

## Performance and Emission Characteristics of Nano Engine Running on Plastic Oil Extract



### Engineering

**KEYWORDS :** brake thermal efficiency, ethanol, gas analyser, gasoline, nano engine, waste plastic oil.

<b>T.Shanmuga vadivel</b>	Professor of Mechanical Engineering, Annamalai University, Chidambaram
<b>P.Balashanmugam</b>	Assistant Professor in Mechanical Engineering, Annamalai University, Chidambaram
<b>T.Sivakumar</b>	Research scholar in Mechanical Engineering, Annamalai University, Chidambaram

### ABSTRACT

*The reserves of petroleum based fuels are being rapidly depleted, because of the increased use of fossil fuels for energy production. It is well known that the future availability of energy resources as well as the need for reducing the emission from the fuels used has increased the need for the utilization of regenerative fuels. In this study, the effects ethanol-gasoline blend with Waste Plastic derived oil in a twin cylinder Nano engine was investigated. This project aims at using the Waste Plastic derived oil as an alternate fuel in petrol engines. The performance and emission tests were conducted in a NANO engine. The main aim of this project is to find a solution to the mounting problem of waste plastic disposal, for which the plastics are converted into useable fuel. The test fuels were prepared using 99.9% pure ethanol and gasoline with WPO blend, in the ratio of E5 + 5 WPO, E15 + 15 WPO, E25 + 25 WPO and the rest gasoline. The experimental results reveal an increase in brake thermal efficiency for the blends when compared to that of sole fuel. During this investigation, the emission tests are made with the help of the AVL di gas analyzer, in which CO, CO<sub>2</sub>, HC, NO<sub>x</sub> is appreciably reduced and O<sub>2</sub> is increased for all the blends when compared to gasoline as the sole fuel.*

### INTRODUCTION

The reserves of the petroleum based fuels are being rapidly depleted, because of the increased use of the fossil fuels for the production of energy. It is well known that 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. The incentives for studying the combustion of alternate fuels or fuel additives in engine may improve the efficiency and may solve the problems related to emissions and detonation. Alternate fuels may help in the conservation of the world's petroleum supplies, as well as being available when those supplies are exhausted.

Alcohol such as ethanol, a colourless liquid with a mild characteristic odour can be produced by fermentation of the biomass crops, mainly from sugarcane, wheat and wood. Usage of alcohol as fuel for S.I. engine has some advantages when compared to the gasoline. Ethanol has better anti-knock characteristics than gasoline. The engine thermal efficiency can be improved with the increase in the compression ratio. Alcohol burns with the lower flame temperature and luminosity owing to decreasing the peak temperature inside the cylinder. So that the heat loss and NO<sub>x</sub> emissions are lower. An Ethanol has a high latent heat of vaporization. The latent heat cools the intake air and so there is an increase in the density and the 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 S.I. engines.

For studying the combustion of alternative fuels or fuel additives in engine may improve the efficiency and can solve the problems related to emissions and detonation. Thus the alternative fuels help in the conservation of the world's petroleum resources. Among these additives are alcohols (especially ethanol). Ethanol has received sporadic attention over a long period. The interest comes partly from the possibility of utilizing products of agriculture, when they are in surplus. Not too long ago, an additional interest was developed from the Possibility that the use of ethanol might result in lower exhaust emissions. Advantages of ethanol includes wider flammability limits, higher octane ratings and higher burning velocity than gasoline. These properties allow the engine to run at higher compression ratios and wider spark timing limits. Also, since the ethanol molecule contains oxygen, it allows the engine to burn the fuel completely, resulting in fewer emissions. Against these, its main operation disadvantage is the difficulty of cold starting that result from its lower vapor pressure at the atmospheric temperature. Another disadvantage of using ethanol is that ethanol has a much lower heating value compared with gasoline that leads to an increase in fuel consumption. In the present analysis, the main objective

is to study the effect of ethanol-gasoline blending ratio on both the engine performance and exhaust emissions from spark ignition engines.

### PREVIOUS WORK

It was observed from the literature survey that works have been carried out on alternative fuels like ethanol in SI engines. But further research has to be attempted to optimize blending of the fuel so as to reduce the emission and to improve the performance of the engine. In this chapter an overview of some important research works on ethanol blended fuels are presented. Wei-Dong Hsieh et al. [1] Extensive study on engine performance and pollutant emission of an SI engine using ethanol-gasoline blended fuels. The purpose of this study is to experimentally investigate the engine performance and pollutant emission of a commercial SI engine using ethanol-gasoline blended fuels with various blended rate (0%, 5%, 10%, 20%, 30%). Results showed that with increasing the ethanol content, the heating value of the blended fuels is decreased, while the octane number of the blended fuels increases. Finally it was noted that NO<sub>x</sub> emission depends on the engine operating condition rather than the ethanol content. M.Al-Hasan[2] investigated the effect of using unleaded gasoline ethanol blends on SI engine performance and exhaust emission a four stroke, four cylinder SI engine (type Toyota, Tercel-3A) was used for conducting this study. Performance and emission tests were conducted. The results showed that blending unleaded gasoline with ethanol increases the brake power, torque, volumetric and brake thermal efficiencies and fuel consumption while it decreases the brake specific fuel consumption and equivalence air-fuel ratio. The CO – HC emissions concentrations in the engine exhaust decreases while the CO<sub>2</sub> concentration increases the 20 volume % ethanol in the fuel blend gave the best results for all measured parameters at all engine speeds. Bang-Quan He et al.,[3] Tested the effect of ethanol blended gasoline fuels on emission and catalyst conversion efficiencies was investigated in a spark ignition engine with an electronic fuel injection EFI system. The addition of ethanol to gasoline fuel enhances the octane number of the blended fuels and changes distillation temperature. Ethanol can decrease engine out regulated emissions. The fuel containing 30% ethanol by volume can drastically reduce engine out total hydrocarbon emission (THC) at operating conditions and engine out HC, CO and NO<sub>x</sub> emissions at idle speed, but unbound ethanol and acetaldehyde emission increases Pt/Rh based three way catalysts are effective in reducing acetaldehyde emissions but the conversion of unburned ethanol is low. Tailpipe emissions of THC, CO and NO<sub>x</sub> have close relation to engine-out emissions, catalyst conversion efficiency, engines speed and load, air/fuel equivalence ratio. More over the blended fuels can decrease brake specific energy consumption. Gao Jian et al., [5] Extensive study

of spray properties of alternative fuels: a comparative analysis of ethanol-gasoline blends and gasoline. Ethanol is an attracted alternative fuel and ethanol-gasoline blends can be used as fuel in order to substitute some part of gasoline engine applications. In this study, the spray properties of different blends of ethanol-gasoline (20%, 50%, 75% and 100% ethanol) as well as pure gasoline are investigated under various ambient conditions by means of high speed schlieren photography technique. Pure gasoline shows a larger core angle at the beginning of injection period.

**EXPERIMENTAL SETUP AND PROCEDURE**

A vertical inclined, water cooled, twin cylinders, four stroke, 73.5mm bore, 73.5 mm stroke, 624 cc displacement, 9.5:1 compression ratio, 25.74 kW power with rated speed of 5000 RPM, Nano engine was used for the experimental work. The engine was coupled to an eddy current dynamometer for load measurement. Hydrocarbon, carbon monoxide, Carbon dioxide, NOx was measured by using AVL 5 gas Analyzer. Before the experiments the emission analyzer and the dynamometer was calibrated. The experiments were performed at variable load by 20%, 40%, 60%, 80% and 100 % with constant speed of 2500 rpm. The volumetric percentages of ethanol – gasoline blends with WPO are in the ratio of E5 + 5 WPO, E15 + 15 WPO, E25 + 25 WPO, and the rest gasoline. These represent the ratios of ethanol and the WPO amount in the total blend. Prepared waste plastic oil is shown in figure 1. Ethanol with a purity of 99.9% was used in the blends. The schematic view of the test equipments is shown in figure 2. The WPO is added to the fuel to improve the operation of the engine and to reduce pollutant released into the atmosphere by the engine running with this fuel. The fuel is made by mixing of ethanol-gasoline with WPO blend. This project aims to run the engine with different percentage of blending of gasoline and ethanol with the additive to reduce the exhaust emissions and also to increase the brake thermal efficiency of the engine. The percentages of blending are given in table 1. The Photographic view of the test engine (nano engine) is shown in figure 3.

**Table 1 The percentages of blending**

Fuel blends	Gasoline %	Ethanol %	WPO %
Sample 1	90	5	5
Sample 2	70	15	15
Sample 3	50	25	25
Sole Fuel	100	-----	-----

**Experimental Procedure**

The following test was conducted on Nano engine, using gasoline and various fuel blends.

- Load test
- Emission test

**Procedure for speed test**

- Check the gasoline level in the fuel tank before starting the engine.
- Load, speed, temperature indicator is switched on.
- Open the fuel flow to the carburetor.
- The engine was started ensuring there is no load.
- The engine is allowed to run at the initial load for a period of 20 minutes to reach the steady state and then apply the required load and speed.
- Fuel consumption is measured by a stop watch with weighing balance.
- In the same way take the readings for 20%, 40%, 60%, 80% and 100% of the loads.
- After taking the reading close the fuel supply and to stop the engine.

**Procedure for emission test**

- Switch on the AVL gas analyzer through the electrical power supply, and also allow it to settle down for 15 minutes. Allow the display to settle at zero readings.

- Run the engine as per speed test procedure.
- Hold the sample-taking probe in the exhaust gas outlet for emission test then digital display will show the readings. These readings start increasing and at the maximum value, the values stand for a few seconds and then the readings start reducing. Take the maximum value of the reading corresponds to CO, CO<sub>2</sub>, HC and NOx.
- Take out the sample taking probe from exhaust gas out and allow the display to settle at zero reading.
- (v) Repeat the same for different speeds of gasoline and blended fuel.

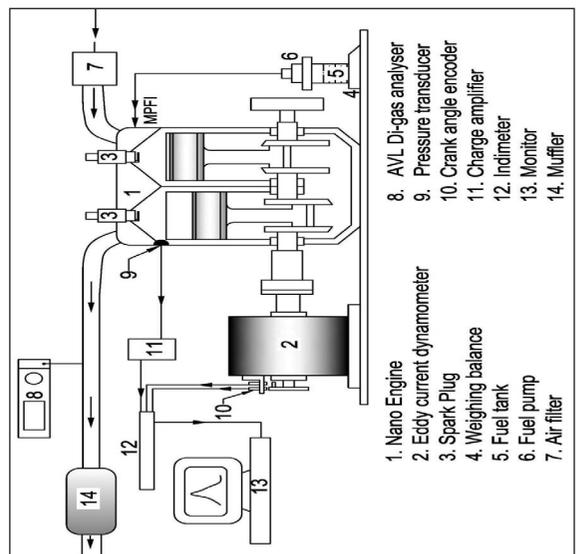
At the end, switch off the power supply for the exhaust gas analyzer.



**Figure 1 Waste plastic oil**

**Specification of the engine**

**Type : Vertical in-line petrol Engine Tata Nano**  
 No of Cylinders : 2  
 Bore : 73.5 mm  
 Stroke : 73.5 mm  
 Displacement : 624 cc  
 Compression Ratio : 9.5:1  
 Cycle : 4 Strokes  
 Max. Power : 125.74 kW @ 5000 rpm  
 Speed : 3000 rpm  
 Cooling System : Water  
 Loading Device : Eddy current Dynamometer



**Figure 2 Experimental setup**



Figure 3 Photographic view of test engine

**Experimental Procedure for gasoline as fuel**  
**Precautions**

- Check the fuel level in the fuel tank.
- Check the water flow
- Check whether the engine is on no-load condition.

**Procedure**

The engine is started by switching the hand electric switch. The engine is allowed to run for 5 to 10 minutes to attain steady state. Then the gear is engaged with the loading device and allowed to run for 5 minutes. The speed and load of the engine were applied. The temperature of the water inlet and outlet temperature were taken. Then the exhaust gas temperature is also measured. The gas analyzer is used to find the amount of HC in ppm, CO in % by volume, CO<sub>2</sub> in % by volume and NOx in ppm is measured. Then the water inlet temperature and outlet temperature is also measured. The load and speed is applied they the fuel consumption is noted. Likewise the same procedure is followed and all the readings above said are noted for all the further loads are applied for various speeds.

The engine was allowed to run with gasoline at various loads of 20%, 40%, 60%, 80% and 100% of load with a constant speed of 2500 rpm. After completing the experiment with gasoline, the experiment was conducted with samples; Fresh gasoline procurements were made for experiments with each sample blend to reduce the effect of storing. Hence to compare the results of the fuel blend runs, base values with gasoline were obtained separately for each fuel blend. After completing the experiments with the first fuel blend, the engine was allowed to run for about 10 minutes with gasoline to eliminate the interference of the first fuel blend. Then for each fuel blend, after completion the gasoline run was repeated. The entire fuel blends were tested by similar procedures.

Table 2 Result Tabulation of Sole fuel

B.P (kW)	$\eta_{bth}$ (%)	CO %by vol.	HC (ppm)	CO <sub>2</sub> %by vol.	O <sub>2</sub> %by vol.	NOx ppm	$\lambda$	EGT (°C)
1.597	11.3	0.005	12	6.58	11.68	132	2.26	54
3.194	16.2	0.005	7	7.4	10.44	343	1.99	147
4.817	21.4	0.01	7	7.8	9.96	482	1.89	228
6.414	26.8	0.02	9	8.4	9.03	503	1.75	279
8.011	27.1	0.03	10	9.1	8.19	650	1.62	339

Table 3 Result Tabulation of Sample 1

B.P (kW)	$\eta_{bth}$ (%)	CO %by vol.	HC (ppm)	CO <sub>2</sub> (%by vol.)	O <sub>2</sub> (%by vol.)	NOx (ppm)	$\lambda$	EGT (°C)
1.597	12.77	0.01	6	6.4	11.65	169	2.275	171
3.194	17.34	0.01	8	7.2	9.97	273	1.970	217
4.817	19.79	0.01	8	8	9.05	374	1.792	291
6.414	20.31	0.03	19	8.6	8.05	102	1.648	327
8.011	23.87	0.1	21	9.2	7.14	139	1.532	375

Table 4 Result Tabulation of Sample 2

B.P kW	$\eta_{bth}$ (%)	CO %by vol.	HC ppm	CO <sub>2</sub> %by vol.	O <sub>2</sub> %by vol.	NOx ppm	$\lambda$	EGT (°C)
1.59	12.5	0.005	6	6.5	11.1	190	2.2	192
3.19	15.8	0.005	7	7.2	10.2	215	2.0	227
4.81	22.4	0.005	10	8	9.1	368	1.79	267
6.41	22.7	0.02	10	8.8	7.98	402	1.53	317
8.01	24.3	0.05	14	9.3	7.27	497	1.54	363

**RESULTS AND DISCUSSIONS**

The effects of ethanol added to gasoline with WPO on SI engine performance and exhaust emissions at varying engine speeds were investigated. The result tabulations of sole fuel, sample 1 and sample2 are given in the table 2, 3 and 4.

**Brake thermal efficiency**

The effect of the gasoline – ethanol with WPO blends, on the brake thermal efficiency is shown in Figure 6.1. The brake thermal efficiency is higher for all the samples when compared to the sole fuel. The brake thermal efficiency is 25.44 % for sample 3 at maximum load is higher when compared to the other sample. A marginal increase of brake thermal efficiency is observed in all samples at all speeds as shown in figure 4. Among the samples, sample 2 shows the maximum brake thermal efficiency. This is due to the increase in octane number of the samples. Hence it is evident that the blended fuel has relatively higher calorific value of 39480 kJ/kg K than the gasoline.

**CO Emissions**

The effect of the gasoline – ethanol with WPO blends, on the CO emissions is shown in figure 5. It can be seen that ethanol with WPO concentration increases and reduces the CO emissions. It is noted that in sample 1 at part load, the concentration of CO emission decreases 0.01 % by volume. The variation of CO emission in the sample 1 is less when compared to that of the other sample. The reason is due to the increase in the percentage of ethanol and additive concentrations because of leaner combustion due to the presence of oxygen in ethanol. Owing to the leaning, CO emissions decrease tremendously. In general, for all concentration blend CO emissions are reduced when concentration increases.

**CO<sub>2</sub> Emissions**

The effect of the gasoline – ethanol with WPO blends on CO<sub>2</sub> is shown in figure 6. In sample 1 and 3, the CO<sub>2</sub> value is 8.5 % by volume at maximum load, which is minimum than other sample. It is obvious that there is a significant reduction in CO<sub>2</sub> emissions when using ethanol blends samples. There is an appreciable reduction in sample 3. This is due to the presence of a maximum blend of WPO in the ethanol – gasoline blends

**HC Emissions**

The effect of alcohol percentage in the blend of WPO on the HC emissions is shown in the figure 7. In all the samples there is an increase in the HC emissions at above part loads. The amount of HC emissions in all samples is lower when compared to that of the sole fuel as part load; it is due to the fact that, ethanol has lower flame speed compared to sole fuel operation. As a result, the less mass fraction of the fuel is burnt in the case of ethanol blends gasoline with WPO. In sample 3, the value of the HC emissions is 4 ppm at part load condition which is minimum than the other samples.

**NOx Emissions**

The effect of the gasoline – ethanol with WPO blends on the speed versus NOx is shown in figure 8. It can be seen that ethanol gasoline blend decreases NOx emissions. This is the main reason attributed to the properties of ethanol blends. For sample 2 and 3 it is found that NOx level is significantly reduced for maximum load. This indicates that they have a lower heating value of ethanol than gasoline. This decreases the combustion heat energy and lowers the combustion temperature in the cyl-

inder. In sample 2, the NOx value is 139 ppm at maximum load condition which is minimum than other samples.

**O<sub>2</sub> Emissions**

Figure 9 shows the effect of gasoline – ethanol with WPO blends on the speed Vs O<sub>2</sub>. All the samples were found to decrease the O<sub>2</sub> emissions at maximum load condition. In sample 2, the value of O<sub>2</sub> emission is 7.14 % by volume at maximum load which is maximum than the other samples. The reason for the increase in oxygen content in the exhaust gas is due to the increase in ethanol and WPDO percentage.

**Exhaust gas temperature**

The effect of the gasoline–ethanol with WPO blends on the exhaust gas temperature is shown in the figure 10. In sample 2, the exhaust gas temperature is 375° C at maximum load which is minimum than other samples. It is obvious that there is a significant reduction in the exhaust gas temperature when using ethanol blend samples.

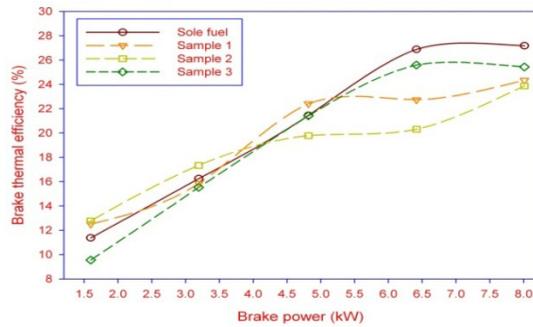


Figure 4. Brake thermal efficiency against speed

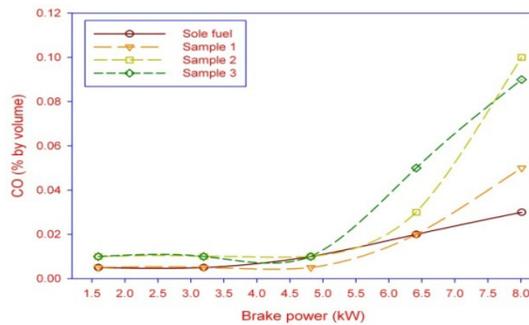


Figure 5 CO against speed

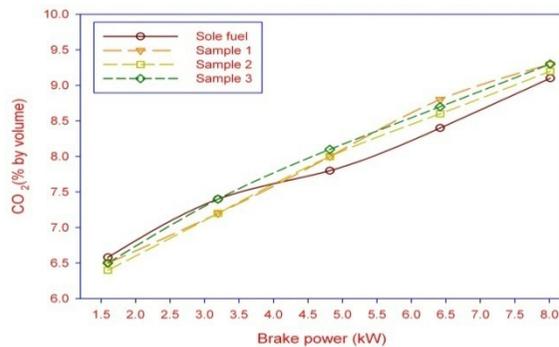


Figure 6 CO<sub>2</sub> against speed

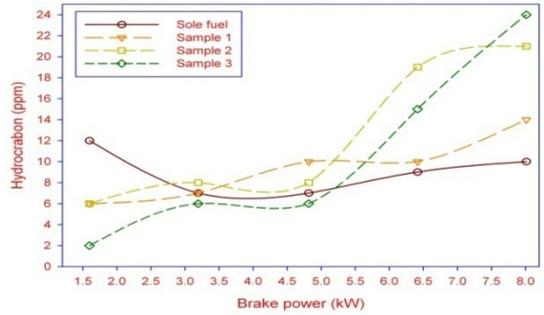


Figure 7 HC against speed

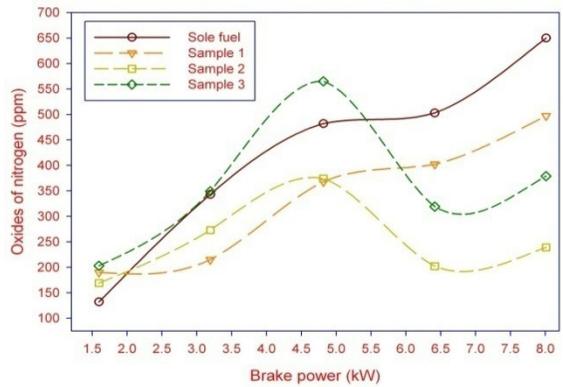


Figure 8 Oxides of nitrogen against speed

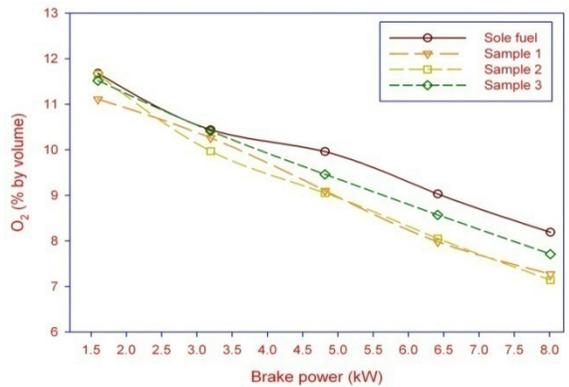


Figure 9 O<sub>2</sub> against speed

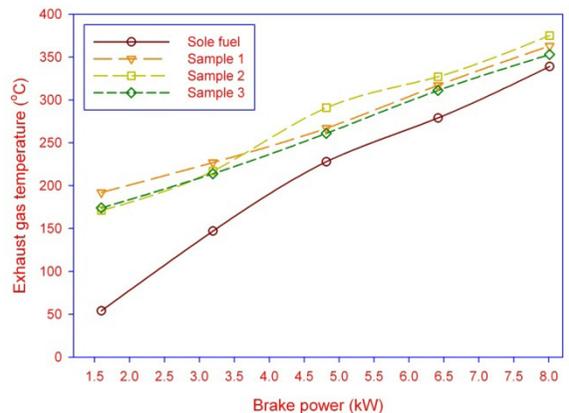


Figure 10 Exhaust gas temperatures against speed

**CONCLUSION**

From the study, the following conclusions can be deduced:

1. Using of ethanol blend as a fuel WPO to gasoline causes improvement in engine performance and exhaust emissions.
2. Ethanol addition results in the increase in brake thermal efficiency.
3. Using of ethanol blended gasoline leads to a significant reduction in exhaust emissions. For all engine speeds the values of CO, CO<sub>2</sub>, HC and NO<sub>x</sub> have been reduced. On the other hand O<sub>2</sub> emissions have been increased significantly.
4. The sample 2 of the ethanol blend gives the best result for the engine performance and exhaust emissions.
  - The brake thermal efficiency is 25.44 % for sample 3 at maximum load
  - The CO emission is 0.01 % by volume at for sample 1 at maximum load
  - The CO<sub>2</sub> emission is 9.2 % by volume for sample 2 at maximum load
  - The HC emission is 6 ppm for sample 3 at part load.
  - The NO<sub>x</sub> emission is 239 ppm for sample 2 at part load
  - The O<sub>2</sub> emission is 9.1% by volume for sample 1 at part load.

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