and regular diesel (B0). Their findings suggested that braking power improves as engine speed increases up to 3000 rpm, at which point it decreases due to the piston's greater frictional resistance in the cylinder. B0, C5, and P5 all achieve a maximum braking power of 36.7 kW, 36.10 kW, and 36.20 kW at 3000 rpm, respectively. [11]

D.H. Qi et al. (2010) synthesised biodiesel from soybean crude oil and evaluated the performance of biodiesel blends on a single-cylinder direct injection diesel engine. Their investigation utilized B0 (100 percent straight diesel), B30 (30 percent biodiesel Plus 70% diesel), B50, B80, and B100 (100 percent straight biodiesel) at various engine loads ranging from 15% to 90% of rated engine load. They analyzed the brake specific fuel consumption (BSFC) fluctuation of biodiesel and its blends in comparison to BMEP at a 1500 r/min engine speed. They discovered that the BSFC rose as the amount of biodiesel in the blends increased. Biodiesel and its mixes have a slightly lower brake thermal efficiency (BTE) than diesel fuel. Diesel fuel has a maximum BTE of 0.35, whereas biodiesel and its mixes have a BTE of less than 0.35. The primary reason for this is that biodiesel is more viscous, denser, and has a lower heating value than diesel fuel.[12]

A.P. Sathiyagnanam and C.G. Saravanan (2011) synthesised biodiesel from cottonseed oil using a transesterification technique and compared it to regular diesel fuel in blends of 25%, 50%, 75%, and 100% by volume. They established that SFC increases as the fraction of biodiesel in mixtures grows because of biodiesel's reduced heating value. At high engine loads, the BTE of biodiesel and its mixtures is somewhat greater than that of diesel but remains almost same at low engine loads.[13]

Amir Khalid et al. (2013) conducted a study to determine the extent to which the impacts of palm oil blending ratio on vehicle performance are substantial. Engine speeds of 1500, 2000, 2500, and 3000 rpm were used in the tests, along with B0, B5, B10, and B15 gasoline. At zero load, the brake power is comparable to that of conventional diesel and variation percentage mixes. At 50% load, the blended palm oil fuels encourage increased torque in the low-speed area, but there is no disparity in fly wheel torque between the blends and basic plain diesel petrol. In contrast to that, the blends have a negligible effect on engine behavior, both torque and flywheel torque, particularly at elevated engine speeds of 3000 rpm.[14]

H. Sharon et al. (2012), Biodiesel from methyl esters of used palm oil (MEPO). MEPO was mixed with diesel in a variety of volume ratios (25 percent, 50 percent, and 75 percent). To evaluate the performance of biodiesel and its mixes, it was run at constant speed with varied loads (between 20% and 100%). All test fuels demonstrated an increase in BTE as the load rose. This might be explained by the fact that as the load grows, the suction pressure created increases, resulting in more efficient combustion. At full load, diesel, B25, B50, B75, and B100 BTE was 30.895 percent, 30.56 percent, 29.22 percent, 29.58 percent, and 28.65 percent, respectively. At full load, diesel and B100 fuels used 274.90 g/kWh and 314.91 g/kWh, respectively. The BSFC of B25, B50, and B75 was found to be 2.59 percent, 8.93 percent, and 9.25 percent greater than that of diesel fuel, respectively.[15]

D.John Panneer Selvam and K.Vadivel (2012) evaluated the performance and efficiency of direct injection diesel engines running on beef tallow methyl esters (BTME) as pure biodiesel (B100) and in blends with diesel fuel (B5, B25, B50, and B75).The BSFC dropped as engine load increased. The BSFC values for biodiesel and its mixes are greater than those for diesel fuel. Biodiesel, B5, B25, B50, and B75 blends have BSFC values of 187,198,213,221,235, and 248g/kw-hr, which are greater than diesel fuel. There is a minor reduction in brake thermal efficiency when using biodiesel and its mixes. Biodiesel and its blends have a BTE of 49.28, 48.45, 47.85, 46.07, 44.85, and 43.25 percent, which is less than diesel fuel at full load. [16]

Rahman et al. (2013) conducted an experimental analysis employing Jatropha curcas methyl esters (JCME) and Moringa oleifera methyl esters (MOME). diesel fuel (B0), the MB10 blend (90 percent diesel and 10% MOME), and the JB10 blend (90 percent JCME and 10% diesel). The test engine was a multi-cylinder diesel engine from Mitsubishi Pajero (model 4D56T). At various engine speeds, the engine braking power (BP) and brake specific fuel consumption (BSFC) of JCME and MOME mixes were measured. The braking power increased linearly with engine speed for all tested fuels. The BP values of biodiesel mixed fuels were lower than those of diesel fuel. The average braking outputs of the B0, JB10, and MB10 fuels were 28.72, 27.32, and 27.51 kW at all test speeds, respectively. In comparison to diesel fuel, the JB10 and MB10 fuels provided much less brake power (approximately 5% and 4%, respectively) due to their reduced calorific values and increased viscosities. The average BSFCs for the B0, JB10, and MB10 were 386, 399, and 406 g/kWh, respectively, across all speed ranges. In comparison to diesel fuel, the BSFCs in the JB10 and MB10 were 3 and 5% higher, respectively. [17]

According to Ertan Alptekin et al. (2015), test fuels prepared include diesel fuel (D), bioethanol (E), fleshing oil biodiesel (FOB), and chicken fat biodiesel (CFB). FOB20 (20% FOB, 80% DF), CFB20 (20% CFB, 80% DF), FOBE5 (20% FOB, 75% DF, 5% E), CFBE5 (20% CFB, 75% DF, 5% E), FOBE10 (20% FOB, 70% DF, 10% E), CFBE10 (20% CFB, 70% DF, 10% E), FOBE20 (20% FOB, 60% DF, 20% E), CFBE20 (20% (20 percent CFB, 60 percent DF, 20 percent E). A water-cooled, turbocharged-intercooled direct injection diesel engine was used for engine testing. The engine tests used four distinct engine loads (150 Nm, 300 Nm, 450 Nm, and 600 Nm) with a constant engine speed (1400 rpm). For all test fuels, the BSFC values fell as the engine load increased. Biodiesels and their mixes with DF have higher BSFC values than DF. AS FOB, CFB, and bioethanol all had lower heating values than diesel fuel by around 13.7 percent, 14.1 percent, and 39.4 percent, respectively.[18]

Prem Kumar et al. (2016) evaluated the effect on engine performance of employing Pongamia(P) and waste cooking (WC) biodiesel, as well as their ternary blend with diesel(D). P100, WC100, (WC 10:P 10:D 80), (WC 20:P 20:D 60), (WC 30: PB 30:D 40), and pure diesel were also examined. The results indicated that P100 has the highest BSFC at all loads compared to other biodiesels, however WC100 has a much lower BSFC than P100.When the load is 25%, the BSFC of P100 is 10.8% more than that of WC100, but when the load is 50%, the BSFC disparity between P100 and WC100 widens to 46.8%, with P100 BSFC being 46.8% greater. WC 100 has a greater BSFC than a ternary mix of WC 20: PB 20: D60. BSFC of WC 10:P 10:D 80 is 24 percent more than that of diesel at 25% loading. At all loading situations, the BSFC of WC 10:P 10:D 80 is equivalent to diesel. The BTE of WC100 stays greater than that of P100. At 25% load, the BTE of (WC10:P10: D80) 12.63 percent is nearly identical to the BTE of diesel at 12%. In all loading circumstances, the BTE of P 100 and WC 100 is less than that of ternary blends and diesel. [19]

Rizalman Mamatb et al. (2015) evaluated the performance of a diesel engine running on diesel and B5 (5 percent palm methyl ester + 95% diesel) mixed fuel. The torque and power of the engine were determined using blended fuels in a four-inline multi-cylinder compression ignition (CI) engine at varied engine speeds. Consumption of gasoline by the brakes, the results established that engines powered by diesel have significantly more brake power as engine speed increases when compared to B5. Diesel produced the highest braking power of 24.61 kW at 2500 rpm. For both fuels, the torque dropped as the engine speed increased. Torque began at 102 Nm at 1000 rpm and gradually reduced to 75 Nm at 3000 rpm for diesel fuel. While the pattern for B5 is rather different, starting at 104 Nm at 1000 rpm, increasing to 115 Nm at 1500 rpm, and then decreasing to 69 Nm at 3000 rpm. Diesel has the lowest BSFC value when compared to B5, with a value of 0.326 kg/kW.hr at 1000 rpm increasing to 0.3906 kg/kW.hr at 3000 rpm. While the BSFC for B5 gasoline rose with engine speed, from 0.3384 kg/kW.hr to 0.4071 kg/kW.hr, a 13.8 percent increase. The increase in BSFC was necessary since biodiesel contains roughly 0.32 percent less energy than diesel. [20]

K. Arumugam et al. (2016) studied the behaviour of a diesel engine that was fed 100 percent methyl ester palm biodiesel. The palm biodiesel test results are compared to those of plain diesel. When tested at full load, the engine fed with 100 percent palm biodiesel performed virtually identically to a diesel engine, with a 10 to 12 percent reduction in brake power and torque. At all speeds, brake specific gasoline consumption increased by 4 to 5%, while brake thermal efficiency decreased by 3 to 4%. [21]

M. Vijayakumar and P. C. Mukesh Kumar (2017) reported an experimental study evaluating the impacts of blending 1-Butanol, n-Propanol, and biofuel with base diesel oil at 5% and 10% concentrations (by vol.). The proportions of the tested blends are D65 (5 percent 1-Butanol+5% n-Propanol+25 percent Cotton Seed biodesel+65 percent diesel) and D65 (10 percent 1-Butanol+10 percent n-Propanol+25 percent Cotton Seed biodesel+55 percent diesel). The mixes' performance was compared to pure diesel D fuel. When compared to diesel fuel, the mixes generated the highest BTE. At all load circumstances, D65 produced the highest brake thermal efficiency. Because the alcohol in the mix decreases the fuel viscosity, the spray properties have improved, resulting in good brake thermal efficiency. The fuel D65 used the smallest amount of energy to produce the same amount of output power as other mixes. Reduced specific fuel consumption is caused by faster vaporization and lower viscosity of mixing gasoline. [22]

Amr Ibrahim (2016) evaluated the effect of mixing diethyl ether (DEE) with diesel fuel in various concentrations up to 15% by volume on diesel engine performance in an experimental study. All of the tests were performed by a single-cylinder direct-injection diesel prime mover that had not been modified, at a stable prime mover velocity of 1500 rpm and varying capacity circumstances. It was discovered that adding DEE as a gasoline additive considerably enhanced engine performance for the majority of engine load circumstances. When 15% DEE was utilised in the fuel blend instead of diesel, the engine's maximum BTE climbed by 7.2 percent and the lowest BSFC reduced by 6.7 percent. [23]

Yahya Celebi and Hüseyin Aydn (2018) performed the impacts of adding n-butanol to safflower biofuel in a diesel engine that was used to power an electrical alternator. On a volume basis, binary butanol-biodiesel blends and ternary diesel-biodiesel–butanol mixtures included 5%, 10%, and 20% butanol, respectively. The experiments were conducted at half load with a steady engine speed of 1500 rpm on a four-cylinder, four-stroke, direct-injection diesel engine. Fuels examined included pure safflower B100, pure alcohol n butanol, 50 percent diesel-50 percent butanol (D50B50), 90 percent safflower-10 percent n butane (B90Bu10), 80 percent safflower-20 percent n butane (B80Bu20), (D45B45Bu10), and (D40B40Bu20). When compared to diesel fuel, the brake specific fuel consumption (BSFC) for (D45B45Bu10) and (D40B40Bu20) mixes rose by just 5% and 4%, respectively. The major cause is diesel fuel's greater heat value, which is 9.6% higher than safflower biodiesel and 21.2 percent higher than butanol. In addition, the BSFC values of n-butanol-containing ternary mixes were lower than biodiesel-diesel blends and differed somewhat from diesel fuel. This can be ascribed to the inclusion of butanol, which enhanced combustion and engine efficiency. The test fuels' brake thermal efficiency (BTE) values at 2.78 bar BMEP suggested that BTE was higher for D45B45Bu10 fuel, which is a ternary mix with less butanol. The BTE value of D40B40Bu20 was also boosted by 1.5 percent, indicating that it is a ternary mix with a greater butanol ratio than diesel fuel. In view of the above-mentioned findings, n-butanol only caused a drop in engine effectiveness when the engine was run on biofuel-butanol. Butanol's lower heating content and cetane number are primary causes of this decrease impact. [24]

Doglas Bassegioa et al. (2019) looked at the performance of a diesel prime mover for energy production that used soybean, linseed, and crambe vegetable-oil-based fuels. Biofuels were produced by combining regular diesel oil with soybean, linseed, and crambe oil at incremental amounts of 10%, 30%, 50%, and 70% vegetal oil in the fuel blend structure. The fuels were put through their paces in a 5-kVA generator engine with loads ranging from 750 to 3000 watts. Their findings showed that linseed biodiesel gives a power gain as a function of the increase in linseed oil fraction under both high and low loads. At low load (750 W), increasing the soybean oil percentage resulted in decreased specific consumption. When compared to standard diesel for fuels, there was a reduction in specific consumption at a high load (3000 W). [25]

Geetesh Goga et al. (2019) studied the influence of blending diesel, rice bran biodiesel, and n-butanol on the performance parameters of a diesel engine. B10, B20, B10 nb10, and B20 nb20 blends of diesel–biodiesel and diesel–biodiesel-n butanol were created. BSFC grew as the amount of biodiesel and n-butanol in the blends increased, and it is now greater than diesel fuel. Brake thermal efficiency increased with the addition of 10% biodiesel in fuel blends and decreased with the addition of 20% biodiesel in fuel blends, and it was lower than diesel for n-butanol blends.[26]

B. Deepanrajb et al. (2019) created a biodiesel from non-edible rapeseed oil (B) and compared it to normal diesel (D) fuel on the characteristics of a four-stroke, single-cylinder 5.95 kW, direct injection diesel engine using an electrical dynamometer at 1500 rpm. On a volume basis, the blends that were evaluated were D, 25% B, 50% B, 75% B, and 100% B. BTE at full load was 27.14 percent, 26.38 percent, 25.46 percent, 25.10 percent, and 23.16 percent for diesel, B25, B50, B75, and B100 fuels, respectively. Because rapeseed oil biodiesel blends have lower calorific values than diesel, their calorific value drops as the amount of biodiesel increases. In addition, as compared to diesel fuel, the BSFC for all mixes was greater. [27]

S.Bari and S.N.Hussien (2019) showed the performance of a palm oil diesel-powered diesel engine (POD). Their findings revealed how engine brake torque varied with braking power at various speeds, with POD brake torques being 5.3 percent lower on average than diesel brake torques. The BSFC of POD was 10% greater on average than that of diesel fuel.[28]

M.A. Asokan et al. (2019) developed a biodiesel from juliflora seeds (B) and investigated its impacts on diesel engine performance. The B20, B30, B40, and B100 fuel mixes were compared to diesel fuel blends (D100). The performance and combustion properties of B20 were found to be nearly identical to findings of diesel petrol. Under peak load, the brake specific fuel consumption (BSFC) of blends B20 and B30 (0.27 kg/KWh) was similar to diesel (0.26 kg/KWh). Juliflora Biodiesel B100 has a BTE of 31.11 percent, which is similar to diesel (32.05 percent) at full load. [29]

V. Gnanamoorthi and M. Murugan (2019) reported experimental research of a single cylinder, four stroke diesel engine employing a waste plastic oil (WPO)–diesel (D) blend as well as oxygenated additives such as diethyl ether (DEE) and methoxy ethyl acetate (MEA). Test fuels included DIESEL (100 percent diesel), WPO (100 percent waste plastic oil), D50W50 (50 percent diesel + 50 percent WPO), D50W40DEE10 (50 percent diesel + 40 percent WPO + 10% diethyl ether), and D50W40MEA10 (50 percent diesel + 40 percent WPO + 10% methoxy ethyl acetate). The test fuel D50W40MEA10 improved brake thermal efficiency by roughly 5.2 percent as compared to plain diesel. The reason for this is that the self-ignition temperature of methoxy ethyl acetate is substantially greater than that of pure diesel, resulting in quick fuel vaporisation and optimal spray atomization. Also, the brake specific fuel consumption of the test fuel D50W40MEA10 is quite similar to that of clean diesel.[30]

Conclusions

On the basis of a comparison between reference diesel fuel tests and various biofuel blends, the impacts on engine performance characteristics were examined under various operating situations and in different engine tests. The following are the broad conclusions that may be drawn:

- The power initially increases with the addition of biodiesel, reaches a maximum value, and then decreases with further increases in biodiesel content, according to many researchers.
- At first, the power increases with the biodiesel supply, reaches a maximum value, and then decreases with further increases in biodiesel content.
- The thermal efficiency of the biodiesel-diesel blend fuel with additives was lower than that of the diesel fuel at all loads because the thermal efficiency of a Diesel engine is inversely proportional to its BSFC and the heating value of the fuel.
- The biodiesel-diesel blend fuel with additives has a lower calorific value, a higher flashpoint, and a higher density.

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