Ethanol, a promising alternative fuel for S. I. Engine: A review

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Abstract— **Ethanol has the potential to be used as S. I. engine fuel as it improve engine efficiency and reduce harmful emissions when used as fuel in a spark-ignition engine. Ethanol is mostly supplied in a splash-blended form with gasoline. This study investigate ethanol as an S. I. engine fuel and the effect of using ethanol blended gasoline as fuel on engine performance and emission characteristics. Petroleum products with the current consumption rate will be depleting in upcoming decades. Ethanol usage in the transport sector can fulfill the requirement, hence it is better to develop the engine which can work on pure ethanol or add ethanol in the petrol and use blends of that. This paper's aim was to study the effect of ethanol/and blends on Spark Ignition (SI) engine behavior. This study concludes that ethanol blending is lowering exhaust emissions with considerable improvement in the performance of the SI engine and also promising as a future fuel which can successfully replace petrol and its depletion problem.**

Keywords: SI Engine, Emission, Ethanol, Blend, Performance parameter, Alternative Fuel

I. INTRODUCTION

Using renewable energy resources has become an important feature of worldwide energy policy which aims to reduce greenhouse gas emissions caused by fossil fuel usage. Alternative transport fuels such as hydrogen, natural gas and biofuels are seen as an option to help the transport sector in decreasing its dependency on oil and reducing its environmental impact.

Ethanol (ethyl alcohol) addition to gasoline results changes to the properties of the fuel and hence affects the vehicle performance in many ways. This includes exhaust and evaporative emissions, fuel economy, full load performance (power) and durability. The changes in fuel composition affects these vehicle performance qualities a purely dependent on the individual vehicle. It will depend on engine design, fuel and control system and also emissions control equipment.

In parallel with the growing world populations, industries, vehicles, and equipment these needs lead to a rise in the demand for energy. It is known that there are a limited amount of fossil-based fuels as a sustainable energy source. During both the periods of the production of these fuels and the use of them, the negative impact on the environment is an important factor and cannot be ignored. So because of these two factors, researchers are focusing on renewable and clean energy sources. Considering the current global economic crisis, the interest in alternative fuels is extremely high. Separately, one of the goals of researchers is the development of high efficiency and clean engines.

Alcohol fuels such as methanol, and ethanol etc. have been appearing as good nominees as alternative fuels for the vehicles equipped with the SI (spark ignition) engines because they are fluid and have several physical and combustion properties similar to gasoline. Besides these facts, ethanol and methanol are produced by fermenting and distilling starch crops, such as corn, sugar etc. It also can be produced from natural gas, gasification of coal, wood, straw, plant stalks, garbage, most biomass, and even combustible trash.

II. FUEL ETHANOL

Ethanol is used as an automotive fuel by itself and can be mixed with gasoline to form what has been called "gasohol". Because the ethanol molecule contains oxygen, it allows the engine to more completely combust the fuel, resulting in fewer emissions. Since ethanol is produced from plants that harness the power of the sun, ethanol is also considered a renewable fuel. Therefore, ethanol has many advantages as an automotive fuel.

a. Ethanol Properties
b. Ethanol Production
c. India`s Potential and necessity to use fuel ethanol

a. Ethanol Properties: Ethanol (ethyl alcohol, grain alcohol, ETOH) is a clear, colorless liquid with a characteristic, agreeable odour. In dilute aqueous solution, it has a somewhat sweet flavour, but in more concentrated solutions it has a burning taste. Ethanol, CH_3CH_2OH, is an alcohol, a group of chemical compounds whose molecules contain a hydroxyl group, -OH, bonded to a carbon atom. Ethanol melts at -114.1°C, boils at 78.5°C, and has a density of 0.789 g/mL at 20°C. [9]

Table 1 Property Comparison of Gasoline and Bioethanol: [10]

Fuel Properties	Gasoline	Bioethanol
Molecular weight [kg/kmol]	111	46
Density [kg/l] at 15°C	0.75	0.80-0.82
Oxygen content [wt-%]	0	34.8
Lower Calorific Value [MJ/kg] at 15ºC	41.3	26.4
Lower Calorific Value [MJ/l] at 15ºC	31	21.2
Octane number (RON)	97	109
Octane number (MON)	86	92
Cetane number	8	11
Stoichiometric AFR [kg air/kg fuel]	14.7	9.0
Boiling temperature [ºC]	30-190	78
Reid Vapour Pressure [kPa] at 15ºC	75	16.5

Energy content: Bioethanol has much lower energy content than gasoline (about two-third of the energy content of gasoline on a volume base)

Octane number: Octane number of ethanol is higher than that for petrol; hence ethanol has better antiknock characteristics. This increases the fuel efficiency of the engine. The oxygen content of ethanol also leads to a higher efficiency, which results in a cleaner combustion process at relatively low temperatures.

Reid vapour pressure (measure for the volatility of a fuel): Very low for ethanol indicates a slow evaporation, which has the advantage that the concentration of evaporative emissions in the air remains relatively low. This reduces the risk of explosions. However, the low vapour pressure of ethanol, together with its single boiling point, is disadvantageous with regard to engine start at low ambient temperatures. Without aids, engines using ethanol cannot be started at temperatures below 20ºC. Cold start difficulties are the most important problem with regard to the application of alcohols as automotive fuels.

Ethanol has a higher octane number, oxygen ratio, flammability limit, low carbon to hydrogen ratio, and is considered to be a renewable fuel. The engine needs only to be slightly modified to use it. Therefore, with this new modification and fuel source, ethanol could use a higher CR (compression ratio) without knock and could produce lower emissions than gasoline. Ethanol also has a high heat vaporization rate, which cools the air entering into the engine and increases the volumetric efficiency and power output. However, they have negative effects such as in cold starting, and a lower latent heating value. Researchers have made many studies concerning the use of alcohol fuels in a pure state or mixing it with gasoline in SI engines. According to the studied research papers, it can be concluded that with the ethanol fuel, while the engine power and the emissions of CO, CO2 and NOx had decreased, BTE (brake thermal efficiency) and UHC (unburned hydrocarbon) emission increased. They showed that the torque and BSFC of engines increased slightly when using blended fuels, and that the CO and UHC emissions decreased due to the lean effect in the mixture caused by the ethanol.

III. Ethanol Production & Cost: Ethanol has been made since ancient times by the fermentation of sugars. All beverage ethanol and more than half of industrial ethanol is still made by this process. Simple sugars are the raw material. Zymase, an enzyme from yeast, changes the simple sugars into ethanol and carbon dioxide. Starches from potatoes, corn, wheat, and other plants can also be used in the production of ethanol by fermentation.

Ethanol is commercially produced using either a wet mill or dry mill process.

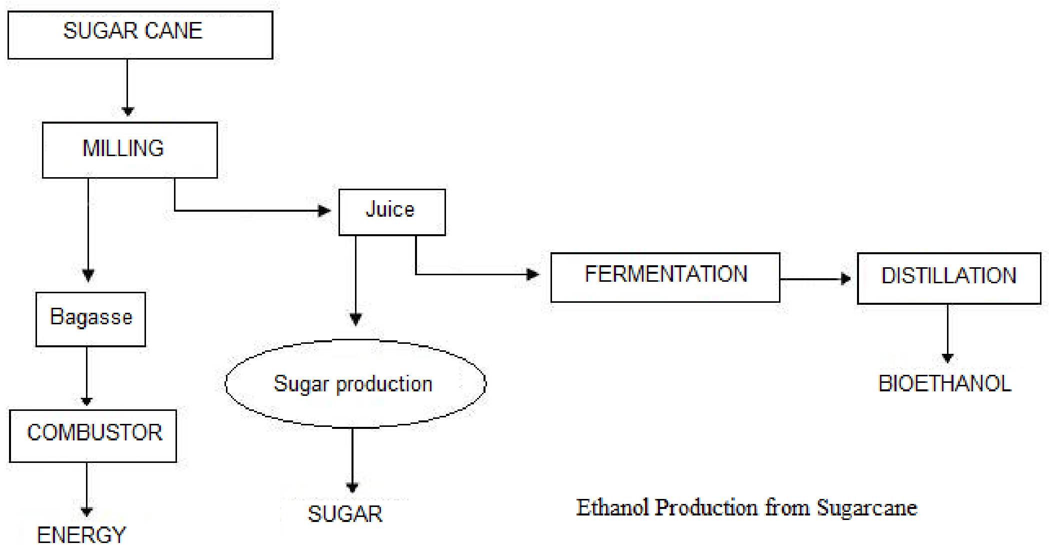

Figure 1: Ethanol Production from Sugar cane [11]

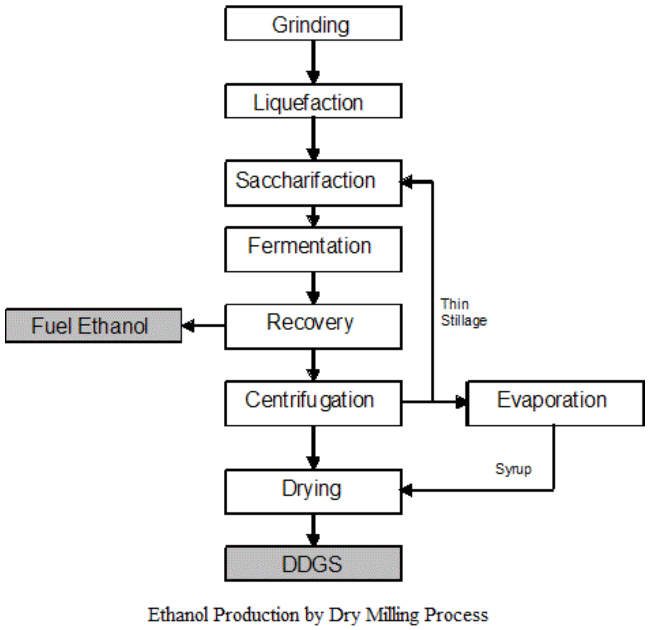

Figure 2: Ethanol Production by Dry Milling Process [12]

DDGS: Distiller's Dried Grains and Soluble
Grain Receiving: Grain is delivered by truck or rail to the ethanol plant where it's loaded in storage bins designed to hold enough grain to supply the plant for 7–10 days.
Milling: The grain is screened to remove debris, then milled into ground material to allow water and enzymes to contact and to react with starch in the ground material.
Slurry Tanks: In slurry tanks, the ground material is mixed with recycled water and enzymes. The contact and reaction of these components cause starch gelatinization.
Primary Liquefaction: In liquefaction tanks, the process hydrolyzes the gelatinized starch into glucose to produce mash.
Simultaneous Saccharification Fermentation: The glucoamylase enzyme breaks down the dextrins to form simple sugars. Yeast is added to convert the sugar to ethanol and carbon dioxide. The mash is then allowed to ferment for 50–60 hours, resulting in a mixture that contains about 15% ethanol as well as the solids from the grain and added yeast.
Distillation: The fermented mash is pumped into a multi-column distillation system where additional heat is added. The columns utilize the differences in the boiling points of ethanol and water to boil off and separate the ethanol. By the time the product stream is ready to leave the distillation columns, it contains about 95% ethanol by volume (190-proof). The residue from this process, called stillage, contains non-fermentable solids and water and is pumped out from the bottom of the columns into the centrifuges.
Denaturant: Before the ethanol is sent to the storage tanks, a small amount of denaturant is added, making it unfit for human consumption. Generally 2 to 5% gasoline is added as denaturant.

	Quantity	Rate Rs/l	Cost Rs/l
Molasses Cost (5kg)			15.22
Steam kg	3.1	0.5	1.55
Power kwh	0.15	4.5	0.68
Chemicals litres	0.002	128	0.26
Labour			0.25
Repair and Maintenance		0.05	0.67
Cost of replacement of molecular sieve			0.04
Manufacturing overheads		0.1	1.91
Depreciation		0.1	1.33
Administrative overheads		0.05	1.12
Interest on borrowed capital (debt/equity ratio 1:5:1)		0.135	1.08
Interest on working capital		0.135	0.81
Total cost of production			24.92
Selling and distribution overheads		0.05	1.27
Total			26.19
cost of conversion			9.70

Source: All India Distillers Association (personal communication 2009)
Table 2: Ethanol Production Costs:

IV. India`s Potential and necessity to use fuel ethanol: With a view to give boost to agriculture sector and reduce environmental pollution, Government of India have been examining for quite some time supply of ethanol-doped-petrol in the country. The main reason for blending ethanol with gasoline is to reduce fossil carbon dioxide emissions (and thus the greenhouse effect) from vehicles by using bio-ethanol originating from renewable sources. Blending bio fuels with a petroleum-based fuel has the twin advantages that even relatively small percentage additions will result in a substantial total volume of gasoline substitution, and the present infrastructure for distributing fuels can be used largely unchanged. India, is currently the fourth largest greenhouse gas (GHG) emitter, the fifth largest energy consumer and the second most populous country in the world. [8] Naturally, there is an increase in energy demand every year. India will need to import huge amounts of energy from other countries in order to meet its energy demands. Although India's per capita emissions are less than half the world's average, in 2010, its transport sector accounted for 13 percent of the country's energy-related carbon-dioxide emissions. Hence, India needs to find sustainable energy generation sources to meet its demands thereby providing a good market for biofuels. [8] In the year 2010-2011, the agricultural residues available for energy applications was 187 megatons (Mt) which were used to produce 50 billion liters ethanol and the net residue availability in 2020-2030 for biofuel production is estimated at 209 Mt which would yield 65 billion liters annually. [8] The recent World Energy Outlook (WEO) report of the International Energy Agency (IEA) projects that India's primary energy demand will increase from 750 Mt to 1200-1600 Mt (the range is defined by WEO 450 Scenario and Current Policies Scenarios) between 2010-2035 (IEA, 2013), it will likely double over these years. [8] The biofuel policy of India has an indicative target of 20 percent blending of bioethanol by 2017. India has 330 distilleries, which can produce more than 4 billion liters of rectified spirit (alcohol) per year in addition to 1.5 billion liters of fuel ethanol which could and should meet the requirement of 5% blending. [8] The Society for Indian Automobile Manufacturers (SIAM) has confirmed the acceptance for use of 5% ethanol-doped-petrol in vehicles. State Governments of major sugar producing States and the representatives of sugar/distillery industries have confirmed availability / capacity to produce ethanol. In 2008 India imported 128.15 million metric tons of crude, constituting 75% of its total petroleum consumption for that year. By 2025 it will be importing 90% of its petroleum consumption (UNESCAP 2009).[8] In an effort to increase its energy security and independence, the Government of India in October of 2007 set a 20% ethanol blend target for gasoline fuel to be met by 2017. [8] In India, the vast majority of ethanol is produced from sugarcane molasses, a by-product of sugar. In the future it may also be produced directly from sugarcane juice.

V. Literature Review:

Number of research papers have been studied to collect information about SI engine behavior when fuelled with ethanol blended gasoline. Important reviews has been taken below to complete the present study.

Namho Kim, Seokwon Cho et al. in their research on "A study on the combustion and emission characteristics of an SI engine under full load conditions with ethanol port injection and gasoline direct injection" investigated the effect of ethanol port fuel injection and gasoline direct injection systems on engine combustion and emission characteristics under full load conditions. The experiment was conducted using two different compression ratios and various ethanol injection timings. In their study, the effects of a ethanol port fuel injection and gasoline direct injection system on the combustion and emission characteristics under full load conditions were observed under two different CR's and various ethanol injection timings. From the experimental results they summarized that as the value CR is increases the amount of CO and THC emissions were lower than those measured under lower CR. Also As the injection timing of the ethanol was retarded, the peak of the size spectra rose and shifted to the larger size. It is thought that a decrease in mixture formation time for ethanol led to less homogeneous mixture, resulting in increased particulate number. [1]

Lan Li , Yunshan Ge et al. in their research "Exhaust and evaporative emissions from motorcycles fuelled with ethanol gasoline blends" investigated the emission characteristics of motorcycles using gasoline and E10 (90% gasoline and 10% ethanol by volume). In their research Exhaust and evaporative emissions of three motorcycles were investigated on the chassis dynamometer over the Urban Driving Cycle (UDC) and in the Sealed Housing for Evaporative Determination (SHED) including regulated and unregulated emissions. The regulated emissions were detected by an exhaust gas analyzer directly. The unregulated emissions including carbonyls and volatile organic compounds (VOCs) were sampled through battery-operated air pumps using tubes coated with 2,4-dinitrophenylhydrazine (DNPH) and Tenax TA, respectively. The experimental results showed that the emission factors of total hydrocarbons (THC) and carbon monoxide (CO) from E10 fuelling motorcycles decreased by 26%–45% and 63%–73%, while the emission factor of NOx increased by 36%–54% compared with those from gasoline fuelling motorcycles. For unregulated emissions, the emission amount of VOCs from motorcycles fuelled with E10 decreased by 18%–31% while total carbonyls were 2.6–4.5 times higher than those for gasoline. For evaporative emissions of THC and VOCs, for gasoline or E10, the diurnal breathing loss (DBL) was higher than hot soak loss (HSL). Using E10 as a fuel does not make much difference in the amount of evaporative THC, while resulted in a slightly growth of 14%–17% for evaporative BETX (benzene, toluene, ethyl benzene, xylene). [2]

Talal Yusaf, David Buttsworth et al. in their research on "Theoretical and experimental investigation of SI engine performance and exhaust emissions using ethanol-gasoline blended fuels" investigated the pollutant emissions and performance of a four stroke SI engine operating on ethanol-gasoline blends. In the theoretical study, a quasi- dimensional SI engine cycle model has been adapted for spark ignition engines running on gasoline-ethanol blends. A mathematical model using Matlab software was developed using the first law of thermodynamics and conservation equations to predict the SI engine performance for different blend ratios. The model was also used to evaluate the engine emissions. Experiments were performed with the blends containing 5, 10, 15 and 20 vol% ethanol. The results show that increasing ethanol-gasoline blended will marginally increase the power and torque output of the engine. For ethanol blends it was found that the brake specific fuel consumption (BSFC) was decreased using 5% and 10% ethanol while the brake thermal efficiency and the volumetric efficiency were increased. [3] Exhaust gas emissions were measured and analyzed for unburned hydrocarbons (UHC), carbon dioxide (CO2), carbon monoxide (CO), Oxygen (O2) and Oxide of Nitrogen NOx at engine speeds ranging from 1000 to 5000 rpm. The concentration of CO and UHC emissions in the exhaust pipe were found to be decreased when ethanol blends were introduced. The concentration of CO2 and NOx was found to be increased when ethanol is introduced. [3] Results obtained from both theoretical and experimental studies were compared. The simulation results have been validated against data from experiments and it results to a good agreement between the trends in the predicted and experimental results. They concluded after their experiment that adding ethanol to gasoline will lead to a leaner better combustion. It was experimentally demonstrated that adding 5-15% ethanol to the blends led to an increase in the engine brake power, torque and brake thermal efficiency, volumetric efficiency and decreases the brake specific fuel consumption. [3] The lean combustion improves the completeness of combustion and therefore the CO emission is expected to be decreased. The oxygen enrichment generated from ethanol increased the oxygen ratio in the charge and lead to lean combustion. The CO2 emission increased because of the improvement of the combustion and the chemical properties of Ethanol. Unburned HC is a product of incomplete combustion which is related to A/F ratio. It can be concluded that that adding ethanol to the blends will reduces the HC emission because of oxygen enhancement. When the combustion process is closer to stoichiometric, flame temperature increases, therefore, NOx formation is expected to be increased. [3]

Mustafa Kemal Balki, Cenk Sayin in their research on "The effect of compression ratio on the performance, emissions and combustion of an SI (spark ignition) engine fuelled with pure ethanol, methanol and unleaded gasoline" investigated the effect of CR (compression ratio) on a SI (spark ignition) engine's characteristics of performance, combustion and emissions by using pure ethanol, methanol and unleaded gasoline. In their experiments, an SI engine having a CR of 8.5:1, having a single cylinder and air-cooled was used. These tests were conducted on four different CRs of 8.0:1, 8.5:1, 9.0:1 and 9.5:1 with a wide-open throttle, original ignition timing and at 2400 rpm. [4] The test results obtained from the three fuel types were compared to each other. The results were shown that the BMEP (brake mean effective pressure), CGP (cylinder gas pressure), BTE (brake thermal efficiency), and BSFC (brake specific fuel consumption) obtained with the use of ethanol and methanol at all CRs were generally increased when they were compared to those of pure gasoline. In general, pure ethanol and methanol provided a lower exhaust emission compared to gasoline's emissions at all CRs. Furthermore, with an increasing CR, the CGP generally increased with the usage of pure ethanol and methanol as compared to unleaded gasoline's study and the CGP and HRR (heat release rate) rose earlier than those values in unleaded gasoline. They concluded that BMEP, BTE, and volumetric efficiency with pure ethanol and methanol were found to be higher than that of unleaded gasoline at all CRs. Also they found that, the BSFC was generally increased with the use of pure ethanol and methanol as compared to unleaded gasoline. However, with an increase of CRs from 8.0:1 to 9.5:1 of the CR, the BSFC began to decline. [4] According to the obtained results from unleaded gasoline at an original CR of 8.5:1, with the usage of pure ethanol and methanol, it was seen that the BMEP had increased to about 5.25% with ethanol and 10.5% with methanol; the BTE rose to about 3.65% with ethanol and 4.51% with methanol; and the BSFC had increased to about 58.9% with ethanol and 30.22% with methanol. [4] Furthermore, with the usage of methanol as compared to ethanol, it was observed that while the maximum values of the BMEP and the BTE increased to 4.99% and 0.84%, respectively, the minimum value of BSFC rose about 33.39%. [4] While the emission values of UHC, CO and NOx decreased by using pure ethanol and methanol instead of unleaded gasoline fuel at all CRs, the CO_2 emission values decreased at the CR of 9.0:1 and then it began to peak up again. [4] The obtained exhaust emission results from unleaded gasoline at the original CR, it was a reduction of the minimum values of the UHC emissions that were obtained from pure ethanol and methanol. They were about 29.01% and 40.12%, respectively, at a CR of 8.5:1. At the same time, the CO emission was about 34.65% and 44.88% for pure ethanol and methanol, but the CO2 emission had increased to about 1.46% with ethanol and to about 2.19% with methanol at the CR of 9.0:1. Meanwhile, the maximum values of NOx emissions had decreased to about 18.1% with ethanol and to about 22.97% with methanol. [4]

Gholamhassan Najafi, Talal Yusaf et al in their research on "Optimization of performance and exhaust emission parameters of a SI (spark ignition) engine with gasoline ethanol blended fuels using response surface methodology" investigated the use of RSM (Response Surface Methodology) to optimize the performance parameters and exhaust emissions of a SI (spark ignition) engine which operates with ethanol gasoline blends of 5%, 7.5%, 10%, 12.5% and 15% called E5, E7.5, E10, E12.5 and E15. [5] In the experiments, the engine ran at various speeds for each test fuel and 45 different conditions were constructed. In comparison with gasoline fuel, the brake power, engine torque, increased using ethanol blends, and the BSFC (brake specific fuel consumption) decreased as well. Moreover, the concentration of CO and HC in the exhaust pipe decreased by introducing ethanol blends, but CO_2 and NOx emissions increased. Optimization of independent variables was performed using the desirability approach of the RSM (Response Surface Methodology) with the goal of minimizing emissions and maximizing of performance parameters. The experiments were designed using a statistical tool known as DoE (design of experiments) based on RSM. Engine-operating parameters were optimized using the Desirability approach of RSM. The performance parameters for different biofuel gasoline blends were found close to gasoline, and emission characteristics of the engine improved significantly. An engine speed of 3000 rpm and a blend of 10% bio-ethanol and 90% gasoline (E10) were found to be optimal values. The results of this study revealed that at optimal input parameters, the values of the brake power, Torque, BSFC, and CO, CO2, HC, NOx were found to be 35.26 (kW), 103.66 (Nm), 0.25 (kg/kW hr), 3.5 (%Vol.), 12.8 (%Vol.), 136.6 (ppm) and 1300 (ppm) respectively. [5]

Hui Liu, Zhi Wang et al in their research on "Dual-Fuel Spark Ignition (DFSI) combustion fuelled with different alcohols and gasoline for fuel efficiency" investigated experimentally Alcohols–gasoline Dual-Fuel Spark Ignition (DFSI) Combustion for knock suppression and high fuel efficiency using a gasoline engine with high compression ratio. Alcohols–gasoline DFSI is organized using a port-fuel injection (PFI) of high oxygenated, high latent heat and high octane number fuel to suppress knock and a direct injection (DI) of high energy density and high volatility fuel to extend high load. Systematical comparison about the effect of stoichiometric M–G (PFI-Methanol and DI-Gasoline), E–G (PFI-Ethanol and DI- Gasoline), E85W15–G (PFI-15% water and 85% ethanol and DI-Gasoline) and G–G (PFI-Gasoline and DI- Gasoline) DFSI on engine knock suppression was conducted. For each test, the percentage of PFI-Alcohol was varied from 0% to 100%. [6] The effects of these combustion modes on knock-limit extension, fuel economy, and combustion characteristics were investigated. Alcohols–gasoline DFSI is a potential approach of using alternative alcohol fuels in practical gasoline engines with significant improvement in engine efficiency and knock suppression. [6] M–G DFSI exhibits better anti-knock performance and achieves higher fuel efficiency than other combustion modes. From their experiment, they concluded that that Alcohols–gasoline DFSI under stoichiometric condition could extend the knock-limit effectively while the fuel economy is improved dramatically. [6] M–G DFSI presents better anti-knock performance and achieves higher fuel efficiency than other combustion modes. [6]

Yuan Zhuang, Guang Hong in their research on "Effects of direct injection timing of ethanol fuel on engine knock and lean burn in a port injection gasoline engine" investigated the effect of ethanol fuel SOI (start of injection) timing on knock mitigation and lean burn. Experiments were conducted on a 250 cc single cylinder spark ignition (SI) engine equipped with EDI + GPI system. Ethanol fuel SOI timing before and after the inlet valve closing, defined as early and late injection timings (EEDI and LEDI) were investigated in engine conditions at knock limited spark advance (KLSA) and lean burn limit. The experimental results showed that LEDI was effective on suppressing engine knock and permitting more advanced spark timing. EEDI was less effective than LEDI on mitigating knock due to the increased heat transfer from cylinder wall to gases. The mixture quality may be deteriorated in LEDI conditions which resulted in low engine efficiency and high emissions. Volumetric efficiency was increased and combustion duration was reduced in EEDI conditions. [7] The combined effects of improved volumetric efficiency, reduced combustion duration and moderately advanced spark timing resulted in increased engine thermal efficiency in EEDI conditions. In lean burn, EEDI was more effective on extending lean burn limit. [7] The maximum lambda achieved in EEDI condition was 1.29 when ethanol energy ratio (EER) was 24% and SOI timing was 29^0 BTDC (before top dead center). [7] LEDI only slightly increased lean burn limit which was just over stoichiometric air–fuel ratio (AFR). [7]

VI. Summary & Conclusion:

The purpose of the study is to collect information on national and international findings and experience related to the use of blends of ethanol in gasoline as fuels in spark ignition engines. The main reason for blending ethanol with gasoline is to reduce fossil carbon dioxide emissions (and thus the greenhouse effect) from vehicles by using bio-ethanol originating from renewable sources. Blending bio fuels with a petroleum-based fuel has the twin advantages that even relatively small percentage additions will result in a substantial total volume of gasoline substitution, and the present infrastructure for distributing fuels can be used largely unchanged.

The main topics discussed in the research papers were the effects of using blends on: vehicle performance, cold starts and drivability, fuel and lubricating oil performance, service and maintenance, compatibility and wear, vapour lock, emissions (regulated and unregulated), fuel consumption, fuel energy content, Reid Vapour Pressure (RVP) and Life Cycle Analyses. From the study, It can be concluded that the ethanol can easily be used as fuel and can be blended in gasoline by well-known methods.

From the literature review, it is understood that ethanol – gasoline blended fuels can effectively lower the pollutant emission without major modifications to the engine design. Ethanol can be made from biomasses hence it can be considered as a renewable energy. Also According to reference [1], it is clear that ethyl alcohol can be successfully used as an alternative fuel for any SI engine. It was found that with blends, the engine operated smoothly. The blends burns more efficiently and generated lower emissions of NOx, CO and CO_2. [1] [3] Various parameters such as brake power, BSFC, TFC, brake thermal efficiency, volumetric efficiency and emission parameters like CO, CO 2, HC and NOx were investigated during combustion process under varying load conditions. For ethanol-petrol blended fuels, there is a considerable improvement in performance of the SI engine.

It was observed that the BTE for E20 blend compared to standard petrol, there was a considerable increase in BTE. [3] Then it was found that BSFC increased with increase in ethanol percentage in petrol but decreases with increase in the load i.e. But there was increase in TFC resulting from ethanol's low higher calorific value (27000kJ/kg) compared to standard petrol (44000kJ/kg). [3] [6] But the advantage of ethanol's high octane rating can be utilized for increase in octane rating of petrol with blending it. [3] Also it is observed that the E100's volumetric efficiency is higher compared to petrol with increase in ethanol percentage in petrol. [6] It was also reported by reference [2] [4] that blends with ethanol allowed the compression ratio to increase by 50% without knock. The most suitable ethanol-gasoline fuel blend in terms of performance and emissions was E50 in a small gasoline engine with low efficiency [4]. Engine power increased with higher percentage of ethanol fuel at high compression ratio compared to running with E0 fuel. [4]

The specific fuel consumption, CO, CO_2, HC emissions were reduced by approximately 3%, 53%, 10% and 12% respectively with ethanol blends. [3] Reference [4] reported that with increasing the ethanol content in gasoline fuel, the heating value of the blended fuels is decreased, while the octane number of the blended fuels increases. NOx emissions are more dependent on the engine operating condition than the ethanol content of the fuel. Reference [5] found that NOx concentrations are adversely affected because of the cylinder temperature increases with increasing ethanol percentage. By this study it is concluded that ethanol blending is more efficient in lowering exhaust emissions with promising as a future fuel which can successfully replace petrol and its depletion problem. Also it can be concluded that Adding ethanol in gasoline fuel can improve engine performance and reduce CO and HC emissions. But it can cause increase in CO2 and NOx emissions. Adding ethanol to gasoline will lead to a leaner better combustion. It was experimentally demonstrated that adding 5-15% ethanol to the blends led to an increase in the engine brake power, torque and brake thermal efficiency, volumetric efficiency and decreases the brake specific fuel consumption [2].

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