Performance Improvement and Exhaust Emission Control on IC Engine Using Multi Fuels: A Review

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***Abstract:*-This paper reviews the literature available concerning the Exhaust emission and air pollution control of Internal Combustion Engines operating with Multi fuels. Now a day's transportation is very important and for that auto vehicles are necessary. The use of vehicle is increasing because of the population and so the Exhaust pollution is also increasing. Emission and air pollution are the most important issues that threaten the peaceful existence of the man-kind. These exhaust gases of the vehicles affect to the Green house effect which is going to decide the health of Earth. These Vehicles are use all around the world so it is impossible to stops the use of vehicles But there are many other ways to decrease the Exhaust Emission of the IC Engine. Exhaust emission causes the serious problem to the people's health. Multi fuels are a very important part for controlling the exhaust emission of the vehicles. Bio gas, CNG (Compressed natural gas), LPG (Liquefied petroleum gas), Dual Fuel like Bio Ethanol, Bio Diesel Petrol, Diesel these all fuels are used in the vehicle. Towards the effort of reducing pollutant emissions, especially soot and nitrogen oxides from the IC engine engineers have proposed various solutions, one of which is the use of a dual fuel combustion engines. This literature study is about the changing the compression ratio according to fuel, blending the fuels , vary the injection pressure, change the angle of advance , convert the petrol engine in to CNG under different condition and reduce the Exhaust emission and improvement in the performance of the IC Engine.**

***Keywords:* Multi fuels, Emission, IC Engine, Vehicle, Pollution**

I. INTRODUCTION

1.1 IC Engine

An internal combustion engine is one type of heat engine which is converts the one form of energy into another form means in mechanical energy. In heat engine heat energy is there and it is a poor form of energy because of lower efficiency but the efficiency of the mechanical energy is high. It is quite different from the External Engine.

The first IC engine was made by Hugens and he used gunpowder as a fuel. It consists of piston, cylinder, rope and pulleys. This engine worked only with a single explosion of gun powder which move the piston in upward direction and with the help of atmospheric pressure return stroke was done. After that many engine are developed like Lenoir engine, Otto-langen free piston engine, Four stroke otto-engine and Diesel Engine. These all engines are Reciprocating engines. Now a day rotary types engines are use because in the reciprocating engines speed was low.

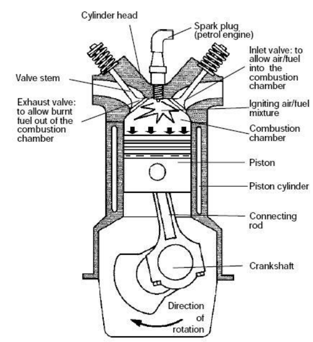

Fig 1. Diagram of IC Engine

1.1.1 IC Engine and Its Components

The cylinder and piston are the main parts of the IC engine, Cylinder is the main body of the ic engine piston reciprocates in the cylinder and develop the power. Cast iorn and Alloy steels are used for the cylinder to resist the wear and tear of parts. One end of the cylinder is closes by the cylinder head.

Piston and piston rings are used in ic engine piston compress the charge and force it to the crank via connecting rod. It is made from Cast Steel and Aluminum Alloy. Piston rings preventing the lekage of high pressure gas.

Connecting Rod and Crank shaft are also the main component of the IC engine. Small end of the connecting rod is connect with piston and Big end is connect with crank by the crank pin. With the help of crank shaft power is produced it is the back bone of the Engine.

Inlet valves and Exhaust valves are also important the fresh charge is enter from the inlet valve and removal of the gas from the exhaust valves.

Cam shaft, Cam and Cam follower, Inlet manifold, Exhaust manifold Crank Case, Carburetor, Spark plug and fuel pump and nozzle all components are important foe IC Engine.[67,68]

1.1.2 Working of IC Engine

The working cycle of the engine is competed in Four stroke: 1) Suction Stroke 2) Compression Stroke 3) Power Stroke 4) Exhaust Stroke.

1) Suction Stroke

The piston is at Top Dead Centre (TDC) and is ready to move down, When the piston moves downwards the fuel-air mixture enter through the inlet valve and suction starts and continues until the piston reach at Bottom Dead Center (BDC).Now the inlet valves are closed and this is called suction stroke where crank rotates by 180.

2) Compression Stroke

Now there is a charge in the cylinder, so piston moves in the upward direction and compress the charge during this inlet and exhaust valves are closed. Here the Pressure and Temperature is increase and when the piston reaches at TDC the spark ignites the mixture, so the pressure and temperature of the gases are increase while volume remains constant.

3) Power Stroke

Because of the high pressure of mixture it forces the piston into the downward direction when piston moves from TDC to BDC the inlet and exhaust valves are closed and the pressure and temperature of gas are very high, when the Piston reaches at BDC the exhaust valve opens and the high pressure suddenly fall to atmospheric pressure at constant volume. Work is done during this stroke so it’s called Power Stroke.

4) Exhaust Stroke

In this stroke the piston goes to the upward direction and the exhaust valve is open and inlet valve is closed. When the piston goes upward it pushes out the burnt gases through the exhaust valve. As the piston reaches at TDC the inlet valve is open again and fresh charge is enter from it and the cycles is repeated. [65, 67]

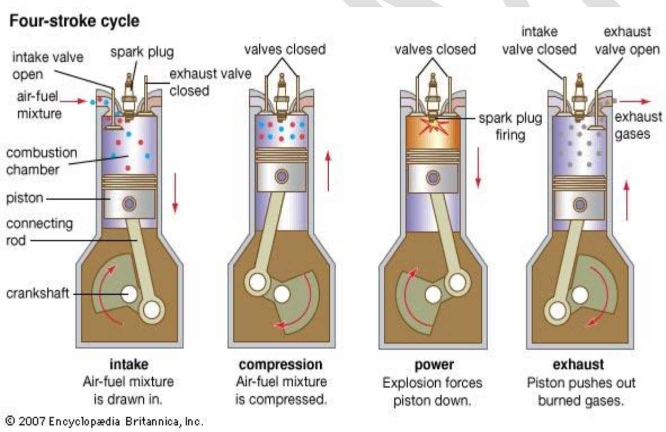

Fig. 2 Working of 4-Stroke Petrol Engine

1.1.3 Application of IC Engine

IC engines are used in all fields of industry and transport. They are used for Water Land and air transport. For power generation CI Engines are used.

2-Stroke engine are used for scooters and lawn movers at 2000 to 5000 RPM. They are very simple and maintenance cost is very low.

4-Stroke petrol engine are used in cars, jeeps, trucks and buses. They are also used in mobile electric generating sets.

4-Stroke Diesel engine are very important now-a-days because the speed of these engine is 100 to 4500rpm.Thet also used in Cars, buses and Trucks.

ICEs drive some of the large electric generators that power electrical grids. They are found in the form of combustion turbines in combined cycle power plants with a typical electrical output in the range of 100 MW to 1 GW. [67]

1.2 Air Cycles

1.2.1 Otto Cycle or Constant-Volume Air Cycle

It is a practical cycle which introduced by a Dr. A.N.OTTO and it was applied for working of petrol and gas engines. Two constant volume processes and two reversible adiabatic processes are there in the cycle.

Here the name of four processes:

1) 1-2 Reversible adiabatic compression

2) 2-3 Heat addition at constant volume

3) 3-4 Reversible adiabatic expansion

4) 4-1 Heat rejection at constant volume

It is assumed that air is working substance and at the end of compression heat is supplied and then heat is rejected at the end of expansion and cycle is repeated.

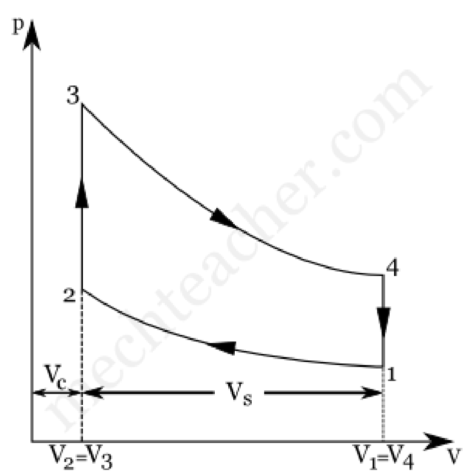

Fig. 3 - p-V Diagram

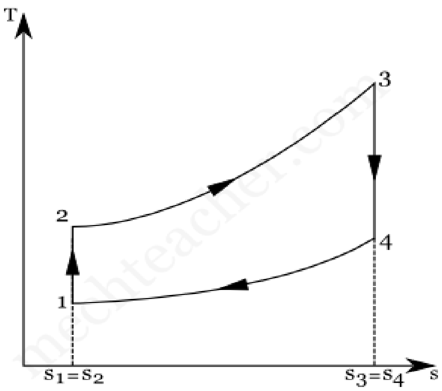

Fig 4 T-s Diagram

The Point 1 shows that cylinder is full with pressure P_1, Volume V_1, Absolute Temperature T_1.

Line 1-2 shows that the adiabatic compression of air due to which P_1 V_1 T_1 changes to P_2, V_2 and T_2 respectively.

Line 2-3 shows that P_2 and T_2 change to P_3 and T_3 because of the supply of heat to the air at constant volume (V_3=V_2)

Line 3-4 shows during adiabatic expansion of air the P_3, V_3 and T_3 change to a final valve P_4, V_4 and T_4 respectively.

Line 4-1 shows the rejection of heat by air at constant volume till original state reaches. [67]

1.3 Air Pollution from Auto-Vehicle

Transport system is the main part of India and automobile play an important role in this system. Car pollution as well as the transport vehicles is increasing day by day because population and living standard is increases. Number of two wheelers is increase rapidly in last 20 years. All these are increasing exhaust pollution mainly in metro cities where density of these vehicles is very high. In Delhi which had only 11,000 registered vehicles in 1948, but now a day 4 million vehicles are there. The Calcutta and Mumbai also count in the same range. In Delhi every day 700 new vehicles are added which counts 0.25 million a year. The total no of vehicles are more than the number of population in Delhi. The rate of growth of the vehicles is so high in the coming years and it's a very serious problem for all.

The daily emissions by the vehicles in Mumbai is 700 tones, in Calcutta 500 tones and in Delhi is 1000 tones as per data available in 2010.India is producing 40 lakhs vehicles per day and gets 1730 tons of pollutants per day. There are 80-90 lakhs vehicles in Delhi. Delhi emits 3500 tones of emission per day and causes a death of 8500 people per day.

The principal air-quality pollutant emissions from petrol, diesel, and alternative-fuel engines are carbon monoxide, oxides of nitrogen, un-burnt hydrocarbons and particulate matter. It is emissions of these pollutants that are regulated by the Euro emissions standards. [68]

1.3.1 IC Engine Emissions

CO, NO_X, unburned hydrocarbons (HC) and other particulate emissions are the main pollutants that contributed by I.C. Engines. All fuel emits the co_2 in very big quantities this cause the problem for green house effect which is going to decide the health of the earth. Human health is directly affected by the pollution of auto-vehicles. [67]

1.3.2 SI Engine Emission

SI Engine emissions divided into three categories as exhaust emission, evaporate emission and crank case emission.

The major contribute pollutants are CO, HC and NO_X in the SI engine exhaust. After the engine shut down fuel is evaporate from the fuel tank and carburetor and these are the unburned HC. Lead is there in the petrol and its effect is very serious on human health.CO and NO_X are forms during the combustion processes. If mixture is rich and O_2 is not burned properly than NO_x is produced because of increasing temperature.CO is also produced in exhaust because of dissociation of CO_2.In SI engine if mixture is lean than the emission is reduced. [68]

1.3.3 CI Engine Emission

CO, HC, SO_2, NO_X are the diesel engine pollutants and smoke is also the pollutant of diesel engine. The smoke is not harmful for health but they have bad smell and it is possible to reduction in visibility. At High loads the HC is increasing but if equivalence ratio is increase than HC is decrease.CO emission is always less and NO_X is high due to increasing in equivalence ratio. [68]

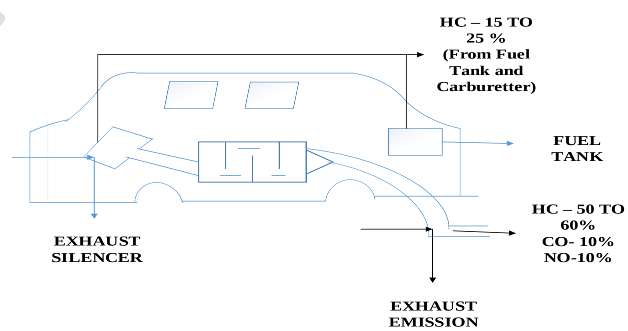

Fig. 5- Percentage of Different Contributes coming out from the Three Sources

1.4 Multi fuels and Their Properties

The increasing industrialization and motorization of the world led to a steep rise in the demand of petroleum products. There are limited reserves of these products. Petrol and Diesel Vehicles are produced the Exhaust Pollution like CO, HC, NO_X. These pollutants are very harmful and it affects the Human Health. So now a day's the use of the Multi Fuels are necessary and it will help to reduce the emission. Bio Gas, Bio Ethanol, Bio Gas CNG and LPG are the good alternative fuels. They all are Eco-Friendly and Produced the more power and Performance of the Engine is Improve.

What is Petrol?

It is the most valuable and commonly used transport fuel. Petrol is a liquid with a strong solvent smell in its natural state. Petrol is produced from petroleum - the thick crude oil that develops under the Earth's surface from the impact of heat, pressure and time on organic matter. It contains a volatile flammable mixture of hydrocarbons.It's also called a Gasoline. [56]

What is Diesel?

It is a liquid fuel used in diesel engines and it is a mixture of hydrocarbons obtained by distillation of crude oil. Cetane number (or cetane index), fuel volatility, density, viscosity, cold behavior, and sulfur content are the characteristic of the diesel. It is very dense and oily. Petroleum diesel, Synthetic diesel and Biodiesel are the types of diesel. [57]

Properties	**PETROL**	**DIESEL**
Chemical composition (% vol)	C_8H_{18}	$C_{12}H_{26}$
Molecular weight (g/mol)	114.236	170
Mass density(kg/m3) at1atmand15 1C	692	820-850
Kinematic viscosity(mm2/s) at40 1C	-	2.6
Boiling point(1C)	37-205	180-360
Flashpoint (1C)	-45	50-90
Minimum Ignition energy (MJ	0.29	-
Flammability limits in air (%vol)	1.0-7.6	1.5-7.6
Auto ignition temperature in air (K)	533-733	527
Higher heating value (MJ/kg)	47.3	44.8
Lower heating value (MJ/kg)	43.8	42.5
Flame velocity in air (cm/s)	37-43	33
Stoichiometric air/fuel ratio (kg/kg)	14.6	15
Octane number (RON	95	30
Octane number (MON)	85	-
Cetane number (ASTM D613)	-	47.5

Table 1 Properties for Petrol, Diesel

What is LPG (Liquefied petroleum gas)?

LPG contains two flammable but nontoxic gases called propane (C_3H_8) and butane (C_4H_{10}) and both are hydrocarbons and it sometimes contains isobutene also. LPG is an odourless and colourless gas in its natural state. PG is produced during oil refining or is extracted during the natural gas production process. LPG is used as fuel in internal combustion engine and also used in industrial, commercial, agricultural, horticultural and manufacturing applications.[58]

What is CNG (Compressed natural gas)?

CNG is used as a fuel in place of Petrol. It is a natural gas that is compressed to high pressure and store in the fuel tank. It contains 85 % Methane, Ethane, Nitrogen and Carbon Dioxide.CNG is used in many vehicles and it emits low emission than the petrol and diesel.

What is Hydrogen?

Hydrogen is a chemical element. An atom of hydrogen consists of only one proton and one electron. Hydrogen is also contains organic compounds, notably the hydrocarbons that make up many of our fuels, such as natural gas, gasoline, and methanol. It is separated from hydrocarbons through the process known as reforming. [60]

Properties	**LPG**	**CNG**	**Hydrogen**
Chemical composition (% vol)	C3H8-30,C4H10-70	CH485%,C2H6-7%,C3H82%,N2-1%,CO2-5%	H_2
Molecular weight (g/mol)	53.87(444)	17.2	2.016
Mass density(kg/m3) at1atmand15 1C	2.26	0.79	0.08
Kinematic viscosity(mm2/s) at40 1C	-	-	-
Boiling point(1C)	−42-0	-161.7	−252.8
Flashpoint (1C)	−60	-188	−231
Minimum Ignition energy (MJ	0.30	-	0.017
Flammability limits in air (%vol)	2.15	5-15	4.75
Auto ignition temperature in air (K)	678–723	540	858
Higher heating value (MJ/kg)	50.152	55	142
Lower heating value (MJ/kg)	45.7	50	120
Flame velocity in air (cm/s)	38.25	34	265–325
Stoichiometric air/fuel ratio (kg/kg)	15.5	17.3	34.2
Octane number (RON)	103–105	120	>130
Octane number (MON)	90–97	120	130
Cetane number (ASTM D613)	-	-	-

Table 2 Properties for LPG, CNG, Hydrogen

What is Ethanol?

It is also called ethyl alcohol or grain alcohol, drinking alcohol and abbreviated as ETOH. It is one type of fuel which is blended with gasoline to produce a fuel with a higher octane rating and fewer harmful emissions than unblended gasoline. Most gasoline is blended with up to 10 percent ethanol, because any vehicle can run on up to a 10 percent blend. E10 is fuel blends of 10 percent ethanol and 90 percent gasoline. It is produced from biomass mostly via a fermentation process using glucose derived from sugars, starch as raw materials and it is renewable. The chemical formula for ethanol is CH_3CH_2OH. [59]

What is Bio Ethanol?

It is denatured alcohol also called Methylated Spirit and produced by the sugar fermentation process. It is renewable and greenhouse gas emissions. [55]

Properties	ETHANOL	BIO ETHANOL
Chemical composition (% vol)	C2H5OH	-
Molecular weight (g/mol)	46	46
Mass density(kg/m3) at1atmand15 1C	809.9	0.7904
Kinematic viscosity(mm2/s) at40 1C	1.2	-
Boiling point(1C)	79	78
Flashpoint (1C)	13	35
Minimum Ignition energy (MJ)	-	-
Flammability limits in air (%vol)	3.3–19	-
Auto ignition temperature in air (K)	696	400
Higher heating value (MJ/kg)	29.7	30
Lower heating value (MJ/kg	26.8	26.8
Flame velocity in air (cm/s)	39	-
\Stoichiometric air/fuel ratio (kg/kg)	9	8.96
Octane number (RON)	108.6	110
Octane number (MON)	89.7	92
Cetane number (ASTM D613)	5–8	11

Table 3 Properties for Ethanol, Bio Ethanol

What is Bio Gas?

It is renewable energy source and produced by processing residual waste from livestock, agricultural waste, food production. It contains Methane, carbon dioxide, Nitrogen and Hydrogen. Biogas burns more cleanly than coal, and produced less carbon dioxide. It is used as fuel in vehicle. [61]

What is Bio Diesel?

It is renewable and made from the vegetable oils and animal fats derived from sunflower, corn, palm etc. It containing single chains of 12 to 24 carbon atoms and also contain a carboxylic acid (COOH) an alcohol(OH).It burnes properly than the petrol so it emits less sulfer and co but power is less. It has higher Cetane number and good lubricating properties and gives complete combustion. [63]

Properties	BIO GAS	Bio diesel
Chemical composition (% vol)	CH_4 50-75%,CO_2 25-50,N_2 0-10%,H_2 0-1%,	-
Molecular weight (g/mol)	-	-
Mass density(kg/m3) at1atm and15 1C	1.2	0.876-0.9
Kinematic viscosity(mm2/s) at 40 1C	-	1.9-6
Boiling point(1C)	-	315-350
Flashpoint (1C)	-	120
Minimum Ignition energy (MJ)	-	-
Flammability limits in air (%vol)	7.5-14	-
Auto ignition temperature in air (K)	650	705-840
Higher heating value (MJ/kg)	20	45
Lower heating value (MJ/kg)	17	39
Flame velocity in air (cm/s)	25	-
Stoichiometric air/fuel ratio (kg/kg)	11	-
Octane number (RON)	130	-
Octane number (MON)	-	-
Cetane number (ASTM D613)	-	50-65

Table 4 Properties of Bio Gas, Bio diesel

II. LITERATURE REVIEW

2.1 Recent study

Some reviews on Exhaust emission and Multi Fuels have been studied and some experimental analysis such as power output from engine, Emission Characteristics, Combustion effect and Specific Fuel Consumption and all Efficiency.

Yanuandri Putrasari et al. [2015] [1] studied the performance and emission of Honda L15A, four cylinders, 1,497 cm3 using electronic control unit with Three different fuel system namely standard gasoline fuel system, commercially CNG conversion kit and proposed CNG conversion kit designed by Research Centre for Electrical Power and Mechatronics – Indonesian Institute of
Science at 25% and 80% throttle opening position with engine speed over 4,800 rpm. At 25% throttle opening position the IMEP of SI engine using standard gasoline fuel system, commercially CNG conversion kit and proposed CNG conversion kit decreased and the brake power is increased, while at 80% throttle opening position it increased with the increasing of engine speed.

Macklini Dalla Nora et al. [2015] [2] gasoline direct injection single cylinder engine was modified to run under the two-stroke cycle by operating the intake and exhaust valves around bottom dead centre (BDC) at every crankshaft revolution and measured the engine output at each engine speed and boost pressure. During the valve overlap period the exhaust gas was scavenged by compressed air. The scavenging process and fuel preparation are the two most important issues affecting the two-stroke poppet valve engine's performance and emissions.

Jiakun Du et al. [2015] [3] studied the effect of combustion phasing and Exhaust Gas Recirculation for various fuels like gasoline/diesel blended fuel on the turbocharged Common-rail Direct Injection engine at a constant engine speed of 1800 r/min and different loads of 3.2 bar, 5.1 bar Indicated Mean Effective Pressure. With The control of EGR and combustion phasing of the gasoline/diesel fuels it can achieve the compound combustion concept with emission lower than conventional DI engines, and efficiency higher than typical SI engines.

Namho Kim et al. [2015] [4] investigated that the engine combustion and emission characteristics affected by the effect of ethanol port fuel injection and gasoline direct injection systems under full load conditions and fuel blending ratio were according to the engine operating condition at two different compression ratios and various ethanol injection timings. The reduction in emission was more at compression ratio of 13.3 than the other ratio Ethanol injection timing is increased than knock frequency decreased.

Yong Qian et al. [2015] [5] studied about single-cylinder Engine and measured combustion and emissions characteristics of reactivity controlled compression ignition (RCCI) combustion. Soot emissions decreased greatly with the increase of premixed ratio When the overall LHVs per-cycle is constant. The ignition delay of ethanol RCCI is longer than that of n-butanol and n-amyl alcohol Under the same overall LHVs per-cycle and premixed ratio.

Gholamhassan Najafi et al. [2015] [6] studied on KIA 1.3 SOHC, four cylinders, and four stroke and SI (spark ignition) gasoline Engine 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 at various speeds for each test fuel and 45 different conditions were constructed. Engine performance improved , CO and HC emissions reduced and also CO2 and NOx emissions increased when ethanol was add in gasoline fuel. A blend of 10% bio ethanol and 90% gasoline (E10) and An engine speed of 3000 rpm were found to be optimal values.

Y. Zhang et al. [2014] [7] investigated seven different operating modes, including: 4-stroke throttle-controlled SI, 4-stroke intake valve throttled SI, 4-stroke positive valve overlap SI, 4-stroke negative valve overlap CAI, 4-stroke exhaust rebreathing CAI, 2-stroke CAI and 2-stroke SI in single cylinder direct injection gasoline engine equipped with an electro-hydraulic valve-train system analyzed and compared at a typical engine calibration operating condition of 1500 rpm and 3.6 bar IMEP in 4-stroke or 1.8 bar IMEP in 2-stroke. due to slow and in-complete combustion. Efficiency of The 2-stroke SI was low. The 2-stroke operation modes and 4-stroke throttle controlled SI and intake valve throttled SI combustion produce more co emissions and NOx emission respectively.

Catapano et al. [2014] [8] observed the emission characteristics of ethanol–gasoline dual fuel combustion by using gasoline port injection system and ethanol direct injection. The study revealed that the increase in ethanol mass leads to a significant reduction in the concentration of accumulation mode particles compared to that in the gasoline direct injection.

Adrian Irimescu et al. [2014] [9] investigated small scale generators driven by internal combustion engines is, however, low fuel conversion efficiency and high specific emissions compared to medium or high scale power units. With the use of a three way catalytic converter, carburetor and fuel injection combined and compared their Performance and emissions and latter solution proving to be more efficient and environmentally friendly. Power quality ratings were obtained for both carburetor and proposed fuel control setup. Improved efficiency of up to 15% on average was obtained mainly due to mixture leaning from rich air–fuel ratios when using the carburetor, to stoichiometric ones when employing the closed loop injection system.

Sulaiman, M. Y. et al. [2013] [10] analyzed the characteristics of single cylinder SI ICE fueled by LPG and measured the torque and engine speed using the universal dynamometer in WOT condition under stable condition. Power output is reduced and the SFC is low so the engine fueled by LPG has better energy price as compared to the conventional fuel, which is ULP.

Luka Lešnik et al. [2013] [11] investigated the influence of mineral diesel fuel and neat biodiesel fuel made from rapeseed oil on mechanically controlled injection system characteristics was tested experimentally on an injection system test-bed and numerically by using the AVL BOOST software and the mixed controlled combustion model under full load and at various engine speeds with the help of numerical simulations it conclude that .The tested biodiesel could be used as replacement for mineral diesel in heavy duty diesel engine that are similar to the tested engine.

Carmelina Abagnale et al. [2013] [12] shows the results of numerical – experimental study of the dual fuel diesel engine and also the effect of different fuel ratios on the performance and emission levels supplied with natural gas and diesel oil. The engine behaviour of NG rate up to 50 % is almost similar to full diesel operation. NG rate at 70 – 90 % levels engine behaviour that is comparable with the one of spark ignition engines close to knocking conditions.

M.J. Abedin et al. [2013] [13] studied about the energy balance including the application of the first-law of thermodynamics, variations in heat transfer correlations for wall heat loss evaluation, thermodynamic models of internal combustion engines operating on alternative fuels and minimize the energy loss from automotive engines. Biodiesels have lower thermal efficiency, BSFC of biodiesels is much higher and heat losses except the exhaust loss are also higher than diesel fuel. Most important requirement for IC engine energy balance is a suitable heat transfer correlation.

Gihun Lim et al. [2013] [14] investigated the 11-L heavy-duty SI engine fuelled with HCNG30 (CNG 70vol %, hydrogen 30vol %) and CNG and observed the effects of the CR on performance and emission characteristics at different compression ratio of 10.5 and 11.5. If compression ratio increases than the overall thermal efficiency increases and also Improving the thermal efficiency, reduces the emission of CO2.

E. Sadeghinezhad et al. [2013] [15] studied the use of a blend of bi-fuel with conventional fuel was suggested to balance its usage because of that extensive utilization of bio-fuel would tax the food chain and could lead to food shortages and provide beneficial greenhouse effect. bio-diesel is consumed more in comparison to the fossil diesel fuel because of lower heating value. concern about environment, engine performance and involved costs has raised by using bio-diesel as an alternative for mineral fuel.

Emad Elnajjar et al. [2012] [16] investigated The effect of LPG fuel with different Propane to Butane volume ratio compositions like 100:0, 70:30, 55:45, 25:75 and 0:100 on the performance of dual fuel, a single cylinder, naturally aspirated, four strokes, indirect injected, water cooled modified Ricardo E6 engine under variable operational and geometrical conditions.25:75 is showing the best performance among the other fuel types with the highest level of efficiency with small noise.

A.K. Hossain et al. [2012] [17] studied about the pyrolysis liquids and gases produced from produced from a variety of feed stocks and using different pyrolysis techniques, against those of fossil fuels and their characteristics like High acidity, the presence of solid particles, high water content, high viscosity, storage and thermal instability, and low energy content. As PL is generally a low- grade fuel, low or medium speed engines tend to be more suitable than high speed engines. Pyrolysis gas can be used either in SI engine as single fuel or in CI engines in dual fuel mode. NOx emissions are lower in the case of PL and higher in the case of PG, in CI and SI engine respectively.

Changwei Ji et al. [2012] [18] converted A gasoline engine into a hybrid hydrogen–gasoline engine (HHGE) by adding a hydrogen injection system and a hybrid electronic control unit, and fueled with the pure hydrogen at cold start to produce almost zero emissions.to improve thermal efficiency and reduce emissions and measured the engine power output.. HC and CO emissions are reduced by 94.7% and 99.5% for the HHGE at cold start, compared with those from the original engine because the hydrogen contains no carbon atom.

Su Han Park et al. [2012] [19] investigated the characteristics like the spray, atomization, combustion and exhaust emissions of DME-fueled engine and also the fundamental fuel properties including the vapor pressure, kinematic viscosity, cetane number, and the bulk modulus. The low viscosity of DME caused the leakage so DME-fueled engine needs the modification of fuel supply and injection system. Due to higher cetane number the ignition of DME fuel in combustion chamber starts in advance compared to diesel or biodiesel fueled compression ignition engine. In a DME-fueled vehicle the exhaust emissions, such as HC, and CO, are at lower level soot emissions are nearly zero and reduce the NOx emission with the help of EGR.

E. Porpatham et al. [2012] [20] investigated The performance, emission and combustion characteristics of A single cylinder diesel engine which modified to operate as a biogas operated spark ignition engine at 1500 rpm at throttle opening of 25% and 100% at various equivalence ratios. There is an improvement in thermal efficiency and brake power output and HC and NO level increase with rise in compression ratio. The reduction in the ignition delay and higher heat release rate with increase in compression ratio.

Charles Sprouse III et al. [2012] [21] studied the conversion of engine waste heat to accomplishes a more useful form of energy, either mechanical or electrical to fuel prices and future carbon dioxide emission limits are creating a renewed interest in methods to increase the thermal efficiency of engines beyond the limit of in-cylinder techniques. Rankine systems use standard components and operate efficiently using these grades of energy so that the ORC's are the most commonly implemented WHR systems in order to generate power from low-grade to medium-grade waste heat.

K.A. Subramanian et al. [2012] [22] investigated an automotive spark ignition vehicle fuelled with the methane enriched biogas (93% CH4) and base CNG (89.14%) under modified Indian driving cycle (MIDC). The fuel economy and mass emission and the transient emissions were measured with respect to time. There is no significant difference in CO2 emission and fuel economy between enriched biogas (24.11 km/kg) and base CNG (24.38 km/kg).The results shows that the enriched biogas can be used as a fuel for the automotive passenger vehicles.

Daniel et al. [2012] [23] investigated a DI injector in a conventional gasoline port fuel injection (PFI) engine using ethanol and methanol and observed changes in engine performance. An improvement in indicated efficiency was observed, especially for higher engine loads. Additionally, at higher engine loads THC and CO emissions decreased as the added amount of ethanol or methanol increased.

Park S H et al. [2012] [24] observed a slight decrease in NOx emissions. A part from emissions, due to the lower calorific values of biodiesel fuels it cause a reduction in engine power and torque and lead to increased fuel consumption in engines with mechanically controlled injection systems. So far, most investigations are done by using experimental testing combined with numerical simulation.

Tira et al. [2012] [25] studied the properties of the direct injection diesel fuels, such as rapeseed methyl ester (RME) and gas-to-liquid (GTL) A Liquefied Petroleum Gas (LPG)-diesel dual fuelled engine and measured combustion characteristics, engine performance and emissions. If lpg concentration increased soot and NOx Emissions decreased. the study confirms that for improved engine-out emissions of LPG-diesel dual fuelling diesel than fuel properties need to be optimised for the different LPG additions.

R. Chandra et al. [2011] [26] converted 5.9 kW stationary diesel engine into spark ignition mode and run on compressed natural gas, methane enriched biogas and biogas produced from bio methanation of jatropha oil seed cakes. The performance of the engine was measured at 30, 35 and 40 ignition advance of TDC at 12.65 compression ratio. The observed power losses had been 31.8%, 35.6% and 46.3% for compressed natural gas, methane enriched biogas and raw biogas, respectively because of the conversion of diesel engine into spark ignition engine. the engine performance of methane enriched biogas containing 95% methane is almost similar to that of compressed natural gas in terms of brake power output, specific gas consumption and thermal efficiency, so the gaseous fuel methane enriched biogas is as good as natural gas.

T. Korakianitis et al. [2011] [27] in this paper's study for SI engines, and for CI engines in the dual-fuel mode using Natural gas is a practical fuel. Gasoline-fueled engines resulting in similar or slightly lower thermal efficiencies compared Natural-gas fueled SI engines can operate at higher compression ratios. High EGR rates as well as catalytic converters to reduce NOx emissions in SI engine at high loads. To improve power output advanced spark timing, high compression ratios and forced induction can be used at all conditions. To reduce emissions of HC and CO natural gas can be used in smaller proportions compared to the pilot fuel at lower loads in dual-fueled CI engines.

Massimo Masi et al. [2011] [28] investigated A four-stroke five-cylinder 2-l engine and measured the Brake performance with petrol and LPG are analyzed and compared. third-generation" standard kit was use for dual-fuel operation. Because of excessive LPG superheating The volumetric efficiency seems to be worse than the theoretical. Because of the deterioration of volumetric efficiency and to insufficient fuel delivery performance in LPG operation is not good. The analysis presented indicates that the performance of the "third-generation" kit for petrol LPG dual-fuel operation is greatly affected by the settings of the mechanical components of the LPG evaporator device.

Cheolwoong Park et al. [2011] [29] performed N2 dilution test in terms of its thermal efficiency, combustion characteristics on and emissions 8-L spark ignition engine fueled by biogas with various methane concentrations at at a constant engine rotational speed of 1800 rpm under a 60 kW power output condition H2 addition tests were carried out in a stoichiometric excess air ratio to improve combustion stability for the lowest energy density fuel. Finally, the engine was tested in various lean mixture conditions in order to satisfy NOx regulations as well as to maximize thermal efficiency.

Dale Turner et al. [2011] [30] performed the experiment on a direct injection spark ignition engine using different blending-ratios of bio-ethanol/gasoline with respect to spark timing and injection Strategies at a part load and speed condition to reduce total CO2 emissions. reduced levels of NOX emissions CO emissions resulting from improved combustion efficiency. a combination of advanced combustion and higher flame speeds because of the Faster combustion and thus higher in-cylinder pressure.

Han et al. [2011] [31] have investigated blends of diesel and gasoline up to 40% with cetane number down to 31. They have highlighted that the soot emissions peak particularly reduces and the effect of high injection pressure on soot emissions can be limited when increasing the gasoline in the blend up to 40%

M.I. Jahirul et al. [2010] [32] analysis the engine performance and exhaust emission on a new 1.6 L, 4- cylinder petrol engine which was converted to the computer incorporated bi-fuel system which operated with either gasoline or CNG using an electronically controlled solenoid actuated valve mechanism. With the help of a computer based data acquisition and control system the engine brake power, brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature and exhaust emissions (un burnt hydrocarbon, carbon mono-oxide, oxygen and carbon dioxides) were measured over a range of speed variations at 50% and 80% throttle positions. The CNG had the lower brake power, lower BSFC, higher brake thermal efficiency, higher engine exhaust gas temperature, lower HC, CO, O2 emission throughout the speed range than the Gasoline, so it indicates that the CNG is a better choice as automobile fuel than the gasoline both economically and environmentally.

Thomas Renald C.Ja et al. [2010] [33] investigated the performance of effective combustion of air, LPG and diesel mixture without any major modification in the engine construction. With the help of the CFD technique the parameters of the LPG jet injector are optimized and also observed the Changes in the performance of the engine and emission levels with the influences of the jet parameters. The thermal efficiency and the mechanical efficiency were increased about 5% when powered with dual fuel. The Specific fuel consumption, NO_X, CO2, CO were reduced in dual fuel mode for 60% of diesel and 40% of LPG, So the better engine performance and reduced emission level can be achieved if the dual fuels proportion lies between 40-60 % of diesel and LPG for the nozzle condition, diameter of 5 mm, x= 10 mm and θ = 30°.

Talal F. Yusaf et al. [2010] [34**]** modified A single cylinder, four-stroke diesel engine and predict the brake power, torque, break specific fuel consumption (BSFC), and exhaust emissions of a diesel engine operating on both compressed natural gas CNG and diesel fuels with the use of artificial neural network (ANN) modeling at different engine loads and speeds. The ANN is demonstrated to be a useful simulation tool in the evaluation of the engine parameters because the experimental data by the ANN revealed that there is good correlation between the simulated results from the ANN and the measured data, with R values are ranging between 0.92 and 0.99.

Cheolwoong Park et al. [2010] [35] investigated SI engine performance, thermal efficiency and emissions. The combustion characteristics of hydrogen enriched gaseous fuel made from ethanol which influence by ethanol fuel. Due to its high octane number and a high latent heat of evaporation, which makes the temperature of the intake manifold lower Ethanol has excellent anti-knock qualities. The compression ratio can be raised so that thermal efficiency and engine power output can be improved Due to the effect of the addition of ethanol on the advance of spark timing For leaner conditions, the decrease in NOx is primarily a reflection of decreasing the combustion temperature.

Tsujimura and Goto et al. [2010] [36] investigated that the combustion performance was affected by the various fuel properties, such as auto-ignitability, volatility and aromatic hydrocarbon components on. They suggested that the poorer auto-ignitability and superior volatility is effective for producing lower soot emission and wider the operation range with ultra low emissions.

Saravanan and Nagarajan et al. [2010] [37] tested a diesel engine fueling with the diesel–hydrogen blends. The experimental results shows that after hydrogen addition the engine brake thermal efficiency was improved by 15% at 75% load. Smoke, CO and CO2 emissions were decreased for the hydrogen–enriched diesel engine and NOx emissions from the hydrogen–blended diesel engine were nearly the same with those from the pure diesel engine.

Yao et al. [2010] [38] studied a heavy-duty diesel engine and observed the effects of n-butanol as a diesel additive on engine performance and emissions .They found that n-butanol can significantly improve the soot and CO emissions if the NOx emissions are approximately equal.

Rakopoulos and Michos et al. [2009] [39] observed the availability analysis on a spark ignition engine fuelled by biogas- hydrogen blends during the closed part of the engine cycle, with volumetric fractions of hydrogen up to 15%. It has been reported that the addition of increasing amounts of hydrogen in biogas promotes the degree of reversibility of the burning process mainly during the combustion of the later burning gas, due to the incurred increase in its combustion temperatures. They also found that, any measure that would increase the temperature of the early burning gas, located in the vicinity of the spark plug, would be beneficial from the second law view point.

H.E. Saleh et al. [2008] [40] studied a two-cylinder, naturally aspirated, four-stroke, DI diesel engine converted to run as pilot-injected dual fuel engine and investigate the effect of variation in LPG composition on emissions and performance characteristics five gaseous fuel of LPG with different composition he best LPG blends in a dual fuel operation was Fuel with butane content 30%. As a higher propane content reduces CO levels while higher butane content lead to lower NOx levels.

Hakan Ozcan et al. [2008] [41] studied on four stroke, single cylinder, water cooled spark ignition engine and simulation was done with varying the stroke length of the engine, which also changed its compression ratio and brake torque and power, brake specific fuel consumption measured at each stroke length. At higher speeds Larger stroke lengths resulted in reduction of the pollutants level about 1.5 % At lower stroke Lengths it increase about 2%.The variable stroke technique can be used to improve the performance and emission characteristics of LPG fueled spark ignition engines.

Saleh et al. [2008] [42] studied about the dual fuel compression engine and the effect of variation of the LPG compositions on the exhaust emission of under different conditions of load with constant engine speed. The study reported that the conventional diesel engine is showing a similar performance compared to the LPG with 70% Propane blend and for that NOx and SO2 emission are decreased by 27% -69% meanwhile, the CO emission increased by 15.7% compared to the conventional diesel engine.

Ganesh et al. [2008] [43] experimentally investigated the performance of a hydrogen engine and the test results confirmed that the power output of the gasoline engine was 20% higher than that of the hydrogen engine. HC and CO emissions from the hydrogen engine were negligible and NOx emissions from the gasoline engine were about four times lower than those from hydrogen engine.

Toru Sekiba et al. [2007] [44] In this study of the conversion characteristics of three-way catalysts, it was found that the conversion efficiency of total hydrocarbons was much lower in the lean-mixture region. The reduced efficiency was traced to lower conversion and poor reactivity of low-end hydrocarbons and to a higher concentration of H20. In addition, the ratio of methane in the exhausted THC was virtually identical to its ratio in the fuel. This indicates that the ratio of each component of exhaust THC can be estimated from its constituent ratio in the fuel.

Masataka Morinaga et al. [2007] [45] performed emission test on a DI diesel engine to evaluate the use of light cycle oil (LCO) as a component of diesel fuel. Most test fuels contained a kind of some LCOs which had varied ranges of the distillation and their performances compared with that of conventional diesel fuel. In this test particulate emissions had no effect on the total aromatic hydrocarbons, the poly-aromatic hydrocarbons significantly affected on SOF in the emissions. Furthermore, to keep the cetane number, the gaseous emissions became same level on any fuels.

Enzo Galloni et al. [2006] [46] in this paper's study numerical modeling used to evaluate the performance of a spark-ignition engine, fuelled by hydrogen enriched gasoline. The thermal efficiency of the fuel processor and the efficiency of the integrated reformer/SI engine system is 80 %.The results of the computational analysis have pointed out that the mean overall efficiency of IRES is close to that of the conventional spark ignition engine.

Luigi Turrio- Baldassarri et al. [2006] [47] analyzed a spark-ignition (SI) heavy-duty (HD) urban bus engine with a three-way catalyst (TWC), fuelled with compressed natural gas (CNG) and tested for genotoxicity and compared with an equivalent diesel engine, fuelled with diesel oil (D) and a blend of the same with 20% vegetable oil (B20). The diesel engine fuelled with D, with respect to the SI CNG engine emissions nearly 50 times higher for carcinogenic PAHs, 20 times higher for formaldehyde, and more than 30 times higher for PM so from that it can be concluded that the use of CNG in public transportation is good and it can improve the urban air, social costs of air pollution and reduce adverse health effects.

Crookes et al. [2006] [48] examined spark and compression ignition engines and observed the performance and emissions with a variety of bio fuels, including simulated biogas and commercial seed oil at an engine speed of 2000 rpm with a relative air fuel ratio ranging from rich to the lean misfire limit and compression ratios of 11:1 and 13:1 in the SI mode. Raising the compression ratio is known to have the effect of increasing in cylinder temperature NOx and HC

Selim et al. [2005] [49] has reported the cycle-to-cycle combustion variation. dual fuel engine using a constant composition LPG as primary main fuel exhibits higher combustion noise than that using methane, increasing the mass of pilot diesel fuel resulted in an increase in the indicated mean effective pressure (IMEP) while it increased the combustion noise. with the help of the type of gaseous fuels used and their concentrations in the cylinder charge we can know about the combustion noise and the cyclic variability in dual fuel engine.

Chunhua Zhang et al. **[2005]** [50] studied on the control scheme of a liquefied petroleum gas (LPG)– diesel dual-fuel engine with electronic control. The experimental results showed that comparing with diesel, the output performance of dual fuel is not reduced, while smoke emission of dual fuel is significantly reduced, NOx emission of dual fuel is hardly changed, but HC emission and CO emission and fuel consumption of dual fuel are increased and reduced respectively.

R.G. Papagiannakis et al. [2004] [51**]** investigated a single cylinder DI Diesel engine run on the the primary amount of fuel is the gas which is ignited by a pilot Diesel liquid injection under dual fuel conditions. At high load the combustion duration under dual fuel operation is short compared to normal Diesel operation, while at low load, it is larger. NOx concentration soot emissions of dual fuel are lower and CO and HC emissions levels are considerably higher than normal Diesel operation.

Cao et al. [2004] [52] analyzed on characteristics between diesel and mixed liquefied petroleum gas (LPG)/ diesel injection engines and also on the engine performance and sprays. The performance test results showed that with LPG the mixed ratio increases, engine power reduces slightly, fuel consumption and engine noise have almost no change. Smoke, CO and NOx emissions at full load are improved significantly, but the amount of unburned HC increases.

Z. Ristovski et al. [2003] [53] investigated the six cylinder sedan car under a variety of operating conditions before and after it has been converted to compressed natural gas (CNG) fuel and measured emissions levels and characteristics of ultra fine particles and the emission levels together with the emissions of gaseous pollutants for a range of operating conditions before and up to 3 months after the vehicle was converted. The emission of particles was not significant change for the vehicle operating on petrol, before the conversion, compared to the emissions for the vehicle operating on CNG, after the conversion. Particle number and mass emissions as well as CO increased when the vehicle was run again on petrol after operating on CNG for some time with lower speeds.

Zhili et al. [2001] [54] showed that the diesel engine can run over a wide range of load with a high efficiency and if an appropriate proportion of di-methyl ether is added with the LPG so NOx emissions can be reduced to near zero level in order to control the ignition and combustion.

2.2 Summary of Literature Review

From this Literature Survey I found that the effect of blending fuel like ethanol and gasoline or Hydrogen and bio gas is very good and with the help of that we can get control over the emission. I also reviewed that with changing the compression ratio, change the advance angle, vary the injection pressure and blending the propane and butane ratio in the LPG, convert the engine from petrol to CNG, Pilot diesel injection under the dual fuel condition these all are important Techniques and parameters to reduce the Exhaust emission. Multi Fuels like Bio gas and Bio diesel are the best fuel in the vehicle to reduce emission, for improve the performance of engine and they are renewable so it is the main advantage for fuel.

2.3 Objectives

- Analysis of Air Pollution.
- To control the air pollution of auto vehicle.
- Analysis Air pollution by using different fuel in IC engine.
- Complete combustion approach.
- Performance improvement approach.

- To use Taguchi method.
- To find out the better Fuel.
- To make a smart Biodiesel.
- To find out the optimum solution for different fuels.
- To find out the good Technique for control the emission.

III.CONCLUSION

Broad Literature survey carried out and from this I found that the effect of blending fuel like ethanol and gasoline or Hydrogen and bio gas is very good and with the help of that we can get control over the emission. I also reviewed that with changing the compression ratio, change the advance angle, vary the injection pressure and blending the propane and butane ratio in the LPG, convert the engine from petrol to CNG, Changing the timing of Ethanol port injection and Pilot diesel injection, the use of catalytic converter under the dual fuel condition these all are important Techniques and parameters to reduce the Exhaust emission. Multi fuels like Bio gas and Bio diesel are the best fuel in the vehicle to reduce emission and they are renewable so it is the main advantage for fuel. Engine Performance is also improvement with the help of Multi Fuels.

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