Optimized Technique of Operating Parameters to Improve Performance on Compression Ignition Engine using Neem Biodiesel

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***Abstract*- In developing countries like India where 70% of country's petroleum demands are met by import, energy security assumes significance in view of uncertainty of supply and increasing price of petroleum fuels. Extensive drive has been given for producing biodiesel from non-edible sources. Scientific research should therefore be directed towards oilseeds like Karanja, Jathropa, Sal, Mahua, Neem, etc. that are widely available and sustainable to the diverse socio-economic and environmental conditions of rural India. The present work deals on the influence of Blend, Load, Speed and Torque of a Compression Ignition Engine using Taguchi L_9 orthogonal array on neem oil as biodiesel. Based on the experimental work carried out and the analysis made using Taguchi method, it was concluded that the performance were increased with decreasing blend and increasing of other parameters like load, speed and torque. Finally the experimental results gave a clear indication that Neem biodiesel can also be used as an alternative fuel for compression ignition engine.**

Keywords: Neem Oil, Diesel Blend, Taguchi Method

I. INTRODUCTION

Moreover the rapid depletion of fossil fuels due to widespread use has forced to search for some low emission and renewable fuel. In the search for alternative fuels, the favorable option was found to be renewable fuels like vegetable oils, alcohol etc. In present investigation neem oil have been taken for study due to eco-friendly nature[1].

A neem tree can produce many thousands of flowers and in one flowering cycle, a mature tree may produce a large number of seeds. Neem trees start bearing harvestable seeds within 3-5 years and full production may be reached in 10 years and this well continues upto 150-200 years of age. A mature neem tree may produce 30-50 kg of fruit each year. By rough estimate India nearly has 20 million trees. Indian neem trees have a potential to provide 1 million tons of fruits per year and 0.1 million tons of kernels per year. Neem seeds yield 40-60% oil[2].

Taguchi method is best suited to find the optimal engine parameters for improving emissions. The investigation is planned based on Taguchi's L9 orthogonal array. Four parameters such as blend, load, speed, and torque each at three levels were considered[3].

II. EXPERIMENTAL SETUP

Experiments were carried out on the computerized engine test rig with the following specifications. Compression ratio varies from 16:1 to 23.12:1, Bore of 70mm, Stroke of 110mm, Eddy current dynamometer with maximum power of 3.75 kw. The experiments have been carried out based on the parameters of different combinations in order to improve the performance of neem biofuel to use as alternative fuel.

III. METHODOLOGY

A. Transesterification Process

The neem oil is taken in glass beaker and oil is heated to a temperature of 65^0C using electric heater. In the mean time calculated amounts of methanol and NAOH are mixed to form a solution. After attainment of 65^0C of oil temperature , the glass beaker is kept on the magnetic stirrer apparatus which also has the heating mechanism. Maitaining the temperature of oil at 65^0C, the solution of methanol and NAOH is added to the oil slowly while the required stirring action is provided by magnetic stirrer equipment. The mixture is maintained at 65^0C with constant stirring for about 40 minutes. Now a small quantity of oil mixture is taken in a test tube and allowed it to settle for about 10 minutes, if there

is any glycerin formation which is indicated by bi layer formation, the process of setting is complete. The oil in the beaker is then transferred to a long conical glass container and the oil is allowed to settle. After settling, the seperated glycerin is removed from glass container to obtain biofuel containing the traces of methanol (improve bio fuel). Then the oil is water washed for about 4-5 times depending upon the amount on soap present in it. The oil is washed till the soap is completely removed from the oil. At the end of this process a neat bio diesel is obatained[4].

B. Taguchi Method for Optimization

Taguchi method uses an orthogonal array to study the entire parameter space with only a small number of experiment. The number of prameters involved in the experiment dtermines the number of trails required for the experiment. To select an appropriate orthogonal array for the experiment, the total design of experiment (DOE) needs to be computed. The DOE are defined s the number of comparisons between design prameters that need to be made. The present study uses four factors at three levels and thus, an L9 orthogonal array with four cloumns and nine rows were used for the construction of experimental layout shown in Table I.

TABLE I. EXPERIMENTAL LAYOUT

Experiment	A	B	C	D
1	A_1	B_1	C_1	D_1
2	A_1	B_2	C_2	D_2
3	A_1	B_3	C_3	D_3
4	A_2	B_1	C_2	D_3
5	A_2	B_2	C_3	D_1
6	A_2	B_3	C_1	D_2
7	A_3	B_1	C_3	D_2
8	A_3	B_2	C_1	D_3
9	A_3	B_3	C_2	D_1

C. Selection of control parameters

The control parameters such as blend, load, speed and torque are given in Table II were selected for the investigation since they have influence on the objective of improving performance.

TABLE II. SETTING LEVELS FOR DESIGN PARAMETERS

Controlled Factors	Level 1	Level 2	Level 3
A: Blend	10	20	30
B: Load	30	50	70
C: Speed	1638	1669	1639
D: Torque	7.06	11.48	16.58

The L_9 orthogonal experiment design is shown in Table III.

TABLE III. EXPERIMENTAL DESIGN

EXPERIMENT	BLEND	LOAD	SPEED	TORQUE
1	10	30	1638	7.06
2	10	50	1669	11.48
3	10	70	1639	16.58
4	20	30	1669	16.58
5	20	50	1639	7.06
6	20	70	1638	11.48
7	30	30	1639	11.48
8	30	50	1638	16.58
9	30	70	1669	7.06

D. Multi Optimization Technique

In Taguchi method we mainly deal with only single response optimization problem only one dependent variable (response) is considered and the optimal levels for the parameters are determined based on the mean response/maximum of mean S/N ratio.

The single objective optimization gives different results. To obtain combination of engine parameters considering performance multi optimization techinque is used. In multi-optimization, weighing factor plays an important role. In assignment of weights method, the multi-response problem is converted into a single response problem.

The weights are determined for larger the better characteristics as follows

$$W_i = (1/R_i)/\sum(1/R) \quad (1)$$

Where R_i = Larger the characteristic for i^{th} trail/experiment

The multi response performance index for i^{th} trails/experiment was calculated using the following equation.

$$M_i = (W_1Y_{11} + W_2Y_{12} + \ldots\ldots + W_jY_{ij}) / \sum W_i \quad (2)$$

Where W_j = Weight of the j^{th} response / dependent variable.

Yij = Observed data of ith trail/experiment under jth response.

E. Procedure

Speed was varied in three levels (1638,1669 and 1638 rpm) and torque was also varied in three levels (7.06, 11.48 and 16.58 N-m) by digital data logger, load was varied in three levels (30, 50 and 70%) by using dynamometer and blend was also varied in three levels (10, 20, and 30%). The experiments were conducted based on Taguchi's L_9 orthogonal array and the measured performance values are tabulated as shown in Table IV [5].

TABLE IV. RESULTS

Experiment	B.P (kW)	I.P (kW)	Mechanical Efficiency (%)
1	1.21	4.8	23.09
2	1.96	5.37	34.74
3	2.67	5.4	47.2
4	2.89	4.4	62.7
5	1.21	4.38	27.6
6	1.96	4.37	44.9
7	1.97	4.38	44.9
8	2.84	4.37	64.9
9	1.23	4.46	27.6

IV. RESULTS AND DISCUSSIONS

In order to get the higher level of performance, larger the best option is used to calculate the S/N ratio values and tabulated as in Table V.

TABLE V. S/N RATIOS OF PERFORMANCES

Experiment	B.P (kW)	I.P (kW)	Mechanical Efficiency (%)
1	1.655707	13.62482	27.26848
2	5.845121	14.59949	30.8166
3	8.530225	14.64788	33.47884
4	9.217957	12.86905	35.94535
5	1.655707	12.82948	28.81818
6	5.845121	12.80963	33.04493
7	5.889325	12.82948	33.04493
8	9.066367	12.80963	36.24489
9	1.798102	12.9867	28.81818

A. Brake Power

Fig.1 shows that brake power are improved for an optimal combination of blend-30%, load-30%, speed 1669 rpm and torque-16.58 Nm.

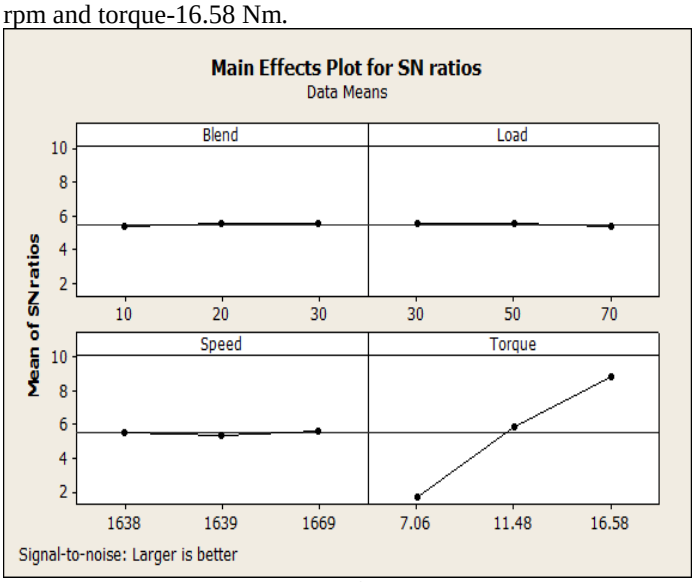

Fig.1. *Variations of Brake Power*

B. Indicated Power

It was seen from Fig. 2, there was a significant increase in the indicated power with blends of neem oil. The indicated power is increased for an optimal combination of blend-10%, load-70%, speed-1669 rpm and torque-16.58 Nm.

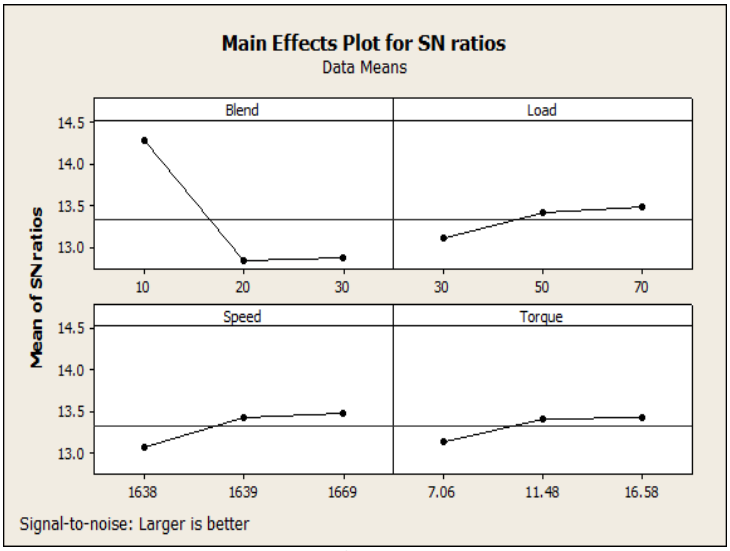

Fig.2. *Variations of Indicated Power*

C. Mechanical Efficiency

Fig. 3 shows the variation in the Mechanical Efficiency. The mechanical efficiency is increased for an optimal combination of blend-30%, load-30%, speed-1638 rpm and torque-16.58 Nm.

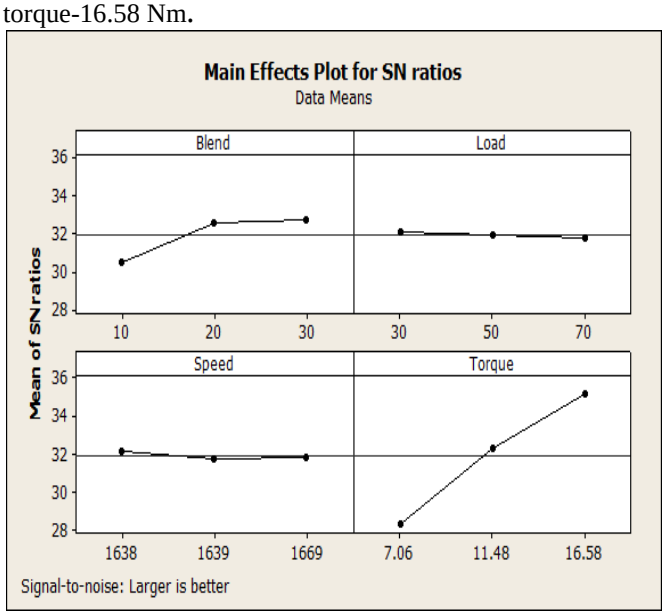

Fig.3. Variations *of Mechanical Efficiency*

Using single objective optimization the optimum parameter obtained are given Table VI.

TABLE VI. OPTIMIZATION PARAMETER FOR EACH RESPONSE VARIABLE

Factors	B.P	I.P	M.E
Blend	30	10	30
Load	30	70	30
Speed	1669	1669	1638
Torque	16.58	16.58	16.58

From the multi-optimization technique it can be observed that Blend-20%, Load-50%, Speed-1669 rpm and Torque-16.58 Nm are the optimal combination which achieve higher performance characteristic of the engine.

D. Confirmatory Test

After selecting the optimum levels of the engine parameter, the final step was to verify the results using optimum design parameter levels. The confirmation test was conducted and the results are given in Table VII, which shows higher performance.

TABLE VII. CONFIRMATORY TEST RESULTS

Sl. No	Response variable	Confirmation Test Values
1	Brake Power (kW)	2.89
2	Indicated Power (kW)	4.46
3	Mechanical Efficiency (%)	64.79

V. CONCLUSION

Experimental investigations have been carried out for improving performance in CI engine using Neem biofuel. The results of this study by multi-optimization technique revealed that a diesel engine operating at a speed = 1669 rpm, load = 50%, and torque = 16.58 Nm for blend = 20% are the optimal combination which improves performance in the engine. From this investigation, neem bio diesel can be used as an alternative fuel to improve performance of an engine.

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