Journal of Advances in Science and Technology
Vol. 12, Issue No. 25, (Special Issue) December-2016, ISSN 2230-9659

Optimisation of Bio-Diesel Engine Parameters Using Taguchi Approach

Prof. N. S. Dhole[1]*, Prof. R. D. Rajopadhye[2], Mr. A. S. Mahajan[3]

[1]Head of Department, Rajendra Mane College of Engineering, Ambav, Maharashtra, India

[2]Assistant Professor, Rajendra Mane College of Engineering, Ambav, Maharashtra, India

[3]Assistant Engineer, Mahindra Engines, Nashik

Abstract – This paper aims to optimize the Bio-Diesel engine parameters of Kirloskar TV1. In India with increase in use of technology, Automobile sector is growing rapidly and search for capable alternative fuel is required. Biodiesel is an alternative to conventional diesel fuel made from renewable resources, such as non-edible vegetable oils. No engine modifications are required to use biodiesel in place of petroleum-based diesel. Petroleum prices approaching record highs and they will deplete within few decades, it is clear that more can be done to utilize domestic non-edible oils while enhancing our energy security. Optimization of Bio-Diesel engine parameter i.e. Mechanical Efficiency is done using Orthogonal Array of L-9 in Taguchi analysis. Optimum levels of variance from test results are taken and confirmed practically.

Keywords—Optimization; Biodiesel; Alternative Fuel Taguchi.

---------------------------♦-----------------------------

INTRODUCTION

Palm oil is obtained from the fruit of Palm oil tree. The palm fruit is the source of both palm oil (extracted from palm fruit) and palm kernel oil (extracted from the fruit seeds). Palm oil itself is reddish because it contains a high amount of beta-carotene. It is used as cooking oil, to make margarine and is a component of many processed foods. Boiling it a few minutes destroys the carotenoids and the oil becomes white. Palm oil is one of the few vegetable oils relatively high in saturated fats (such as coconut oil) and thus semi-solid at room temperature.

Chemical Composition:

The palm oil and palm kernel oil are composed of fatty acids, esterified with glycerol just like any ordinary fat. Both are high in saturated fatty acids, about 50% and 80%, respectively. The oil palm gives its name to the 16 carbon saturated fatty acid palmitic acid found in palm oil; monounsaturated oleic acid is also a constituent of palm oil while palm kernel oil contains mainly lauric acid. Palm oil is the largest natural source of tocotrienol, part of the vitamin E family. Palm oil is also high in vitamin K and dietary magnesium.

Transesterification Process:

Biodiesel is a very versatile transport fuel and can be produced from local raw material or collection of used vegetable or frying oil in rural regions of developing countries. There are three basic routes to biodiesel production from oils and fats. [12]:

- Base catalyzed transesterification of the oil
- Direct acid catalyzed transesterification of the oil
- Conversion of oil to its fatty acids and then to biodiesel

Transesterification reaction is a stage of converting oil or fat into methyl or ethyl esters of fatty acid, which constitutes to biodiesel. Biodiesel (methyl ester) is obtained through the reaction of triglycerides of vegetable oils with an active intermediary, formed by the reaction of an alcohol with a catalyst.

The general reaction for obtaining biodiesel through transesterification is.

Oil or Fat + Methanol → Methyl Esters + Glycerol

Oil or Fat + Methanol → Ethyl Esters + Glycerol

Transesterification reactions may employ various types of alcohols, preferably, those with low molecular weight, with the most studied ones being the methylated and ethylated alcohols. Studies have shown that transesterification with methanol is more viable technically than with ethanol. Ethanol may be used as long as it is anhydrous (with a water content of less than 2%), since the water acts as an inhibitor reaction. Another advantage in using methanol is the separation of glycerin (obtained as a by-product of the reaction) from the reactive medium, since, in the case of synthesis of the methylated ester, this separation may be easily obtained through simple decantation illustrates the simplest procedure of manufacturing.

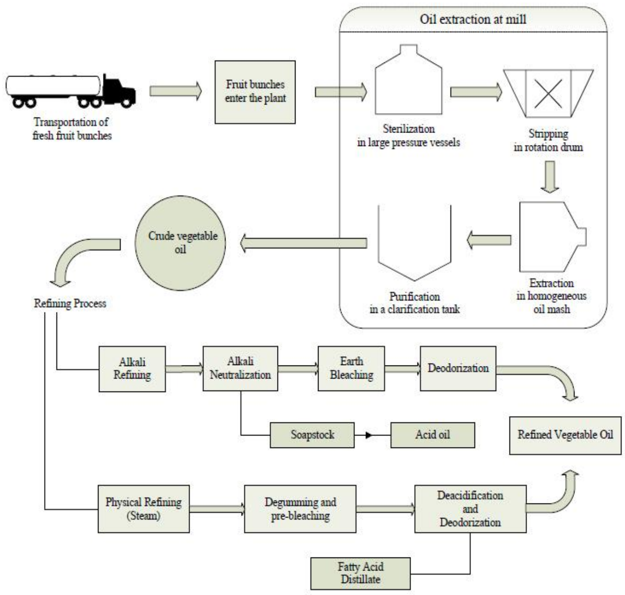

Fig. 1: Manufacturing process of Bio-Diesel

Bio-Diesel Blend:

Biodiesel is a domestically produced, renewable fuel that can be manufactured from new and used vegetable oils, animal fats, and recycled restaurant grease. Biodiesel's physical properties are similar to those of petroleum diesel, but it is a cleaner-burning alternative. Using biodiesel in place of petroleum diesel significantly reduces emissions of toxic air pollutants. What is a biodiesel blend? Biodiesel can be blended and used in many different concentrations, including B100 (pure biodiesel), B20 (20% biodiesel, 80% petroleum diesel), B5 (5% biodiesel, 95% petroleum diesel), and B2 (2% biodiesel, 98% petroleum diesel). B20 is a common biodiesel blend in the United States.

Blending biodiesel with petroleum diesel may be accomplished by:

1. Mixing in tanks at manufacturing point prior to delivery to tanker truck
2. Splash mixing in the tanker truck (adding specific percentages of biodiesel and petroleum diesel)
3. Inline mixing, two components arrive at tanker truck simultaneously.
4. Metered pump mixing petroleum diesel and biodiesel meters are set to X total volume, transfer pump pulls from two points and mix is complete on leaving pump.

Splash Mixing Method:

The most common and least accurate method of blending used for biodiesel is splash blending. Splash blending is done when a truck is already having diesel pumped with biodiesel. The temperature of biodiesel should be 18 to 20 degree Celsius when diesel is colder than 8 degree Celsius.

In Line Mixing Method:

Inline blending is done with two storage tanks containing biodiesel components and refinery-produced diesel or diesel components passing through a pipe and hose, mixed in a particular ratio and collected in a third, final product tank. This method allows large volume blends in one go. To avoid the risk of shock crystallization, it is better to have biodiesel temperature 6 degrees Celsius above cloud point. Keeping biodiesel in a diesel tank for a long time is not advisable. Although this method offers better blend consistency for biodiesel than splash blending, density and viscosity changes in the biodiesel require adjustments to the meters for an accurate blend.

Injection Mixing:

Injection mixing is the blending of fuels in tanks at a manufacturing point prior to delivery to the tanker truck. In this method, valve controls ensure that a particular quantity of biodiesel components is injected along with the diesel product in a particular ratio.

Experimental Setup:

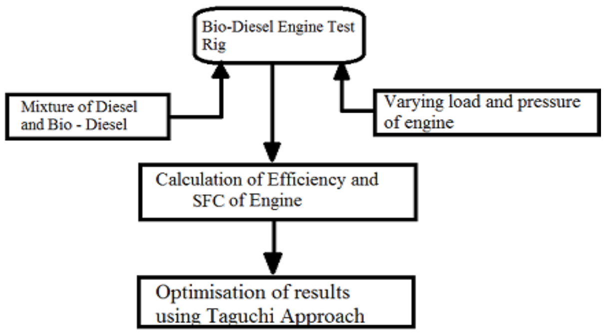

Fig. 2: Block diagram of the experimental process

The test rig details are as in the Table:

Table. 1 : Test Rig Description

Engine Parameters	Description
Engine Type	Single Cylinder I.C Diesel Engine
Make	Kirloskar TV1
Cooling System	Water cooled
Power	5.2 KW
Compression Ratio	17.50
Cylinder Bore	87.50(mm)
Stroke Length	110.00(mm)
Connecting Rod length	234.00(mm)
Swept volume	661.45 (cc)

Fig. 3: Bio-Diesel Test Rig

Selection of Orthogonal Array:

To select an appropriate orthogonal array for conducting the experiments, the degrees of freedom are to be computed. The same is given below:

- Degrees of Freedom: 1 for Mean Value, and 8= (2x4), two each for the remaining factors
- Total Degrees of Freedom: 9

The most suitable orthogonal array for experimentation is L9 array as shown in Table

Table02: Selection of L-9 Orthogonal Array

Exp	Column		
	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Analysis:

Test results using L-9 orthogonal array:

S/N Ratio of Mechanical Efficiency:

$$SN_T = -10\log\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{Y_i^2}\right)$$

$$SN_L = -10\log\left(\frac{1}{1}\sum_{i=1}^{1}\frac{1}{40.95^2}\right) = 32.245$$

I. S/N Table03 : S/N Ratio of Mech. Efficiency

Exp	Diesel / Biodiesel Proportion (%)	Load (Kg)	Injection Pressure (MPa)	Mech. Efficiency (%)	SN_L
1	85/15	4.3	17	40.95	32.24
2	85/15	8.5	19	51.04	34.15
3	85/15	13.1	21	62.43	35.90
4	80/20	4.3	19	31.3	29.91
5	80/20	8.5	21	58.98	35.41
6	80/20	13.1	17	66.56	36.46
7	75/25	4.3	21	56.95	35.10
8	75/25	8.5	17	54.9	34.79
9	75/25	13.1	19	64.2	36.15

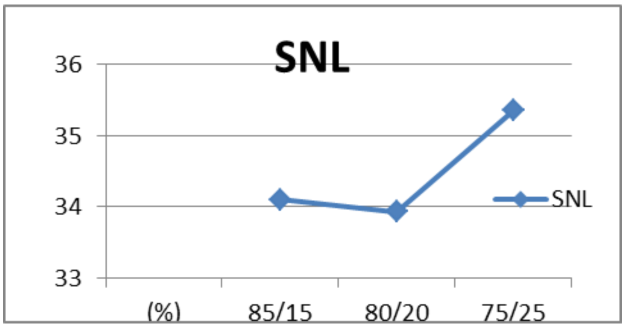

Fig. 4: S/N$_L$ Ratio v/s Bio-Diesel Proportion of Mechanical Efficiency

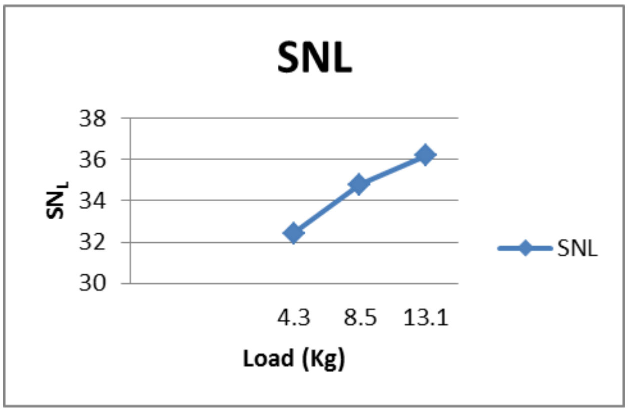

Fig. 5: S/N$_L$ Ratio v/s Load of Mechanical Efficiency

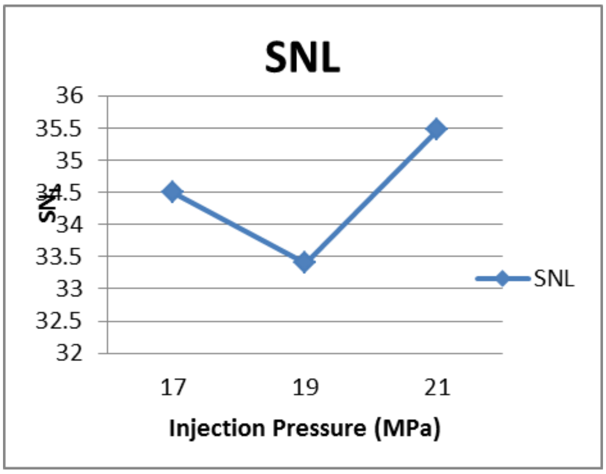

Fig. 6: S/N$_L$ Ratio v/s Injection Pressure of Mechanical Efficiency

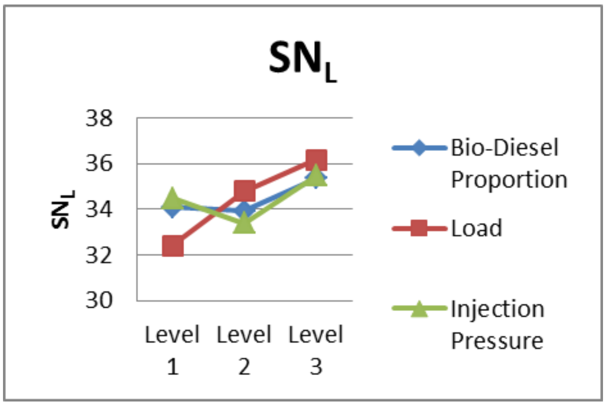

Fig07: S/N$_L$ Ratios of Variance v/s Levels

Table04: Response Table of Mech. Efficiency

Sr. No.	Engine Parameters	Mean S/N$_L$ Ratio				
		Level1	Level 2	Level3	Max - Min	Opt. Level
1	Bio-Diesel Proportions	34.10	33.92	35.35	1.42	35.35
2	Load	32.42	34.78	36.17	3.75	36.17
3	Injection Pressure	34.50	33.40	35.47	2.07	35.47

Table. 5: ANOVA Table of Mechanical Efficiency

Symbol	Engine parameter	Degree of freedom	Sum of square	Mean square	F test	% contribution
A	Bio-Diesel Proportion	2	3.60	1.80	0.80	9.98
B	Load	2	21.6	10.8	4.83	59.8
C	Injection Pressure	2	6.43	3.21	1.44	17.8
Error		3	4.46	2.23		12.3
Total		9	36.1	18.0		100

CONCLUSION:

The optimum values obtained from the analysis for Mechanical efficiency is 3-3-3 (Bio-Diesel Proportion-Load-Injection Pressure). The optimum levels are as follows,

1. 75% Diesel and 25% Bio-Diesel Proportion
2. 13.1 (Kg) Load
3. 21 (Mpa) Injection Pressure

Using these optimum values the test was conducted again and the value of Mechanical Efficiency obtained is 68% approximately.

REFERENCES

W.H. Yang et al, *Design optimization of cutting parameters for turning operations based on the Taguchi method,* Journal of Materials Processing Technology 84 (1998) 122–129

Nazan Danacioglu et al, *Taguchi Techniques For 2k Fractional Factorial Experiments* , Hacettepe Journal of Mathematics and Statistics Volume 34 (2005)

Prof. N. S. Dhole[1]*, Prof. R. D. Rajopadhye[2], Mr. A. S. Mahajan[3]

Dong-Woo Kim et al, *Application of Design of Experiment Method for Thrust Force Minimization in Step-feed Micro Drilling,* Division of Mechanical Engineering, Inha University, Incheon

Jayashri N Nair et al, *Study of Biodiesel Blends and Emission Characteristics of Biodiesel,* International Journal of Innovative Research in Science, Engineering and Technology

T. W. Simpson, *Concurrent Engineering*

Edwin B. Dean, *Taguchi Approach To Design Optimization For Quality And Cost: An Overview*

Zurnila Marli Kesuma, *Analysis of Variance for Attribute Data in Taguchi 's Approach*

Jawad Nagi et al, *Palm Biodiesel an Alternative Green Renewable Energy for the Energy Demands of the Future,* Universiti Tenaga Nasional, *Malaysia*

Raghu N. Kacker et al, *TaguchVs Orthogonal Arrays Are Classical Designs of Experiments,* Journal of Research of the National Institute of Standards and Technology

N.K. Sharma et al, *Signal-to-Noise ratio and design complexity based on Unified Loss Function–LTB case with Finite Target,* International Journal of Engineering, Science and Technology Vol. 3, No. 7, 2011, pp. 15-24

Rama Rao. S et al, *Application of Taguchi methods and ANOVA in optimization of process parameters for metal removal rate in electrochemical machining of Al/5%SiC composites,* International Journal of Engineering Research and Applications (IJERA) Vol. 2, Issue 3, May-Jun 2012, pp. 192-197

Corresponding Author

Prof. N. S. Dhole*

Head of Department, Rajendra Mane College of Engineering, Ambav, Maharashtra, India

E-Mail – nimdho@rediffmail.com