Use of Ethanol on Construction Site

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***Abstract*—Bio fuels, Ethanol being the most promising among them is experimented to find out if it has potential to replace conventional high speed diesel used as a fuel in construction machineries like Dump Truck, Road roller and excavator at construction sites. This is done by quantifying the vehicular pollution parameters; CO, CO2, NOx and HC emitted from these vehicles while using high speed diesel and Ethanol as fuels. Considerable reduction in a green house gas like CO2 is observed when High speed diesel is replaced by Ethanol. The quantification of pollutants is done by using empirical formulas used by researchers earlier. Also considerable reduction in Carbon Monoxide (CO) and Hydrocarbons (HC) is also observed, but the increase in oxides of Nitrogen (NOx) is found to be an issue although not very significant since it can be resolved by adding some catalysts or by make modification in the catalytic converter of the exhaust of the construction machineries. The study highlights the use of ethanol as future fuel which is not only economical but is also environment friendly**

***Index Terms*—Petroleum base fuels, Pollution, construction, Ethanol, Fuel consumption, construction site**

I. INTRODUCTION

India is a developing country and there is a rapid growth in its Infrastructure. This growth has brought a large population from rural areas to urban cities resulting in overcrowding of cities. To solve this problem, many areas have seen a tremendous amount of construction of residential as well as commercial structures.

The building materials used in construction sites are found to cause all the types of pollution which includes air, water and soil pollution to the residential areas which are in nearby of such construction sites. The effect of such pollution may be minimized by taking precautions and using eco-friendly material However the pollution generated in the form of dust and air pollution by the machinery like Cranes, Excavators, Diesel operated generators, vibrators etc, is most often neglected due to its insignificant value when compared to other sources. But this insignificant value adds up to become severe due to rapid growth and increased quantum of construction

Non Conventional fuels have a potential to replace fossil fuel at the construction sites but its replacement will be possible when its advantages over conventional fuel like diesel will be known and accepted universally over a period of time. However use of petroleum based products in the form of diesel for operating machineries and in transportation is still in existence in many parts of the developing countries like India.

Diesel is a compound of hydrocarbons obtained by refining petroleum oil. All vehicles that use diesel release toxic pollutants into the atmosphere. The incomplete burning of diesel generates soot /particulate matter along with gases like nitrogen and sulfur, which are directly released into the atmosphere. These gases are invisible and the vehicle releases emissions even when it is idling.

Toxic fumes from the burning of diesel contribute to the production of ground-level ozone which damages crops, trees, and other vegetation. Also It produces acid rain, which affects soil, lakes, and streams and enters the human food chain via water, produces, meat and fish.

Considering all the above factors, diesel still contributes to a big portion of the pollutants in the air and therefore there is a need to use fuels that are alternatives to diesel.

Biofuels are liquid fuels that are made from biomass which is a cheap renewable source of energy. Ethanol and biodiesel are some of the types of biofuels available today, as alternative to petrol and diesel fuel In order to promote the use of Biofuels output for the growth ahead, the Union Cabinet (Govt. of India) has made new amendments in the National Policy.

Among these amendments, the Centre has allowed more feed stocks for biofuels productions and also plans to advance the ethanol blending target in petrol. Immense benefits like saving of Rs 30,000 crore of foreign exchange per year, energy security and lower carbon emission are expected for the country by simply allowing 20% ethanol blending in petrol and diesel for commercial activities. The other benefits for the country would be a better air quality, self-reliance, use of damaged food grains, increasing farmers' incomes, employment generation, and greater investment opportunities.

1.2 PROBLEM STATEMENT

1.2.1 Generation and direct release of particulate matter(soot) and flue gases like oxides of nitrogen (NOx) and sulfur (SOx), into the atmosphere due to use of diesel in construction machineries and transport vehicles .

1.2.2 Unavailability of the cost effective alternative to diesel as fuel in construction machinery and transport vehicles.

1.3 OBJECTIVE

Based on the discussion under the problem statement the following objectives are decided for carrying out the present work.

1.3.1 To study the types of construction equipment used on-site and study their fuel consumption and quantify their pollution potential.

1.3.2 To study types of bio fuels that can replace diesel, study and quantify their expected reduced pollution potential.

1.3.3 Compare pollution generated by use of diesel at construction sites with that generated by replacing diesel with specific type of bio fuel.

1.4 SCOPE OF PROJECT WORK-

Due to time and monitory limitation, the field work for actual carbon emission by petroleum diesel and Ethanol may be difficult however the present procedure could be observed and studied with available resources and try standardizing it within these limits. The work is proposed to be carried out within Pune.

81.5.1 Accurate quantification of pollution generated by use of diesel and its replacement may diesel requires expensive instruments and equipment to monitor emissions

1.5.2 Requires a completely detailed entry log of all the equipment used on site

1.5.3 Requires a list of vehicles used for transporting materials and other equipment

II. LITERATURE REVIEW

According to Paul Norton,in his 'The Ethanol Heavy-Duty Truck fleet demonstration' project,An ethanol engine could perform as well as a conventional diesel engine under the demanding condition of heavy-duty vehicle fleet operation. He also concluded that during the test, the drivers could not find a difference in horsepower or overall performance between ethanol and diesel. Also ethanol engines are as durable as diesel engines [1]

Rudolph Diesel (1900s) has tested peanut oil in his first engine after coal was found to be unusable Since the beginning of the automotive industry, Bio-fuels have been used in engines . In the 1940s, bio-ethanol blends, such as Monopolin, Agrol , and Discol, were commonly used in the World [2]

U.S. Department of Energy (1990) in their report have stated that during the late 1990s, with the rise in crude oil prices and concerns over energy security, the USA and many nations in Europe developed policies in support of domestic biofuels industries The interest in biofuels further increased in the past decade with the development of policies on climate change mitigation and strategies to reduce GHG emissions from the transport sector. More than 60 countries have since launched biofuels programmes and set targets for blending biofuels into their fuel pools [3]

Christian Rodriguez Coronado et Al (2007), have observed that after the Second World War, petroleum-derived fuel became cheaper hence further development of bio ethanol ceased. During the oil crisis in the 1970s, many countries showed renewed interest in the production of commercial bio-fuels; however, only Brazil started to produce ethanol on a large scale as part of the National Ethanol Programme 'Proálcool'[4]

In the research by Hasan Koten, result of the analyses, under stoichiometric conditions, with increasing ethanol content, there is a slight increase in indicated engine power and a decrease in ISEC values. Increasing ethanol amounts and maximum in-cylinder pressure and maximum normalized HRR data were closer to the TDC, and pressure data were

increased.Increasing ethanol ratio caused CO and specific THC emissions to improve significantly. Maximum improvement on specific CO emission was 7.33%, and maximum improvement on THC emissions was 6.62%.[5]

Ioannis Tsiropoulos et al (2014) have found that the reductions in Greenhouse gases emissions from biofuels are achieved at the expense of acidification, eutrophication, water footprint, and biodiversity loss [6]

Ioannis Tsiropoulos et Al (2014) concluded that the Indian government's plan on introducing biofuels to the market does not cause higher environmental impacts than those of other sugarcane ethanol-production chains. However, this conclusion is limited to the production in UP. Also, the low yields, their dependency on groundwater irrigation, the constrained ethanol production based on sugarcane molasses and potential displacement effects, the high input of agrochemicals and the current electricity of sugar mills indicate unexploited opportunities for global players, governments and other stakeholders to support implementation of better practices and improve the GHG emission, NREU, HH and EQ performance of Indian ethanol production.[6]

Marco L. Trani, et al (2016) proposed a quantitative method to predict the onsite fuel consumption of earthworks activities. First, the research identified fuel consumption agents related to earthworks activities. Then, an analysis of on-site fuel consumption was carried out by characterizing fuel equipment and load factors. Using data available from producers' technical manuals, and applying a cluster analysis method and then a linear regression, calculated load factors for a medium-sized tracked excavator, a small wheel loader, and a vibratory soil compactor. An analysis of transport fuel consumption was also undertaken. [7]

In another case, the Trani K.L. et al (2016), have developed an onsite model during planning stage and predicted onsite fuel consumption and corresponding carbon dioxide emissions arising from earthworks in residential construction projects. Then the next steps included onsite fuel consumption analysis for earthwork activities like Stripping overburdens, excavations, embankments and compaction. Characterization of fuel equipment and load factor (Average proportion of equipment power that is actually used) followed by Fuel consumption analysis in transport and estimation of onsite fuel consumption based on earthwork in the building projects [7]

Curto, J.W.(2020) have explained the different types of Bio- diesel, their origins and their unique characteristics and also include the emission trends of varying mixtures of diesel and bio-diesel. It was found that as bio-diesel concentrations increased in the fuel mixtures, carbon monoxide levels decreased. The carbon monoxide concentration held a 55negative linear relationship with increasing percentage of bio-diesel the fuel that less releases CO2 to the atmosphere is ethyl alcohol; on the contrary, the fuel that releases highest CO2 emission to the atmosphere is diesel fuel. Due to the oxygenated nature of biodiesel, where more oxygen is available for burning, this fuel produces decreased rates of unburned hydrocarbon and CO emissions in the exhaust. The main advantage is that CO2 emissions, in the case of use of biodiesel, can be regarded as carbon credit as it is a biofuels, produced by photosynthesis. Therefore, the emission levels using this kind of biofuels are 78.45% lower in comparison with those of diesel fuel. The real parameter considering the biodiesel life cycle is 0.578 ton CO2/m3 (B100). [10]

Renewable Fuel Standard (RFS) in the USA and the Renewable Energy Directive (RED) in Europe are the most notable standards [11]

While analysing the data collected on emission Mujtaba Hassani says that the researchers were convinced that pre-processing of the data set has a significant impact on the accuracy of the models, among to pre-processing approaches mean-centering and max-min scaling feature improves the forecasting degree of the models remarkably in the field of this data set. [12]

According to the report 'Roadmap for Ethanol Blending in India 2020-25' by Niti Aayog, Government of India has taken initiative to reduce the use of conventional fuel. By the year 2025, Flexi-fuel vehicles will be introduced which will run on E20 Fuel. Government has also announced tax benefits and financial aid for the production, vending and consumption of Ethanol and Ethanol blended [13]

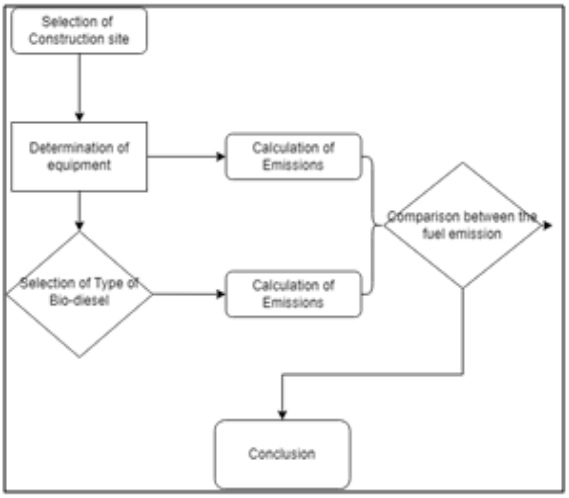
Important observations from the literature survey

1. Bio-fuels are looked upon as alternatives to petroleum-based diesel created from renewable resources.
2. Bio- diesel and Ethanol may prove to be good options for diesel.
3. Ethanol is produced from sugarcane molasses and use of Ethanol results into fewer emissions as compared to conventional fuels.
4. Little to no modification is required to use ethanol in diesel engine. Modification to Engine bore, Fuel Pump and other modification is necessary for biodiesel therefore Ethanol may prove to be a better fuel choice.

III. METHODOLOGY

The work is done according to the following process

1. Determination the consumption of diesel used in Road roller, Dump truck and excavator used at the Pride city's construction site.
2. Determination of the emissions of the particular vehicles and economical worth of that fuel
3. Selection of the type of bio-fuel for the given equipment based upon the environment as well as economical aspect
4. Comparison of cost, efficiency, and pollution potential of the use of Petroleum diesel and the bio-diesel of choice.
5. Concluding the results.



IV. EXPERIMENTAL ANALYSIS

4.1 Fuel choice:

For the alternative fuel, we will be using Ethanol. Ethanol requires little to no engine modifications. When Ethanol is used in a Compression Engine, the higher compression ratio gives the ethanol efficiency.

4.2 Details of construction site and machineries:

According to our methodology, we have to find the fuel consumption of the Road roller, dump truck and excavator used on the construction site. The construction site chosen for the work is Pride world City, Pune.

Pride world city is located in Charholi budruk area of Pune city. The construction project is of 400 acres. The building chosen for the research is a 20- storey apartment building.

Figure 4.1: Map of the location

At present, the construction ruction of about 8 buildings is going on in different stages of construction. The machineries used for carting of material and other work like excavation and refilling and leveling of road work are Road Roller, Dumper truck and Excavator, breaker, Paver etc.

For this study we will consider the following equipment and vehicles:-

Road Roller
Dumper Truck
Excavator

4.1 Road Roller

The Road roller used on site is a old TATA S1210. The roller is 40 years old and well maintained. The road roller is powered by a 110 HP Diesel engine. It is used to flatten the surface, Consolidate and compact soil.

On the given site, the roller is used for approximately 5 to 5.30 hrs daily. The fuel required daily is 60-70 liters depending on the condition of soil.

Figure 4.2: Road Roller

4.2 Dumper truck

Figure 4.3: Dumper Truck

The dumper truck used on site is TATA LPK 2518. The truck is 3 years old. The truck is powered by 180HP diesel Engine with 700Nm of torque. It has a tipper of 14 cum and maximum permissible GVW of 25000 kg.

The truck is used for multiple purposes. For this study we have considered the use of the truck for dumping the excavated material out of the construction site. The dumping ground is 1.8 Km from the site. The road on the way to dumping ground is slight inclined and not in good condition.

The Truck consumes approximately 2-3 liters per trip to the dumping ground. On a average day it makes approximately 15- 20 trips a day to dump site. So it average daily consumption is 40 liters

4.3 Excavator

The Excavator used on site is JCB (3DX 2WD). The vehicle is 15 yrs old and is well maintained. The Excavator is powered by 75HP diesel engine. Its front loader has a capacity of 1.1 cum and backhoe (Large bucket at the end) loader has 0.26 cum. It can dig up to 5 meters.

The excavator uses 20 Liters of diesel per hour on full load for slightly deep, well drained, fine, calcareous soils on very gently sloping lands with mesas (small hill) and buttes (flat topped hill with slopes) with moderate erosion.

On average the excavator is used 2 Hours on full load and 2 hours on half load in a day. So it uses 60 liters of diesel on average per day.

Figure 4.4: Excavator

Next we are going to find the emissions given by the vehicles. For this we will be testing for the instantaneous emissions due to limitation in sampling method.

We will be using an Exhaust gas analyzer and Smoke Meter.

The Exhaust gas analyzer shows the percentage of CO, CO2 and it shows Hydrocarbons in PPM. The smoke meter shows the light absorption which indirectly shows the soot in the exhaust gas.

4.4 Exhaust Gas analyzer

The gas analyzers works on Non dispersive Infrared sensor (NDIR). The main components of NDIR sensors are an infrared source, a sample chamber and an infrared (IR) detector. The IR light is passed through the sample cell & Reference cell and reaches the detector. Reference cell is filled with a gas, typically nitrogen. The gas to be measured is called as sample gas. This sample gas passes through the sample cell. A chopper is used to split the source i.e. IR rays to pass via both sample and reference cells. The parts of the Gas analyzer are shown in Figure 4.5 while the Gas analyzer is shown in Figure 4.6.

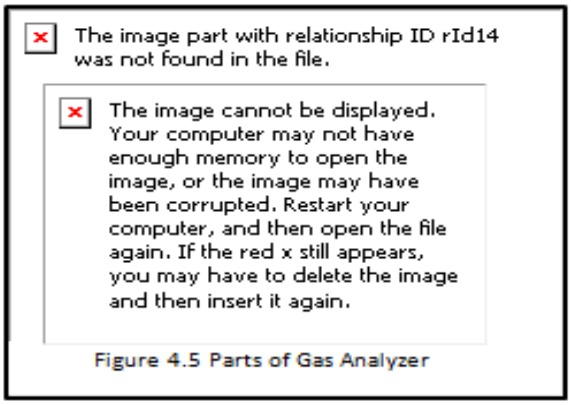


Figure 4.5 Parts of Gas Analyzer

The gas in the sample cell causes absorption of specific wavelengths according to the Beer–Lambert law, and the attenuation of these wavelengths is measured by the detector to determine the gas concentration. The detector has an optical filter in front of it that eliminates all light except the wavelength that the selected gas molecules can absorb.

Beer - Lambert Law:
I = I 0 e kP
where:
I = the intensity of light striking the detector
I 0 = the measured intensity of an empty sample chamber
k = a system dependent constant
P = the concentration of the gas to be measured
NDIR sensors can be used to measure practically all inorganic and organic gases, but are most often used for measuring carbon dioxide because no other sensing method works as simply and reliably for this gas. Calibration gases of specific concentration are available for determining the system constant k for any particular sensor design.

Figure 4.6 Gas Analyzer

4.4.1 Gasses Measured, Method:
The following pollutants except NOx mentioned below are measured in the form of gases by using, non dispersive Infrared sensor (NDIR) method.
HC (Hydrocarbon)
CO (Carbon Monoxide)
C02(Carbon Dioxide)
NOx (Nitric Oxide): Electrochemical Method

4.4.2 Measurement Range, Resolution:
The following pollutants mentioned below are measured in the form of gases by using Non dispersive Infrared sensor (NDIR) method.
CO : 0-9.99%: 0.01%
C02: 0-20.00%: 0.10%
HC (Propane): 0-20,000 ppm : 1.ppm
Lambda: 0.200 - 1.800%: 0.001 %
Air I fuel: 0-30:1:1

4.5 Fuel consumption calculation.
The fuel consumption equation [1] is a self derived equation derived with reference to reference [7] & [10]
So the total fuel consumed per day on construction site is

$$Fuel_{total} = Fuel_{road\ roller} + Fuel_{excavator} + Fuel_{truck} \quad [1]$$

$$Fuel_{total} = 65 + 60 + 40$$

$$Fuel_{total} = 165 \text{ Liters}$$

Following are the data found for the emissions test. The results are directly taken from the gas analyzer readings

4.5.1 Emission test for Diesel:
Road roller

Parameter	At Idle RPM	At 2500 RPM
CO	4.0	4.7
Acceptable CO	5	5
CO2	3	3.5
Acceptable CO2	4	4
NOx	0.1	0.1
Acceptable NOx	0.3	0.4
HC	0.15	0.15
Acceptable HC	0.19	0.25
Light Absorption	0.82	0.89
Acceptable Light Absorption	1.62	1.62

Table 4.1: Emission of High speed diesel in a Road Roller

Dump truck

Parameter	At Idle RPM	At 2500 RPM
CO	4.8	5
Acceptable CO	5	5
CO2	3.1	3.1
Acceptable CO2	4	4
NOx	0.15	0.2
Acceptable NOx	0.3	0.4
HC	0.15	0.15
Acceptable HC	0.19	0.25
Light Absorption	0.75	0.801
Acceptable Light Absorption	1.62	1.62

Table 4.2: Emission of High speed diesel in a Dump Truck

Excavator

	At Idle RPM	At 2500 RPM
CO	4	4
Acceptable CO	5	5
CO2	4	4
Acceptable CO2	4	4
NOx	0.2	0.3
Acceptable NOx	0.3	0.4
HC	0.2	0.2
Acceptable HC	0.19	0.25
Light Absorption	0.90	0.95
Acceptable Light Absorption	1.62	1.62

Table 4.3: Emission of High speed diesel in a Excavator

Now we test for Ethanol blended High speed diesel for the same total quantity of 160 litres with same construction machineries viz. Road roller (65), Excavator (60) and Dump truck (40). The blend used in this study is E100 which is 100% Ethanol.

Following is the results of the emission test

4.5.2 Emission test for E100 Ethanol:

Road roller

Parameter	At Idle RPM	At 2500 RPM
CO	2.8	3.3
Acceptable CO	5	5
CO2	2.1	2.5
Acceptable CO2	4	4
NOx	0.12	0.12
Acceptable NOx	0.3	0.4
HC	0.10	0.10
Acceptable HC	0.19	0.25
Light Absorption	0.50	0.50
Acceptable Light Absorption	1.62	1.62

Table 4.4: Emission of E100 Ethanol in a Road

Dump truck

	At Idle RPM	At 2500 RPM
CO	3.4	3.5
Acceptable CO	5	5
CO2	2.1	2.1
Acceptable CO2	4	4
NOx	0.20	0.23
Acceptable NOx	0.3	0.4
HC	0.10	0.10
Acceptable HC	0.19	0.25
Light Absorption	0.55	0.55
Acceptable Light Absorption	1.62	1.62

Table 4.5: Emission of E100 Ethanol in a Dump truck

Excavator

Table 4.6: Emission of E100 Ethanol in an Excavator

Parameter	At Idle RPM	At 2500 RPM
CO	2.7	2.7
Acceptable CO	5	5
CO2	2.8	2.8
Acceptable CO2	4	4
NOx	0.22	0.32
Acceptable NOx	0.3	0.4
HC	0.16	0.18
Acceptable HC	0.19	0.25
Light Absorption	0.65	0.65
Acceptable Light Absorption	1.62	1.62

4.5.3 Economical aspect:

The rate of Diesel at the time of study is Rs 102.87 and the rate of Ethanol is Rs 63.45.

The Ethanol has a calorific value of 29.87 whereas High speed Diesel has a calorific value of 44 - 46. As we can see that ethanol has less calorific value, we need to burn more ethanol to get same power as diesel. The Equation 2 & 3 are self derived from the reference [7] & [10]

The total ethanol fuel required is calculated as

$$F_{ethanol} = \frac{\text{calorific value of diesel}}{\text{calorific value of ehanol}} \times \text{total diesel fuel required} \quad [2]$$

Which in this case is

$$F_{ethanol} = \frac{45}{29.87} \times 165$$

$$F_{ethanol} = 248 \text{ liters}$$

But when the ethanol is used in the diesel engine, it is more efficient due the greater compression ratio. This is makes ethanol 30% more efficient.

Therefore, the actual ethanol required is

$$F_{actual} = F_{ethanol} - \left(F_{ethanol} \times \frac{30}{100}\right) \quad [3]$$

$$F_{actual} = 248 - (248 \times \frac{20}{100})$$

$$F_{actual} = 198.4 \text{ liter} \sim 199 \text{ liters}$$

Therefore the total cost of Diesel is

$$102.87 \times 165 = \text{Rs. } 16973.55$$

And the total cost for ethanol will be

$$63.45 \times 199 = \text{Rs. } 12626.55$$

Cost difference

$$16973.55 - 12626.55 = \text{Rs. } 4347$$

V. RESULTS AND DISCUSSION

The field work is done at Pride city Construction sites to collect details of three types of construction

machineries; Road Roller, Dump truck and Excavator for calculating the their pollution emissions when used with two types of fuel viz. High speed diesel and 100E Ethanol.

The prominent pollution parameters viz. Carbon Monoxide (CO), Carbon dioxide (CO_2), Oxides of Nitrogen (NOx) and Hydrocarbons (HC), emitted by Road roller using two types of fuels viz. High speed diesel and Ethanol in equal quantities of 65 litres each is plotted against % in Air and is shown in Figure 4.7.

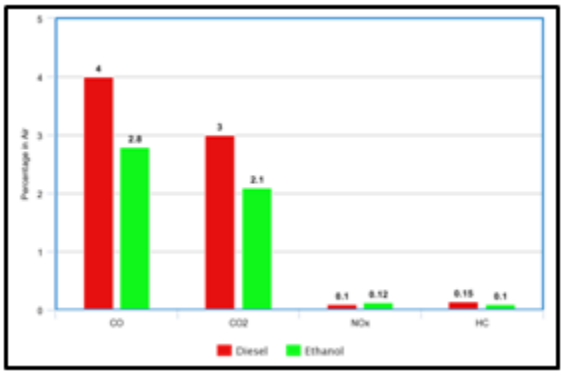


Figure 4.7 Emission Comparison for Road roller

The study of Figure 4.7 shows that the each CO and CO2 emissions are reduced by 30% when high speed diesel is replaced by E100ethanol. Although reduction in remaining two parameters viz. NOx and HC is not considerable but margins reduction is seen.

Similarly the graph between the prominent pollution parameters viz. Carbon Monoxide (CO), Carbon dioxide (CO_2), Oxides of Nitrogen (NOx) and Hydrocarbons (HC), emitted by Dump truck using two types of fuels viz. High speed diesel and E100 Ethanol in equal quantities of 40 litres each is plotted against % in Air and is shown in Figure 4.8.

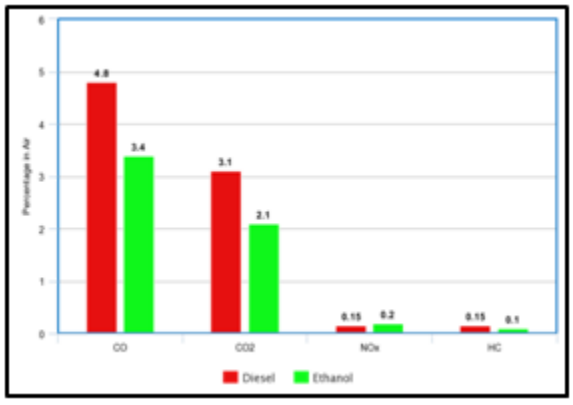


Figure 4.8 Emission Comparisons for Dump Truck

The study of Figure 4.8 shows that the each CO and CO2 emissions are reduced by 70% and 60 % respectively when high speed diesel is replaced by E100ethanol in Dump truck. Although a slight reduction in HC emission is seen there is a slight but not considerable increase in NOx is seen.

Similarly the graph between the prominent pollution parameters viz. Carbon Monoxide (CO), Carbon dioxide (CO_2), Oxides of Nitrogen (NOx) and Hydrocarbons (HC), emitted by Excavator using two types of fuels viz. High speed diesel and E100 Ethanol in equal quantities of 60 litres each is plotted against % in Air and is shown in Figure 4.9.

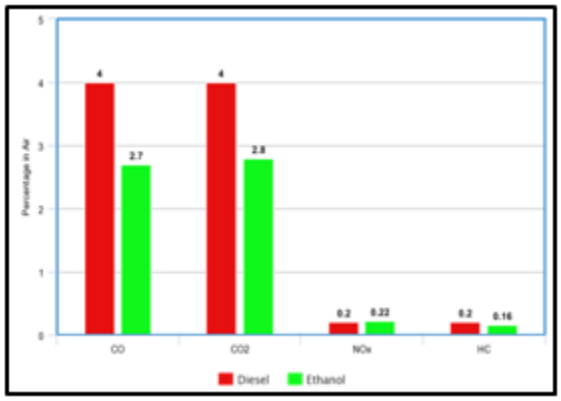


Figure 4.9 Emission Comparisons for Excavator

The study of Figure 4.9 shows that the each CO and CO2 emissions are reduced by 67% and70 % respectively when high speed diesel is replaced by E100ethanol in Dump truck. Although a slight reduction in HC emission is seen there is a slight but not considerable increase in NOx is seen.

The above discussion also confirms the consideration that unlike petroleum based fuels; ethanol produces no net carbon dioxide emissions since it is from plants that remove carbon dioxide from the air while growing.

The economical aspects of use of replacing High speed diesel with E100 Ethanol is also found to be promising since due to less calorific value of Ethanol(29.87), more quantity of ethanol i.e. 199 litres is required to be burnt to produce equivalent power produced by 165 litres of High speed diesel. Therefore even after considering higher consumption of E100 Ethanol, the saving in cost by replacing High speed diesel with E100 Ethanol works out to Rs.4347.00 and is calculated using equation 3

.Although not tested but with physical observation it is found that the combustion of Ethanol produces less soot than that of diesel resulting in less smoke due to clean burning of fuel

Therefore the Ethanol, which is produced at a cheaper cost than diesel, and is also found to reduce the majority of gaseous pollutants including green house gas CO2, it has a promising future to prove itself as a better choice for replacing diesel in construction machineries. Thus Ethanol is a future fuel with duel benefits of economy and environment friendly.

VI. CONCLUSION

The study carried out to find the feasibility of replacing use of High speed diesel by 100E Ethanol as fuel in construction machineries like Road Roller, Dump truck and Excavator used at Pride city Construction sites shows promise since it is cost effective and environment friendly.

The reduction in green house gas like CO2 emitted from the construction machineries is found to the great extent when diesel is replaced by Ethanol. Also there is a considerable reduction in Carbon Monoxide (CO) and Hydrocarbons (HC), but the increase in oxides of Nitrogen (NOx) is an issue although not considerable since it can be reduced by adding some catalysts or by make modification in the catalytic converter.

The pollution at the construction sites can be reduced by using bio-fuels which is possible since the use of ethanol requires no changes in engine. Therefore the contractors can easily adopt the same in their work. The availability of ethanol pumps for refilling which is a issue at this point of time may be resolved in future since Govt. of India has already approved its use and is giving subsidy and other encouragement to promote its use. Thus the ethanol has a potential to prove itself as a promising fuel of tomorrow.

FUTURE SCOPE OF WORK

There is a lot of research to be made for E100 fuel. Companies should be encouraged to build new hybrid and ethanol engines. These engines can be less effective to the wear and tear due to less lubricating properties of ethanol. Governments should incentivizing auto makers and general public to shift to ethanol based blends. Government should encourage citizens by creating awareness for use of ethanol

New methods should be found in order to reduce the NOx emissions, as current methods viz catalytic converters are not that efficient.

Also new and better ways to improve the ethanol production economy and efficiency are to be researched and found.

Incentivizing farmers and small producers to produce more crops that are used in production of ethanol can solve to problem of dependency for fuel on other country and can help stabilize India's economy

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