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Performance Analysis & Optimization of IC Engine Process Parameters Using Bio-blended Diesel–Methanol with Waste Cooking Oil through Taguchi Method

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Abstract : The energy consumption is always on the rise increasing worldwide warming too. This has brought renewable energy source and alternate fuels into centre, with biodiesel is a new option but its expenditure is more. Thus a feasible choice is to blend biodiesel with other fuels to make it environment eco-friendly and decrease the demands on mineral fuels. The bio-fuels used for improving the performance of an engine so, in this work waste cooking oil used as alternative fuel. Current one of the main intends of this work is to improve the performance of IC engine by bio blended fuels. The process parameter mostly affected on engine performance. These process parameters of IC engine have been optimized by using alternative fuels with the help of Taguchi method. An experimental investigation has been conducted on I.C engines, the results will be compared with that of diesel in terms of performance. Experimental layout designed by employing design of experiments methods and the tests will be conducted with combination of factors as per Taguchi's orthogonal array. The optimum combination level of factors will be obtained by using Taguchi parametric design. Finally obtained response results will be compared with pure diesel responses values.

Keywords :
Keywords: Bio-diesel,IC engine,Waste Cooking oil,Taguchi Method

Nomenclature

B Blended
L3 Level3
IC Internal Combustion
L1 Level1
S/N Signal to Noise
L2 Level2
BP Brake power
V Voltage
IP Indicated Power
I Current
FC Fuel Consumption
PD Pure Diesel

I. Introduction

In recent times, the world has been confronted with the energy crisis due to depletion of natural [1] resources and increased environmental problems. The situation has led to the search for an alternative fuel, which should be not only sustainable but also environment friendly. For developing countries, fuels of bi-origin, such as alcohol, vegetable oils, biomass, biogas, synthetic fuels, etc. are becoming important [2]. Such fuels can be used directly, while others need some sort of modification before they are substituted for conventional fuels. The energy consumption is ever on the rise increasing global warming too. This has brought renewable energy source and alternate fuels into focus. Using biodiesel is another new option but its cost is more [3, 4]. Thus a viable option is to blend biodiesel with other fuels to make it environment friendly and reduce the pressure on mineral fuels. Optimization technique plays a vital role to increase the Performance of the IC Engine. Quite a lot of research attempts have been made for Modelling of IC Engine process [5, 6] an investigation of the process performance to recuperate Mechanical Efficiency. Improving the Mechanical Efficiency and Fuel Consumption are still challenging problems that restrict the expanded application of the technology [7, 8].

2. Methodology

To fulfil the objective of the present work various theories, methods and techniques like DESIGN of Experiments and Taguchi.
The following are the steps involved in this approach
Selecting the alternative fuel Trasistification

- Produced alternative fuel
- Blending of alternative fuel with diesel
- Designing the experimental layout-DOE
- Create experimental layout
- Conduct experiments on Engine
- Optioned Results
- Optimization Method-Taguchi
- Conformation Test

2.1 Taguchi design

Dr. Genichi Taguchi is regarded as the foremost proponent of robust parameter design which is an engineering method for product or process design that focuses on minimizing variation and/or sensitivity to noise. When used properly, Taguchi designs provide a powerful and efficient method for designing products that operate consistently and optimally over a variety of conditions. Taguchi proposed several approaches to experimental designs that are sometimes called "Taguchi Methods." These methods utilize two, three, four and five and mixed-level fractional factorial designs. Taguchi refers to experimental design as "off-line quality control" because it is a method of ensuring good performance in the design stage of products or process products or processes.

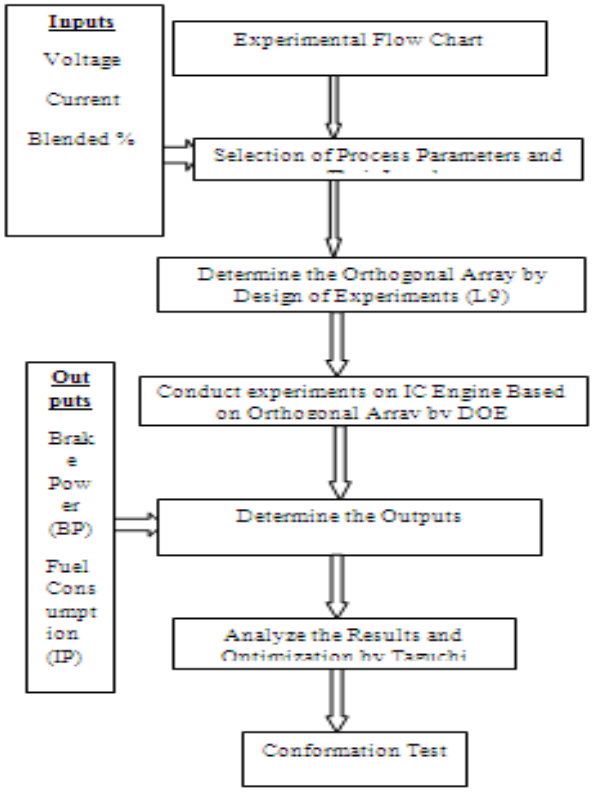
3. Experimental Work

A Taguchi design or an orthogonal array the method is designing the experimental procedure using different types of design like, two, three, four, five, and mixed level. In the study, a three factor mixed level by that L9 orthogonal array was chosen.

Table 2.1: Process Parameters and their levels

S.No	Process parameters	units	L1	L2	L3
1	Voltage	Volts	200	225	250
2	current	Amp	8	12	16
3	Blended %	%	B10	B25	B35

Figure 2.1 Methodology - Flow Chart



.1 Orthogonal array experiment

To select an appropriate orthogonal array for the experiments, the total degrees of freedom need to be computed. The degrees of freedom are defined as the number of comparisons between process parameters that need to be made to determine which level is better and specifically how much better it is. According to DOE, the orthogonal array can be calculated as

Orthogonal array = (L-1)*f+1

L= number of levels

f= number of factors

Table3.1: Experimental Layout using L9 orthogonal array

S.NO	Design of Experiments (L9 orthogonal array)		
	Voltage	current	Blended %
01	200	8	B10
02	200	12	B25
03	200	16	B35
04	225	8	B25
05	225	12	B35
06	225	16	B10
07	250	8	B35
08	250	12	B10
09	250	16	B25

Table4.1: Response Table

S.NO	Voltage (V)	Current (I)	Blended %	Brake Power	Fuel Consumption	Mechanical %
01	200	8	B10	2.000	0.8368	68
02	200	12	B25	3.000	1.0159	59
03	200	16	B35	4.000	1.0338	74
04	225	8	B25	2.250	0.7088	53
05	225	12	B35	3.375	0.5972	71
06	225	16	B10	4.500	0.7532	82
07	250	8	B35	2.500	0.5375	86
08	250	12	B10	3.750	0.6148	80
09	250	16	B25	5.000	0.5862	70

Here BP calculated by using below formula
Brake power (BP) = (V*I)/ (Efficiency of generator* 1000)
Where Efficiency of generator = 0.8

4. Results &Discussions

This is related about the influence of Brake Power, fuel Consumption and Mechanical Efficiency [9]
finding the result which combination of the factors Voltage, Current and Blended Percentage is most efficient with the help of Taguchi method. The experimental values shown in below

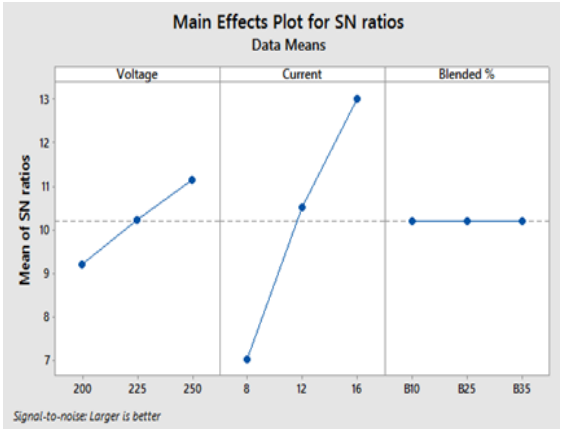
Hence the S/N ratio of Brake Power, Fuel Consumption and Mechanical Efficiency values are calculated by using following equations

S/N Ratio for Brake Power = 20 log(y) ---------- for larger is better S/N Ratio for Fuel Consumption = -20 log(y) ---------- for smaller is better

Table 4.2: S/N Ratios of Brake Power, Fuel Consumption and Mechanical Efficiency

S/N Ratio for Mechanical Efficiency = 20 log(y) ---------- for larger is better

Then the S/N ratio values for Brake Power, Fuel Consumption and Mechanical efficiency are shown in below.



4.1 S/N Ratio plots for Brake power

Figure 4.1:S/N Ratio plots for Brake Power

The above figure gives optimized best sequence for Brake Power .i.e.Voltage=250 volts; Current=16 amps Blended% = B10 or B25 or B35

4.2 S/N Ratio plots for Fuel Consumption

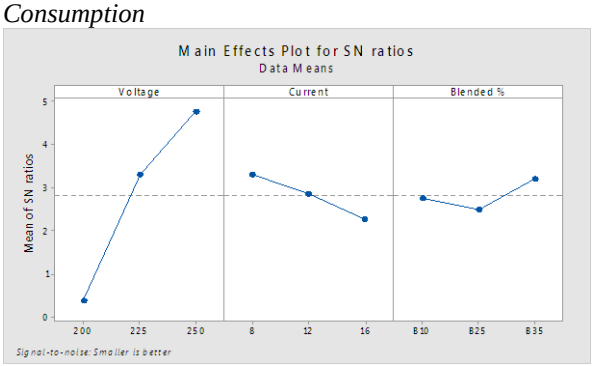
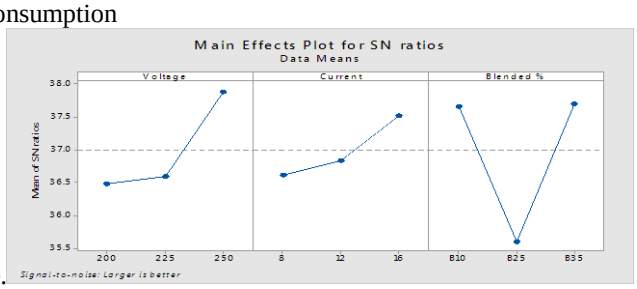


Figure 4.2: S/N Ratio plots for Fuel Consumption

The above figure gives optimized best sequence for Fuel Consumption



i.e.

4.3 S/N Ratio plots for Mechanical Efficiency

Voltage=200 volts;Current=16 amps;Blended% = B25

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Figure 4.3:S/N Ratio plots for Mechanical Efficiency

S.NO	Voltage	current	Pure Diesel	Brake Power	Indicated Power	ηMechanical %
01	200	8	PD	2.000	2.70	74
02	200	12	PD	3.000	3.70	81
03	200	16	PD	4.000	4.70	85
04	225	8	PD	2.250	2.95	77
05	225	12	PD	3.375	4.07	82
06	225	16	PD	4.500	5.20	86
07	250	8	PD	2.500	3.20	78
08	250	12	PD	3.750	4.45	84
09	250	16	PD	5.000	5.70	87

The above figure gives optimized best sequence for Fuel Consumption i.e. Voltage=250 volts;

Current=16amps Blended% = B10 or B35

4.4 Experimental Values for Pure Diesel

Table 4.3: Experimental Values for Pure Diesel

5. Conclusion

The experimental investigation was carried out for different blends of Waste cooking oil and Methanol and the performance was evaluated and compared with pure diesel. The work has presented the use of Taguchi Method for optimization of the IC Engine process parameters. The following factor settings have been identified as to yield the best combination of process variables:

- For Brake Power

Voltage = 250volts, Current= 16amp, and Blended Percentage = Optional-B10 or B25 or B35.

- For Fuel Consumption

Voltage = 200volts, Current= 16amp, and Blended Percentage = B25

- For Mechanical Efficiency

Voltage = 250volts, Current= 16amp, and Blended Percentage = Optional-B10 or B35

The performance characteristics such as Brake Power, Fuel Consumption and Fuel Consumption were improved through this approach. Hence, Finally the IC engine process was optimized.

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