Experimental Investigation on CI Engine Using Alcohol Fumigation Method for Emission Reduction

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Abstract— Currently any internal combustion engine requires high performance and reduced emissions. The use of alternative fuels in CI engine that are produced from non-petroleum resources is suggested as one of the promising methods for improving performance and reduction emissions. This Fuels are suggested by researchers are alcohols, ethers, vegetable oils and bio-diesel etc. Alcohol is oxygenated fuel which promising fuel characteristic reduction in emission that have for better combustion in C.I engine and has low viscosity than diesel fuel which makes the alcohol easily to be injected and atomized and mixed with air. There are several techniques available for using alcohol as a fuel in CI engine like Alcohol fumigation, Alcohol-diesel blend, emulsification and duel injection in which problem associated is stability of fuel which can be overcome by alcohol fumigation. Alcohol fumigation is a dual fuel engine operation technique in which alcohol fuels are premixed with intake air. Alcohol fumigation is getting high demand as an effective measure to reduce pollutant emission from CI engine vehicles. The aim of this study is to identify the potential use of alcohol in fumigation mode on diesel engine. This study investigates the exhaust emissions and exhaust emission characteristics of CI engine using fumigated alcohol. Find out optimum percentage of the premixing alcohol.

Keywords: CI Engine, Emission Reduction

I. Introduction

Fossil fuels are the most imperative parameters to flourish the every sphere of modern civilization including industrial development, transportation, and power generation and easing the accomplishment of works. The rapid increase in usage of fossil fuel has unavoidable deleterious effect on environment. The international consciousness for environment protection is growing and evermore strict emission legislations are being enacted. Simultaneously the storage of fossil fuel is depleting. Hence, the above situations promote the scientists to find an alternative sustainable fuel along with their suitable using technique which will reduce the pollutant emission and will be applicable for gaining's at is factory engine performance. In these perspectives, alcohol fumigation is getting high demand as an effective measure to reduce pollutant emission from diesel engine vehicles. Alcohol fumigation is a dual fuel engine operation technique in which alcohol fuels are premixed with intake air.

A. Alcohol as an Alternative Fuel:

The use of alcohol fuels in internal combustion engine is not new. These fuels have been used intermittently in internal combustion engine since their invention. The first commercial use of ethanol as fuel started when the automobile company Ford designed Henry Ford's Model T to use corn alcohol, called ethanol in 1908. Ethanol became established as an alternative fuel in 1970s due to oil crisis. However, fossil fuel has been the predominant transportation fuel since the invention period of automotive engines due to the ease of operation for engine and availability of supply. But compared to alcohol fuels, fossil fuels have some disadvantages as an automotive fuel. Petroleum fuel has lower octane number and emits much more toxic emission than alcohol fuels. Due to having much more physical and chemical divers than alcohol, complex refining processes are required to ensure the consistent production of diesel and gasoline from petroleum fuel Moreover in recent years concern about environmental pollution has been increased. Therefore, alcohol fuels are attracting attention worldwide as supplementary fuel.

B. Ethanol Fuel

Ethanol consists of carbon, hydrogen and oxygen. Ethanol contains 2- carbon atoms having the molecular formula CH3CH2OH and isometric with di-methyl-ether (DME). Ethanol is capable to Ethanol is capable to mix with water completely. Ethanol has strong corrosion effects on aluminum, brass and copper made mechanical components. Ethanol also reacts with rubber and causes clogging inside fuel pipe. To avoid this problem, it is recommended to use fluorocarbon rubber instead of rubber However, due to higher compression ratio, ethanol allows more engine power than gasoline fuel. Ethanol is safer for transportation and storage for its higher auto ignition temperature than that of diesel fuel by fermentation and distillation process, ethanol can be produced from starch crops after converting into simple sugars.

Ethanol can be produced from a variety of cellulosic feedstock such as rice straw, corn stalks, sugarcane bagasse, switch grass and pulpwood. Ethanol from waste wood has significant potentiality to reduce CO2 emission from the life-cycle greenhouse g

C. Methanol Fuel

Methanol (CH_3OH), the most simple of the alcohols, is a light, colorless, volatile, flammable liquid with a distinctive odor Methanol does not contain sulphur or complex organic compounds Methanol gives higher thermal efficiency and emits less amount of pollutant emission than petroleum fuels. Due to having higher octane number, methanol is superb fuel for engines having high compression ratio. As an alcohol fuel, potential resources of methanol are huge. It can be made from any organic source including biomass. Although, most of methanol is produced from coal and natural gas, recently a number of studies have been done to evaluate the feasibility of bio methanol production from renew- able and sustainable sources. In this regard, forest biomass has obtained considerable attention to be an environmentally friendly sustainable source of methanol production However, methanol has lower calorific value and density than petroleum fuel hence larger storage tank is required to be installed in vehicles.

D. Properties of Alcohol

Alcohol fuels such as ethanol and methanol are viable alternative fuels for compression ignition (CI) engines. Alcohol has some effective characteristics which support complete combustion process and reduce pollutant emission from diesel engine. The characteristics are

Alcohol has low viscosity than diesel fuel which makes the alcohol easily to be injected and atomized and mixed with air.

Due to having high oxygen content, high stoichiometric air–fuel ratio, high hydrogen carbon ratio and low sulphur content, alcohol emits less emission.

Since alcohol has higher heat of vaporization, which results in cooling effect in the intake process and compression stroke. As a result the volumetric efficiency of the engine is increased and the required amount of the work input is reduced in the compression stroke.

Alcohol has high laminar flame propagation speed, which may complete the combustion process earlier. This improves engine thermal efficiency.

Alcohol fuels such as ethanol and methanol have the same physical properties as that of petroleum fuels. The physical properties of alcohol fuels in comparison to diesel fuel are given in Table 1.

	METHANOL	ETHANOL	DIESEL
FORMULA	CH3OH	CH3CH2OH	C14H30
MOLECULAR WEIGHT (G/CM3)	32.04	46.07	198.4
DENSITY	0.792	0.785	0.856
N. BOILING POINT	64	78	125-400
LHV (KJ/CM3)	15.82	21.09	35.66
LHV(KJ/KG)	19.99	26.87	41.66
EXERGY (MJ/LTR)	17.8	23.1	33.32
EXERGY (MJ/KJ)	22.36	29.4	46.94
CARBON CONTENT (WT %)	37.5	52.2	87
SULPHUR CONTENT	0	0	250

Table 1.1: Properties of Fuels

E. How to use alcohol in CI engine

Several techniques are available involving Ethanol diesel dual- fuel operation in CI engine. The most common methods applied for achieving dual fuel operation are:

– Ethanol blend- in this mode, alcohol and diesel fuels are premixed uniformly and then injected into cylinder directly through the fuel injector
– Ethanol –diesel emulsification- this mode, an emulsifier is used to mix the fuels to prevent separation.
– Dual injection- in this mode separate injection systems are used for fuels injection
– Alcohol fumigation- in this mode, alcohol fuel is introduced into the intake air up stream of the manifold by spraying or carbureting. Shown in fig:

II. EXPERIMENTAL SETUP

The experiment was carried out on single cylinder four stroke diesel engine. The main aim of the experimentation is to identify the potential use of alcohol in fumigation mode on diesel engine. This study investigates the exhaust emissions and exhaust emission characteristics of CI engine using fumigated alcohol. Brake specific fuel consumption and performance of the engine will also be observed at different loading conditions

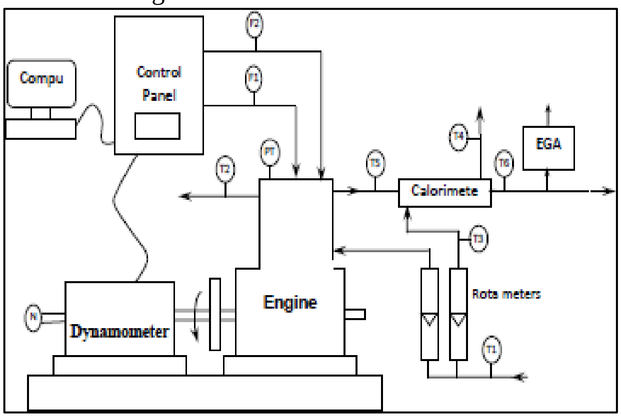

Fig: 2.1: Line diagram of experimental setup

Fig: 2.2: Experimental setup with instrumentation

Schematic diagram of experimental setup is shown in figure 2.2. The experimental setup comprises of single cylinder, four stroke, Multi-fuel, research engine. This engine is connected to eddy-current type Different other instruments are provided to interface are air box, fuel flow meter, temperatures and load measurement devices.

The specifications of the single cylinder four stroke C I engine used in this experiment is as shown in table 2.1

Engine manufacturer	Kirloskar (AV 1)
Software	Engine soft Engine performance analysis software
Engine type	Single cylinder four stroke engine
No. of cylinder	1
Type of cooling	water cooled
Rated power	3.7 kW @ 1500 rpm
Cylinder diameter	80 mm

Stroke length	110 mm
Lubrication	Wet sump Lubrication
Fuel tank capacity	6.5L
Fuel Supply	Direct injection
Starting	Hand Cranking
Dynamometer	eddy current, water cooled, with loading unit

Table 2.1: Engine Specification

For Alcohol fumigation, the separate setup is require which inject the alcohol inside the intake manifold. Different type of the component in the setup is given below:

1) Fuel pump
2) Alcohol injector
3) ECU
4) Encoder
5) Fuel tank
6) Fuel line

A. ECU and injector timer software:

Fig. 2.1: ECU

ECU and injector timer software are Show in figure aand 4.3 with using this we can set the injection pulse from 2 milli second to 20 mili second as per requirement and we obtain require premixing of alcohol

B. Encoder

Table 2.3 INJECTOR SPECIFICATION	
Hole	4
Spray shape	Circular
Injector pressure	5 bar
Length	729
Top diameter	10
Bottom diameter	9
Inner diameter	250
Electronically operated	

Fig. 2.2: Encoder

Shown in the figure encoder and how to assemble with engine. Encoder are driven by the engine using of pulley which rotate at same speed at which engine are running , it is use for the cut off the injection and then ECU generate the pulse according to the we set on injector timer software. This encoder are cut off the injection one time in two revolution.

C. Injector

Fig. 2.3: Injector

Fig. 2.3(b): Injector after fitting

For the alcohol injection into the intake manifold we use the injector which have injection pressure is 5 bar and operate by the electronic pulse which give by the ECU.at this pressure of 5bar alcohol is injected inside the intake manifold where the alcohol is premixed with the intake air.

D. Fuel Pump

Fig. 2.4: Fuel Pump

Pressure max	5 bar
Material	Aluminium
Battery	12 volt
Flow rate	250 LPH
Input diameter	11 mm
Output diameter	10 mm
Weight	0.366 kg
Length	120mm
Diameter	39.6 mm

Table 2.4: Fuel pump specification

Shown in figure the pump which used for alcohol injection. Which has aluminum body and length approximately 120 and diameter 39.4 and which develop 5 bar pressure required for the alcohol injection. Fuel pump operated by the 12 volt battery. This pump give flow rate of 250 LPH.

III. Result and Discussion

This chapter consists of comparatively analysis of results obtained from various percentage of premixed ethanol with diesel and diesel. Results from the premixed alcohol with diesel and diesel are compare and discussed through graphical representation This section consist of comparison of emission parameters for diesel and premixed ethanol. Emission parameters which are comparing are pollutants oxides of nitrogen (NO_x), hydrocarbon (HC), carbon monoxide (CO), and carbon dioxide (CO_2).

A. NOx emission

Variation of oxides of nitrogen (NO_x) with varied premixed quantity of ethanol with diesel are shown in below graphical representation as shown in figure 3.1

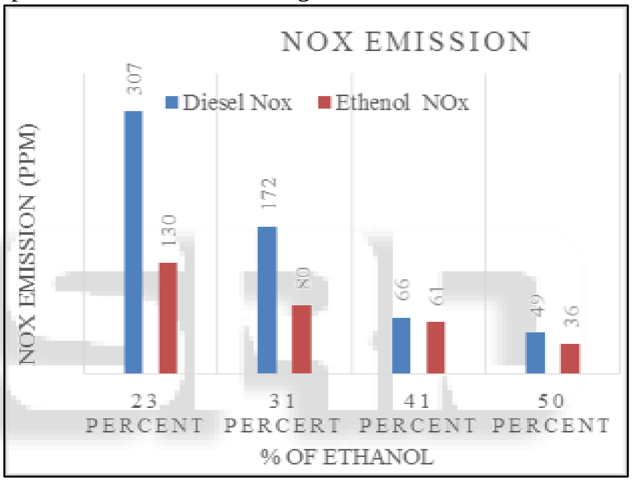

Fig. 3.1: comparison of oxides of nitrogen (NO_x)

Figure 3.1 shows the comparison of oxides of nitrogen (NO_x) emission at different percentage of alcohol are compare to diesel as shown figure 7.4. Emission of NOx at 23% premixing (at load=1.2), 31% premixing (at load= 0.8), 41% premixing (at load= 0.4) and 50 premixing (at load =0.2) is shown in graph. As shown in graphical representation NOx emission is lower with ethanol fumigation. NOx emission is increase as load increase and at low load NOx emission is lower where NOx emission is low at all the percentage of mixing comparatively diesel only to engine.

B. HC Emission

Variation of Hydro carbon (HC) with varied premixed quantity of ethanol with diesel are shown in below graphical representation as shown in figure 3.2.

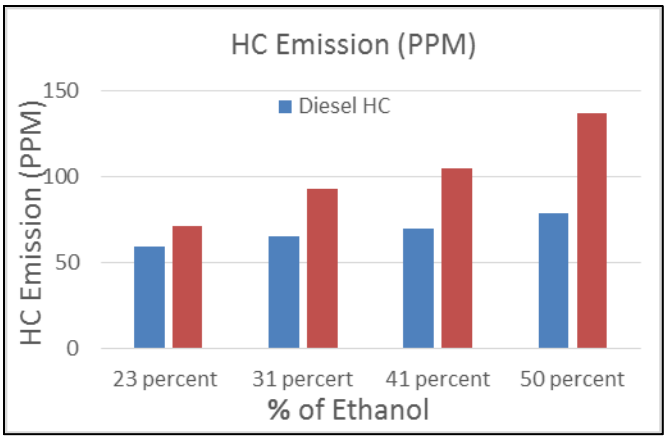

Fig. 3.2: comparison of hydrocarbon (HC)

Figure 3.2 shows the comparison of hydrocarbon (HC) emission at different percentage of alcohol are compare to diesel as shown figure 7.4. Emission of hydrocarbon (HC) at 23% premixing (at load=1.2), 31% premixing (at load= 0.8), 41% premixing (at load= 0.4) and 50% premixing (at load =0.2) is shown in graph. As shown in graphical representation hydrocarbon (HC) emission is increase with ethanol fumigation. Hydrocarbon (HC) emission is decrease as load increase and at low load hydrocarbon (HC) emission is higher where hydrocarbon (HC) emission is higher at all the percentage of mixing comparatively diesel only to engine.

C. CO2 emission

Variation of Carbon dioxide (CO2) with varied premixed quantity of ethanol with diesel are shown in below graphical representation as shown in figure 3.3.

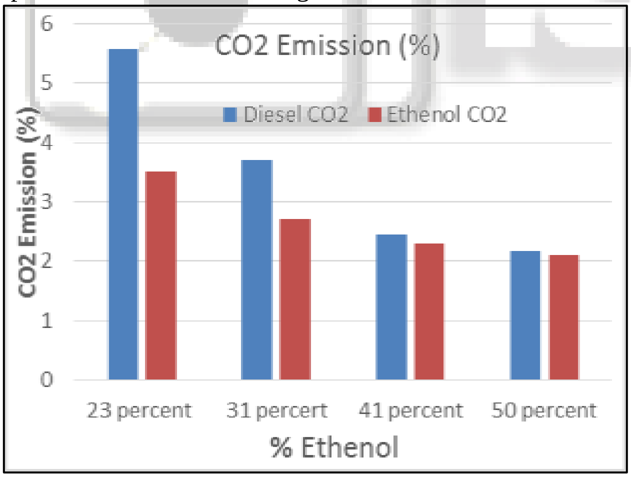

Fig. 3.3: Comparison of CO_2 Emission

Figure 3.3 shows the comparison of Carbon dioxide (CO2) emission at different percentage of alcohol are compare to diesel as shown figure 3.3. Emission of Carbon dioxide (CO2) at 23% premixing (at load=1.2), 31% premixing (at load= 0.8), 41% premixing (at load= 0.4) and 50% premixing (at load =0.2) is shown in graph. As shown in graphical representation Carbon dioxide (CO2) emission is lower with ethanol fumigation. Carbon dioxide (CO2) emission is increase as load increase and at low load Carbon dioxide (CO2) emission is lower where Carbon dioxide (CO2) emission is low at all the percentage of mixing comparatively diesel only to engine.

D. CO Emission

Variation of carbon monoxide (CO) with varied premixed quantity of ethanol with diesel are shown in below graphical representation as shown in figure 3.4.

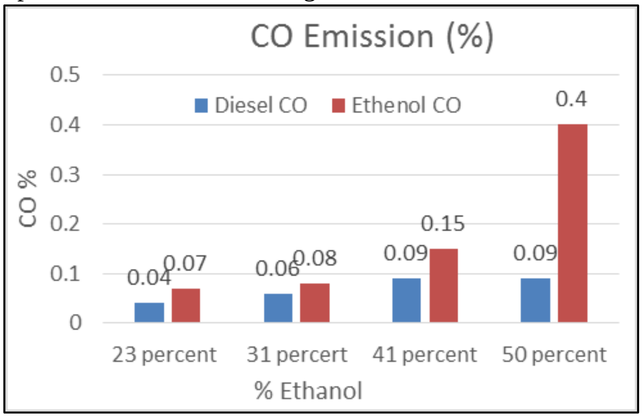

Fig. 3.4:

Figure 3.4 shows the comparison of carbon monoxide (CO) emission at different percentage of alcohol are compare to diesel as shown figure 7.4. Emission of carbon monoxide (CO) at 23% premixing (at load=1.2), 31% premixing (at load= 0.8), 41% premixing (at load= 0.4) and 50% premixing (at load =0.2) is shown in graph. As shown in graphical representation carbon monoxide (CO) emission is increase with ethanol fumigation. carbon monoxide (CO) emission is decrease as load increase and at low load carbon monoxide (CO) emission is higher where carbon monoxide (CO) emission is higher at all the percentage of mixing comparatively diesel only to engine.

E. PM emission

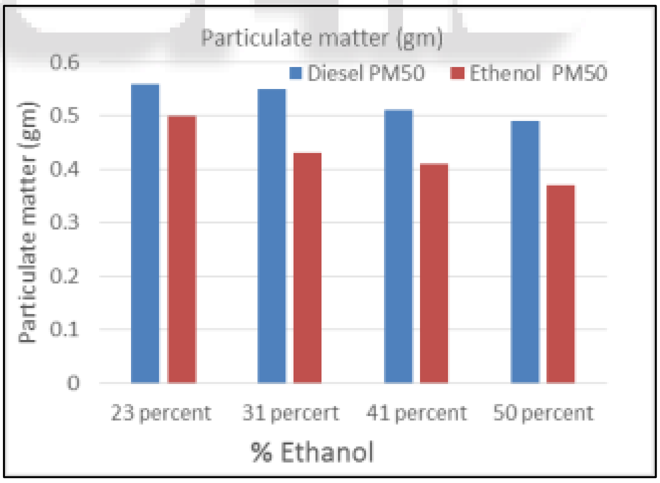

Fig. 3.5: PM emission

Fig 3.5 shows the comparison of particulate matter (PM) emission at different percentage of alcohol are compare to diesel as shown figure 7.4. Emission of particulate matter (PM) at 23% premixing (at load=1.2), 31% premixing (at load= 0.8), 41% premixing (at load= 0.4) and 50% premixing (at load =0.2) is shown in graph. As shown in graphical representation particulate matter (PM) emission is increase with ethanol fumigation. particulate matter (PM) emission is decrease as load increase and at low load particulate matter (PM) emission is higher where particulate matter (PM) emission is higher at all the percentage of mixing comparatively diesel only to engine.

IV. CONCLUSION

Ethanol fumigation is premixing method of reducing exhaust emission from the C.I engine which It's concluded from present research work that 23% premixing (at load=1.2), 31% premixing (at load= 0.8), 41% premixing (at load= 0.4) and 50% premixing (at load =0.2) of ethanol are supplied which can reducing the exhaust pollutant mainly PM and NOx. While other pollutant CO are increase but not too much but which can be control by some easy method. Few aspects that are concluded from present research work are as follow.

- By premixing of Alcohol with diesel can effectively reduce exhaust emission from conventional diesel engine.
- Here we found that Emission parameter are improved due to alcohol fumigation at higher load is more effective as compare to lower load so that we can say that 23% of alcohol fumigation are more effective as compare to other % of mixing.
- By the Alcohol fumigation, NOx and PM are reduce effectively where other side the CO is increase but not too much and this can be reduce by the oxygen catalyst.

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