International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Optimization of Ethanol-Gasoline Petrol Engine Parameters by Experimental & MINITAB Tools

[1]Gol Niraj Khimjibhai, ,[2]Vivek Singh
1 M.TECH Scholar, SRK University, Bhopal
2 Asst. Professor, SRK University, Bhopal
E Mail: niraj.gol@gmail.com, viveksinghrkdf1995@gmail.com

ABSTRACT:

Improvement in the engine performance and its efficiency, fuel additives play a colossal role. Quotidian progress suggested that the design of engines is one face of the coin whereas fuel is contraposition of the coin. This gumption was initiated by Henry Ford to usher Ethanol in automobile engineering as fuel in Model T. The advancement of technology shows the diversified progress of automobile engines. Technology in automobile not only relates to the engine but their adjunct microprocessors - Electronic Control Unit with reliable software programming.

Apart from online performance analyzers, there are assorted tools which are capable of offline solutions. Such dynamic soft tools give chastener performance of automobile engines. Researchers are deliberately analyzing the relevance of ethanol in automobile engines. Few types of research are also taken into account to identify the better and optimized condition to utilize the ethanol in engines. Every aspect has its own features in research; few are observed as key account and other are negotiated with research conditions. Soft tools are a main part of any optimization looking to a future scenario like software offered by various automobile industries for its own purpose.

INTRODUCTION:

Future of automobile is also based on optimization by soft tools because experimental approaches are limited and quite expensive compared to simulation. Simulation and soft computing can be repeated again and again without complete setup rearrangement, it provides a versatile environment where implementation is quite effortless approach. Design, assembly, and simulation environment for an automobile are available from CAD (Computer Aided Design, Computer Aided Manufacturing, Computer Aided Engineering etc.); apart from it some more dedicated soft tools available for this purpose.

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1. Internal Combustion Engine
2. Important terms in IC engine
3. Fuel Blending
4. Software deals with Automobile Engineering
5. MINITAB
6. Optimization Techniques

1.2 Internal Combustion Engines

1.1 Working of Petrol Engine

In the most general form, an internal combustion engine is a device that converts chemical energy into useful work, through a combustion process. Combustion is the course of action of convert chemical energy into thermal energy, using fuel and an air Internal refers to the combustion process taking place inside the engine, in a combustion chamber. There are many internal combustion engine concepts, but the most common are the reciprocating engine. The piston move up and down, piston driven by the thermal energy from the combustion process.

The combustion process is a set of reactions, which release energy or heat through oxidization.

A typical combustion reaction is the methane-oxygen reaction:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + energy$$

All combustion reaction are exothermic reactions, meaning that they release energy to the Environment. This energy is what can be converted into useful mechanical energy in a reciprocating engine. The IC engine is called a four-stroke engine for the reason that the piston travels before it completes the combustion process. The four strokes create it possible to complete a thermodynamic cycle.

In a internal combustion engine is an engine in which the piston completes four split strokes while turn a crankshaft.

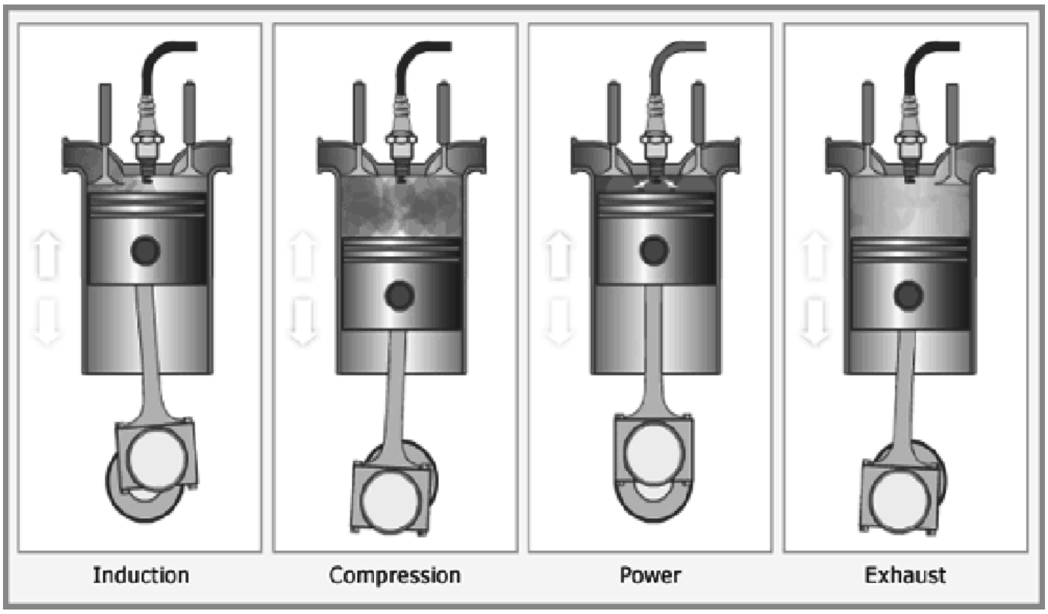

Fig. 1.1 Strokes of Engine [11]

The four strokes are discussed below:

a) Inlet(suction)

b) Compression

c) Combustion

d) Exhaust

a) Inlet: In inlet stroke the position of piston begins at T.D.C. and ends at B.D.C.. In this stroke, the valve open position while the piston suck an air-fuel mixture into the cylinder by producing vacuum pressure into the cylinder through its up and down motion.

b) Compression: Compression stroke begins at B.D.C, the end of the suction stroke, and ends at T.D.C. the piston compress the air-fuel mixture in preparation for ignition during the power stroke. The inlet valve and exhaust valves are closed during this stage.

c) Combustion: Also known as, the power stroke, Combustion starts of the second revolution of crank. At this point, the crankshaft has completed a full 360-degree revolution. While the piston is at TDC. The compressed mixture is go up in flames by a spark plug and heat generated by high pressure, forcefully returning the piston to BDC. this stroke makes mechanical work from the engine to turn the crankshaft.

d) Exhaust: also known as an outlet. In this stroke, the piston once again returns from B.D.C. to T.D.C. while the exhaust valve is open. This action expels the exhausted gases through the exhaust valve.

An engine is a devise which is convert the chemical energy of the fuel is released inside the engine and used directly for mechanical work, The IC engine was conceived and developed in the late 1800s. It has had a major impact on humanity and is measured one of the most amazing inventions of the previous century. The IC engine has been the groundwork for the successful development of a lot of industrial technology. This type of engine has changed the automobile sector, allowing the discovery and progress of automobile industry.

In the most of petrol engines, the fuel and air are usually stoichiometric mixture before compression. The stoichiometric mixture prepared by carburetor, but now it is done by electronically controlled fuel injection, with the exception of in small engines where the cost and complication of electronics does not validate the added engine efficiency. The procedure differ from a diesel engine in the mixing the fuel and air.

IC engines are device that produce work using the petroleum fuel ignition the working substance rather than as a heat transfer medium. To make work, the combustion is carried out in a way that crates high-pressure combustible products that can be expanded through a piston. these high pressure systems introduces a number of features that profoundly influence the creation of waste product carbon monooxside,NO2, SO2,etc, and pollutes the air, soil, or water..

There are three main types of IC (internal combustion) engines used in current scenario:

1. The SI engine, which is used mainly in automobiles

2. The diesel engine, which is used in vast vehicles and industry where the enhancement in cycle efficiency make it advantageous over the more compact and lighter-weight SI engine.

3. The gas turbine, which is mainly used in aerospace due to its high power and immobile power generation.

FUEL- Generally, modern fuels are made up of hydrocarbons LIKE methane, butane, propane and are derived mostly from fossil fuels . Fossil fuels include gasoline, petroleum and diesel fuel, and the rarer use of propane. Most of internal combustion engines that are designed for gasoline use can run on natural gas or liquefied petroleum gases exclusive of major modifications. Large diesels can run with air mixed with gases and a pilot diesel fuel ignition injection. Liquid gaseous bio fuels, ethanol , biodiesel can also be used. Engines with proper modifications can also run on hydrogen , charcoal gas, producer gas made from other suitable biomass. Experiments have also been conducted using powdered solid fuels, such as the magnesium injection cycle**.**

LITERATURE REVIEW

It is found in US that SI engines using blended fuel increase day by day. It is also with fact that lesser quantity of alternate use with gasoline. Engine runs on different mixtures like pure petrol, 10% ethanol and 20% ethanol to examine the performance and emissions of IC engine. Reviewer observed the results that there is no negative feedback of using 100% ethanol in the engine, CO emission gradually reduced, same as the 20% ethanol blends decreased the fuel conversation efficiency and brake power of the engine, it also affects the CO emission by its amount reduction.[1]

The decrease in heating value; increase in octane number in blended fuel by the addition of ethanol. Results obtained by researcher like slightly increase in engine power and specific fuel consumption of engine by ethanol-gasoline blending. CO emission decreases with increase in ethanol addition. Hydrocarbons emission also decreases, but CO2 emission increase with improved combustion in engine. The use of blended fuel, it was observed that CO2 emission increased by 5-10% but CO emission reduced by 10 to 30%. The specific fuel consumption increased by 2 to 3 % and engine power increased by 5%.

Experiments for equivalence A/F ratio, fuel consumption, volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specific fuel consumption. Analysis if carbon monoxide (CO), unburned hydrocarbon and carbon dioxide (CO2) done, it was performed by experiments of blending the gasoline and ethanol with various percentages of fuel at 3/4th position and variable speed of engine range from 1000 to 4000 rpm. There was increase in brake power, fuel consumption, torque, brake and volumetric thermal efficiency. Same experiment also shows that decrease in brake specific fuel consumption and equivalence A/F ratio. Emission of CO and HC decreases with increase in CO2 emission, the blended fuel of 20% volume gives required effective results with all measured parameters at any engine speeds. [3]

Paper supported application of blended fuel will be future technological renaissance. Experiment was carried out at 5% and 10% blended fuel in commercial 2 stroke SI engine without modification. Thermal efficiency of engine observed peaks once 5% of proportional to ethanol blended fuel kept in whilst overall. Researcher also observed that the fuel consumption was least at 5% of blended fuel. This experiments shows that the increase in the thermal efficiency and reduction in fuel consumption. [4]

In this paper, the blended fuel range from C2 to C6 used for the experiment. "Solver" a tool of Microsoft excel used to get the optimum blended fuel. Maximum heating Value (MaxH), Maximum research octane number (MaxR) and Maximum Petroleum (MaxD) used as 3 tools for optimizing tools of blend ratios. In 4 cylinder petrol engine by wide opening throttle condition used the blended fuel with variable speeds, ethanol gasoline blend of 15% was introduce to compare the obtained outcomes. Results of MaxR, MaxD and MaxH reduced to 14%, 14.57% and 20.76% NOx emission in E15. The optimized blend also shows higher brake torque and brake thermal efficiency (BTE), apart from it brake specific fuel consumption (BSFC) reduced. [5]

IMPLEMENTATION

This work focuses on gasoline and ethanol blending, the following properties being identified and properly implement during this work.

Property		**Fuels**
	Gasoline	Ethanol
Molecular Formula	C_7H_{17}	C_2H_5OH
Molecular Weight (kg/kmol)	100-110	46
Lower Heating Value (MJ/kg)	44	26.9
Density (g/cm^3)	0.72-0.78	0.78
Stochiometric Fuel/Air Ratio	0.068	0.11
Octane Number	91-96	106-110
Heat of Vaporization (KJ/kg)	305	840

Table 4.1: Properties of Gasoline and ethanol

To understand the engineering systems, the IC engine involves in reducing the useless emissions that exhausted during the combustion inside the engine. It is also an important part that exhaust emissions are depending on the fuel elements, A/F equivalence ratio, operating techniques, oxygen demand and the chemical composition of additives used for the engine. Today, global warming, smog, odours and acid rains are a major issue of environmental pollution and causes the health problems. As on date, catalytic converters are an additional device used in automobiles to reduce the pollution and follow the environmental protocols. Some of the elements of the reason of environmental pollution are discussed as follows:

Nitrogen Oxides

During the combustion process, a large amount of Nitrogen is present in the atmosphere creates the Nitrogen oxide (NOx). Photochemical smog creates because of NOx that reacts with ozone present in the atmosphere. Health issues observed due to NOx like harmful reaction with lungs and the biological tissues. NOx emission reduces during the combustion of blended fuel between 0 to 30% by volume and also found that the NOx emission remains same as Ethanol of 10 % and petrol.

Carbon Monoxide

The major issue of Carbon Monoxide is that it is odorless, colorless and creates the poisonous gases, CO is not inert in nature and reacts with oxygen that dissolved in human blood that causes sudden death in case of an excess of CO inhaled. CO emission caused by lower air-fuel ratio and this issue can be resolved by introducing low HC blended with gasoline that makes complete combustion.

Carbon Dioxide

CO_2 does not affect the human health directly, but for the environment, it is quite harmful and major contributor to global warming. Carbon dioxide evolved in ethanol blended fuel and pure petrol remains same approximately. Since higher utilization of fuel differentiates the CO_2 emission from both of the blending and pure gasoline.

The experiment was performed in pure petrol, E10 & E20, there are nine sets prepared and tried to perform the experiment to obtain the successful desired outcomes. To perform the test, some practice done as follows:

During the experiment, use of the weighing burette to create a mixture of the desired quantity. The proper quantity of ethanol is mixed with petrol. Burette or any tank used for the test, before any test empties the tank and fuel refilled. The engine started and stabilized the engine speed first for few minutes and then perform the test to calculate the following quantities like fuel flow, air flow, engine speed, dynamometer force, the concentration of CO, CO_2, NOx, and O_2.

Fuel	**Fuel Flow (Counts/10 Seconds)**
Petrol	100
Petrol	200
Petrol	300
10% Ethanol	100
10% Ethanol	200
10% Ethanol	300
20% Ethanol	100
20% Ethanol	200
20% Ethanol	300

Table 4.2: Fuel flow reading at 2500 RPM of petrol, 10% Ethanol and 20% Ethanol blend

Test Performed practically in test labs and the report obtained from blending of Fuel and then optimization is done on MINITAB:

4.2 Work Cycle (kJ) w.r.t. Fuel Flow rate (kg/hr)

Fuel Flow		**Work Cycle (kJ)**	
(kg/hour)	**Gasoline**	**10% Ethanol**	**20% Ethanol**

2.0	0.1	0.1	0.1
2.2	0.3	0.26	0.3
2.4	0.5	0.42	0.5
2.6	0.7	0.58	0.7
2.8	0.9	0.74	0.9
3.0	1.1	0.9	1.1
3.2	1.27	1.07	1.272
3.4	1.44	1.24	1.444
3.6	1.61	1.41	1.616
3.8	1.78	1.58	1.788
4.0	1.95	1.75	1.96
4.2	2.096	1.892	2.108
4.4	2.242	2.034	2.256
4.6	2.388	2.176	2.404

4.8	2.534	2.318	2.552
5.0	2.68	2.46	2.7
5.2	2.804	2.568	2.84
5.4	2.928	2.676	2.98
5.6	3.052	2.784	3.12

Table 4.3: Work cycle (kJ) w.r.t. fuel flow (kg/hr)

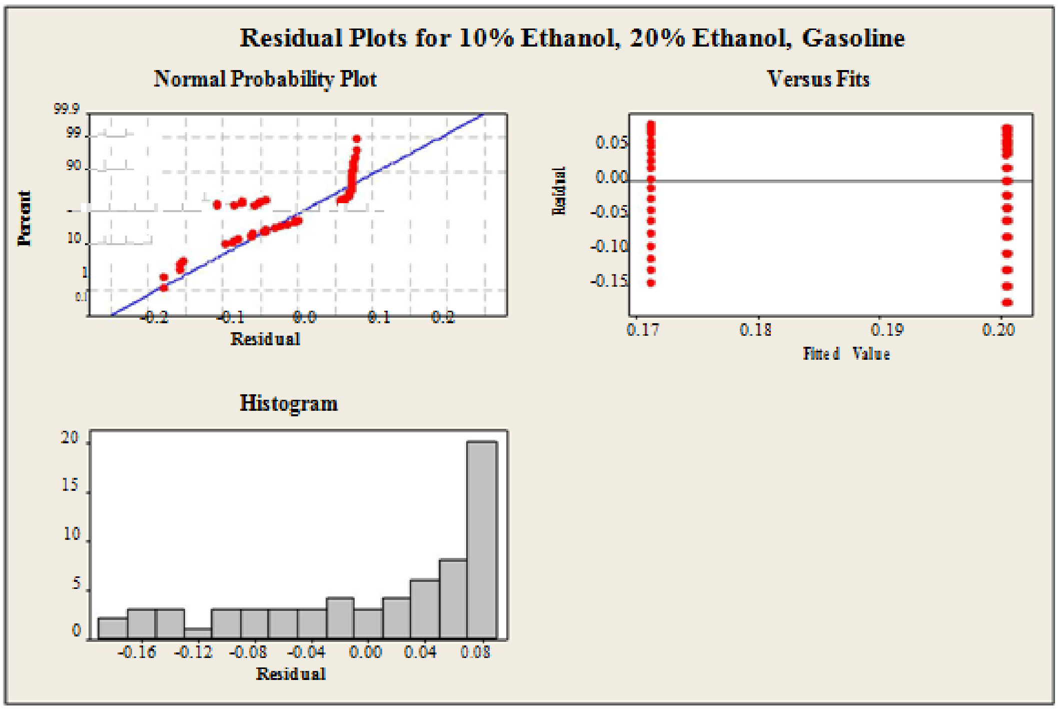

Fig 4.1 Residual Plots for Work Cycle

RESULT AND ANALYSIS

Test Performed and the report obtained from optimization done on MINITAB:

Fuel Flow		**Work Cycle (kJ)**	
(kg/hour)	**Gasoline**	**10% Ethanol**	**20% Ethanol**
2.0	0.1	0.1	0.1
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5.4	2.928	2.676	2.98
5.6	3.052	2.784	3.12
5.8	3.176	2.892	3.26
6.0	3.3	3	3.4
6.2	3.4	3.2	3.6

Table 5.1 Work Cycle (kJ) w.r.t. Fuel Flow rate (kg/hr)

The residual plot of fuel flow of work cycle is shown in fig.[5.1]. This layout is useful to determine whether the model meets the assumptions of the analysis.

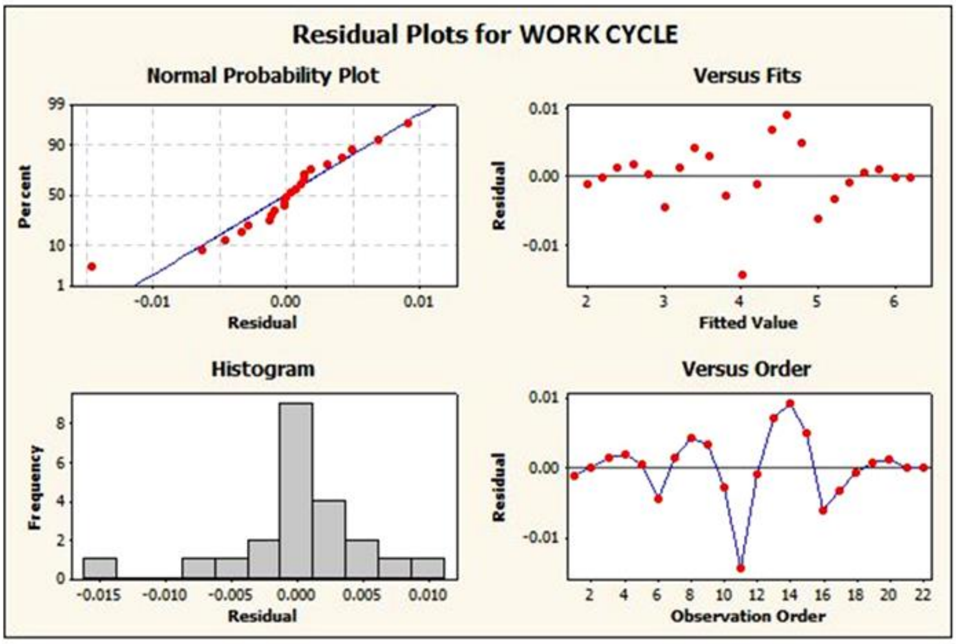

Fig 5.1 Residual Plots for Work Cycle

The residual plots of work cycle in the graph and the interpretation of each residual plot indicate below:

- Normal probability plot indicates the data are normally distributed and the variables are influencing the response. Outliers don't exist in the data.
- Residuals versus fitted values indicate the variance is not constant and a nonlinear relationship exists as well as no outliners exist in the data.

- Histogram proves the data are **not suddenly change direction** and no outliners exist
- Residuals versus order of the data indicate that there are systematic effects in the data due to time or data collection order.

Fig. [5.2] shows the main effect plot of work cycle which shows the individual effect of process parameters on the fuel flow

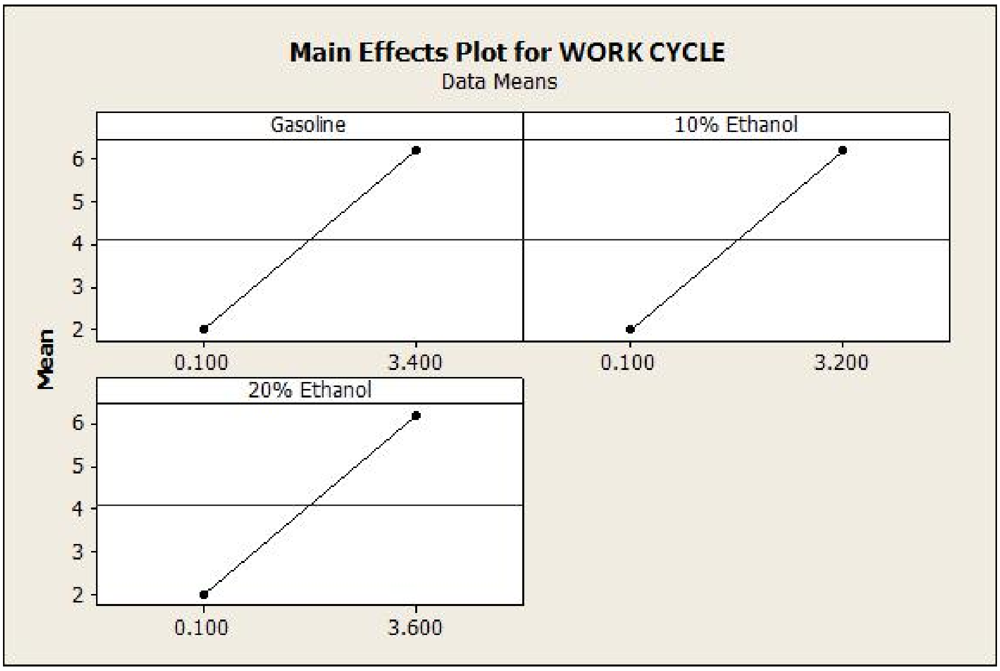

Fig 5.2 Main Effects Plot for Work Cycle

Points come out from main effect plot of the work cycle is listed below.

- Effect of gasoline indicated that fuel flow initially decreases and after that fuel flow level increases as increase the quantity of gasoline.
- Effect of 10% ethanol and 20% ethanol behaviour is same as gasoline observed that fuel flow initially decreases at a certain level and after that level of fuel flow increases as increase the quantity of 10% ethanol and 20% ethanol.

ANOVA analysis

Table[5.3] is ANOVA table for fuel flow, which shows the factor degree of freedom, the sum of square, mean square, f- value and percentage contribution.

For calculating the degree of freedom;

The degree of freedom = level- 1

Source	DOF	Sum of squares	Mean square	F value	% contribution
Gasoline	1	35.1429	35.1429	4.23	26.78
10% ethanol	1	0.1034	0.1034	0.67	4.24
20% ethanol	1	0.0945	0.0945	10.89	68.96

Table 5.2: Analysis of variance for fuel flow

Work cycle of gasoline, 10% ethanol & 20% ethanol w.r.t. Fuel flow rate factor gives % contribution of 26.78 %, 4.24 % & 68.96 % in analysis of variance. Practically also observed the same contribution of analysis of variance with 4.8 % base variation.

Table 5.3 Break Specific Fuel Consumption (kg/kJ) w.r.t. Fuel flow rate (kg/hr)

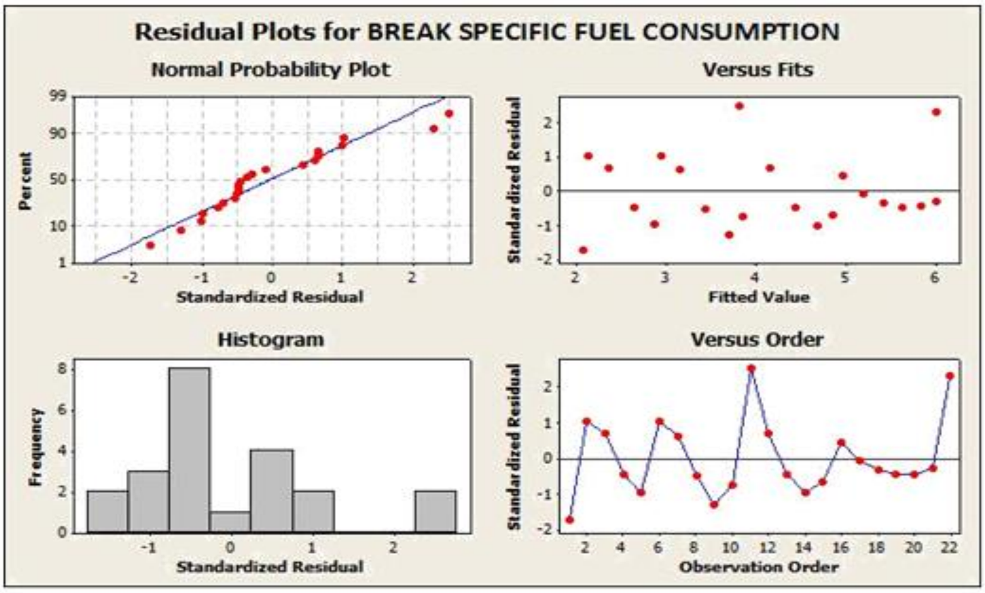

Fig 5.3: Residual Plots for BREAK SPECIFIC FUEL CONSUMPTION

The residual plots of BSFC in the graph and the interpretation of each residual plan indicate below:

- Normal possibility graph indicates the data are normally distributed and the variables are influencing the response. Outliers don't exist in the data.
- The Residuals versus integral values indicates the variance is not constant and a nonlinear correlation exists as well as no outliners exist in the data.
- The Histogram proves the data are not skewed and no outliners exist.
- Residuals versus order of the data indicate that there are systematic effects in the data due to time or data collection order.

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