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Investigation of the Effectiveness of Xtreme Fuel Treatment (XFT) Additive in Fuel Conservation in Engines Using Paired Sample T – Test Statistics

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Abstract The effectiveness of Xtreme fuel treatment (XFT) additive which is one of the fuel additives that have been recently flooded into the markets by many distributors with wide speculations and claims that the additive is effective in improving the fuel economy of engines, thereby reducing the rate of fuel consumption by the engines is tested/investigated in FIR-MAN SUMEC 2900 generator set using paired sample t-test statistics. Ten sets of data on rate of fuel consumption per minute was collected for the generator set when it was ran without the XFT additive, and another ten sets of data/samples were equally collected when the same gen set was ran with the XFT additive administered in its tank mixed with gasoline fuel. The two samples were compared and analyzed using Paired sample T-test statistical method to determine if there is any significant difference in the rate of fuel consumption using our set out null and alternative hypotheses. The result of our analysis indicated that there is no enough significant statistical evidence not to reject the null hypothesis in favour of the alternative that there should be reduction in the rate of fuel consumption when the generator is ran with the XFT additive. Hence, based on the statistics, it can be stated that the XFT additive is not effective enough in reducing rate of fuel consumption in generator set.

Keywords Energy Conservation, Fuel-additives, Engines, Hypothesis and t-Test

1. Introduction

The increased use of fossil fuels for energy production is rapidly depleting the reserves of petroleum based fuels. It is well known that the fast decrease in the future availability of energy resources as well as the need for reducing the emissions from the fuels used has increased the need for the utilization of regenerative fuels [1]. The increase in the cost of these petroleum products such as diesel fuel, gasoline/petrol, natural gas and kerosene have resulted in an unprecedented interest in products that have the potential to improve fuel economy/conservation of these products when used in our engines. Research interest in non- polluting and renewable fuel sources has developed due to rapidly increasing fuel cost, regularly decreasing the sources of conventional fuels and pollution in the environment. The maximum energy need of the world is obviously fulfilled by the fossil fuels. Combustion of these fossil fuels causes acid rains and air pollution in the cities and continuous efforts have been made to replace these fossil fuels with renewable energy sources.

In modern economy, economic growth of any country depends on its energy resources and their utilization. The use of products (additives) on these fossil fuels which have potential to conserve the product by improving fuel economy and reducing harmful emissions of our engines have been advocated. Most oil industry relied heavily on the use of additives to improve the performance of its products with respect to one (or more) important properties. Additives are materials used at low concentrations either to improve the performance of a product with respect to some existing property or to confer on the product some entirely new property. They are soluble chemicals mixed with petroleum fuel to enhance certain performance characteristics or to provide characteristics not inherent in the fuel. Typically, they are derived from petroleum-based raw materials and their function and chemistry are highly specialized. They produce the desired effect at the parts-per-million (ppm) concentration range. (One ppm is 0.0001 mass percent or 1mg/kg.). High Quantity of additives can alter chemical and physical properties such as: density, volatility, viscosity and cetane index of fuel significantly.

To prepare blends of additives and fuel with engines so many of the additives are readily available in the market. Oxygenated compounds are most widely used among various additives available, because availability of extra oxygen leads to better combustion and thus lowering emissions.

Other additives readily available are antiknock compounds. They increase the antiknock quality by increasing the octane number of fuel and include materials based on:

- Lead alkyls, such as tetraethyl lead (TEL) and tetramethyl lead (TML)
- Manganese, called methylcyclopentadienyl manganese tricarbonyl (MMT)
- Iron, called ferrocene.

The thermal efficiency of an engine can be improved with the increase in compression ratio [2]. Alcohol burns with lower flame temperature and luminosity owing to the decrease in peak temperature inside the cylinder as a result of heat loss and NOx emission also found decreased. Ethanol has high latent heat of vaporization. The latent heat cools the intake air and hence there is an increase in density and volumetric efficiency. However, the oxygen content of ethanol reduces the heating value compared to gasoline. It is evident that Ethanol can be used as fuel in SI engines. Serdar *et al*, [3] and Hsieh *et al*, [4] investigated the engine performance and emission of a spark ignition engine, experimentally using ethanol–gasoline blended fuels in the ratio of 5%, 10%, 20% and 30% respectively. The results of their work showed that when the ethanol rate was increased the heating value of the blended fuel was found decreased but at the same time it increased torque of the engine. Ethanol has high affinity for water. But this is not a problem for pure ethanol because it fully mixes with water, any how some serious problem may arise when gasoline – ethanol blends are used. Phase separation can also occur in gasoline – ethanol blends as gasoline and ethanol are immiscible. This problem can be overcome by using semi – polar co-solvents (solubility improvers) such as isopropanol, [5]. Guerrieri *et al*, [6] tested gasoline and gasoline–ethanol blends on six in-use vehicles to determine the effects of ethanol content on emissions and fuel economy. HC and CO emissions as well as fuel consumption found decreased in most vehicles, when the ethanol content was increased in the fuel. At the highest ethanol concentration of 40%, HC emission, CO emission and fuel consumption was found decreased by about 30%, 50% and 15%, respectively. Wu *et al*, [7] investigated the effect of air–fuel ratio on SI engine performance and pollutant emissions using ethanol–gasoline blends. The engine performance tests showed that torque output improved when ethanol– gasoline blends were used. However, there was no appreciable difference in the brake specific heat consumption. Hence CO and HC emissions were reduced when there was an increase in ethanol content in the blended fuel. It is proved in their study that by using 10% ethanol fuel, pollutant emissions can be reduced efficiently. He *et al*, [8] investigated the effects of ethanol–gasoline blends on emissions and catalyst conversion efficiencies in a spark ignition engine. It is proved that the blended fuels reduced CO, HC and NOx emissions. Wang *et al*, [9] explore the possibility to significantly reduce the particulate matter (PM) emissions by new fuel design. Several oxygenated blends were obtained by mixing the biodiesel, ethanol, and Dimethyl carbonate (DMC), and diesel fuels. The tests were conducted on two heavy-duty diesel engines, both with a high-pressure injection system and a turbocharger. The total PM and its dry soot (DS) and soluble organic fraction (SOF) constituents were analyzed corresponding to their specific fuel physiochemical properties. Bhavi *et al*, [10] worked on the properties of synthetic oxygenates and their effect on emission from engine and found that oxygenates play good role in reducing PM, CO, and HC without increase in NOx. Nibin, [11] carried out an investigation to improve the performance of a diesel engine by adding oxygenated fuel additive of known percentages. Palmer [12] reported that all oxygenated blends gave a better anti – knock performance during low speed acceleration than hydrocarbon fuels of the same octane range. Consequently, the use of gasoline – ethanol blends with fuel additives in the S.I. engines is more practical than using ethanol alone.

In this report, the effectiveness of Xtreme Fuel Treatment additive in reducing rate of fuel consumption when used in petrol engine generator set which is highly used in many homes today was investigated using paired sample t-test statistics. The product was one of the fuel additives recently introduced and distributed in the market by Syntek Global Inc., and there have been wide speculations that the product is a multi-purpose and comprehensive fuel treatment which has been extensively tested in various businesses and industries and has proven to result in positive economic, operational and environmental benefits. Xtreme Fuel Treatment contains an oil soluble organo-metallic compound which functions as a burn rate modifier and catalyst to lower the ignition point of fuel in the combustion chamber by several hundred degrees. Simply stated this means that the fuel burns longer and more efficiently, causing your engine to burn more of the available fuel it gets rather than less of it. The use of this product has been deployed on a worldwide basis in multiple sectors of the transportation, mining and power generation industries and there have been claims that it produced significant results in all benefit categories. It is a soluble product that contains many ingredients which include combustion catalyst, detergents, lubricant, fuel stabilizer, rust and corrosion inhibitor and demulsifies each designed for a specific purpose.

2.1. Paired sample t–test analysis

T – Test is one of the statistical test tools used for comparing the mean of a population when the population is normally or approximately normally distributed, with the standard deviation unknown [13]. Mathematically, the formula for t-test analysis is given by;

$$t = \frac{Dav - \mu D}{Sd\sqrt{n}} \tag{2.1}$$

Where D_{av} = mean of the difference between two populations say X and Y

S_d = Standard deviation

n = Number of distribution

μ_D = Mean of null hypothesis which is zero.

Important terms that are associated with the use of t – test analysis are;

Degree of freedom given by,

$$df = n - 1 \tag{2.2}$$

Level of significant alpha (α) and the critical values for the t – test at the chosen level of significant and the degree of freedom.

The conditions for usage of this statistical tool are that the calculated t - test statistic must be greater than the critical t – test value at the given degree of freedom and level significant for the null hypothesis to be rejected, otherwise the null hypothesis is not to be rejected in the favour of the alternative hypothesis

3.1. Materials and Method Used

The materials used in carrying out this work were as follows; FirMann Sumec2900 Generator Set, Petrol fuel, Stopwatch and the Xtreme Fuel Treatment Additive (XFT). The stopwatch was used to record time in minutes that the generator set took to burn quantities of petrol administered to its tank.

3.2. Method of Data Collection

Two sets of data were collected for analysis in this work. These included; data without XFT additive and data with XFT additive.

3.2a Data collection when generator set is run without XFT additive

Here, series of quantities of petrol were filled one after the other in the tank of the generator set, and the time it took to burn in the generator set was recorded by the stopwatch. The rate at which the petrol was consumed by the generator set was computed as follows;

$$\text{Rate of petrol consumption} = \frac{\text{quantity of petrol (liter)}}{\text{time (minute)}} \tag{3.1}$$

This was done for ten series of quantities of petrol and in each case the rate of fuel consumption was computed for analysis using statistical tool.

3.2b Data collection when the generator set was run with XFT additive

In collecting this data, 2 mills (two mills) of the XFT additive were first administered in the tank of the generator set before filling with ten liters of petrol fuel and ran. This was done for two times to make the additive get acquainted with the engine of the generator set. Thereafter, 1 mill (one mil) of the additive was used each time with the series of quantity of petrol. The rate of fuel consumption was computed for each quantities of petrol administered with the XFT in the tank of the generator set and time taken for each of the quantities to burn was recorded by the standby stopwatch.

3.3. Data Analysis and Hypothesis Formulation

The statistical tool paired sample t – test is used to compare the means of the two sets of data (data without additive and data with additive). The sample or data collected are considered dependent sample or data as the subject of interest which was the rate of consumption of petrol by the generator set were paired in some way. Thus the choice of paired sample t-test is suitable to account for any effect of the XFT additive in reducing rate of fuel consumption by the generator set. In employing the t-test sample analysis, the rate of fuel consumptions for the two data (without additive was denoted by X and with additive by Y) were paired off as shown in the table 4.3 for onwards analysis. The hypothesis test in the course of this project was formulated as follows;

The rate of fuel consumption per minute by the generator when run without XFT additive is higher than when it was operated with the XFT additive administered in the generators tank. Hence if μ_1 and μ_2 denote the mean of the two data sets X and Y respectively, then the difference $\mu_1 - \mu_2$ between the two means must be greater than zero. To this end the null and alternative hypotheses are:

Null hypothesis Ho: $\mu_1 - \mu_2 = 0$.

Alternative hypothesis Ha: $\mu_1 - \mu_2 > 0$.

That is,

H_0: $\mu_D = 0$ (the mean of the differences is zero; i.e., the XFT is ineffective).

Ha: $\mu_D > 0$ (the mean of the differences is positive; i.e., the XFT additive is effective).

4. Result and Discussion

Table 4.1: Rate of petrol consumption for generator without XFT additive

S/n	Quantity of petrol (liters)	Time (minutes)	Rate of fuel consumption (liter/minute)
1	3.00	220	0.0136
2	4.00	329	0.0122
3	4.00	383	0.0104
4	4.00	346	0.0116
5	4.00	350	0.0114
6	4.00	359	0.0111
7	4.50	403	0.0112
8	5.00	423	0.0118
9	4.00	363	0.0110
10	6.00	446	0.0135

Table 4.2: Rate of petrol consumption for generator with XFT additive

S/n	Quantity of petrol (liters)	Time (minutes)	Rate of fuel consumption (liter/minute)
1	10.00	895	0.0112
2	4.80	440	0.0111
3	4.80	420	0.0114
4	3.45	294	0.0117
5	4.00	336	0.0104
6	4.44	392	0.0113
7	4.00	359	0.0111
8	1.00	93	0.0108
9	2.00	174	0.0115
10	4.00	323	0.0124

Table 4.3: Paring off of rate of fuel consumption for X and **Y**

S/N	X (lit/min)	Y (lit/min)
1	0.0136	0.0112
2	0.0122	0.0111
3	0.0104	0.0114
4	0.0116	0.0117
5	0.0114	0.0104
6	0.0111	0.0113
7	0.0112	0.0111
8	0.0118	0.0108
9	0.0110	0.0115
10	0.0135	0.012

4.2. Testing of the Hypothesis

In testing of the hypothesis using the paired sample t- test statistical tool, the critical value for the t-test for the distribution at α=0.05 significant level was found using standard table displayed in appendix A, by reading off the value where the degree of freedom 9 and significant level α = 0.05 intercepted. The t-test value of the data is computed via the table 4.4 of the data analysis which contain the relevant terms that are contain in t-test formula.

$$t = \frac{Dav - \mu D}{Sd/\sqrt{n}} \qquad (4.1)$$

4.3. Data Analysis

Table 4.4: Data analysis table

S/n	X	Y	$D = X - Y$	$D^2 = (X - Y)^2$
1	0.0136	0.0112	0.0024	0.00000576
2	0.0122	0.0111	0.0011	0.00000121
3	0.0104	0.0114	-0.001	0.000001
4	0.0116	0.0117	-0.0001	1E-08
5	0.0114	0.0104	0.001	0.000001
6	0.0111	0.0113	-0.0002	4E-08
7	0.0112	0.0111	1E-04	1E-08
8	0.0118	0.0108	0.001	1E-06
9	0.011	0.0115	-0.0005	0.00000025
10	0.0135	0.0124	0.0011	0.00000121

Now

$\sum D$ = 0.0049

$(\sum D)^2$ = 0.00002401

$Dav = \frac{\sum D}{n} = \frac{0.0049}{10}$ =0.00049

$\sum D^2$ = 0.00001149

So that, standard deviation S_d becomes

$$S_d = \sqrt{\frac{n\sum D^2 - (\sum D)^2}{n(n-1)}} = \sqrt{\frac{10(1.149\times10^{-5}) - 0.00002401}{10(10-1)}} = 0.001005$$

And the standard error in mean, SEM is $\frac{Sd}{\sqrt{n}} = \frac{0.001005}{\sqrt{10}}$ = 0.000178

The t-test value is computed via its formula as follows:

$$t = \frac{Dav - \mu D}{Sd/\sqrt{n}} = \frac{0.00049 - 0}{0.001005/\sqrt{10}} = 1.542$$

Now the critical t-test value at 0.05 significant levels on 9-degree of freedom for 2-tailed test from standard t-test table is 2.62.

That is, $T_{crit, \alpha, 2, (df)} = T_{crit, 0.05, 2 (9)} = 2.62$.

To establish the confidence limits at the 95% level, the expression
CL = $D_{av} \pm Tcrit \times SEM$ is used.
Thus the lower and upper confidence limits at 95% levels are as follows:
$L_L = 0.00049 - 2.62 \times 0.000178 = -0.0003427$
$L_U = 0.00049 + 2.62 \times 0.000178 = 0.0013226$

4.4. Output of Data Analysis

The output of the analyzed data using paired sample T-test statistics were compared on table 4.5.

Table 4.5: Output of data analysis

	PAIRED DIFFERENCE					T	df	Sig. 2-tailed
	MEAN OF DIFF	STD	SEM	95% CI of diff				
				Lower	Upper			
PAIRED $X - Y$	0.00049	0.001005	0.000178	-0.0003427	0.0013226	1.54	9	0.05

In this output, it can be seen that the sample mean of the difference in the rate of fuel consumption was 0.00049 and the standard deviation of the difference was 0.001005. The calculated T-test statistic (with 9-degree of freedom) at 0.05 significant level was 1.54. We noticed that the mean of the rate of fuel consumption without XFT minus the rate of fuel consumption with XFT additive by the generator set was positive, which was in supportive of our alternative hypothesis Ha; that is $\mu_D > 0$. Since this experiment from its inception was interested in detecting a reduction in the rate of fuel consumption by the generator set when XFT additive was administered in the tank of the gen set, it can be viewed as one sided or one tailed test. The critical t-test value for two tailed and one tailed test at 0.05 significant level and 9 degree of freedom were 2.621 and 1.833 respectively. These values were greater than the calculated t-test statistic of 1.54. Thus at $\alpha = 0.05$ level of significant, we were not to reject the null hypothesis Ho, and it can be stated that the XFT additive was not effective enough in reducing rate of fuel consumption.
The output also included a 95% confidence interval on the mean difference. It should be noted that this confidence interval -0.0003427 and $+0.0013226$ in this case, for the fact that the confidence interval contained both negative and positive values and each was not far from zero suggested statistically, that the XFT additive was not effective enough in reducing rate of fuel consumption in the generator set.

4.5. Decision Making

Here, we did not to reject the null hypothesis, (Ho: $\mu D = 0$), in favor of the alternative hypothesis (Ha: $\mu D \neq 0 > 0$), since the t-test statistic value is less than the t-test critical value. That was that $1.54 < 2.62$.
Hence, the null hypothesis Ho, that the XFT additive has no effect was not rejected in favour of the alternative hypothesis Ha; that there was statistically significant difference in the rate of fuel consumption when XFT additive was administered in the tank of the generator set.

5. Conclusion

In conclusion, we inferred from this work that the Xtreme Fuel Treatment (XFT) that was been advertised and claimed to increase fuel economy of engines was not effective in reducing rate at which petrol was consumed in generator set.

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