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EVALUATION OF PERFORMANCE AND COMPARISON OF S.I.ENGINE FUEL WITH GASOLINE AND GASOLINE ALCOHOL BLEND

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Abstract: Internal combustion reciprocating engines have become integrated part of human in current era of civilization. They became the major role player in transportation, industries, power generation and agriculture. The major objective of this research study is to prepare the engine test bed having multi cylinder S.I. Engine and to compare the performance of integrated system fueled with conventional and renewable fuels (alcohols) and to find the economic feasibility and validation of the results. It will involve Test performance and Optimization of experimental results and Validation of experimental data.

I. INTRODUCTION

Heat engines have been serving human from last two and a half century. During 19th century, many developments were there in design of internal combustion engines. Many rotary engine models were also purposed. Fossil fuel occupied the place of major fuel as the I.C. Engine came in existence. The tetra ethylene lead an anti-knocking agent was discovered. It was available in market in 1923-1930 in U.S.A and Europe. Estimated 7 million vehicles run on gases from gasification during this period. The work on efficiency was simultaneously going on. The maximum efficiency achieved till then was approximately 20%. On the same time humans came to know about the bad effect of pollutants emitted from I.C. Engine. This made researcher to thought about efficiency and emissions simultaneously. The present energy scenario has stimulated active research interest in non-petroleum, renewable, and non-polluting fuels. In last few decades due the scarcity of fossil fuel concentration of researchers was shifted for alternative fuels. Many alternative fuels were used for I.C. Engines. Some of them are biogas, producer gas, synthesis gas, Alcohol, Hydrogen and a lot more. It is not sufficient to change the design of motor to cope with the legal regulations, so it is necessary to continue to work on alternative fuel technologies. Alcohols have been used as a fuel for engines since 19th century. Among the various alcohols, ethanol is known as the most suited fuel for Spark Ignition (SI) engines. Petrol fuel also known as gasoline is a complex mixture of hydrocarbon compounds. Gasoline is an extremely flammable fuel source for automobiles and other vehicles and equipment. Gasoline is produced by refining petroleum, and it consists of a complex mixture of over 150 chemicals. The actual make-up of these chemicals varies by petroleum source, manufacturer, and even the time of year.

Gasoline, as used worldwide in the vast number of internal combustion engines used in transport and industry, has a significant impact on the environment, both in local effects (e.g., smog) and in global effects. In some cases, however, the unburned mixture can auto ignite by detonating from pressure and heat alone, rather than ignite from the spark plug at exactly the right time, which causes rapid pressure rise which can damage the engine. Alcohols fuels are an attractive fuel because they can obtained from both natural and manufactured sources. Alcohol fuels, methanol and ethanol have similar physical properties and emission characteristics as that of petroleum fuels. Ethanol was first suggested as an automotive fuel in USA in the 1930s, but was widely used only after 1970. Nowadays, ethanol is used as fuel, mainly in Brazil, and as a gasoline additive for octane number enhancement and improved combustion in USA, Canada and India. Brazil has most developed technology for the alcohol fueled Otto cycle (4 strokes) internal combustion engines. In the early 1980s, there were more than 3.5 million alcohol-powered automobiles in Brazil. In order to make alcohol engines more practical, functional, durable, and economical, engineers made several changes in the regular gasoline engines. It is beyond the scope of this research paper to descriptively report all the references listed under the various headings. Therefore, an attempt is made to portray the entire literature in a format so that only a few research articles are covered in the explanation for each category as a representative work in that particular category. It helps in deriving important inferences regarding the trend and potential for further research in that field. A wide range of application areas is presented by various researchers in the available literature. For the current dissertation work an extensive and exhaustive literature survey is done. The literature review helped to find the research objective. The summary of literature reviewed is as under: Jun Li found the effects of injection and ignition timings on combustion and emissions from a high-compression direct-injection stratified charge spark-ignition methanol engine have been investigated experimentally. Methanol injection timing and ignition timing have significant effects on methanol engine performance, combustion, and exhaust emissions. [1] Costa and Sodre investigates the influence of compression ratio on the performance of a spark ignition engine fuelled by a blend of 78% gasoline-22% ethanol (E22) or hydrous ethanol (E100). A 1.0-L, eight-valve, four cylinder, production engine was tested in a dynamometer bench varying the speed. [2] M.A. Costagliola experimental shows the influence of some bio-fuels on the spark-ignition engine combustion efficiency and engine-out emissions was investigated. Study of combustion development was made through the heat release analysis of pressure cycles measured in combustion chamber. [3]

Simeon Iliev demonstrates the influences of ethanol and methanol addition to gasoline on SI engine performance and emission characteristics. General results concluded from this study can be summarized as follows. When the ethanol content in the blended fuel was increased, the engine brake power decreased for all engine speeds. [4] Eyidogan investigate that when a vehicle was fueled with ethanol–gasoline (E5, E10) and methanol–gasoline (M5, M10) fuel blends, bsfc will be higher than that of pure gasoline. Indeed, these results are expected because the heating values of the alcohols are 37–53% lower than that of unleaded gasoline. At the same time, low heating value of alcohols led to lower exhaust temperatures at both vehicle speeds. [5] Gong investigates the effects of injection timing, ignition timing, and injection nozzle parameters on the regulated emissions from a high compression ratio direct-injection spark-ignition methanol engine were investigated experimentally and its emission characteristics were compared with the diesel counterpart. The main results can be summarized as follows. The injection and ignition timings affect emissions significantly. The best compromises between the brake thermal efficiency and three emission pollutants were obtained at the optimal injection and ignition timings. The effects of injection nozzle parameters on emissions from the methanol engine are significant. [6] Alberto Boretti describes how a state-of-the-art pure ethanol engine designed using fast actuating high pressure fuel direct injection, high boost turbo charging and fully variable valve actuation may perform. Extensively validated engine and vehicle simulations packages have been used to produce engine brake specific fuel consumption maps and vehicle fuel economy over driving cycles expected to be within 5–10% accuracy vs. experiments. [7] Ashraf Elfasakhany studied that the engine performance and pollutant emissions from different blended fuels in types (ethanol, methanol and gasoline) and rates (3e10 vol.% methanol and/or ethanol in gasoline) have been investigated experimentally. The test results indicated that ethanol emethanole gasoline blends (EM) burn cleaner than both ethanol gasoline blends (E) and the neat gasoline fuel (G); however, the methanole gasoline blends (M) confirm the lowest emissions of CO and UHC among all test fuels. [8]
Adrian Irismesu experimentally studied the fuel conversion efficiency of a SI engine. To this end, a passenger car powered by a port injection engine was used, with experimental trials undertaken on a chassis dynamometer. In this way, the results were obtained in conditions very close to real world engine operation in automotive applications. As biofuels are set to play an important role in the future energy mix, measurements were conducted with gasoline, 10, 30 and 50% isobutanol mixed with the fossil fuel, on a volumetric basis. [9] Xie & Li discussed the engine load control strategy which is based on EGR and ignition timing on performance and emissions under the condition of stoichiometric mixture and WOT has been investigated experimentally. [10] There are basically two types of I.C. ignition engines, internal are divided into spark ignition engines and compression ignition engines. Almost all automobiles today use spark ignition engines while trailers and some big trucks use compression ignition engines. The main difference between the two is the way in which the air to fuel mixture is ignited, and the design of the chamber which leads to certain power and efficiency characteristics.

II. PERFORMANCE ANALYSIS

Volumetric Efficiency

Fig. 4.3 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:

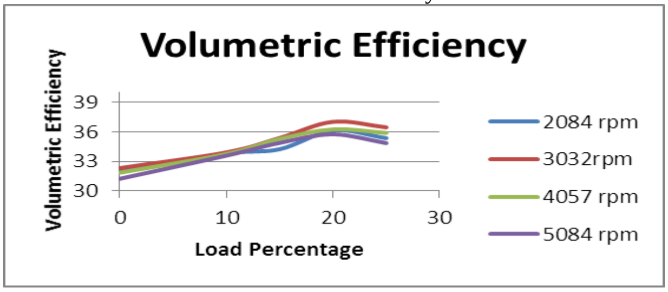
$$\Delta T = T_h - T_v \text{ and } Ta = T_h + \Delta T$$

As the E% in t22he 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 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: Effect of the ethanol–gasoline blends on the Volumetric Efficiency



Brake Thermal Efficiency

Fig.4.4 presents the effect of using ethanol–unleaded gasoline blends on brake thermal efficiency. As shown in the figure, $\eta_{b.th}$ increases as the E% increases. The maximum $\eta_{b.th}$ 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 η_i). Since the mechanical efficiency η_m is a function of engine speed only, the effect of increasing E% on brake thermal efficiency is the same as that on indicated efficiency ($\eta_{b.th} = \eta_i \ \eta_m$). A further increase in the E% beyond 20% results in decreasing $\eta_{b.th}$.

This behavior has the same explanation as that of the η_v variation with E%. The effect of engine speed on $\eta_{b.th}$ can be explained through its effect on the equivalence air–fuel ratio and volumetric efficiency (η_v). As the engine speed increases to 3032 rpm, $\eta_{b.th}$ increases, whereas equivalence air–fuel ratio decreases and η_v increases. Further increases in engine speed beyond 3032 rpm, lead to a decrease $\eta_{b.th}$ 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 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

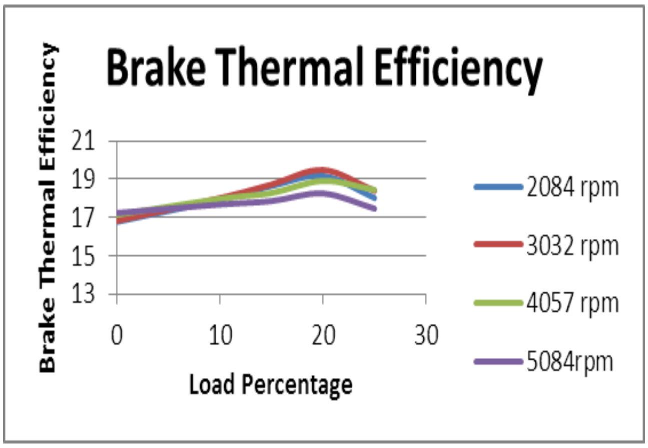


Figure 4.4 Effect of using ethanol–gasoline blends on brake thermal efficiency.

4.4.4 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. 4.3 and 4.4. 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-4.5 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

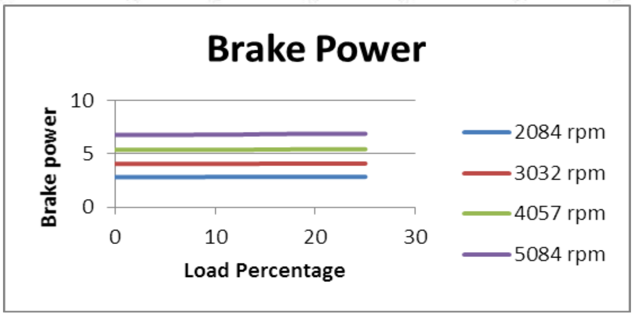


Figure: 4.5 Effect of the ethanol–gasoline blends on the Brake Power

Table Torque at Variable Speed of Engine and Different Fuel Blends of Gasoline-Ethanol

Brake Power					
Speed	E0	E10	E15	E20	E25
2084	2.82	2.84	2.854	2.858	2.86
3032	4.05	4.07	4.08	4.104	4.1
4057	5.37	5.38	5.40	5.44	5.43
5084	6.77	6.79	6.84	6.89	6.88

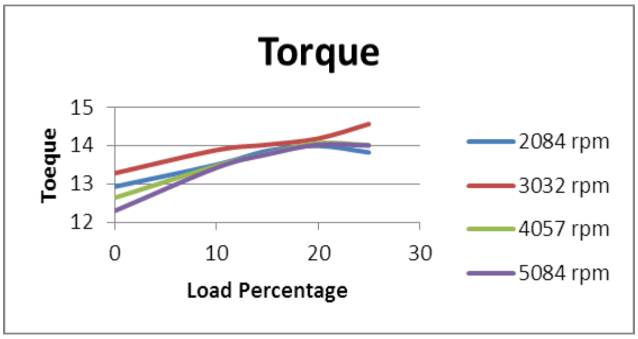


Figure: 4.6 Effect of the ethanol–unleaded gasoline blends on the Torque

Table-4.8 The Summarized results of performance analysis at various speeds at different blends of fuels

Engine Parameter					Mean
	2084	3032	4057	5084	Value %
Volumetric	9.03	10.5	11.18	10.50	10.07
Efficiency					
Brake Thermal	14.37	15.87	10.38	5.91	11.63
Efficiency					
Brake Power	1.347	1.330	1.303	1.772	1.438
Torque	8.197	6.77	11.23	13.98	10.40

III. CONCLUSION

From the results of the study, conclusion can be deduced that using ethanol as a fuel additive to unleaded gasoline causes an improvement in engine performance. Ethanol addition results in an increase in torque power, brake thermal efficiency and volumetric efficiency by about 10.40%, 1.438%, 11.63% and 10.07% mean average values, respectively. Ethanol could reduce petroleum imports, improve the balance of payments, improve national energy security, and reduce the reliance on petroleum from unstable areas of the world. Bio ethanol if cheaply produced can reduce demands for fossil fuels and the growth in fossil fuel prices. It was also found that the brake thermal efficiency and volumetric efficiency increase when ethanol–gasoline blends are used.

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