Effect of Methanol – Gasoline Blends on S.I. Engines Performance and Pollution

Sahib Shihab Ahmed
Assistant Lecturer
College of Engineering
Department of Mechanical Engineering
University of Kufa, Najaf, Iraq

Abstract This study discusses the performance and exhaust emissions of a vehicle fueled with low content alcohol (methanol) blends and pure gasoline. In this study, experiments have been done to measure the performance and emissions of a 4-stroke S.I. Engine, one by using the commercial imported gasoline, another by using the gasoline-methanol blends. The engine is run at different loads and methanol blending percentages. It is found that increasing the blending percentage reduces the emitted concentration of carbon oxides and HC. However, it is found that brake power and brake thermal efficiency are increased with increasing methanol blending percentage due to higher cylinder temperatures. The results showed that the use of 10% volume of methanol blending with the gasoline appears to be a good option for replacing any oxygenate additives in the gasoline, where the CO, CO2, and HC are minimum and the fuel consumption of the blend is lower than that of the commercial gasoline.

Index Term-- gasoline engine, methanol blending, pollution

I. INTRODUCTION

The combustion engines derive their name from the fact that the transformation of the energy from chemical (that is to say contained into the fuel that is being burned) to mechanical-and therefore available to the motor shaft to operate various devices (cars, trucks, alternators, dynamos, etc.) [1]. Internal combustion engines have been in use for more than a century and have undergone tremendous changes in design, materials used and operating characteristics. Never ones during their long history of development have they lost their importance as the planet most widely used prime movers. In the past few decades, research efforts have been focused largely on better spark ignition engine, from the perspective of reducing the pollutant emissions without sacrificing performance and fuel economy. Another driving force behind the need to design engines amenable to operate on non-conventional fuels is the rapid depletion rate of currently used fossil fuels [2]. The importance of environment and energy is emphasized in various sectors. Increase in stringent emission regulations and anticipated depletion of worldwide petroleum reserves in future provide a strong encouragement to carry out research on alternate fuels. Among the various alternate fuels, like methanol, hydrogen, ethanol...etc. [3]. Considering pollution problems today, investigations have been concentrated on lowering the concentration of toxic components in combustion products. In many areas of the world, there has been tremendous progress in reducing and eliminating the use of lead and methyl tertiary butyl ether (MTBE) in gasoline. There is now virtually universal acceptance of the need to eliminate lead and MTBE from gasoline. Numerous researchers in many countries have definitively established its adverse neurological effects, especially on children. When lead is phased out of gasoline, the population’s exposure to lead drops in a predictable manner [4]. Bahattin M.C. [5] studied the effect of pure methanol at high CR on performance and emission was experimentally investigated in a single cylinder engine with low efficiency. For this purpose, the engine’s CR was raised from 6/1 to 10/1 and it was tested at different compression ratios with methanol and gasoline. The results showed that there are positive and negative effects of both increasing CR and pure methanol on engine behaviour. By using methanol at the same CR, the power slightly decreased, and CO, CO2 and NOx emissions also decreased. The brake thermal efficiency increased. On the other hand, HC emissions increased. When CR was increased with the same fuel (methanol), the power and the brake thermal efficiency increased, and SFC decreased. Moreover, CO decreased and CO2, NOx and HC increased. The negative effects of both increasing CR and pure methanol on the engine behaviour were decreased by using methanol at a high CR (10/1). But, both increasing CR and methanol increased only HC emissions. Ozsezen A.N. [6] This study discusses the performance and exhaust emissions of a vehicle fueled with low content alcohol (ethanol and methanol) blends and pure gasoline. The vehicle tests were performed at wide-open throttle and at vehicle speeds of 40 km h_1, 60 km h_1, 80 km h_1 and 100 km h_1 by using an eddy current chassis dynamometer. The test results obtained with the use of alcoholegasoline blends (5 and 10 percent alcohol by volume) were compared to pure gasoline test results. The test results indicated that when the vehicle was fueled with alcoholegasoline blends, the peak wheel power increased. On the other hand, HC emissions increased. When CR was increased with the same fuel (methanol), the power and the brake thermal efficiency increased, and SFC decreased. Moreover, CO decreased and CO2, NOx and HC increased. The negative effects of both increasing CR and pure methanol on the engine behaviour were decreased by using methanol at a high CR (10/1). But, both increasing CR and methanol increased only HC emissions. Ozsezen A.N. [6] This study discusses the performance and exhaust emissions of a vehicle fueled with low content alcohol (ethanol and methanol) blends and pure gasoline. The vehicle tests were performed at wide-open throttle and at vehicle speeds of 40 km h_1, 60 km h_1, 80 km h_1 and 100 km h_1 by using an eddy current chassis dynamometer. The test results obtained with the use of alcoholegasoline blends (5 and 10 percent alcohol by volume) were compared to pure gasoline test results. The test results indicated that when the vehicle was fueled with alcoholegasoline blends, the peak wheel power and fuel consumption slightly increased. And also, in general, alcoholegasoline blends provided higher combustion efficiency compared to pure gasoline use. In exhaust emission results, a stable trend was not seen, especially for CO emission. But, on average, alcohole gasoline blends exhibited decreasing HC emissions. In 100 km h_1 vehicle speed test, the alcohole gasoline blends provided lower vehicle performance and lower NOx emission values compared to pure gasoline. At all vehicle speeds, minimum CO2 emission was obtained when 5% methanol was added in gasoline. The low content alcohol blends did not reveal any starting problem, or irregular operation on the engine. Tiegang Hu [7] Used A three-cylinder, with a bore of 68.5 mm port fuel
injection, engine was adopted to study the combustion and emission characteristics of a methanol/gasoline-fueled engine during cold start and warm up. The cylinder pressure analysis indicates that engine combustion is improved with the methanol addition into gasoline. With the increase of the methanol fraction, the flame developing period and the fast burning period are shortened and the indicated mean effective pressures become higher during the first 50 cycles. Meanwhile, a novel quasi-instantaneous measurement system was designed to measure engine emissions during this process. With the increase of the methanol fraction (below 30%), the unburned hydrocarbon and carbon monoxide (CO) are decreased obviously. The measured results show that the hydrocarbon is reduced about 40% at 5 °C and 30% at 15 °C during the cold-start and warm-up period; CO is reduced nearly 70% when the engine is fueled with M30 (30% methanol in volume), and a higher difference in the exhaust gas temperature of about 140 °C is achieved at 200 s after starting than fueled with gasoline.

Abu-Zaied M. [8] carried out an experimental study of the effect methanol addition to gasoline on the performance of spark ignition engines. The performance tests were carried out, at wide open throttle and variable speed conditions, over the range of 1000 to 2500 rpm, using various blends of methanol-gasoline fuel. It was found that methanol has a significant effect on the performance of the gasoline engine. The best engine performance (within the range studied) for maximum power output, and minimum brake specific fuel consumption, occurs when a mixture of 15 volume percent methanol and 85% gasoline blend is used. The addition of methanol to gasoline increases the octane number, thus engines fueled with methanol-gasoline blend can operate at higher compression ratios.

Mallikarjun M.V. [9] In the present day scenario emissions associated with the exhaust of automobiles resulting in global warming is a major menace to the entire world and also detrimental to health. Here an experimental attempt has been made to know the level of variation of exhaust emissions (Carbon monoxide, Hydrocarbons, Nitrous oxides) in S.I. four cylinder engine by adding methanol in various percentages in gasoline and also by doing slight modifications with the various subsystems of the engine under different load conditions. For various percentages of methanol blends (0-15%) pertaining to performance of engine it is observed that there is an increase of octane rating of gasoline along with increase in brake thermal efficiency, indicated thermal efficiency and reduction in knocking. On the other hand exhaust emissions CO and HC are considerably decreased but CO2 and Nox simultaneously slightly increasing. It is notable that for these methanol blends combustion temperature is found to be high and exhaust gas temperature decreasing gradually.

The present experimental work is concerned with the study the performance and emissions of a single cylinder air cooled four stroke spark ignition engine operated with methanol blended gasoline fuel. The present work are explore the effect of using methanol blending on the emissions levels of (CO , CO2 and HC) at differed loads and explore the effect of using methanol blending on the performance (Thermal efficiency, brake mean effect pressure and consumption fuel) at differed loads.

II. EXPERIMENT RIG

This part describes the experimental equipment and measuring instruments used to investigate experimentally the effect of methanol blending on spark ignition engine performance and pollutants concentration. A TD110-TD115 single cylinder spark ignition engine. The methanol is added to the gasoline by volume replacement ratio of methanol: (0%,3%,5%,7%,10%). The experimental rig consists of the engine test unit, the gas analysis unit. Fig (1) show the experimental rig photographically. The exhaust gas constituents (CO, CO2, HC) are measured in this research by non-dispersive infrared analyzer NDIR, for HC by flame ionization detector FID show in Fig (2).

III. ENGINE PERFORANCE CALCULATION

The engine power is determined by measuring the value of the rotation speed, thus the brake power developed by the engine is calculated using the following relation [1]:

\[ p = \frac{T \cdot N \cdot 2 \cdot \pi}{60000} \] ..........................1

To determine the efficiency (which is the thermal energy obtained from the fuel converted into mechanical energy), together with the engine power output, the fuel flow must be measured [1].

\[ \eta_{th} = \frac{p \times 3600}{\rho \cdot c \cdot H_i} \times 100\% \] ..........................2

The specific fuel consumption can be determined from the following relationship [1]:

\[ sfc = \frac{\rho \cdot c}{p} \times 1000 \] ..........................3

Fig. 1. photograph of the component part of the Experimental Rig
CO reduces. This is due to the better combustion of gasoline when methanol used as an additive. The concentration of CO decreases with the increase in percentage of methanol in the fuel. This may be attributed to the presence of O2 in methanol, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO2). It is observed that hydro carbon (HC) decreases with increasing load for all the percentage of methanol. If percentage of additive of methanol increases, HC reduces. The hydrocarbon emissions are inversely proportional to the percentage of methanol added in the fuel. The petrol fuel operation showed the slightly higher concentrations of HC in the exhaust at all loads. Since methanol is an oxygenated fuel, it improves the combustion efficiency and hence reduces the concentration of hydrocarbon emissions (HC) in the engine exhaust.

IV. RESULTS AND DISCUSSION

The experimental results of the effect of methanol addition to gasoline fuel on the performance and emissions of a spark ignition engine have been presented and discussed. It must be mentioned here that the methanol blending is based on volume replacement ratio. The experimental program is limited to a torque range from 0-10 (N.m) and a methanol blending range from 0%-10%.

Figures (3 to 5) show the effect of the load at different methanol blending ratio on the brake power, brake thermal efficiency and specific fuel consumption, respectively.

The brake power increases as the percentage of methanol addition increases for constant load. This is due to the high combustion efficiency. The thermal efficiency increases as the percentage of methanol addition increases for constant load. This due to the improvement of combustion process. The thermal efficiency is higher for various additives because of improve combustion efficiency. The brake thermal efficiency is based on B.P and calorific value of the engine. Brake thermal efficiency gradually increases with increase in percentage of additives.

The specific fuel consumption decreases as the percentage of methanol addition increases for constant load. The variation of SFC with load for different percentage of additives of methanol with the gasoline. The additive of methanol shows lower SFC compare to gasoline because of it has oxygen content so complete combustion takes place in combustion chamber. However SFC is lower for all the other additives. The SFC decreases with the increasing loads. It is inversely proportional to the thermal efficiency of the engine.

Figures (6 to 8) show the variations of exhaust pollutants, namely, carbon dioxide, carbon monoxide and HC respectively with methanol blending ratio at different loads.

The results show that the concentration of carbon dioxide and carbon monoxide decreases with increases methanol blending ratios. This is due to the reduction in carbon atoms concentration in the blended fuel and the high molecular diffusivity and high flammability limits which improve mixing process and hence combustion efficiency. It is observed that CO increases with increasing load for all the percentage of methanol. If percentage of additive increases

---

**Fig. 2.** Photograph of the gas analysis unit

**Fig. 3.** Effect of load on brake power with different methanol blending ratios.

**Fig. 4.** Effect of load on the thermal efficiency with different methanol blending ratios.

**Fig. 5.** Effect of load on the brake SFC with different methanol blending ratios.
1. The blending ratio of 7% and 10% by volume of methanol gives the maximum improvement in engine efficiency.
2. The combustion process is improved by added methanol.
3. The brake power increase as methanol blending increase.
4. The blending ratio of 10% methanol gives the maximum reduction in S.F.C.
5. The concentrations of carbon dioxide and carbon monoxide decreases as methanol blending increase.
6. The blending ratio of 7% methanol gives the maximum reduction in HC.

REFERENCE


NOMENCLATURE

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Power</td>
<td>kW</td>
</tr>
<tr>
<td>T</td>
<td>Torque</td>
<td>N.m</td>
</tr>
<tr>
<td>N</td>
<td>The rotation speed of engine</td>
<td>Rpm</td>
</tr>
<tr>
<td>C</td>
<td>Fuel flow rate</td>
<td>(liters/h)</td>
</tr>
<tr>
<td>( \eta )</td>
<td>Effective efficiency</td>
<td>-</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Density</td>
<td>kg/liter</td>
</tr>
<tr>
<td>SFC</td>
<td>The specific fuel consumption</td>
<td>g/kWh</td>
</tr>
<tr>
<td>Hi</td>
<td>Fuel calorific value</td>
<td>kJ/g</td>
</tr>
</tbody>
</table>

Fig. 6. Effect of methanol blended on the CO with different load.

Fig. 7. Effect of methanol blended on the CO\textsubscript{2} with different load.

Fig. 8. Effect of methanol blended on the HC with different load.

IIIV. CONCLUSION

The following conclusions can be drawn from the percent work: