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# Performance analysis of Variable Compression Ratio Engine using Argemone Mexicana Biodiesel

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## Abstract

Alternate fuel has gained increasing attention among researchers in twenty first century due to continuous rise in conventional fossil fuel price. The fossil fuels like diesel and petrol are also not environmental friendly as they produce noxious gases. Biodiesel is one of the most prominent alternate fuels as its properties are similar to that of diesel. Researches are being carried out on enhancing performance parameters of internal combustion engine by using different biodiesels and engine modifications are suggested accordingly. To do modification in existing engine is not a cost effective affair. In the present work, attempt has been made to prepare biodiesel from Argemone Mexicana and run a variable compression ratio (VCR) diesel engine without any engine modification. The performance results obtained are within acceptable limits.

***Keywords:*** *argemone mexicana, biodiesel, diesel engine, performance, transesterification, blends*

## Introduction

Biodiesel is regarded as a substitution fuel for internal combustion engine in recent years due to depletion of diesel fuel. In direct method, raw vegetable oils can be used as a fuel for diesel engine, but it gives rise to the problems like injector choking, knocking as well as improper combustion due to their high viscosity. Therefore, the processes like heating, pyrolysis and transesterification are adopted in order to make them suitable for the engine. Both edible and nonedible oil are considered as the source of biodiesel production. From the economy point of view nonedible oils can be used as best source for biodiesel production. The nonedible oils such as mahua, jatropha, karanja, castor, neem etc are generally used to produce biodiesel as these oils are easily found and has low cost. Jatropha and karanja found in the tropical forests are the leading sources of biodiesel production (Chauhan et al. 2012; Mamualiya and Lal, 2015). Liaquat et al. (2013) studied engine performance and emission by using biodiesel produced from coconut oil. The engine brake power and torque are found to be lower than diesel fuel. Similarly Chavan et al. (2015) carried out their investigation on performance analysis of variable compression ratio diesel engine using jatropha biodiesel. Prabhu et al. (2013) studied the performance, combustion as well as emission characteristics of diesel engine using different blends of neem biodiesel and found higher thermal efficiency of B20 blend than diesel fuel. Kumar et al. (2015) experimented palm oil biodiesel as a fuel for single cylinder diesel engine at different injection pressures for performance evaluation. They obtained highest thermal efficiency at a pressure of 260 bar. However, Specific fuel consumption (SFC) was found to be highest at an injection pressure of 220 bar. Arunkumar et al. (2019) experimentally investigated the performance of diesel engine using castor biodiesel and obtained favourable results. They emphasised on more cultivation on castor plant which could lead to employability as well as a new source for diesel engine fuel. Bajpai and Das (2014) carried out their experimental work on running engine with alkyl esters of Jatropha, Karanja and castor. They found lower blends of higher alkyl esters giving the performance result close to diesel oil. Ogunkunle and Ahmed (2019) carried out their research on optimizing the biodiesel production from sand apple which is widely cultivated in Africa and subsequent its use in diesel engine to run. They obtained good result on engine performance with no modification in engine. Saheb et al. (2015) carried out their experimental work on enhancement of engine performance by blending mahua oil with diesel. Pradhan et al. (2016) obtained biodiesel from mahua seed by pyrolysis process for using in diesel engine.

In the present work, biodiesel has been prepared from Argemone Mexicana oil and prepared biodiesel is used to run a VCR diesel engine to carry out engine performance investigation. The performance analysis of engine reveals that the brake power (bp), brake thermal efficiency ($\eta_{bth}$), and specific fuel consumption (SFC) increases for Argemone Mexicana biodiesel at low loads as compared to diesel fuel.

## Material and Methodology

Argemone Mexicana is a common herb found in road side, agricultural and waste land all over the world. In India it is popularly called as Satyanashi having yellow colour flower shown in Figure 1. The oil obtained from Argemone Mexicana seeds mainly consists of linoleic acid and oleic acid is nonedible in nature. The free fatty acid (FFA) content of Argemone Mexicana oil is nearly 2 % which is less in comparison to Jatropha oil (14%) and Mahua oil (19%).

*Figure 1.* Argemone Mexicana Herb

**Properties of oil**

In the present work, the properties of crude Argemone Mexicana oil were found to be slightly deviating from the reported values. The acid value and viscosity of the Argemone Mexicana oil was high which depends upon the purity of the oil sample collected. However, the saponification value of oil was reported slightly lower than the actual value.

Table 1 *Properties of Argemone Mexicana oil*

| Properties | | Crude Oil | Reported Value |
|---|---|---|---|
| Color | - | Yellow | Yellow |
| Density(kg/m$^3$) | - | 947.1 | 963.1 |
| Viscosity | - | 322.07 | 279.03 |
| Saponificationvalue | - | 76.225 | 110.31 |
| Acid value | - | 2.39 | 1.81 |
| Free fatty acid | - | 1.349 | 2.9 |

**Preparation of biodiesel**

The biodiesel was obtained from Argemone Mexicana oil by means of transesterification process. As the free fatty acid (FFA) content of the biodiesel is very less, esterification process is not required. In the transesterification process, 1 litre of Argemone Mexicana oil was preheated in biodiesel reactor shown in Figure 2, to remove moisture content and thereafter added with 200ml of methanol and 10gm of KOH. The heating was carried out at 62$^o$C for 3 hours with constant rate of stirring. After 3hours of heating, the mixture was poured into a separating funnel for about 12hours, where two layers were formed. The upper layer contained methyl ester and the lower layer containing glycerol, extra methanol, catalyst and other by products were separated from the mixture. The upper layer of methyl ester or Argemone Mexicana biodiesel was collected and washed several times with de-sterilized water until the washing water become neutral. The biodiesel layer was filtered to remove impurities and then heated up to 100$^0$C to remove any remaining water. The biodiesel was tightly sealed and kept for storage.

*Figure 2.* Biodiesel Reactor

## Performance Test

Different blends of Argemone Mexicana biodiesel such as B10, B20 and B30 were prepared by blending with diesel. For example, in a B10 Argemone Mexicana biodiesel, there is a composition of 10% Argemone Mexicana biodiesel and 90% diesel. The biodiesel blends were then tested in variable compression ratio engine shown in Figure 3, where there is a provision to change the compression ratio by changing clearance volume of the engine cylinder. The engine was started and run idle for 10 minutes. Now the compression ratio of the engine is set at 18. Then Argemone Mexicana biodiesel of B10 blend was poured in fuel tank and the engine was run with no load condition. The load was increased to 2kg by means of variac. Important performance parameters of the engine such as Brake Power (BP), Brake Thermal Efficiency (BTH) and Specific Fuel Consumption (SFC) were obtained from a computer integrated with VCR engine. Gradually the engine load was increased to 4, 6 and 10 kg and corresponding values of performance parameters were recorded. This procedure was followed for B20 and B30 blend of Argemone Mexicana biodiesel.

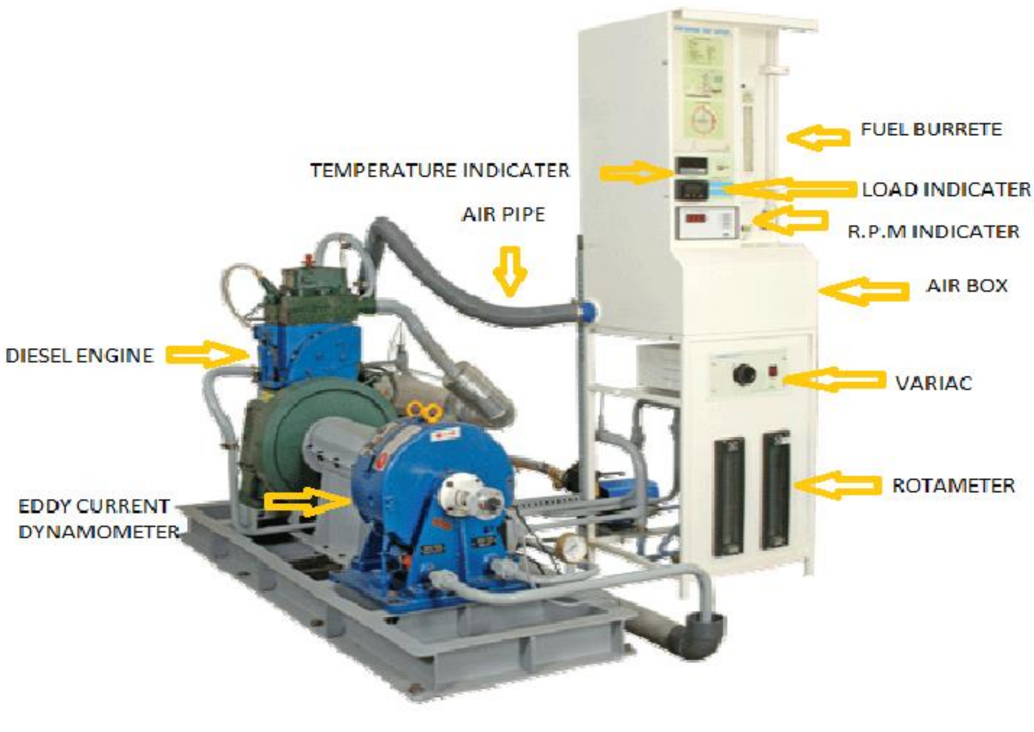


*Figure 3.* Variable Compression Ratio Engine

## Result, Discussion and Conclusion

The performance comparison of VCR engine using different blends of Argemone Mexicana biodiesel and conventional diesel was shown in Table 6-10 and graphs were plotted accordingly.

Table 2 *Break Power (BP) of conventional diesel and different Argemone Mexicana biodiesel blends*

| Load (Kg) | BP (kW) Diesel | BP (kW) B10 | BP (kW) B20 | BP (kW) B30 |
|---|---|---|---|---|
| 2 | - 0.71 | 0.79 | 0.81 | 0.76 |
| 4 | - 1.17 | 1.21 | 1.23 | 1.20 |
| 6 | - 1.78 | 1.82 | 1.83 | 1.79 |
| 8 | - 2.33 | 2.34 | 2.34 | 2.30 |
| 10 | - 2.72 | 2.71 | 2.70 | 2.68 |

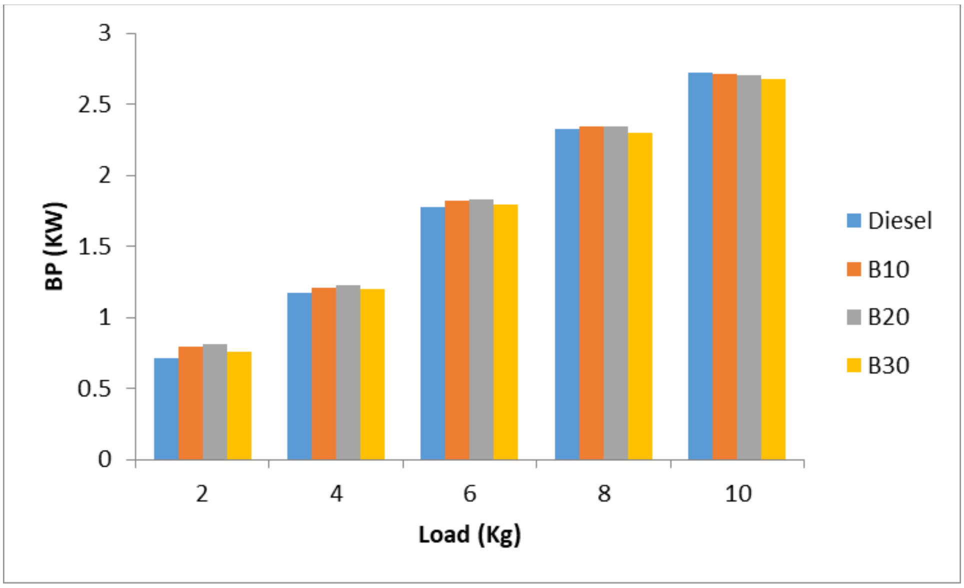


*Figure 3.* Brake Power Vs Load of different Argemone Mexicana biodiesel blends.

From the graph, it is observed that there is an increase in brake power output for Argemone Mexicana biodiesel blends B10, B20 and B30 in comparison to conventional diesel. This is due to higher energy content per volume of biodiesel. However for higher loads, there is no significant increase in brake power and it drops slightly for B30 biodiesel blend. The decrement in power output is less than 2% though the engine is run with biodiesel blend of 30%. This shows that Argemone Mexicana is suitable to be used as biodiesel.

Table 3

*Break Power (BP) of conventional diesel and different Argemone Mexicana biodiesel blends*

| Load(kg) | SFC (kg/kWh) | SFC (kg/kWh) | SFC (kg/kWh) | SFC(kg/kWh) |
|---|---|---|---|---|
| | - Diesel | B10 | B20 | B30 |
| 2 | - 0.7 | 0.94 | 0.96 | 0.99 |
| 4 | - 0.51 | 0.57 | 0.59 | 0.62 |
| 6 | - 0.39 | 0.4 | 0.41 | 0.43 |
| 8 | - 0.34 | 0.35 | 0.37 | 0.39 |
| 10 | - 0.3 | 0.32 | 0.35 | 0.37 |

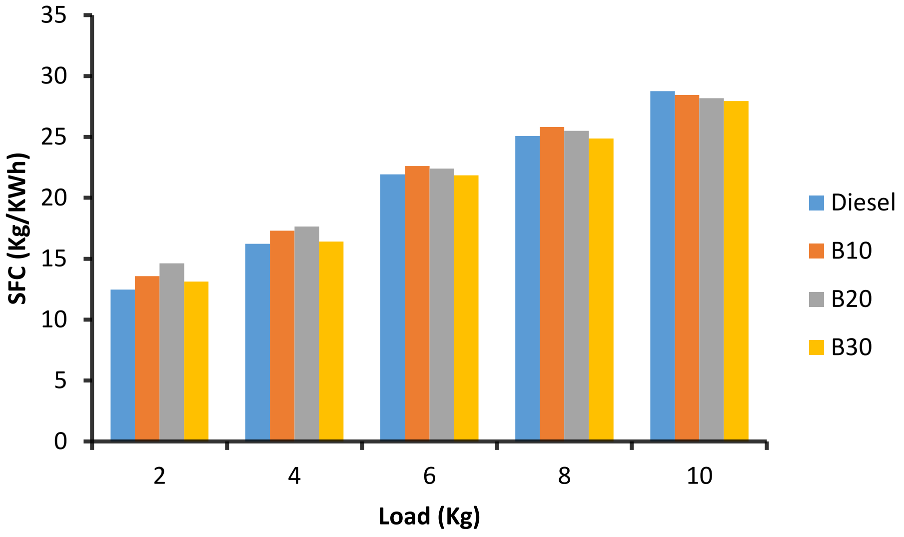


*Figure-4*. SFC Vs load of different Argemone Mexicana biodiesel blends.

From Figure 2, there is increasing trends of specific fuel consumption as the blending percentage of Argemone Mexicana increases. The increment percentages for B10, B20 and B30 in comparison to conventional biodiesel are 34.28%, 37.14%, 41.42% respectively at a constant load of 2kg. The increase in specific fuel consumption (SFC) of biodiesel especially for higher blends is due to the reason that the Calorific Value (CV) of Argemone Mexicana biodiesel is less as compared to convention diesel fuel. However, at higher loads this increment is limited to within 15%.

Table 4

*Brake Thermal Efficiency (BTE) of conventional diesel and different Argemone Mexicana biodiesel blends*

| Load (kg) | | $\eta_{bth}$ | $\eta_{bth}$ | $\eta_{bth}$ | $\eta_{bth}$ |
|---|---|---|---|---|---|
| 2 | - | 12.48 | 13.57 | 14.62 | 13.12 |
| 4 | - | 16.23 | 17.3 | 17.65 | 16.4 |
| 6 | - | 21.92 | 22.62 | 22.41 | 21.84 |
| 8 | - | 25.08 | 25.82 | 25.49 | 24.87 |
| 10 | - | 28.75 | 28.44 | 28.18 | 27.95 |

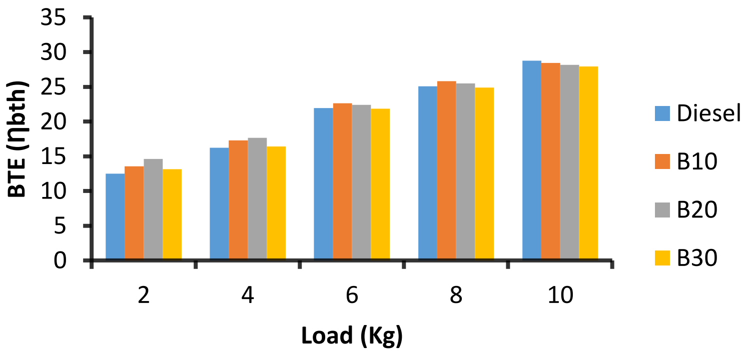


*Figure-5*. BTE Vs. load of different Argemone Mexicana biodiesel blends.

From the table and graph, the brake thermal efficiency (BTE) of different Argemone Mexicana biodiesel blends is observed to be increased as compared to conventional diesel at different loads. The increments in the values of brake thermal efficiencies for biodiesel blends B10, B20 and B30 in comparison to conventional diesel are 1.07%, 1.98% and 2.78% respectively at constant compression ratio of 18. The decrement for a higher load of 10 kg is limited to only 3% which proposes Argemone Mexicana biodiesel for running a diesel engine without any damage.

The biodiesel obtained from Argemone Mexicana oil has good inherent properties and most of its properties are similar with diesel fuel. The performance parameters of the variable compression ratio diesel engine was analysed at a fixed compression ratio of 18 and compared when the engine was running with same operating conditions. From the above result it can be stated that the Argemone Mexicana biodiesel can be used as an alternative fuel to run a diesel engine without any engine modification. The reduction in performance parameters is limited to 5% for a biodiesel of 30 % blending, which is acceptable. Hence Argemone Mexicana oil is a good replacement for conventional diesel fuel at lower blends.

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