A Research on Determining Some Performance Values by Using Proportional Mixture of Vegetable Oils and Diesel Fuel at a Diesel Engine

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The purpose of this particular study was to research the effects on characteristics of a diesel engine by using different diesel fuel and vegetable oil blends. As experimental material 6 LD 360 type diesel engine with single cylinder, direct injection, four cycles, 5.52 kW defined power was used. Nothing was changed on the diesel engine parts and refined vegetable oils were chosen to add into fuel oil. In this research, depending on the number of revaluation and time, the air intake inlet temperature, exhaust gas outlet temperature, fuel consumption, volume efficiency, engine oil pressure, cylinder indicated pressure, the quantity of soot were determined. The results in the of sunflower oil and diesel fuel blends were found better than the soybean oil and diesel fuel blends. In addition, lubrication oil of the engine by using the soybean and diesel fuel blends were get dirty excessively and viscosity of the engine lubrication oil was reduced more than the others. The results by using 75% diesel fuel+25% sunflower oil blend showed nearly the same results by using diesel fuel.

Keywords: Alternative diesel fuel, oil blends, fuel consumption, volume efficiency.

Bir Dizel Motorda Dizel Yakıta Belirli Oranlarda Karıştırılan Bitkisel Yağların Motorun Bazı Karakteristik Değerleri Etkisinin Saptanması Üzerine Bir Araştırma

Bu çalışmanın amacı farklı oranlarda dizel yakıtına karıştırılan bitkisel yağların motorun karakteristik özelliklerine etkilerini saptamaktır. Bu amaçla tek silindirli 6 LD 360 tipi, direk püskürtmeli, dört zamanlı, 5.52 kW gücünde dizel motoru kullanılmıştır. Yağ karışımlarının kullanılması sonucu motor parçalarında bir hasar oluşmamıştır. Bu çalışmada motor devir sayısı ve zamana bağlı olarak hava giriş ve eksoz gazı sıcaklıkları, yakıt tüketimleri, hacimsel verim, motor yağ basıncı değerleri, is kalitesi saptanmıştır. Ayçiçeği yağı karışımları soya yağı karışımlarından daha iyi sonuçlar vermiştir. Ayrıca soya yağı karışımlarında motor yağ daha fazla kirlenmiş ve viskozitesi daha çok azalmıştır. %75 dizel yakıtı + %25 ayçiçeği yağı karışımı kullanıldığında nerdeyse yalnızca dizel yakıtın kullanıldığı sonuçlar elde edilmiştir.

Anahtar kelimeler: Alternatif dizel yakıtı , yağ karışımları, yakıt tüketimi, volumetric verim.

Introduction

The recent downturn in petroleum-based energy costs has stifled research in the area of alternative fuels. However, a number of researchers have reviewed available technologies in terms of vegetable oil as a diesel engine fuel. An appropriate one-sentence summary of the status and research priorities might be that vegetable oils have a lot potential as diesel engine fuels but there is a need for a continued and concentrated research effort. For diesel engines, vegetable oils hold promise as alternate fuels.

Energy inputs and outputs were comparatively analyzed for vegetable oil fuels. Three-year average prices and production quantities were also compared. All non-irrigated oil crops had favorable energy ratios. Soybean, peanut and sunflower oils were the most promising as domestic fuel sources. Rapeseed oil would also be promising if significant domestic production can be established. Soybean oil is considered a leading vegetable oil candidate for engine fuel because it is cheapest, available in the largest quantities, has the highest energy yield per hectare. Peanut oil and sunflower oil are also good candidates as engine fuel because of their very high energy yields per hectare and favorable ratios of energy. Corn oil and cottonseed oil are good fuel candidates only when produced as by products of corn starch and cotton lint production, respectively. (Goering and Daugherty, 1982).

Baldwin et al. (1983) operated four tractors with 3,6 L engines in highway right-of-way mowing. Fuels containing 10%, 20%, and 40% fully refined soybean oil were used. One tractor operated on 100% diesel fuel to serve as a control. The engines operated for 255 to 422 hours. Minor problems were encountered with microbial growth in the tests fuels. Analysis of crankcase indicated no abnormal engine wear combustion chamber deposits were found in all engines, but no difference was found between the engines with the test fuels and engine with the 100% diesel fuel.

Vellguth (1983) tested direct injection diesel engines using fully refined rape oil in German agricultural applications. Vellguth reported severe injector damage after 50 h of operation at 75% of maximum load. At the same time, piston carbon was found to be severe. After 200 hours of operation, lubricating oil contamination occurred due to rape oil moving past stuck piston ring and entering the crankcase.

Numerous combinations of vegetable oils, oil removing and refining processes and engines have been studied. Mora and Peterson (1985) suggested that all reported vegetable oil research falls into one of the following categories: (a) selection of desirable vegetable oils, (b) chemical modification of vegetable oils, (c) use of additives and (d) mechanical modification of engines.

Kaufman et al. (1986) tested six tractors that were fueled with 25% alkali refined, winterized sunflower oil / 75% diesel fuel and 50% alkaline refined, winterized sunflower oil / 50% No.2 diesel fuel. All engines were turbocharged, direct injection diesel engines. No power losses were detected during the test period. However, one engine experienced camshaft/valve train failure while service. Based on this study, use of a 25% sunflower oil / 75% No.2 diesel fuel blend or a 50% sunflower oil / 50% No.2 diesel fuel blend as a substitute diesel fuel cannot be recommended. However, under emergency conditions, a 27/75 blend of alkali refined, winterized sunflower oil / diesel fuel could be used as a diesel engine fuel, but the operator must be aware that reduced diesel engine life occur.

Schilick et al. (1988) reported that looking at only the power output, thermal efficiency and lubricating oil data from the EMA screening tests, one would conclude that the 25:75 (v/v) blends of soybean and sunflower oil with number 2 diesel fuel performed satisfactorily. However, when the general condition of the combustion chamber and fuel injectors after 200 h of operation is considered, one cannot expect satisfactory performance of a direct-injection diesel engine powered with these fuels. Different operating conditions and different proportions of vegetable oil and diesel fuel could result in a different conclusion.

The effects of diesel fuel and three lubricating oils on microbial communities in marine sediment were investigated in a field experiment at Casey Station, Antarctica. Sediment from a pristine site in Antarctica was treated with either Special Antarctic Blend (SAB) diesel, a synthetic lubricant (Mobil 0W-40), the same lubricant after use in a vehicle or an equivalent unused biodegradable lubricant (Titan GT1). The sediment was re-deployed in trays on the seabed for 5 weeks during the austral summer. The microbial community structure in the sediment upon collection, deployment and retrieval was investigated using denaturing gradient gel electrophoresis (DGGE), most probable number (MPN) counts and direct microscopic counting. It was found that only minor changes occurred in the microbial communities due to the experimental protocol. After 5 weeks however, there were significant differences between the communities in the SAB and clean and used lubricant (Mobil 0W-40) as compared to the control treatment. There was no significant difference between the control and biodegradable oil (Titan GT1) treatment (Powell at all, 2005) .

Oil was extracted from tomato seeds, tested for several important alternative fuel properties and compared with other vegetable oils. The oil yield of tomato seeds is about 35% on a dry weight basis. This vegetable oil has low volatility, low sulphur, low ash content, and high viscosity. Cetane number, density as well as the cold flow properties are similar to those of other vegetable oils. The fatty acid profile of tomato seed oil shows that there is a predominance of compounds containing an even number of carbon atoms, especially C-16 and C-18. The total saturated and unsaturated fatty acid composition is 18.28% and 81.72%, respectively, and the most abundant fatty acid is linoleic acid (56.12%). This study indicates that tomato seed oil is a renewable energy source and a promising fuel substitute which could be used in the diesel engine to bring down the consumption of the conventional petroleum products (Giannelos at all, 2005).

The viscosity of raw vegetable oil is rather higher than that of diesel fuel. High viscosity has a negative effect on atomization quality, and so engine performance and exhaust emission are affected badly; this causes failure of engine parts. To decrease viscosity of vegetable oil, methyl ester was produced and tested as an alternative fuel in a single cylinder, four strokes, air-cooled diesel engine. The viscosity of sunflower oil methyl ester obtained after transesterification was reduced considerably and heating value was improved. Engine tests were carried out at full load-different speed range; the engine torque and power of sunflower oil methyl ester was lower than that of diesel fuel in range of 6 - 18% and specific fuel consumption was higher than that of diesel fuel of approximately 3%. CO_2, CO and NOx emissions of sunflower methyl ester were lower than that of diesel fuel. The sunflower oil methyl ester fuel was used successfully as alternative fuel in short-term tests (Ilkilic ve Yucesu, 2005).

Materials and Methods

In this research, air-cooled, one cylinder, 5.52 kW power, four-stroke cycle and 6 LD 360 Model Lombarghini a diesel engine was used. Compression ratio of the engine was 18:1. In performance tests, fuels containing 25%, 50%, 75% fully refined soybean oil and 25%, 50%, 75% fully refined sunflower oil were used. In addition, for controlling 100% diesel fuel was used in the tests. For measurements, a digital sound meter, a K-type thermocouple, a compression test device, a Three-phase D-C motor, a digital tachometer, an injection test device and a fuel consumption measurement apparatus were used. The test apparatus was shown in Figure 1.

Measured values on each fuel blends and only diesel fuel are shown as fellow:

- Intake inlet air, T_{in} and exhaust outlet, T_{ex} temperature
- Fuel consumption
- Lubricating oil pressure

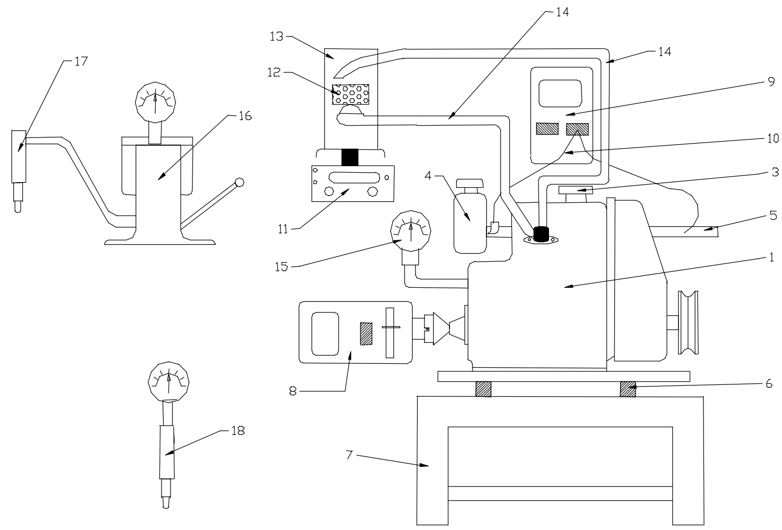
Then, volumetric efficiency, η_{vol} was computed by equation given below:

$$\eta_{vol} = \frac{288}{T_{in}}\left[\frac{1}{\varepsilon - 1}.\left(1 - \frac{T_{in}}{T_{ex}}\right) + a\right]$$

In this equation, ε is compression rate and a is cylinder filling rate.

In addition, the relationships between measured values and engine speeds were investigated.

Each test on the fuel blends and on the diesel fuel lasted 12 h and consisted of six engine speed settings, 1300 to 2800 rpm with 300 rpm interval. The tests were made as three replications. The engine was warmed up to operating temperature by operating for approximately 10 min prior to the start of each run. After each fuel blend test fuel injector, top piston ring, second piston ring and piston oil control ring were changed.



1. Test engine
2. Injection pump
3. Injector
4. Air filter
5. Exhaust outlet
6. Vibration absorbing block
7. Engine table
8. Digital tachometer
9. Thermocouple
10. Thermocouple sensor
11. Digital balance
12. Fuel filter
13. Fuel measuring vessel
14. Fuel hose
15. Lubrication pressure manometer
16. Injection test adapter
17. Injector
18. Compression meter device

Figure 1. The test apparatus

Result and Discussion

The test results used in diesel fuel to compare with other blends are shown in Table 1.

The test results used sunflower oil + diesel fuel blends are shown in Table 2 and Figure 2. Minimum exhaust outlet temperature was found in 25% sunflower oil + 75% diesel fuel blend at 1300 rpm and maximum exhaust outlet temperature was found in the same blend at 2800 rpm. Exhaust outlet temperatures increased with engine speed in all blends and their values were close each other. However, exhaust outlet temperature in 100% diesel fuel was lower than the others at all engine speeds. On the contrary, the volumetric efficiency of 100% diesel fuel was higher than the others at all engine speeds. There is no differences between 100% diesel fuel and 25% sunflower oil + 75% diesel fuel blend in terms of lubrication oil pressures at all engine speeds. The fuel consumption was minimum with 167 g/h in 25% sunflower oil + 75% diesel fuel blend at 1300 rpm and was maximum with 424 g/h in 50% sunflower oil + 50% diesel fuel blend at 2800 rpm. The fuel consumption of all blends were higher than 100% diesel fuel.

Table 1. Test results in 100% diesel fuel at six different engine speed.

Engine Speed (rpm)	T_{in} (^oC)	T_{ex} (^oC)	η_{vol} (%)	Fuel Consumption (g/h)	Lubricating Oil Pressure (bar)
1300	19	72,0	89,7	181,0	3,1
1600	19	81,7	89,8	200,0	3,8
1900	18	90,0	90,4	228,0	3,8
2200	17	103,0	90,8	272,0	4,1
2500	16	115,7	91,3	316,0	4,4
2800	14	132,3	92,0	368,0	4,1

Table 2. Test results in sunflower oil + diesel fuel blends at six engine speeds

Blends	Engine Speed (rpm)	T_{in} (°C)	T_{ex} (°C)	η_{vol} (%)	Fuel Consumption(g/h)	Lubricating Oil Pressure (bar)
%75	1300	22	79,3	88,8	196,0	4,3
D. Fuel	1600	22	94,3	89,1	232,0	4,3
+	1900	22	104,0	89,0	260,0	3,9
%25	2200	25	115,3	88,3	300,0	4,1
Sunflower	2500	23	127,0	89,1	389,0	4,3
Oil	2800	21	145,3	89,3	423,0	4,3
%50	1300	25	87,7	87,8	170,0	2,2
D. Fuel	1600	23	92,0	88,8	207,0	2,9
+	1900	17	103,0	90,6	225,0	2,8
%50	2200	19	117,7	90,1	296,0	3,2
Sunflower	2500	18	127,0	90,0	350,0	3,3
Oil	2800	16	140,0	91,6	424,0	4,2
%25	1300	20	80,0	89,4	167,0	3,0
D. Fuel	1600	21	85,7	89,3	225,0	3,2
+	1900	17	101,0	90,7	264,0	3,3
%75	2200	16	115,3	91,2	296,0	3,5
Sunflower	2500	16	135,3	91,5	360,0	4,2
Oil	2800	16	142,0	91,5	376,0	3,8

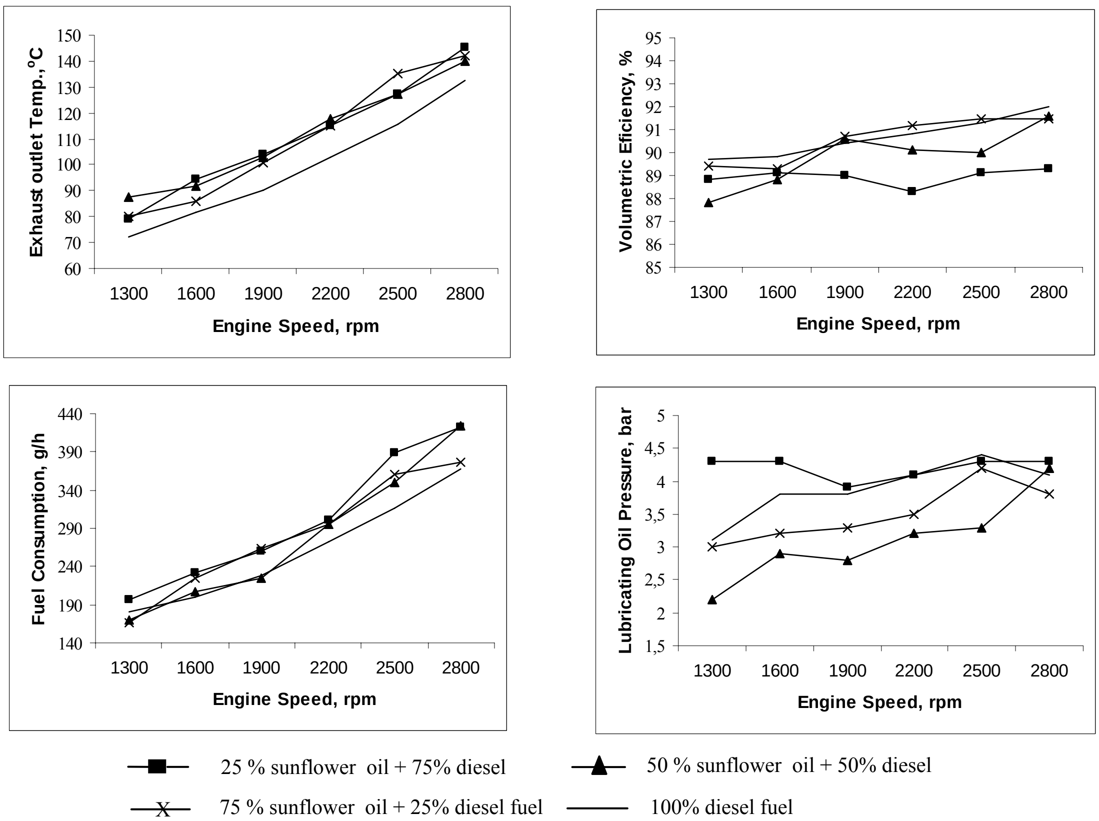


Figure 2. Measured values of three sunflower oil blends and 100% diesel oil vs. engine speed

Table 3. Test results in soybean oil + diesel fuel blends at six engine speeds

Blends	Engine Speed (rpm)	T_{in} (^oC)	T_{ex} (^oC)	η_{vol} (%)	Fuel Consumption(g/h)	Lubricating Oil Pressure (bar)
%75	1300	22	73,0	88,7	158,0	2,7
D. Fuel	1600	21	85,0	89,2	188,0	3,1
+	1900	20	97,0	89,7	228,0	3,8
%25	2200	19	107,7	90,0	280,0	3,8
Soybean	2500	17	119,7	91,0	319,0	3,5
Oil	2800	17	139,0	91,0	360,0	3,8
%50	1300	30	92,7	86,6	168,0	1,8
D. Fuel	1600	29	97,7	86,8	197,0	2,4
+	1900	27	107,0	87,5	236,0	2,6
%50	2200	25	123,3	88,3	302,0	2,7
Soybean	2500	24	135,0	88,7	332,0	2,9
Oil	2800	25	152,0	88,8	374,0	3,3
%25	1300	24	113,0	88,7	203,0	1,9
D. Fuel	1600	25	120,0	88.3	241,0	2,2
+	1900	26	129,3	88,2	271,0	2,4
%75	2200	26	143,3	88,3	360,0	2,7
Soybean	2500	26	154,7	88,5	390,0	2,8
Oil	2800	25	167,0	88,9	422,0	3,2

The test results used soybean oil blends are shown in Table 3 and Figure 3. The exhaust outlet temperature was minimum in 25% soybean oil + 75% diesel fuel blend at 1300 rpm and was maximum in 75% soybean oil + 25% diesel fuel blend at 2800 rpm. . The exhaust outlet temperatures of other blends were higher than 100% diesel fuel at all engine speeds. The volumetric efficiencies of all blends at six engine speeds were lower than 100% diesel fuel. There are no differences between 100% diesel fuel and 25% soybean oil + 75% diesel fuel blends in terms of lubrication oil pressures at all engine speeds. The lubrication oil pressures of the other blends were lower than their values. The fuel consumption was maximum with 422 g/h in 75% soybean oil + 25% diesel fuel blend at 2800 rpm and was minimum with 158 g/h in 25% soybean oil + 75% diesel fuel blend at 1300 rpm. The fuel consumption of the other blends at all engine speed were higher than 100% diesel fuel.

Measured exhaust outlet temperature-engine speed relationships in sunflower oil + diesel fuel blends and soybean oil + diesel fuel blends are given Table 4. High relationships in the all blends except 25% sunflower oil + 75% diesel fuel were found.

Table 4. Relationships between exhaust outlet temperature and engine speed

Blends	Model	a	b	R^2
%100 M	Y=exp(a+bX)	3.75	$4.019x10^{-4}$	99.8**
%75F+%25A	$Y=aX^b$	$3.1x10^{-11}$	2.05	32.2
%50F+%50A	Y=exp(a+bX)	4.03	$3.28x10^{-4}$	98.9**
%25F+%75A	Y=exp(a+bX)	3.82	$4.16x10^{-4}$	98.3**
%75F+%25S	Y=exp(a+bX)	3.77	$4.144x10^{-4}$	99.6**
%50F+%50S	Y=exp(a+bX)	4.06	$3.407x10^{-4}$	98.8**
%25F+%75S	Y=exp(a+bX)	4.37	$2.684x10^{-4}$	99.6**

(X: Engine speed, Y: Predicted values, F: Diesel Fuel, A: Sunflower oil, S: Soybean oil)

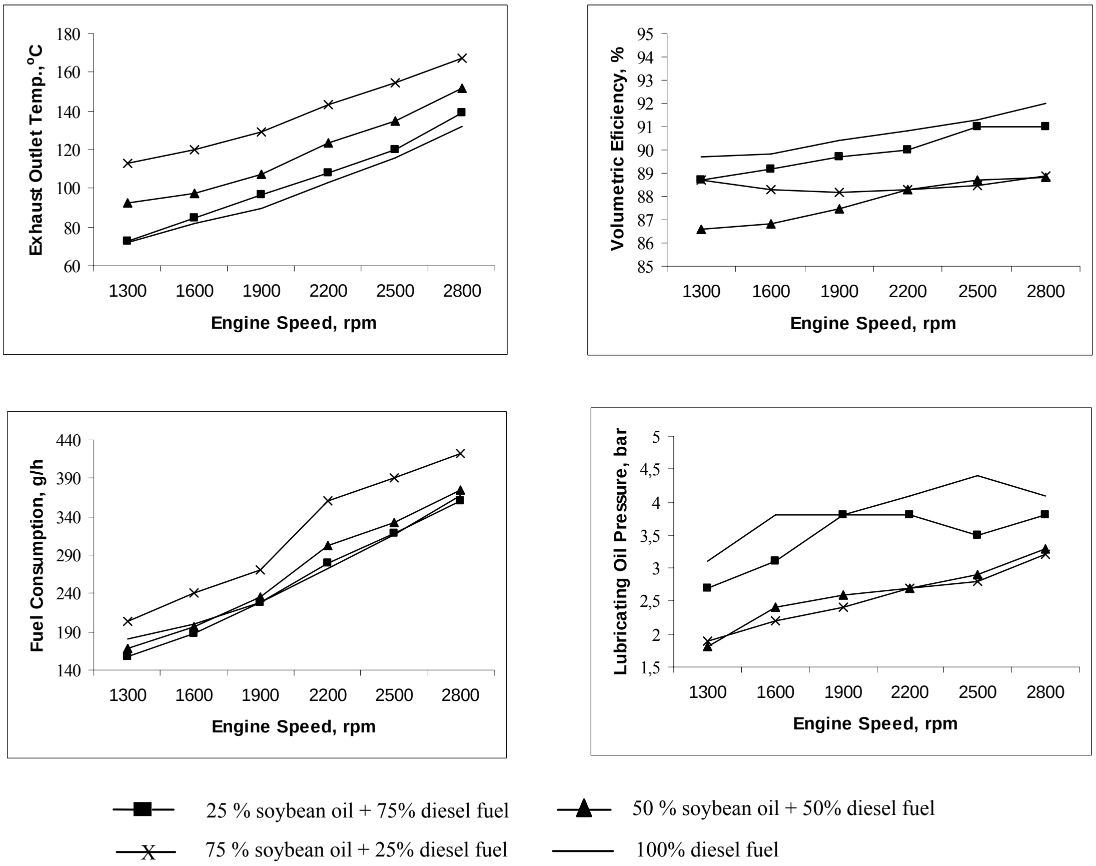


Figure 3. Measured values of three soybean oil blends and 100% diesel oil vs. engine speed

Measured volumetric efficiency-engine speed relationships in sunflower oil + diesel fuel blends and soybean oil + diesel fuel blends are given Table 5. High relationships in the all blends except 25% sunflower oil + 75% diesel fuel blends and 25% soybean oil + 75% diesel fuel blends were found.

Table 5. Relationships between volumetric efficiency and engine speed

Blends	Model	a	b	R^2
%100 F	Y=exp(a+bX)	4.47	1.721×10^{-5}	97.3**
%75F+%25A	Y=a+bX	88.58	1.71×10^{-4}	7.6
%50F+%50A	Y=exp(a+bX)	4.45	2.348×10^{-5}	77.5*
%25F+%75A	Y=exp(a+bX)	4.47	1.853×10^{-5}	86.3**
%75F+%25S	Y=a+bX	88.58	1.64×10^{-4}	96.2**
%50F+%50S	Y=exp(a+bX)	4.44	1.90×10^{-5}	95.3**
%25F+%75S	Y= exp(a+bX)	4.48	1.83×10^{-6}	11.2

(X: Engine speed, Y: Predicted values, F: Diesel Fuel, A: Sunflower oil, S: Soybean oil)

Relationships between lubricating oil pressure and engine speed in all blends and 100% diesel fuel are given Table 6. Correlation in all blends except 25% sunflower oil + 100% diesel fuel was highly significant. Especially, high relationship in 75% soybean oil + 25% diesel fuel was found (R^2=98,2).

Table 6. Relationships between lubricating oil pressure and engine speed

Blends	Model	a	b	R^2
%100 F	$Y=aX^b$	0.031	0.3759	79.34*
%75F+%25A	Y=exp(a+bX)	1.424	$4.76x10^{-6}$	0.43
%50F+%50A	Y=exp(a+bX)	0.379	$3.576x10^{-4}$	88.5**
%25F+%75A	Y=exp(a+bX)	0.845	$1.96x10^{-4}$	80.5*
%75F+%25S	$Y=aX^b$	0.013	0.4126	70.2*
%50F+%50S	Y=a+bX	0.840	$8.67x10^{-4}$	93.3**
%25F+%75S	Y=exp(a+bX)	0.242	$3.284x10^{-4}$	98.2**

(X: Engine speed, Y: Predicted values, F: Diesel Fuel, A: Sunflower oil, S: Soybean oil)

Relationships between fuel consumption and engine speed in all blends and 100% diesel fuel are given Table 7. Highly significant relationships in the all blends were found. Correlation coefficient (R^2) of all blends was over 97%.

Table 7. Relationships between fuel consumption and engine speed

Blends	Model	a	b	R^2
%100 F	Y=exp(a+bX)	4.54	$4.85x10^{-4}$	99.4**
%75F+%25A	Y=exp(a+bX)	4.59	$5.28x10^{-4}$	98.5**
%50F+%50A	Y=exp(a+bX)	4.33	$6.114x10^{-4}$	98.9**
%25F+%75A	Y=a+bX	-8.01	0.141	98.3**
%75F+%25S	Y=a+bX	-28.57	0.1386	99.6**
%50F+%50S	Y=exp(a+bX)	4.42	$5.537x10^{-4}$	98.4**
%25F+%75S	Y=a+bX	-3.93	0.155	97.3**

(X: Engine speed, Y: Predicted values, F: Diesel Fuel, A: Sunflower oil, S: Soybean oil)

Conclusions

The following conclusions were obtained from this investigation:

1. The exhaust outlet temperature was found higher in 75% soybean + 25% diesel fuel blend. In addition, fuel consumption was also found high in the same blend. The molecular scattering of this blend is not enough because of viscosity of the blend is high. This condition is not different in the other having high oil ratio blends. This is cause of increasing fuel consumption and exhaust outlet temperature.
2. The results of sunflower oil + diesel fuel blends were better than soybean oil + diesel fuel blends. Specially, the test results of 25% sunflower oil + 75% diesel fuel blends had nearly same results of 100% diesel fuel. But, investigation of effects on engine parts like piston, cylinder, rings of this blend by long time working is necessary.

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