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LITURATURE REVIEW ON EFFECT OF OXYGENATED ADDITIVES ON S.I. ENGINE PERFORMANCE & EMISSIONS

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Abstract: *The Petrol engines provide the major power source for the transportation needs of the mankind. However the emission from the engines threatens the environment seriously and they are considered as the major source of the air pollution. They are confirmed to cause the environmental problems like Global Warming, Greenhouse gases and the acid rain. The addition of an oxygenating agent into fuel oil is one of the possible approaches for reducing this problem because of the obvious fuel oil constituent influences on engine emission characteristics. This paper reviews the available oxygenated additives and compares their effect on exhaust gas emission with help of conference papers and journals. During study of available material, it is found that oxygenated additives are an effective method for reducing PM, CO and HC without significant increase in the NOx emission.The objective of the present paper is to investigate the effect of these oxygenated additives on spark ignition engine performance and emission characteristics at variable engine speed operating conditions.*

Keyword: *Oxygenated additives, SI Engine, HC, CO, NOx*

I. INTRODUCTION

Scientists all around the world have been trying to explore the new possible sources of energy to meet the ever increasing energy thirst. The IC Engines are widely used power source due to their simple mechanism, excellent performance, easy maintenance, low fuel oil cost, low fuel consumption rate, low breakdown rate, high compression ratio, high power/weight ratio, high fuel oil density, high thermal efficiency and durability. Diesel engines are the most fuel-efficient combustion engines in human history. However, diesel engines are also considered a major source of air pollution in port and urban areas because of their black smoke, HC,NO*x*, particulate matter (PM), CO, CO2, SO_x emissions. [1]

Oxygenated fuel is nothing more than a fuel that has a chemical compound containing oxygen. These are the fuels infused with oxygen. They are used to reduce the carbon monoxide emissions creating when burning fuel. Oxygenates can be based on either alcohol or ethers. Oxygenates are added to motor vehicle fuels to make them burn more cleanly, thereby reducing toxic tailpipe pollution, particularly carbon monoxide. Oxygenates are favored not only for their vehicle emission benefits but also their blending properties in motor gasoline (e.g., octane). Advantages of using oxygenated fuel as an alternative fuel results in the reduction of net carbon dioxide emissions, lower emissions of CO, NO_x and HC. and cut down on some types of atmospheric pollution. In many cases, it is credited with reducing the smog problem in major urban centers. It can also reduce deadly carbon monoxide emissions. Oxygenated fuel works by allowing the gasoline in vehicles to burn more completely. Because more of the fuel is burning, there are fewer harmful chemicals released into the atmosphere. In addition to being cleaner burning, oxygenated fuel also helps cut down on the amount of non-renewable fossil fuels consumed. [2].

Oxygenated fuel has a number of different additives that can be inserted in order to produce the desired effect. For many years, MTBE was a common additive for oxygenated fuel. However, MTBE was later found to be harmful to groundwater and has since been outlawed as a gasoline additive ins ome countries. In more recent years, ethanol has become the additive of choice for oxygenated fuel in many places around the world. In the United States, it is produced mainly from corn. In Brazil, sugar is the crop of choice for producing ethanol. Research continues to look at ways to use other products for the manufacturing of ethanol. For example, switch grass is targeted as the next generation ethanol oxygenated fuel.

The use of an oxygenating agent with fuel oil to adjust the fuel constitution has been considered as one of possible approaches for improving the emission characteristics of diesel engines.

II. LITERATURE SURVEY

D. Gopinath, E. Ganapathy Sundaram in 2012, investigated the use of DMC i.e. an oxygenated additive in order to improve the efficiency, combustion stability and emission performance of a spark ignition engine. They added oxygenated fuel (DMC) to gasoline. In this experimental work, the effect of using 100% gasoline and gasoline-DMC blends (D5, D10, D15 and D20) on four cylinder engine performance and exhaust emissions were investigated for different engine speeds. The investigation was conducted on a multi cylinder, four stroke spark ignition engine. The emissions were measured using exhaust gas analyzer. The experimental results show that the blending of DMC with gasoline increases the thermal efficiency of engine as compared to 100% gasoline as a fuel. The study also found that decrease of CO and HC with the blending of DMC with gasoline.[2]

Jing GONG, Yingjia ZHANG, Chenglong TANG and Zuohua HUANG in 2014 investigated the different characteristics using iso propanol as an additive. The effects of different iso-propanol percentages, loads and exhaust gas re-circulation rates on emissions were analysed. Results show that the introduction of exhaust gas re-circulation reduces the NOx emission and NOx emission gives the highest value at full load condition. HC and CO emissions present inconspicuous variations at all the loads except at the load of 10%. Additionally, HC emission shows a sharp increase for pure Propanol when the exhaust gas re-circulation rate is up to 5%, while little variation is observed at lager exhaust gas re-circulation rates. Moreover, the particulate matter number concentration increases monotonically with the increase of load and the decrease of exhaust gas re-circulation rate. There exists a critical spark timing that produces the highest particulate matter number concentration at all the blending ratios. [3]

C Anish Raman, Dr. K. Varatharajan, P. Abinesh, Dr. N. Venkatachalapathi, in March 2014 carried out the analysis of MTBE as an oxygenated additive. In order to improve the emission properties and performance an oxygenated additive MTBE (Methyl tertiary butyl ether), is blended with gasoline. Tests were carried out with 100% pure gasoline and MTBE –blended gasoline (M5, M10). The BSFC and BTE of MTBE blended gasoline were observed to increase when compared to pure gasoline. Significant reduction in HC and CO emissions were observed with MTBE blended gasoline; however, CO2 and NOX emissions were increased. [4]

Dhanapal Balaji, Periyasamy Govindarajan and Jayaraj Venkatesan in 2010 carried out the investigation of the effect of using unleaded gasoline and additives blends on Spark Ignition engine (SI engine) combustion and exhaust emissions. A four stroke, single cylinder SI engine was used for conducting this study. Exhaust emissions were analysed for Carbon Monoxide (CO), Hydrocarbon (HC) and Oxides of Nitrogen (NOx) and carbon dioxide (CO2) using unleaded gasoline and additives blends with different percentages of fuel at varying engine torque condition and constant engine speed. The result showed that the blending of unleaded gasoline increases the octane number and power output this may lead to increase the brake thermal efficiency. The CO, HC and NOx emissions concentrations in the engine exhaust decreases while the CO2 concentration increases. Thus they concluded that Using ethanol as a fuel additive to unleaded gasoline causes an improvement in combustion characteristics and significant reduction in exhaust emissions. [5]

S.Babazadeh, Shayan, F.Ommi, S.M.Seyedpour, M.Alizadeh in 2011 studied the influence of oxygenates blending with gasoline on fuel properties. The purpose of their research was to study the effect of oxygenate additives into gasoline for the improvement of physicochemical properties of blends. Methyl Tertiary Butyl Ether (MTBE), ethanol, Tertiary butyl alcohol (TBA), and Di-isopropyl ether (DIPE) have been blended into unleaded gasoline with various blended rates of 2.5%, 5%, 7.5%, 10%, 15%, and 20%. The Reid vapour pressure (RVP) of gasoline was found to increase with the addition of the oxygenated compounds. All oxygenates improve both motor and research octane numbers. [6].

H S Farkade, A P Pathre in April 2012 did the experimental investigation of methanol, ethanol and butanol blends with gasoline on SI engine.Thestudy of three alcohols was done in two parts. Comparative study of methanol, ethanol and butanol on the basis of blending percentage is first part, followed by investigation of oxygen role on the basis of oxygen percentage in the blend. The result shows highest replacement of gasoline by butanol at 5 % of oxygen content, the performance of same oxygen percentage for other two alcohols are also better. Presence of oxygen gives you more desirable combustion resulting into low emission of CO, HC and higher emission of CO2 as a result of complete combustion, higher temperature is also favorable for NO emission resulting higher emissions for it. [7]

III. OXYGENATED FUEL ADDITIVES

A. Types Of The Oxygenated Fuel Additives:

The oxygenated fuel additives have generally alcohol and ether as base. The shortlisted fuel additives can further categorized as:

Alcohol: -methanol, ethanol, isopropyl alcohol, n-butanol

Ethers: - methyl tertiary butyl ether, ethyl tertiary butyl ether, diisopropyl ether, tertiary amyl Methyl ether, tertiary amyl ethyl ether and tertiary hexyl methyl ether.

Apart from the above mentioned additives, DMC (Di Methyl Carbonate) and EGM (Ethylene Glycol Mono acetate) are also used.DMC is an oxygenated fuel with the oxygen content of 53.3%, which is usually used as an oxygenated additive to blend with fuels to improve combustion and reduce emissions of engines.

Methanol behaves much like petroleum and so, it can be stored and shifted in the same manner. It is more fixable fuel than hydrocarbon fuels permitting wider variation from ideal A: F ratios. It has relatively good lean combustion characteristics compared to hydrocarbon fuels. Its wider inflammability limits and higher flame speeds have showed higher thermal efficiency and lesser exhaust emissions compared with petrol engines.

Exhaust CO and HC are decreased continuously with blends containing higher and higher percentage of methanol. 1% methanol in petrol is used to prevent freezing of fuel in winter. Because of its excellent anti-knock characteristics of the fuel, it is much suitable for S.I. engines.

Ethanol was the first fuel among the alcohols to be used to power vehicles in the 1880s and 1890s. Henry Ford presented it as the fuel of choice for his automobiles during their earliest stages of development.

The blending of methyl tertiary butyl ether (MTBE) into motor gasoline has increased dramatically since it was first produced 20 years ago. MTBE usage grew in the early 1980's in response to octane demand resulting initially from the phase-out of lead from gasoline and later from rising demand for premium gasoline. Keskin and Guru indicated the addition of iso-propanol decreased NO*x* and CO2 emissions, while increased CO and HC emissions. Lu *et al*. reported that a large proportion of iso-propanol addition combined with cold exhaust gas recirculation (EGR) could reduce the combustion rate and increase CO and HC emissions. Isopropyl alcohol is also used as anti-icing agent in carburetor.

ETBE has higher boiling point and lower vapor pressure than MTBE, which ensure that ETBE is compatible to be blended into gasoline, allowing a more efficient blending and the mixed gasoline can be transported via pipeline without any problem.

Isopropyl alcohol is a major ingredient in "gas dryer" fuel additives. In significant quantities, water is a problem in fuel tanks, as it separates from the gasoline, and can freeze in the supply lines at cold temperatures. Alcohol does not remove water from gasoline; rather, the alcohol solubilizes water in gasoline. Isopropyl alcohol is also used to remove brake fluid traces from hydraulic braking systems, so that the brake fluid does not contaminate the brake pads, which would result in poor braking.

TAME (tertiary amyl ethyl ether) is mostly used as an oxygenate to gasoline. It is added for three reasons: to increase octane enhancement, to replace banned tetraethyl lead, and to raise the oxygen content in gasoline. It is known that TAME in fuel reduces exhaust emissions of some volatile organic compounds.

B. Theoretical Analysis:

First step in understanding the effect of additive is to understand its physio-chemical properties. So First we tabulated the properties of additives to understand their behavior as shown in table 4.2.1

The chemical properties of all the shortlisted additives are tabulated as follows:

Table No. 4.2.1 Comparison Table of properties of different Additives

Additives	Molecular Formula	Molar Mass (g/mol)	Appearance	Density (g/cc)	Melting Point (°c)	Boiling Point (°c)	Solubility In Water (g/l)	Heating Value (MJ/KG)	Flash Point (°c)
DMC	C3H6O3	90.08	Clear liquid	1.069-1.073	4-Feb	90	13.9	13.5	-
MTBE	C5H12O	88.55	-	0.7404	-109	55.2	26	35.1	-10
Ethanol	C2H6O	46.07	Colorless	0.789	-114	78.37	Miscible	26.95	16
Isopropyl alcohol	C4H8O	60.1	Colorless	0.786	-89	82.6	Miscible	30.44	11.7
N Butanol	C4H10O	74.12	Colorless refractive liquid	0.81	-89.8	117.7	Very soluble in acetone	33.075	35
ETBE	C6H14O	102.17	Clear colorless liquid	0.7364	-94	69	Miscible	36.31	-19
TAME	C6H14O	102.17	Clear colorless liquid	0.7404	-80	86.3	Soluble	36.392	-11

IV. TESTING METHODOLOGY

During literature survey we also focus on testing methodology adopted during experimentation .Its observed as follow

A. Experimental Setup

Experimentation is carried out on computerised SI Engine which is connected to gas analyser as shown in figure 5.1.1. Most of SI Engine were single cylinder eddy current dynamometer. Tests were conducted on two basis Variable load condition or Variable speed condition. Then reading of performance parameter and emission parameter were recorded using computer software.

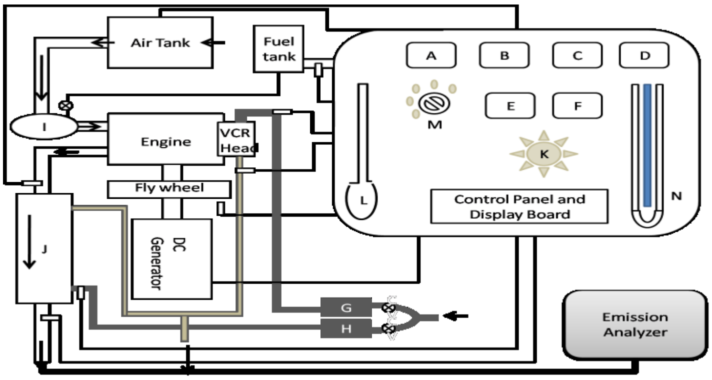

Fig. 5.1.1 Experimental Setup [L6]

V. OBSERVATIONS

Through literature survey, we note down the effect of different additive on SI engine performance and emission. Based on it effect wether positive or negative we arrange it in tabular form as shown in

Table 6.1 : Comparison of Effects of the Additives on Emissions

Additive	CO	HC	CO_2	NO_X	BSFC	BTE
MTBE	Improvement	Improvement	Negative Effect	Negative Effect	Negative Effect	Improvement
DMC	Improvement	Improvement	Negative Effect	Negative Effect	Improvement	Improvement
N-BUTANOL	Improvement	Improvement	Negative Effect	Negative Effect	Negative Effect	Improvement
ETHANOL	Improvement	Improvement			Improvement	Improvement
ETBE	Improvement	Improvement		Improvement		
IPA	Improvement	Negative Effect	Improvement	Improvement	Negative Effect	

Improvement   Negative Effect

VI. CONCLUSIONS

The characteristics of performance and various emissions of a Spark ignition engine fuelled with different oxygenated fuels were investigated as shown in the table 4.4.1 from the table we conclude that most of the oxygenated additives show improvement in the performance. This positive effect results in

- Reduced CO emissions
- Reduced CO2 emissions
- Reduced HC emissions

Thus these additives can be blended to obtain optimum performance & reduced emissions. However the major drawbacks in the use of oxygenated fuel additives include the cost and the fact that they are not abundantly available among others. Also in most of the cases we observe that though with positive effects, the BSFC increases which may not be desirable & increases the cost as well.

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