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ASSESSMENT OF EFFECTIVENESS OF S.I. ENGINE FUEL WITH ALCOHOL BLEND

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Abstract - Internal combustion reciprocating engines have become integral component of human in modern era of civilization. They rose to become a key participant in agriculture, industry, power production, and transportation. The main goal of this research study is to set up an engine test bed with a multi-cylinder S.I. engine, compare the performance of an integrated system powered by alcohol and conventional fuels, and determine whether the results are economically feasible. It will involve test performance, experiment result optimization, and experiment data validation.

I. INTRODUCTION

Since the last 25 years, heat engines have been helping people. Internal combustion engine design underwent a lot of changes in the 19th century. Many rotary engine models were also purposed. As the I.C. Engine developed, fossil fuel took the place of main fuel. The tetra ethylene lead an anti-knocking agent was identified. It was on the market in the US and Europe from 1923 and 1930. During this time, an estimated 7 million automobiles run on gas from gasification. Efficiency improvements were being made at the same time. The maximum efficiency obtained till then was roughly 20 percent. Humans first learned about the negative effects of I.C. engine pollution around the same period. This prompted researchers to consider efficiency and emissions at the same time. The present energy scenario has encouraged strong research interest in non-petroleum, renewable, and non-polluting fuels. Due to the paucity of fossil fuels, research focus has switched in recent decades to alternative fuels. Many different fuels were used for I.C. Engines. Some of these are biogas, producer gas, synthesis gas, Alcohol, Hydrogen and a lot more. It is not sufficient to adjust the design of motor to meet with the legal regulations, hence it is vital to continue to work on alternative fuel solutions. Since the 19th century, alcohols have been employed as an engine fuel. Ethanol is regarded as the alcohol that works best as a fuel for Spark Ignition (SI) engines among all the other alcohols. A complex blend of hydrocarbon molecules makes up gasoline, commonly known as petroleum fuel. For use in cars and other vehicles and machinery, gasoline is a highly flammable fuel source. Gasoline is manufactured by refining petroleum, and it consists of a complex mixture of over 150 compounds. These compounds' actual composition vary depending on the producer, petroleum supply, and even the season. Gasoline has a tremendous impact on the environment, both locally and globally, due to the massive amount of internal combustion engines it is utilized in worldwide. However, there are some circumstances when the unburned mixture can auto-ignite by detonating from heat and pressure alone, rather than igniting from the spark plug at precisely the appropriate time. This results in a quick pressure rise that can harm the engine. Because they may be obtained from both natural and artificial sources, alcohol fuels are a desirable fuel. The physical qualities and emission characteristics of alcohol fuels, including methanol and ethanol, are comparable to those of petroleum fuels. Ethanol was first recommended as an automotive fuel in USA in the 1930s, but was widely used until after 1970. Nowadays, ethanol is mostly utilized as fuel in Brazil and as a gasoline additive in the United States, Canada, and India to increase octane and improve combustion. For internal combustion engines with an Otto cycle and four strokes that run on alcohol, Brazil possesses the most advanced technology. In Brazil, there were more than 3.5 million vehicles running on alcohol in the early 1980s. Engineers created a number of modifications to conventional gasoline engines to make alcohol engines more usable, robust, and cost-effective. To describe every reference given under each subject would go beyond the scope of this research work. Therefore, an effort is made to provide the full body of literature in a way that only a select few research papers serve as an example of that category's representative works in the explanation for each category. It aids in obtaining key judgments regarding the trend and possibility for additional research in that sector. In the literature that is now available, numerous researchers describe a broad range of application fields. For the current dissertation study an intensive and detailed literature survey is done. The literature review helped to determine the research objective. The following is a synopsis of the literature review: Jun Li discovered that the experimental investigation of the effects of injection and ignition timings on combustion and emissions from a high-compression direct-injection stratified charge spark-ignition methanol engine. Methanol injection timing and ignition timing have major influence on methanol engine performance, combustion, and exhaust pollutants [1]. The M.A. Costagliola experiment demonstrates the effect of certain biofuels on the efficiency of spark-ignition engine combustion and engine-out emissions. Study of combustion development was done using the heat release analysis of pressure cycles monitored in combustion chamber [2]. Simeon Iliev gives an example of how adding ethanol and methanol to gasoline affects the efficiency and emission characteristics of SI engines. The overall findings of this study can be summed up as follows. For all engine speeds, the engine brake power reduced as the ethanol level in the blended fuel increased [3]. A high compression ratio direct-injection spark-ignition methanol engine's emission characteristics were compared to those of its diesel equivalent in Gong's investigation into the impacts of injection time, ignition timing, and injection nozzle parameters on the regulated emissions. The key findings can be summed up as follows. Significant effects on emissions are caused by the injection and ignition timings. The ideal injection and ignition timings resulted in the optimum trade-offs between the brake thermal efficiency and three emission pollutants. The specifications of the injection nozzle have a considerable impact on the emissions from the methanol engine [4]. Alberto Boretti illustrates how a state-of-the-art pure ethanol engine developed employing rapid actuating high pressure fuel direct injection, high boost turbo charging and fully variable valve actuation may function. Engine brake-specific fuel consumption maps and vehicle fuel economy over driving cycles have been produced using extensively tested engine and vehicle modeling packages, with accuracy expectations of 5–10% vs. experiments [5]. The effectiveness of a SI engine's fuel conversion was experimentally investigated by Adrian Irismesu. To achieve this, experiments were conducted on a chassis dynamometer using a passenger automobile with a port injection engine. The results were attained under circumstances that were extremely similar to actual engine operation in car applications. Measurements were made using gasoline, 10, 30, and 50% isobutanol combined with the fossil fuel, on a volumetric basis, as bio fuels are expected to play a significant role in the future energy mix [6]. Under the conditions of stoichiometric mixture and WOT, Xie & Li explored the engine load control method that is based on EGR and ignition timing on performance and emissions [7]. There are generally two types of I.C. ignition engines, internal are separated into spark ignition engines and compression ignition engines. Today, trailers and certain large trucks employ compression ignition engines, but the majority of cars use spark ignition. The method used to ignite the air-fuel mixture and the chamber's design, which results in particular power and efficiency characteristics, are the key differences between the two.

II. PERFORMANCE ANALYSIS

Volumetric Efficiency

Fig. 1 shows an increase in the volumetric efficiency as the percentage of ethanol in the fuel blends increases. This is due to the decrease of the charge temperature at the end of the induction process(T_a).This decrease is attributed to the increase in the charge temperature by an amount T_h as a result of the heat transfer from the hot engine parts and the residual gases in the charge. At the same time, the charge temperature drops by an amount T_v due to vaporization of the fuel blend in the inlet manifold and engine cylinder. Therefore, the total change in the charge temperature (ΔT) could be expressed by the following simple equation:

$$\Delta T = T_h - T_v \text{ and } Ta = T_h + \Delta T$$

As the E% in fuel blend increases, the volatility and the latent heat of the fuel blend increases. Meanwhile, with increasing volatility and latent heat of the fuel blend, the drop of the charge temperature Tv increases. At the same conditions, the total heat capacity of the charge increases, since the specific heat of the ethanol fuel is higher than that of the unleaded gasoline fuel, and this led to decreases in the drop of the charge temperature Tv. Therefore, increasing the ethanol in the fuel blend has two contradicting effects on Tv. Hence, the value of Tv depends upon which effect is more dominant. As the quantity of ethanol in the fuel blend increases to 20%, the effect of the increasing volatility and latent heat of the fuel blend is more significant, resulting in Tv increasing. With further increase, the effect of increasing the total heat capacity of the charge is more pronounced, and hence, Tv decreases. It is clear that as the E% in the fuel blend increases from 0% to 20%, the volumetric efficiency increases due to the DT decrease and Tv increase. Conversely, as the E% changes from 20% to 25%, the volumetric efficiency decreases as DT increases and Tv decreases. The effect of engine speed on ηv can be also explained from Fig.2. As the engine speed increases to 3032 rpm, ηv increases, as the amount of air introduced to the engine cylinder increases. Further increase in the engine speed results in a decreasing ηv, where the amount of air decreases as a result of choking in the induction system.

Table 1 Volumetric Efficiency at Variable Speed of Engine and Different Fuel Blends of Gasoline-Ethanol

Volumetric Efficiency					
Speed	E0	E10	E15	E20	E25
2084	32.01	33.80	34.24	36.15	35.37
3032	32.32	33.92	35.28	37.03	36.47
4057	31.86	33.76	35.29	36.26	35.90
5084	31.23	33.59	34.89	35.76	34.86

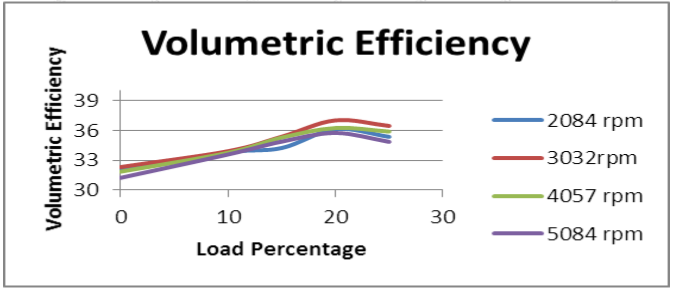

Figure 1 : Effect of the ethanol–gasoline blends on the Volumetric Efficiency

Brake Thermal Efficiency

Fig.2 presents the effect of using ethanol–unleaded gasoline blends on brake thermal efficiency. As shown in the figure, ηb.th increases as the E% increases. The maximum ηb.th is recorded with 20% ethanol in the fuel blend for all engine speeds. To discuss the nature of the previous result, it is necessary to discuss the nature of the compression and combustion processes. The vaporization of fuel continues during the compression stroke.

This tends to decrease the temperature of the working charge (i.e., reduces the compression work) and increase the quantity of vapor in the working charge (i.e., increases the compression work). When the latent heat of the fuel used is low, as in the case of unleaded gasoline, the effect of cooling is not sufficient to overcome the effect of additional vapor. Increasing the latent heat of the fuel blend used by increasing the E% increases the effect of cooling (i.e., reduces the compression work). On the other hand, as E% increases in the fuel blend, the pressure and temperature decrease at the beginning of combustion (i.e., the delay period increases or the crank angle at which maximum pressure is achieved increases).

However, increasing E% increases the air–fuel ratio, i.e., decreases the heat transfer to the cylinder walls (heat losses) due to incomplete combustion, and therefore, increases the value of maximum pressure. From the previous discussion, it could be concluded that as the E% increases in the fuel blend, the indicated work increases (i.e., increases the indicated efficiency ηi). Since the mechanical efficiency ηm is a function of engine speed only, the effect of increasing E% on brake thermal efficiency is the same as that on indicated efficiency (ηb.th = ηi ηm). A further increase in the E% beyond 20% results in decreasing ηb.th.

This behavior has the same explanation as that of the ηv variation with E%. The effect of engine speed on ηb.th can be explained through its effect on the equivalence air–fuel ratio and volumetric efficiency (ηv). As the engine speed increases to 3032 rpm, ηb.th increases, whereas equivalence air–fuel ratio decreases and ηv increases. Further increases in engine speed beyond 3032 rpm, lead to a decrease ηb.th whereas equivalence air–fuel ratio increases and decreases. This behavior validates the fact that at points were equivalence air–fuel ratio is minimum (i.e., leaner mixture), the brake thermal efficiency is maximum.

Table 2 Brake Thermal Efficiency at Variable Speed of Engine & Different Fuel Blends of Gasoline-Ethanol

		Brake Thermal Efficiency			
Speed	E0	E10	E15	E20	E25
2084	16.77	17.93	18.65	19.18	18.02
3032	16.82	18.02	18.73	19.49	18.40
4057	17.14	17.98	18.28	18.92	18.45
5084	17.34	17.68	17.86	18.26	17.46

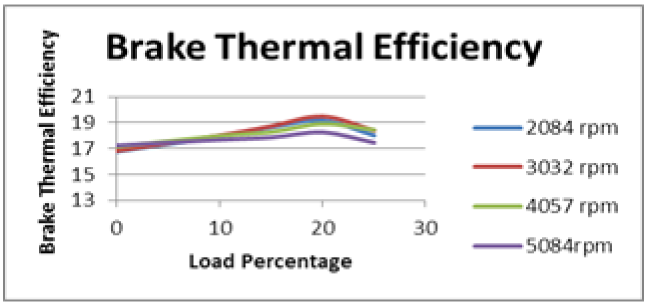

Figure 2 Effect of using ethanol–gasoline blends on brake thermal efficiency

Brake Power & torque The effect of ethanol–unleaded gasoline blends on brake torque and brake power is illustrated in Figs.4.5 and 4.6, respectively. It is clear in these two figures that both T and Bp increases the E% increases for all engine speeds. This increase continues until the E% reaches 20%. After this point, T and Bp start to decrease. This behavior agrees with that of the volumetric and brake thermal efficiencies shown in Figs..3 and 4. Generally, the brake torque has a significant dependence on the volumetric efficiency and only a slight dependence on the engine speed. As a consequence, the influence of engine speed on T is similar to its influence on the volumetric efficiency. However, as the brake power is proportional to the product of the engine torque and speed, which suggests that Bp increases as the engine speed increases.

Table No-3 Brake Power at Variable Speed of Engine and Different Fuel Blends of Gasoline-Ethanol

	Torque				
Speed	E0	E10	E15	E20	E25
2084	12.93	13.50	13.86	13.99	13.82
3032	13.28	13.88	14.02	14.18	14.56
4057	12.64	13.47	13.78	14.06	14.01
5084	12.30	13.42	13.77	14.02	14

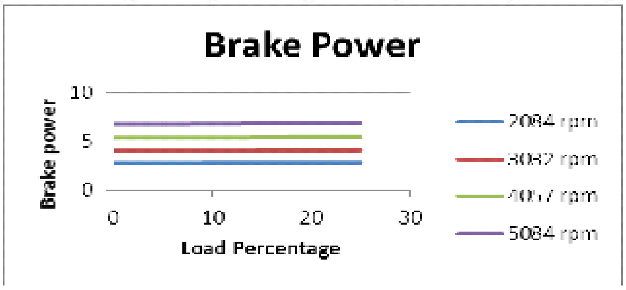

Figure: 3 Effect of the ethanol–gasoline blends on the Brake Power

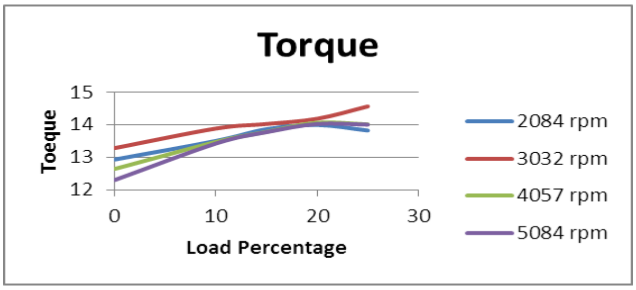

Figure: 4.6 Effect of the ethanol–unleaded gasoline blends on the Torque

III. CONCLUSION

The study's findings support the hypothesis that adding ethanol as a fuel additive to unleaded gasoline enhances engine performance. When ethanol is added, torque power, braking thermal efficiency, and volumetric efficiency all rise by roughly 10.40%, 1.438%, 11.63%, and 10.07% mean average values, respectively. Petroleum imports could be decreased, the balance of payments could be improved, national energy security could be increased, and less reliance on oil from unstable regions of the world might all result from ethanol use. If generated at a low cost, bioethanol can lower the demand for fossil fuels and the rise in their prices. Additionally, it was shown that using ethanol–gasoline mixes increases the thermal and volumetric efficiency of the brakes.

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