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Parametric Optimization of Single Cylinder Diesel Engine for Specific Fuel Consumption Using Palm Seed Oil as a Blend

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Abstract: *In this study, a blend of Palm seed oil is in the various proportions like 10%, 20%, 30%, and up to in the diesel fuel added in a direct injection diesel engine. Engine performance have been investigated and compared with the ordinary diesel fuel in a diesel engine. Experimental results show that the SFC characteristics of the mixture of Palm seed oil–diesel fuel are close to the values obtained from diesel fuel.There is required number of experiments which gives results in the form of set of parameter. This set of parameter give different performance with reduction in different fuel consumption. From this sets of parameters, there must be choose set of parameters.in this study, the effects of parameters' i.e. load, injection pressure, blend are taken as variable for optimization. Taguchi method of optimization is used in this experiment, using Taguchi method numbers of reading are taken so Taguchi experiment identify that injection pressure 200 bar, engine load 10 kg and blend B0D100 are optimum parameter setting for higher brake thermal efficiency*

Keywords: *Diesel, palm seed oil, parametric optimization, Specific fuel consumption (SFC), Taguchi method.*

I. Introduction

Vegetable oils are among the various sources of energy fuels being considered as alternatives to fossil fuels. Rapeseed, soybean, sunflower, coconut and palm oils have been the main raw materials for biodiesel production. Today it is very essential to use alternative fuel because of energy security, environmental concerns and socio-economic reasons. Over the last few years biodiesel has gained importance as an alternative fuel for diesel engines. Manufacturing biodiesel from used vegetable oil is relatively easy and possesses many environmental benefits. In such multivariate problems, use of nonlinear techniques like Design of Experiments (DoE), fuzzy logic and neural network are suitable to explore the combined effects of input parameters. The optimum operating parameters for a given system can be determined using experimental techniques but experimental procedure will be time consuming and expensive when the number of parameters is in the order of 20, 30 etc., like in the case of IC engines. In such situations mathematical Modeling will be a very useful tool for optimizing the parameters. Such mathematical tool is Design of Experiment. Although few studies were reported using DoE in IC Engine applications, the study on combined effects between input system parameters such as injection pressure, load, blend proportion on the performance and emission characteristics of CI engine was scarce and offered a scope for this study. This research is presents the results of the experimental of the characteristic of palm seed oil as an alternative fuel. This biodiesel is defined as the methyl ester of palm oil also known as palm oil diesel. The results of this investigation will be used to find compatible lubricant for biodiesel engine.

II. Palm Seed oil

Palm oil is one of the most popular fuels in this world. Palm oil can produced the variety of product and is widely use as cooking oil. Palm oil like other vegetable oils can be used to create biodiesel for internal combustion engines. Biodiesel has been promoted as renewable energy source to reduce net emissions of carbon dioxide into atmosphere. Palm seed oil properties like density, Flash point and fire point were higher than this may result in improper spray characteristic. Cetane number of palm seed oil higher than diesel so it would positive impact on combustion quality of biodiesel. So the palm seed oil is used as different blending proportion.

2.1 Properties of palm seed oil

Fuel properties	ASTM	Palm seed oil	Unite
Density at 15°C	D4052	882	Kg/m^3
Kinematic viscosity at 40ºC	D445	7.01	cSt
Flash point (PMCC)	D93	110	ºC
Fire point	D93	140	ºC
Cetane number	D613	77	%by mass
Gross calorific value	D4809	33345.27	Kj/l

Table.1 properties of palm seed oil

III. Effect Of Parameter

Parameter plays most significant and effective role in internal combustion engine. Parameter affect on the fuel consumption, performance of internal combustion engine significantly.

3.1 Injection Pressure

Injection pressure is a pressure which is required to inject the fuel into cylinder. For smooth function of injector, it is required that the injection pressure is higher than cylinder pressure. Higher the injection pressure gives better the dispersion and penetration of the fuel into all desired locations in combustion chamber.

3.2 Blend Proportion

Blend ratio is percentage of alternate fuel or additive in the convention fuel by V/V ratio. When bland ratio increase or decrease, its changes the fuel consumption and consequently brake power and mechanical efficiency also change in brake thermal efficiency. When alcohol is a content of blend, it provides oxygen. So that, combustion becomes smooth and complete. Sometimes due to additive in the blend, there may be decrease in CO and HC emission. Blend ratio is vastly influence on the combustion characteristics, performance and emission. So that, if change in blend ratio, it may be change in above characteristics.

3.3 Engine Load

As engine speed increases, the loss of heat during compression decreases with the results that both temperature and pressure of the compressed air tends to rise, thus the increase in turbulence, however may tend to increase the heat loss in some cases.

Experimental Setup

The setup consists of single cylinder, four stroke, multi-fuel, research engine connected to eddy type dynamometer for loading. The operation mode of the engine can be changed from diesel to Petrol of from Petrol to Diesel with some necessary changes. In both modes the compression ration can be varied without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement.

The injection point and spark point can be changed for research tests. Setup is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The set up has stand-alone panel box consisting of air box, two fuel flow measurements, process indicator and hardware interface. Rota meters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement.

Fig.1. Experimental setup

The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Lab view based Engine Performance Analysis software package “Engine soft” is provided for on line performance evaluation[2].

No. of cylinder	Single cylinder
No. of strock	4
Cylinder dia.	87.5 mm
Stroke length	110 mm
C.R. length	234 mm
Orifice dia.	20 mm
Dynamometer arm length	185 mm
Fuel	Diesel
Power	3.5 kw
Speed	1500 rpm
C.R. range	12:1 to 18:1
Inj. Point variation	0 to 25 Btdc

Table.2 Engine Specification

IV. Optimization Mathod

In this method, the fuel selected for research is mixed with standard diesel oil in various proportions on volume basis and its properties such as calorific value was evaluated before admission. The blends are in 10%, 20% & 30% palm seed oil with standard diesel fuel. A method called “Taguchi” was used in the experiment for simultaneous optimization of engine such as injection pressure and load condition.

4.1Taguchi Method of Optimization: Taguchi method is a simplest method of optimizing experimental parameters in less number of trials. The number of parameters involved in the experiment determines the number of trials required for the experiment. More number of parameters led to more number of trials and consumes more time to complete the experiment. Hence, this was tried in the experiment to optimize the levels of the parameter involved in the experiment. This method uses an orthogonal array to study the entire parameter space with only a small number of experiments .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 design parameters that need to be made.The present study uses three factors at four levels and hence, an L16 orthogonal array was used for the construction of experimental layout (Table 3, column 1, 2, 3&4).The L16 has the parameters such as blend, injection pressure and load arranged in column 2, 3 and 4. According to this layout, sixteen (16) experiments were designed and trials were selected at random, to avoid systematic error creeping into the experimental procedure. For each trial the brake specific fuel consumption was calculated and used as a response parameter. Taguchi method uses a parameter called signal to noise ratio (S/N) for measuring the quality characteristics. There are three kinds of signal to noise ratios are in practice. Of which, the smaller-the-better S/N ratio was used in this experiment because this optimization is based on higher SFC. The Taguchi method used in the investigation was designed by statistical software called “Minitab 16” to simplify the Taguchi procedure and results. A full range experiment for the selected blend was also conducted for after modifying the engine operating parameters. This is mainly to optimize the performance characteristics of palm seed oil-diesel blend[1].

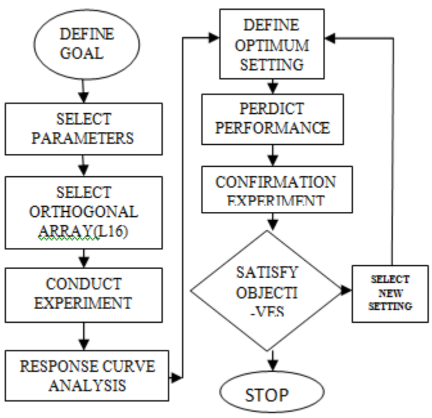

Fig.2. Flow chart of the Taguchi method

V. Result And Discussion

In this experiment blend, injection pressure and load are taken for optimization with the help of mini tab graph is generated for BTE. There are 16 sets of parameter are taken for find out the result.

Sr no.	Blend	Injection pressure	Load	SFC
1	B0D100	160	1	1.33
2	B0D100	180	4	0.41
3	B0D100	200	7	0.32
4	B0D100	220	10	0.28
5	B10D90	160	4	0.44
6	B10D90	180	1	1.27
7	B10D90	200	10	0.29
8	B10D90	220	7	0.33
9	B20D80	160	7	0.30
10	B20D80	180	10	0.30
11	B20D80	200	1	1.21
12	B20D80	220	4	0.44
13	B30D70	160	10	0.28
14	B30D70	180	7	0.33
15	B30D70	200	4	0.42
16	B30D70	220	1	1.30

Table.3 L16 orthogonal array

5.1 Response curve analysis.

Response curve analysis is aimed at determining influential parameters and their optimum levels. It is graphical representations of change in performance characteristics with the variation in process parameter. The curve give a pictorial view of variation of each factor and describe what the effect on the system performance would be when a parameter shifts from one level to another. Figure shows significant effects for each factor for five levels. The S/N ratio for the performance curve were calculated at each factor level and average effects were determined by taking the total of each factor level and dividing by the number of data points in the total. The greater difference between levels, the parametric level having the lowest S/N ratio corresponds to the parameters setting indicates highest performance[1].

From below Fig.3, the mean is an average value for reading taken for a particular parameter. From the graph, the mean value is the maximum (0.8525) for B0D100 Blend & minimum (0.5625) for B20D80 Blend. The mean value is the maximum (0.5875) for 160 bar and 220 bar injection pressure and minimum (0.5600) for 200 bar injection pressure. The mean value is the maximum (1.2775) for 1 kg engine load and minimum (0.2875) for 10 kg engine load. Delta is difference of maximum value and minimum value. Delta value is maximum for load parameter (0.9900) and minimum (0.0225) for the blend parameter. The Delta value of blend is between other two parameters. So that effect of load is a maximum and effect of blend is minimum on specific fuel consumption.

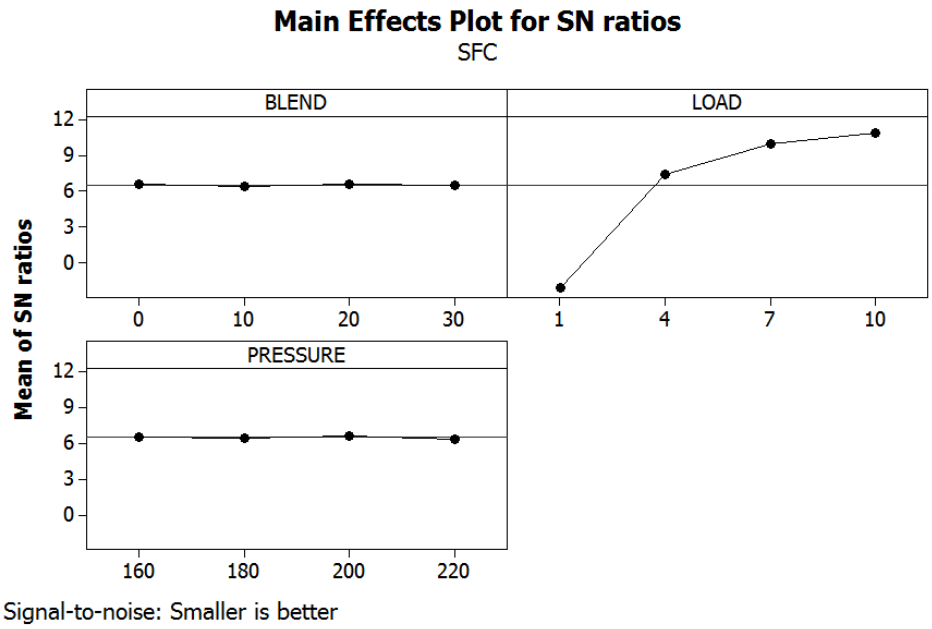

Fig.3 main effects plot for means SFC

From the below fig.4, the response curve for S/N ratio, the highest S/N ratio was observed (25.54) at B0D100 blend, engine load

10kg (10.831) and injection pressure 200 bar (6.632), which are optimum parameter setting for highest specific fuel consumption. From delta values as mention above, maximum of engine load is 12.95 and the minimum for blend is 0.238. The parameter engine load is the most significant parameter and blend is less significant for specific fuel consumption

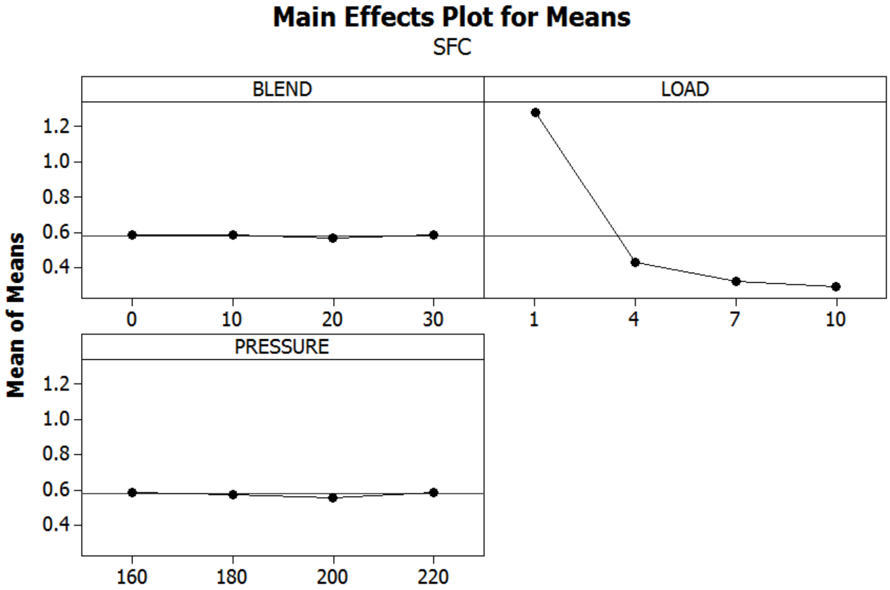

Fig.4 main effects plot for SN ratio SFC

5.1Choosing optimum parameter of levels

Level 1	Blend	Pressure	Load
1	6.555	6.542	-2.122
2	6.359	6.439	7.385
3	6.598	6.632	9.904
4	6.486	6.385	10.831
Delta	0.238	0.247	12.953
Rank	3	2	1

Table.4 Response table for signal to noise ratio

VI. Predict performance at optimum setting

S/N RATIO	SFC
11.02	0.28

Table.5 Optimum output

Using optimum set of parameters, which was achieved by response curve analysis was used for prediction by Minitab software. Minitab software for Taguchi method of optimization was suggested specific fuel consumption 0.28 and S/N ratio was 11.02 for optimum set of parameter as shown in table 5.

VII. Conclusion

Result of Taguchi experiment identified that 10 Kg load, 200 bar injection pressure and B0D100 blend are optimum parameter setting for minimum specific fuel consumption, engine performance is mostly influenced by engine load and least influenced by injection pressure.

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