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Evaluation of Methanol Gasoline Fuel Blends on Performance of Single Cylinder SI Engine : A Mathematical Model

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Abstract

Energy experts for auto sector are looking for renewable energy source for providing solution to depleting fossils fuel and environment degradation. Methanol is one such option that can be utilized in the form of blends with existing fuel without changing the engine configuration. In this paper a review about the existing work done on methanol, its usage as a fuel in IC Engine and the challenges that has to be overcome before it can be used in the existing engine is also discussed. In this research a mathematical analysis is made with the help of Correlation regression for 20 % blends on different parameters. The parameters Thermal efficiency, specific fuel consumption & calorific value can be calculated with respect to the change in methanol blends with the help of equations developed. The regression lines for these parameters are $= 25.79 + 0.0492$, $Y = 0.3166 + 0.00066X$, $Y = 40.076 + 0.2172X$ *and Correlation coefficient are 0.437, 0.459, -1. These results indicated that brake thermal efficiency increases, specific fuel consumption decreases, calorific value decreases as we increase the methanol % up till 15%. The result obtained through the proposed study is in good agreement with the results obtained by the researcher working on methanol in this area.*

Keywords: Gasoline, Methanol, Blends, Correlation coefficient, Regression analysis.

Introduction

"Methanol is the simplest form of alcohol having single carbon solution as it has no carbon carbon bond, so it does not emit particulate matter making the fuel clean," [1][2][3]. Methanol is a toxic, colorless, tasteless liquid with a very faint odour treated like petrol. Though it is presently being made from natural gas, it can also be produced from a range of renewable sources such as agricultural waste, forest residue and naphtha and wood, coal and biomass through gasification. With methanol blends up to 15 percent the existing engine with minor modification can be made compatible. For more or neat methanol the engine needs alteration [1]. The high octane ratings and greater heat of evaporation values of methanol make them suitable fuels for high compression ratios engines with high powers. Methanol's advantages include lower emissions, higher performance and lower risk of flammability than petrol. The auto-ignition temperatures of methanol is higher than those of gasoline, which make it safer for transportation and storage. Since the heat of evaporation of methanol is 3–5 times higher than that of gasoline, this makes the temperature of the intake manifold lower, and increases the volumetric efficiency. The laminar flame speed of methanol is significantly higher than those of most of the hydrocarbon fuels [1]. High laminar flame speed increases thermal efficiency by completing the combustion earlier which decreases heat losses from the cylinder.

Methanol exhaust contains lower concentrations of particulate matters and nitrogen oxides than gasoline exhaust. The molecule of methanol has an oxygen atom that makes the gasoline-methanol blends more oxygenated. This directs to better combustion of the fuel and reduces carbon monoxide and hydrocarbon emissions [4][5][6]. In the paper Regression lines and correlation coefficients for different percentages of methanol gasoline blends with respect to brake thermal efficiency, specific fuel consumption& calorific value were calculated and analysized up till 20% of blend ratio. The regression lines for these parameters are $= 25.79 + 0.0492X$, $Y = 0.3166 + 0.00066X$, $Y = 40.076 + 0.2172X$and Correlation coefficient are 0.437, 0.459, -1. These results indicated that brake thermal efficiency increases, specific fuel consumption decreases, calorific value decreases as we increase the methanol % up till 15%.

Challenges of using methanol in S.I Engines

1. Methanol is corrosive, highly toxic, colorless, odorless and tasteless [7. This is due to the presence of oxygen which having high atomic weight, its energy density is lower than base gasoline.

Remedy

The corrosion problem can be avoided by not using materials from copper, brass, aluminum or rubber materials for the fuel delivery system. Use of fluorocarbon rubber as a replacement for rubber was suggested by [8].

2. Methanol also has high volatility rate which increase in aldehyde emissions and cause phase separation. Methanol volatility also cause increase in Reid vapor pressure which will effect in giving high temperature in the combustion cylinder and drivability problems such as vapor lock.

Remedy

In order to avoid phase separation, only blend the methanol and gasoline at the service pump station be provided in order to prevent phase separation in the fuel distribution system. The problem of volatility is solved by fuel reforming, fuel heating, intake air heating, blend fuel and supplementary fuel in many of the investigations done on methanol. [9][10][11].

1.1 Scope and Objective of Present Work:

In the present work, our objective is to mathematically analyze the data present in the literature and make inferences based on the results obtained. For the present study a 350 cc single cylinder bullet [12] engine having conventional carburettor was chosen. Methanol is blended with petrol & the blend contains 5%, 10%, 15%, 20%, 25% methanol and 95%, 90%, 85%, 80%, 75% petrol respectively (called M5, M10, M15, M20, M25) was feed to the engine. The engine rpm is set and the time taken for consuming a known volume of the prepared blends is measured. This measurement is done under two conditions at constant speed of the engine with no load and under certain load. When the engine was made to run on the similar conditions i.e rpm 1330, load 78.48 N, & Calorific value of Methanol 22.7 KJ/Kg

table 1was obtained from as per the reference **3 & 12**.

Sr.No	Blend Type	Calorific Value (KJ/Kg) [2]	BP (KW)	SFC (kg/kw-hr)	η_{bth} %
1	neat	44.42	7.651	0.324	25.23
2	M5	43.334	7.651	0.316	26.33
3	M10	42.248	7.651	0.321	26.41
4	M15	41.162	7.651	0.313	27.63
5	M20	40.076	7.651	0.342	25.81

Table 1 Experimental Data

Correlation and regression analysis

The statistical tool with the help of which we are in a position to estimate the unknown values of one variable from known values of another variable is called regression. There are two important points of difference between correlation and regression analysis:

1. Whereas correlation coefficient is a measure of degree of relationship between X and Y, the objective of regression analysis is to study the 'nature of relationship' between the variables.
2. The cause and effect relation is clearly indicated through regression analysis than by correlation. Correlation is merely a tool of ascertaining the degree of relationship between two variables and, therefore, we cannot say that one variable is the cause and the other the effect.

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Regression analysis between % Methanol blends (X) & Brake thermal efficiency (Y)

With the help of data given in table 1 a measure of degree of relationship between blend percentage and brake thermal efficiency is analyzed through correlation and regression analysis. From the data at table 1 the graph between % methanol blends and η_{bth} is presented in the figure 1. When the regression analysis is made till 15% of methanol blends regression line of nature $Y = 25.79 + 0.0492X$ is obtained with the data at table 2. The η_{bth} reaches a peak value at 15% blend of methanol this is due to some oxygen content in methanol which helps in proper oxidation. After brake thermal efficiency reaches a peak, η_{bth} declines due to less calorific value of blend due to increased % of methanol in the mixture.

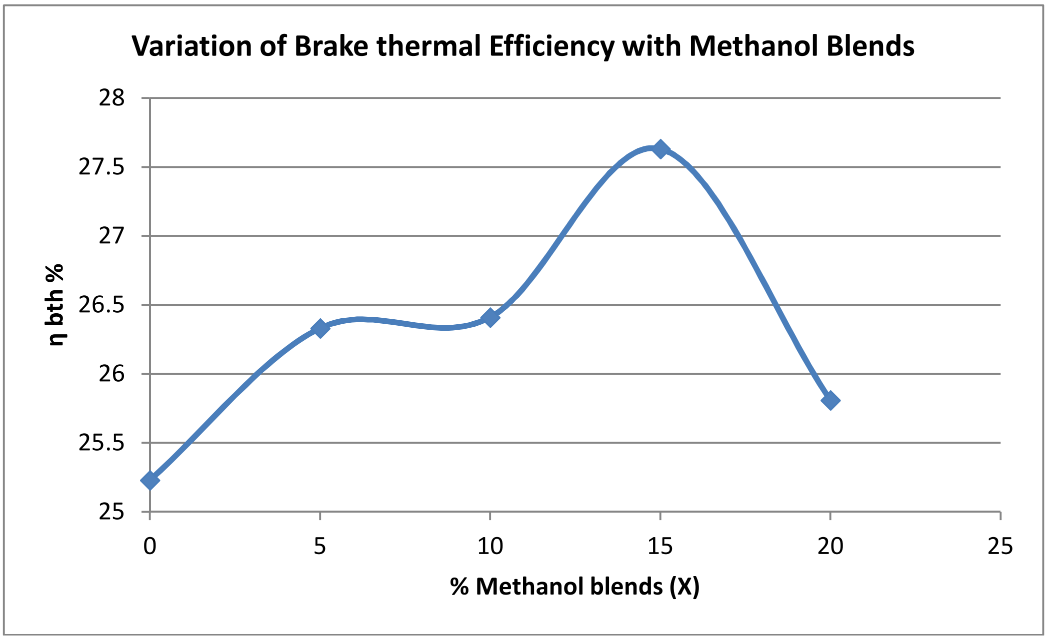

Figure 1 Variation of brake thermal efficiency with methanol blends

Sr.No.	% Methanol blends (X)	Brake thermal efficiency(Y)	X^2	XY
1	0	25.23	0	0
2	5	26.33	25	131.65
3	10	26.41	100	264.1
4	15	27.63	225	414.45
5	20	25.81	400	516.2
	∑X=50	∑Y=131.41	∑ X^2=750	∑XY=1326.4

Table 2 Table for regression analysis between % Methanol blends (X) & Brake thermal efficiency (Y)

Regression equation obtained after calculation i.e Y on X through equation $Y = a + b$ is $Y = 25.79 + 0.0492X$. With the help this equation we can predict the efficiency by changing the ratios of the blends of methanol with gasoline.

Correlations Coefficient between % Methanol blends (X) & Brake thermal efficiency (Y)

Table 3 is prepared for calculating correlation coefficient.

Sr.No.	% Methanol blends (X)	$x=X-X_{avg}$	x^2	Brake thermal efficiency(Y)	$y=Y-Y_{avg}$	y^2	xy
1	0	-10	100	25.23	-1.052	1.106704	10.52
2	5	-5	25	26.33	0.048	.002304	-0.24
3	10	0	0	26.41	0.128	.016384	0
4	15	5	25	27.63	1.348	1.817104	6.74
5	20	10	100	25.81	-0.472	.222784	-4.72
	∑X=50	∑x=0	$\sum x^2=250$	∑Y=131.41	∑y=0	$\sum y^2=3.16528$	∑xy=12.3

Table 3 Table for calculating Correlations coefficient

Correlations coefficient is given by the formulae

$$r = \frac{\sum x}{\sqrt{\sum x^2 \sum y^2}} = 0.437$$

Correlation coefficient has been calculated and is found to be having a value of r= 0.437 which indicates the degree of association between these two parameters.

Regression analysis between % Methanol blends (X) & Specific fuel consumption(Y)

From the data at table 1 the graph between % methanol blends Specific fuel consumption (Y) is presented in the figure 2. When the regression analysis is made till 15% of methanol blends regression line of nature $Y = 0.3166 + 0.00066X$ is followed this prepared with the help of table 4. The SFC reaches a lowest peak value because of the complete combustion of the blend due the presence of oxygen in the methanol chemical structure. After lowest peak specific fuel consumption starts rising due to less calorific value of blend due to increased % of methanol in the mixture.

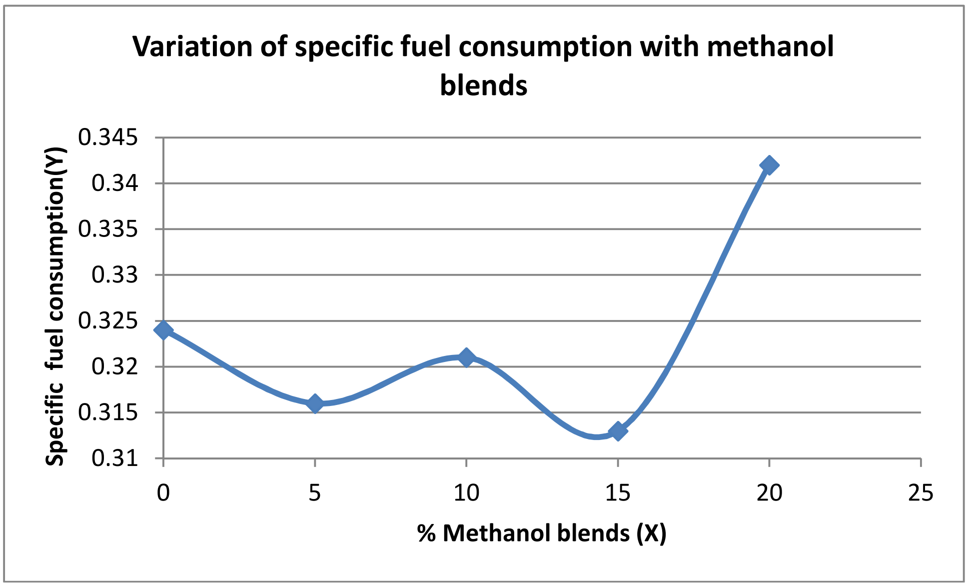

Figure 2 Variation of SFC with Methanol Blends

Regression equation obtained after calculation i.e Y on X through equation $Y = a + b$ is $Y = 0.3166 + 0.00066X$ with the help of this equation we can predict the specific fuel consumption by changing the ratios of the blends of methanol with gasoline.

Sr.No.	% Methanol blends (X)	Specific fuel consumption(Y)	X^2	XY
1	0	0.324	0	0
2	5	0.316	25	1.58
3	10	0.321	100	3.21
4	15	0.313	225	4.695
5	20	0.342	400	6.84
	∑X=50	∑Y=1.616	$\sum X^2=750$	∑XY=16.325

Table 4 Table for regression analysis between % Methanol blends (X) & SFC (Y)

Correlations Coefficient between % Methanol blends (X) & SFC (Y)

Table 5 is prepared for calculating correlation coefficient.

Sr.No.	% Methanol blends (X)	$x=X-X_{avg}$	x^2	Specific fuel consumption (Y)	$y=Y-Y_{avg}$	y^2	Xy
1	0	-10	100	0.324	0.0008	$6.4x10^{-7}$	-0.008
2	5	-5	25	0.316	-0.0072	$518.4x10^{-7}$	0.036
3	10	0	0	0.321	-0.0022	$48.4x10^{-7}$	0
4	15	5	25	0.313	-0.0102	$1040.4x10^{-7}$	-0.051
5	20	10	100	0.342	0.0188	$3534.4x10^{-7}$	0.188
	∑X=50	∑x=0	$\sum x^2=250$	∑Y=1.616	∑y=0	$\sum y^2=5148x10^{-7}$	∑xy=0.165

Table 5 Table for calculating Correlations coefficient

Correlations coefficient is given by the formulae

$$r = \frac{\sum x}{\sqrt{\sum x^2 \sum y^2}} = 0.459$$

Correlation coefficient has been calculated and is found to be having a value of r= 0.459 which indicates the degree of association between these two parameters.

Regression analysis between % Methanol blends (X) & Calorific values (Y)

From the data at table 1 the graph between % methanol blends & Calorific values (Y) is presented in the figure 3. When the regression analysis is made till 15% of methanol blends regression line of nature $Y =$

$40.076 + 0.2172X$ is followed. The calorific values of the blend decreases with the increased percentage of methanol in the blend. This because of the lower calorific value of methanol in comparison to gasoline.

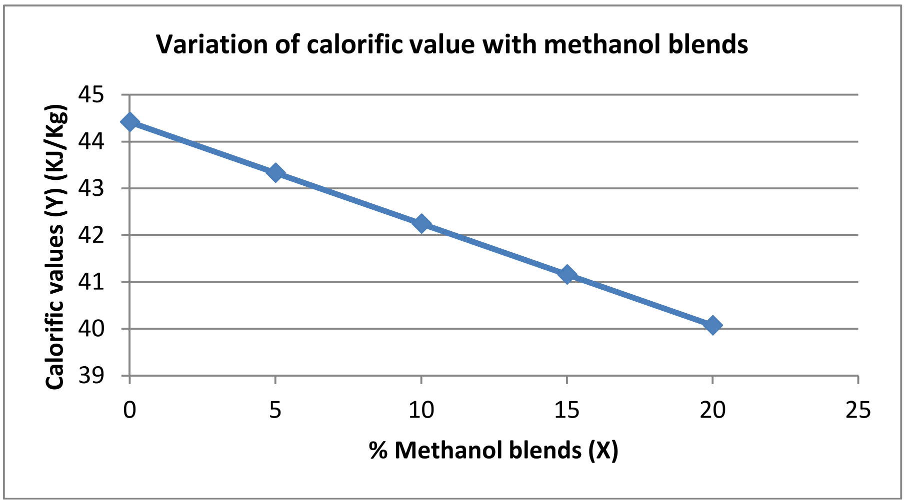

Figure 3 Variation of calorific value with methanol blends

Regression equation obtained after calculation i.e. Y on X through equation is $Y = a + b$ is $Y = 40.076 + 0.2172X$ prepared with the help of table 6. With the help of this equation we can predict the calorific value of the blend by changing the ratios of methanol with gasoline.

Sr.No.	% Methanol blends (X)	Calorific values (Y) (KJ/Kg)	X^2	XY
1	0	44.42	0	0
2	5	43.334	25	216.67
3	10	42.248	100	422.48
4	15	41.162	225	617.43
5	20	40.076	400	801.52
	∑X=50	∑Y=211.24	$\sum X^2=750$	∑XY=2058.1

Table 6 Table for regression analysis between % Methanol blends (X) & Calorific value (Y)

Correlations Coefficient between % Methanol blends (X) & CV (Y)

Table 7 is prepared for calculating correlation coefficient

Sr.No.	% Methanol blends (X)	$x=X-X_{avg}$	x^2	Calorific values KJ/Kg(Y)	$y=Y-Y_{avg}$	y^2	xy
1	0	-10	100	44.42	2.172	4.7175	-21.72
2	5	-5	25	43.334	1.086	1.1793	-5.43
3	10	0	0	42.248	0	0	0
4	15	5	25	41.162	-1.086	1.1793	-5.43
5	20	10	100	40.076	-2.172	4.7175	-21.72
	∑X=50	∑x=0	$\sum x^2=250$	∑Y=211.24	∑y=0	$\sum y^2=11.7936$	∑xy= -54.3

Table 7 Table for calculating Correlations coefficient

Correlations coefficient is given by the formulae

$$r = \frac{\sum x}{\sqrt{\sum x^2 \sum y^2}} = -1$$

Correlation coefficient has been calculated and is found to be having a value of r = -1 which indicates the degree of association between these two parameters.

Result and discussion

Our result is in congruence with the result of the various author performed experiment on single cylinder 4S SI Engine with methanol gasoline blend and found indicated power, brake power, torque, specific fuel consumption, and thermal efficiency increases by using various methanol gasoline blends with various operating condition [3][9][13][14][15][16][17].

Conclusion

In the paper Regression lines and correlation coefficients for different percentages of blends with respect to brake thermal efficiency, specific fuel consumption& calorific value were calculated and analysis for blends ratios up till 20%. From the data available from the literature, The regression lines for these parameters are $= 25.79 + 0.0492X$, $Y = 0.3166 + 0.00066X$, $Y = 40.076 + 0.2172X$ and Correlation coefficient are 0.437, 0.459, -1. These results indicated that brake thermal efficiency increases, specific fuel consumption decreases, calorific value decreases as we increase the methanol % up till 15%.

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