Optimization of performance of VCR Engine Blended with palm oil biodiesel Using Taguchi Method

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ABSTRACT

The performance characteristics of a VCR engine when fuelled with palm oil and its 0%, 10%, 20% blends with diesel (on a volume basis) are investigated and compared with unblended diesel. Experiments were conducted at constant speed of 1500 rpm, and at different loads (4, 6, 8,) and at compression ratios of 16:1, 17:1, and 18:1. The effects of compression ratio on brake power, brake thermal efficiency, BSFC characteristics has been investigated and presented. In this study the parameters i.e. load, compression ratio and blend are taken as variable for optimization. As the experiment required simultaneously optimization of three parameters with three levels, Taguchi orthogonal array (L9) is used in this experiment .The emission of CO, HC dropped with an increase in blending ratio and compression ratio of maximum load. The results of Taguchi experiment identify that 18 compression ratio, B0 and engine load 8 kg are optimum parameters for highest brake thermal efficiency. Engine performance is most influence by load and least influence by compression ratio.

Keywords:BP, VCR, Palm oil, Taguchi method, BSFC.

I INTRODUCTION

The growth of any developing country will depend upon the use of petroleum fuels, in various areas as like industry, aviation, transportation, power production etc. The demand of energy has increased rapidly with growing of world population. Consumption of energy is proportional to the progress of the mankind. Therefore other systems based on nonconventional and renewable sources are being tried by many countries based on solar, wind, and biomass, tidal, geothermal and hydro. Among the various alternative fuels being developed, the biodiesel has received special attention because it is easy to produce from available and renewable sources (vegetable oils and animal fats), safe to handle and use, eco-friendly, and miscible with petroleum diesel in all proportional for use in existing diesel engines without modification [1].

Modi et al. (2016) In their study experiment is conducted for palm seed oil blended with diesel used in a single cylinder diesel engine. Study, the effects of parameters` i.e. load, compression ratio and injection pressure are taken as variable for optimization. The results of the Taguchi experiment identify that 16 compression ratios, injection pressure 180 bar and engine load 10kg are optimum parameter setting for highest brake thermal efficiency. Engine performance is mostly influenced by engine load and is least influenced by compression ratio [2]. In a similar work Prajapati et al. (2017)The effects of various parameters i.e. blend ratio, compression ratio, injection pressure and load are taken as variable for optimization. The results of the Taguchi experiment identifies that 0% blend ratio, 18 compression ratio, injection pressure 160 bar and engine load 9 kg are optimum parameter setting for highest brake thermal efficiency [3].

Gopinath et al. (2008) analyze the performance characteristics to improve brake thermal efficiency. Injection parameters include injection pressure and Number of holes was optimized with L9 orthogonal array with suitable biodiesel blends. Optimization technique was made by Taguchi method and suitable orthogonal array L9 was selected for a design of experiments. Injection pressure and Number of holes includes 190,200,210 bar and 1, 3, 4 holes respectively. The optimum level of parameters was identified by using different injection pressures, Number of holes and fuel. Thus, validation experimental proves that optimum parameters provide high brake thermal efficiency. Taguchi design approach provides the limitation of one response parameters. The Brake thermal efficiency was 30.31% in better optimum levels were the injection parameters are IP 190 bar, N h 4 and fuel as diesel[4].

In the present work optimization of engine performance such as brake thermal efficiency and brake fuel specific consumption were studied when engine is run POME blended fuel and load ,CR and blend taken as variable process parameters. The BTE , BSFC were taken as performance response.

II MATERIAL AND METHODELOGY

2.1 Biodiesel

In this work palm oil biodiesel used as fuel for VCR engine in different ratio B0, B10 and B20.The various fuel properties like, kinematic viscosity, density, calorific values are found similar to diesel. These fuel properties were compared with diesel fuel. Density and kinematic viscosity were higher than diesel this confirmed the safety of biodiesel storage. Kinematic viscosity and density were higher than diesel this may result in improper combustion.

Table 1.Physical-chemical properties of diesel & palm oil biodiesel blends.

S.N	Blends	Density(g/ml)@40°c	K.viscosity (cst)@15°c	Calorific value(cal/gm)
1	Pure diesel	0.843	3.37	10490
2	B10	.852	3.62	10409
3	B20	.859	3.80	10324
4	B100	.878	4.48	9628

2.2 Experimental Set up

The setup consists of single cylinder, four stroke, and VCR (Variable Compression Ratio) Diesel Engine. A Kirloskar TV1 having power 3.50 KW @ 1500 rpm which consists of single Cylinder, Four stroke , Constant rpm Water cooled Variable compression ratio (VCR) Diesel Engine is used for the experiments. Experiments were conducted with Diesel and different volume proportions of palm seed oil as a Blend by 0%, 10% and 20% with Diesel. In this experiment, diesel engine is used and connected with the eddy current dynamometer with the help of dynamometer, varies the load on the engine or load remain constant . The reading takes by varying the load on the engine using the dynamometer. Engine performance such as brake power, indicated power, brake thermal efficiency, brake specific fuel consumption etc. found from the experiments.

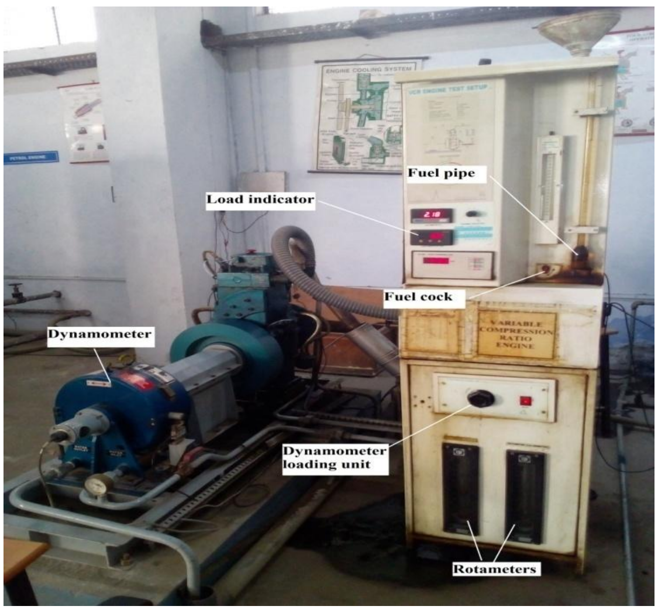


Fig 1. The VCR Engine available at KIET Ghaziabad

2.3 Methodology 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 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 three levels and hence, an L9 orthogonal array was used for the construction of experimental layout. The L9 has the parameters such as compression ratio, load and blend arranged in table. According to this layout, nine (09) experiments were designed and trials were selected at random, to avoid systematic error creeping into the experimental procedure. For each trial the BTE, BSFC, CO, and HC was calculated and used as response parameters. 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 higher-the-better S/N ratio was used in this experiment because this optimization is based on brake thermal efficiency. In the experiment, three parameters for three levels were considered. Control parameter and their level are given in table (2). L9 single orthogonal array was selected for the experimental investigation. “Bigger-the-better” is being taken as quality characteristics, since the objective function is to maximize performance.

Table 2: Variables and their Levels

Variable	Level 1	Level 2	Level 3
CR	16	17	18
LOAD	4	6	8
BLEND	B0	B10	B20

Table 3: L_9 Orthogonal layout

Exp. No.	**CR**	**LOAD (Kg)**	**BLEND**
1	16	4	B0
2	16	6	B10
3	16	8	B20
4	17	4	B10
5	17	6	B20
6	17	8	B0
7	18	4	B20
8	18	6	B0
9	18	8	B10

III RESULT AND DISCUSSIONS

The L9 orthogonal array along with the average reposes was shown in table 4. It is clear from table 4, that at constant CR as load increases the brake thermal efficiency is increases and brake specific fuel consumption decreases. The increase in BTE because at higher load there will be higher the value of torque which increases the brake power and brake power and brake thermal efficiency directly proportional.

Table 4: Calculation of BTE and BSFC (L9 Orthogonal array)

Exp. No.	CR	LOAD (Kg)	Blend	BTE (%)	BSFC(Kg/Kwh)
1	16	4	B0	20.65	0.40
2	16	6	B10	26.87	0.34
3	16	8	B20	27.73	0.35
4	17	4	B10	19.64	0.44
5	17	6	B20	23.48	0.37
6	17	8	B0	32.67	0.24
7	18	4	B20	18.05	0.43
8	18	6	B0	28.36	0.26
9	18	8	B10	31.39	0.25

Table 5. ANOVA of BTE

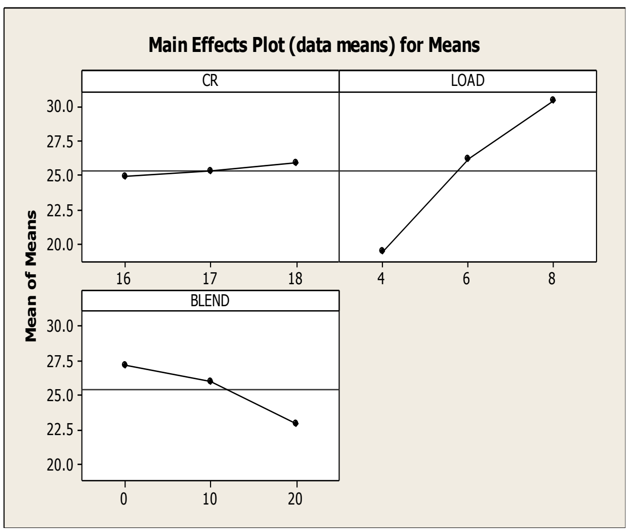
Source	DF	SS	Adj MS	F	Contribution
CR	2	1.603	0.801	1.45179	0.74 %
LOAD	2	184.322	92.161	166.91	85.16%
BLEND	2	29.417	14.709	26.64	13.60%
ERROR	2	1.104	0.552		0.50%
TOTAL	8	216.446			100%

Table 6: ANOVA of BSFC

Source	DF	SS	Adj MS	F	Contribution
CR	2	0.0040222	0.0020111	13.92	8.53%
LOAD	2	0.0324222	0.0162111	112.23	68.76%
BLEND	2	0.0104222	0.0052111	36.08	22.10%
ERROR	2	0.0002889	0.0001444		0.61%
TOTAL	8	0.0471556			100%

3.1Analysis for Response Curve

The variation of Brake Thermal efficiency of engine with POME and its blends is shown in above figure and it is compared with the diesel base line data obtained from it. As POME percentage increases than Brake thermal efficiency decreases because of its calorific value decreases and density, viscosity increases that affect the combustion of fuel. Variation of BTE with CR When CR is increased from 16 to 18 a slight increase in BTE is observed for all the



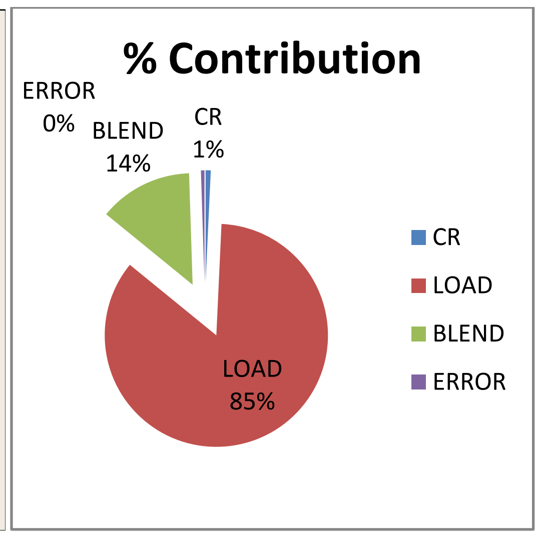
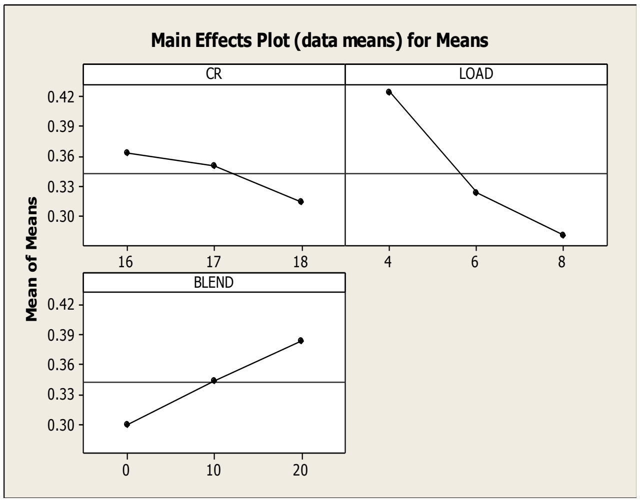


Figure 2: The variation for BTE **Figure 3: Percentage contribution for BTE**

blends. The reason behind that the proper atomization of fuel at higher compression ratio and as BTE increases with load that increases the brake power whereas the BTE of all blends and at all CR and loads was observed lower than pure diesel because of lower calorific value and higher density of POME blends. As load increases BTE is increases because at higher load higher BP is obtained.



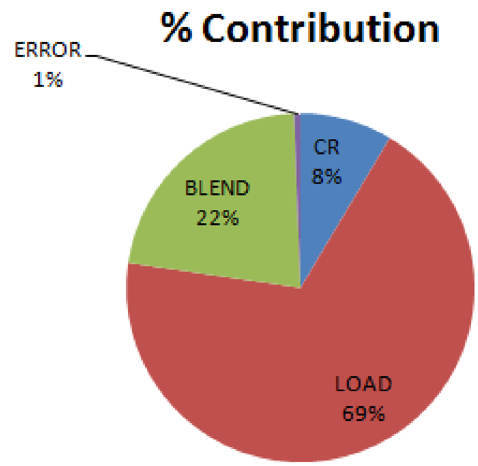


Figure 4: variation of BSFC **Figure 5: Percentage contribution**

It is clear from the graph the BSFC is decreasing with increase in load and increases with as blend percentage increases as the calorific value for POME is less than that of diesel. The BSFC is slightly higher than that of diesel fuel.At low load condition the BSFC is higher for all the blends as load increases BSFC start to decreasing because at higher load inside temperature of cylinder increases. This increase in temperature results decrease in viscosity of POME blends which causes in proper atomization of fuel. At higher load BP is increases which result in decrease in BSFC. It can be seen from the graph the maximum BSFC is for the blend B20 for all CR and all loads and minimum for pure diesel.

IV CONCLUSION

A single cylinder VCR engine of rated power 3.5 KW and constant speed RPM 1500 was operated successfully using biodiesel produced from palm oil and its blends as fuel. The Tagauchi method is used for quantifying the effect of control parameters such as CR, LOAD, and BLENDS. The highest brake thermal efficiency is found at compression ratio 18 and at a load 8 kg and for blend B0. However increase in blending with blending percentages above B0% results in reduced efficiency compared to diesel. This is due to increased density and lower calorific value of mixture. The BSFC is found optimum for diesel , compression ratio 18 and load 8 kg. engine successfully run without any modification using biodiesel blended with diesel.

REFERENCES

[1] Maulik A Modi, Tushar M Patel , Gaurav P Rathod, parametric optimization of single cylinder diesel engine for palm seed oil & diesel blend for brake thermal efficiency using taguchi method ISSN (e): 2250-3021, ISSN (p): 2278-8719 Vol. 04, Issue 05,2014, PP 49-54.

[2] Jinalben M Prajapati, Pragna R Patel, Dr.Tushar M Patel, parametric optimization of single cylinder diesel engine fueled with karanja biodiesel & diesel blend for brake thermal efficiency using taguchimethod ISSN: 2320-334X, Volume 14, Issue 2 Ver. V, 2017, PP 107-111.

[3] Mr.Krunal B Patel, Prof.Tushar M Patel, Mr.Saumil C Patel, Parametric Optimization of Single Cylinder Diesel Engine for Pyrolysis Oil and Diesel Blend for Specific Fuel Consumption Using Taguchi Method ISSN: 2278-1684 Volume 6, Issue 1 ,2013, PP 83-88.

[4] T. Ganapathy, K. Murugesan , R.P. Gakkhar, Performance optimization of Jatropha biodiesel engine model using Taguchi approach, Applied Energy 86 2476–2486, 2009.