Experimental Analysis of Specific Fuel Consumption using RSM method on C.I Diesel engine fueled with Diesel and Jatropha biodiesel

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Abstract: The purpose of Experiment study is to check the performance of Diesel Engine using Jatropha and Diesel blend. Then after optimize the Value of Specific Fuel Consumption by applying Response Surface Method (RSM) with the parameter such as percentage of blend, Load and Exhaust Gas Recirculation at various levels and verify the optimum value of SFC. For verification of SFC it has to be Compare the Experimental value with Predicted value. And also by RSM method we can analyze individual as well as combined effect of all parameters examined under this experiment.

Keywords: SFC optimization; RSM; Jatropha biodiesel; EGR

1. INTRODUCTION

In the application of automotive equipment, the various developing countries increase day by day to controlling demand and supply of country. Sudden change in source of power from petroleum to electrically or solar power is much difficult. To resolve this situation middle and easiest way is using biodiesel product with blend in diesel. So, it will help to control the fuel prices and supply of fuel.

The objective of study is to reduce the fuel consumption and optimize the fuel consumption value with using blending of diesel and jatropha carcass bio-oil. Experiment is performed on the CI Diesel engine with Rope break dynamometer.Das et al.(2018) represent An experimental study on the combustion, performance and emission characteristic of diesel engine fueled with diesel castor oil blend[1].Prakas et al.(2018) studied on Effect of ternary blends of bio-ethanol, diesel and castor oil on Performance, Combustion and Emission IN A CI engine[2]. Kaisen et al.(2017) presented Exhaust emissions of biodiesel binary and multi-blends from cotton , jatropha and neem oil from stationary multi cylinder C.I engine[3].Amin et. al.(2016) Experimental and empirical study of diesel and castor biodiesel blending effect ,on kinematic viscosity ,density and calorific value[4]. Prabhu et.al.(2013) Experimental analysis of jatropha carcass Bio diesel for optimum blend characteristics[5]. Rao et. al.(2009) represented Experimental investigation on jatropha biodiesel and additives.[6] Acharya et.al.(2017) work on Comparatively study of Mahua and jatropha biodiesel and its blend in CI engine.[7].

2. MATERIAL AND MODEL

The experiment analysis held on 5 hp CI engine with rope break dynamometer with Diesel and Jatropha biodiesel blend a single-cylinder, 4-Stroke, water-cooled diesel engine of 5 hp rated power is considered for the experimentation. The Engine is connected with the Rope Brake Dynamometer which is used to measuring Load. A stationary, 5 hp direct injection diesel engine is used to conduct experiments. Its specifications are given in table 1. Exhaust Gas Recirculation system is attached with Engine to control emission temperature.

Table 1 Engine specifications

Parameter	Details
Engine	Single Cylinder High Speed Diesel Engine
Cooling	Water cooled
Bore × Stroke	80 mm × 110 mm
Compression ration	16 : 1
Maximum Power	5 hp or 3.7 kW

Rated speed	1500 rpm
Capacity	553 CC

3. METHODOLOGY

RSM method is used to find Optimum value from the relationship between Factors and Responses. In this study RSM is applies to find optimum Input Parameter gives maximum efficiency, minimum fuel consumption and less emission. The work investigates the influence of Load, Blend Ratio (%) and Exhaust Gas Recirculation (EGR) on the performance of Diesel Engine fueled with Jatropha Biodiesel (0%, 50% and 100%). The Experiment was designed using statistical tool DESIGN OF EXPERIMENT (DOE) based on Response Surface Methodology. The RSM result model was helpful to predict the responses parameter such as Break Specific Fuel Consumption, Break thermal Efficiency and Mechanical Efficiency. Optimization of parameters was performed using the desirability approach of the response surface methodology for better performance.

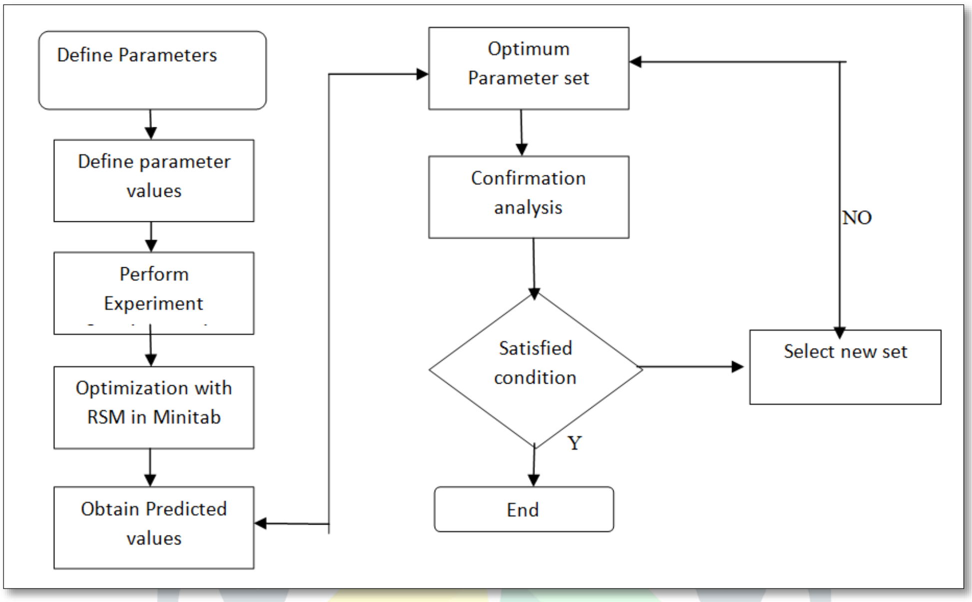

Fig.1 Flow Chart of Experiment

4. RESULT AND DISCUSSION

The selected variables are on 3 levels with central composite method

Table 2 Parameters and their Levels

Process Parameter	-1	0	1
Percentage of Blend (%)	0	50	100
Load(Kg)	1	6	11
EGR	0	25	50

Above table indicate all the Input parameter describes as decided level. and in further research above levels is applied in whole Experiment.

Table 3 all the process parameter over output parameter

Run order	A	B	C	SFC(kg/KW.hr)
1	50	6	25	0.34879
2	100	1	0	1.70702
3	100	1	50	2.11671
4	50	6	25	0.34879
5	50	1	25	1.84842
6	100	11	0	0.22967
7	50	6	25	0.3479
8	50	6	25	0.34879
9	0	1	0	1.47375
10	0	1	50	1.77691
11	50	6	25	0.34879
12	0	11	0	0.22330
13	50	6	50	0.38551
14	0	6	25	0.36579
15	50	6	25	0.34879
16	0	11	50	0.22316
17	100	11	50	0.18622
18	100	6	25	0.33002
19	50	6	0	0.34431
20	50	11	25	0.19952

A.B and C represented the all process parameter respectively.
The entire coefficients are to be estimated using experimental data as on table 3.

Table 4 Response surface Regression: SFC vs. A,B,C

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	8.46490	0.94054	367.90	0.000
Linear	3	6.25560	2.08520	815.64	0.000
A	1	0.02568	0.02568	10.04	0.010
B	1	6.17945	6.17945	2417.14	0.000
C	1	0.05047	0.05047	19.74	0.001
Square	3	2.09173	0.69724	272.73	0.000
A*A	1	0.00089	0.00089	0.35	0.568
B*B	1	1.19082	1.19082	465.80	0.000
C*C	1	0.00000	0.00000	0.00	0.974
2-Way Interaction	3	0.11757	0.03919	15.33	0.000
A*B	1	0.04555	0.04555	17.82	0.002
A*C	1	0.00050	0.00050	0.20	0.668
B*C	1	0.07152	0.07152	27.98	0.000
Error	10	0.02557	0.00256		
Lack-of-Fit	5	0.02557	0.00511	*	*
Pure Error	5	0.00000	0.00000		
Total	19	8.49047			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0505620	99.70%	99.43%	97.19%

4.1 Statistical Inferences:

1. The Model F-Value of 367.90 implies the model is significant. There is no chance that a "Model F-Value " of this much value could occur due to other parameters.
2. The "Lack of Fit F-Value" doesn't indicate any such value which is good.
3. The "Pred R- Squared " of 0.9719 is in reasonable agreement with the "Adj R-Squared" of 0.9943.
4. Values of "Prob > F" less than 0.0500 Indicate model terms are significant. In this case A, B, C, AA, BB, AB, BC are significant model terms.

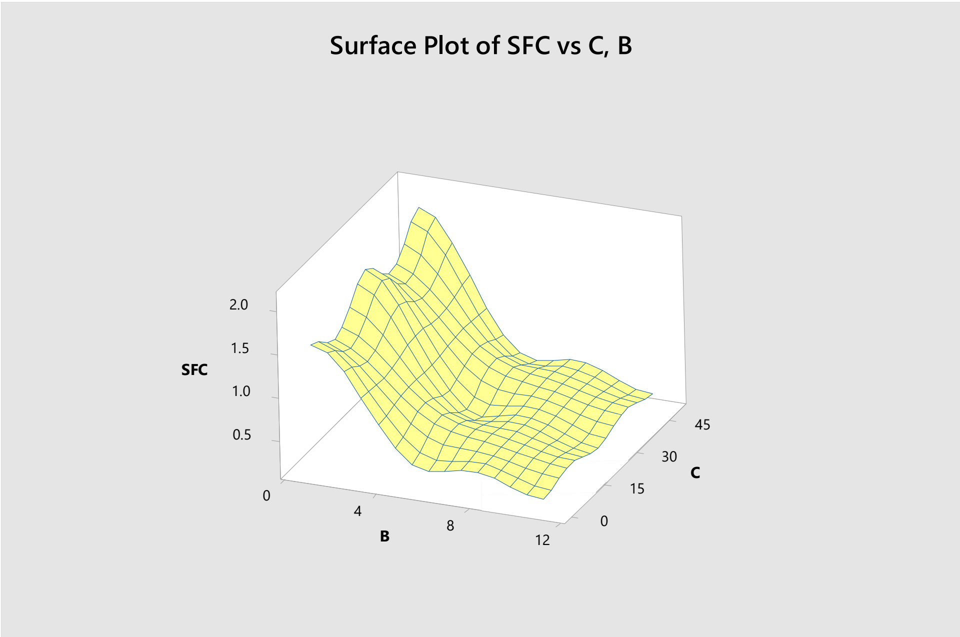

Fig 2. 3D Surface plot for Specific Fuel Consumption

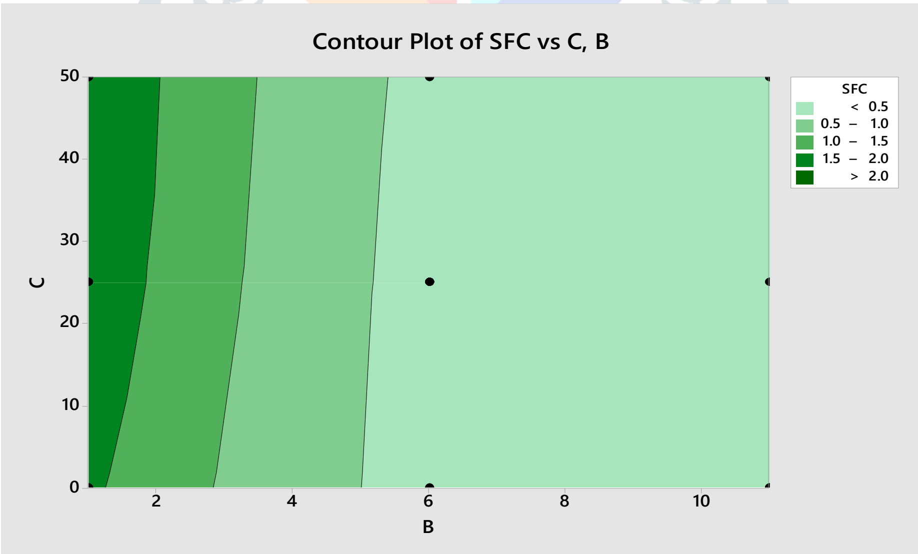

Fig 3. Contour Plots for Specific Fuel Consumption

Figure 2 and Figure 3 3D surface diagram and contour diagram represent the all the desirable condition of Specific fuel consumption with the parameter of load and EGR.

Four Residuals plots are drawn for estimating the accuracy of the model. The histogram plot indicates a mild tendency for the non normality; however the normal probability plots of these residuals do not reveal any abnormality, Residuals versus fitted value and residual versus observations order plot do not indicate any undesirable effect

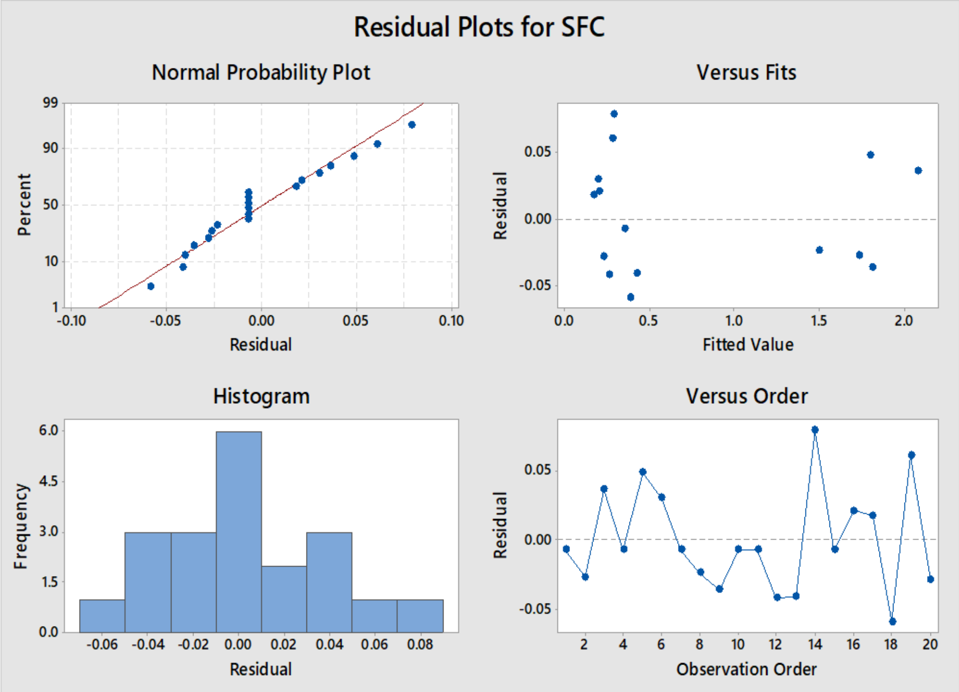

Fig.4 Residual plots for SFC

Above Figure 4 represent the residual plot for Specific Fuel Consumption to check the data for the non random variation, non constant variance and outliners. On the Normal Probability plot the straight line indicate residual are normally distributed. Versus fits, Histogram and versus graph represent there is no undesirable effect.

And for the prediction Values of Specific Fuel Consumption can be calculated from the Regression Equation (1),

$$SFC = 1.9097 + 0.00339\times A - 0.4391\times B + 0.00715\times C - 0.000007\times A\times A + 0.02632\times B\times B - 0.000002\times C\times C - 0.000302\times A\times B + 0.000006\times A\times C - 0.000756\times B\times C$$

Table 5 Experimental and Predicted values of SFC

Run Order	Experimental SFC	Predicted SFC	Error	R^2
1	0.34879	0.35562	-0.0068267	0.9970
2	1.70702	1.73572	-0.0286955	
3	2.11671	2.08042	0.0362904	
4	0.34879	0.35562	-0.0068267	
5	1.84842	1.79992	0.0484990	
6	0.22967	0.20112	0.0285524	
7	0.34879	0.35562	-0.0068267	
8	1.47375	1.49692	-0.0231680	
9	1.77691	1.81162	-0.0347093	
10	0.34879	0.35562	-0.0068267	
11	0.34879	0.35562	-0.0068267	
12	0.22330	0.26432	-0.0410242	
13	0.38551	0.42472	-0.0392117	
14	0.36579	0.28672	0.0790710	
15	0.34879	0.35562	-0.0068267	
16	0.22316	0.20102	0.0221365	
17	0.18622	0.16782	0.0184009	
18	0.33002	0.38952	-0.0594953	
19	0.34431	0.28402	0.0602933	
20	0.19952	0.22732	-0.0277977	

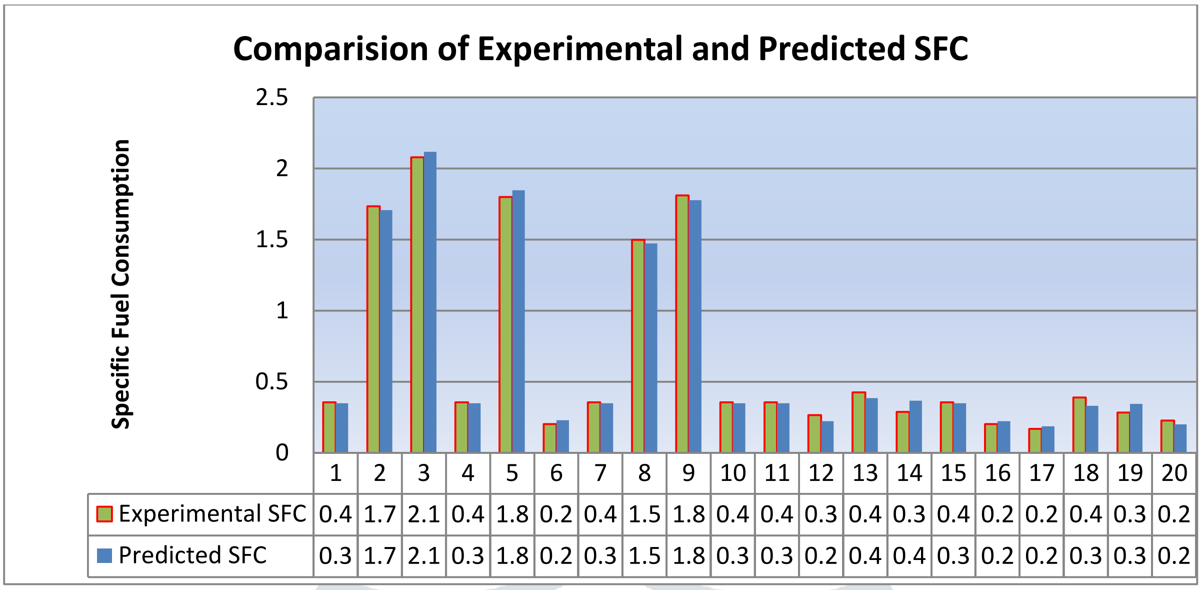

Fig. 5 No. of Experiment vs. SFC

Figure 5 describes the comparison between Experiment and Predicted Values of SFC. On the graph all the values of SFC with respect to number of Experiment is close to each other, which indicate a linear distribution in graph.

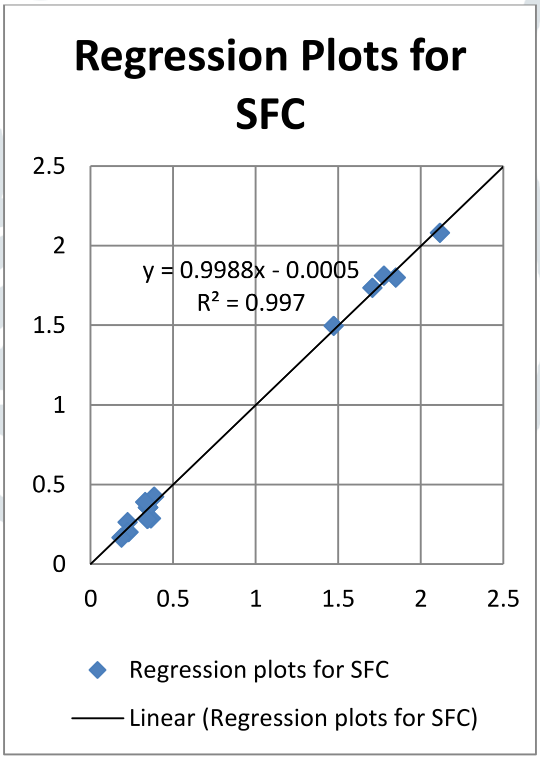

Fig 6 Regression Plots for SFC

Figure 6 is Regression Plots for SFC and from the equation y = 0.998x - 0.000,we can find the Experimental as well as Predicted value.

4.2 Optimum value for Specific fuel consumption:

Table 6 Optimum value for Specific Fuel consumption

SR. NO.	VARIABLE	OPTIMUM SET OF PARAMETER	RESPONSE	OPTIMUM VALUE	PREDICTED VALUE
1	Load(Kg)	11	Specific Fuel consumption (Kg/KWh)	0.18622085	0.16782
	% Of blend	100			
	EGR	50			

5. CONCLUSION

The RSM method is used to find out optimum sets of parameter for specific fuel consumption. the test has been conduction with the percentage of blend(0,50,100), load at(1.6,11) and EGR (0,25,50).After the optimization of RSM optimum value of the Specific Fuel Consumption is 0.18622085 at11 kg of load, 100% blend and 50% EGR with error of 0.16782.

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