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Performance Parameter Optimization for CI Engine Fueled with PP-PO and Diesel.

Chirag N Panchal[1], Dr. Tushar M Patel[2], Maulik A Modi[3]
[1](*ME Scholar, Department of Mechanical Engineering, LDRP-ITR, Gandhinagar, India*)
[2](*Professor, Department of Mechanical Engineering, LDRP-ITR, Gandhinagar, India*)
[3](*Lecturer, Department of Mechanical Engineering, LDRP-ITR, Gandhinagar, India*)

Abstract:
A review is done that utilization of petroleum derivatives is expanding which directly results into expanding contamination, so to decrease the utilization of non-renewable energy sources, alternate fuel is the better choice. PP pyrolysis oil can be utilized as an alternative fuel as the properties of PP and diesel are exceptionally close. PP oil is developed from pyrolysis process. In this study the parameters that is % biodiesel, compression ratio, injection pressure and full load are viewed as the variable for improvement. As these four boundaries in the trial needs advancement at the same time, we have involved Taguchi's technique in this analysis. The outcome gained from Taguchi explore shows that 100 percent - % biodiesel, 17-CR, 220-IP, 100-load are ideal arrangement of boundaries for getting most big break thermal heat efficiency, lower specific fuel consumption and lower fuel consumption. Load affects more on BTHE and % biodiesel affects less on BTHE, Load affects more on SFC and % Biodiesel affects more on SFC and load affects less on FC and IP affects less on FC. Trial was performed and it shows that BTHE found by explore is nearer to the predicted value.

***Key Word**: PP pyrolysis oil, Alternative fuel, Taguchi method, BTHE, SFC, FC.*

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I. Introduction

Expansions in the expense of petroleum and diesel in this day and age is the most concerning issue and aside the utilization of non-renewable energy source results directly influences the expense. Utilization of alternate fuel is the best arrangement as a methodology. There are a few cycles for biodiesel development, for example, pyrolysis, trans esterification, emulsification etc. Biodiesel development sources utilized are ecofriendly and produce less production. Many cooking oil, for example, (palm, soybean, groundnut), non-cooking oils (Jatropha, neem, Karanja), plastic waste etc. can be changed over. There are numerous advancement strategies that are utilized for concentrating on engine, for example, Taguchi's strategy, RSM technique, nonlinear relapse technique etc. Taguchi strategy is the best technique for engine as it gives the best result. Taguchi strategy creates symmetrical graphs from hypothesis of DOE to look at a more noteworthy number of factors with less number of parameters. Number of input parameters were given by Taguchi strategy which increase BTHE, decrease the Specific Fuel Consumption (SFC) and Fuel Consumption (FC). Impacts of % biodiesel, load, CR, IP are considered on brake thermal heat efficiency. In this paper PP pyrolysis oil is utilized as an alternate fuel to get the best ideal readings for BTHE, SFC and FC.

Zsolt et al (2019) Thermal pyrolysis of HDPE, LDPE, PP, PS, PET and PUR plastic wastes were performed in a batch reactor equipped with a temperature-controlled reflux and the yields of pyrolysis oils and liquid fuels suitable for transportation were determined. Pyrolysis of HDPE, LDPE, PP, PS, PET and PUR plastic wastes was investigated. The pyrolysis runs were performed in a batch reactor equipped with temperature-controlled reflux to enhance the gasoline content of pyrolysis oils. The temperature of the cracked plastic oil vapor exiting the reflux was not exceeding 200 °C **[1]. Walid et al (2020)** The recycling of plastic waste is a good idea for countries which concern air pollution, CO2 emission, and public health. In this research article, PET, as one of the significant plastic waste, was selected to dissolve in phenol for value- added liquid fuels and hydrogen gas production. This research aims to provide insight into the mechanism of PET waste and phenol steam reforming reaction. In this article, catalytic steam reforming of PET-phenol to produce value-added liquid fuel and hydrogen using Ni-Pt/Al-Ti catalyst with the detailed reaction mechanism was adopted. This research has emphasized the potential approach of solving the threat of PET plastic waste towards the production of valuable fuels as well as hydrogen gas **[2].Kundan et al (2020)** In our general public today plastic materials are utilized in day today life, which prompts the augmentation of plastic waste. Henceforth, plastic reusing is principle focal point of analysts in recent decades. Strategies for reusing of plastic as land filling, dumping, remote ocean dumping, cremation and so on from all the most proficient strategy pyrolysis of plastics.

Production of fuel from waste plastic by pyrolysis method is a simple method for conversion of Plastic into fuel **[3].Gin et al (2021)** Discharge of non-biodegradable plastic waste and lignocellulosic biomass into the environment, and the resultant pollution has persistently increased all over the globe. This activity poses a threat not only to mankind, but also to the environment. This review has focused on the catalytic co-pyrolysis of plastic and lignocellulosic biomass wastes to produce liquid fuel. The exploitation of biomass waste as co-feed in the co-pyrolysis of plastic waste will positively influence the quality and quantity of liquid fuel due to the synergetic interaction between the feedstock**[4].Kuan et al (2019)** Coronavirus Diseases 2019 (COVID-19) pandemic has a huge impact on the plastic waste management in many countries due to the sudden surge of medical waste which has led to a global waste management crisis. Improper management of plastic waste may lead to various negative impacts on the environment, animals, and human health. However, adopting proper waste management and the right technologies, looking in a different perception of the current crisis would be an opportunity. This generation of plastic wastes after the COVID-19 crisis has surged tremendously. Among the consequences left during COVID-19 pandemic is the sudden increase of plastic waste, especially for personal protection and healthcare products. Plastic plays a vital role amidst of fighting against COVID-19 pandemic as most of the protective equipment are made of plastic materials. The heat of the pandemic leaves a great impact to the environment. Tons of plastic wastes have been produced globally and most of the wastes are disposed to landfills with less portions being recycled**[5].**

- Suggestions from Literature Review: **-**

1. Waste Plastic Pyrolysis is the best option for plastic waste transformation and furthermore prudent in wording.
2. Has better execution qualities yet the exhaust boundaries show increase.

- Literature review objectives of this research paper: **-**

1. To diminish the exhaust emanations.
2. To get the best ideal boundaries for execution and exhaust attributes.

II. Material and Methods

- Polypropylene (PP) is a plastic polymer of the chemical designation C_3H_6. It is used in many different settings, both in industry and in consumer goods. It can be used both as a structural plastic and as a fiber.
- Polypropylene is a tough, rigid and crystalline thermoplastic produced from propene monomer. It is a linear hydrocarbon resin.
- Polypropylene a synthetic resin built up by the polymerization of propylene.
- Polypropylene is a very tough, heat-resistant plastic that retains its shape after a lot of torsion, bending and flexing.
- Polypropylene has good resistance to environmental stress cracking.

Figure 1: Pyrolysis of plastic waste

III. Methodology

There is an interest of high effectiveness in engine which is the most serious issue and with that high BTHE, low specific fuel consumption and fuel consumption. There are a few strategies/procedures to tackle this issue. A portion of the techniques utilized for concentrating on engine are Taguchi's strategy, RSM strategy, non-direct relapse strategy and so on. Taguchi's mom is an assortment of numerical and measurable methods utilized for parametric enhancement and examination of issues which inspect a more noteworthy number of factors with less number of parameters.

Steps for Experiments: -

1. Arrange the essential engine arrangement.
2. Then characterize the objective that is the presentation boundary and exhaust boundaries.
3. Now characterize every one of the sign factors and level for each variable.
4. Then make a symmetrical cluster and characterize custom that which is plan. Decide ideal boundary set.
5. Now forecast the exhibition unsubstantiated examination in the event that not happy with the outcome, then, at that point, select new arrangement of ideal boundaries.

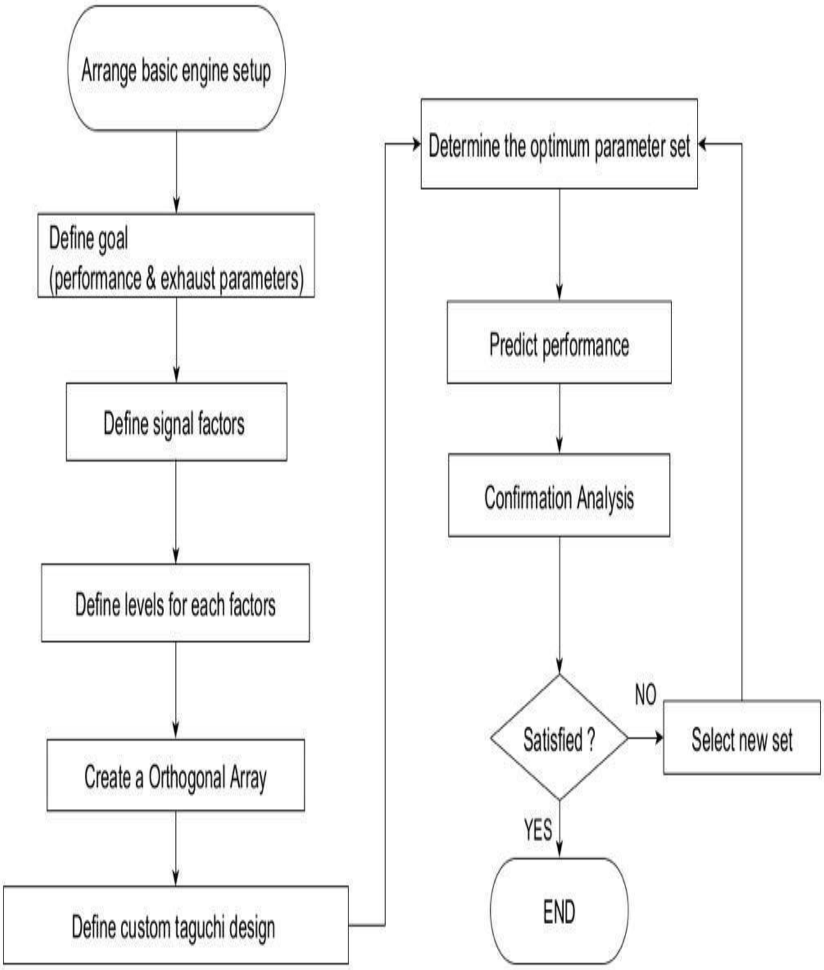

Fig 2: Flow Chart of Experiment

IV. Selection Of Parameters and Levels

Tests are finished with Taguchi's symmetrical graph for % biodiesel, CR, IP and full load. It has 32 trails and number of tests with 4 segments at 3 level and 4 boundaries.

Selected factors and their levels are shown below.

The SN ratio are considered for this selection optimum set of parameters. There are mainly 3 categories such as (1) lower the better, (2) higher the better, (3) nominal the better. The category higher the better is used to calculate S N ratio for BTHE and the category lower is better is used to calculate SN ratio for SFC and FC. Taguchi method is being applied.

Table no 1: Selection of parameters and levels.

PARAMETERS	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
% Biodiesel	0	100	-	-
CR	15	16	17	18
IP	180	200	220	240
Load (%)	0	33	66	100
FUEL	CV (kj/kg)	Density (kg/m^3)		
Diesel	41990	830		
PPE	41426	736		

V. Experimental Setup

The set up comprises of single chamber, four stroke, water cooled modernized research engine in which loading has been given by vortex flow dynamometer. Set up is furnished with instruments for estimation of ignition pressure, Diesel line strain and wrench point. Pressure wrench point outlines were given by signals communicated with PC for. Different instruments for wind current, fuel stream, temperatures and full load estimations are additionally given.

The set-up comprising of air box, two gas tanks for double fuel test, transmitters for air and fuel stream estimations, fuel estimating unit, manometer, process marker and equipment interface. Rotameter is utilized for calorimeter water and cooling water stream estimation. A battery, starter and battery charger have been accommodated engine electric start. Different sensors and instruments are coordinated with information obtaining framework for online estimation of load, air and fuel stream and various temperatures.

The arrangement empowers the assessment of thermal performance and emission constituents of a engine. Thermal performance boundaries incorporate brake power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, volumetric effectiveness, explicit fuel utilization, A/F proportion, heat balance and so on. The constituents of the fumes gas like CO, HC and NOx are estimated with fumes gas analyzer. Lab view-based Engine Performance Analysis programming bundle "Engine Soft" has been accommodated on line execution assessment.

Table no. 2: - Engine Technical Specifications

Make	Kirloskar Oil Engines
Type	Four stroke, Water cooled, Diesel
No. of cylinder	One
Bore	87.5 mm
Stroke	110 mm
Combustion principle	Compression ignition
Cubic capacity	0.661 liters
Compression ratio 3 port	18:01
Peak pressure	77.5 kg/cm2
Direction of rotation	Clockwise (Looking from flywheel end)
Fuel timing for std. engine	0 to 25 BTDC
Power	3.5 kW @ 1500 rpm
Inlet opens BTDC	4.5
Inlet closes ABDC	35.5
Exhaust opens BBDC	35.5
Exhaust closes ATDC	4.5
Lub. Oil pump delivery	6.50 lit/min.
Break Mean Effective	6.35 kg/cm2
Connecting rod length	234 mm

Figure 3: Front View of Experimental Setup

VI. Results and Discussion

The consequences of BTHE, SFC and FC are broke down utilizing Minitab 18. Minitab offers four kinds of planned tests: factorial, reaction surface, blend, and Taguchi (hearty). The means continue in Minitab to make, investigations, and diagram an exploratory plan are comparative for all plan types. Subsequent to leading the examination and entering the outcomes, Minitab gives a few logical and diagramming instruments to assist the outcomes. The S/N proportion for ideal BTHE are going under "Higher-is-Better" trademark, and the S/N proportion for ideal SFC and FC are going under "Lower-is-Better" attributes which can be determined as logarithmic change of the misfortune work. In the analysis, four boundaries are viewed as like as % Biodiesel, CR, Injection pressure, Load. Primary Effects Plot for Mean information and S/N proportion information are shown that shows ideal consequences of BTHE, SFC and FC.

- **Analysis Result for BTHE (%)**

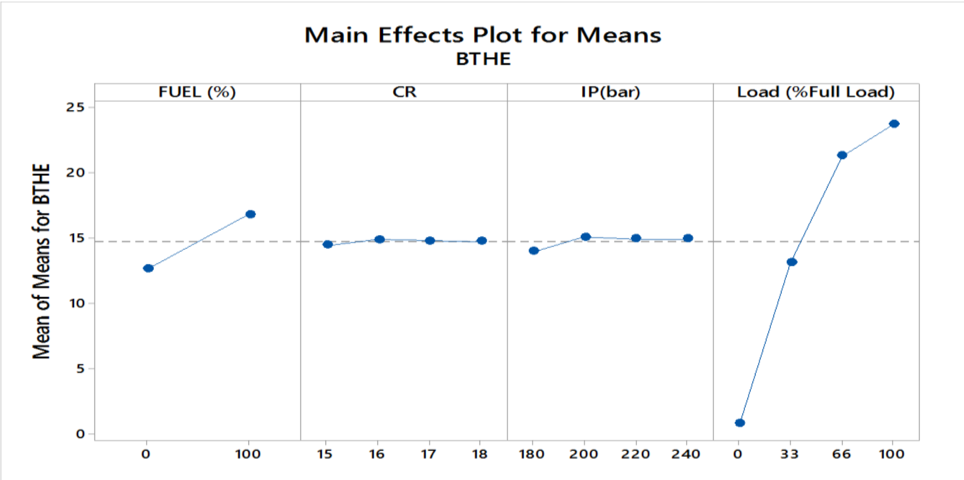

Fig 4: Main Effects Plot for Means Data Means BTHE (%)

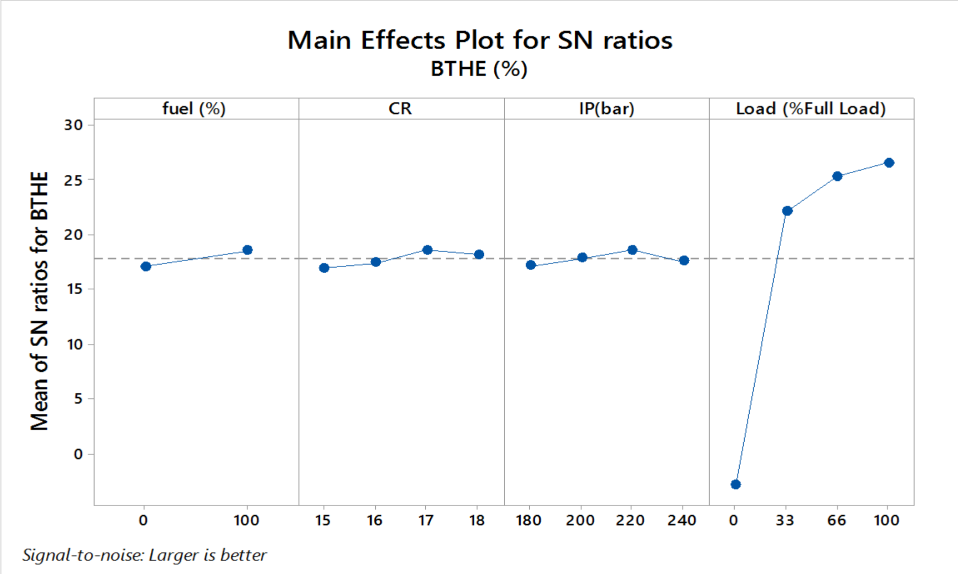

Fig 5: Main Effect for SN Ratios BTHE (%)

Table no. 3: Response Table for Signal to Noise Ratios BTHE (%) (Larger is better)

Level	% Biodiesel (%)	CR	IP (bar)	Load (%Full Load)
1	17.055	17.64	16.979	-2.520
2	19.720	18.30	18.985	22.255
3		19.106	19.213	26.446
4		18.978	18.372	27.367
Delta	2.665	1.942	2.234	29.888
Rank	2	4	3	1

Table no. 4: Predicted Values for S/N Ratio plot BTHE (%)

OPTIMUM SET OF PARAMETERS					
% Biodiesel	CR	IP	LOAD	S/N ratio	Predicted Value
100	17	220	100	30.2450	21.4741

Table no. 5: Validation Experiment Results and Error BTHE (%)

Basis	Fuel (%)	CR	IP (bar)	Load (% full Load)	Predicated BTHE (%)	Experimental BTHE (%)	Error
S/N ratio	100	17	220	100	21.4741	20.81	1.94%

- Validation experimental results are very closer to predicted results. The errors are less than 1.94%.
- As means of means plots are showing combined effects of signal (selected parameters) and noise (unselected parameters), while S/N ratio plot gives effect of signal (selected parameters) only. So, S/N Ratio plot is considered for selection of optimum set of parameters.
- Hence the optimum (maximum) BTHE (%) is achieved when fuel =100%, CR =17, IP (bar)=220, load =200 (%). It is also called optimum set of parameters. The predicted value of BTHE (%) with optimum set of parameters is 21.4741.

- **Analysis Result for SFC (kg/kWh)**

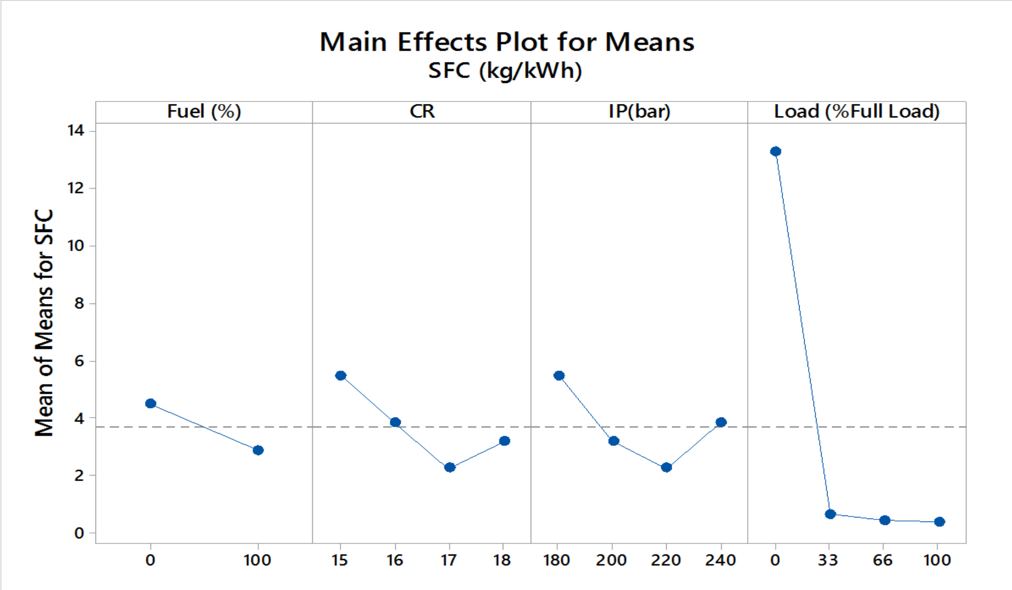

Fig 6: Main Effects Plot for Means Data Means SFC (kg/kWh)

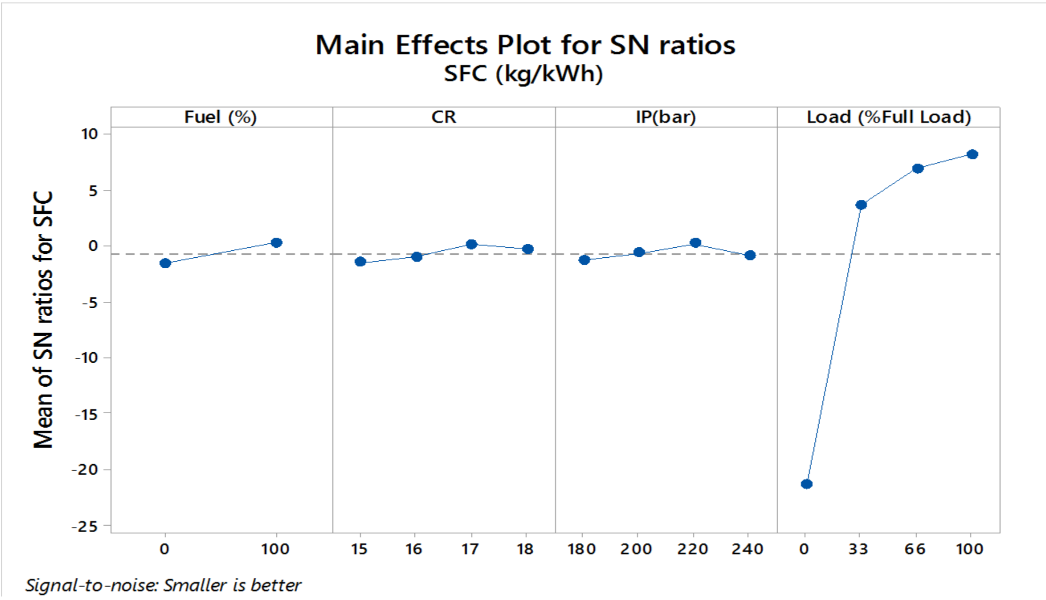

Fig 7: Main Effect for SN Ratios SFC (kg/kWh)

Table no. 6: Response Table for Signal to Noise Ratios SFC (kg/kWh) (Smaller is better)

Level	Fuel (%)	CR	IP (bar)	Load (%Full Load)
1	-1.6084	-1.5590	-1.7442	-21.2434
2	0.9383	-0.4220	0.2628	3.5336
3		0.3845	0.4914	7.7241
4		0.2564	-0.3501	8.6455
Delta	2.5467	1.9435	2.2357	29.8889
Rank	2	4	3	1

Table no. 7: Predicted Values for S/N Ratio plot SFC (kg/kWh)

OPTIMUM SET OF PARAMETERS					
% Biodiesel	CR	IP	LOAD	S/N ratio	Predicted Value
100	17	220	100	10.6514	-3.27787

Table no. 8: Validation Experiment Results and Error SFC (kg/kWh)

Basis	Fuel (%)	CR	IP (bar)	Load (% full Load)	Predicated SFC (kg/kWh)	Experimental SFC (kg/kWh)	Error
S/N ratio	100	17	220	100	-3.27787	0.39	2.96%

- Validation experiments results are very closer to predicted results. The errors are less than 2.96%.
- As means of means plots are showing combine effects of signal (selected parameter) and noise (unselected parameters), while S/N ratio plot gives effects of signal (selected parameters) only. So, S/N ratio plot is considered for the selection of optimum set of parameters.
- Hence, the optimum (minimum) SFC (kg/kWh) is achieved when Fuel=100%, CR=17, IP (bar) =220, Load=100%. It is also called optimum set of parameters. The predicted value of SFC with optimum set of parameters is -3.27787.

- **Analysis Result for FC (kg/hr)**

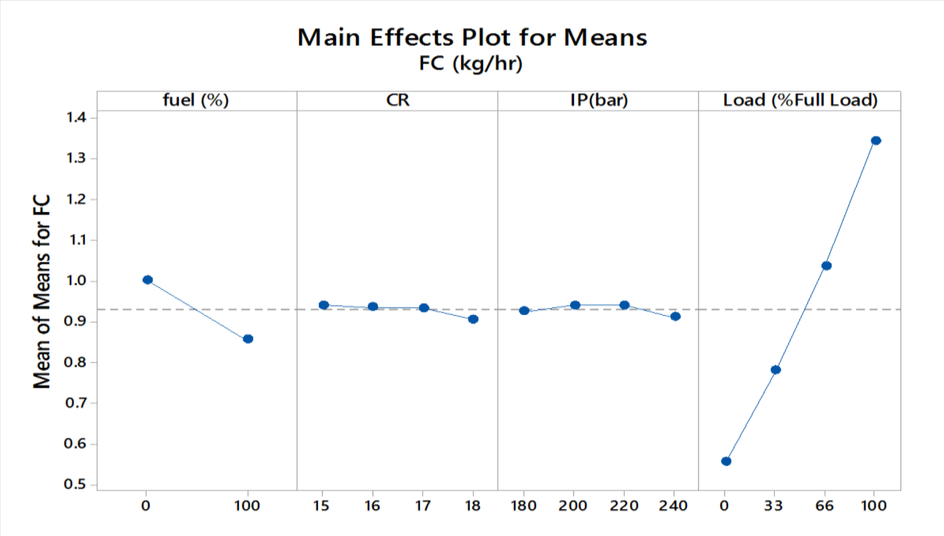

Fig 8: Main Effects Plot for Means Data Means FC (kg/hr)

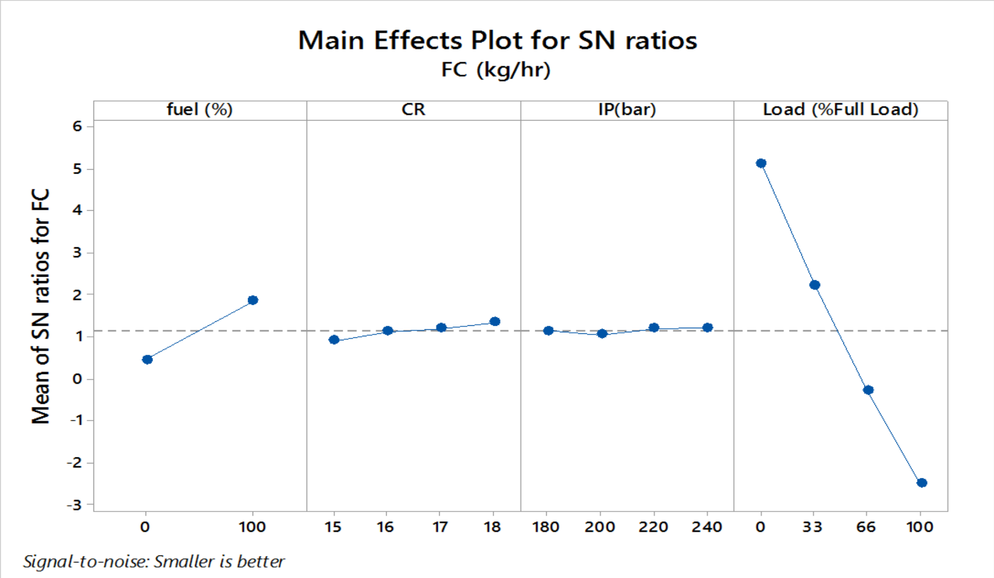

Fig 9: Main Effect for SN Ratios FC (kg/hr)

Table no. 9: Response Table for Signal to Noise Ratios FC (Kg/hr) (Smaller is better)

Level	% Biodiesel (%)	CR	IP (bar)	Load (%Full Load)
1	0.4382	0.9928	0.7400	4.2940
2	2.1362	1.2577	1.5405	2.1830
3		1.4236	1.5976	0.5451
4		1.4746	1.2705	-1.8734
Delta	1.6980	0.4818	0.8575	6.1675
Rank	2	4	3	1

Table no. 10: Predicted Values for S/N Ratio plot FC (kg/hr)

OPTIMUM SET OF PARAMETERS					
% Biodiesel	CR	IP	LOAD	S/N ratio	Predicted Value
100	18	220	0	5.64087	0.484928

Table no. 11: Validation Experiment Results and Error FC (kg/hr)

Basis	Fuel (%)	CR	IP (bar)	Load (% full Load)	Predicated FC (kg/hr)	Experimental FC (kg/hr)	Error
S/N ratio	100	18	220	0	0.48928	0.69	1.25%

- Validation experiments results are very closer to predicted results. The errors are less than 1.25%.
- As means of means plots are showing combine effects of signal (selected parameter) and noise (unselected parameters), while S/N ratio plot gives effects of signal (selected parameters) only. So, S/N ratio plot is considered for the selection of optimum set of parameters.
- Hence, the optimum (minimum) FC (kg/hr) is achieved when Fuel=100%, CR=18, IP (bar) =240, Load=0%. It is also called optimum set of parameters. The predicted value of SFC with optimum set of parameters is 0.48928.

VII. Conclusion

The best and productive strategy was established by Taguchi Method for getting the impact of control boundaries. Result talks about underneath,

- As means of means plots are showing combined effects of signal (selected parameters) and noise (unselected parameters), while S/N ratio plot gives effect of signal (selected parameters) only. So, S/N Ratio plot is considered for selection of optimum set of parameters.
- For BTHE, Validation experimental results are very closer to predicted results for BTHE. The errors are less than 1.94%.
- Hence the optimum (maximum) BTHE (%) is achieved when fuel =100%, CR =17, IP (bar)=220, load =100 (%). It is also called optimum set of parameters. The predicted value of BTHE (%) with optimum set of parameters is 21.4741..
- For SFC, Validation experiments results are very closer to predicted results for SFC. The errors are less than 2.96%.
- Hence, the optimum (minimum) SFC (kg/kWh) is achieved when Fuel=100%, CR=17, IP (bar) =220, Load=100%. It is also called optimum set of parameters. The predicted value of SFC with optimum set of parameters is -3.27787.
- For FC, Validation experiments results are very closer to predicted results for FC. The errors are less than 1.25%.
- Hence, the optimum (minimum) FC (kg/hr) is achieved when Fuel=100%, CR=18, IP (bar) =220, Load=0%. It is also called optimum set of parameters. The predicted value of SFC with optimum set of parameters is 0.48928.

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