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RESEARCH ARTICLE

COMBINE EFFECT OF DIMETHYL ETHER (DME) AS AN ADDITIVE & THE INJECTION PRESSURE ON BSFC & BRAKE THERMAL EFFICIENCY OF 4 STROKE C.I ENGINE

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Abstract

In this work, an experimental work is carried out on single cylinder four stroke diesel engine. Dimethyl ether (DME) is used as an additive with diesel in different percentage (5%,10%,& 15%). DME [CH_3O CH_3] is mostly commonly produced from natural gas. Also DME has a high cetane number and superior vaporization quality compare with diesel. So it is suitable to use in diesel engine for better performance of engine. For this experiment, Taguchi method is used for optimization. For this optimization, parameters are taken as % of DME, Injection pressure and Load. Injection pressure taken as 160bar,180bar,200bar &220bar. Load is taken as 1kg,4kg,7kg & 10kg. After an experiment, taguchi gives optimum result for lowest brake specific fuel consumption (BSFC) and higher brake thermal efficiency($b_{theffi)}$ at 15% DME, 180bar injection pressure, 10kg load. It is also concluded that engine performance is mostly affected by Load and little the effect of injection pressure

INTRODUCTION

The reserve of petroleum over the world is limited. It is very important to save petroleum fuels or find some substitutes. The precise scale of oil reserves left and the ultimate availability of fossil fuels worldwide are hard to determine. Petroleum energy is the basic energy source in the transportation and industrial fields. Many alternative or blend fuels are indentified and tested successfully in the existing engine with and without engine modification. However, research is still continuing in this field to find the best alternative fuel for the existing diesel fuel. As per current scenario, India is a diesel based economy. Diesel consumption is around five times the consumption of petrol. So, to reducing the pollution & achieve a great economical benefit, we have to find suitable alternatives for diesel engine and must be do research work on them. DME has a higher cetane number than diesel, and hence can be used in diesel engines. It is completely safe with no adverse impact on health, and hence no health hazards are foreseen with widespread use of DME. It has no sulfur content, and hence does not produce Sox emissions. It has no direct carbon-carbon bond and hence has lower chances of soot formation. An experimental work for I.C engine involves the many number of experiments, so time consumption & cost of experiment are increases. Therefore design of experiment methods are employed in some experimental work. Applying the DOE methods, it decreases the number of experiments with gives best combination of parameters. Parameters like involves are different blends, injection pressure, load etc.

DI-METHYL ETHER (DME)

Di-methyl ether is the simplest ether, consisting of two methyl groups bonded to a central oxygen atom, as expressed by its chemical formula CH_3-O-CH_3. DME most commonly produced from natural gas. Other potential uses of DME include a substitute for other fuels in power generation and in the household and, in the future, a source of hydrogen for fuel cells.

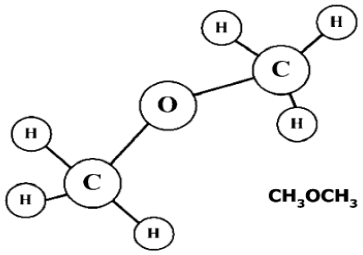

Fig. 1 Structure of DME

DME contains oxygen and no carbon-carbon bonds, thus seriously limiting the possibility of forming carbonaceous particulate emission during combustion. When used as a CI engine fuel, DME provides reduced NOx emission, but increase CO and HC, which however, can be easily controlled by an oxidation catalyst.

Table 1 Properties of diesel and DME

Properties (condition)	Unit	DME	Diesel
Chemical structure		CH_3-O-CH_3	
Molar mass	g/mol	46	170
Carbon content	Mass%	52.2	86
Hydrogen content	Mass%	13	14
Oxygen content	Mass%	34.8	0
C-to-H ratio		o.337	0.516
Cetane number		>55	40-50
Auto-ignition temperature	K	508	523
Stoichiometric A-F ratio		9	14.6
Lower heating value	Mj/kg	27.6	42.5
Density	Kg/m^3	660	832
Viscosity	cSt	1	3

EXPERIMENTAL SET-UP

The setup consists of single cylinder, four stroke, water cooled diesel engine. The engine is coupled to a rope brake dynamometer through a load cell. The injection point can be changed for research tests. On the upper part of plunger the adjustable screw is attached to the injector. By varying the position of plunger, change in injection pressure is achieved. A simple and accurate flow measuring device utilizes a pipette of 50 ml capacity for engine of small and medium size. The pipette is then supported vertically in a suitable holder at height considerable above that of carburetor float chamber of the engine. The lower outlet of pipette, the main fuel supply pipe and the pipe to carburetor or pump are all connected to union of three way cock.

Table 2 Engine Specification

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

METHODOLOGY

The experiment has been performed on 4 stroke single cylinder diesel engine. In this experiment, Dimethyl ether (DME) used as an additive with diesel with different percentage of 5%, 10% & 15% With supplying of these blends , injection pressure was also change. Taguchi method is used for this experiment. This method uses a special set of arrays called orthogonal arrays. These standard arrays stipulates the way of conducting the minimal number of experiments which could give the full information of all the factors that affect the performance parameter. The orthogonal arrays method lies in choosing the level combinations of the input design variables for each experiment. In this present study, three factors and four levels are involved with taguchi method. So, the orthogonal array becomes L16 for conduct the experiment. Three factors are included that % of DME, Injecton pressure and Load.

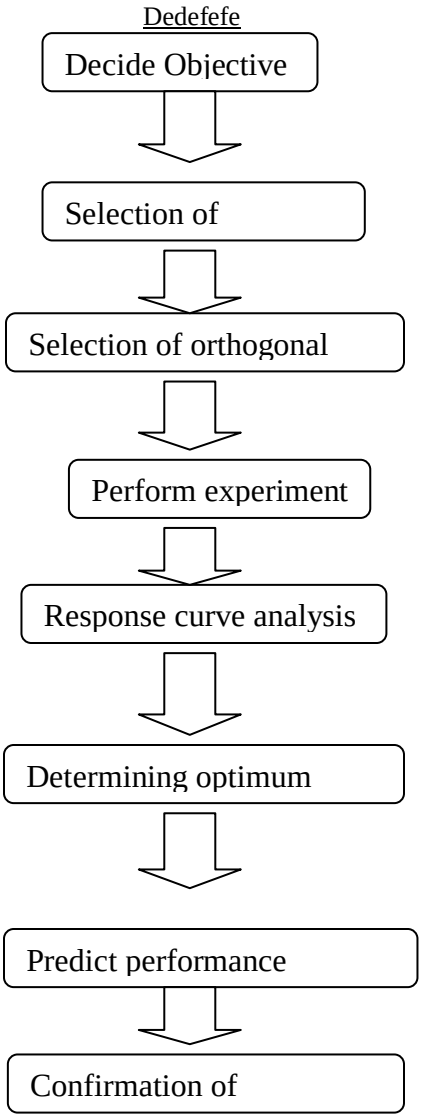

Fig. 2 Steps of Taguchi Method

Table 3 Selection of parameters & levels

SR NO.	Parameter	Level 1	Level 2	Level 3	Level 4
1	% of DME with diesel	0	5	10	15
2	Injection Pressure (bar)	160	180	200	220
3	Load (kg)	1	4	7	10

After completing an experiment as per orthogonal array, analysis was done in taguchi method in Mini tab 16 software. The graph includes means of means and S/N Ratio. Higher S/N ratio is considered for optimum value.There are three kinds of S/N ratio. For BSFC lower -the-better is used. For brake thermal efficiency larger-the-better is used. Optimum combinations of BSFC & Brake thermal efficiency are evaluated from the graph, response tables and predicting the values.

RESULT AND DISCUSSION

An experiment was done as per L16 orthogonal array. Table no. 4 indicates the dfferent values of BSFC and Brake thermal efficiency for different number of experiment. The table is obtain in taguchi method in Minitab 16 software.

Table 4 L16 Orthogonal array

SR NO.	% of DME with diesel	Injection Pressure (bar)	Load (kg)	BSFC (brake specific fuel consumption) kg/kWh	B_{thef} (brake thermal efficiency) %
1	0	160	1	1.4700	5.830
2	0	180	4	0.4800	17.800
3	0	200	7	0.3260	26.250
4	0	220	10	0.2700	31.660
5	5	160	4	0.4600	18.730
6	5	180	1	1.3700	6.350
7	5	200	10	0.2640	32.940
8	5	220	7	0.3150	27.670
9	10	160	7	0.3094	28.580
10	10	180	10	0.2530	34.940
11	10	200	1	1.3900	6.350
12	10	220	4	0.4420	20.010
13	15	160	10	0.2410	37.240
14	15	180	7	0.2980	30.150
15	15	200	4	0.4430	20.270
16	15	220	1	1.4800	6.058

RESPONSE CURVE ANALYSIS FOR BSFC:

Response curve analysis is the graphical representation of the variation of input and output parameters. It gives the optimum combination of parameters. For BSFC variation of input and output parameters are graphically indicated in fig.3 and fig. 4. Graph indicates Main effect plot for means and Main effect plot for S/N ratio.

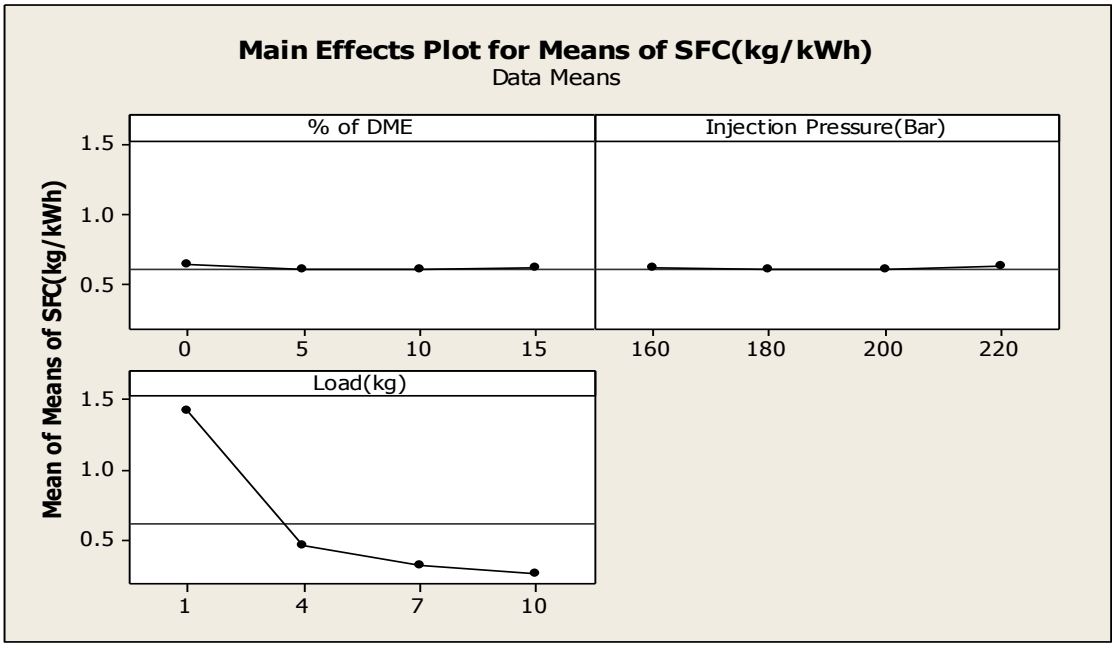

Fig. 3 Main effect plot for means of SFC(kg/kWh)

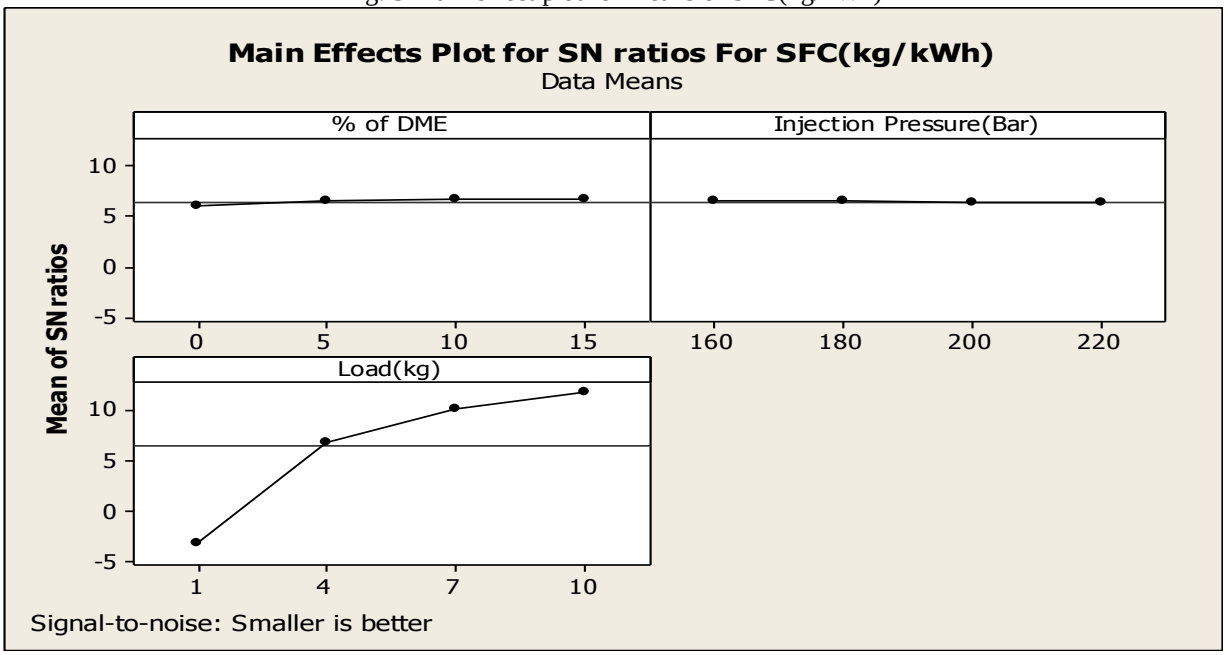

Fig. 4 Main effect plot for S/N Ratio for SFC(kg/kWh)

CHOOSING OPTIMUM COMBINATION OF PARAMETER LEVEL

Table 5 is a response table for S/N Ratio corresponding with graph. Delta is the difference between higher value and lower value. Higher rank indicates the it has a major effect on engine performance. In this experiment Load has a more effect and lower effect of Injection pressure. As per shown in response table and graph for S/N Ratio the optimum values of parameters are 15% of DME, 180bar Injection pressure, 10kg Load.

Table 5. Response table for SN ratio for BSFC

RESPONSE TABLE FOR SN RATIO FOR BSFC			
LEVEL	**% OF DME**	**INJECTION PRESSURE (Bar)**	**Load (kg)**
1	6.034	6.487	-3.087
2	6.403	6.524	6.821
3	6.59	6.379	10.119
4	6.636	6.273	11.809
Delta	0.601	0.25	14.896
Rank	2	3	1

PREDICT PERFORMANCE AT OPTIMUM SETTING

Table 6 Optimum output

S/N Ratio	**SFC (kg/kWh)**
12.1373	0.246325

RESPONSE CURVE ANALYSIS FOR BRAKE THERMAL EFFICIENCY:

Graphical representation is shown below graph for brake thermal efficiency Vs % of DME, Injection pressure (bar), Load (kg).

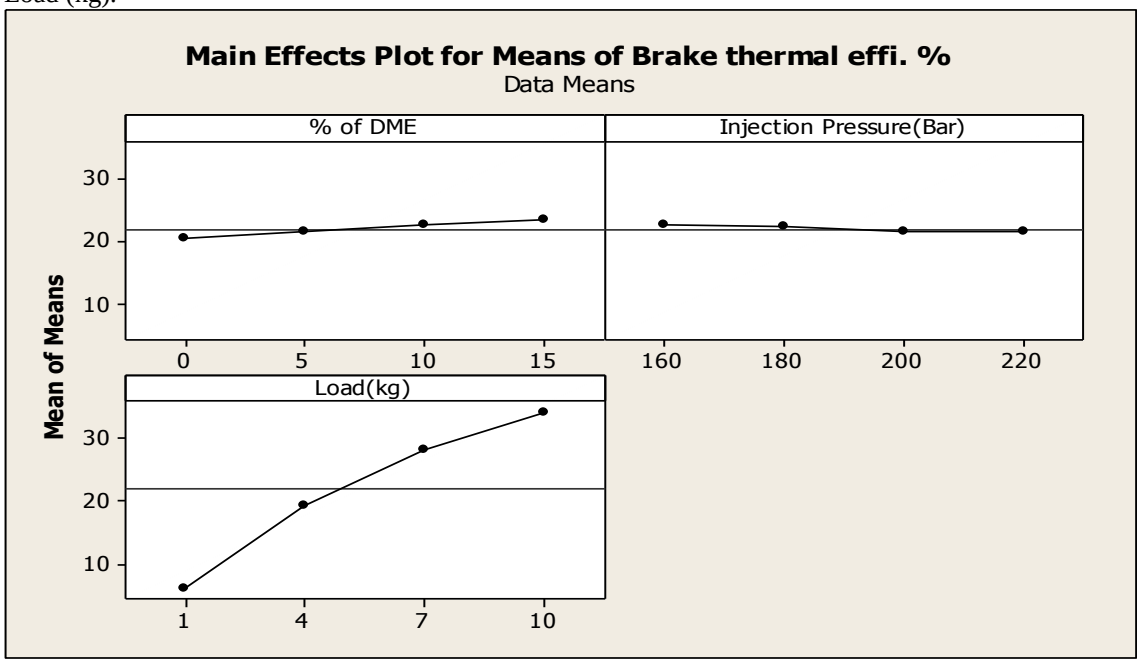

Fig. 5 Main effect plot for means of Brake thermal efficiency(%)

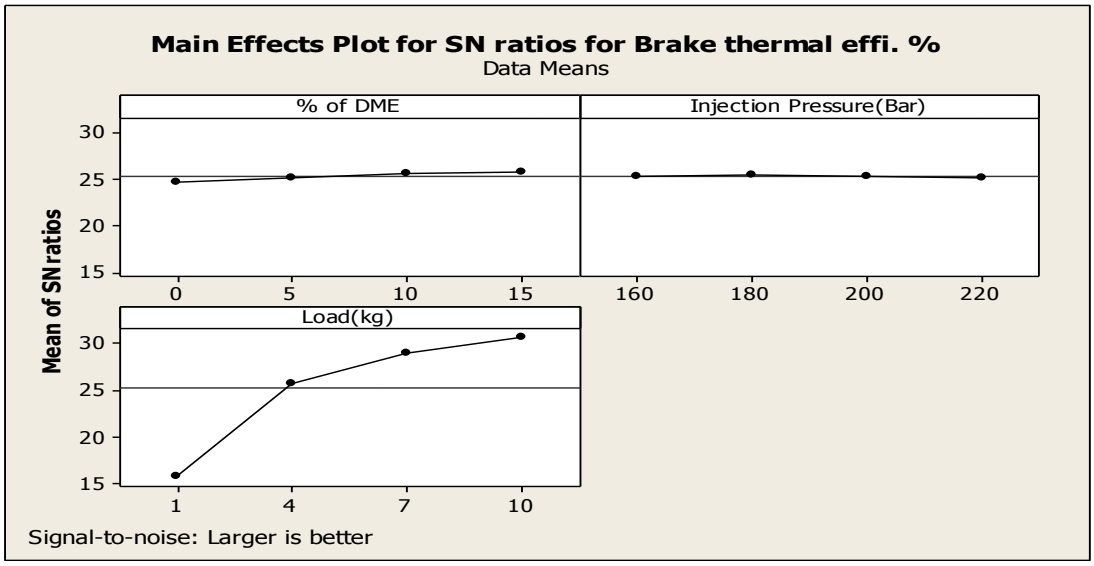

Fig. 6 Main effect plot for **S/N Ratio** of Brake thermal efficiency(%)

From the graph of means and SN Ratio it indicates that Brake thermal efficiency slightly increases with increasing % of DME with diesel. There is a no effect of injection pressure. Major effect is done by Load, when it increases, Brake thermal efficiency is increased. For brake thermal efficiency higher the better SN Ratio considered.

CHOOSING OPTIMUM COMBINATION OF PARAMETER LEVEL

From the table 7 it is concluded that there is a little effect of injection pressure.

Table 7 Response table for SN Ratio for Brake thermal efficiency

Response table for SN RATIO OF BRAKE THERMAL EFFICIENCY %			
LEVEL	% of DME	INJECTION PRESSURE(Bar)	Load(kg)
1	24.68	25.33	15.77
2	25.18	25.38	25.66
3	25.52	25.23	28.98
4	25.7	25.13	30.66
Delta	1.02	0.25	14.9
Rank	2	3	1

Optimum combination of parameter for higher Brake thermal efficiency are 15% of DME, 180bar Injection pressure, and 10kg Load.

PREDICT PERFORMANCE AT OPTIMUM SETTING

Table 8 Optimum Output

S/N Ratio	**Brake thermal efficiency %**
31.2051	36.081

CONCLUSION:

From the above analysis it is concluded that for lower BSFC and Higher Brake thermal efficiency, Optimum parameters are 15% of DME, 180bar Injection pressure and 10kg Load. For both cases it is noted that little effect of injection pressure and major effect of Load are occur. Brake thermal efficiency slightly increases with increasing % of DME in diesel.

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