Performance, Emission and Visiographic Analysis of Gasoline Engine with Cyclohexylamine and n-Butyl alcohol Additives

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Abstract: In this work, two oxygenated additives like Cyclohexylamine and n-butyl alcohol are recognized for the experimental investigation by blending them to 5 ml with gasoline sole fuel. The performance and emission analysis were tested in twin cylinder SI engine with both additives blend with gasoline. The physical and chemical properties of the gasoline fuel and additives are tested through ASTM standards and reported. From the experimental results, it was found that brake thermal efficiency increased to 1.25% and emissions like HC and CO reduced to 5.3% and 17%, respectively for addition of Cyclohexylamine and n-butyl alcohol. NOx emission found increased in the both additive cases. The Fuel spray images were captured by AVL Visio scope with pixel fly VGA Camera and necessary equipment's.

Key Words: Gasoline engine, Cyclohexylamine, *n*-butyl alcohol, Performance, Visio graph.

NOMENCLATURE:

Sample -1	- Cyclohexylamine
Sample-2	- *n*-butyl alcohol
Rpm	- Revolution per minute
HSU	- Hatridge smoke unit
Ppm	- Parts per million
BP	- Brake power
BTE	- Brake thermal efficiency
HC	- Hydrocarbon emission
CO	-Carbon monoxide emission
NOx	- Oxides of nitrogen emission
ASTM	- American Standard Testing Materials

1. INTRODUCTION

The major exhaust emissions HC, CO, SO_2, NOx, solid particles are and performance is increased by adding the suitable additives to the fuel reduced with the present technology [1]. Additives are integral part of today's fuel. Together with precisely formulated base fuel composition they contribute to efficiency and long life [2, 3]. They are chemicals, which are added in small quantities either to increase fuel performance, or to correct a deficiency as desired by the current legislation [4]. They can have surprisingly large effects even when added in little amount. Additives are blended into fuel by refineries or end users [5]. However use of metallic additives was successively discontinued primarily because of concern about the toxicity of the barium compounds in the exhaust emission. But the interest is revised freshly to verify the possible use of additives to reduce emission level [6]. Alcohol has been used as a fuel for Auto-engines since 19th century; it is not extensively used because of high price. Alcohol is one of the fuel additive (Ethanol ,Methanol) has certain advantage over gasoline such as better antiknock characteristics and the reduction of CO and HC emissions [7,8]. Numerous additives (oxygenated organic compounds) such as methanol, ethanol, tertiary butyl alcohol and methyl tertiary butyl ether are used as fuel additives [9]. While having these advantages, due to confines in technology, economic and regional considerations alcohol fuel still cannot be used extensively [10]. Ethanol can be fermented and distilled from biomasses; it can be considered as renewable energy beneath the environmental consideration, using ethanol blended with gasoline is better than methanol because of its renewability and less toxicity [11]. In this study to improve the performance and reduce the harmful emissions like HC and CO, and Cyclohexylamine, *n*-butyl alcohol additives are blend with gasoline fuel in the proportion of 5ml.

2. FUEL MODIFICATION

Cyclohexylamine and n- Butyl alcohol were added with gasoline fuel with 5ml/litre and set aside in a homogenizer to make proper blend of fuel and additive. The thermo-physical properties of fuel before and after addition of Cyclohexylamine and n-Butyl alcohol have tabulated in Table 2 and chemical properties have tabulated in Table 1.

Table 1 Properties of Cyclohexylamine and n- Butyl alcohol
(Source: **The European Fuel Oxygenates Association, 2006)**

Properties	Cyclohexylamine	*n*-Butyl alcohol
Molecular formula	$C_6H_{11}NH_2$	$C_4H_{10}O$
Molecular weight (g/mol)	99.177	74.12
Boiling point (°C)	134.5	117.2
Vapour pressure (mmHg at 20°C)	11	7.024

Table 2 Physical and chemical properties of petrol, Cyclohexylamine and n- Butyl alcohol
(**Source: ETA Laboratory, Chennai**)

Property	Petrol	Cyclohexylamine	*n*-Butyl alcohol
Specific gravity	0.72	0.7437	0.7457
Kinematic viscosity	1.37	1.39	1.37
Flash point°C	-43	-11	-10
Fire point °C	-13	-10	-8
Pour point °C	-32	-15	-17
Gross calorific value (kJ/kg)	45650	45709	45797
Acidity as mg of KoH/gm	0.024	0.010	0.01
Density@ in gm/cc	0.71	0.7442	0.7437

3. EXPERIMENTAL SETUP

The experimental setup is shown in Figure 1. The level of the fuel and lubricating oil were analyzed before starting the engine. The eddy current dynamometer control unit panel is switched "ON' to note down the speed, load and temperature from the indicator provided in the panel board. Then the ignition switch is turned "ON" position. The fuel discharged from the fuel tank through the electronic fuel injection pump and then started the engine at no load condition. The engine was allowed to run with sole fuel by varying speed of (2000, 2200, 2400, 2600 and 2800 rpm) for nearly 30 minutes to obtain steady state condition. The cooling water temperature reached 50°C. Fuel consumption was measured by stop watch for one minute of fuel. In the same readings for various speeds 2000, 2200, 2400, 2600 and 2800 rpm were observed. After taking the required readings the ignition switch is turned "OFF" position to stop the engine and the eddy current dynamometer control unit panel was also switched "OFF".

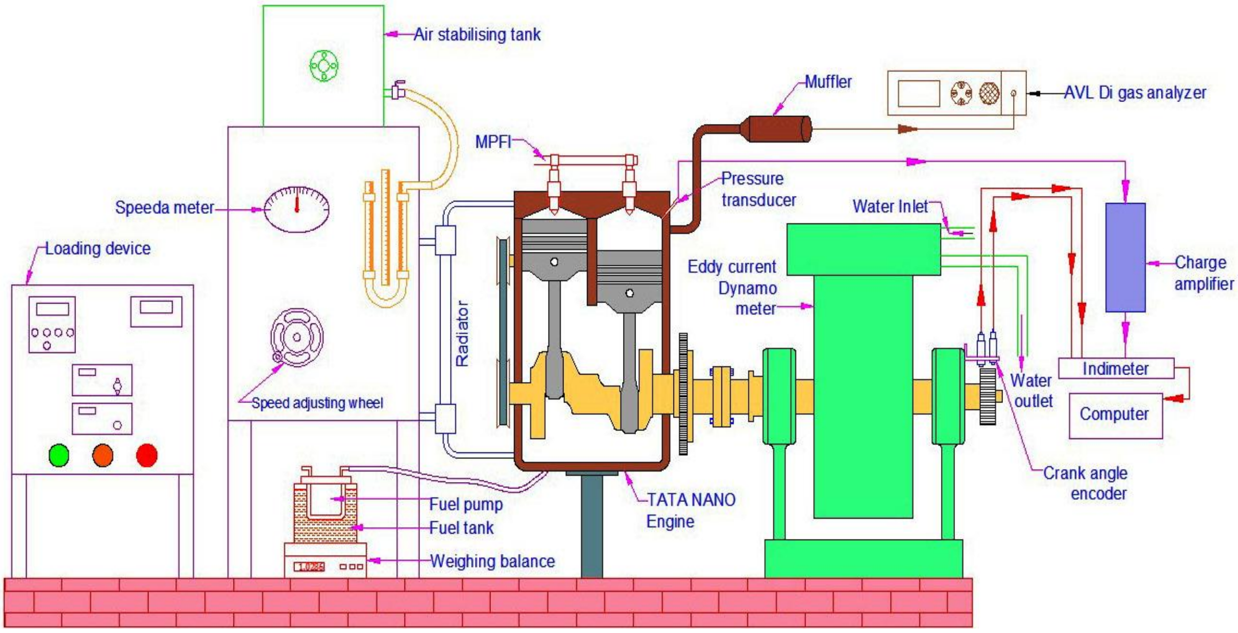


Figure 1 Experimental setup

Table 3 Specification of the test engine (TATA NANO)

Type	Vertical In-line Engine with MPFI
No. of Cylinder	2
Displacement	624 cc
Bore	73.5 mm
Stroke	73.5 mm
Compression Ratio	9.5:1
Fuel	Petrol
Cycle	4-Stroke
Max. Engine output	25.74 kW @ 5250 rpm
Max. Torque	48 Nm @ 3000 rpm
Speed	2500 rpm
Orifice Diameter	20 mm
Cooling System	Water
Loading Device	Eddy current Dynamometer

4. FUEL SPRAY VISUALIZATION

The spray visualization was studied through the AVL Visioscope with all the necessary equipment's. The Visioscope equipment was consists with the following accessories;

- Pixel fly VGA camera
- Visio Sparkplug
- Endoscopic unit
- Light Control unit with flash
- AVL Micro IFEM
- AVL Indimodule
- AVL Visio FEM
- Crank angle encoder
- AVL Visioscope 1.4 Software

The AVL Visioscope is a fully digital, triggerable video system specifically designed for IC Engine research. It is used to observe periodic phenomena in IC engines using a strobe. The images delivered by a digital CCD Camera are transmitted straight to the PC as digital data (and therefore with no loss of quality). Synchronization with the engine is achieved via an AVL Angle Encoder (365Cor365X). A strobe connected to the Light Unit is used for convenient correction angle adjustment. The proven endoscopy technology provides optical access to any type of series engine without interfering with the in-cylinder processes.

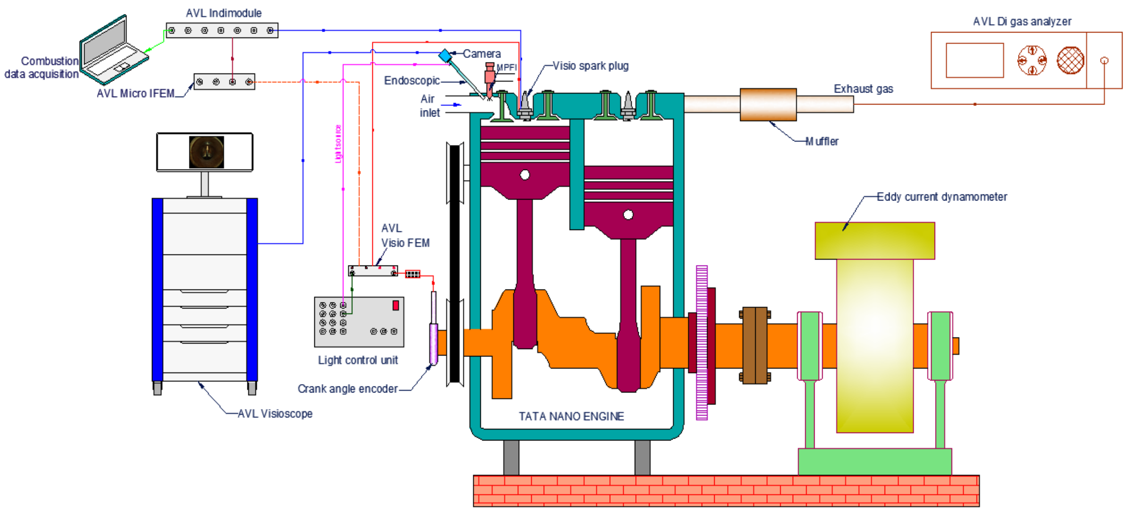
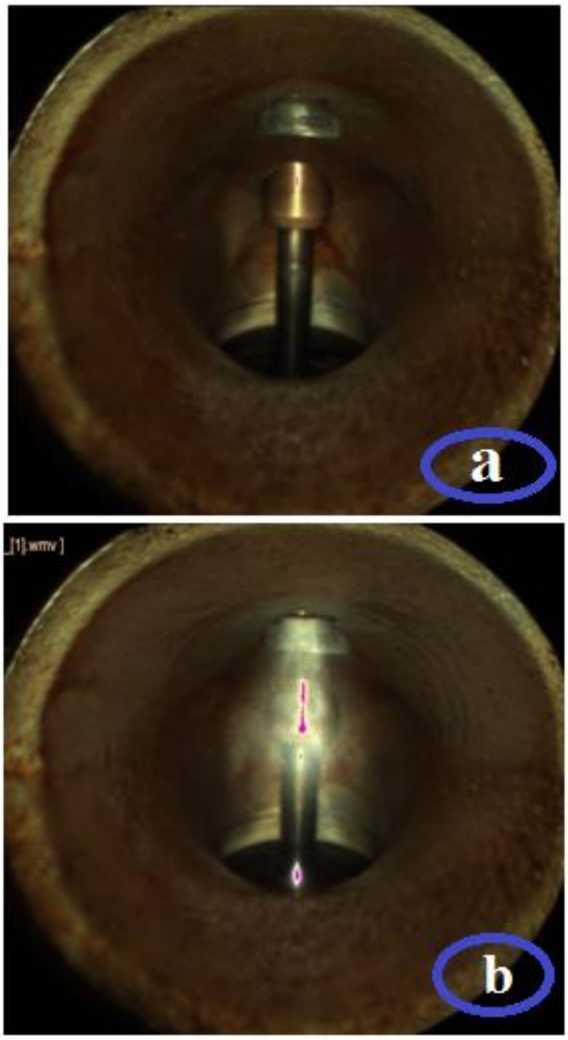


Figure 2 Experimental setup with AVL Visioscope

Figure 3 Photographic view of AVL Visioscope unit with accessories

Figure 4 Photographic view of endoscope fitted in test engine



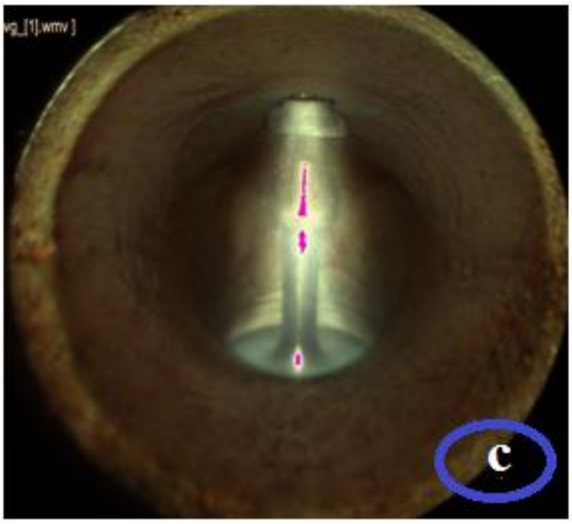


Figure 5 Photographic view of Spray Visualization (a) without fuel spray (b) with fuel spray (c) fuel spray ending

5. RESULT AND DISCUSSION

The experimental investigations were conducted by gasoline fuel with two types of oxygenated additives such as Cyclohexylamine and n-butyl alcohol. The investigations were experimentally conducted in TATA NANO gasoline engine by various speed conditions of the engine.

5.1 PERFORMANCE CHARACTERISTICS

5.1.1 BRAKE THERMAL EFFICIENCY

Figure 6 shows the variations of brake thermal efficiency (BTE) with speed for various blends of gasoline with fuel additives. It is clearly seen from the graph that the gasoline fuel blended with additives gives improved performance when compared to that of sole fuel. The Sample-2 (*n*-butyl alcohol) along with gasoline blends shows increased brake thermal efficiency when compared with other additive. The BTE of Sample-2 at 2600 rpm is 22.9% and 2800 rpm is 22.5%. Further increases the speed from 2600 rpm the BTE was gradually decreased. The possible reason may be due to the presence of additional oxygen present in the additive provides better combustion that results in increased brake thermal efficiency at 2600 rpm. It has shown an increase of 1.2% when compare to sole fuel at 2600 rpm speed of the engine.

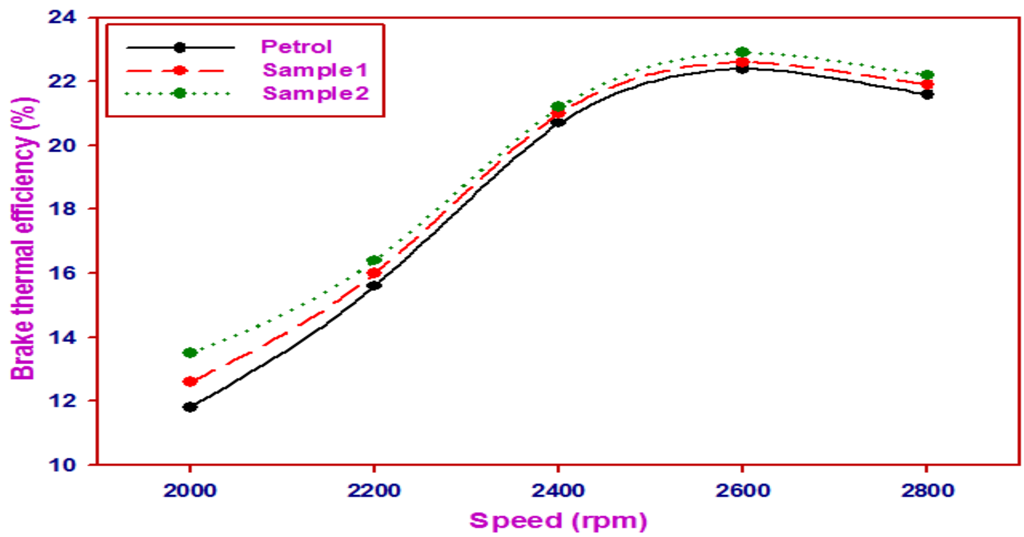


Figure 6 Variations of brake thermal efficiency with Speed

5.1.2 SPECIFIC FUEL CONSUMPTION

Figure 7 shows the variations of specific fuel consumption with speed for various blends of gasoline fuel additives. Brake power increases, SFC decreases. Among the gasoline blends Sample-2 shows lower specific fuel consumption when compare to other additives. The reason is complete combustion of the fuel achieved by oxygenated additive.

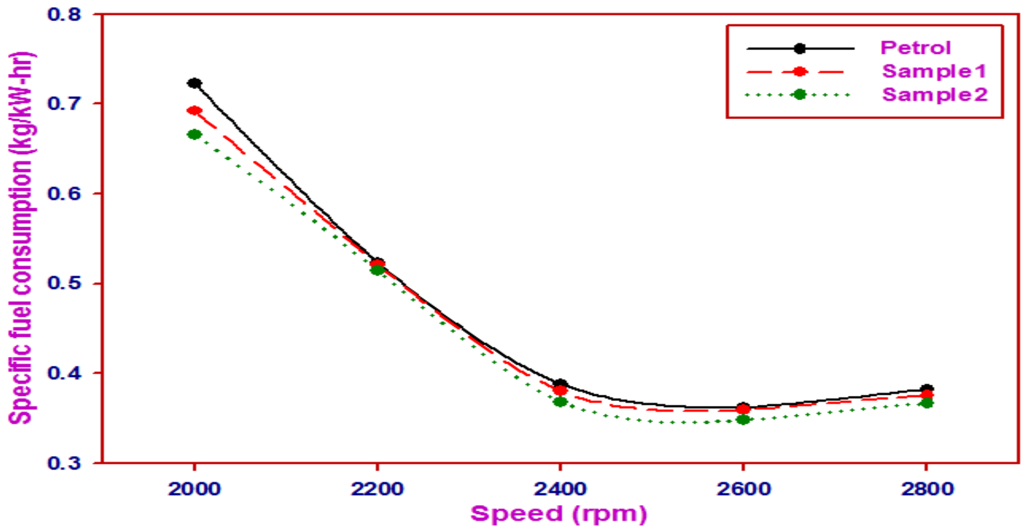


Figure 7 Variations of specific fuel consumption with speed

5.2 EMISSION CHARACTERISTICS

5.2.1 OXIDES OF NITROGEN (NOx)

Figure 8 shows the variations for oxides of nitrogen with speed for various blends of gasoline with fuel additives. Sample-2 shows increase in NO_x concentration when compared to that of sole fuel and other gasoline blends with additives. An increase of 4.25% was observed when compared to that of gasoline sole fuel. The increased oxygen content provides better combustion thereby in cylinder temperature is increased due to which an increased NO_x emission is observed for Cyclohexylamine additive with sole gasoline fuel at maximum speed of the engine.

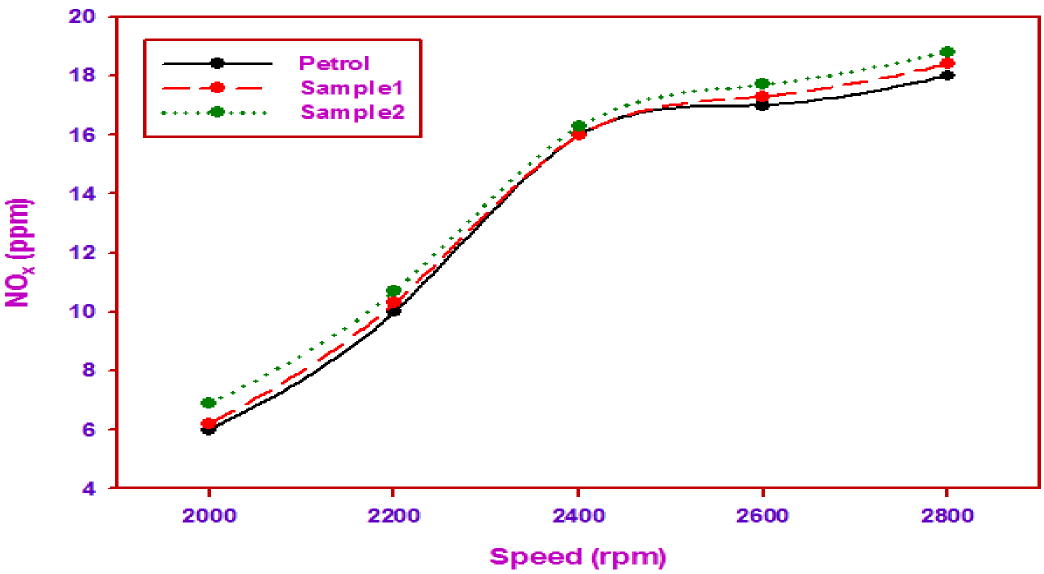


Figure 8 Variations of oxides of nitrogen with Speed

5.2.2 CARBON MONOXIDE (CO)

Figure 9 shows the variations of carbon monoxide with speed for various gasoline blends and fuel additives. Sample-2 blend shows decreased CO emission since the availability of additional oxygen content improve the combustion process and converts CO into CO_2. A decrease of 17% was observed when compared to that of sole gasoline fuel. The CO emission for sole fuel, additive-2 at maximum speed of the engine is 0.76, 0.63 % by vol. respectively

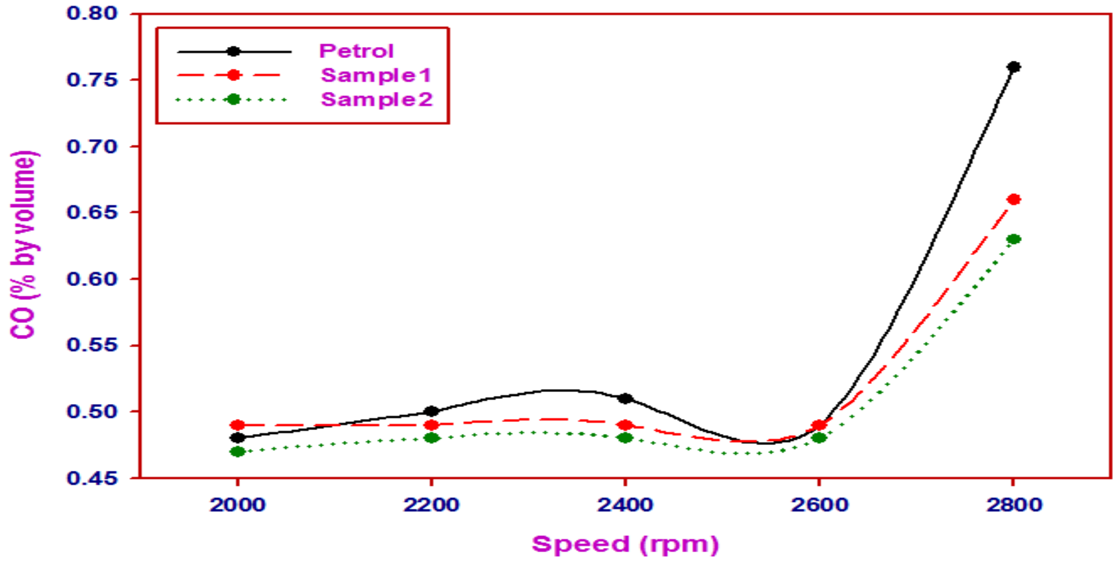


Figure 9 Variations of CO with Speed

5.2.3 HYDROCARBON (HC)

Figure 10 shows the variations of Hydrocarbon emission with speed for various gasoline blends with fuel additives. Sample-2 shows decrease in HC emission when compared to that of sole gasoline fuel. The reason is due to complete combustion provided by the oxygenated additive. It has shown a decrease of 5.3% when compare to neat sole gasoline fuel. The HC emission of sole fuel and sample-2 is 28.4, 26.9 ppm respectively with maximum engine speed.

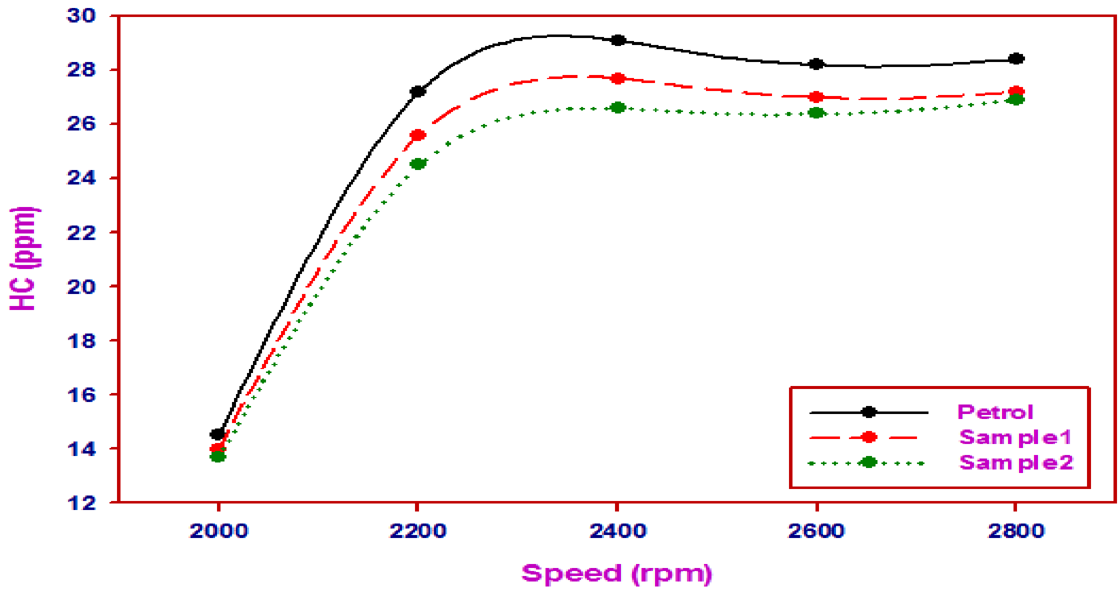


Figure 10 Variations of HC emission with Speed

CONCLUSION

The main conclusions of this study are;

1. The Sample-2 shows increased brake thermal efficiency at 2600 rpm speed than that of other additives. If increases the speed from 2600 rpm the BTE is gradually decreased. From this investigation concluded by 2600 rpm is optimum speed of the engine. It has shown an increase of 1.2% when compared to other sample and sole gasoline fuel.
2. The Sample-2 gasoline fuel show significant reduction in CO, HC emission and increases of NO_x emission when compared to that of sole gasoline fuel. The CO and HC emission was decreased by 17%, 5.3% respectively.
3. The fuel spray visualization images were captured through AVL Visioscope with pixel fly VGA camera, endoscopic unit and necessary equipment's.

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BIOGRAPHIES

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