RESEARCH PAPER | Engineering | Volume : 5 | Issue : 4 | April 2015 | ISSN - 2249-555X

Parametric Optimization of ci Engine with Bsfc by using Coconut Biodiesel and Diesel Blend

KEYWORDS: Parametric Optimization, specific fuel consumption (SFC), Coconut Cooking Oil, Coconut biodiesel, RSM.

Vishal H Amin
Master Scholar, Mechanical Engineering, Kadi Sarva Vishwavidyalaya, Gandhinagar, Gujarat, India.

Gaurav P Rathod
Assistant Professor, Mechanical Engineering, Kadi Sarva Vishwavidyalaya, Gandhinagar, Gujarat, India

Tushar M Patel
Associate Professor, Mechanical Engineering,Kadi Sarva Vishwavidyalaya,Gandhinagar, Gujarat, India

ABSTRACT *In present research effect on input parameters such as injection pressure and load on the performance of single cylinder diesel engine fueled with coconut biodiesel and also its blend. The number of test are carried out with three different injection pressure (160, 200, 240 bar), load (1, 6, 11) and blend (100%, 50%, 0%). In this study research is completed by use of Response Surface Methodology to optimize the performance parameter such as specific fuel consumption (SFC) and brake thermal efficiency (BThEff). A set of experimental runs was established using a Central Composite Design (CCD) and the response surface method was employed to obtain the regression model for the specific fuel consumption for different values of input parameter. The experimental results reveal that the coconut biodiesel and its blend provide better engine performance and reduce specific fuel consumption (SFC) compared to diesel with little change in input parameter*

INTRODUCTION

India is the Developing country, and growth of nation affected by price of fossile fuels and pollution due to exhaust gases. Researcher were tried to find the best alternate option of fossile fuels. Alternative fuels for transport such as natural gas, hydrogen and biofuels are seen as an option to help in transport area to overcome the demand of oil [1]. The best record available is that of the Czech Republic, which insists on 100% biofuel use for transportation (Paramathma 2004) [2]. Today many countries of worldwide, with including India, produces and use biodiesel in different area. Biofuel resources, specially coconut cooking oil have attracted much attention as an alternative energy source. It is renewable, easily available and has proved to be a cleaner fuel and more eco friendly than the fossil fuels.

LITERATURE REVIEW

Due to continuously increase of fuel demand day by day which also increases the consumption of fossile fuels i.e. diesel because diesel is a main source of transportation and passenger vehicle. To overcome the demand of diesel and reduce diesel fuel consumption, alternate biofuel or blended fuel used in IC engine which can be partially mixed with diesel and gives the better performance on diesel engine. There are number performance parameters in diesel engine like Power, BSFC, Brake thermal efficiency and specific fuel consumption. The parameter SFC is normally used for to compare performance of different engines. It is defined as the amount of fuel consumed for each unit of brake power per hour.

The brake specific fuel consumption found decreasing as the injection pressure decrease (250-200-150) on a light duty direct injection diesel engine.. The compression ratio 18 is also very close to optimum value. (C.R. = 15, 16, 17, 18, 19). with increase in Compression Ratio the specific fuel consumption decreases. The BSFC generally increased with the increase in biodiesel percentage in the fuel blend. So the there is need to do engine modification for to achieve better performance. It is also observed that the increased injection pressure & compression ratio gave the better results for BSFC and BTE compared to the original and decreased in DI diesel engine fueled with biodiesel-blended diesel fuel [3].

COCONUT OIL

Coconut oil is an edible oil extracted from the kernel or meat of matured coconuts harvested from the coconut palm (Cocos nucifera). It has various applications in food, medicine, and industry. Because of its high saturated fat content it is slow to oxidize and, thus, resistant to rancidification, lasting up to two years without spoiling. It is an actual nut from the Coconut Palms. Coconut Palms are one of the few crops that can tolerate poor sandy soils with saline water and survives frequent cyclones. Coconut Palms can bear a bunch of fruits each month for about 65 of their 70 to 80 year life span and it require minimum maintenance. They call the coconut palm the "Tree of Life". Coconut Biodiesel (CB) is a blend of diesel fuel and CME at a certain proportion by volume. The Table 1 shows the various physico-chemical properties of biodiesel derived from different feed stocks.

TABLE – 1
PHYSICO-CHEMICAL PROPERTIES OF DIFFERENT BIO-DIESELS [2].

Parameters	Diesel	Coconut oil
Colour	Orange	Water clean
Cetane Number	62.8	51
Gross Calorific Value (MJ/kg)	46	42
Flash Point	49°C	114°C
Sulfur Content	0.05%	0%
Oxygen Content	0%	11%
Kinematic Viscosity	3-4 cst	2-3 cst
Lubricity (BOCLE)	3,800gms	>7,000 gms
Boiling point °C	248	122.56±0.51
Density at 15°C	820- 950	924

Volume : 5 | Issue : 4 | April 2015 | ISSN - 2249-555X

EXPERIMENTAL SETUP

The setup consists of single cylinder, four stroke, multi-fuel, research engine connected to eddy type dynamometer for loading as shown in Fig.1. The operation mode of the engine can be changed from diesel to Petrol of from Petrol to Diesel with some necessary changes. 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. A battery, starter and battery charger is provided for engine electric start arrangement.

Figure 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, BSFC, 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. Table 2 shows Technical specification of C.I Engine [1].

TABLE – 2
TECHNICAL SPECIFICATIONS[1]

Item	Specification
Model	TV1
Make	Kirlosker Oil Engines
Type	Four stroke, Water cooled, Diesel
No. of cylinder	One
Bore	87.5 mm
Stroke	110 mm
Compression ratio	12 to 18
Power rating	7.5 HP
Injection timing	≤ 25˚ BTDC

METHODOLOGY

There are number of optimization techniques used for engine investigation are like full factorial design, response surface method, mixture design, simplex method, ANN, genetic algorithm (GA) and Taguchi method. The simplex method is started to be efficient for optimization without interaction effects but with insertion of interaction effects, the method becomes computationally expensive and complex [2]. In response surface method, efficient engine control optimization could be achieved by a response surface satisfying the prediction accuracy could be created. RSM technique has been popular for parameter optimization in design of experiments (DOE) for decades due to its excellent characteristics like orthogonality, rotatibility and uniformity[2] . The curvature shapes like cube, sphere etc. can easily solved by Response surface method. RSM comprises of three techniques or methods (Myers and Montgomery, 1995): (1) Statistical experimental design, in particular, two-level factorial or fractional factorial design, (2) Regression modelling techniques, and (3) Optimization methods. Steps for the Experiment for RSM

1. Determination of independent variables and their levels :- select the parameters (variable) that have major effects on output. The levels of the parameters are determined. The range of coded variable -1 to 1. Equation of coding is given below [5]:

$$X = \frac{x - [x_{max} + x_{min}]/2}{[x_{max} - x_{min}]/2} \quad (1)$$

Where,

X = coded variable
x = natural variable
x_{max} ,x_{min} = maximum and minimum values of the natural variable

2. Selection of the experimental design, and prediction and verification of model equation:- Experimental design are generated. Then the model equation is defined. For to compare these data the statical method of root mean square error (RMSE) and coefficient of multiple determination (R^2) values are used. These values are determined by following equation [1]:

$$RSME = \left[\frac{1}{n}\sum_{j=1}^{n}|a_j - p_j|^2\right]^{1/2} \quad (2)$$

$$R^2 = 1 - \left[\frac{\sum_{j=1}^{n}(a_j - p_j)^2}{\sum_{j=1}^{n}(p_j)^2}\right] \quad (3)$$

Where,
a_j = Experimental Specific consumption

p_j = Predicted Specific consumption

3. Graphical presentation of the model equation:- The prediction of model equation is done by the surface and contour plot. The surface plot is the 3 dimensional plot which showing the relationship between response and the variable.

EXPERIMENTAL METHOD

TABLE – 3
ACTUAL AND CODED LEVELS OF THE INDEPENDENT VARIABLES IN THE EXPERIMENTAL DESIGN

Variable	Symbol		Level	
	Actual	Coded	Actual	Coded
BR	A	X_1	0	-1
			50	0
			100	1
IP	B	X_2	160	-1
			200	0
			240	1
Load	C	X_3	1	-1
			6	0
			11	1

The selected process variables were varied up to three levels and central composite rotatable design. Response

Volume : 5 | Issue : 4 | April 2015 | ISSN - 2249-555X

Surface Methodology was used to develop second order regression equation relating response characteristics and process variables. The process variables and their ranges are given in Table 3.

RESULT AND DISCUSSION

Fitting the model and analysis of variance (ANOVA)

The analysis experiments were conducted, with the process parameter levels set as given in Table 3, to study the effect of process parameters over the output parameters. Experiments were conducted according to the test conditions specified by the second order central composite design. Experimental results for BSFC are given in Table 4. Altogether 20 experiments were conducted using response surface methodology

TABLE – 4
EXPERIMENTAL LAYOUT OF CENTRAL COMPOSITE DESIGN AND ITS CORRESPONDING OBSERVED VALUES OF BSFC

RUN	Variable properties			
	Blend Ratio	Injection Pressure	Load	BSFC
1	100	160	1	0.99
2	100	200	6	0.38
3	50	200	6	0.35
4	50	200	6	0.35
5	50	200	6	0.35
6	50	160	6	0.35
7	0	200	6	0.33
8	50	200	6	0.35
9	50	200	11	0.29
10	50	200	1	1.36
11	50	200	6	0.35
12	0	160	1	1.24
13	50	240	6	0.35
14	100	240	11	0.29
15	0	160	11	0.26
16	100	240	1	1.3
17	50	200	6	0.35
18	0	240	11	0.26
19	0	240	1	1.17
20	100	160	11	0.26

For good predicted model the value of R^2 are come closer to 1 and value of RMSE are come close to 0(zero).

TABLE – 5
TARGET VS PREDICTED BSFC

RUN	Target SFC	Predicted SFC	Error	R^2	RMSE
1	0.99	1.12975	-0.13975	0.993829	0.052625
2	0.38	0.347	0.033		
3	0.35	0.351	-0.001		
4	0.35	0.351	-0.001		
5	0.35	0.351	-0.001		
6	0.35	0.324	0.026		
7	0.33	0.355	-0.025		
8	0.35	0.351	-0.001		
9	0.29	0.272	0.018		
10	1.36	1.212	0.148		
11	0.35	0.351	-0.001		
12	1.24	1.24025	-0.00025		
13	0.35	0.378	-0.028		
14	0.29	0.34625	-0.05625		
15	0.26	0.30025	-0.04025		
16	1.3	1.28625	0.01375		
17	0.35	0.351	-0.001		
18	0.26	0.25175	0.00825		
19	1.17	1.19175	-0.02175		
20	0.26	0.18975	0.07025		

Here error is show the difference between the targeted and predicted value of BSFC. The value of R^2 and RMSE are calculated by

equation (2) and (3). The value of R^2 is 0.99 which are close to the 1 and the value of RMSE is 0.052 which is close to 0. So, the model is making a good prediction.

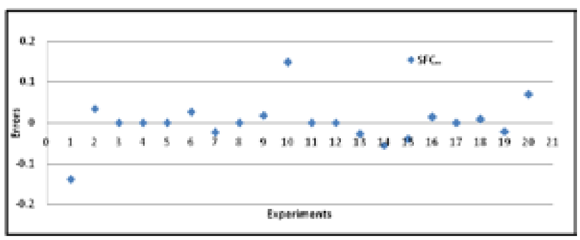

Figure 2: Experimental vs. Error

COMPARISON OF RESULTS

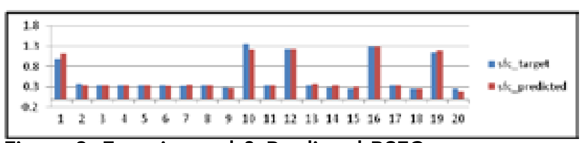

Figure 3: Experimental & Predicted BSFC

The error of the experiment are shown in graph which are above and below the 0 value.
The predicted value of BSFC of model is compared with the actual target value of experiment is shown in figure 3 by different colors. It is clear from graph that predicted results are very close to actual targets.

The second-order polynomial models used to express the BSFC as a function of independent variables (Eq. (4)) is shown below in terms of coded level:

SFC(Coded) $=0.370000-0.027000x_1-0.493000x_2+\ 0.050000x_3-$

Volume : 5 | Issue : 4 | April 2015 | ISSN - 2249-555X

$0.045000x_1^2+0.425000\ x_2^2-0.050000x_3^2-0.010000x_1x_2+0.080000x_1x_3+0.002500x_2x_3 \quad (4)$

TABLE – 6
ANOVA FOR RESPONSE SURFACE MODEL

Source of variation	Co-efficient	p-Value probability
Blend Ratio, A	-0.0270000	0.134
Load, B	-0.493000	0.000
Injection pressure, C	0.0500000	0.013
A^2	-0.0450000	0.601
B^2	0.425000	0.002
C^2	-0.0500000	0.895
AB	-0.0100000	0.185
BC	0.0800000	0.000
AC	0.00250000	0.145

Statistical inferences:
Values of "p-value" less than 0.0500 indicate model terms are significant. In this case blend ratio A, compression ratio B, load D etc are significant model terms.

The coefficient of determination (R^2) and adjusted coefficient of determination (R^2 adj) were indicated that the estimated model fits the experimental data satisfactorily. Lee et al. (2010) suggested that for a good fit of a model, R^2 should be at least 80 %. The R^2 for these response variables was higher than 80 %, indicating that the regression models explained the mechanism well [4].

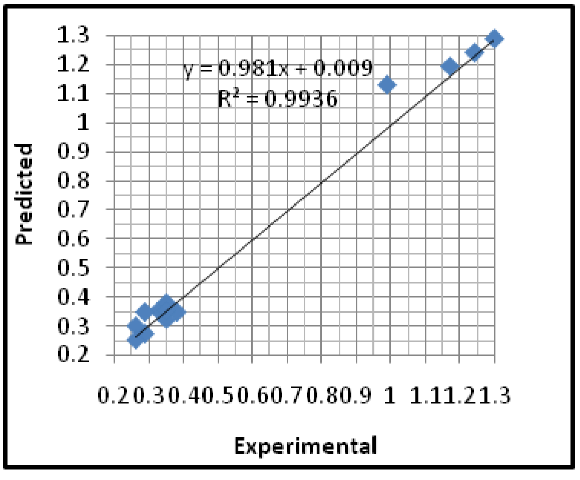

Fig 4: Experimental vs Predicted BSFC

Fig. 4 shows the experimental versus predicted BSFC obtained from Eq. (4). A linear distribution is observed which is indicative of a well-fitting model. The values predicted from Eq. (4) were close to the observed values of BSFC.

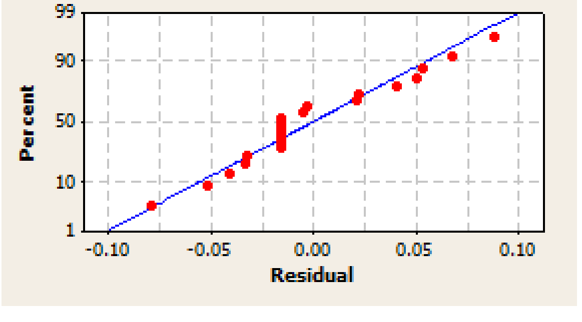

Figure 5: Normal probability of residuals

The normal probability plot is also presented in Fig.5.The plot indicates that the residuals (difference between actual and predicted values) follow a normal distribution and form an approximately straight line.

Effect of independent processing parameters
The effect of the four independent variables on the BSFC is shown in Fig. 6.

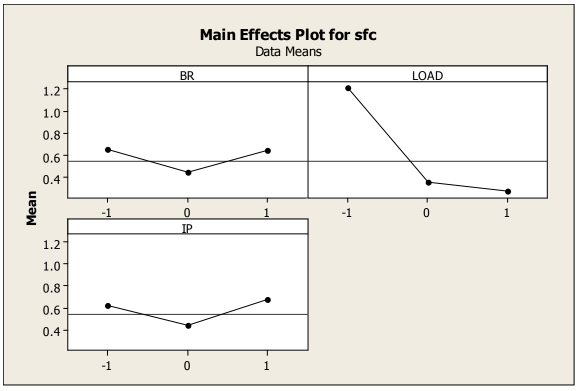

Figure 6: Main Effect Plot of BSFC

BSFC improved with increasing Blend Ratio(A) as shown in Fig. 6, when the blend ratio was increased from 0 to 50% . However, after that the increases in blend ratio decrease in the BSFC. So 50 % blend ratio is choosen as optimum blend ratio for BSFC.

BSFC improve with increasing injection pressure(C) from 160 to 200 bar then after decreasing BSFC with increase in injection pressure.

As shown in Fig.6 increasing load reduces BSFC. As load increase from 1 to 11 kg the BSFC decreases. This can also confirmed by ANOVA table indicating *p*-value of 0.00 indicating the load is significant value for BSFC.

CONCLUSIONS
The present investigation aimed at optimization of BSFC for CI engine. This analysis is carried out by developing BSFC models based on L20 CCD in Response surface optimization technique. Model for BSFC prediction draws the following conclusions.

It is proved that each predicted BSFC values are very close to the experimental results. It is also conclude that the RSM may be used as a good alternative for the analysis of the effects of engine parameters on the BSFC.

The modeling of the effects of engine parameters (Blend ratio, Injection pressure, Load) on the BSFC depending on various processing parameters, an RSM-based approach has been suggested.

Volume : 5 | Issue : 4 | April 2015 | ISSN - 2249-555X

REFERENCE [1] Patel, T. M., Patel, K. B., & Patel, S. C. (2013). Artificial Neural Network Based Prediction of Performance Characteristic of Single Cylinder Diesel Engine for Pyrolysis Oil and Diesel Blend. International Journal of Computer Science & Applications (TIJCSA), 2(03). | [2] Ganapathy, T., Gakkhar, R. P., & Murugesan, K. (2011). Optimization of performance parameters of diesel engine with jatropha biodiesel using response surface methodology. International Journal of Sustainable Energy, 30(sup1), S76-S90. | [3] Hossain, A. B. M. S., & Mazen, M. A. (2010). Effects of catalyst types and concentrations on biodiesel production from waste soybean oil biomass as renewable energy and environmental recycling process. Alcohol, 1, 1-5. | [4] Lee, A., Chaibakhsh, N., Rahman, M. B. A., Basri, M., & Tejo, B. A. (2010). Optimized enzymatic synthesis of levulinate ester in solvent-free system. Industrial Crops and Products, 32(3), 246-251. | [5] Baş, D., & Boyacı, İ. H. (2007). Modeling and optimization I: Usability of response surface methodology. Journal of Food Engineering, 78(3), 836-845. |