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Experimental Investigation of Emission Characteristic of Tert Butyl Alcohol and Gasoline Blend Using Two Stroke Si Engine

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ABSTRACT:-
Internal combustion engine are the mostpreferred prime mover across the world. Spark ignition engine is preferred locomotive prime mover due to its smooth operation and low maintains. The gasoline is fossil fuel which is limited in reservoirs causes varieties of study in search of alternative fuel for SI engine, where alcohol promises best alternative fuel. In this paper study of alcohols are tried to investigate in two parts. Comparative study of tert butyl alcohol on the basis of blending percentage is first part, followed by investigation of oxygen role on the basis of oxygen percentage in the blend. The result shows highest replacement of gasoline by butanol at 5 % of oxygen content, the performance of same oxygen percentage for other two alcohols are also better. Presence of oxygen gives you more desirable combustion resulting into low emission of CO, HC and higher emission of CO2 as a result of complete combustion, higher temperature is also favorable for NO emission resulting higher emissions for it.

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I. INTRODUCTION

The concern of rapidly change of climate along with the increase of access use of the fossil fuel impact drastic change in our environment. Scarcity and availability of fossil fuel leading to increase the interest in the renewable energy sources, which have the potential to fulfill all the global energy demand. Renewable energy sources have low power densities and required more surface land area to produce the given amount of power. This is especially true for the solar and wind energy, which are most promising renewable energy sources. The world is now motivated to push their potential to increase the renewable energy sources- solar and wind chief among them, but also hydro- power, geothermal power, and biofuels are the major source of renewable energy. In this motorized world the alternative fuel for the reciprocating engine such as spark ignition and compression ignition engines are the source of power producing in a efficient manner. The SI and CI engines are widely adopted as a power sources for the passenger, commercial and electricity power generation. They are also used in the industrial fields for heavy purposes because of their high power density and high efficiency. Human beings are greatly depends upon the fossil fuel because the combustion of the gasoline is one of the important energy conversion method of the fuel that convert chemical energy into the heat.The use of petroleum based fossil fuel increases the green house gases (GHG) emission. This is one of the major causes of the climate change and global warming. Global warming is caused due to an increase in the global temperature by the atmospheric greenhouse effect. From a technical point of view, the wide use of renewable biofuels or alternative fuels can also directly contribute to improvements in engine performance and emission characteristics. The balance between fuel efficiency and hazardous emissions, such as unburned hydrocarbon (HC), carbon monoxide (CO), nitrogen oxides (NO_x) and particulate matter (PM), has always been an important issue in the engine research field. Since the combustion of fuel is determined by the air–fuel interaction, the unique properties of alternative fuels can be advantageously and directly utilized during the engine combustion process. Research is being conducted worldwide on the application of alternative fuels to ICEs to reveal their potentials.

Alcohol fuels are mostly used as the biofuel in the internal combustion engine, after knowing the property of alcohol fuel. Ethanol, tert butyl alcohol, propanol and butanol are some alcohol fuels, which are used from past several years and its use is increases day by day. Ethanol and tert butyl alcohol are most commonly used alcohol fuel in the internal combustion engine. Due to their property to achieve the higher thermal efficiency, lower green house emission gases and its production from the renewable sources is gain attention to use them in the internal combustion engine as an alternative fuel.

Ethanol is produce from the biomass-based renewable fuel that can be produced by alcoholic fermentation of the sugar from vegetable material, as sugar come the most popular raw material, followed by corn and starch (1,2, trindade). Ethanol is already adopted as alternative fuel for the internal combustion engine by considering the effective engine performance and efficiency of the ethanol as compared to the gasoline (4,5, trindade).

Tert butyl alcohol is manufactured by coal, natural gas, coke-oven gas, hydrogen and biomass. But mostly tert butyl alcohol is produced by synthesis gas, which is composed of carbon monoxide and hydrogen (50 bae). It has been found that the tert butyl alcohol has high octane no., which significantly increase the performance of the engine as compared to gasoline fuel.

Butanol is another alcohol fuel which was initially not used but it is another promising renewable fuel for IC engine. It is also biomass-based renewable fuel that can be produced by the fermentation of the biomass feed stock (8-10 trindade). At present time butanol production rate is lower than the ethanol and tert butyl alcohol. This is disadvantage of the butanol (10 trindade). Butanol has the higher heat of evaporation than ethanol, which is beneficial for reducing the combustion temperature and possibly leading to the reduction of formation of NO_x. Application of the butanol fuel in the internal combustion engine and their effect will be studied in this research.

II. LITERATURE REVIEW

Some consideration should be taken to substitute the conventional fuel with the alternative fuel for both spark ignition and compression ignition engines. The property of the alternative fuel so that the drawback of conventional fuel may mitigated. These properties are combustion property, physical properties, lower heating value, compatibility with engine, manufacturing cost, octane no. and cetane number. Different properties of the fuel play a specific role in the performance and emission characteristic of the engine. Combustion properties tell us the if given alternative fuel is suitable for engine operation or not. Octane and cetane no. determine the knock resistant of a given fuel and confirm that weather fuel is suitable for the SI and CI combustion engine or not. Physical property determineweather the fuel possessufficient volatility and property to make a suitable combustible mixture of air and fuel. Material compatibility of the engine with fuel is needed otherwise additional cost is required for some modification in the engine to perform with the alternative fuel. Manufacturing cost is one of the major factor for the consumer. As the new technology have improved, manufacturing cost is not a big matter. But the price of alternative fuel is still more than the conventional fuel gasoline and diesel [11, bae). The SI and CI engines which are used for the gasoline and diesel respectively have some definite property and if we want to use the mixture of alternative fuels and conventional fuel. Their property should be match with engine design parameter. Some property of the fuel like octane no. flammability related to lean limit and combustion stability, laminar burning velocity, LHV, volatility, vapour pressure etc.

The octane no. determines the knock resistance quality of the fuel and decideswhether the fuel can be used in the SI combustion engine or not. If auto ignition takes place in the SI enginethen this phenomenon is referred to as knock but this auto ignition is an undesirable and abnormal combustion phenomenon.Knock can be multi point auto ignition that occurs throughout the engine. The main source foe the knocking is the design parameter of the engine and fuel property of the alternative fuel use in the engine. If the octane no. is more than the compression ratio will increase and hence efficiency of the system will also increase.

Lean combustion concept has been explored to mitigate the pumping loss of SI engine at part load conditions. Due to lean mixture there is possibility of the more NOX emission. The solution to reduce the NOX emission is to apply exhaust gas recirculation (EGR) to substitute for the excessive amount of O2. Lean mixture is also determined by the flammability of the fuel itself. Alternative fuel with wider flammability windows can helpful in increasing the EGR tolerance leading to further reduction of NOX emission. The volatility or evaporation characteristic of the alternative fuel is very important to ensure that the fuel is well pre mixed before the spark ignition and also due to good volatility it form the homogeneous mixture and also reliable startability at cool condition. From different research we observe that emission characteristic of the ethanol and tert butyl alcohol with respect to gasoline at different speed is shown.

III. EMISSION OF TERT BUTYL ALCOHOL AND ETHANOL

HC/CO

Carbon monoxide generally produced due to deficiency of the oxygen in the combustion chamber because due to deficiency of oxygen incomplete combustion of the fuel take place and carbon monoxide is produced. When we use the alcohol fuel then it will cause the decrease in HC and CO as compared to the gasoline fuel. It has been seen that ethanol and tert butyl alcohol uses decrease the emission at the ratio of 29.07% and 31.34% (balki) as compared to gasoline. When we increase the speed of engine then CO emission decrease.

Hydrocarbon emission also produces due to incomplete combustion of the fuel. When there is lack of air supply to the combustion chamber then formation of hydrocarbon take place. Result of hydrocarbon is power loss in the engine and it creates the less break thermal efficiency. When you add the alcohol fuel to the gasoline then it will reduce the HC emission and eliminate the need of after treatment of the emission gases (farkad). It was seen that ethanol and tert butyl alcohol uses decreased the Hc emission at the ratio of 13.6% and 27.12% respectively, when compared to the gasoline.

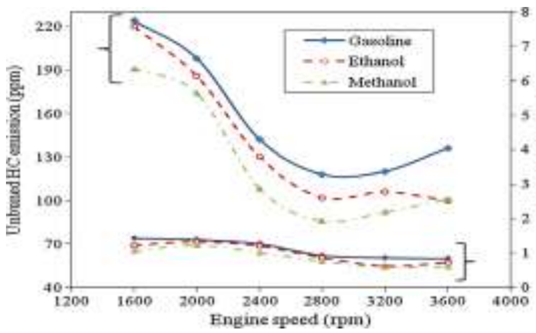

Figure 1: Above diagram shows the comparison of CO and HC emission of the pure gasoline,tert butyl alcohol and ethanol at different engine speed.

CO2/NOX

As we seen due to incomplete combustion of the fuel CO and HC produce but when there is sufficient amount of air supply to the combustion chamber then carbon dioxide is product of complete combustion of fuel and higher emission of CO2 is desirable. Carbon dioxide emission can be controlled if we burn less fuel efficiently by using more efficient engine. The carbon rate in the fuel compound of the alcohol fuel is lower than gasoline. The amount of alcohol fuel taken for the same throttle position is two times when compared to the gasoline. The carbon rate of the alcohol fuel is greater than the carbon rate of the gasoline fuel. Hence, due to increase in carbon rate of alcohol fuel caused to increase in the CO2 emission. Formation of nitrogen oxide is an endothermic process which absorbs heat from surrounding lowering down the temperature of surrounding. NO formation occurs at low equivalence ration and high adiabatic flame temperature. NO can be controlled by lowering down the flam temperature. As the oxygen percentage increase provides complete combustion with higher temperature resulting in higher NO formation as observed in graph also the graph shows increasing trend of NO for increase loading.

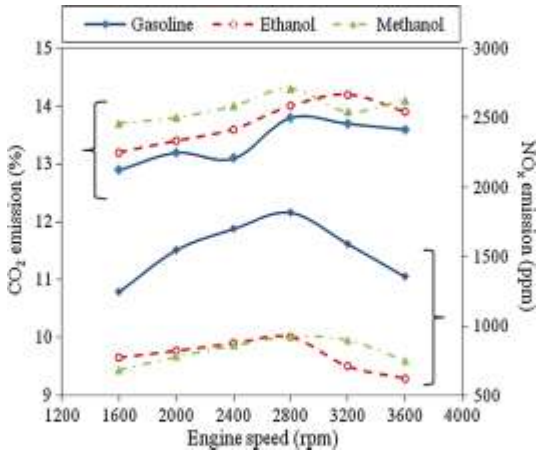

Figure 2: In our experiment we will study the carbon monoxide, hydrocarbon, carbon dioxide and nitrous oxide emission with respect to the variation different load.

IV. METHODOLOGY

The engine that we use is 150 cc engine, which is single cylinder, two stoke, spark ignition and forced air cooled engine.In this two stroke experimental rig the load is varying from manual switch, in which each switch is of 2KW. The power which is produced by the engine is used to run alternator. To increase the load in the engine we put the switch on each switch increases the load of 1KW. Hence speed of the engine and fuel consumption increases. By varying load we will calculate emission characteristic of the gasoline and tert butyl alcohol blend in different ratio that is TBA10, TBA20 AND TBA30. The exhaust emission of CO, HC, CO_2, O_2 and $NO_x$from the engine is measured by the avl gas analyser. The engine was started and allowed to warm for the period of 10-15 minute. First reading was taken for the pure gasoline in which emission of gas is measured. Before running to the engine for next fuel blend it is allowed to consume all the fuel by running for the sufficient time. For each experiment on an average four reading should be taken and average of all the four readings is the measuring value. HC, CO and NO_X emission is to be calculated on the basis of observation. We are varying load from no load condition to 5KW load and CO, HC, CO_2, O_2 and NO_x emission of the gases is calculated by the gas analyser. Similarly we calculate reading for different load and gasoline blend.

Figure 3: Experimental Setup

V. RESULT AND DISCUSSION

The experimental result for different load condition and with different percentage of tert butyl alcohol in gasoline mixture i.e. TBA10, TBA20, TBA30 is calculated. Our main concern is to calculate emission characteristic of the blended gasoline and TBA mixture for different loading condition. Generally emission of CO, HC, CO_2, O_2 and NO_x depend upon the kind of engine being tested, operating condition and blending ratio of the fuel.

The test rig comprises of air cooled petrol Engine in which temperature is measured by digital temperature indicator the specification of Engine is given as following

S. No.	Description	Data
1.	Type of Engine	Two Stoke Petrol Engine
2.	No. of Cylinder	Single Cylinder
3.	Max B.P.	5.93 k.w
4.	Max. Speed	5000 rpm
5.	Direction of Rotation	Clockwise
6.	Bore Diameter	57 mm
7.	Stroke Length	57 mm
8.	Cubic Capacity	150 cc

HC

Hydrocarbon is also product of incomplete combustion of fuel. The formation of hydrocarbon is due to lack of complete air supply. The results obtained for alcohols blending are plotted against different loading condition.

HC emission indicate power loss, higher the hydrocarbon emission higher the power loss resulting into less brake thermal efficiency. Complete combustion for HC then can be achieved by after treatment processes. Addition of
alcohol gives you lesser hydrocarbon emission eliminating need of after burner and other devices. When gasoline tested of engine the HC emission was significantly high. But with addition of methanol, hydrocarbon emission lowered down significantly. The emission for hydrocarbon shows declined trend for higher loading.

Addition of tert butyl alcohol gives lesser hydrocarbon emission. The value of HC emission for thee gasoline is decrease with the increase of load. When we use of blend of gasoline and tert butyl alcohol the value of HC emission constantly decrease as we increase the percentage of tert butyl alcohol in the gasoline. The minimum value of HC emission is shows as for the TBA30 at the 5kw of loadcondition. The decreasing trend of the HC emission with the varying load as shown in figure. As the load increases the value of HC emission is decreases for all fuel blends that is TBA10, TBA20, TBA30. But trend of HC emission for TBA30 is lowest.

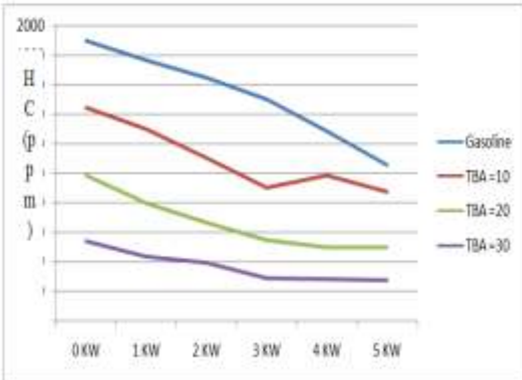

Figure 4: HC Emission with varying load on Replacement Basis

CO

The effect of CO emission with variable load condition is represented in the graph. From the graph it is clear that CO emission for pure gasoline. Carbon monoxide is product of incomplete combustion of fuel. Formation of carbon monoxide indicates loss of power, result of oxygen deficiency 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.

From the graph it is clear that CO emission of the gasoline is higher than the other fuel blends that are TBA10, TBA20 and TBA30. In gasoline and tert butyl alcohol blend as we increase the percentage of tert butyl alcohol then co emission for the less load condition is lower but as we increase the load the value of co emission increases because of incomplete combustion takes place at higher load condition and less oxygen supply. The lowest value of the CO emission is for the TBA30 at no load condition. The overall CO emission decrease is decreased then gasoline but increase with the increase in load.

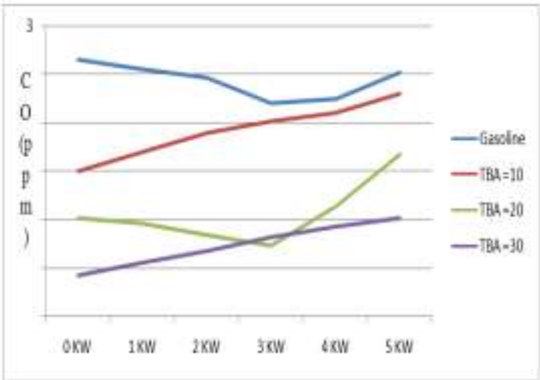

Figure 5: CO Emission with varying load on Replacement Basis

NOx

Formation of nitrogen oxide is an endothermic process which absorbs heat from surrounding lowering down the temperature of surrounding. NOx formation occurs at low equivalence ration and high adiabatic flame temperature.

NOx can be controlled by lowering down the flam temperature. As the oxygen percentage increase provides complete combustion with higher temperature resulting in higher NOx formation as observed in graph (Fig. 6), also the graph shows increasing trend of NOx for increase loading.

From the graph the value of NOx emission is lowest for the TBA20 at no load condition. But overall NOx emission is lowest for the gasoline. TBA10 is shows the rapidly increase in the NO x emission. Similarly TBA20 shows the increasing trend but not steeper curve as for TBA10. TBA30 shows the increasing trend of the NOx emission with the increasing load, but its graph is mostly parallel the gasoline and slightly increasing in the NOx emission with respect to the gasoline.

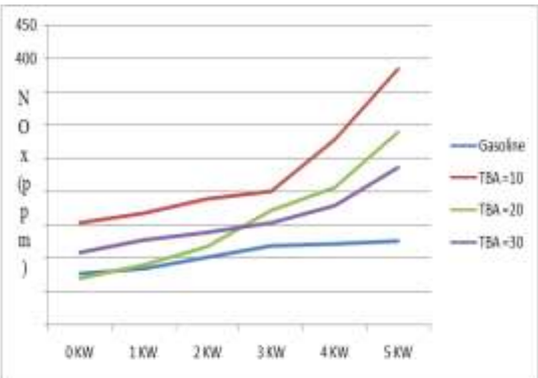

Figure 6: NOx Emission with varying load on Replacement Basis

VI. CONCLUSION

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.

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 and HC emission reduces with increase in oxygen contain when we consider blends of tert butyl alcohol, the emission for CO and HC is least for TBA30 almost at all operating conditions.CO and HC after complete combustion produces CO2 and water for HC, thus result of which show increased percentage of carbon dioxide. Also the carbon dioxide emission increases with increase in load as inverse to HC emission.

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