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Performance analysis of Light Transport Vehicle using Biofuels in SI engine

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ABSTRACT

The purpose of this study is to review the engine performance and pollutant emission of the commercial SI engine using biofuels. Using biofuels satisfactory results were obtained, using alcohol as fuel it was found to be the good option that's why it was used as fuel till 19TH century but because of its high cost researchers found alternates of alcohol like ethanol, methanol and butanol etc. in this research paper it is reviewed that by going through the results of the experiments that were done by the researchers in their research paper that biofuels would be the best option to be used as fuel in a blended form with gasoline. Here we reviewed that the engine performance and pollutant emission of the commercial SI engine using alcohol-gasoline, ethanol-gasoline, butanol-gasoline and other blended fuels with various blended rates (0%, 5%, 10%, 20%, 30%). Fuel properties of blended fuels were first examined by the standard ASTM methods. Results showed that with increasing the alcohol content, the heating value of the blended fuels is decreased, while the octane number of the blended fuels increases. It was found that with increasing the ethanol content, the volatility of the blended fuels initially increases to maximum and then decreases. Finally it was noted that NO_X emissions depends on the engine operating condition rather than the ethanol content.

Keywords-Methanol; Ethanol; Butanol; Engine Performance; Pollutant Emissions; Gasoline Blends.

I. INTRODUCTION

During past few years there has been a mark increase in air pollution emitted by Transport Vehicles. Motor vehicles account for a significant portion of urban air pollution in much of the developing world. According to Goldemberg, motor vehicles account for more than 70% of global carbon monoxide (CO) emissions and 19% of global carbon dioxide (CO2) emissions. CO2 emissions from a gallon of gasoline are about 8 kg. There are 700 million light duty vehicles, automobiles, light trucks, SUVs and minivans, on roadways around the world. These numbers are projected to increase to 1.3 billion by 2030, and to over 2 billion vehicles by 2050, with most of the increase coming in developing countries. This growth will affect the stability of ecosystems and global climate as well as global oil reserves. The world's total proven oil, natural gas and coal reserves are respectively, 1707 billion barrels (that is sufficient to meet 50.6 years of global production), 186.6 trillion cubic meters, and 231 million tons (fell by 6.2% in 2015 largest decline on record) by the end of 2016. Interest in the use of bio-fuels worldwide has grown strongly in recent years due to the limited oil reserves, concerns about climate change from greenhouse gas emissions and the desire to promote domestic rural economic conditions. As air pollution and day by day decrease of non renewable fuels has become a major problem so researches are being done by the scientists day by day to find a fuel whichcauses less air pollution and gives higher or satisfactory efficiency and which could be renewable and easily available. To find a fuel which would have both the characterstics. Researchers have done experiments on bio-fuels which could be obtained from crops and which can be generated by biological processess. Few examples of those fuels which were obtained from biological processes are Alcohol, Ethanol, Methanol, Butanol etc. These allwere tested by the researchers to find the best of all which will give higher efficiency and generates lower pollution. Alcohol has been used as a fuel for auto-engines since 19^{TH}century, however, it is not widely used because of itshigh price. Due to limitation in technology, economic and regional considerations, alcohol fuel still cannot be used extensively. Under the environmental considerations, using ethanol blended with gasoline is better than methanol because of its renewability and less Fuel compared to ethanol. Butanol contains 22% oxygen making it a beneficiary fuel extender that is cleaner burning than ethanol.

II. LITERATURE REVIEW

W. D. Hsieh et al.,[1]Alcohol, such as methanol (CH_3OH) or ethanol (C_2H_5OH), is a pure substance. However, gasoline is composed of C4-C12 hydrocarbons, and has wider transitional properties. The alcohol contains an oxygen atom so that it can be viewed as a partially oxidized hydrocarbon. The alcohol is completely miscible with water in all proportions, while the gasoline and water are immiscible. Furey and Perry[2]. This may cause the corrosion problems on the mechanical components. To reduce this problem on fuel delivery system, such materials mentioned above should be avoided . Coelho et al.,[3] Alcohol was found to be reactive with the most rubber and creates jam in fuel pipe. Naegeli et al.,[4] suggested to use fluorocarbon rubber as a replacementfor rubber. On combustion characterstics, the auto-ignition temperature and flash point of alcohol are higher than those of gasoline, which makes it safer for transportation and storage. The latent heat of evaporation of alcohol is 3-5 times higher than that of gasoline; this makes the temperature of the intake manifold lower, and increases the volumetric efficiency. The heating value of alcohol is lower than that of gasoline . therefore, we need 1.5-1.8 times more alcohol fuel to achieve the same energy output. The stoichiometric air-fuel ratio (AFR) of alcohol is about 2/3-1/2 that of the gasoline, so the required amount of the air for complete combustion is lesser for alcohol.

Since using ethanol-gasoline blended fuels can ease off the air pollution and the depletion of petroleum fuels simultaneously, many researchers Gorse; Salih and A ndrews; Chandler et al.,[5]; and so on. Have been devoted to studying the effect of these alternative fuels on the performance and pollutant emission of an engine. Palmer[6] used various blend rates of ethanol-gasoline fuels in engine tests. Results indicated that 10% ethanol addition increases the engine power output by 5%, and the octane number can be increased by 5% for each 10% ethanol added. Abdel-Rahman and Osman[7] recently had tested 10%, 20%, 30% and 40% ethanol of blended fuels in a variable-compression-ratio engine. They found that the increase of ethanol content increases the octane number, but decreases the heating value. The 10% addition of ethanol had the most obvious effect on increasing the octane number. Under various compression ratios of engine, the optimum blend rate was found to be 10% ethanol with 90% gasoline.

Bata et al.,[8] studied different blend rates of ethanol-gasoline fuels in engines, and found that the ethanol could reduce the CO and UHC emissions to some degree. The reduction of CO emission is apparently caused by the wide flammability and oxygenatedcharacterstic of ethanol. In the study of Palmer, 1986. He indicated that 10% of ethanol addition to gasoline could reduce the concentration of CO emission up to 30%. Alexandrian and Schwalm,[9] showed that the AFR has great influence on the CO emission. Using ethanol-gasoline blended fuel instead of gasoline alone, especially under fuel-rich conditions, can lower CO and NO_x emissions. However, studies of Chao et al., and Rideout et al.,[10] pointed out that using ethanol-gasoline blended fuels increases the emission of formaldehyde, acetaldehyde and acetone 5.12-13.8 times then those from gasoline. Although the emission of aldehyde will increase when we use ethanol as a fuel, the damage to the environment by the emitted aldehyde is far less than that by the poly-nuclear aromatics emitted from burning gasoline. Methanol has a significant effect on the increase the performance of the gasoline engine .The addition of methanol to gasoline increases the octanenumber, thus engines performance increase with methanol-gasoline blend can operate at higher compression ratios.

D. Balaji et al.,[11] mentioned influence of isobutanol blend in spark ignition engine performance operated with gasoline and ethanol. A four stroke, single cylinder SI engine was used for conducting this study. Performance tests were conducted for fuel consumption, volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specificfuel consumption, using unleaded gasoline and additives blends with different percentages of fuel at varying engine torque condition and constant engine speed. The result showed that blendingunleadedgasoline with additives increases the brake power, volumetric and brake thermal efficiencies and fuel consumption addition of 5% isobutanol and 10% ethanol to gasoline gave the best results for all measured parameters at all engine torque values.

F. N. Alasfour,[12] used butanol as alternative to fuel and additives, the availability analysis of a spark-ignition engine using a butanol-gasoline blend had been experimentally investigated with Hydra single-cylinder, spark-ignition, fuel-injection engine was used over a wide range of fuel/air equivalence ratios (Φ = 0.8-1.2) at a 30% volume butanol-gasoline blend and studied the effect of using a butanol-gasoline blend in a spark-ignition engine in terms of first- and second-law efficiency. Results show that, at Φ = 0.9, when a butanol-gasoline blend is used, the energy analysis indicates that only 35.4% of the fuel energy can be utilized as an indicated power, where 64.6% of fuel energy is not available for conversion to useful work. The availability analysis shows that 50.6% of fuel energy can be utilized as useful work (34.28% as an indicated power, 12.48% from the exhaust and only 3.84% from the cooling water) and the available energy unaccounted for represents 49.4% of the total available energy. Further, 30% blend of butanol were investigated for NOx emission by two way dividing two part by preheating the air and by varying the ignition timing, under differentvalues of inlet air temperatures ,10% increase in NOx was observed when the inlet air temperature increased from 400 to 608^{o}C. For 30% iso-butanol-gasoline blend experimental results show that preheating inlet air causes knock and misfire to occur at less advanced ignition timing. Retarding ignition timing causes the engine thermal efficiency to decrease.

AlvydasPikuna et al.,[13] presented the influence of composition of gasoline-ethanol blends on parameters of internal combustion engines .The study showed that when ethanol is added, the heating value of the blended fuel decreases, while the octane number of the blended fuel increases .Also the results of the engine test indicated that when ethanol–gasoline blended fuel is used, the engine power and specific fuel consumption of the engine slightly increase. Effect of ethanol–unleaded gasoline blends on engine performance and exhaust emission was studied by M .Al- Hasan et al.,[14] A four stroke, four cylinder SI engine Experimental Study of Gasoline –Alcohol Blends on Performance of Internal Combustion Engine was used for conducting the study .The study showed that blending unleaded gasoline with ethanol increases the brake power, torque, volumetric and brake thermal efficiencies and fuel consumption, while it decreases the brake specific fuel consumption and equivalence air–fuel ratio .The 20 %volume ethanol in fuel blend gave the best results for all measured parameters at all engine speeds.

CenkSayin et al.,[15] Higher octane causes higher ignition temperature at high load and causes sudden and more strong explosion than designed value which cause more wear and tear of engine leading to reduced life of engine.

Higher octane rating of alcohol and its blending provides us to work with higher compression ratio; the effect of varying the compression ratio with ethanol gasoline blend introduced by HuseyinSerdarYucesu et al.,[16] used three compression ratios, with increasing compression ratio engine torque increased about 8%. At the higher compression ratios the torque output did not change noticeable, highest increment was obtained for fuels E40 and E60 as nearly 14%, considerable decrease of BSFC was about 15% with E40 fuel at 2000 rpm engine speed. TolgaTopgu et al.,[17] also investigated the effect of varying compression ratio with hydra engine by varying the ignition timing, blending unleaded gasoline with ethanol increased the brake torque when the ignition timing was retarded.

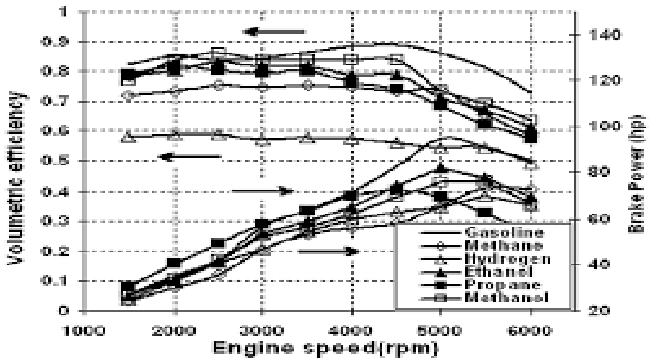

Fig. 1.variation of volumetric efficiency and brake power with different fuels versus engine

Ibrahim ThamerNazzal et al.,[18] investigated the effects of alcoholblends on the performance of a typical spark ignition engine and compared the engine performance with using 12%ethanol–88%gasoline blended fuel and 12%methanol–88%gasoline blended fuel and 6% ethanol-6% methanol – 88% gasoline with gasoline fuel .The engine performance was measured at a variety of engine operating conditions.

H. S. Farkade et al.,[19] reviewed changes in the different performance characterstics.

2.1 Brake Thermal Efficiency

Brake thermal efficiency is the function of actual power gain from total supplied energy input. More heat input gives you better results thus higher the calorific value of fuel and better the performance, table shows highest calorific value for the gasoline clearly pointing for better thermal efficiency of gasoline than any other blending. But, graph for methanol blending shows higher thermal efficiency for M10 blend. Even with lower calorific value, result for methanol blend is higher the reason behind the performance is the presence of oxygen in blend, 5% oxygen contain give more desirable combustion than that of plain gasoline resulting into increase brake mean effective pressure which gives higher thermal efficiency. (Fig 2) shows comparison of three blends of methanol, the thermal efficiency of M10 blend is highest but then after the thermal efficiency for further blends of methanol shows lower performance even with higher oxygen contain. M30 blend shows you lowest thermal efficiency having lowest calorific value. Behavior of graphs plotted (Fig 3) for various blend of ethanol follows the similar pattern, blend E10 shows better performance than other two blending, but the performance of E10 is somewhat better than M10 as result suggest, it may be result of oxygen compensation for ethanol blend is better than methanol blend resulting into better performance of E10blends.Also calorific value for ethanol is higher than that of methanol that is another reason for higher thermal efficiency of ethanol blend. Likewise the performance of E20, E30 is lower than E10, butis parallel comparison with methanol; ethanol shows better performance as discussed. M30 shows lowest brake thermal efficiency at full load condition.

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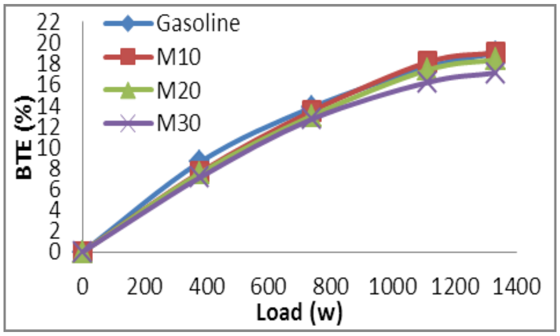


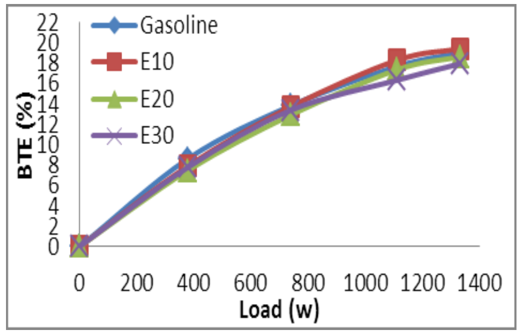


Fig. 2. Brake Thermal Efficiency of methanol blends

Fig. 3. Brake Thermal Efficiency of ethanol blends

(Fig.4) for comparison of performance of thermal efficiency for different butanol blends shows better performance for B20 blend, when we observe closely the calorific value and presence of oxygen play important role in alcohol blending likewise in E10 the percentage of oxygen is nearer to the five percent and thus in comparison butanol shows better result. Further increase in butanol in blend shows similar results as seen in case of methanol and ethanol.

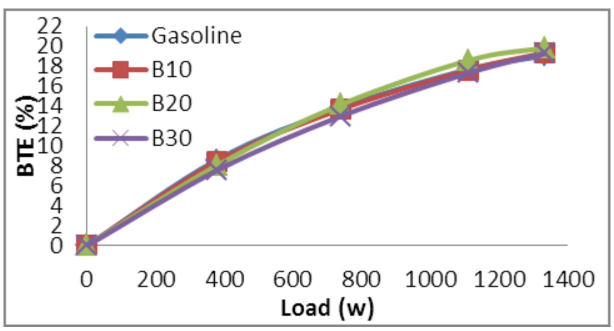
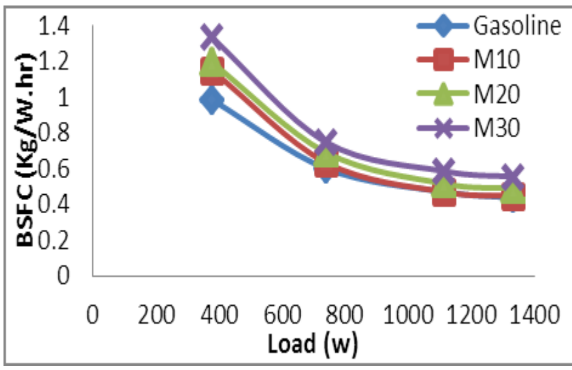


Fig. 4. Brake Thermal Efficiency of butanol blends

2.2 Brake specific fuel consumption

Fuel consumed for one kilowatt power generation in one hour is defined as brake specific fuel consumption. The brake specific fuel consumption decreases when heading towards loading condition, brake specific fuel consumption for full load condition is least. Comparison with fuel consumption shows you opposite trend of graph, fuel consumption increases with increasein load but brake specific fuel consumption decreases withincrease in loadasit is function of fuel consumption and brake power. (Fig 5) for methanol blend showing brakes specific fuel consumption at various loading condition. Graph shows least fuel consumption of fuel for initial loading of gasoline blend, but at full loading condition the brake specific fuel consumption for M10 is least. The brake specific fuel consumption for

M30 shows highest value on graph.Better thermal efficiency of M10 as discussed before is resulting of complete combustion and thus M10 shows least brake specific fuel consumption. Result of other two blends is as expected from brake thermal efficiency graph; the brake specific consumption is higher for it.Lower calorific value of methanol blends need higher fuel supply for producing same power at given rpm. Likewise the brake specific fuel consumption for butanol at twenty percent and for ethanol at ten percent show least brake specific fuel consumption (Figs. 6 and 7).The lower calorific values of blending resulting into higher fuel consumption thus considering brake specific fuel consumption rather than fuel consumption gives you better analytical results.



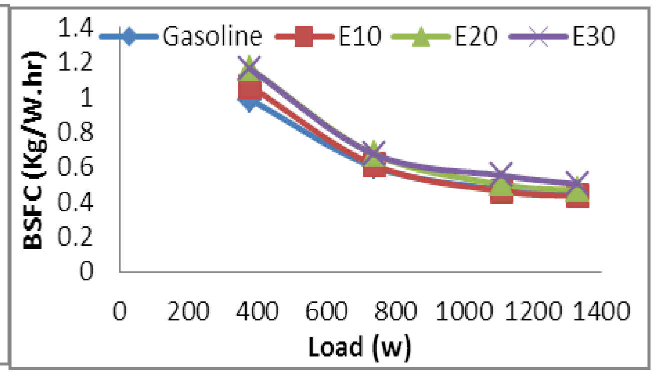
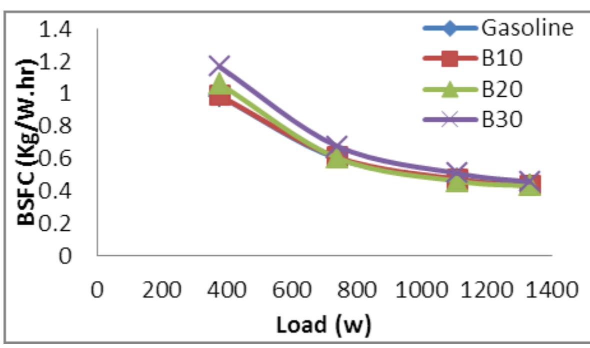


Fig.5brake specific fuel consumption for methanol blends **Fig.6 brake specific fuel consumption for ethanol blends**



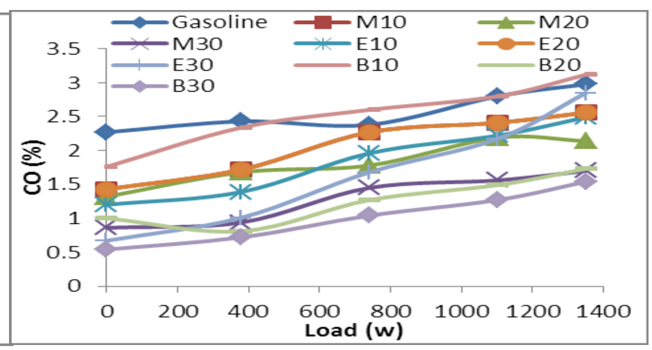


Fig. 7 brake specific fuel consumption for butanol blends **Fig. 8 CO emission with varying load on replacement basis**

2.3 Emissions:CO

Carbon monoxide is product of incomplete combustion of fuel. Formation of carbon monoxide indicates loss of power, result of oxygen deficiency in combustion chamber. Emission of CO is unavoidable with available technology, since it is not possible to achieve supply of required air with proper mixing in combustion chamber which can sufficiently burn all fuel or even with higher air, the emission of carbon monoxide increase result of higher oxygen molecule.

The blends of methanol in graph shows lower carbon monoxide emission compared to gasoline, primarily presence of oxygen can be considered as reason for reduction in CO emission further it is validated by higher blending of methanol. Methanol with thirty percent has highest oxygen showing lowered emission of CO. The graphs (Fig. 8) for ethanol and butanol also shows similar trend of CO emission. Butanol with 30% blending percentage shows least emission of CO.

III. CONCLUSION

Bio-ethanol is by far the most widely used bio-fuel for transportation worldwide. Brake thermal efficiency increases for particular alcohol blending percentage and the percentage of blending for different alcohols are different. After particular fix percentage, the performance of alcohol blending decreases, the alcohol in gasoline provide oxygen which result into more desirable combustion of fuel. The combustion of fuel gives higher brake effective pressure which compensate the effect of low heating value or even rise of pressure cause higher thermal efficiency. Addition of oxygenates in gasoline provides better combustion resulting into significant reduction in CO and HC emission. These provides heat addition to actual performance their by increase break thermal efficiency of engine. It is observed that the CO emission reduces with increase in oxygen contain when we consider blends of methanol, the emission for CO is least for M30 almost at all operating conditions.CO and HC after complete combustion produces CO_2 and water for HC, thus result of which show increased percentage of carbondioxide. Also the carbon dioxide emission increases with increase in load as inverse to HC emission. Nitrogen in air reacts with available oxygen at higher temperature; the condition of better combustion produces higher temperature resulting into increased combustion for oxides of nitrogen. Further increase in load causes even higher temperature resulting into higher NO emission as observed. As the oxygen contain increases, normally more desirable combustion observed in most of the cases and thus the emission for CO_2 increases for 7.5% oxygen containing blend than 5% and 2.5% of oxygen contain. And CO, HC emission decreases.Reviews showed that using ethanol–gasoline blended fuels, the torque output and fuel consumption of the engine slightly increase; CO emissions decrease dramatically as a result of the leaning effect caused by the ethanol addition; and CO_2 emission increases because of the improved combustion. In this study, we found that using ethanol–gasoline blended fuels, CO emissions may be reduced 10–90% and 20–80%, respectively, while CO_2 emission increases 5–25% depending on engine conditions.

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