STUDY OF PERFORMANCE AND EMISSIONS OF ETHANOL BLENDS IN SI ENGINES

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BY

AMAN SHYAMSUKHA

1301021012

LAVANSHU AGRAWAL

1301021068

Under the guidance

Of

ABHISHEK VISHWAKARMA

(Assistant professor)

Department of Mechanical Engineering

JECRC University, Jaipur

Rajasthan, India, 302033

CERTIFICATE

This is to certify that the Project work titled "**Study of performance and emission of ethanol blends in SI engines**" that is being submitted by **Aman Shyamsukha** and **Lavanshu Agrawal** is in partial fulfillment of the requirements for the award of **Bachelors of Technology**, is a record of bona fide work done under our guidance. The contents of this mini Project work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

Prof. M.M.S. Sodhi

HOD

Mechanical Engineering Department

Abhishek Vishwakarma

Assistant professor

Mechanical Engineering Department

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Aman Shyamsukha
Lavanshu Agarwal

ABSTRACT

In SI engines the combustion process takes place inside the cylinder through the spark plug. Generally gasoline is used as fuel in SI engines and there is no oxygen in its chemical structure so combustion of fuel is not proper which results in increase in emissions. So, we have to go to the alternative fuel such as ethanol. Ethanol is produced from agricultural feed-stocks such as sugarcane, maize. It is a renewable fuel which has high octane number which increases the combustion rate of fuel which enhance performance and reduce emissions.

In this present study the effect of ethanol addition to gasoline on the performance and emission parameters of a Spark Ignition Engine is monitored. Study is done at constant load and varying in speed by blending ethanol with gasoline at 20% by volume in gasoline. Results shows that blending with 20% ethanol in gasoline leads to increase in Brake Thermal Efficiency, Brake Power, Indicated Power, Indicated Thermal Efficiency, Mechanical Efficiency with slight increase in BSFC and for emission parameters using 20% ethanol leads to decrease in CO and HC and NO_x emissions.

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CHAPTER 1

INTRODUCTION

1.1. HISTORY OF ETHANOL

The first use of ethanol to power an engine was in 1826 and 1876. Nicolaus Otto, the inventor of 4-cycle internal combustion engine, used ethanol to power an early engine. Ethanol was also used for lighting up the fuel in the 1850s, but its use shortened while it was taxed as alcohol to help pay for the Civil War. The blending of ethanol and gasoline for the first time for use as an octane promoter occurred in the 1920s and 1930s, and was in high ultimatum during World War II because of fuel unavailability.

Today's ethanol production initiated in the 1970s when petroleum-based fuel turn into expensive and environmental concerns comprising leaded gasoline formed a need for an octane. Corn turn into the major feedstock for ethanol production because of its large quantity and easiness of conversion into alcohol. Federal and state supports for ethanol helped to have the fuel in production when ethanol costs fell with crude oil and gasoline prices in the initial 1980s. The use of ethanol as an oxygen additive reduces carbon monoxide emissions, cheered to increased production of the fuel through the decade and into the 1990s.[1]

1.2. Bioethanol Production

From biological routes, bioethanol could be created on any biomass containing substantial amounts of sugar and starch. At the present time, there is a slight majority of production based on starchy resources (53% out of the total), such as corn, wheat, cereals and other grains. In such circumstances, transformation technology usually starts by splitting, cleaning and crushing the grains. Crushing may be wet, where grains are submerged and fractionated before the starch change into sugar (wet crushing process), or dry, when this is done during the transformation process (dry crushing process). In both circumstances starch is normally converted into sugars by means of an enzymatic process, applying higher temperatures. Sugars released are formerly yeast-agitated and the wine made is distilled and purified to form bioethanol. In addition to bioethanol, these methods typically involve numerous co-products, which vary according to the biomass used. [1]

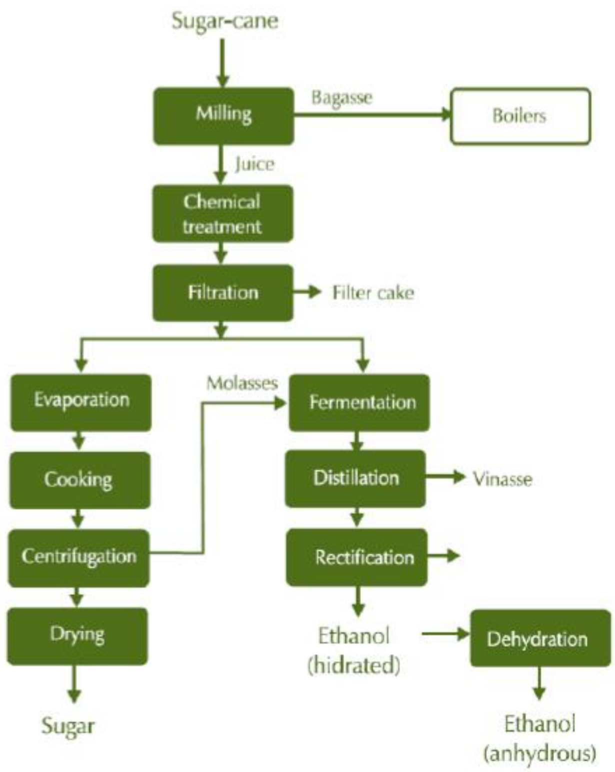

Fig.1.1 Flow chart of Sugar and Sugarcane bioethanol production. [1]

S.NO.	Countries	Production (tones)
1	Brazil	739,267
2	India	341,200
3	China	125,536

Table No.1.1 Sugarcane producing countries [2]

1.3. Ethanol (C_2H_5OH)

Ethanol is a renewable fuel which can be produced from agricultural feed – stocks for example sugarcane and likewise from wood waste of forest and agricultural remains. Ethanol can also be derived from ethylene or ethane chemically. It has a simple chemical structure with C, H and O atoms and along with definite physical and chemical properties. It can be employed for transport fuel even in its usual form and can also be simply blended with fuels for example gasoline and diesel. At present, there is a lot of curiosity in ethanol production from renewable feed – stocks, to decrease the emissions of carbon dioxide, a greenhouse gas which adds to global warming. [3]

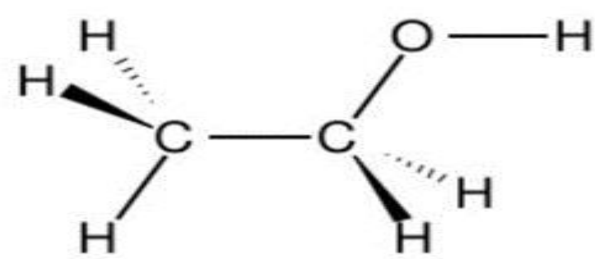

Fig.1.2 Structure of ethanol [3]

Ethanol contain greater anti – knock characteristics than gasoline. The thermal efficiency of an engine can be increased with the increase in compression ratio. Alcohol burns with lower flame temperature and luminosity owing to reducing the peak temperature inside the cylinder, as a result the heat loss and NO_x emissions are lower. Ethanol has high latent heat of vaporization**.** All transportation vehicles with SI and CI (compression ignition) engines are likewise responsible for the emitting various kinds of pollutants. Several of these are major kinds having direct dangerous effect such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x) etc., while others are minor pollutants such as ozone, etc., which go through a series of reactions in the atmosphere and become harmful to health. When ethanol is added to gasoline, it results in the improvement of the octane number of blended fuels and changes the distillation temperature, separately from decreasing the engine emissions. [3]

1.3.1 Ethanol used as a fuel

In spite of the fact that ethanol has been routinely considered as a refreshment item for utilization in brew, spirits, and wine, ethanol is an imperative, practical different option for unleaded gasoline fuel. Ethanol is utilized as a part of cars; it can likewise be utilized as a part of exceptionally composed engines, or mixed with gasoline and utilized with no engine alterations. It can likewise be utilized as a part of Motorboats, cruisers, lawnmowers, cutting tools and so forth these can all use the cleaner gasoline/ethanol fuel. In particular, the huge number of autos out and about today can utilize this enhanced fuel. Fuel ethanol what has been called "gasohol" - the most widely recognized mixes contain 10% ethanol blended with 90% gasoline (E10). Since ethanol is created from plants that bridle the force of the sun, ethanol is likewise viewed as a renewable fuel. Subsequently, ethanol has numerous points of interest as an automotive fuel. [4]

1.4. Advantages of ethanol as a fuel in environment

1.4.1. Carbon dioxide

The Carbon dioxide is produced from the burning of fossil fuels is the major solo source of greenhouse gases from human actions, demonstrating about half of greenhouse gas emissions. With use of 20% ethanol-blended fuels outcomes in a 8-12% CO_2 reduction and when using higher levels of ethanol can additional reduce the net amount of CO_2 emitted into the atmosphere. More CO_2 is fascinated by the growth of crop than is released by industries and using ethanol. The carbon dioxide which is formed through ethanol production and gasoline, combustion is extracted from the atmosphere by plants for starch and sugar formation during photosynthesis. It is integrated in the crop in its stalks, roots and leaves which typically return to the soil to sustain organic matter and the grain, the portion presently used to yield ethanol. [5]

1.4.2. Carbon Monoxide (CO)

The Carbon monoxide is formed, when there is incomplete combustion of fuel, and is created most readily from petroleum fuels, which contain no oxygen in their chemical structure. Since, ethanol and other oxygenated mixtures contain oxygen, their combustion in IC engines is more complete. It results in considerable decrease in carbon monoxide emissions. From the research it shows that reductions up to 30%, depending on type and age of automobile in which the automobile emission system used, and also from the atmospheric conditions in which the automobile operates. Since, the health concerns from the carbon monoxide, the 1990 amendments to the U.S. Clean Air Act ordered the use of oxygenated gasoline in many major town centers throughout the winter (when atmospheric carbon monoxide levels are highest) to reduce this pollution.[5]

1.4.3. Nitrous Oxide (N_2O)

Ethanol made from the agricultural feed-stocks may produce a small increase in nitrous oxide (N_2O) emissions causing from the use of heavy fertilizer. Though, various research and advances in agricultural technology, in production of grain are causing in a decrease of these emissions, repeatedly to levels below other common crops.[5]

1.5. Properties of ethanol blended with gasoline

Sample Code	Ethanol (%)	Gasoline (%)	Flash Point	Auto ignition temp.	Energy Density (MJ/L)	Octane Number	Specific gravity
E00	00	100	-65	246	34.2	91	0.7474
E20	20	80	-20	279	32	94	0.7605
E30	30	70	-15	281	31.5	95	0.7782

Table No.1.2. Properties of ethanol gasoline[6]

1.5.1. Comparison of physical properties of ethanol and gasoline

Fuel property	Gasoline	Ethanol
Auto ignition temperature	($536\text{-}853^{o}F$)	($793^{o}F$)
Latent heat	223.2	725.4
Octane No.	88-100	108.4
Density	765	785
Net LHV	43.5	29.7
Calorific value	43500	29700
Specific Gravity	0.72-0.79	0.79

Table No. 1.3. Physical properties of ethanol and gasoline [6]

1.5.2. Comparison of chemical properties of ethanol and gasoline:

Fuel property	Gasoline	Ethanol
Fuel	Flammable material	Flammable material
Fuel	Motor fuel	Motor fuel
Flash point	($-55^{o}F$)	($-5^{o}F$)
Boiling point	($100^{o}F$ & $400^{o}F$)	($173^{o}F$)

Table No. 1.4. Chemical Properties of ethanol and gasoline[6]

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Gasoline does not contain any oxygen in its atomic structure and when ethanol in gasoline is mixed extra oxygen is included which results in decrease of emissions. Because of higher no. of octane no. of ethanol it reduces knocking to the engine.

2.2 Alternate fuel

During 21st century, the products of petroleum becomes costly. Meanwhile, the number of vehicles and other internal combustion engine increase rapidly. Though fuel consumption of engines is greatly improve from the past, numbers of request for fuel is still high. There are various engines fueled with other than petrol or diesel fuel but they are few in number. To overcome this problem, various countries started using manufactured alcohol as their key automobile fuel. Additional reason for motivating the growth of substitute fuel for decrease of emissions from petrol and diesel engines. Collective with other air polluting systems, the large number of vehicle is a major supplier to the air quality problem of the world.[7]

2.2.1 Ethanol

Ethanol is otherwise called ethyl alcohol or grain alcohol. Ethyl ethanol is an alcohol produced from grain. Ethanol was initially used to expand gasoline supplies among the gasoline lack of the 1970s. Ethanol has an oxygen constituent of pretty nearly 35 percent, accordingly a 10 percent focus adds around 3.5 percent oxygen to blend. Like gasoline, ethanol contains hydrogen and carbon, yet ethanol likewise contains oxygen in its chemical structure. The expansion of oxygen makes for a cleaner flaming fuel than gasoline. Another advantage of ethanol is that it increases the octane rating of fuel. A 10 % ethanol blend will raised an 87 octane fuel by no less than 2.5 octane numbers. Then again, the alcohol added to the base gasoline moreover raised uncertainty of the fuel around 0.5 psi or 3.5 kPa. Most vehicles makers allow up to 10 % ethanol if drivability issues are not experienced.[8]

2.2.2 Gasohol

Gasohol is a combination of gasoline and ethanol. It is introduce in 1990s and mostly use in Brazil. It is usually a mixture of 10 % ethyl alcohol and 90 % unleaded gasoline. Ethyl alcohol is made from sugar, grain or other organic living material. It is believe that the use of gasoline and alcohol ease the demand of crude oil. Gasoline ethanol reduces the use of gasoline with not any modification needed to automobile engine.[8]

Various research papers are reviewed, some of them are discussed below:-

Hollembeakn et al. says that gasoline blended with 10% alcohol or less does not require changes to the fuel system. However, vehicles burning any amount of gasohol may require to change the fuel filter. This is due to the cleaning effect that alcohol has on the vehicle's fuel tank. Oxygenates suspend water in fuel and tend to keep it from accumulating in the gas tank. One gallon of gasoline can hold only 0.5 teaspoon of water. As a result, the water separates and accumulates at the bottom of the tank. [9]

Lan-bin Wen et al. investigated that additives which contain oxygen are usually used to improve gasoline's performance and reduce exhaust emissions. In this study, the effect of oxygen containing additives on gasoline blended fuels on exhaust emissions was investigated for different engine speeds in a single cylinder, 4-stroke, and spark-ignition engine. The results indicate that CO and HC exhaust emissions are lower when using with ethanol–gasoline and DMC (Di-Methyl Carbonate) –gasoline blended fuels as compared to the use of unleaded gasoline. On the other hand, the effect of ethanol-gasoline and DMC–gasoline blended fuels on NO_x exhaust emission is insignificant. Since by using lower heating value of additives may results to the higher fuel consumption. [10]

Govindarajan et al. investigates the effect of using unleaded gasoline and additives blends on 4-stroke, single cylinder SI engine to test the performance and exhaust emissions. Performance tests were conducted for brake power, engine torque and brake specific fuel consumption, fuel consumption, volumetric efficiency, brake thermal efficiency, while exhaust emissions were analyzed for carbon monoxide (CO), Hydrocarbon (HC), and Oxides of nitrogen (NO_x) using unleaded gasoline and additives blends with different percentages of fuel when varying of engine speed and at constant speed. The result revealed that blending unleaded gasoline with additives increases the brake power, volumetric and brake thermal efficiencies and fuel consumption. The CO and HC emissions concentrations in the engine exhaust decreases while the NOx concentration increases. When adding of 5% isobutanol and 10% ethanol to gasoline gave the best results for all measured parameters at all engine torque values.[11]

Kumar et al. In this study gasoline is blended with gasoline. Physical properties relevant to the fuel were determined for the 4 blends of gasoline and ethanol. A 4-cylinder, 4- stroke, Petrol engine connected with eddy current type dynamometer was run on blends containing 5%, 10%, 15%, 20% ethanol and performance characteristics were investigated. In this paper it is shown that the higher blends can remove gasoline in a Spark Ignition (SI) Engine, results showed that exhaust gases are reduced and increase in Mechanical efficiency, Brake Specific Fuel Consumption (BSFC) and air fuel ratio on blending. From result we have concluded that using 20% ethanol blend is most effective and we can employ it for further use in SI engines.[12]

Shrivastava et al. investigated on performance of 2- stroke single cylinder spark ignition engine with ratio of 10% 20% and 30%by volume of ethanol in gasoline. Performance parameters like brake power, brake thermal efficiency, brake specific energy consumption and brake specific fuel consumption were determined when blended with ethanol gasoline at different loads. The comparison was made on performance of conventional SI engine with pure gasoline operation. Experiment shows that brake power, brake thermal efficiency, brake specific fuel consumption and brake specific fuel consumption showed comparable performance when compared with pure gasoline performances.[13]

2.3. LITERATURE GAP

From above literature review it is investigated that by using 20% ethanol gasoline blends it shows better performance and emission characteristics. Presently, very less work is done on second generation fuel which is iso-butanol. The ongoing researches show that it displays the best engine performances as compared to the other mixtures.

CHAPTER 3

DISCUSSION

Ethanol is oxygen additives, and they are blended with gasoline and performance characteristics and emissions are known.

3.1. Performance Parameters

Performance characteristics include variation of Brake Power (BP), brake specific fuel consumption (bsfc), mechanical efficiency, Brake Thermal Efficiency, Indicated Power, Indicated Thermal Efficiency, Volumetric Efficiency of SI engine running with pure gasoline and ethanol gasoline.

3.1.1. Performance characteristics curves at constant load with variation in speed.

3.1.1.1. Brake Power

Fig shows the variation of brake power at constant load at 4kg with variation in speed from 1500 rpm to 3500 rpm with step size 500 rpm.

Brake Power is increased when engine speed is increased. For maximum time brake power for ethanol gasoline is higher than that of pure gasoline for all engine speeds. As the ethanol content in the blend increases, the power increases slightly for all speeds because of ethanol has higher heat of vaporization, which provides cooling of the air fuel charge, hence the density increases, thus more fuel can be used, and power increases.

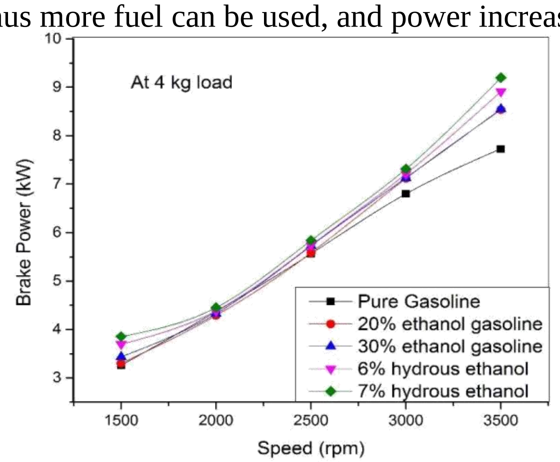

Fig.3.1. Variation of Brake Power at constant load with variation in speed[14]

3.1.1.2. Brake Specific fuel Consumption (BSFC)

Fig. shows variation of brake specific fuel consumption at 4kg load with variation in engine speed varies from 1500 to 3500 rpm with step size of 200 rpm.

From the graphs BSFC is found higher at lower engine speed due to increased time for heat transfer from the working fluid to the cylinder walls.

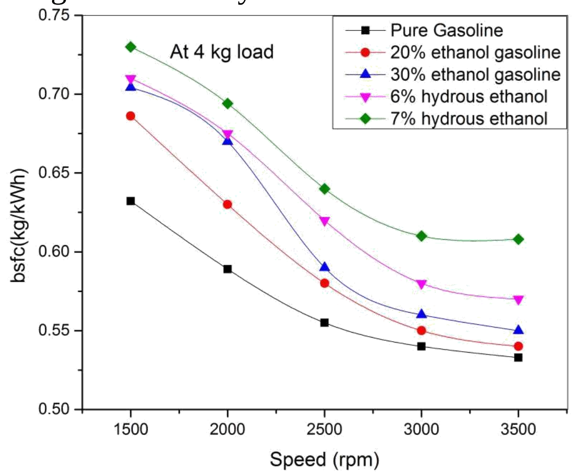

Fig.3.2. Variation of BSFC at constant load with variation in speed[14]

3.1.1.3. Brake Thermal Efficiency:

Shows the variation of brake thermal efficiency at constant load at 4kg with variation in speed from 1500 rpm to 3500 rpm with step size of 500 rpm. Since, Break Thermal Efficiency is inversely proportional to BSFC (break specific fuel consumption) and since the value of BSFC is decreasing with speed hence, Break Thermal Efficiency increases.

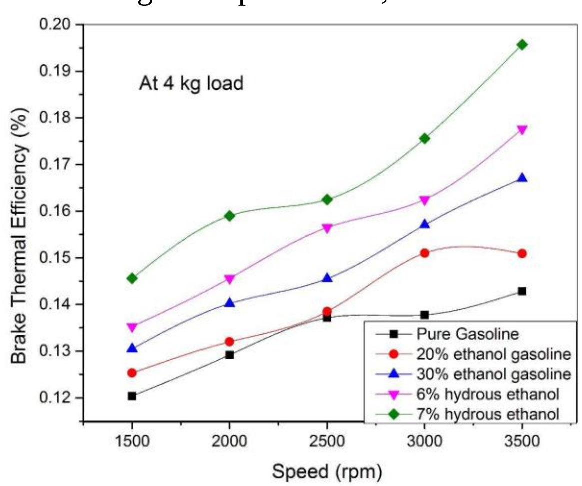

Fig.3.3 Variation of Brake Thermal Efficiency at constant load with variation in speed.[14]

3.1.1.4. Volumetric Efficiency

Volumetric Efficiency is due to decrease of the charge temperature at the end of the induction process and the increase of the amount of air introduced in the engine cylinder. This decrease in charge temperature is attributed by an amount as a result of the heat transfer from hot engine parts and the residual gases in the charge. Since the consumption of fuel is increased for higher speeds thus, more amount of air is also required. Hence, the volumetric efficiency is increased for higher speeds.

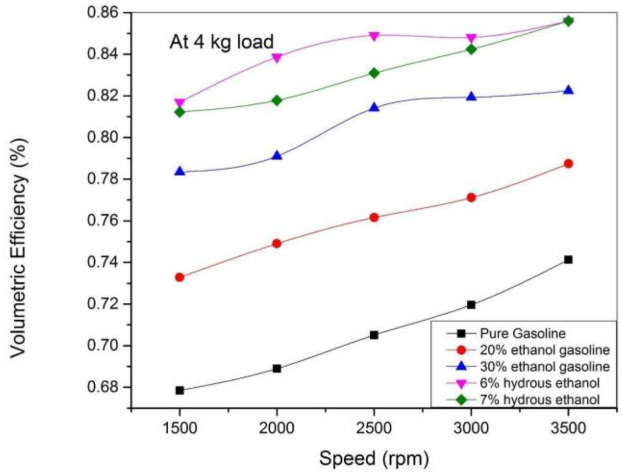

Fig.3.4. Variation of Volumetric Efficiency at constant load with variation in speed[14]

3.1.1.5. Indicated Power

Indicated Power increases always because friction losses increase with speed and become dominant at higher speeds. From graph we have find that for 20% ethanol shows higher Indicated Power as compared to pure gasoline.

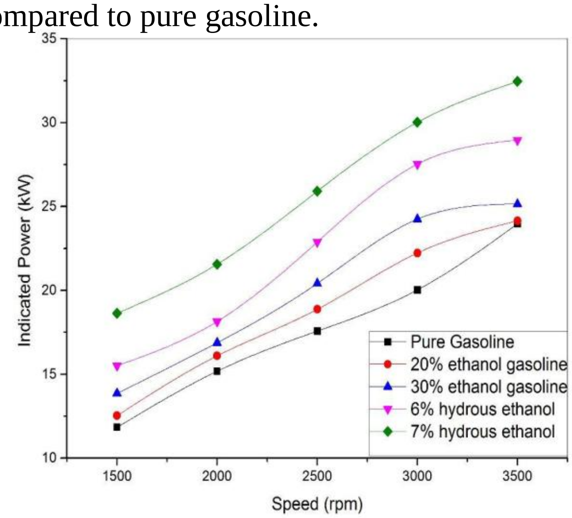

Fig. 3.5. Variation of Indicated Power with Speed[14]

3.1.1.6. Indicated Thermal Efficiency

Indicated Thermal Efficiency increases with increase in Indicated Power as the engine speed increases.

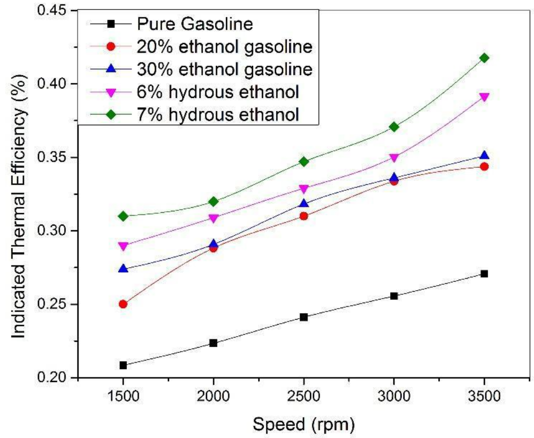

Fig.3.6 Variation of Indicated Thermal Efficiency with speed.[14]

3.1.1.7. Mechanical Efficiency

Mechanical efficiency usually lies between 80 to 90%. It can also be defined as ratio of brake thermal efficiency to indicated thermal efficiency. From graph we have found that at 20% ethanol shows better mechanical efficiency as compared to the pure gasoline.

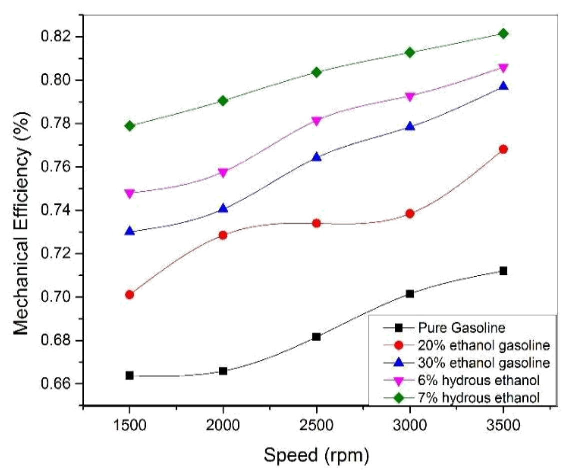

Fig.3.7. Variation of Mechanical Efficiency with speed[14]

3.2. Exhaust emission characteristics

Emission characteristics include variation of carbon monoxide (CO) emission, Nitrogen Oxide (NO_x) emission and hydrocarbon (HC) emission from the exhaust of SI engine running on pure gasoline and Ethanol gasoline.

3.2.1. Emission characteristics curves at constant load with variation in speed

3.2.1.1. Carbon Monoxide (CO) emission

Fig. show variation of carbon monoxide (CO) emission at constant load of 4 kg with variation inn engine speed from 1500 to 3500 rpm with step size of 500 rpm. CO emission characteristics increases with an increase in speed due to incomplete and late burning at high speeds. Ethanol gasoline relatively lower CO emission as compared to gasoline. Since in ethanol oxygen is present which promotes combustion and convert CO into CO_2.Thus for ethanol at 20% shows lower CO emission as compared to pure gasoline.

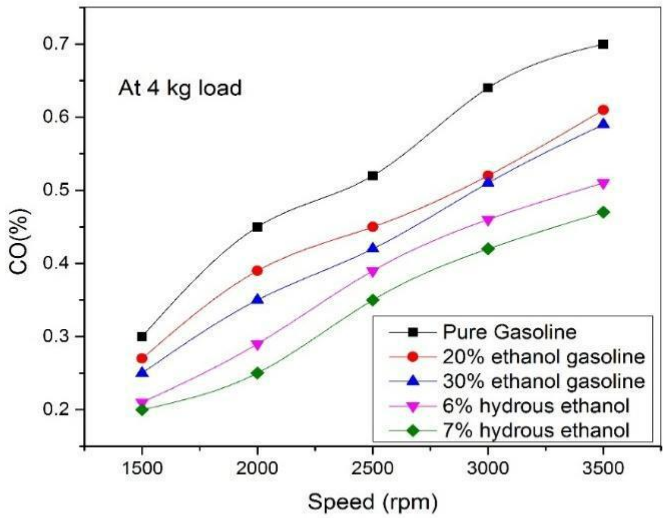

Fig.3.8. Variation of CO emission at constant load with variation in speed[15]

3.2.1.2. NO_x (Nitrogen Oxide)

Major factor contributing to NOx emissions include high flame temperature and presence of oxygen during combustion. Due to much lower flame temperature the ethanol contributes its NOx emissions are usually lower than that of gasoline. Shows the variation of Nitrogen oxide (NO_x) emission at constant load of 4kg with variation in engine speed from 1500 to 3500rpm with step size of 500 rpm. From the graph we have find that for 20% ethanol shows lower NO_x emissions as compared to pure gasoline.

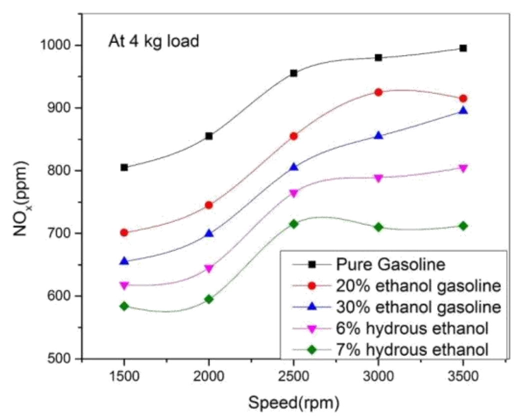

Fig.3.9.NO_x emission variation with speed at constant load.[15]

CHAPTER 4

CONCLUSION

The aim is to study the experimental investigation of performance and emissions of ethanol and gasoline mixture in SI engine. By doing experiment following results were found and conclusions were summarized as follows.

- From study, the performance characteristics of ethanol gasoline are comparatively improved with respect to pure gasoline.

- For all, 20% ethanol at constant load with variation in speed it shows higher break power as compared to pure gasoline.

- Brake specific fuel consumption (BSFC) for 20% ethanol at constant load and variation in speed shows higher value as compared to pure gasoline.

- Indicated Power at 20% ethanol shows higher value as compared to pure gasoline.

- Break Thermal efficiency, Indicated thermal efficiency, Mechanical efficiency, and volumetric efficiency for 20% ethanol blends shows higher value as compare to pure gasoline.

- Using 20% ethanol to gasoline leads to a significant reduction in exhaust emissions like CO and HC emissions and NOx emissions.

CHAPTER 5

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