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Research Article

Evaluation of *Catharanthus roseus* Biodiesel as an Alternative Fuel to study the Performance and Emission Characteristics via 4-S Internal Combustion Engine

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Abstract

Global warming and pollution alert distress worldwide. Owing to increasing air pollutions by vehicles and industries has totally disturbed the resources on earth. As a result demand for energy altogether increasing steadily around the world. In India, the demand for energy raised 7.3% per annum and the import of crude around 70%. As a result of increasing energy demad, there has been a strong demand for alternate fuel like biodiesel for the proper performance in burning engine. Biodiesel has property of non-toxic, renewable and a perishable fuel and their physicochemical properties are clearly different from crude fuel. In the present work, biodiesel produced from *Catharanthus roseus* seeds by acid-base catalyzed transesterification method was results blended with varying proportions of diesel (B20, 40, 60, 80, & B 100) and examined in 4-S diesel engine. The performance of 4-S diesel engine such as brake thermal efficiency, heat input, specific fuel consumption and mechanical efficiency were studied. Emission characteristics were studied by analyzing the exhaust gas temperature, smoke density and hydrocarbon, carbon dioxide, nitrogen oxides and carbon monoxide content.

Keywords: *Catharanthus roseus* biodiesel; Diesel; Performance; Brake thermal efficiency; Emission.

Introduction

Today most of the countries in the world are the importers of energy. The largest demand occurred word wide in the energy system, especially for petroleum-based products [1-3]. In such a scenario, Biodiesel is an able alternative which is an environmentally friendly, renewable source, a nontoxic and biodegradable matter which obtained from bio-oils mainly extracted plants and their products [4-6]. It has monoalkyl esters of long-chain fatty matters, and it collects from vegetable oil, animal fats, algae and non-edible oils. Biodiesel produced by triglycerides in vegetable oils like Soya, Palm, Rapeseed, Sunflowers etc. [7-9]. Likewise other sources from non-edible sources like Pongamia oil, Castor oil, Mahua oil, Jatropha oil, Camelina oil, Neem oil, and Cottonseed oils. Chemically biodiesel named as fatty acid methyl esters (FAME) and the process of obtaining it is generally called Transesterification [10-12].

Biodiesel has a parallel range of the properties like petrodiesel and used for automobiles. Biodiesel and its products after combustion are less harmful to the environment [13-18]. The purpose of the present research work is to study the emission and performance analyses of biodiesel in an internal combustion engine.

Experiment

The 4-S Internal Combustion (IC) engine was started by operating from the decompressed level and cracking with the help of a ladle as shown in figure 1. Engine was allowed with a load for some time and the speed was adjusted. At no load condition, the following readings are noted, time taken for 10ml of fuel consumption and load in Kg, increase in the load by operating the switches on load. Readings are noted for the given loads. Observations examined were the brake thermal efficiency, volumetric efficiency, heat input and specific fuel consumptions, etc. The emissions parameters like hydrocarbon, carbon dioxide, nitrogen oxides and carbon monoxide are calculated. Repeated the research for various proportions of biodiesel blended with diesel fuel and results were recorded.

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Figure 1. Four stroke diesel engine

Results and discussion

Exhaust gas temperature (EGT)

Exhaust gas temperature (EGT) analysis of biodiesel studies have distributed for various blends like B20, 40, 60, 80, & B 100 compared with diesel oil. The results of lower and better emission in exhaust gas have examined and shown in figure 2. Exhaust gas temperature rising equally in engine load additionally as in biodiesel blends. In nature, the engine to want an extra quantity of fuel to form further power necessary to hold out conditional loading.

Hydrocarbon (HC)

Hydrocarbon is toxins and contributes to forming smog. Emission of an organic compound could be a sign of poor ignition fuel. The results of hydrocarbon emission with totally different blends have distributed and shown in figure 3. The utmost and least quantity of hydrocarbon emission present in several blends and their values have calculated. The Cetane number of diesel oil is lowered when put next to biodiesel. Oxygen presence within the biodiesel causes the lesser emission of the hydrocarbon.

Nitrogen oxides (NOx)

Nitrogen Oxides is toxic and extremely reactive gases. Once the fuel has burned at a higher temperature this gas formed. The nitrogen oxides for varied proportions of biodiesel are shown in figure 4. The emitted nitrogen oxides results are found be terribly low in pure *Catharanthus roseus* biodiesel compared with diesel. The lower and better amounts of nitrogen oxides emissions results calculated.

Carbon dioxide (CO_2)

Carbon dioxide emission is directly proportional to the engine load as a result of the load enhanced emission also raised. The result of CO2 emission at varied extents is calculating and shown in figure 5. When put next to diesel CO_2 emission is a lesser quantity present in B 20, 40, 60 blends.

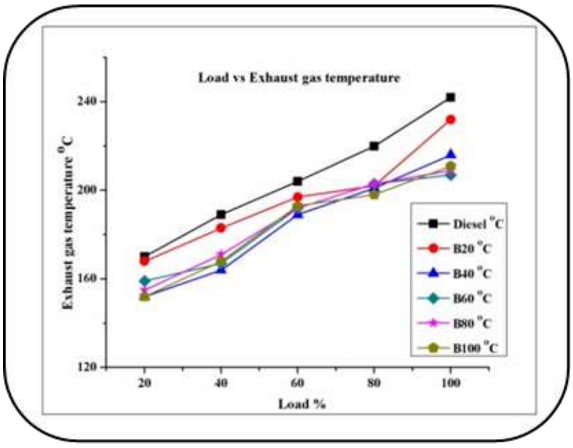

Figure 2. Exhaust gas temperature analysis for different load and various ratio of biodiesel in diesel

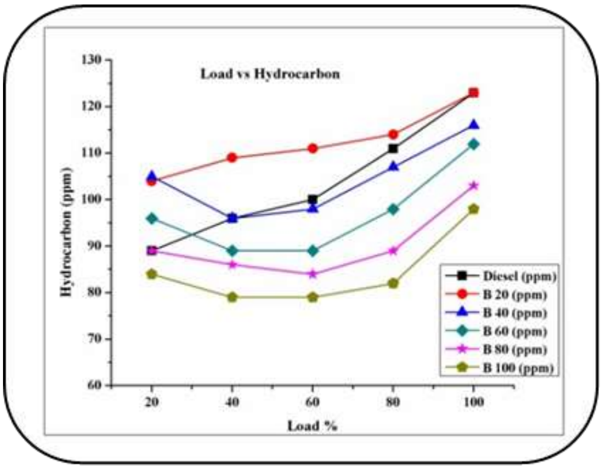

Figure 3. Hydrocarbon analysis of exhaust gas for different load and various ratio of biodiesel in diesel

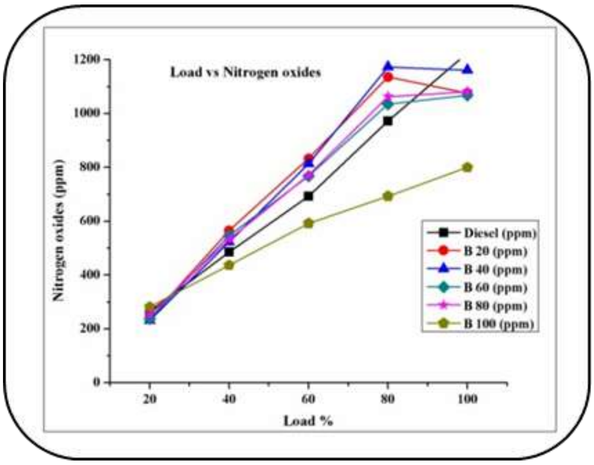

Figure 4. Nitrogen oxides analysis of exhaust gas for different load and various ratio of biodiesel in diesel

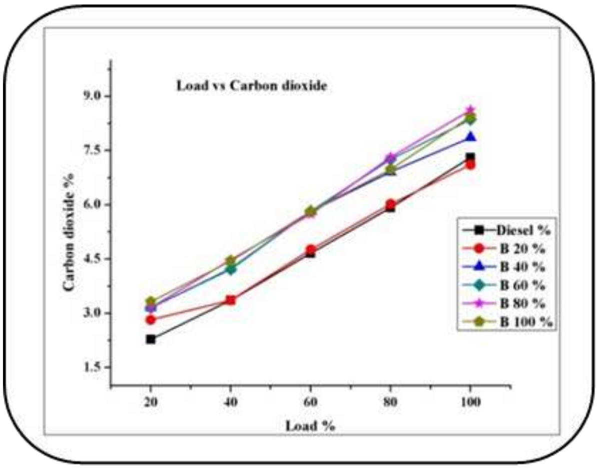

Figure 5. Carbon dioxide analysis of exhaust gas for different load and various ratio of biodiesel in diesel

Carbon monoxide (CO)

Carbon monoxide emitted 0.05% present in the first loading condition of the engine and the results calculated and shown in figure 6. A lower concentration of biodiesel results in obtaining clean burning within the combustion chamber as a result of an element present in it. During this same approach, the concentrations are higher in biodiesel results in emitting the CO emission are higher in number and presence of high consistency and relative density.

Smoke meter (SM)

An instrument which analyzes the smoke exhaust emitted from the engine systems. Different types of smoke emitted by engine systems such as black smoke, white smoke, and blue smoke. The smoke meter uses the filter paper method to decide the soot concentration in the exhaust of diesel and GDI engines shows that figure 7. A variable, but exactly defined sampling volume is a sample from the engine exhaust pipe and passed through clean filter paper inside the device and the result analyzed by a microprocessor.

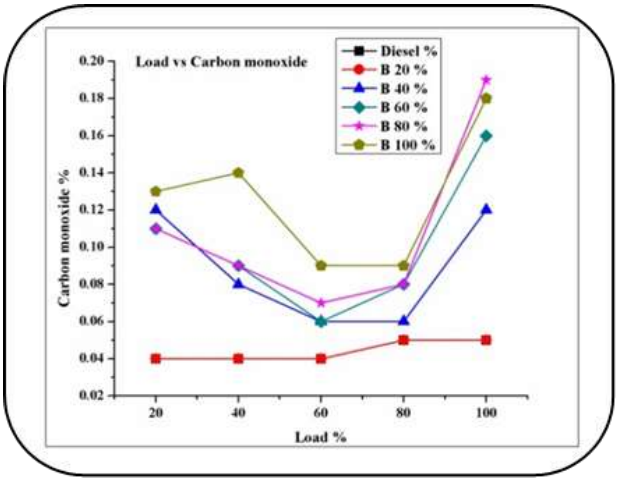

Figure 6. Carbon monoxide analysis of exhaust gas for different load and various ratio of biodiesel in diesel

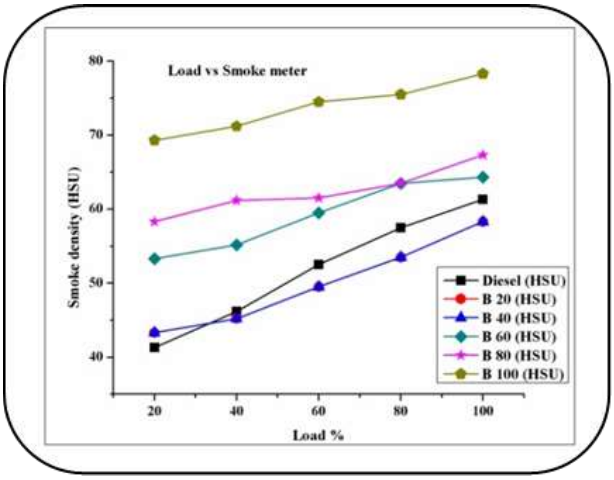

Figure 7. Smoke density analysis of exhaust gas for different load and various ratio of biodiesel in diesel

Engine Performance Study

Engine performance analyses distributed in a Kirloskar single cylinder four stroke internal-combustion engine trainer rig with eddy current dynamometer computer primarily based kind. The processed trainer rig used for the performance testing parameters like temperature, fuel rate, air rate and load. During this performance test principally specialize in load for calibrating pressure, brake thermal efficiency, specific fuel consumption, total fuel consumption and volumetric efficiency. Experiments dispensed through internal-combustion engine with totally different mix ratios are (Biodiesel:Diesel) 20:80, 40:60, 60:40, 80:20 and 100% by volume.

Brake thermal efficiency

The figure 8 shows that the results observed from BTE of biodiesel blends are lower compared to diesel fuel. The variations of BTE obtained from the output of the combustion engine with respect to energy supplied from the diesel fuel. Compared to blends BTE increases with the load and is higher in diesel fuel and their readings are given the table 1 to 6. When compared to diesel, biodiesel and its various proportions have shorter ignition delay and combustion initiated much before the top dead center reached.

Specific fuel consumption

The figure 9 shows that the results from SFC varying with brake power. When the brake power has increased in all the fuels, the values of specific fuel consumption are lesser. SFC values for 100 % load condition are 1.94, 1.44, 1.24, 1.34, 1.54, and 1.87 for diesel and blends (B20, B40, B60, B80 & B100 %) and their readings are given in table 1 to 6.

Mechanical efficiency

The performance values of mechanical efficiency for all load variations will be equal to diesel fuel as shown in figure 10 and the volumetric efficiency variations shown in the figure 11. With respect to different load proportions, the performance values will be lower. Along with all the blends, B20 (52.88 %) shows the higher efficiency value than that of diesel (52.41 %). Mechanical efficiency values for 100 % load condition is 52.14, 51.27, 52.88, 51.67, 49.91, and 49.23 for diesel and blends (B20, B40, B60, B80 & B100 %) and their readings are given in the table 1 to 6.

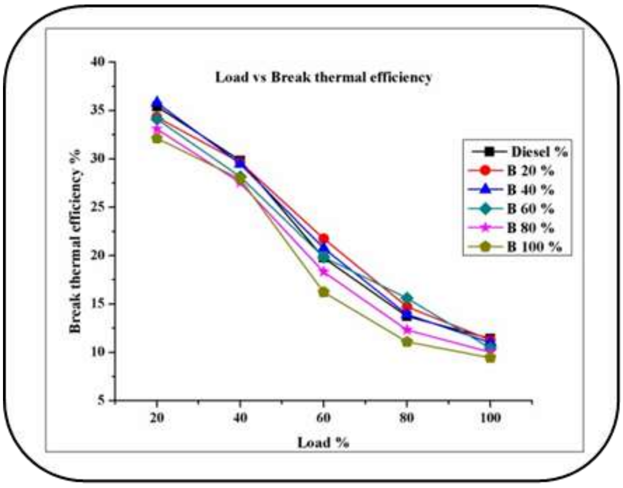

Figure 8. Break thermal efficiency of IC engine for different load and various ratio of biodiesel in diesel

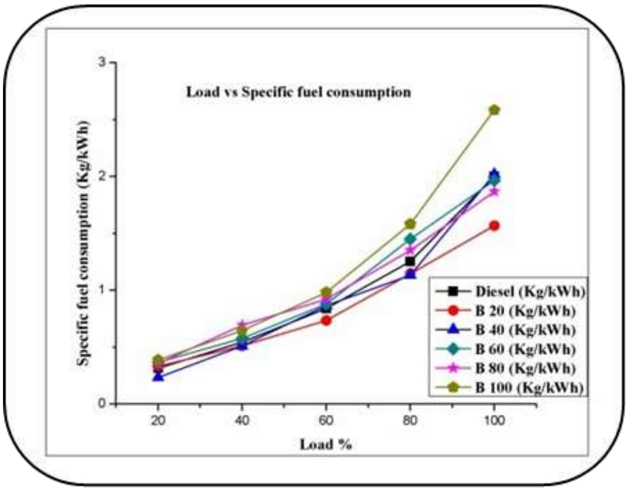

Figure 9. Specific fuel consumption of IC engine for different load and various ratio of biodiesel in diesel

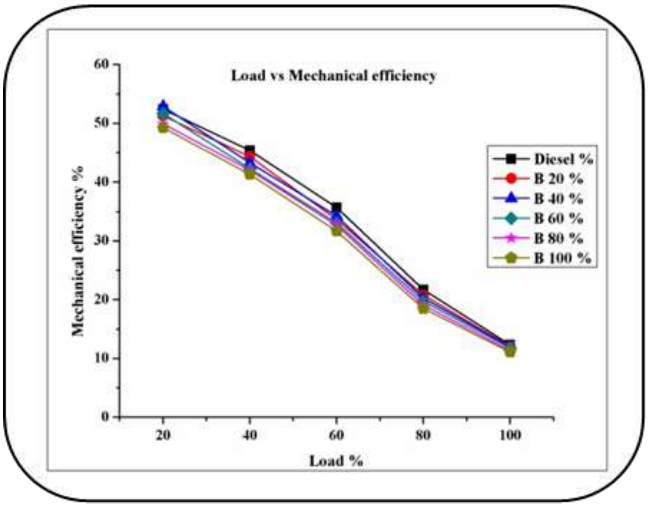

Figure 10. Mechanical efficiency of IC engine for different load and various ratio of biodiesel in diesel

Table 1. Performance Analysis for Diesel Fuel

S.No.	Load (%)	BP (kW)	TFC (Kg/h)	IP (kW)	SFC (Kg/kWh)	HI (kJ/s)	ηBTE (%)	ηMech (%)	ηVol (%)
1	20	3.32	0.74	6.96	0.314	8.42	35.42	52.41	44.87
2	40	2.49	0.66	8.14	0.546	9.36	29.84	45.42	44.87
3	60	1.66	0.65	10.37	0.839	10.39	19.76	35.68	43.88
4	80	1.12	0.35	11.74	1.252	11.89	13.72	21.72	43.88
5	100	0.83	0.41	13.51	2.002	13.11	11.44	12.35	43.88

Table 2. Performance Analysis for 20% blend with Diesel Fuel

S.No.	Load (%)	BP (kW)	TFC (Kg/h)	IP (kW)	SFC (Kg/kWh)	HI (kJ/s)	ηBTE (%)	ηMech (%)	ηVol (%)
1	20	3.42	0.64	5.94	0.332	8.32	34.32	51.27	43.88
2	40	2.59	0.56	7.81	0.511	8.76	29.64	44.32	43.68
3	60	1.76	0.51	10.37	0.734	9.29	21.76	33.68	43.44
4	80	1.12	0.45	11.84	1.146	9.79	14.72	20.79	43.44
5	100	0.86	0.37	13.67	1.567	10.21	11.27	12.10	43.44

Table 3. Performance Analysis for 40% blend with Diesel Fuel

S.No.	Load (%)	BP (kW)	TFC (Kg/h)	IP (kW)	SFC (Kg/kWh)	HI (kJ/s)	ηBTE (%)	ηMech (%)	ηVol (%)
1	20	3.42	0.57	6.56	0.234	8.12	35.82	52.88	43.68
2	40	2.59	0.52	7.64	0.512	8.32	29.49	43.32	43.51
3	60	1.86	0.46	11.37	0.866	9.19	20.76	34.23	43.51
4	80	1.22	0.42	11.74	1.132	10.89	13.92	20.27	43.51
5	100	0.93	0.39	14.51	2.019	11.11	11.02	12.01	43.51

Table 4. Performance Analysis for 60% blend with Diesel Fuel

S.No.	Load (%)	BP (kW)	TFC (Kg/h)	IP (kW)	SFC (Kg/kWh)	HI (kJ/s)	ηBTE (%)	ηMech (%)	ηVol (%)
1	20	3.22	0.66	5.96	0.367	9.42	34.12	51.67	43.21
2	40	2.59	0.59	7.14	0.578	9.76	28.14	42.31	42.56
3	60	1.76	0.57	10.37	0.878	10.39	19.86	33.07	42.56
4	80	1.02	0.49	11.24	1.450	10.89	15.62	19.76	42.56
5	100	0.93	0.41	14.01	1.966	11.31	10.44	11.75	42.56

Table 5. Performance Analysis for 80% blend with Diesel Fuel

S.No.	Load (%)	BP (kW)	TFC (Kg/h)	IP (kW)	SFC (Kg/kWh)	HI (kJ/s)	ηBTE (%)	ηMech (%)	ηVol (%)
1	20	3.42	0.74	5.68	0.358	8.24	33.09	49.91	43.16
2	40	2.49	0.66	7.04	0.694	9.63	27.53	42.06	42.63
3	60	1.86	0.61	9.37	0.921	10.43	18.34	32.68	42.63
4	80	1.12	0.43	11.72	1.352	10.89	12.32	19.10	42.63
5	100	0.93	0.32	14.19	1.867	11.45	10.02	11.35	42.63

Table 6. Performance Analysis for 100% Biodiesel Fuel

S.No.	Load (%)	BP (kW)	TFC (Kg/h)	IP (kW)	SFC (Kg/kWh)	HI (kJ/s)	ηBTE (%)	ηMech (%)	ηVol (%)
1	20	3.52	0.74	4.68	0.389	8.88	32.12	49.23	43.05
2	40	2.89	0.66	7.32	0.646	9.86	27.94	41.33	42.83
3	60	2.16	0.65	10.17	0.982	10.92	16.23	31.69	42.83
4	80	1.12	0.35	11.84	1.582	11.19	11.09	18.52	42.83
5	100	0.83	0.41	14.67	2.584	11.61	9.46	11.13	42.83

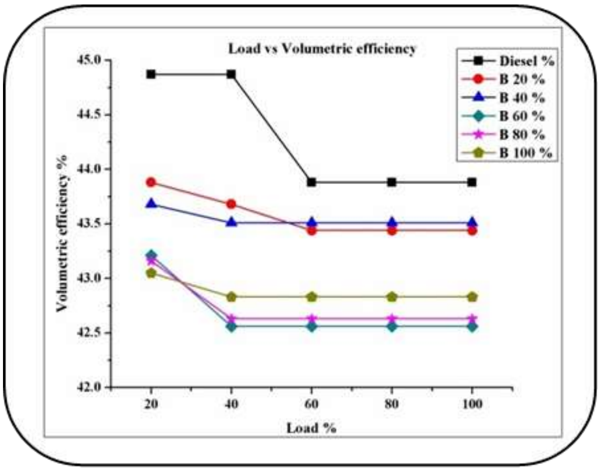

Figure 11. Volumetric efficiency of IC engine for different load and various ratio of biodiesel in diesel

Conclusions

Today there is an enormous demand for crude petroleum and its derivatives which dive the global economy. However, a contribution of fresh energy just like the biodiesel will cut the stress on oil reserves. Biodiesel involves less production cost, environmentally friendly, renewable, nontoxic and biodegradable. In this examination, a novel source *Catharanthus roseus* was used as a feedstock for the generation of biodiesel utilizing the transesterification process. *Catharanthus roseus* biodiesel gives prominent results using single cylinder four stroke diesel engines for emission and efficiency performance of biodiesel with various blends. *Catharanthus roseus* oil methyl esters and their blends can be used directly in a diesel engine without any changes placed on it. Compare to any or all blends, B20 (20% of biodiesel +80% of petrodiesel) blends gives prominent results and get closer to the diesel properties. Among these results from our research, *Catharanthus roseus* biodiesel will act as a better replacement for diesel in diesel engine applications like industrial and automobile sectors. The conversion of bio-oil to biodiesel from *Catharanthus roseus* seeds is humble yet ambitious attempt to make the alternative fuel work and save our environment from harmful effects.

Conflicts of interest

Authors declare no conflict of interest.

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