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Recognition of Engine Parameters for Mahua Biodiesel by Analyzing the Performance Using OFAT Approach

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Abstract

The review work deals with the prediction of significant engine input parameters by the use of one factor at a time approach. The technique is a trial of experiments by varying only one engine input parameter and others remain at constant values. The various engine input parameters are found from the literature review. In the current work, six engine input parameters are predicted from the past research. These are blending ratio of biodiesel to diesel, compression ratio, load torque, engine speed in rpm, injection pressure and injection timing. It has been observed from OFAT approach that three significant engine parameters are Blending ratio, Compression ratio and load torque. These parameters are further used in optimizing the engine parameters for desirable performance, combustion and emission analysis. The design engineer can select any of the optimum combination of parameters depending upon the requirements.

Keywords: Engine parameters, Mahua biodiesel, OFAT approach, blending ratio, performance, combustion, emission analysis

INTRODUCTION

The biodiesels are used for so many years in order to run the compression ignition engine. In 1960's Rudolf Diesel invented diesel engine and to run the CI engine, vegetable oils were used. It was found that the engine is successfully operated and these oils acted as fuel for CI engine for few years. Since vegetable oils are used for domestic purpose, so research was done on non-edible oils. Out of various non-edible oils available, Mahua oils are found in some parts of Madhya Pradesh, India. This review is based on Mahua oil-based biodiesel in a single cylinder variable compression engine. One factor at a time approach is applied to analyze the performance of the engine [1, 2].

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The inspiration for hydrocarbon biofuel is energy certainty and utilization in ozone draining substance discharge. The earliest sustainable biofuels were bioethanol and biodiesel. The usage of energy has broadened in view of the change of the way of life with the headway of masses. The consistent advancement of energy essentially makes the lack of the fossil oil and standard starting points for result, overall warming, etc. Oil grounded things are bound supply of energy; so that from this point forward, it is needed to explore for an optional resource of energy which will be monetarily remarkable, socially agreeable, and biologically consistent. This drives an optional fuel named

"Biodiesel". Comprehensive practical power creation has been developing unequivocally and replacing the exceptional extents of advancement and energy stock. This advancement has been coordinated by US and Brazil for ethanol creation and European relationship for biodiesel making and moreover lots of juvenile nations have course of action of their own public biofuel plans. Because of the rising perception of the lessening of non-sustainable power source supplies and climate issues, solicitation of biodiesel skewed profoundly over the latest two or three numerous years. Biodiesel creation is an elevating and key area of assessment; in this manner, it gets importance from the expansion of oil cost and its environmental benefits [3, 4].

Nowadays it is crucial to use substitutes of fuel as a result of energy security, environmental commitments and monetary causes. In most recent years biodiesel work has reached out as a substitute fuel for diesel motors.

Creation of biofuels from reused vegetable oil is easier and has various natural benefits. The vegetable oils utilized as rice bran oils and the pre-owned oil which is left behind can make a trouble in removal. However, it is valuable for biodiesel fabricating because of its minimal expense. Reused vegetable oil is known as a 'sustainable fuel and it does not transmit abundance CO_2 to air as contrast with fossils energies.

The designed course of making plant-based oil is the most puzzling starting part to make biodiesel considering the qualification in unmixed oily substance to unsaturated fat methyl ester is higher and the cycle period is sensibly less. The most common method for producing biodiesel involves trans-esterification, which is a catalyzed chemical process that combines vegetable oil with alcohol to create fatty acid alkyl esters (biodiesel) and glycerol.

Top-quality blends like E85 should be used in flexible fuel. Biofuels decline risks of gas release. Switching from biogas feedstock to biofuels represents a crucial step for climate action. Biofuels can play a significant role in promoting environmental sustainability, particularly by reducing pollution emissions. Closer view the truth of mankind caused climate warming; at present we revolve around the course of action to reduce the problem for approaching ages.

Jena *et al*. combined mahua and simmarauba oils to first reduce the free fatty acid content present in the mixture up to 1% by acid pretreatment process and then trans-esterified using methanol and catalyst KOH [1]. The genetic algorithm coupled with artificial neural network was applied to obtain the best pretreatment process parameters for bringing down the FFA content of the oil. The quality of biodiesel was checked by gas chromatography (GC) which indicates above 90% ester conversion. The fuel properties of produced biodiesel were closer to commercial diesel and latest biodiesel standards. Similarly, waste rapeseed oil was utilized by Yuan *et al*. to reduce the free fatty acid content and then for predicting optimum conditions for biodiesel conversion by response surface methodology (RSM) based on central composite rotatable design (CCRD) [2]. Also, the properties of produced biodiesel were within the range of China (GB252-2000) and the biodiesel standard of America (ASTM D6751).

Conversion of waste edible oils to fatty acid methyl esters was optimized by Zhang *et al*., using response surface methodology [3]. The reaction was done by selecting sulphuric acid as catalyst for trans-esterification and esterification simultaneously and adding tetrahydrofuran as a cosolvent for producing homogeneous media. The optimum conditions were methanol/oil molar ratio of 21:1, 3.95% of sulphuric acid based on the oil mass, and reaction period of 3.3 h at 64°C in the presence of tetrahydrofuran, obtaining fatty acid methyl esters yield of 98.2%.

The use of Sunflower seed oil in the production of biodiesel by adding methanol and ethanol separately in the presence of suitable amount of NaOH catalyst has been studied by Giorgogianni *et al*. [4]. It was found that *in situ* trans-esterification, the use of ultrasonication and mechanical stirring produced high biodiesel yields of 95% (with reaction time of 20 min) and 98% (with reaction time of 40 min) respectively. Enzymatic trans-esterification of Sunflower oil with ethanol in the presence of Lipase type catalyst was done by Encinar *et al*., and 95–98% (by weight) biodiesel yield was produced after 20 to 25 h [5].

Shu *et al*. investigated trans-esterification of cottonseed oil with methanol in the presence of carbon based solid catalyst and 89.93 % biodiesel yield (by weight) was produced after 3.0 h of reaction time [6]. Azcan and Danisman produced the biodiesel from cottonseed oil by alkali catalyzed trans-esterification using microwave irradiation and 89.2–92.7% (by weight) of biodiesel yields were observed [7]. Response surface methodology technique was applied by Giovanilton *et al*. by choosing Soybean oil with ethanol and following optimum reaction conditions were found [8]: Reaction temperature of 56.7°C, reaction time of 80 min, molar ratio of 9:1 and catalyst concentration of 1.3 M. The addition of different catalyst "mesoporous silica" was analyzed in the trans-esterification of soybean oil using ethanol by Quintella *et al*. [9]. The biodiesel yield of 80% (by weight) after 6 h was observed.

The biodiesel and ethanol blends investigation in direct injection diesel engine was presented by Zhu *et al*. [10]. The reduction of NO_x and particulate emissions at 5% blending ratio in the diesel engine was observed. Mudgal *et al*. applied an Artificial Neural Networks in biodiesel fuel transit buses for the prediction of emissions [11]. An optimum architecture was found for the reduction of emissions. Hashemi and Clark investigated the emissions of heavy-duty diesel vehicles in Southern California by using Artificial Neural Network [12]. Also, ANN tool was applied in spark ignition engine by Kiani *et al.* for prediction of performance and exhaust emissions using ethanol-gasoline blends [13]. The performance, combustion and emission parameters of the biodiesels produced have been evaluated by blending them with commercial diesel in a CI engine. The actual testing has been performed in a single cylinder direct injection four stroke diesel engine available at DCRUST, Murthal, Haryana (India).

Test setup comprises of a 4-stroke, single cylinder variable, compression ratio (VCR), ignition engine test bed water cooled with electric dynamometer. The torque applied to engine with electrical eddy current dynamometer device. They consist of control unit from where all the readings can be found out during the experiment and further with help of these readings, we can make analysis about various parameters of engine. The block diagram of the test setup is as shown in Figure 1.

The engine test set up was fitted with single cylinder variable compression ratio engine. The maximum engine capacity is 22 Nm. A Digital device is used for torque measurement. Generally, the speed remains constant at various torques because of governor fitted which changes mass flow rate accordingly. Fuel tank is also connected to the engine set up with supply and return pipe.

The analysis was done with blends prepared by mixing Diesel, Karanja and Castor oil and the entire experiments can be done under steady conditions of engine (Figure 1). In the beginning, the test rig was tested using regular fuel and noted down readings; after that the engine was tested for other blends of fuel and readings were recorded; and during this, no prior engine modification was required.

METHODOLOGY

- Trial run for getting the working range of different parameters for current research work.
- Experimental design using RSM based method.
- Performing experiment on engine test as per planned experimental design in step.
- Data collection and analysis can be done after performing experiment on engine test.
- Drawing conclusion after analysis.
- After this, last step is report writing.

The various parameters affecting the performance, combustion and emission characteristics of a compression ignition engine have been found from various research studies [1–13]. The input engine

Figure 1. Test setup single cylinder VCR engine.

parameters for evaluating the produced biodiesels are found to be: Blending ratio (BR), load torque (LT), compression ratio (CR), injection timing (IT) and engine speed (N). Injection pressure (IP) is also the parameter but there is no provision available to vary it. Hence it is fixed by providing the fuel injector of pressure 220 bars with spray angle of 120°.

From the various input engine parameters, the significant parameters have been scrutinized by preliminary investigations using one-factor-at-a-time (OFAT) approach. It has been observed that blending ratio, compression ratio and load torque have significant effect on performance, combustion and emission parameters while the effect of engine speed and injection timing is not that significant. Hence only three input engine parameters (BR, LT and CR) have been considered for evaluating the performance, combustion and emission parameters.

The input engine parameters (from preliminary investigations), their symbols, units and optimum ranges are shown in Table 1.

It is observed from Figures 2–6 that the performance of diesel engine is varied by increasing the blending ratio, load torque and compression ratio. Furthermore, when injection and engine speed are increased, the engine performance is not affected. Hence in order to optimize the engine, the significant parameters have to be considered i.e., Blending ratio, load torque and compression ratio.

Table 1. Parameters constraint for diesel engine.

S.N.	Parameters	Symbol	Unit	Range
1	Blending ratio	BR	% V/V	5–35
2	Load torque	LT	N-m	0–22.56
3	Compression ratio	CR	V/V	12–18
	Fixed parameters			
4	Injection timing	IT	CAD	345
5	Engine speed	N	rpm	1500

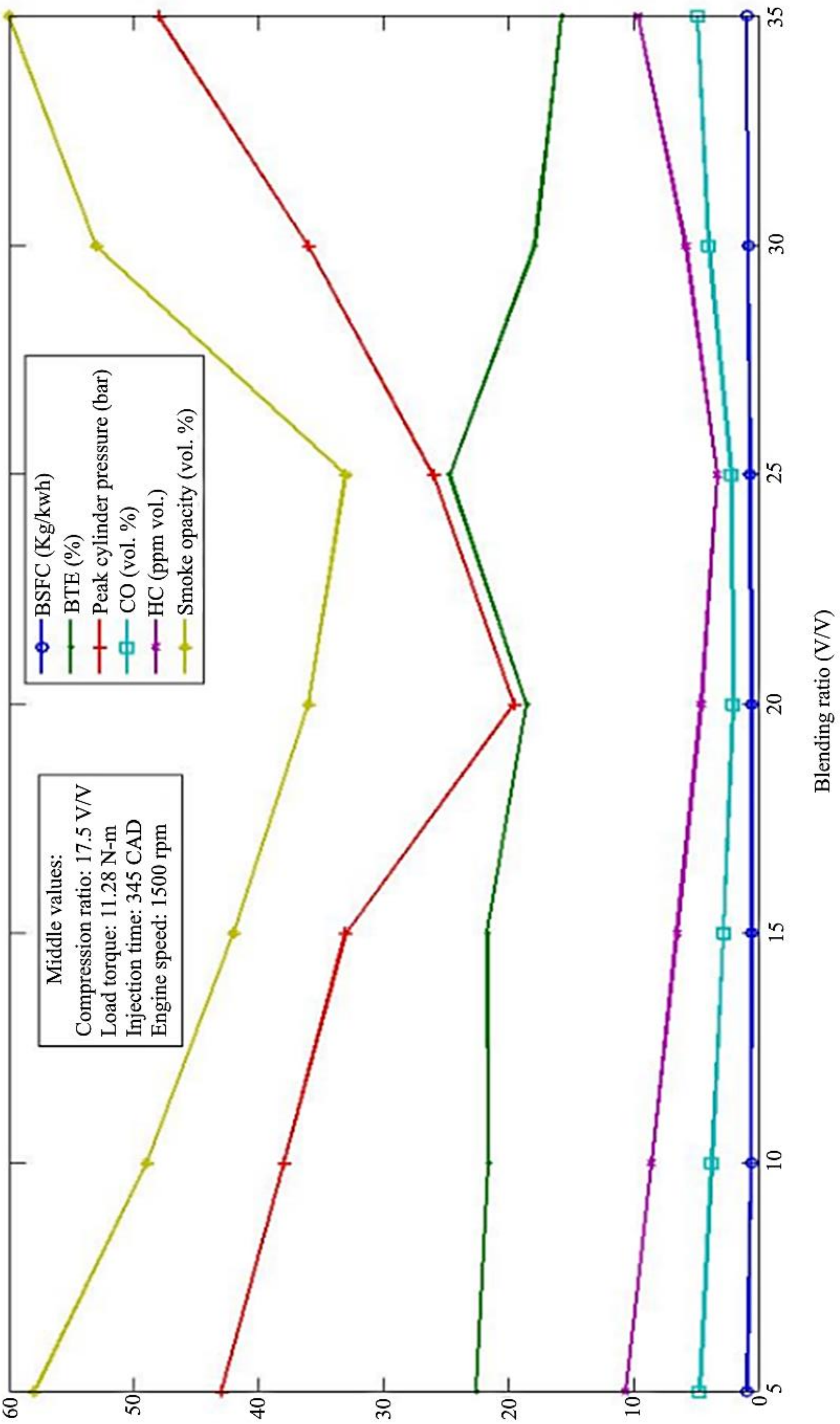

Figure 2. Variation of performance parameters with blending ratio.

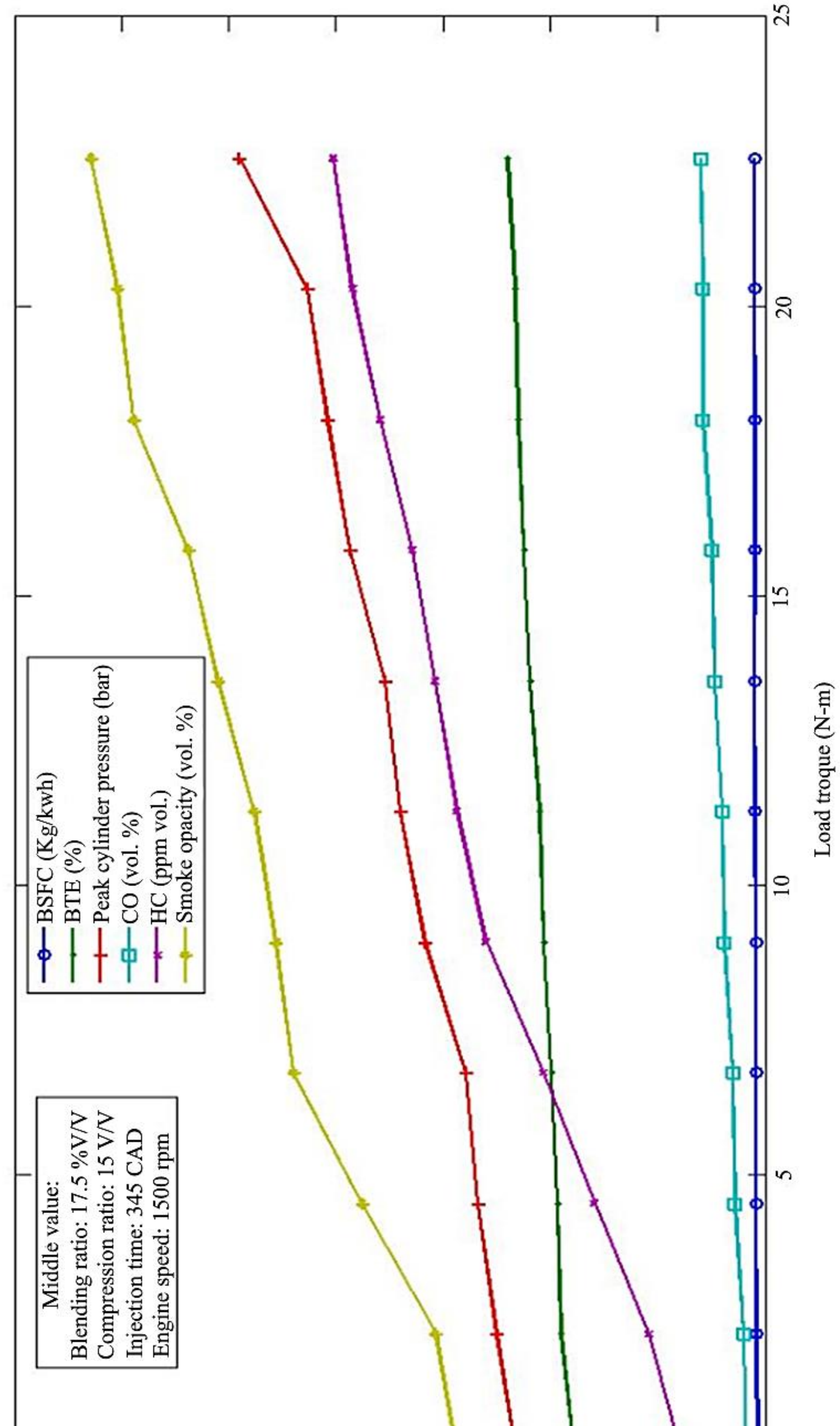

Figure 3. Variation of performance parameters with load torque.

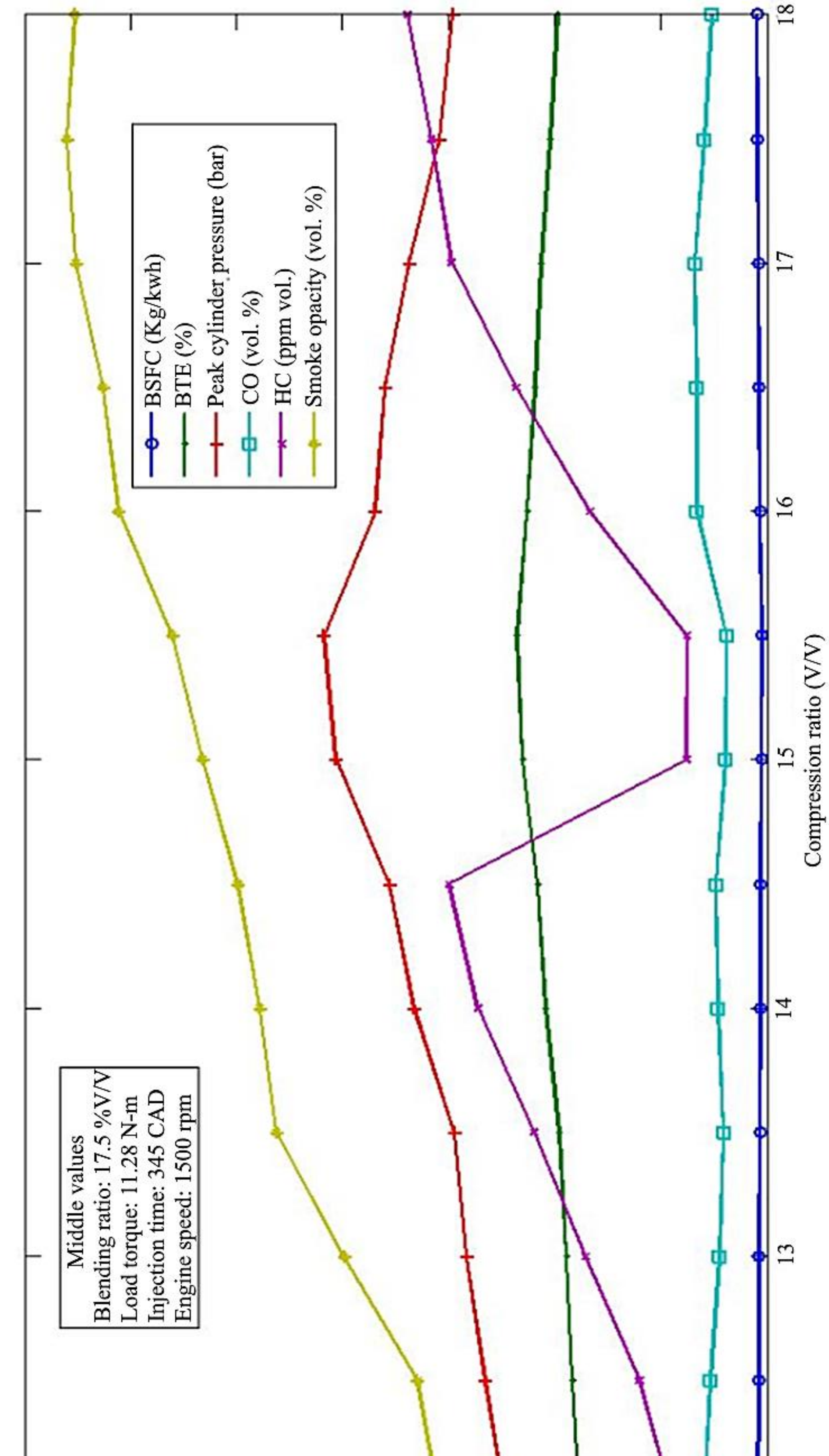

Figure 4. Variation of performance parameters with compression ratio.

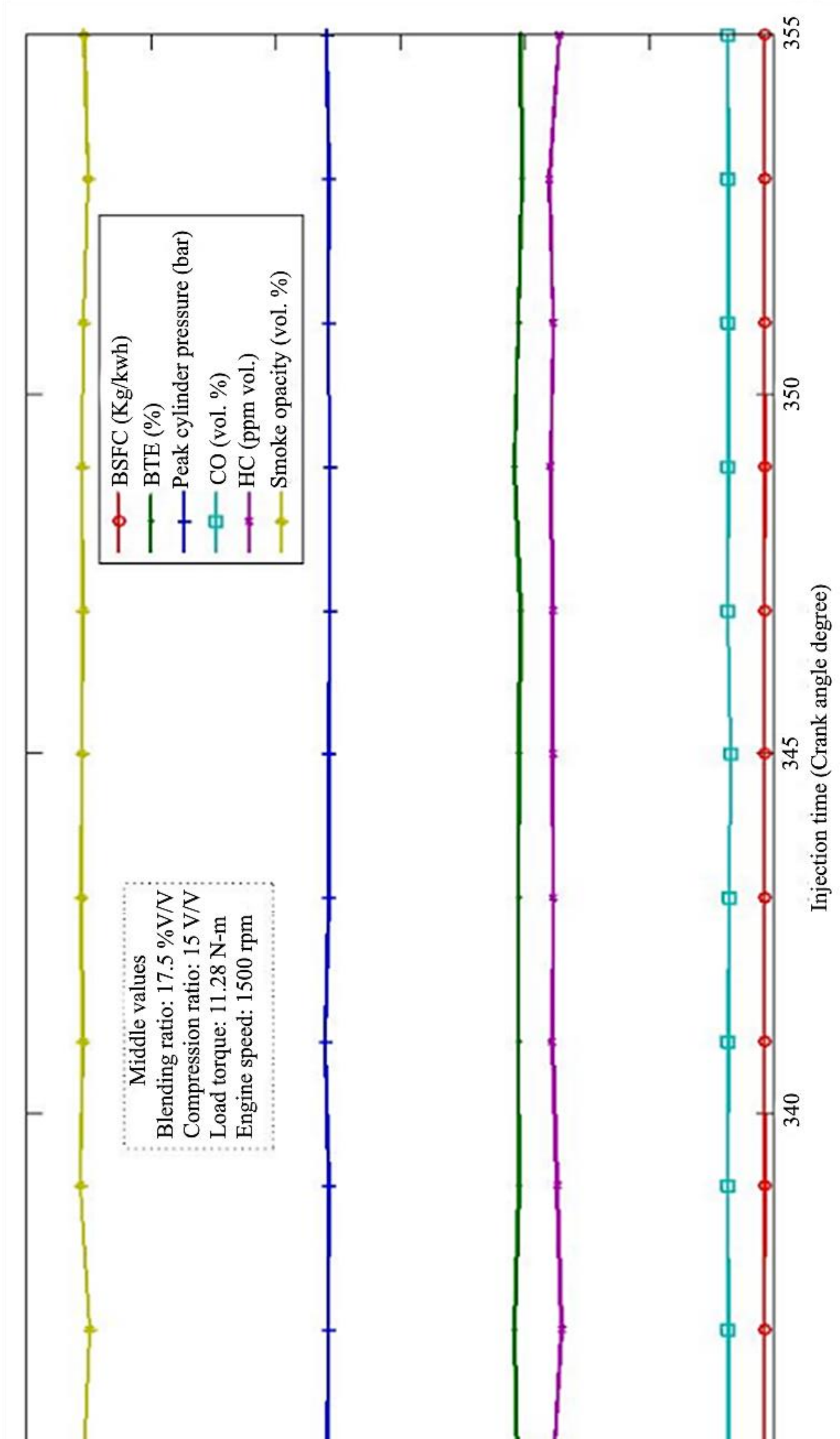

Figure 5. Variation of performance parameters with injection time.

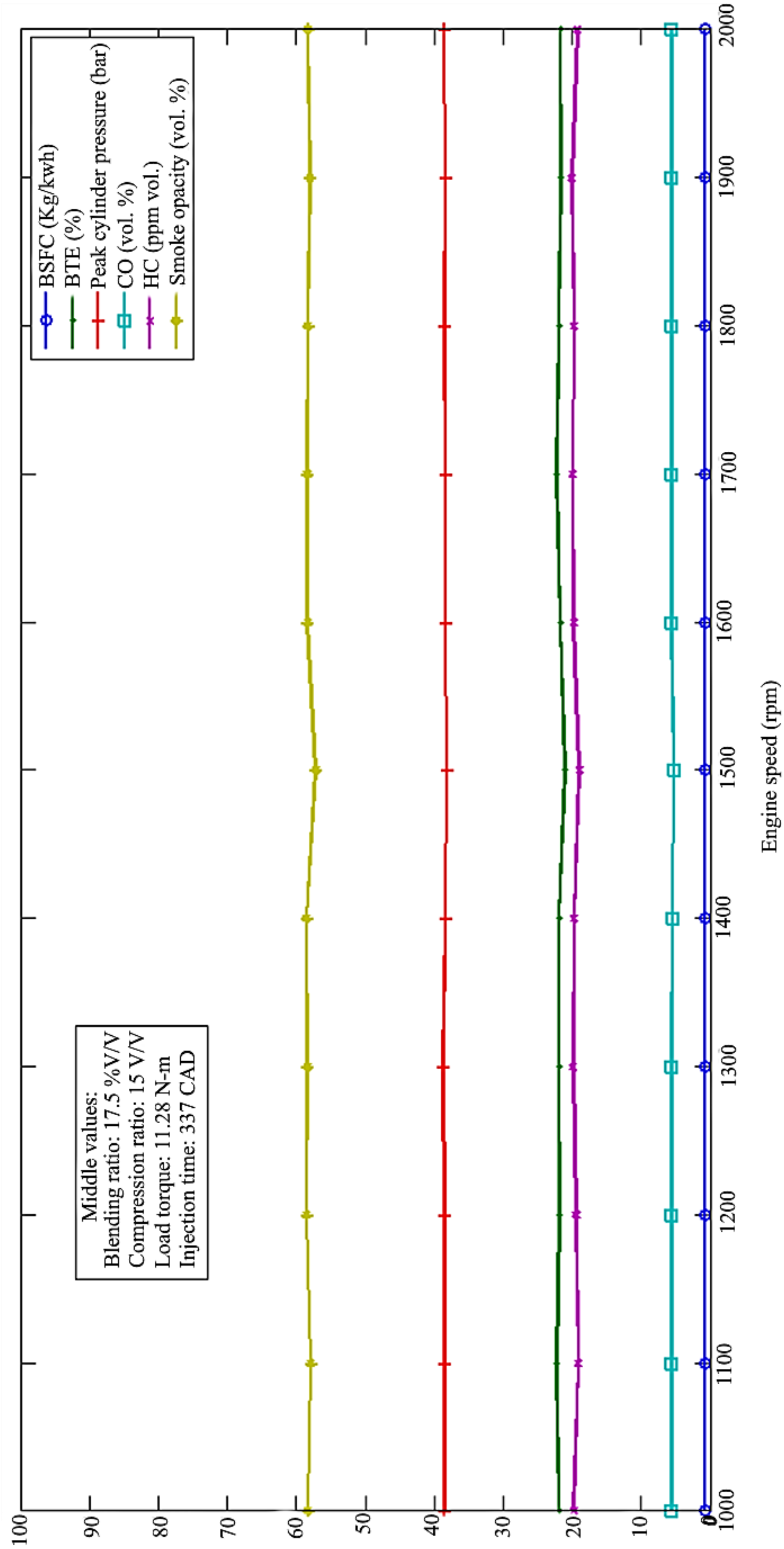

Figure 6. Variation of performance parameters with engine speed.

CONCLUSION

1. One Factor at a Time Approach is mandatory method in predicting the significant process parameters.
2. Among the various engine parameters selected for experimentation Blending ratio, load torque and compression ratio are found to be significant in comparison to Injection time and Engine speed.

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