IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 17, Issue 2 Ser. I (Mar - Apr 2020), PP 33-42
www.iosrjournals.org

Performance Analysis of Single Cylinder CI EngineFuelled with Diesel, Olive Oil and Kerosene Blends Using Taguchi's Approach

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Abstract: *The point of this work is to break down of the exhibition for different mixes of the Diesel, Kerosene and Olive Oil biodiesel. Tests have been completed utilizing a solitary chamber, four-stroke, variable pressure proportion CI engine filled with Olive Oil biodiesel and its mixes with Diesel and Kerosene. The test has been led utilizing the Olive Oil was mixed with (Diesel 70% + Kerosene 30%) by rates of (Diesel 70% + Kerosene 30%) 95% + Olive Oil 05%, (Diesel 70% + Kerosene 30%) 90% + Olive Oil 10% and (Diesel 70% + Kerosene 30%) 85% + Olive Oil 15%.The percent biodiesel (Diesel100, DK, DK95O5, DK90O10, DK85O15) and load (2, 4, 6, 8, 10 kg) are considered as input parameters. The responses for the experiments are specific fuel consumption (SFC), brake thermal efficiency (BTHE), mechanical efficiency (ME) and fuel consumption. Taguchi approach is used to reduce the number of experiments. The optimum sets of the parameters are selected on signal-to-noise ratio basis.*

Keywords: *Diesel, Kerosene, Olive Oil, Performance.*

Date of Submission: 28-02-2020 Date of Acceptance: 13-03-2020

I. Introduction

Everyday populace is expanding. The improvement of megacities and urban areas increments with the goal that the utilization of car vehicles, for example, vehicle, bike, business vehicle, and so forth increments (Wang et al., 2004). Air contamination is an effect medical issue. Vehicle exhaust in many gases is hydrocarbons (HC), carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NOx), lead, smoke or molecule matters, Sulphur dioxide (SO_2) and so forth (Parikh et al., 2007; Samaras et al., 2008). Air contamination can hurt wellbeing like aggravation of eyes, nose, throat torment, hacking, chest snugness issue, and so forth (Parks et al., 2007). Air contamination can cause an assortment of ecological impacts. Corrosive downpour is precipitation containing destructive measures of nitric and sulfuric acids. These acids are shaped basically by nitrogen oxides and sulphur oxides discharged into the air when non-renewable energy source is copied (Wang et al., 2007; Tiwari et al., 2007). This influences untamed life, water, ozone consumption, harvest and backwoods harm, nursery impact. Outflow of carbon monoxide is delivered by absence of air in burning chamber(Achten et al., 2008). Absence of air through inadequate ignition process happens and CO is discharged into the climate. Overabundance air in suction valve so complete ignition through HC and CO recused however high temperature makes and nitrogen oxide increment (Lapuerta et al., 2008). In Indian market transport area, 70% diesel fuel utilization, both immediate just as retail deals, is appeared at all Indian states. Low business vehicles (LCV), high business vehicles (HCV), and transports together expend about 38% fuel utilization. This is because of the biggest separation transports merchandise just as travellers. Vehicle and utility vehicles (UVs) classification contributed almost about 22%, in which private vehicles devour somewhat less than 60% of the aggregate in this class. Agribusiness segment expends around 13% fuel utilization (Johnson et al., 2002; Majewski et al., 2006).

II. Materials And Test Methods

2.1. Experimental setup and test installations

The reason for mixing (Diesel 70% + Kerosene 30%) with Olive Oil was to inquire about the probability direct utilization of vegetable oils in Diesel engines. Therefore, test fuels were prepared by blending (Diesel 70% + Kerosene 30%) 95% + Olive Oil 05%, (Diesel 70% + Kerosene 30%) 90% + Olive Oil 10% and (Diesel 70% + Kerosene 30%) 85% + Olive Oil 15%. The resulting (Diesel 70% + Kerosene 30%) 95% + Olive Oil 05%, (Diesel 70% + Kerosene 30%) 90% + Olive Oil 10% and (Diesel 70% + Kerosene 30%) 85% + Olive

Oil 15%fuelsvery like traditional Diesel fuel in its fundamental attributes. Some of the properties of the Olive Oil, Kerosene and Diesel were estimated and are introduced in table 1.

Table 1: Properties of fuel

	Olive Oil	Kerosene	Diesel
MELTING POINT	-6.0 °C	-51°C	-9°C
BOILING POINT	190 °C	150 °C TO 300 °C	140-360°C
SPECIFIC GRAVITY	At 20°C (0.911)	0.820	0.82 to 0.95
VISCOSITY	At 20°C (5.2 cP)	At 20°C (.64cP)	At 20 °C (6 cP)
DENSITY	0.92 g/mL	0.78-0.81 g/mL	0.832 g/mL
CETANE NUMBER	-	75	45-55
CALORIFIC VALUE	39560 kJ/kg	43100 kJ/kg	43000 kJ/kg

Calorific value and Density of the (Diesel 70% + Kerosene 30%) 95% + Olive Oil 05%, (Diesel 70% + Kerosene 30%) 90% + Olive Oil 10% and (Diesel 70% + Kerosene 30%) 85% + Olive Oil 15% is show in table 2.

Table 2: Calorific value and density

	Calorific Value	Density
(Diesel 70% + Kerosene 30%)	43050.3 kJ/kg	825.4 kg/m^3
(Diesel 70% + Kerosene 30%) 95% + Olive Oil 05%	42905.786 kJ/kg	829.93 kg/m^3
(Diesel 70% + Kerosene 30%) 90% + Olive Oil 10%	42690.700 kJ/kg	834.46 kg/m^3
(Diesel 70% + Kerosene 30%) 85% + Olive Oil 15%	42427.626 kJ/kg	838.99 kg/m^3

Schematic graph of trial arrangement is found in Figure. 1. The arrangement comprises of single chamber, four strokes, VCR (Variable Compression Ratio) Diesel engine associated with vortex current sort dynamometer for stacking. The pressure proportion can be changed ceaselessly the engine and without modifying the ignition chamber geometry by uncommonly structured tilting chamber square course of action. Arrangement is given important instruments for burning weight and wrench edge estimations. This sign is interfaced to PC through engine marker for Pθ-PV outlines. Arrangement is additionally made for interfacing wind current, fuel stream, temperatures and burden estimation. The set-up has remained solitary board box comprising of air box, two fuel tanks for mix test, manometer, fuel estimating unit, transmitters for air and fuel stream estimations, process pointer and engine marker. Rotameters are accommodated cooling water and calorimeter water stream estimation. The arrangement empowers investigation of VCR engine execution with EGR for brake control, demonstrated power, frictional power, BMEP, IMEP, brake warm proficiency, showed warm productivity, Mechanical effectiveness, volumetric productivity, explicit fuel utilization, A/F proportion and warmth balance. Labview based Engine Performance Analysis programming bundle "ICEngineSoft" is accommodated on line execution assessment. A mechanized Diesel infusion pressure estimation is alternatively given. Table 3 show the Specifications of the Diesel engine.

Figure 1: Schematic outline of trial arrangement

Table 3: Specifications of the Diesel engine

Engine Manufacturer	**Apex Innovation**
Product	Research engine arrangement single chamber, 4-stroke, multi fuel, Electronic
Engine cylinder size	Stroke 110mm, Bore 87.5mm, limit 661 cc
Diesel mode	Power 5.2 kW, speed 1500 rpm, CR go 12:1-18:1, infusion variety 0-25º BTDC
Petrol mode	Power 4.5 KW at 1800 rpm, speed go 1200-1800 rpm, CR extend 6:1-10:1, flash variety 0-700 BTDC
Dynamometer	Whirlpool ebb and flow, water cooled with stacking unit
Temperature sensor	RTD type, PT 100 and thermocouple
Load indicator	Computerized, run 0-50 kg
Load sensor	Strain check, 0-50 kg
Software	Enginesoft, engine performance and analysis

2.2 Methodology

The Taguchi strategy is utilized for straightforward and successful answers for study the exhibition parameters just as trial arranging. Taguchi try in utilized in two-advance improvement process: S/N proportion recognizable proof and no-influence clamor factor. In Taguchi examination, the mean of means and S/N proportion are considered. S/N proportions measure how the reaction fluctuates comparative with the ostensible. S/N proportion is picked by objective of investigation. Minitab programming offers four sorts of S/N proportion: bigger is better, littler is better, ostensible best, ostensible is ideal (default), littler is better. In the trial performed previously, Taguchi investigation table is produced by Minitab programming, which shows the control factor mix proportions and engine load (Table 4). DOE strategy is utilized to recognize the key elements of analysis. DOE counsel symmetrical exhibit is chosen based on control factor and level of examination. Investigation in two number of components with 5 level so L25 plan of exhibit produced.

Table 4: Setting Level of Design Factor

CONTROL FACTOR	**LEVEL 1**	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**	**LEVEL 5**
BLEND	D100	DK	DK95O5	DK90O10	DK85O15
LOAD	2	4	6	8	10

III. Observation And Result Table

3.1 Taguchi Analysis for Mechanical Efficiency

Table 5 shows, mean is average value for reading taken for Mechanical Efficiency. Figure shows, mean worth ishighest (49.14) for Diesel and smallest (40.71) for DK blend. Mean worth ishighest (58.85) for 10kg load and smallest (25.58) for 2kg load. Delta is difference of highest value and smallest value. Delta value is highest for load (33.27) and smallest (8.43) for blend.

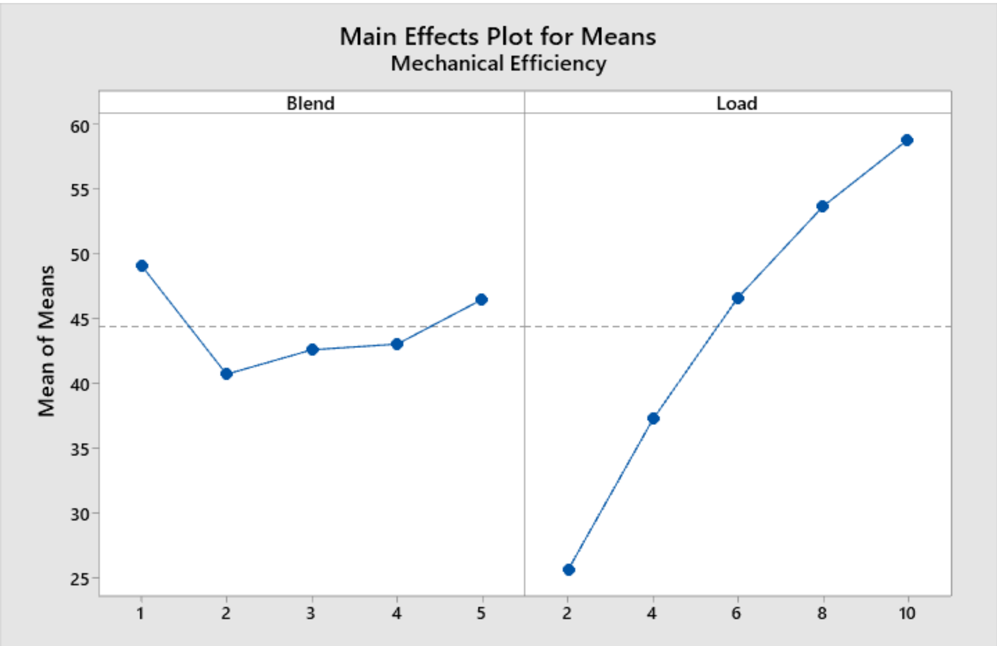

Figure 2: Main Effects Plot for Means of Mechanical Efficiency

The term ideal setting is reflecting just ideal mix of the parameters characterized by this trial. The ideal setting is dictated by picking the level with the most noteworthy S/N proportion.Referring (figure) the response curve for S/N ratio, the highest S/N ratio was observed at Diesel Fuel, engine load 12 kg which are idealparameters setting for highest Mechanical Efficiency. Delta value for Mechanical Efficiency for load (7.27) and blend (1.76) shown in Table 6.

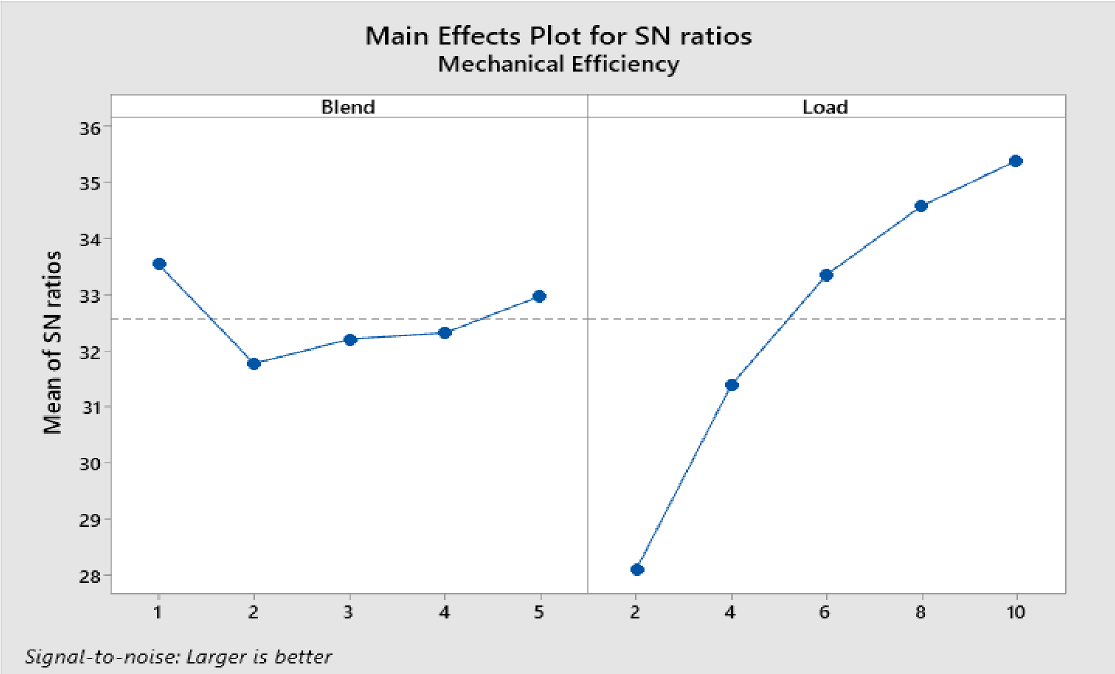

Figure 3: Main Effects Plot For S/N Ratio of Mechanical Efficiency

Table 5: Response Table for Means of Mechanical Efficiency

LEVEL	BLEND	LOAD
1	49.14	25.58
2	40.71	37.24
3	42.59	46.64
4	43.03	53.68
5	46.51	58.85
Delta	8.43	33.27
Rank	2	1

Table 6: Response Table for Sn Ratio of Mechanical Efficiency

LEVEL	BLEND	LOAD
1	33.54	28.11
2	31.78	31.39
3	32.21	33.35
4	32.32	34.58
5	32.98	35.38
Delta	1.76	7.27
Rank	2	1

Table 7: Validation Result for Mechanical Efficiency

Predicted Value	Experimented Value	Error %
63.59	63.05	0.84

3.2Taguchi Analysis for Brake Thermal Efficiency

Table 8 shows, mean is average value for reading taken for Brake Thermal Efficiency.Figure shows, mean worth ishighest (20.58) for Diesel and smallest (20.01) for DK85O15 blend. Mean worth ishighest (26.93) for 10kg load and smallest (10.95) for 2kg load. Delta is difference of highest value and smallest value. Delta value is highest for load (15.99) and smallest (0.57) for blend.

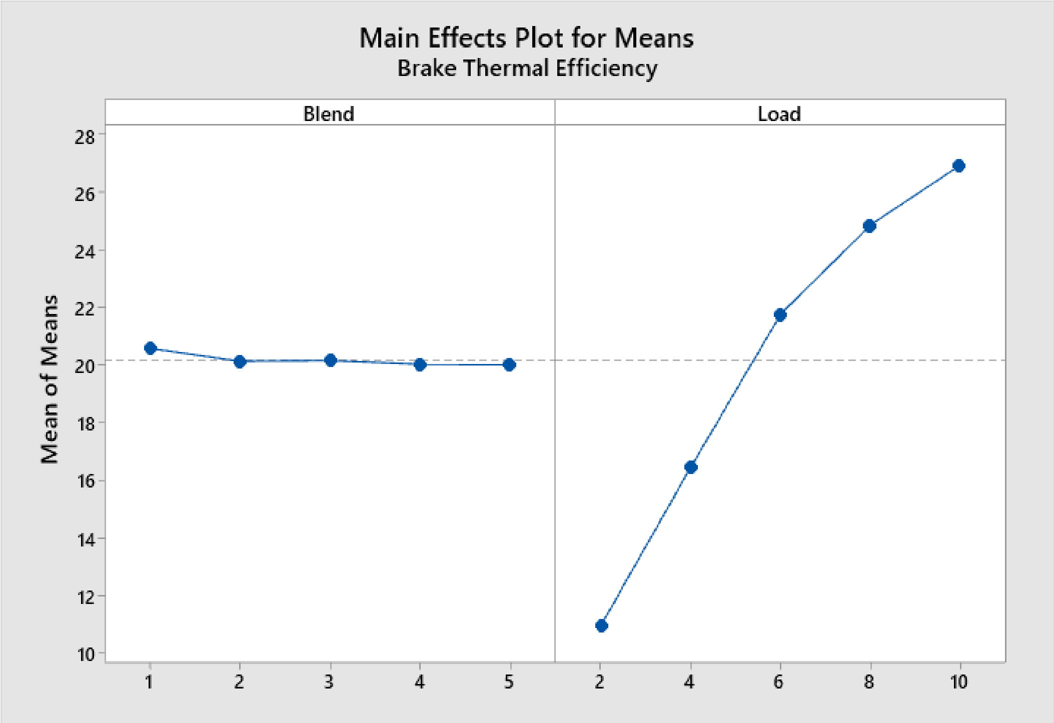

Figure 4: Main Effects Plot for Means of Brake Thermal Efficiency

The term ideal setting is reflecting just ideal mix of the parameters characterized by this trial. The ideal setting is dictated by picking the level with the most noteworthy S/N proportion.Referring (figure) the response curve for S/N ratio, the highest S/N ratio was observed at Diesel Fuel, engine load 12 kg which are idealparameters setting for highest Brake Thermal Efficiency. Delta value for Brake Thermal Efficiency for load (7.83) and blend (0.29) shown in Table 9.

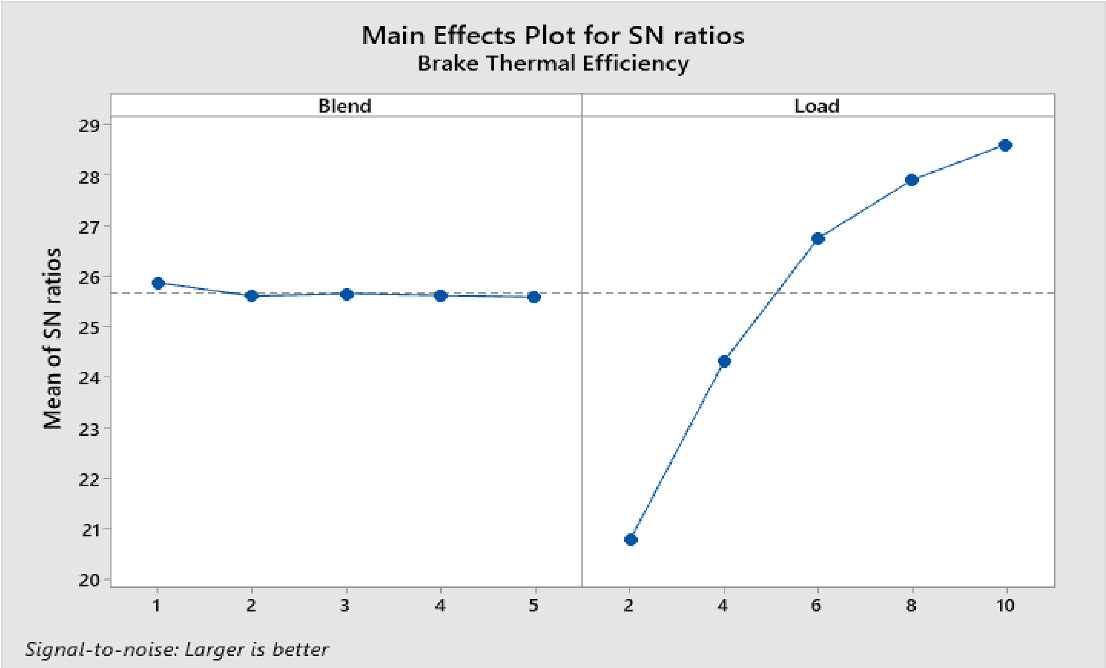

Figure 5: Main Effects Plot For S/N Ratio of Brake Thermal Efficiency

Table 8: Response Table for Means of Brake Thermal Efficiency

LEVEL	BLEND	LOAD
1	20.58	10.95
2	20.14	16.44
3	20.16	21.75
4	20.03	24.85
5	20.01	26.93
Delta	0.57	15.99
Rank	2	1

Table 9: Response Table for Sn Ratio of Brake Thermal Efficiency

LEVEL	BLEND	LOAD
1	25.87	20.77
2	25.61	24.32
3	25.65	26.75
4	25.62	27.90
5	25.59	28.61
Delta	0.29	7.83
Rank	2	1

Table 10: Validation Result for Brake Thermal Efficiency

Predicted Value	Experimented Value	Error %
27.33	27.51	0.65

3.3Taguchi Analysis for Specific Fuel Consumption

Table 11 shows, mean is average value for reading taken for Specific Fuel Consumption.Figure shows, mean worth ishighest (0.4736) for DK85O15 and smallest (0.4479) for Diesel blend. Mean worth ishighest (0.7702) for 2kg load and smallest (0.3123) for 10kg load.Delta is difference of highest value and smallest value. Delta value is highest for load (0.4579) and smallest (0.0257) for blend.

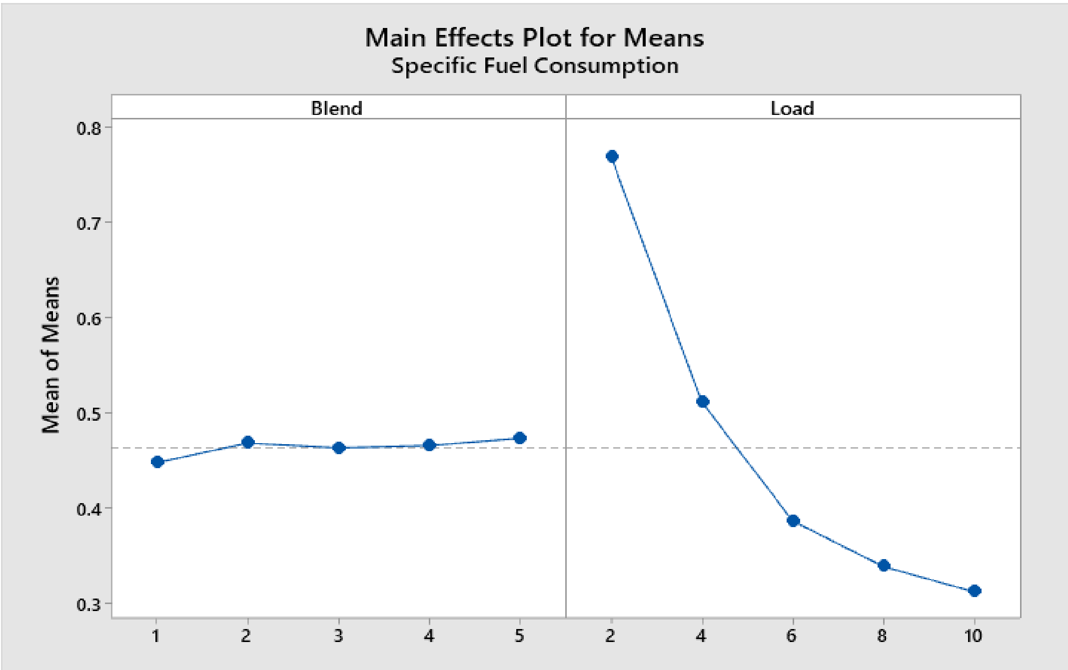

Figure 6: Main Effects Plot for Means of Specific Fuel Consumption

The term ideal setting is reflecting just ideal mix of the parameters characterized by this trial. The ideal setting is dictated by picking the level with the most noteworthy S/N proportion.Referring (figure) the response curve for S/N ratio, the highest S/N ratio was observed at Diesel Fuel, engine load 10 kg which are idealparameters setting for Smaller Specific Fuel Consumption. Delta value for Specific Fuel Consumption for load (7.831) and blend (0.40) shown in Table 12.

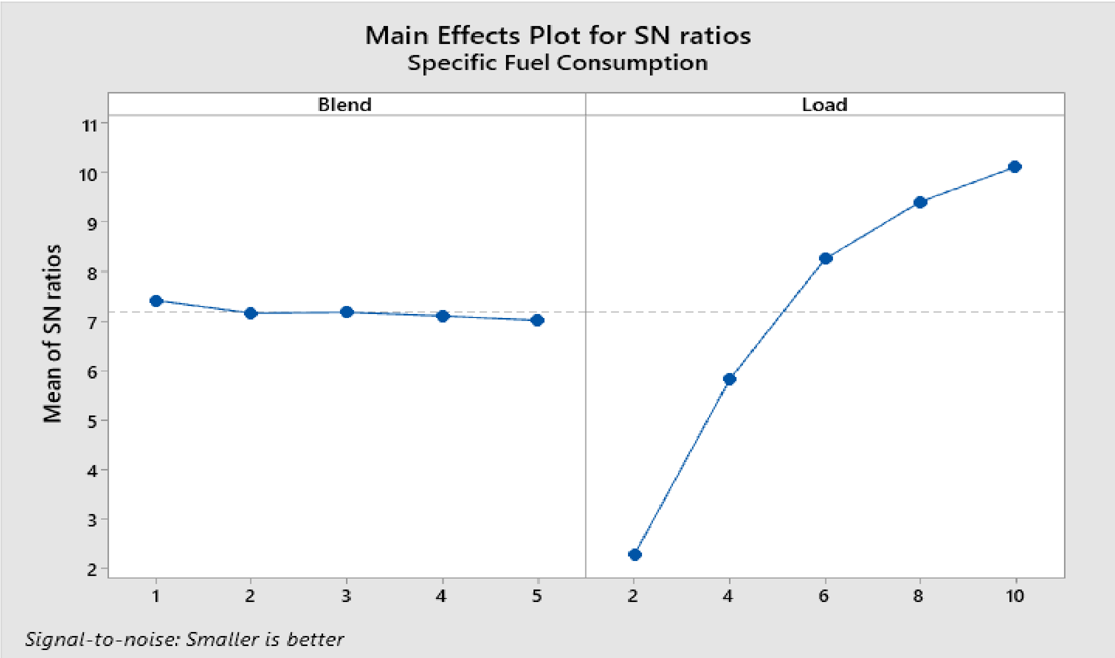

Figure 7: Main Effects Plot For S/N Ratio of Specific Fuel Consumption

Table 11: Response Table for Mean of Specific Fuel Consumption

LEVEL	BLEND	LOAD
1	0.4479	0.7702
2	0.4686	0.5117
3	0.4636	0.3868
4	0.4660	0.3387
5	0.4736	0.3123
Delta	0.0257	0.4579
Rank	2	1

Table 12: Response Table for Sn Ratio of Specific Fuel Consumption

LEVEL	BLEND	LOAD
1	7.417	2.2280
2	7.161	5.821
3	7.179	8.253
4	7.104	9.409
5	7.014	10.111
Delta	0.40.	7.831
Rank	2	1

Table 13: Validation Result for Specific Fuel Consumption

Predicted Value	Experimented Value	Error %
0.296	0.30	1.35
0.316	0.319	0.94
0.311	0.32	2.89
0.314	0.316	0.63
0.321	0.323	0.62

3.4Taguchi Analysis for Fuel Consumption

Table 13 shows, mean is average value for reading taken for Fuel Consumption.Figure shows, mean worth ishighest (0.7262) for DK90O5 and smallest (0.6789) for Diesel blend. Mean worth ishighest (0.8981) for 10kg load and smallest (0.5288) for 10kg load.Delta is difference of highest value and smallest value. Delta value is highest for load (0.3693) and smallest (0.0473) for blend.

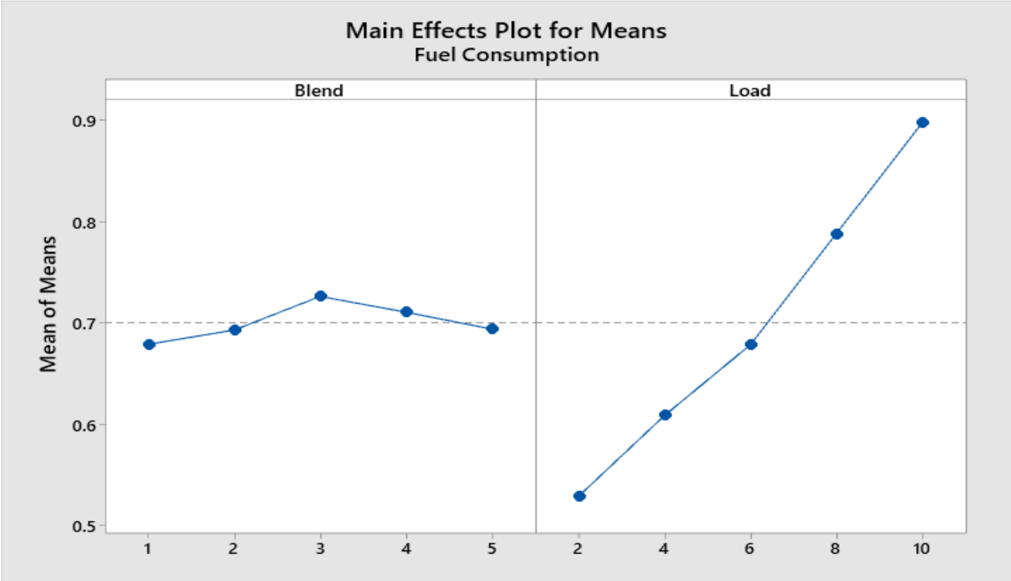

Figure 8: Main Effects Plot for Means of Fuel Consumption

The term ideal setting is reflecting just ideal mix of the parameters characterized by this trial. The ideal setting is dictated by picking the level with the most noteworthy S/N proportion. Referring (figure) the response curve for S/N ratio, the highest S/N ratio was observed at Diesel Fuel, engine load 2 kg which are idealparameters setting for Smaller Fuel Consumption.Delta value for Fuel Consumption for load (4.6034) and blend (0.5786) shown in Table 14.

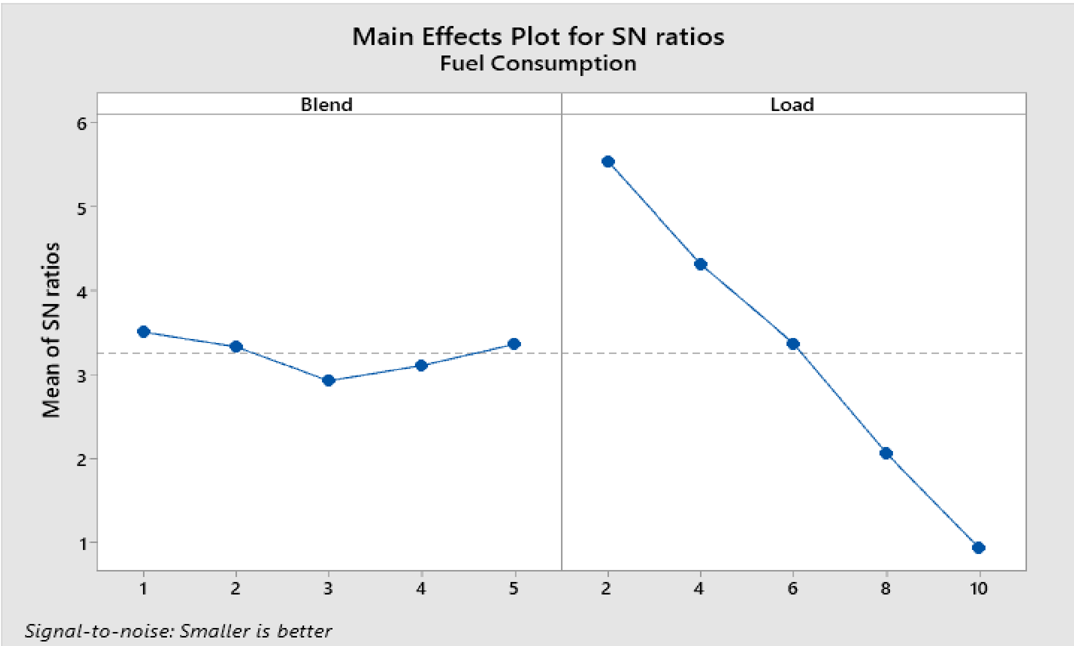

Figure 9: Main Effects Plot For S/N Ratio of Fuel Consumption

Table 13: Response Table for Mean of Fuel Consumption

LEVEL	BLEND	LOAD
1	0.6789	0.5288
2	0.6930	0.6087
3	0.7262	0.6789
4	0.7106	0.7884
5	0.6939	0.8981
Delta	0.0473	0.3693
Rank	2	1

Table 14: Response Table for Sn Ratio of Fuel Consumption

LEVEL	BLEND	LOAD
1	3.5071	5.5421
2	3.3323	4.3161
3	2.9285	3.3737
4	3.1093	2.0685
5	3.3620	0.9387
Delta	0.5786	4.6034
Rank	2	1

Table 15: Validation Result for Fuel Consumption

Predicted Value	Experimented Value	Error %
0.876	0.85	2.96
0.89	0.89	0
0.923	0.95	1.93
0.908	0.90	0.88
0.891	0.91	2.13

IV. Conclusions

The Taguchi approach used and find out optimum set of parameters for MechanicalEfficiency, Brake Thermal Efficiency, Specific Fuel Consumption and Fuel Consumption.The test has been conducted using the fuel blends of D100, DK, DK95O5, DK90O10, DK85O15 and load (2, 4, 6, 8, 10kg) are considered as an input parameter.

- Optimum set for Mechanical Efficiency is D100 and 10 kg engine load. The predicted value of Mechanical Efficiency (63.59 %) is nearer to the experimented value (63.05 %) of Mechanical Efficiency at this level.
- Optimum set for BTHE is D100 and 10 kg engine load. The predicted value of BTHE (27.33 %) is nearer to the experimented value (27.51 %) of BTHE at this level.
- Optimum set for SFC is D100 and 10 kg engine load. The predicted value of SFC (0.296 kg/kWh) is nearer to the experimented value (0.30 kg/kWh) of SFC at this level.
- Optimum set for SFC is DK and 10 kg engine load. The predicted value of SFC (0.316 kg/kWh) is nearer to the experimented value (0.319 kg/kWh) of SFC at this level.
- Optimum set for SFC is DK95O5 and 10 kg engine load. The predicted value of SFC (0.319 kg/kWh) is nearer to the experimented value (0.320 kg/kWh) of SFC at this level.
- Optimum set for SFC is DK90O10 and 10 kg engine load. The predicted value of SFC (0.314 kg/kWh) is nearer to the experimented value (0.316 kg/kWh) of SFC at this level.
- Optimum set for SFC is DK85O15 and 10 kg engine load. The predicted value of SFC (0.321kg/kWh) is nearer to the experimented value (0.323 kg/kWh) of SFC at this level.
- Optimum set for FC is D100 and 10 kg engine load. The predicted value of FC (0.876 kg/hr) is nearer to the experimented value (0.85 kg/hr) of FC at this level.
- Optimum set for FC is DK and 10 kg engine load. The predicted value of FC (0.89 kg/hr) is nearer to the experimented value (0.89 kg/hr) of FC at this level.
- Optimum set for FC is DK95O5 and 10 kg engine load. The predicted value of FC (0.923 kg/hr) is nearer to the experimented value (0.95 kg/hr) of FC at this level.
- Optimum set for FC is DK90O10 and 10 kg engine load. The predicted value of FC (0.908 kg/hr) is nearer to the experimented value (0.90 kg/hr) of FC at this level.
- Optimum set for FC is DK85O15 and 10 kg engine load. The predicted value of FC (0.891 kg/hr) is nearer to the experimented value (0.91 kg/hr) of FC at this level.

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Masi Mohmad Jilani,etal. "Performance Analysis of Single Cylinder CI EngineFuelled with Diesel, Olive Oil and Kerosene Blends Using Taguchi's Approach." *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 17(2), 2020, pp. 33-42.