Performance Optimization of CI Engine Fueled by Biodiesel and Hydrogen with Dee Injection

J.Dhiyaneswaran, S.Mohamed Raakin , M.Praveen Kumar, A.Kapilan, J.Manikandaprasanth

Abstract: The present concern on energy demands, leads to a growing interest on alternative fuels like biodiesel, alcohol, biogas, hydrogen and producer gas. To provide a sustainable solution, conventional engines suitably modified and experimented for favorable results. In this context the present work deals with a newer approach of performance optimization of CI engine using biodiesel and hydrogen with Diethyl ether (DEE) injection. Biodiesel from pongamia pinnata and hydrogen are used as fuel and DEE is used as an ignition improver. To optimize the engine performance following parameters are considered injection timing of DEE and crank angle position. With the help of taguchi technique L25 orthogonal array is used to have various combinations of parameters. Experiments has been conducted for 12 lpm of hydrogen at constant flow rate. The DEE is injected at 44°, 88°, 132°, 176°, and 220° of crank angle position with help of electronic control unit. Compared to diesel the biodiesel hydrogen blend, operation with ignition improver at 3 ms of DEE and 132° of crank angle position, brake thermal efficiency is increased with considerable reduction in emission.

***Index Terms*: DEE,CI,Hydrogen,Pongamia Pinnata**

I. INTRODUCTION

Among the several alternative fuels, hydrogen is a long-term renewable and least polluting fuel (produced from renewable energy sources). Its clean burning characteristics help to meet the stringent emission norms. Hydrogen is expected to be one of the most important fuels in the near future to meet the stringent emission norms [1,2]. A significant reduction in power output was observed while using hydrogen in SI engine In addition pre ignition, backfire and knocking problems were observed at high load. These problems have resulted in using hydrogen in SI engine within a limited operation range [3,4].

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A. Methodology

The methods followed in the project has been discussed below.

I. Selections of load variations, and then different type of fuel used
II. Optimizing number of parameters and the outputs
III. The methodology of this work is given in Figure
IV. The Pongamia pinnata biodiesel is used as the fuel for the CI engine. Along with the biodiesel, DEE is injected and the hydrogen is inducted, finally optimized the best injection timing of DEE and crank angle positions

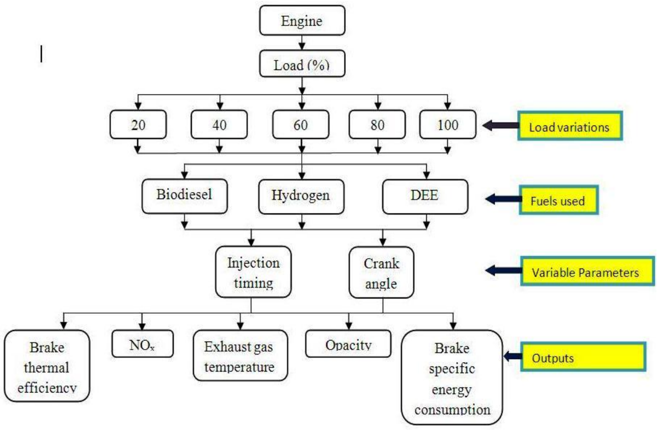

Figure.no 1.1 Methodology

II. PROCESS PARAMETERS

From the literature review and the previous work can be done by researchers were concluded that these are most important process parameters which have the greater influence than other process parameters. The most important process parameters are

- Injection timing-DEE (ms)
- Crank angle (°)

A. SELECTION OF LEVELS

Selection of level for the parameters depends upon the number of experiments were carried out and the working range of process parameters. The range of process parameters selection and their levels for the present study and the constant process parameters are shown in the Table 1.1.

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Table no 1.1 Process Parameters and Levels

Crank angle (°)	Injection timing-DEE (ms)
44	1
88	1.5
132	2
176	2.5
22O	3

B. SELECTION OF ORTHOGONAL ARRAY

Hence we choose L25 orthogonal array was selected. Selection of process parameters under the present study is two, and the number of levels for each parameter is five. To calculate the degrees of freedom (DOF) by using the formula is

Degree of freedom (DOF) = N*(n-1)

Where, N = Number of process parameters

n = Number of levels

DOF = 2*(5-1) = 8.

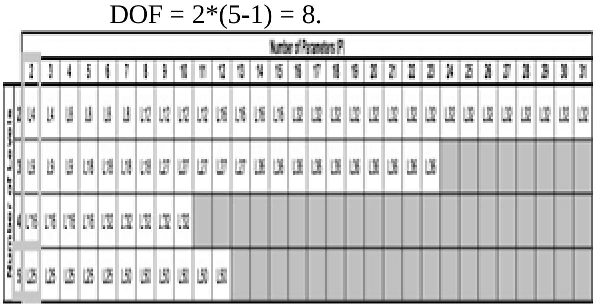

Figure no. 1.2 Array selector

From the array selector table the horizontal part shows the number of parameters and vertical shows the number of levels. For two parameters and five levels L_{25} array is chosen from the reference Figure.

III. ENGINE DESIGN AND MODIFICATIONS

A single-cylinder, 4-Stroke, water-cooled diesel engine of 5.2 kW rated power is considered for the purpose of experimentation. The schematic layout of the experimental set up is shown in Figure 1.3.

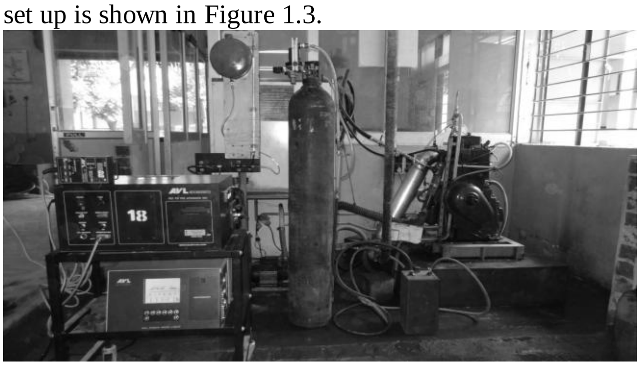

Figure.no.1.3 Experimental Setup Overview

Cooling water is circulated separately to the engine at the required flow rates. Necessary provisions are made to regulate and measure the flow rates of the air, fuel and the coolant. Based on the temperature indicator and smoke meter, the engine performance is tested. A smoke meter type AUL 437C with paper feed is used. The smoke meter is connected to the exhaust line. The exhaust smoke temperature and the opacity of smoke are measured.

IV. RESULTS AND DISCUSSION

A. FIND THE OPTIMUM POINT FOR MAXIMIZE THE ENGINE PERFOMANCE

To determine the optimum point for each parameter, the average value of SN ratio has to be determined. From the results obtained the optimum value for brake thermal efficiency is found. The optimum value of injection timing DEE was 3 ms and crank angle was 132°. The graph is plotted in Figure 1.4.

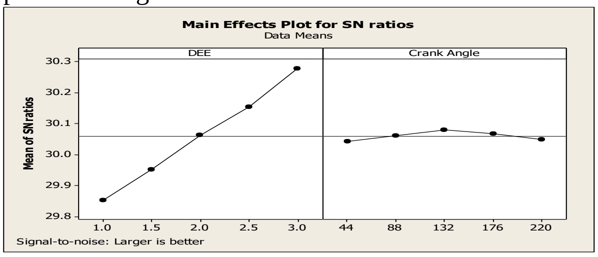

Figure.no 1.4 Response Value for Brake Thermal Efficiency

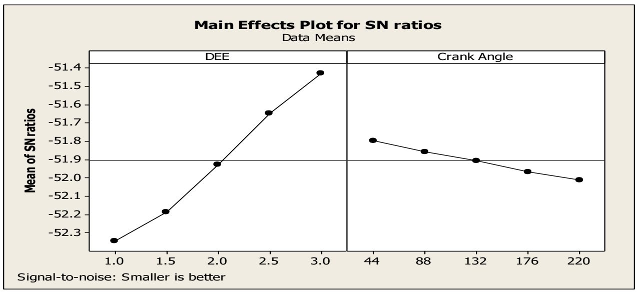

Figure.no 1.5 Response Value for Engine Exhaust Temperature

From the results obtained the optimum value for engine exhaust temperature is found. The optimum value of injection timing DEE was 3 ms and crank angle was 44°. The graph is plotted in Figure 1.5.

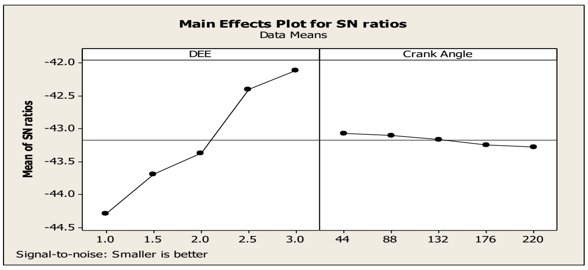

Figure.no 1.6 Response Value for Oxides of Nitrogen

From the results obtained the optimum value for oxides of nitrogen is found.

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The optimum value of injection timing DEE was 3 ms and crank angle was 44°. The graph is plotted in Figure1.6.

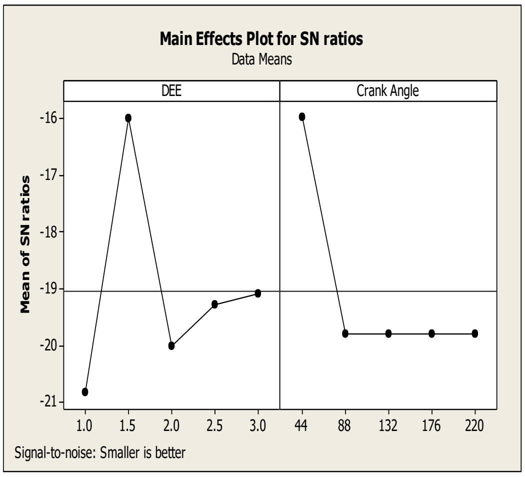

Figure.no 1.7 Response Value for Hydrocarbon

From the results obtained the optimum value for hydrocarbon is found. The optimum value of injection timing DEE was 1.5 ms and crank angle was 44°. The graph is plotted in Figure1.7.

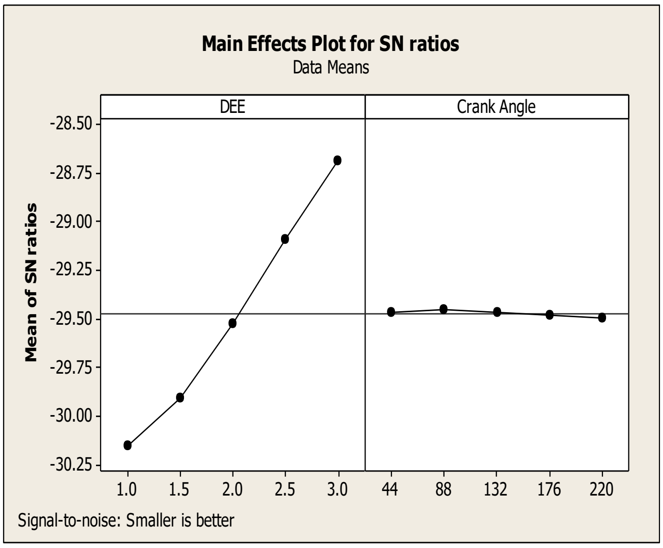

Figure.no 1.8 Response Value for Smoke

From the results obtained the optimum value for smoke is found. The optimum value of injection timing DEE was 3 ms and crank angle was 88°. The graph is plotted in Figure1.8.

B. BRAKE THERMAL EFFICIENCY

The brake thermal efficiency of biodiesel and hydrogen with DEE injection are given in Table1.2.
The efficiency is higher when engine operated at 12 lpm of hydrogen, injection timing of DEE at 3 ms with 80% load conditions.

Table no 1.2 Brake Thermal Efficiency

LOAD (%)	DIESEL (%)	BIODIESEL (%)	BIODIESEL+ H_2 @10 LPM (%)	BIODIESEL + H_2 @ 12 LPM +DEE (1ms) (%)	BIODIESEL + H_2 @ 12 LPM + DEE (2ms) (%)	BIODIESEL + H_2 @ 12 LPM +DEE (3ms) (%)
20	16	14.72	15.98	16.17	16,34	16.98
40	22	20.49	21.97	21.84	22.13	22.98
60	28	25.45	28,03	27.97	28.31	29.85
80	32	29.32	31.76	31.17	31.94	32.73
100	31	28.28	30.56	30.89	31.29	-

V. CONCLUSION

The engine was operated at a constant speed of 1500 rpm with load percentages varying from 20%, 40%, 60% up to the full load with biodiesel and hydrogen-DEE blend. For each loads the engine performance and emission parameters such as brake thermal efficiency, exhaust gas temperature, NOx, HC and smoke percentage are recorded, tabulated and plotted. The experiments were carried out for constant flow of H2 and biodiesel as a main fuel with DEE injected through the high pressure injector. Injection timing of DEE was set to 1 ms,1.5 ms, 2 ms, 2.5 ms and 3 ms. Two bar pressure was maintained in the injection circuit. The crank angle was varied from 44°, 88°, 132°, 176° and 220°. The maximum efficiency has been achieved at the following parameters such as 80% of load applied, 12 lpm of hydrogen, 3 ms of DEE injection and 132° crank angle position. The optimum point for DEE injection timing and crank angle are 3 ms and 44° for both the engine exhaust gas temperature and oxides of nitrogen. The optimum point of the injection timing of DEE and crank angle of engine for hydrocarbon are 1.5 ms and 44° respectively. The optimum point of the injection timing of DEE and crank angle of engine for smoke are 3 ms and 88° respectively.

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