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EFFECT OF ALCOHOL ADDITIVES IN GASOLINE ENGINE PERFORMANCE AND EMISSIONS

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Abstract

Exhaust pollution and engine performance have been experimentally studied for gasoline and gasoline- n-butanol blends in a wide range of working speeds (1000–2500 r/min) without any tuning or modification on the SI engine systems. For each blend (5, 10,15 and 20 vol.% butanol) and neat gasoline. The experimental work was conducted on the experimental research SI engine, single cylinder, four strokes, carburettor fuel system variable compression duel Diesel / Petrol cycles with Dynamometer test unit type (GR0306/000/036A).

The experiment can evaluate performance and emission characteristics, such as thermal efficiency, fuel consumption, exhaust gas temperature and concentrations of CO and HC. Results of the SIengine test indicated that using gasoline blended fuels slightly decrease the output torque, power, exhaust gas temperature of the engine. As a consequence of the learning effect caused by the (n-butanol addition); CO and HC emissions decrease dramatically for all blended fuels compared to regular gasoline because of the improved combustion since n-butanol has extra oxygen.

Keywords: Fuel additive; Butane–unleaded gasoline blend; Alternative engine fuel; Exhaust emissions

1-INTRODUCTION

It is the dream of engineers and scientists to develop engines and fuels such that very few quantity of harmful emissions is generated, and these could be let into the surroundings without a major impact on the environment. Air pollution is predominately emitted through the exhaust of motor vehicles and the combustion of fossil fuels. Government around the world has set forth many regulatory laws to control the emissions. One of the serious problems facing the modern technological society is the drastic increase in environmental pollution by internal combustion engines (IC engines). All transport vehicles with SI and CI (compression ignition) engines are equally responsible for the emitting different kinds of pollutants. Some of these are first kids having the direct hazardous effect such as carbon monoxide, hydrocarbons, nitrogen oxides, etc/ while others are secondary pollutants such as ozone, etc., which undergo a series of reactions in the atmosphere and become hazardous to health [1].

n-Butanol is one of the second-generation biofuels. It can be produced in a similar process to the production of ethanol. Compared to gasoline, corn-based n-butanol as a transportation fuel could save about 39–56% fossil fuel while reducing greenhouse gas emissions by up to 48% on a lifecycle basis [2] n-Butanol has a lower auto-ignition temperature than methanol and ethanol. Therefore, n-butanol can be ignited easier when it is burned in gasoline engines. Besides, butanol has some advantages over ethanol and methanol in the transport sector. It is as easily transported as gasoline through pipelines because it has physical properties similar to gasoline and, in turn, it has the lower tendency to separate from the base fuel when contaminated with water. Also, n-butanol can be blended with gasoline fuel without phase separation. This could make it more cost-effective with the existing gasoline infrastructure [3]. Bata et al. [4] and Kelkar et al. [5] showed that using isobutanol blends of about 30 vol.% gave reductions in power, exhaust temperature and thermal efficiency compared to pure gasoline. The experimental work by Alasfour [6] investigated the NOx emission from a spark ignition engine using 30 vol.% isobutanol blend. Results indicated that NOx emission is reduced by 9% compared to neat gasoline. Another study by Alasfour [7] investigated the effect of using 30 vol.% isobutanol blend on hydrocarbon (HC) emission and found that HC emission reduced by 12%. Nevertheless, none of the early studies presents the direct Evaluation of the combustion characteristics of isobutanol blends via measurements [8].

2- Experimental

2. 1. Engine and Equipment

The IC engine used in the experiments is a single cylinder, variable compression ratio type (GR 306/000/037A) made by the Prodi company, (Italy). It is four strokes is connected to the hydraulic dynamometers. The IC engine is adaptable to run either as an SI or as a CI engine. SI engines are used in this study. The (CR) was varied from (4 to 18).

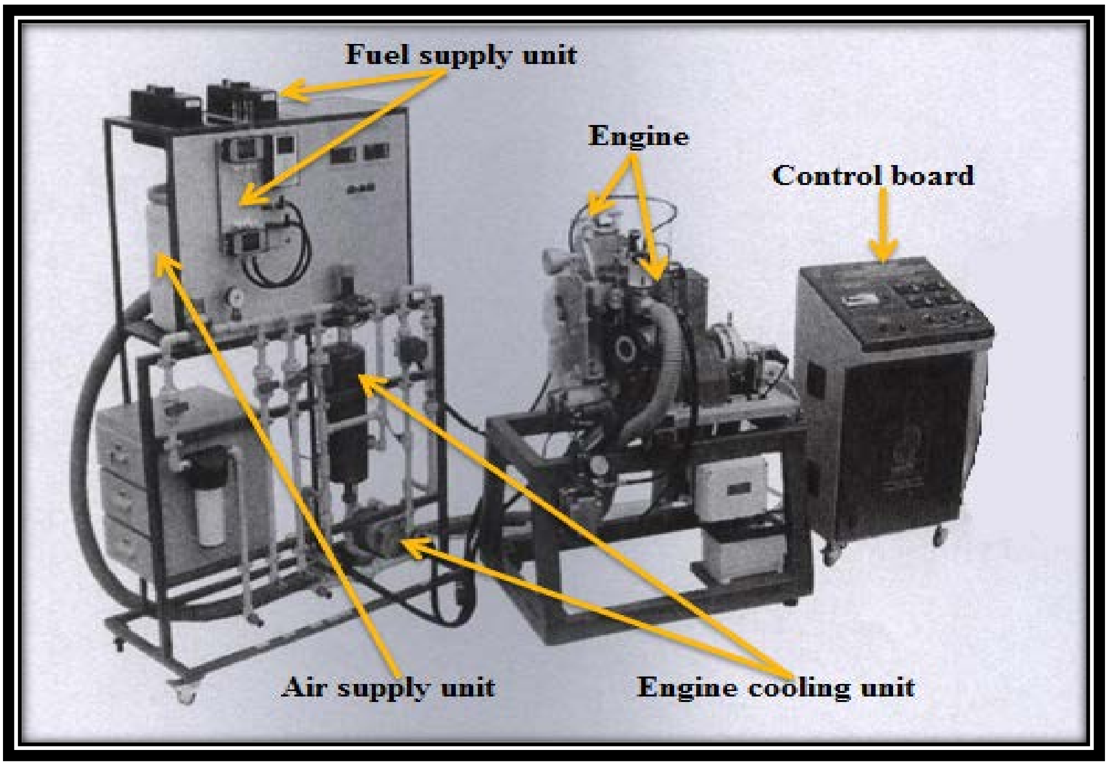

Fig (1): A photographic picture of the experimental rig

2.2-Exhaust Gas Analyser

The exhaust gas analyser type (mod 2000- 4 Italy) was used to analyse the emissions of the exhaust as shown in figure (2).The analyser detects the CO-CO2-HC contents. The exhaust gases are picked up from the engine exhaust pipe using the probe.

A

B

Figure (2): **A—** the exhaust gas analyser type (TEXA).

B— the gases probe.

2. 3. BLENDING METHOD

Five different fuel samples were experimentally investigated during this study. Base gasoline was obtained from the ALDORA Oil Refinery Company. Butanol with the purity of 99.9% was obtained from Chemical Laboratory. The base gasoline (G) was mixed with butanol (B) to get four test mixtures(B5, B10, B15 and B20).The fuel butanol blend was prepared just before starting the experiment works, to ensure that the fuel mixture is homogeneous.

<u>3- Results and discussions</u>

Fig. 1 represents the effect of engine speed on the (ηbth) of various fuels at a constant load. It is shown in the figure that (ηbth) increases with the increase in engine speed (RPM) and "The reason is that at higher speed, less quantity of heat is being lost through the cylinder wall. Maximum thermal efficiency (ηbth) was obtained for butanol blended 20% at an engine speed of 2500 rpm.

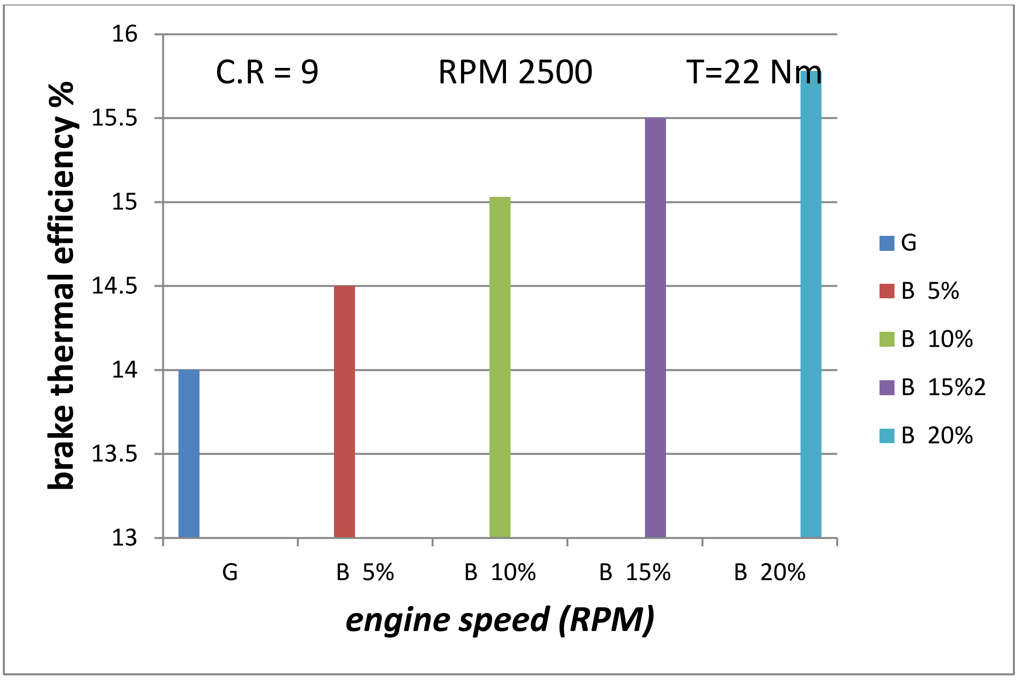

Fig. 1. Brake thermal efficiency versus engine speed.

Fig.2 shows the variations in brake specific fuel consumption with the engine speed at constant load. It is shown in the figure (2) that 20% butanol addition in base fuel causes the increment in BSFC in comparison to gasoline at 2500 rpm. It is well-known fact that heating value of fuel affects the BSFC. The lower energy content of butanol fuels causes some increment in BSFC of the engine when it is used without any modification. The increase mainly depends on upon the percentage of butanol addition in gasoline.

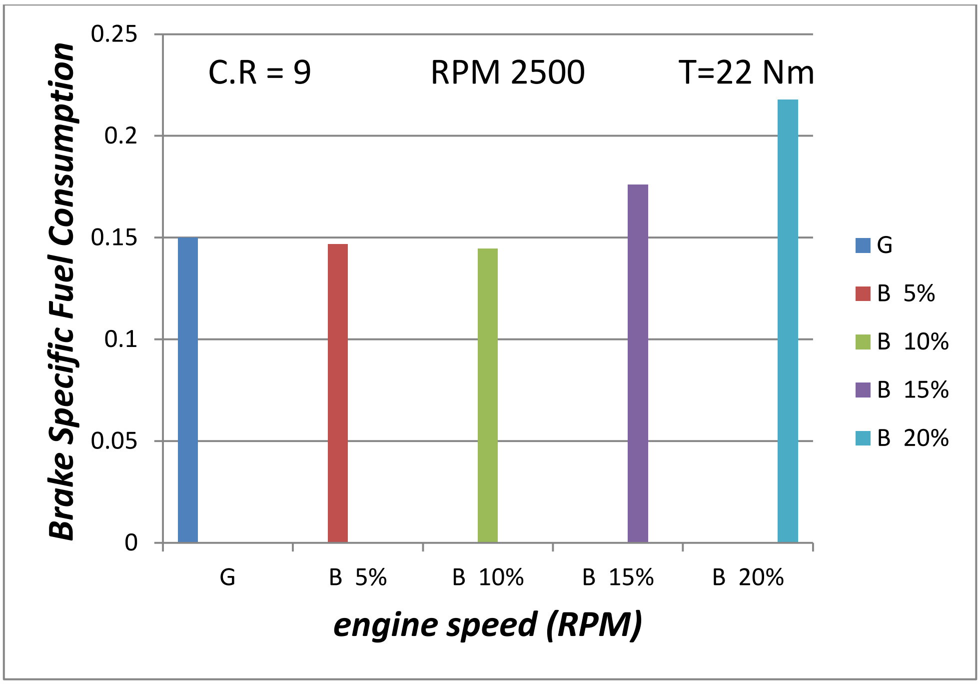

Fig.2 . Brake specific fuel consumption versus engine speed.

Fig.3 shows the specific fuel consumption of different fuels. All blends have higher specific fuel consumption than gasoline because of their lower LHV, so its specific fuel consumption is the largest at the same output torque. The fuel energy input changes with the fuel properties, mainly based on the ratio of lower heating value to stoichiometric air demand. To ensure an unbiased comparison and to better evaluate the fuel economy of alternative fuels,

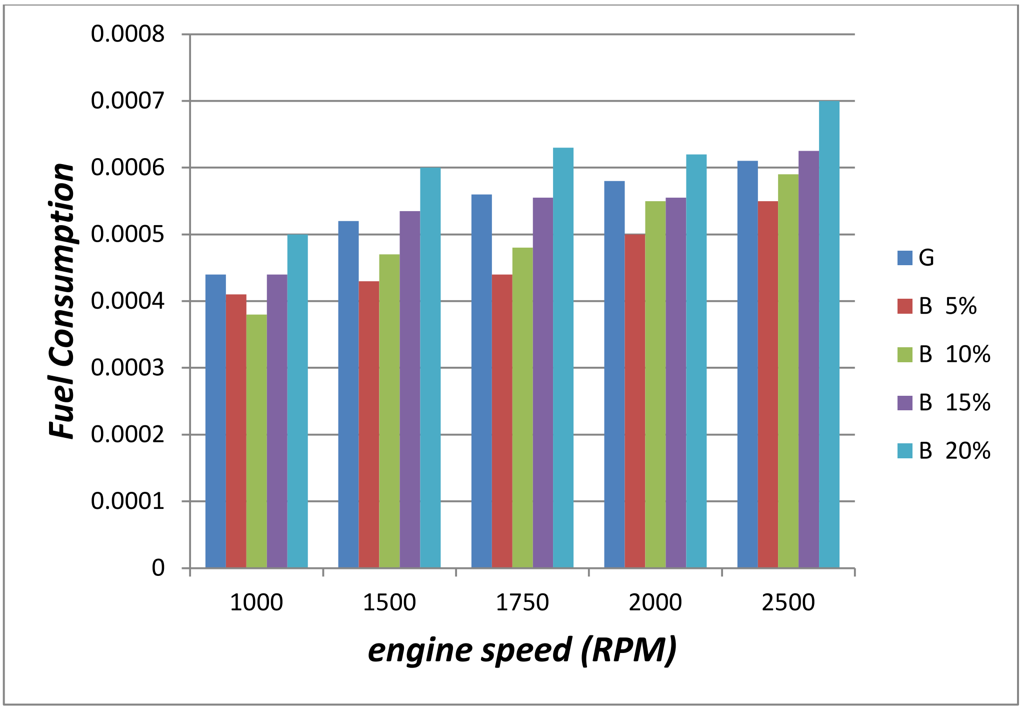

Fig 3. Fuel consumption versus engine speed.

The CO in the exhaust gases represents the lost chemical energy that is not entirely used in the engine. Co emission is affected by (A/F), fuel kind, IC Engine Combustion design and separation rate, begin of injection timing, injection pressure, engine load, and speed. The most important among these parameters is the air–fuel ratio. The variation in the CO of the engine is shown in Fig 4. When butanol blended fuels are compared to pure gasoline. The results indicate that the concentration of CO decreases with increases butanol blended ratio. This due to the reduction in (C atoms) concentration in the mixed gasoline and the high-level molecular diffusivity and senior flammability limits which improve a mixing process and hence combustion efficiency.

Unburned hydrocarbon emissions (HC) consist of fuel that is a combination of completely unburned and partially burned. (HC) Pollution is mostly due to the retention of incomplete burn fuel in a slot in the cylinder block. Figs. 5 show the changes in the (HC) emission of the engine using butanol blended and gasoline fuels. As seen in the Fig. 5, the (HC) emission was gradually reduced when the butanol ratio increased in the fuel mixture, due to the effect of different butanol contents on (HC) emission. Fig.6 shows the variations in exhaust gas temperature on engine speed (RPM) for various fuels type test at regular load. It is shown in the fig that exhaust temperature(Tex) increases with the increase in engine speed (RPM) for all the test. This is explained with several reasons. With the increase in engine speed(RPM), combustion gases gets less time to remain in contact with cylinder wall engine and therefore more quantity of energy is released with exhaust gases which increase the temperature of exhaust gases (Tex). At 2500 rpm, the value of (Tex) is maximum for the base gasoline (G) and minimum for B20% fuel. These variations in exhaust temperature (Tex) can be attributed to increasing in thermal efficiency or A/F ratio which affects the combustion temperature.

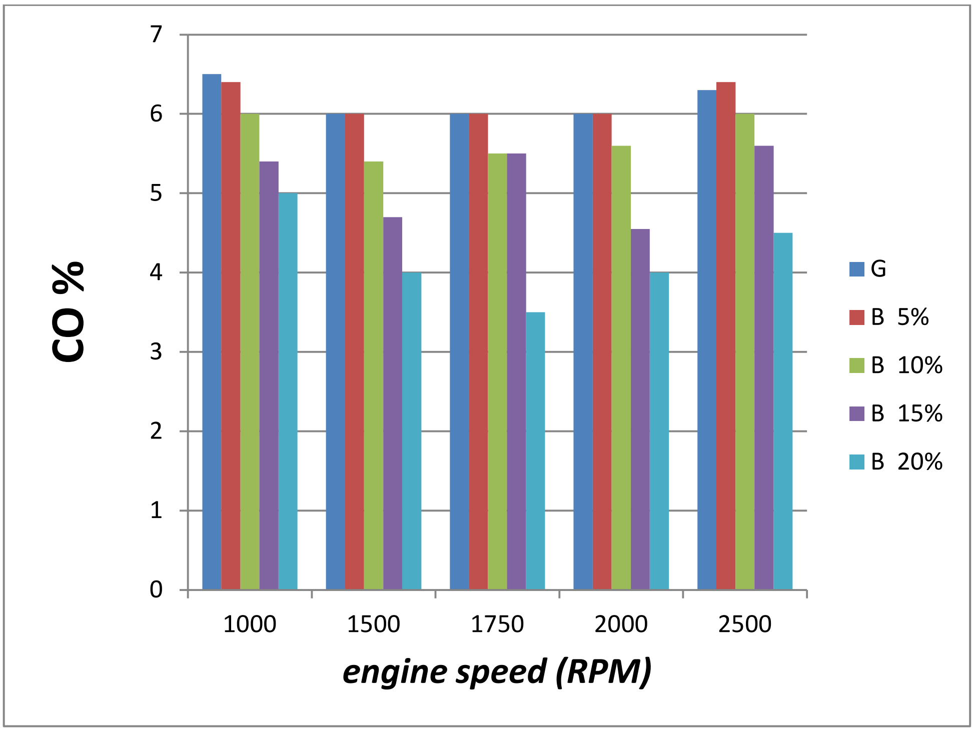

Fig. 4. Carbon monoxide versus engine speed.

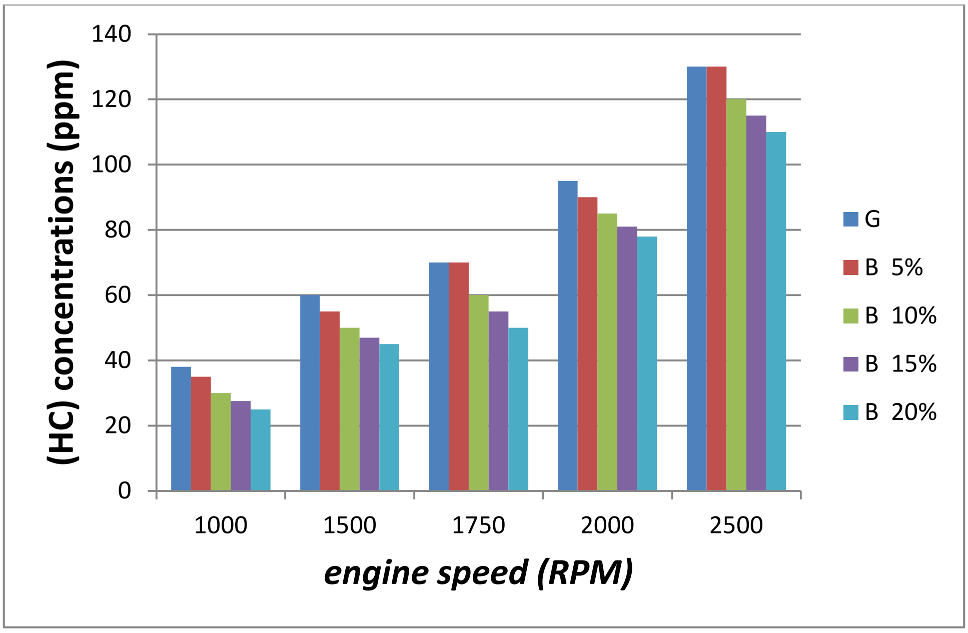

Fig. 5. Unburned hydrocarbon (UHC) versus engine speed.

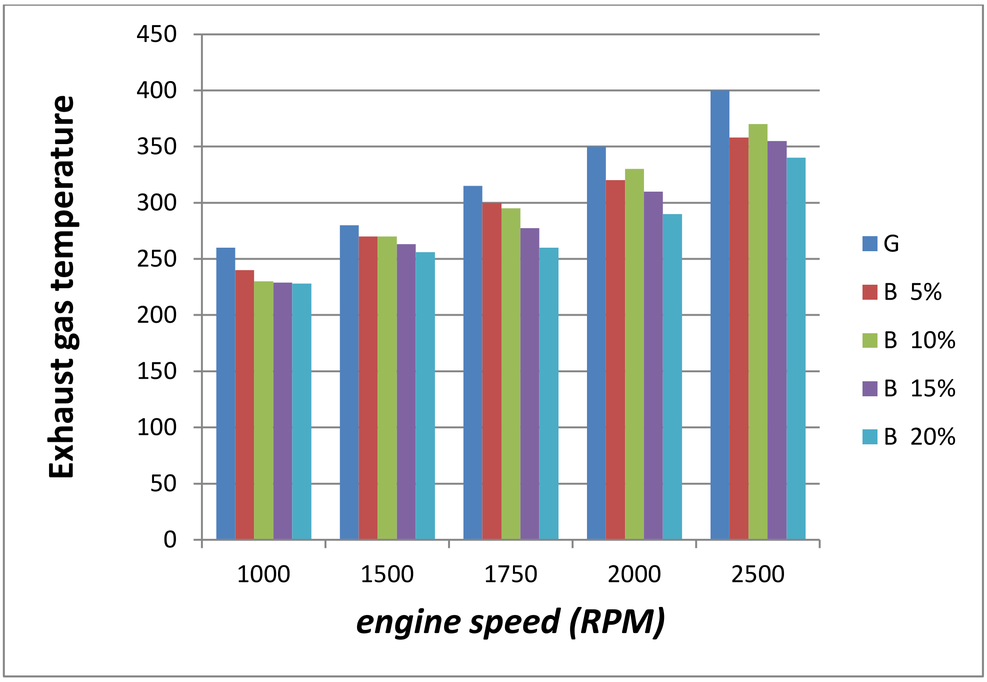

Fig. 6. Exhaust gas temperature versus engine speed.

4- Conclusions

In this study, engine performance, emissions of butanol-gasoline blends vis-a-baseline gasoline were experimentally evaluated in a medium duty SI engine without any hardware modifications at various engine speeds and loads. In this study, it was seen that when an engine was fueled with butanol–gasoline blend, engine performance parameters such break thermal efficiency increases with increasing butanol amount in the blended fuel while(bsfc) decreased. The results show that the concentration of exhaust emissions decreases with increases butanol blending ratios.

The following equations were used in calculating engine performance parameters.

1- The brake specific fuel consumption.

$$bsfc = \frac{\dot{m}f}{bp} \times 3600 \quad kg/(kW.hr) \ldots\ldots(1)$$

2- Brake thermal efficiency (ηbth) is defined as in Eq.

$$\eta bth = \frac{bp}{\dot{m}f\ L.C.V} \ldots\ldots\ldots\ldots (2)$$

3- Air mass flows rate

$$\dot{m}a, act = \frac{12\sqrt{(h\_o\ )}}{3600} \times \rho\ air \quad kg/sec \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

4- Fuel mass flows rate

$$\dot{m}f = \frac{vf \times 10^{-6}}{time} \times \rho_f \quad kg/sec \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

5- Air-fuel ratio

$$A/F = \frac{\dot{m}a}{\dot{m}f} \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

6- Brake power

$$bp = \frac{2\pi \times N \times T}{60 \times 1000} \quad kW \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

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