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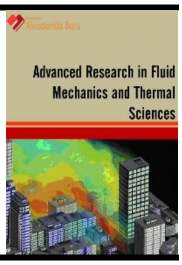

A Review of Comparative Characteristic Study on Effect of Biodiesel B20 on Compression Ignition (C.I.) Engine Performances and Exhaust Emissions

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ABSTRACT

This paper presents the comparative study of effect usage Biodiesel B20 blended in the Compression Ignition (C.I.) engine compared to the diesel fuel. The reduction of petroleum production by the organization of petroleum exporting country make many researchers start does the research of biodiesel as an alternative fuel. The biodiesel B20 have significant as an alternative fuel because of biodiesel come from renewable energy. In numerous previous studies, the Performance of the B20 biodiesel in BSFC of the fuel increase significantly compared to the diesel at high load condition while the reduction in Brake thermal efficiency and exhaust gas temperature. B20 effect the reduction of CO concentration of emission in the engine compared to the diesel fuel. The Biodiesel B20 produces higher concentrations of NOX for the emission compared to the diesel. More consistently, smoke concentrations of this review are generally lower with the biodiesel fuels than with petroleum diesel. Ultimately, B20 Biodiesel can indeed become the appropriate source as an alternative fuel, with environmental benefits in the engine without sacrificing mechanical reliability and durability.

1. Introduction

The reduction of petroleum production by an organization of petroleum exporting country makes many researchers start doing the research on biodiesel as an alternative fuel. Biodiesel production reduces the dependency on imported oil and supports the agricultural sector. Consequently, the forecasts specify that the biofuels will be growth by usage in 2012 with the high number per day with 1.3 million barrels of oil equivalent to projection per day of 2040 with 4.6 million barrels of oil [1]. Biodiesel one of the alternative fuels that normally extracted from renewable bases for example waste frying oils, vegetable oil or waste oil derived from the animal [2].

The formation of the biodiesel is a combination of the renewable sources is blended with the chemical to give corresponding fatty-acid-methyl-ester (FAME) [3]. The FAME generally classed from

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the development of trans-esterification that form alkyl-ester and takes the pattern of methyl-ester. The variety formation glycerin-free mono-alkyl esters of long-chain fatty acids transformed from triglycerides such as organically based oils and adipose tissue. The properties of B20 biodiesel fuel lower than standard diesel as shown in Table 1. The properties of the biodiesel will be effected the engine performances. Nevertheless, an increasing trend for biodiesel as an alternative fuel has been observed because in the automotive industry, the fuels can reduce emissions like the particle matter (PM) and Carbon dioxide (CO2) [4]. Moreover, the usages of the biodiesel in the engine are very user-friendly because of the biodiesel not required any modification of the engine. In the global transportation sectors, there are representing transportation-based energy by less than 3%. In term of using biodiesel, there can substantially improve our global energy consumption and reduction emission rate since this is the readily available technology [5-6]. The higher oxygen contents affect better in the combustion of the fuel in the engine. Various researches obligate assessed the concern of biodiesel on a compression ignition engine in term of efficiency, performance, emissions [4-8].

The pollution and formation of the greenhouse can be reduced by biodiesel because of the major oxygen component in its formation chemical bond. Energy sustainability can be gained by improving environmental conditions as an alternative fuel such as biodiesel. However, the use of biodiesel also causes increased NO_X emissions and increased fuel consumption [9-13]. Others than that, the usage of biodiesel will be furthered to enhancement in worldwide energy utilize and CO_2 emission [14, 15].

Table 1
Typical fuel properties – diesel and biodiesel [17]

Characteristics	Method	Diesel	Biodiesel
Fuel Standard		ASTM D975	ASTM D7467
Calorific Value, kJ/l	ASTM D240	~35,970	-
Kinematic Viscosity @40 oC, cSt	ASTM D445	1.3-4.1	1.9-4.1
Flash Point, oC	ASTM D93-10**	60 to 80	Min 52
Density @ 15 oC, g/l	ASTM D4052-09	0.8483	-
Cetane Number	ASTM D613	40-55	Min 40

In this paper, the properties of the B20 are reviewed focus on calorific value, kinematic value, density, flash point and cetane number [19]. The effect of the properties in term of performance and emission were discussed. The type of based fuel such as palm oil, fish oil, canola oil, jatropha, and others also included the properties of the biodiesel as shown in Table 2. The potential of the biodiesel usage has high potential in term of increasing the fuel consumption without losing power and reduction of emission in form of hydrocarbon (HC), carbon dioxide (CO) and particulate matter (PM) emission. The production of the biodiesel was explained in earlier work done by another researcher, so this paper will focus on the various report about performance and emission characteristics in compression ignition engine. The tabulated thermal and physical properties will be deep discussing and understand in this paper.

Table 2
Physical and thermal properties of B20 biodiesel

Country	Fuel type	Calorific value (kJ/l)	Kinematic viscosity (cSt)	Flash point (oC)	Density (g/l)	Cetane number	Ref
India	Cotton seed oil	45.42	2840.00	49.00	854.80	46.50	[20]
Australia	Microalgae	44.97	2800.00	77.60	870.00	51.20	[21]
India	Karanja oil	44.83	2771.00	71.00	834.20	-	[22]
India	Silk-cotton tree	44.30	2860.00	38.00	829.90	59.00	[23]
Egypt	Sunflower oil	43.95	-	60.00	855.80	60.71	[24]
Malaysia	Palm oil	43.90	3043.70	90.00	828.60	-	[25]
India	Waste plastic oil	43.69	3040.00	96.00	851.00	51.70	[26]
Vietnam	Palm oil	43.11	3380.00	-	845.00	54.50	[27]
Turkey	Canola oil	42.69	4690.00	200.00	855.00	-	[28]
India	Karanja biodiesel	42.60	2710.00	110.00	835.60	-	[29]
India	Mahua methyl ester	42.00	3200.00	66.00	837.80	57.20	[30]
India	Calophyllum inophyllum	42.00	3300.00	66.00	840.20	55.90	[31]
India	Mahua seed oil	41.85	2730.00	69.00	823.00	-	[10]
India	Fish oil	41.84	4100.00	44.00	852.00	-	[32]
India	Pangamic	41.78	4430.00	-	821.00	45.00	[33]
China	Bunge seed	41.70	2780.00	96.00	856.00	-	[34]
Malaysia	Coconut oil	41.70	2780.00	96.00	856.00	-	[35]
India	Mahua oil	41.69	3560.00	68.00	843.30	53.85	[36]
India	B20	41.58	3500.00	76.00	843.00	49.00	[37]
Turkey	Cooking oil	41.45	2750.00	66.00	827.00	-	[38]
Turkey	Tea seed oil	41.31	3400.00	72.00	845.00	-	[39]
USA	Palm oil	41.29	2750.00	197.00	852.50	49.30	[40]
Lithuania	Rapeseed oil	40.81	4510.00	90.70	863.00	50.70	[41]
India	Garcinia gummi-gutta methyl ester	40.36	3800.00	76.00	826.40	48.20	[42]
Malaysia	Calophyllum inophyllum	39.70	2280.00	-	830.00	45.00	[43]
Egypt	Jojoba methyl ester	39.70	3100.00	36.00	824.90	44.70	[44]
Egypt	Jojoba	39.50	4700.00	-	880.00	46.80	[45]
India	Karanja oil	39.47	3871.00	81.00	847.00	-	[46]
India	Methanol	39.20	4310.00	169.00	860.00	54.00	[15]
Turkey	Soybean	37.53	5249.00	148.00	890.00	37.53	[47]
India	Koroch seed oil	37.23	4700.00	-	884.00	51.00	[48]
Turkey	Canola	-	4526.00	177.60	884.40	54.30	[11]

2. Properties of B20 Biodiesel

The properties of B20 biodiesel in form of calorific value, kinematic value, density, flash point, and cetane number are discussed in the following sub-chapter.

2.1 Calorific Value

Few years later, a new research group is formed to further investigate the flow structure on the blunt-edged delta wing, the team called as Vortex Flow Experiment (VFE-2). The main objective of the VFE-2 test was to validate the results of Navier-Stokes calculations and to obtain a more detailed experimental data. The VFE-2 experiments were carried out for both sharp and blunt leading edge shape delta wing [1-3].

The energy subject matter each element volume of the petroleum is called as calorific value. Calorific value can be specified as released energy of heat whereas totally burning identified petroleum when the ending of the products is chilled to original temperatures [17]. Heating system number is dignified by calorimeter that burning a known mass of fuel, and the temperature divergence is used to measure the calorific value of the fuel. From previous studies, mostly the calorific content of the biodiesel fuel was lesser than the conventional diesel, formerly the variance is not radically greater as implied fuel in diesel engine [6]. Referable to the lower number of the calorific content of the biodiesel, it requires additional energy of the biodiesel that creates the equivalent energy as diesel. From Table 2, the higher of the energy contained in 45.7 MJ/kg as palm oil-based fuel than follow by koroch seed oil, jojoba oil and etc. On the other side, the lower on the energy content is bio-ethanol based fuel with 28.9 MJ/kg [18].

2.2 Kinematic Viscosity

The behavior contraction of the fluid and the solid boundary is called kinematic viscosity. The attributes of the kinematic viscosity are measured of its resistance to gradual deformation of shear stress or tensile stress. The standard of ASTM D445 is used in method test measure the kinematic viscosity of transparent and opaque liquids [19]. The viscosity is defined based on the mass of the liquid movement, the size of the hole and the time. The changing of viscosity value depended on temperatures exposes. The viscosity of the biodiesel will decrease with increasing the temperature. Mostly cases examples, the viscosity of the diesel is lower than biodiesel. Because of the value viscosity of biodiesel is higher; the fragmentation properties were trimmed back. Hence this will decrease the misses spray projection of the fuel compared with the diesel. The emission of the biodiesel will increase as soot caused by injected biodiesel with the larger droplet size [19-21]. Others than that, an increase in the number of viscosity in fuel will be turned as an agent of lubrication then improving the mechanical efficiency of the system. The value of the kinematic viscosity was quantified stated in centipoises (cP). For others reference, 1 mm^2s^{-1} equal to 10-6 $m^2s^{-1,}$ 1cst. The values of the viscosity diesel have lower compared to the biodiesel. From Table 2, all the based fuel, biodiesel has a kinematic viscosity value lower than mm^2s^{-1} [22].

2.3 Density

Characterize as material varies with temperature and pressure known as density. The properties of fuels have impacted by adding up to the utilization of fuel and fuel consumption. The Mixing properties will be influenced the fuel’s density. For example, time-consuming in mixing the fuel furthermore attributes of spray. From observances in term of density, most of the diesel fuel was observed to be lower than biodiesel. Then the volume of diesel would be lower for the same volume of biodiesel. The infiltration spray properties of biodiesel will be great also the injection of fuel would get progressed of biodiesel contrasted related to the diesel [23].

2.4 Flashpoint

The fuel properties are the minimum temperature for an ignition Indicated as a flashpoint. The minimum temperature at when the fuel crops sufficient vapor to catch lighter, which presented to outer fire represented as a flashpoint. The usage of fuel will be more secure when the flash point is larger. From Table 2, In this manner, the usage of biodiesel is more secure compared to diesel. The fiber-based biodiesel has a significantly lower flash point such as cottonseed oil and silk-cotton tree have a lower value compared to other bio-oil based as shown in Table 2. Other than that, the fish oil based on biodiesel also shown below the specification of standard biodiesel because of produced from inedible animal tallow. The main reason this requirement is to guarantee that the industrial biodiesel follows the standard of the biodiesel specification as shown in Table 1 [24].

2.5 Cetane Number

The Biodiesel B20 has a high cetane number, only a lower heating value compared to the diesel fuel. This property doesn't produce a substantial difference in term of fuel economy condition. Cetane number is specified at a constant velocity when combustion executes in C.I engine. The value of the cetane number is evaluated based on the combustion characteristic of the fuel in C.I engine. The number of carbon and hydrogen ratio indicated by fuel cetane number. The stable composite of highest cetane numbers is 100 with is N-hexadecane (C10H34) so it is they consider as highest ignition quality while lower cetane number is Heptamethylnonane with a 15 certain number [25]. A similar method was rehashed with various reference fills at various pressure proportions for each fuel, to accomplish start deferral of 13 BTDC. At the point when the pressure proportion of the tested fuel is sectioned through the fuel properties, and afterward cetane number was introduced. The lesser start delay influence by the higher cetane numbers. The late start delay reduces the amassing of infused fuel in the chamber, so thumping in C.I motor is lessened by a smooth ascent in temperature and weight inside the chamber. Most diesel properties have a lower cetane number compared to the diesel, so the usage of biodiesel may expand the lifespan of the motor. Palm oil and squander oil have the highest cetane number with 67 and 70, respectively [26].

3. Performances of the Compression Ignition Engine Fueled With B20

The performances of B20 biodiesel depend on brake specific fuel consumption, brake thermal efficiency, and exhaust gas temperature will be discussed as subchapter as followed below.

3.1 Brake Specific Fuel Consumption (BSFC)

BSFC is well-defined as the equivalent fuel energy required to produce brake power for all fuel BSFC decreases with an injection pressure initially and increases thereafter. The BSFC can be increased with increasing fuel usage or decrease engine performances. The power that produces from the engine will be separated based on frictional power and brake power [49].

Most of the engine power is utilized to dealing with frictional resistance of the engine parts in idle condition and lower engine load. Thus, the BSFC decreasing with increasing the engine load [50]. The variation of the BSFC performance is presented in Table 3. Base on that Table 3, A. Turkan [8] shown that that the BSFC of the fuel increase significantly compared to the diesel at high load condition. They claim that the increase of value BSFC is due to the advancing the injection timing by using high percentage ethanol content in an ethanol-diesel blend. O.A. Elsanusi et al. discovered that the BSFC of B20 blended biodiesel is higher than the diesel. This due to the less heat content of biodiesel than diesel fuel [51]. But there are different founded by s. Channapattana [52] which is the performance of BSFC decrease. They found that the influences of decrease the BSFC effect by increasing injection pressure. The injection pressure will help improve the better atomization which is the area of fuel droplet exposes in the large surface area lead to complete combustion of fuel in high-temperature air condition. F. Jaliliantabar *et al.*, found that BSFC of the biodiesel-diesel blends is lower than the diesel fuels. The maximum of BSFC are coffee, cardoon, and Brassica is 7.54%, 9.09%, and 12.03%. The lower heating value of biodiesel fuel will affect the increase in fuel consumption[53]. S. Ramalingam et al. In their early investigations on the use BSFC for diesel is higher than biodiesel, ascribed to the higher calorific value of the diesel. Then, as a consequence, the energy drop because of the lower in calorific value of the B20 can be achieved by injecting more fuel into the engine to get the similar power output, which would succeed in a significant increase in fuel consumption of fuel [54].

Table 3
Performances of the engine fuelled by B20 compared with diesel fuel

Engine type	RPM	kW	BSFC	BTE	EGT	Ref
Single cylinder	1500	3.50	Increase	Decrease	Decrease	[55]
Single cylinder	1500	3.70	Increase	Increase	Decrease	[13]
Single cylinder	1500	3.70	Increase	Decrease	Increase	[56]
Single cylinder	1500	3.70	Increase	Decrease	Decrease	[57]
Single cylinder	1500	3.70	Increase	Decrease	Increase	[58]
Single cylinder	1500	4.40	Decrease	Increase	Increase	[59]
Single cylinder	1500	4.40	Increase	Decrease	Decrease	[60]
Single cylinder	1500	5.77	Increase	Increase	Decrease	[61]
Single cylinder	1500	5.77	Increase	Decrease	Decrease	[62]
Single cylinder	1500	5.77	Increase	Decrease	Increase	[63]
Single cylinder	1500	9.00	Increase	Decrease	Increase	[64]
Single cylinder	3600	7.50	Increase	Decrease	Increase	[65]
Two cylinders	3600	17.00	Increase	Increase	Decrease	[21]
Four cylinders	3800	28.30	Decrease	Decrease	Decrease	[51]
Four cylinders	7500	37.00	Increase	Decrease	Decrease	[66]
Four cylinders	3800	85.31	Increase	Decrease	Increase	[67]

3.2 Brake Thermal Efficiency (BTE)

Thermal performance parameter conducted by S.V. Channapattana [52] affected by injection pressure for honor biodiesel. They establish that the BTE is increasing in the fuel tested and they iteratively said that the higher of degree atomization of injection pressure in the main effect of assuring complete combustion through the quantity of fuel being thrown in. The ascent of the BTE is as the rise of the increasing engine load. The oxygen content in biodiesel stimulates the better burning efficiency even though the biodiesel has a lower heat release compared than diesel fuel due to heating value. Thus, biodiesel blends have a little bit higher in BTE matched to diesel at all engine conditions. Similarly, blended fuels significantly the engine’s BTE can be improving. This is affected by the micro-explosion of mixed fuel and water vanishing through combustion develops air-fuel mixing, hence achieve to improving the efficiency of the combustion. They also claim that the water content in the emulsions of biodiesel blend can substitute the neat diesel fuel for improving the BTE in the compression engine [51]. M. Hoseinpour *et al.*, found BTE of the engine will increase as an increasing load of the engine all tested fuel such as biodiesel and diesel fuel. Yet, they claim that the further improve the quality of engine speed will help dropped the BTE of the engine due to a radical increase in the amount of fuel use of goods and services. The BTE of biodiesel-blended is slightly higher compared to the diesel at various applied load. This phenomenon causes of higher oxygen content in biodiesel, which resulted in better combustion, and then a better thermal efficiency can be achieved [13]. But, at low loads, the viscosity value of biodiesel becomes the dominating reason, causing the low quality of combustion and reducing the brake thermal efficiency [58-60]. Chandrashekharapua found that the decreasing of the BTE influences by higher the injection pressure due to the decreasing of the depth of penetration of fuel make the combustion become ineffective. The BTE will be improved with advancing increasing the fuel injection pressure and the fuel injection timing as discovered by while studied wasted cooking-oil-based fuel [71].

3.3 Exhaust Gas Temperature (EGT)

The decreasing of the EGT of study by S.V. Channapattana [52] conducted by increasing the injection pressure. That phenomenon is caused to higher heat is produced in the exhaust to make complete combustion of the fuel at higher injection pressure. The EGT also lower compared to diesel oil. That effect may be ascribable to the amount of the calorific value of home oil-based biodiesel lower than diesel oil, which is 367.9°C and 369.19° C respectively. O.A. Elsanusi *et al.*, found that the EGT from biodiesel higher than the diesel fuel as direct proportional with an increase in engine speed and load. They claim that the existing water in blend fuel effected in immersion the combustion, that leads to a lowering in the temperature of the flame [51]. M. Hoseinpour *et al.*, in their study observed that the engine fueled with B20 have resulted in a reduction of exhaust temperature about 13% as matched to diesel fuel. The lower exhausts temperature lead to earlier combustion resulted due to the lower heating value and higher oxygen content in biodiesel[13].

4. Emission of a Compression Ignition Engine Fueled with B20

The emission of B20 biodiesel measured depend on carbon monoxide, un-burn hydrocarbon, nitrate oxide, smoke, and carbon dioxide as discuss as subchapter below.

4.1 Carbon Monoxide (CO)

The emission of carbon monoxide biodiesel reduces comparability to the diesel. This is affected due to fine droplets produced by the fuel which is atomized during injunction and extra surface area is existing for the combustion, which is resulting in the creation of a better fuel fusion which is causing better combustion [52]. They also said that the higher combustion efficiency, temperature, increasing the load and adequate turbulence and high-temperature environment, led to help to reduce CO emission [51]. M. Hoseinpour *et al.,* in their experimentation found increasing engine load decreased CO emission. This could be due to an increase in combustion temperatures and more complete burning. From their experiment, they establish the emission CO fuel by B20 biodiesel lower than diesel fuel and that should be affecting by weak atomization and lack air-fuel mixing process.

Regarding the emission of the CO, the biodiesel blended fuels have the lowest amount at common conditions of engine load and velocity. [13].

4.2 Un-burn Hydrocarbon (UBHC)

The emission of the HC is reduced in studied honey oil blended biodiesel compared to the diesel fuel by Channapattana etc. [52] as shown in Table 4. The reducer of HC content after combustion is influenced by how complete the combustion as an effect of the higher content of oxygen in the blend. From O.A. Elsanusi *et al.*, experiment, they found that the Biodiesel blends emit lower HC compared to the diesel for common engine conditions. The average reduction in HC of B20 was nearly 40%, respectively, compared with the diesel fuel [51]. M. Hoseinpour *et al.,* discover that emission of UBHC decreased commonly as increasing engine load due to the same cause specified for the emission of the CO [13]. The decreasing of emission in UBHC of biodiesel can be achieved due to the higher combustion efficiency of higher cetane number and oxygen content in biodiesel [72]. Through the process of combustion, the trapped air-fuel mixture in gaps on the cylinder wall, as well as those adsorbed mixtures in oil film, will be effected UBHC formation, especially when the air-fuel mixture turns out to be rich at a higher level of injection [13].

4.3 Nitrate Oxide (NOx)

The variation of the NOx is presented in Table 4. Base on that Table 4, the blended Honne Oil biodiesel influence the increase of the NO_X compare with the pure diesel. Honne oil-based biodiesel has higher oxygen content compared to the diesel and higher temperature produces during combustion in the cylinder [52]. O.A. Elsanusi *et al.,* found that the shorted ignited delay at higher engine speed will help improve the reduction of the NO_X emissions [51]. Similar results in reduction Emission in shorted ignited delay also founded by Man *et al.,* [60] and Buyukkaya [70]. On the other hand, an additional detailed study is needed to investigate the effect of speed of the engine on NO_x emissions. M. Hoseinpour *et al.,* found that the higher engine load will influence an increased percentage of NOx which caused exhaust gas to increase in temperature of combustion as earlier explained. However, decreasing NOx emission can be achieved when increasing the engine speed. These phenomena happen because in that respect is the NOx formation was stopped, in spite of the increase in temperature. Furthermore, when engine fueled with biodiesel, the formation of NOx emission are higher as opposed to diesel, which is about 4% at the difference of biodiesel and diesel [13]. A. Nayyar *et al.*, discover that a reducing tendency of NO_x is always related with consistent growth in smoke. Though, a diverse tendency which NO_x reduces with increasing butane content in the blends [9]. A. Nayyar *et al.*, have analyzed and discussed the decrease in NO_x will be clarified by two reasons. This is the improved mixing of air-fuel and decreases the temperature in the cylinder. The peak temperature will result increase the combustion, but at the same time, the total period of dispersal combustion and total combustion reduces because of better combustion flame speed [9].

4.4 Smoke

The volume of smoke is decreasing with increasing the injection pressure of biodiesel compared to the pure diesel. O.A. Elsanusi *et al.,* in their study state that smoke intensity in the exhaust gas increased at higher contents of biodiesel in biodiesel-diesel blends, perhaps due to the higher viscosity of biodiesel. The over penetration of the due to increasing the injection pressure will have wall-quenching in the burning chamber. They claim that the reduction of smoke intensity can be done by optimizing the better fuel formation, atomization of fuel and fuel vaporize by the injector [51]. M. Hoseinpour *et al.,* concluded that increasing the engine speed and load increased will effect in increasing the smoke opacity and particle matter[13]. It means that poor homogeneity of a fuel mixture when the fuel is injected into the compressed air in the combustion chamber would result in the formation of fuel-dense pockets and consequently to soot generation when the fuel is ignited [73]. A. Nayyar *et al.,* found the load of the engine and blending ratio variation cause of smoke emission for n-butanol biodiesel blends. The differences result may be because they found sufficient time of fuel-air mixing and good volatility of n-butanol boiling temperature at 118 °C in compared to the pure diesel with the temperature around 180 to 360 °C, improve the quality of the combustion due to increased ignition delay [9]. The biodiesel has the amount of oxygen contains, locally over rich state reduces and crucial smoke was restricted form by the advantageous consequence of oxygen content in biodiesel [74].

4.5 Carbon Dioxide (CO_2)

It is recognized that CO_2 acts as a central part in the whole world temperature rising and are viewed as a significant greenhouse gas, therefore reduction of CO_2 emission can be a good product. But it must be well-known that reducing CO_2 will give a negative impact on combustion [13]. The variation of the CO_2 is presented in Table 4. Base on that Table 4, the emission of the CO_2 studied by S.V. Channapattana *et al.,* [52] increasing fuel by one oil blended biodiesel compared to the diesel. This phenomenon is influenced by biodiesel have higher oxygen content so the carbon becomes oxygenated through combustion that makes the emission of the CO_2 increase. The previous researcher recognized the statement that biodiesel as an oxygenated fuel. The oxygenated fuel will affect the combustion manner and produce in upsurge the concentration of CO_2 in the exhaust gas [70].

Table 4
Emission of the engine fueled by B20 biodiesel

Engine Type	Rpm	kW	CO	HC	NO_X	Smoke	CO_2	Ref
Single cylinder	1500	5.7	Decrease	Decrease	Increase	Decrease	-	[54]
Single cylinder	2200	19.6	Decrease	Decrease	Increase	Decrease	Increase	[75]
Single cylinder	3600	7.5	Decrease	Increase	Increase	Decrease	-	[76]
Single cylinder	1500	5.77	Increase	Decrease	Decrease	Increase	Decrease	[24]
Single cylinder	1500	3.7	Decrease	Decrease	Increase	Increase	-	[12]
Single cylinder	1500	3.5	Decrease	Decrease	Increase	Increase	Increase	[52]
Single cylinder	2000	-	Decrease	Increase	Decrease	-	-	[77]
Single cylinder	3600	8	Decrease	Decrease	Increase	Decrease	Increase	[78]
Single cylinder	2000	3.5	Decrease	Decrease	Increase	Increase	-	[79]
Single cylinder	1500	4.4	Decrease	Decrease	Decrease	Decrease	-	[80]
Single cylinder	1500	3.7	Decrease	Increase	Increase	Decrease	-	[67]
Single cylinder	1500	5.2	Decrease	Decrease	Increase	Decrease	Increase	[64]
Single cylinder	2400	8.8	Decrease	Decrease	Increase	Decrease	Increase	[35]
Single cylinder	1500	5.77	Decrease	Increase	Increase	-	-	[81]
Four cylinders	3800	28.3	Decrease	Decrease	Increase	-	Increase	[82]
Four cylinders	4000	77	Increase	Decrease	Increase	Decrease	-	[8]
Four cylinders	2000	51	Decrease	Decrease	Increase	Decrease	Increase	[13]
Four cylinders	3800	95	Increase	Increase	Decrease	-	-	[83]

5. Advantage and Disadvantages of B20 as an Automotive Fuel

Based on previous researchers, the advantage and disadvantage of the B20 can be summaries as follow.

5.1 Advantage of Biodiesel B20 Compared to Petroleum-Based Diesel Fuel

i. Biodiesel is as an alternative fuel because it is a renewable energy source and available across around the world.
ii. Biodiesel has remarkable advantages such as lower HC, CO, and particulate emissions by reducing the soot and CO emissions and shortening the penetration of lower NO_x emissions due to high fuel-borne oxygen content.
iii. The lesser content of sulfur in biodiesel decreases sulfuric acid formation that the influences of engine wear so it can be improving the lubricity in the combustion chamber.
iv. Biodiesel will shorter ignition delay, and lesser occurrence of knocking phenomena in the burning process.
v. Biodegradability, renewable, sustainable nature and reduced greenhouse gas emissions like CO, CO_2 and HC fairly similar or superior cetane number, flash point, non-toxic, biodegradable and better inherent lubricity characteristics than diesel fuel.
vi. Higher oxygen content presented in B20 biodiesel improves the combustion efficiency.

5.2 Disadvantage of B20

i. The higher oxygen content in biodiesel decreases the calorific value of the fuel.
ii. Biodiesel fuel mostly produces higher BSFC but the low ability and low torque due to less calorific value compared to diesel fuel.
iii. Emission of NOx produced by B20 was higher compared to diesel.
iv. B20 is less stable compared with diesel because it will get simply oxidized than to slow the oxidation process, the antioxidant is needed to add, and it will cost in making the fuel.

6. Conclusions

As a conclusion, we can conclude that the properties of the fuel will influence the combustion characteristic. For instance, B20 biodiesel has a lower calorific value compared to Diesel fuel around 10 percent volume. Other than that, most of the B20 biodiesel blended have a higher kinematic viscosity compared to the diesel fuel. These higher properties of the kinematic viscosity will be acting upon the reduction of the combustion efficiency, but biodiesel fuel will play as a lubricator so the mechanical efficacy will improve efficiency. Regard the lower cetane number of biodiesel than diesel effect the less ignition delay compared to diesel. While the knocking and vibration phenomena in the combustion chamber will be shortened due to less accumulation of fuel within the piston chamber. Biodiesel will reduce the combustion quality caused by lower calorific value and higher viscosity in their fuel properties. From Table 3, most of the cases shown that biodiesel combustion produced a lower exhaust gas temperature. The UBHC also reduced due to the higher cetane number during combustion. Biodiesel has less calorific value than diesel then it may be affected by the higher BSFC value than diesel fuel. The higher oxygen capacity in biodiesel improves the combustion quality then it leads to increasing the NO_X emission. The less emission of CO also reduces by using biodiesel. The alternative fuel such as biodiesel is very user-friendly because of user can use it in the conventional engine without major modification. To reduce the UBHC will be accomplished by increasing the fuel injection pressure. Usage B20 biodiesel in HCCI engine will improve the emission because the biodiesel produces less CO compare than diesel.

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