ISSN: 2348 – 8360 /doi:10.14445/23488360/IJME-V5I5P101 © 2018 Seventh Sense Research Group®

Optimizing the Performance and Emission Parameter of Single Cylinder Diesel Engine by using Nanoparticle as Additive by Taguchi Method

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Abstract — *This study involves the evolution of the optimum ci engine parameter using nanoparticles as additives in-plane diesel. Nanoparticles such as Titania (TiO2) Cerium Oxide (CeO2) are used for doping. The nanoparticle's only 30ppm is used and mixed using the ultrasonicator three variable parameters to experiment: comperation ratio, load, and injection pressure for Taguchi analysis.*

Keywords — *Titania (tio2), cerium oxide (ceo2), Ultrasonicator, Taguchi.*

I. INTRODUCTION

According to the statistical review of world energy published by British Petroleum, the increase of oil reserves worldwide from 2012 to 2013 is 0.60%, whereas oil consumption increases from 2012 to 2013 is 1.40%. [1] Due to the increasing awareness of the depletion of fossil fuel resources and environmental issues, biodiesel became more attractive. Biodiesel is a promising field of research because it provides a good result. [2] In the present situation, there is much possibility of a multifold increase in the research in biodiesel, vegetable oils like soybean oil, rapeseeds oil, sunflower oil, methanol, ethanol, and other alternate fuels. Continuous research is a substitute for diesel. Researchers are constantly discovering the best elective arrangement, which gives the best execution and fuel attributes. [3]

DOE is a technique of defining and investing all possible combinations in an experiment involving multiple factors and identifying the best combination. In this, different

Factors and their levels are identified. DOE is likewise valuable to join the variables at fitting levels, each with the satisfactory individual range, to produce the best results and yet exhibit minimum variation around the optimum results. The methods of Design of Experiment are as follows:

1) Full Factorial method,
2) Taguchi method,
3) Response surface method and
4) Mixture method.

Among the available methods, Taguchi design is one of the most powerful DOE methods for analyzing the experiment. The salient features of this method are [3]

1) A simple, efficient, and systematic method to optimize the process to improve performance and reduce cost.
2) Help arrive at the best parameters for the optimal conditions with the least number of experiments.

II. EXPERIMENT SETUP

A single cylinder 4 stroke Diesel, water-cooled, control 3.5 kW at 1500 rpm engine is used to experiment with the detailed sketch shown in the figure below. (1)

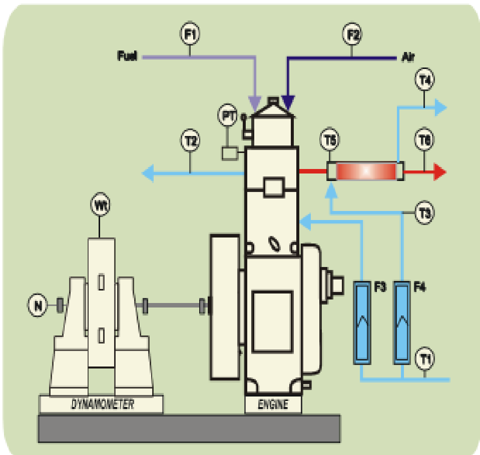

Figure 1: engine line diagram

The equipment used for proper mixing of nanoparticle with nanoparticles is ultrasonicator, which uses the sound at a high frequency that is 45KH which vibrates the diesel to a level that it will form a homogeneous mixture .for making of 30ppm an amount of 0.024g of the nanoparticle is used .the amount required is weighed by using a high precision weighing machine. Figure (2) shows the ultrasonic or used for mixing of the nanoparticle.

Figure 2: Ultrasonictor

III. Taguchi's Design Method

Optimization of process parameters is the key step in the Taguchi method for achieving high quality without increasing cost. This is because the optimization of process parameters can improve quality characteristics. The optimal process parameters obtained from the Taguchi method are insensitive to the variation of environmental conditions and other noise factors. Established process parameter configuration is perplexing and difficult to utilize. An extensive number of trials must be completed when the number of process parameters increments. To solve this task, the Taguchi method uses a special design of orthogonal arrays to study the entire process parameter space with a small number of experiments only. A loss function is then defined to calculate the deviation between the experimental value and the desired value. Taguchi recommends using the loss function to measure the deviation of the quality characteristics from the desired value. The value of the loss function is further transformed into a signal-to-noise (S/N) ratio. There are 3 Signal-to-Noise ratios of common interest for optimization

(1) Smaller-The-Better:
N= - 10 Log10 [mean of the sum of squares of measured
Data]
(2) Larger-The-Better:
N= - 10 Log10 [mean of sum squares of reciprocal of measured data]
(3) Nominal-The-Best:
N=10 Log10 (square of the mean)/Variance.

A. Work Material

The work material used for the present work is *Titania (tio2), cerium oxide (ceo2), Ultrasonicator, Taguchi.*

Table 1.parameters and their levels

Parameters	Symbol	Level1	Level2	Level3
Load (KG)	A	3	6	9
Injection Pressure (IP)	B	160	170	180
Compression ratio (CR)	C	16	17	18

B. L9 Taguchi Orthogonal Array

Taguchi's orthogonal design uses a special set of predefined arrays called orthogonal arrays (OAs) to design the experiment's plan. These standard arrays stipulate the method for full data of the considerable number of components that influence procedure execution (process responses). The corresponding OA is selected from the set of predefined OAs according to the number of factors and their levels used in the experiment. In the present study, three 3-level process parameters, i.e., Load, Injection Pressure (IP), Completion ratio (CR), are considered. The values of the ENGINE process parameters are listed in Table (). The ranges and levels are fixed based on the screening experiments. The interaction effect between the parameters is not considered.

Table2.Orthogonal array"

Expt no	***Process parameters***		
	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

C. Analysis Of S/N Ratio

In the Taguchi method, the term 'signal' represents the desirable value (mean) for the output characteristic, and the term 'noise' represents the undesirable value (standard deviation) for the output characteristic. In this manner, the S/N proportion to intend to the SD. S/N proportion is used to quantify the quality characteristics for desire value. The S/N ratio S is defined as S= -10 log (MSD), where MSD is the mean square deviation for the output characteristic. To obtain optimal engine performance, higher-the-better quality characteristics for thermal brake efficiency must be taken. The MSD is the higher-the better quality characteristic can be expressed

M.S.D. = $\sum 1/P_i 2$

Where P_i is the value of penetration.

Table3. Experimental result for BTHE % and CO%

Expt No	**L**	**Injection Pressure (IP)**	**Compration ratio (CR)**	**BTHE % Tio2**	**BTHE % Ceo2**
1	3	160	16	10.69	11.14
2	3	170	17	10.55	8.55
3	3	180	18	9.48	9.28
4	6	160	17	16.26	16.5
5	6	170	18	16.07	15.26
6	6	180	16	14.39	14.3
7	9	160	18	19.71	19.74
8	9	170	16	19.46	18.59
9	9	180	17	16.75	17.04

Fig No 3. Main Effects Plot SN for tio2Ratio Means for bthe %

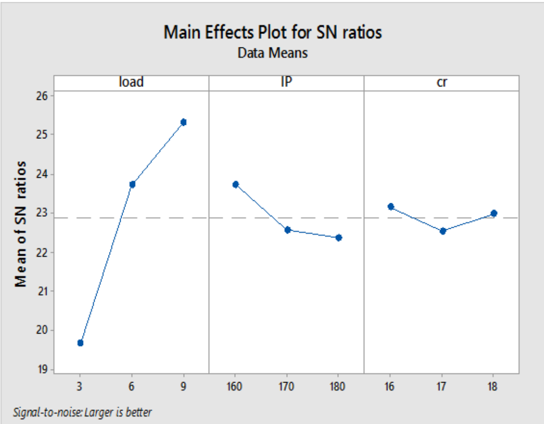

Table no 4. S/N ratio for bthe %

sr	**load**	**IP**	**cr**	**SNRA1**
1	3	160	16	20.57955
2	3	170	17	20.46505
3	3	180	18	19.53617
4	6	160	17	24.22241
5	6	170	18	24.12032
6	6	180	16	23.16122
7	9	160	18	25.89373
8	9	170	16	25.78286
9	9	180	17	24.4803

Fig. No 4. Main Effects0020Plot S/N for ceo2 ratio bthe %

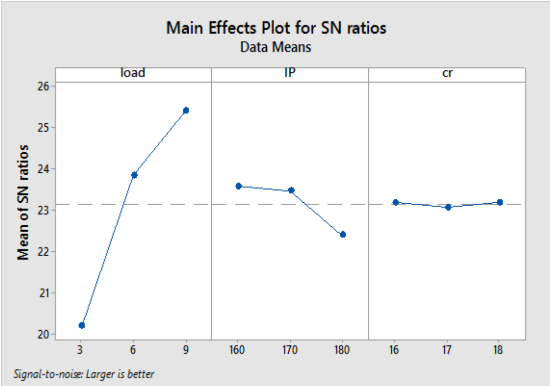

Table no 5. S/N ratio for bthe %

sr	**load**	**IP**	**cr**	**SNRA1**
1	3	160	16	20.9377
2	3	170	17	18.63932
3	3	180	18	19.35096
4	6	160	17	24.34968
5	6	170	18	23.67109
6	6	180	16	23.10672
7	9	160	18	25.90694
8	9	170	16	25.38559
9	9	180	17	24.62939

Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio. The S/N response table for hardness is shown in Table4 below

D. ANOVA (Analysis Of Variance)

The purpose of the variance analysis (ANOVA) is to investigate which design parameters significantly affect the quality characteristic. This is to achieve by isolating the aggregate inconstancy of the S/N proportions, which is estimated by the whole of the squared deviations from the aggregate mean S/N proportion, into contributions by each of the design parameters and the error. First, the total sum of squared deviations SST from the total mean S/N ratio can be calculated

Table6.Analysis of Variance BTHE % versus load, IP, cr

Source	DF	Seq SS	Contribu tion %	F-Value	P-Value
load	2	108.409	92.82	218.85	0.005
IP	2	7.403	6.34	14.95	0.063
cr	2	0.485	0.42	0.98	0.505
Error	2	0.495	0.42		
Total	8	116.793	100.0		

Table7.Analysis of Variance bthe versus load, IP, cr

Source	DF	Seq SS	Contributi on%	F-Value	P-Value
load	2	119.523	92.51	226.19	0.004
IP	2	8.185	6.34	15.49	0.061
cr	2	0.958	0.74	1.81	0.355
Error	2	0.528	0.41		
Total	8	129.194	100.00		

IV. CONCLUSIONS

From the above results and Taguchi and ANOVA analysis following conclusion are done

1. Taguchi method is found to be suitable for obtaining optimum parameters.
2. The optimum parameter for tio_2 nanoparticles mix diesel is 9 load in Kg,160 injection pressure in bar,16 compression ratio
3. The optimum parameter for ceo_2naopaticle mix diesel is 9 load in Kg,160 injection pressure in bar,16 compression ratio
4. From the ANOVA method, it is clear that the load contribution to performance in max e.i up to 92%.

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