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# Analysis of Diesel Engine operating with Ethanol – Diesel Blends

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**Abstract**—globally there is renewed interest in the production of alternate fuels in the form of ethanol and biodiesel. This is mainly due to the realization that crude oil stocks are limited hence the swing towards more renewable sources of energy. The addition of alcohol to diesel fuel simultaneously decreases cetane number, high heating value, aromatics fractions and kinematic viscosity of alcohol blended diesel fuels and changes distillation temperatures. The stability and physiochemical properties of different diesel-alcohol blends and their composition depends on the solubility properties of the alcohols which are mainly dependent on the carbon chain length of the alcohol, their water content, additives, temperature and also on the hydrocarbon composition of the diesel fuel. Also various other physical properties such as stability, density, kinematic viscosity, flash point, surface tension, lubricity, safety and materials compatibility of most stable blends (both ethanol and butanol as per ASTM standards) also need to be considered. The blend of ethanol diesel of 5% was found to be more stable compared to other blends.

**Keywords**- Ethanol; biodiesel; cetane number; additives; flash point; blends.

## I. INTRODUCTION

In the last few decades, global warming, which is the rise in average temperature of the earth and climate change coupled with the threat to energy security are undeniably predominant among the most important issues in the world. With a rising population there is growing demand in products and services as economic development is accelerated which translates to an increased energy demand, which is projected to double by 2050. This means that in the years to come, the world's population is projected to increase and so is the demand in energy, which is in a paradoxical state with the fact that the traditional fossil fuels are finite in abundance. The fossil fuel production is more likely to peak in the 21st century with the additional fact that carbon emissions may rise due to falling fuel prices as a result of energy policies that focus on green energy. Fossil fuels are expected to be

extracted more from their current in a bid to avoid market competition from alternative fuels of the future leading to a risk of even higher temperatures. In addition to the traditional natural gas, coal, and petroleum oil, there is the recent introduction of shale oil and gas as a fossil fuel. Thus, it is easy to say the world is faced with a double edged sword of fossil fuel depletion and increased environmental degradation.

Transport sector especially road transport is a major contributor of the global warming via direct emissions of greenhouse gases such as carbon dioxide (CO<sub>2</sub>), and indirect greenhouse gases nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO) and volatile organic compounds (VOCs) and furthermore aerosols and particulate matter (PM), which affect the oxidation–reduction capacity of the atmosphere. This is due to the fact that transport sector is a major consumer of fossil fuels (gasoline, diesel, petroleum gas, natural gas, coal) as well as other kinds of fuels. In addition to contributing to the greenhouse gases' emissions, the transport sector is culpable for the deteriorating air quality in the urban areas which is a major risk to human health and it is expected to be the highest source of air pollution in the foreseeable future [1].

With increase in demand of petroleum products, corresponding decrease in availability and increase in oil prices with environmental pollution problems associated with the use of fossil fuel. The conservation of both the environment and energy sources has become important issues in the industrial and transportation sectors. As a result, the solution is to find new potential fields of petroleum and increase the efficiency with decrement in environmental pollution. In response to these social trends, many automotive companies and research centers have attempted to develop new engine technologies in order to meet strengthened exhaust emission regulations to satisfy the goals of saving energy and protecting the environment, many researchers have recently attempted to apply various alternative fuels [2].

India is importing the petroleum product from OPEC. It is facing the problem of hiking of prices for petroleum products and pollution caused by the

vehicles. Oil provides energy for 95% of transportation and the demand of transport fuel continues to rise. The requirement of Motor Spirit is expected to grow from little over 7 MMT in 2001 – 02 to over 10 MMT in 2006-07 and 12.848 MMT in 2011-12 and that of diesel (HSD) from 39.815 MMT in 2001-02 to 52.324 MMT in 2006-07 and just over 66 MMT in 2011-12. The domestic supply of crude will satisfy only about 22% of the demand and the rest will have to be met from imported crude. Our dependence on import of oil will continue to increase in the foreseeable future. It has been estimated that the demand for crude oil would go up to 85 MMTPA from about 50 MMTPA in 2001-02 while the domestic production will be around 22% of the demand. The crude prices and availability are subject to great volatility depending upon the international situation and, therefore, attempt needs to be made to reduce dependence on imports [3].

The popular option around the world for the current scenario is blending or mixing the petroleum product with easily available liquid i.e. various alcohols such as methanol, ethanol and butanol blended effectively with diesel or gasoline. These are becoming potential alternative fuels due to their liquid nature, high oxygen contents, high octane number and their production from renewable biomass. Hence the use of blends as fuel can ease the economic pressure globally and stress on non-renewable sources of energy would be minimized.

Rudolf Diesel invented and patented the diesel engine in 1892. This invention presented superior fuel efficiency, higher thermal efficiency, greater power output, better fuel saving, lower CO<sub>2</sub> emission, superior torque and longer durability in comparison to the spark ignition engine. Due to high fuel efficiency, the diesel engine became the engine of choice for on-road and off-road operations such as passenger vehicles, heavy trucks, buses, trains, boats and ships greatly impacting on agriculture, power generation and mass transportation sectors. The diesel engines can either be two-stroke or four-stroke. These engines release power by compressing air to attain high pressure and temperature of the injected fuel, which release chemical energy and work is done when there is expansion of the combustion gases. Hence, it is also called compression-ignition engine. Comparatively, a higher efficiency of diesel engine is achieved by operating at higher compression ratios and at relatively greater air to fuel ratios as well as having more rapid combustion and lower throttling losses. The diesel engine functions on diesel, which is a mixture of hydrocarbons with carbon number C<sub>6</sub>–C<sub>20</sub> aliphatic alkanes such as tetra-, penta- and hexa- decane being the major components, but with small quantities of branched alkanes and aromatic alkanes. Unfortunately, the major disadvantage of

diesel engines is that the combustion of diesel fuel either complete or incomplete results in emissions of hundreds of so called gaseous and particulate criteria pollutants such as CO<sub>2</sub>, CO, NO<sub>x</sub>, SO<sub>x</sub> and PM as well as non-criteria toxic pollutants such as PAHs, VOCs, dioxins and dioxin like compounds. These emissions pose a threat to the environment both atmospheric and ecological. Generally, the diesel engine emissions are chemically complex and vary widely. Primarily, the type and nature of diesel engine pollutants depends on the non-homogeneous nature of diesel fuel combustion, the combustion process conditions and the composition of diesel fuel and lubricating oils as well as the type and age of the engine, the operating conditions (temperature, air–fuel ratios, humidity etc.) and type of emission control devices used. Furthermore, the diesel engine actually is a source of hundreds of compounds and constituents in either gaseous or particulate forms only few of these have been classified as pollutants with potential impact to human health. This has been proven through measurements and studies done via tunnel studies; plume chase/on road studies, remote sensing or road side studies, chassis dynamometer studies and engine dynamometer studies. These pollutants are toxic and pose health problems in terms of respiratory complications as well as cardiovascular and carcinogenic and mutagenic diseases as indicated by human and animal toxicological tests [1].

## II. DIESEL FUEL

Diesel fuel is made from petroleum. All petroleum crude oils are composed primarily of hydrocarbons of the paraffinic, naphthenic, and aromatic classes. Each class contains a very broad range of molecular weights. Diesel fuel is refined petroleum product, divided into two classes high speed diesel and low speed diesel. The main characteristic of diesel fuel is that it is easily ignite and introduction is as short as possible. This means that the diesel fuel should contain hydrocarbon molecules as far as possible the straight chain with minimum of aromatic content and side chain hydrocarbon molecules [4].

Refining is the process of converting crude oil into high value products. The most important are transportation fuels: gasoline, jet fuel, and diesel fuel. Other products include liquefied petroleum gas (LPG), heating fuel, lubricating oil, wax, and asphalt. High-gravity crude oils contain more of the lighter products such as gasoline and generally have lower sulfur and nitrogen contents, which makes them easier to refine. These refining processes can be divided into three basic categories:

1. Separation processes
2. Upgrading processes
3. Conversion processes

A schematic layout of a modern, fully integrated refinery is shown in Figure (The diesel fuel related streams are highlighted in blue.) Crude oil is fed to the distillation column where straight-run naphtha, light and heavy gasoline, chemical naphtha, kerosene, and diesel are separated at atmospheric pressure. The diesel fuel produced by a refinery is a blend of all the appropriate available streams: straight-run product, FCC light cycle oil, and hydrocracked gas oil. The straight-run diesel may be acceptable as is, or may need minor upgrading for use in diesel fuel prepared for off-road use. To meet the 15 ppm sulfur limit, all the streams used to prepare diesel fuel need hydro treating to lower the sulfur concentration.

### III. ADDITIVES FOR DIESEL FUELS

#### Types of Additives

Diesel fuel additives are used for a wide variety of purposes. Four applicable areas are:

- A. Engine and fuel delivery system performance
- B. Fuel handling
- C. Fuel stability
- D. Contaminant control

#### A. Engine and Fuel Delivery System Performance Additives:

This class of additives can improve engine or injection system performance. The effects of Different members of the class are seen in different time frames. Any benefit provided by a cetane number improver is immediate, whereas that provided by detergent additives or lubricity additives is typically seen over the long term, often measured in thousands or tens of thousands of miles.

##### i. Cetane Number Improvers (Diesel Ignition Improvers)

Cetane number improvers raise the cetane number of the fuel. Within a certain range, a higher number can reduce combustion noise and smoke and enhance ease of starting the engine in cold climates. The magnitude of the benefit varies among engine designs and operating modes, ranging from no effect to readily perceptible improvement.

2-Ethylhexyl nitrate (EHN): 2-Ethylhexyl nitrate (EHN) is the most widely used cetane number improver. It is also called octyl nitrate. EHN is thermally unstable and decomposes rapidly at the high temperatures in the combustion chamber. The products of decomposition help initiate fuel combustion and thus shorten the ignition delay period from that of the fuel without the additive. The increase in cetane number from a given concentration of EHN varies from one fuel to another. It is greater for a fuel whose natural cetane number is already relatively high. The incremental

increase gets smaller as more EHN is added, so there is little benefit to exceeding a certain concentration. EHN typically is used in the concentration range from 0.05 to 0.4 percent mass and may yield a three to eight cetane number benefit. A disadvantage of EHN is that it decreases the thermal stability of some diesel fuels. This can be compensated for by the use of thermal stability additives.

Di-tertiary butyl peroxide (DTBP): Di-tertiary butyl peroxide (DTBP) is another additive which is used commercially as a diesel cetane improver; it is a less effective cetane number improver than EHN. However, DTBP does not degrade thermal stability of most diesel fuels, and it does not contain nitrogen (which may be important for meeting some reformulated diesel fuel regulatory requirements). Other alkyl nitrates, as well as ether nitrates, peroxides, and some nitroso compounds, have also been found to be effective cetane number improvers, but most are not used commercially. The effects of these other cetane number improvers on other fuel properties, such as thermal stability, are not fully known.

##### ii. Injector Cleanliness Additives

Fuel and/or crankcase lubricant can form deposits in the nozzle area of injectors i.e. the area exposed to high cylinder temperatures. The extent of deposit formation varies with engine design, fuel composition, lubricant composition, and operating conditions. Excessive deposits may upset the injector spray pattern which, in turn, may hinder the fuel-air mixing process. In some engines, this may result in decreased fuel economy and increased emissions. These additives are composed of a polar group that bonds to deposits and deposit precursors, and a non-polar group that dissolves in the fuel. Thus, the additive can re-dissolve deposits that already have formed and reduce the opportunity for deposit precursors to form deposits. Detergent additives typically are used in the concentration range of 50 to 300 ppm.

##### iii. Lubricity Additives

Lubricity additives are used to compensate for the lower lubricity of severely hydrotreated diesel fuels. They contain a polar group that is attracted to metal surfaces that causes the additive to form a thin surface film. The film acts as a boundary lubricant when two metal surfaces come in contact. Three additive chemistries, mono acids, amides, and esters, are commonly used. Mono acids are more effective, therefore lower concentrations are used (10 to 50 ppm). Because esters and amides are less polar so they require a higher concentration range from 50 to 250 ppm. Most ultra-low sulfur diesel fuels need a lubricity additive to meet the ASTM D 975 and EN 590 lubricity specifications.

##### iv. Smoke Suppressants

Some organometallic compounds act as combustion catalysts. Adding these compounds to fuel can reduce the black smoke emissions that result from incomplete combustion. Such benefits are most significant when used with older technology engines which are significant smoke producers. There is significant concern regarding potential toxicological effects and engine component compatibility with metallic additives in general. During the 1960s, before the Clean Air Act and the formation of the U.S. EPA, certain barium organometallics were occasionally used in the U.S. as smoke suppressants. The EPA subsequently banned them because of the potential health hazard of barium in the exhaust. Smoke suppressants based on other metals, e.g., iron, cerium, or platinum, continue to see limited use in some parts of the world where the emissions reduction benefits may outweigh the potential health hazards of exposure to these materials. Use of metallic fuel additives is not currently allowed in the U.S., Japan, and certain other countries.

#### B. Fuel Handling Additives

##### i. Antifoam Additives

Organosilicone compounds and are typically used at concentrations of 10 ppm or lower.

##### ii. De-Icing Additives

Low molecular weight alcohols or glycols can be added to diesel fuel to prevent ice formation. The alcohols/glycols preferentially dissolve in the free water giving the resulting mixture a lower freezing point than that of pure water.

##### iii. Low Temperature Operability Additives

Most of these additives are polymers that interact with the wax crystals that form in diesel fuel when it is cooled below the cloud point. The polymers mitigate the effect of wax crystals on fuel flow by modifying their size, shape, and/or degree of agglomeration. The polymer wax interactions are fairly specific; a particular additive generally will not perform equally well in all fuels.

The additives can be broken down into three idealized groups:

- Specialized additives for narrow boiling range fuels
- General purpose additives
- Specialized additives for high final boiling point fuels

##### iv. Conductivity Additives

In order to prevent static charge accumulation, anti-static additives can be used to improve the electrical conductivity of fuel. Anti-static additives are available in both metallic and non-metallic chemistries and are typically used at concentrations of 10 ppm or less.

##### v. Drag Reducing Additives

The high molecular weight polymers change the turbulent flow characteristics of fluids flowing in a

pipeline, which can increase the maximum flow rate from 20 to 40 percent. Drag reducing additives are typically used in concentrations below 15 ppm.

#### C. Fuel Stability Additives

Fuel instability results in the formation of gums that can lead to injector deposits or particulates that can plug fuel filters or the fuel injection system. The need for a stability additive varies widely from one fuel to another. It depends on how the fuel was made –the crude oil source and the refinery processing and blending. Stability additives typically work by blocking one step in a multi-step reaction pathway. Because of the complex chemistry involved, an additive that is effective in one fuel may not work as well in another.

##### i. Antioxidants

Antioxidants work by interrupting the chain reactions. Hindered phenols and certain amines, such as phenylenediamine, are the most commonly used antioxidants. They typically are used in the concentration range from 10 to 80 ppm.

##### ii. Stabilizers

The stabilizers used to prevent these reactions typically are strongly basic amines and are used in the concentration range from 50 to 150 ppm.

##### iii. Metal Deactivators

When trace amounts of certain metals, especially copper and iron, are dissolved in diesel fuel, they catalyze (accelerate) the reactions involved in fuel instability. Metal deactivators tie up (chelate) these metals and neutralize their catalytic effect. They are typically used in the concentration range from 1 to 15 ppm.

##### iv. Dispersants

Dispersants typically are used in the concentration range from 15 to 100 ppm.

#### D. Contaminant Control

This class of additives mainly is used to deal with housekeeping problems in distribution and storage systems.

##### i. Biocides

The best choice is an additive that dissolves in both fuel and water to attack the microbes in both phases. Biocides typically are used in the concentration range from 200 to 600 ppm.

##### ii. Demulsifiers

Demulsifiers are surfactants that break up emulsions and allow the fuel and water to separate. Demulsifiers typically are used in the concentration range from 5 to 30 ppm.

##### iii. Corrosion Inhibitors

Corrosion inhibitors are compounds that attach to metal surfaces and form a protective barrier that prevents attack by corrosive agents. They typically are used in the concentration range from 5 to 15 ppm [4, 5].

#### IV. ETHANOL

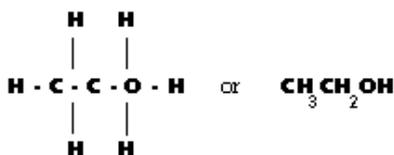
Ethanol is an attractive alternative fuel because it is a biological resource base and it is oxygenated, thereby providing the potential to reduce particulate emissions in compression ignition engines. It is accepted that the addition of ethanol to diesel oil have the beneficial effect of reducing emissions of particulates [6].

Raw material used for producing ethanol varies from sugar, cereals, sugar beet to molasses in India. Brazil uses ethanol as 100 % fuel in about 20 per cent of vehicles and 25% blend with gasoline in the rest of the vehicles. USA uses 10 % ethanol-gasoline blends whereas a 5% blend is used in Sweden. Australia uses 10% ethanol- gasoline blend. Use of 5% ethanol- gasoline blend is already approved by BIS and is in progressive state of implementation in the country. BIS standards for 10% blends need to be drafted after conducting trials and fixing parameters. Ethanol is generally used to blend in diesohol.

##### A. Characteristics of Ethanol

Ethanol is a

- Colorless, volatile, flammable liquid that is the intoxicating agent in liquors and is also used as a fuel or solvent
- It may be shown as:



- In its pure form, ethanol is a colorless clear liquid with a mild characteristic odor which boils at 78° C (172° F) and freezes at -112° C (-170° F).
- Ethanol has no basic or acidic properties.
- When burned, ethanol produces a pale blue flame with no residue and considerable energy, making it an ideal fuel.
- Ethanol mixes readily with water and with most organic solvents. It is also useful as a solvent and as an ingredient when making many other substances including perfumes, paints, lacquers, and explosives.

##### B. Manufacturing process of Ethanol

Ethanol can both be derived from fossil fuels, biomass, or perhaps most simply, from carbon dioxide and water. Ethanol is a product of fermentation. The major source of ethanol production in the country is via sugarcane-sugar molasses route. Fermentation is a sequence of reactions which release energy from organic molecules in the absence of oxygen. In this application of fermentation, energy is obtained

when sugar is changed to ethanol and carbon dioxide. Changing corn or sugar molasses to ethanol by fermentation takes many steps. Starch in corn must be broken down into simple sugars before fermentation can occur. In earlier times, this was done by chewing the corn. This allowed the salivary enzymes to naturally break down the starch. Today, this is achieved by cooking the corn and adding the enzymes alpha amylase and glucoamylase. These enzymes function as catalysts to speed up the chemical changes. Once a simple sugar is obtained, yeast is added. Yeast is a single-celled fungus that feeds on the sugar and causes the fermentation. As the fungus feeds on the sugar, it produces alcohol (ethanol) and carbon dioxide. In fermentation, the ethanol retains much of the energy that was originally in the sugar, which explains why ethanol is an excellent fuel [1].

#### V. ETHANOL DIESEL BLENDS (E DIESEL)

The equations are an exception to the prescribed Diesel generation in general emits large quantity of particulate matter and especially below micron 2.5 which being very small pass the protection system of the body to get lodged in lungs causing reduction in its vital capacity. More seriously than this is the association of the particulate matter with unburnt oil those are potential carcinogenic to human or animals.

For this reason, such particles are called respiratory particulate matter and in metro diesel driven vehicles are being phased out. Hence ethanol diesel blending is preferred; however the blend provides certain technical problems –

- The ethanol reduces the flash point of blend to 13<sup>0</sup>C i.e. at the level of pure ethanol which is 50<sup>0</sup>C lower than that of diesel. For the higher ambient temperature of the country, this disadvantage is not desirable and some additive may be required.
- Blend reduces the lubricity of the fuel and increases the wear of the piston rings and injector. In coming years, the sulphur content of the diesel is expected to be lower to 15 ppm and the lubricity of the blend may get further reduced.
- Ethanol and diesel fuel do not mix properly. It is found that the presence of water, or extreme cold temperature, causes the mixture to separate. The fuel mixture is known as a micro-emulsion and is prepared by splash blending in presence of a blending agent. Tolerance of water is influenced by the amount of aromatics level in diesel but generally is of the order of 0.1%. E-Diesel owes its commercial viability to the development of the

effective emulsifier, Puranol, invented by Pure Energy Corporation (PEC). Development of more effective emulsifiers is required.

- The cetane number of the ethanol is just 8 and so reduces the cetane number of diesel on blending.

The calorific value of ethanol is 42% lower than that of diesel on volume basis and would decrease the fuel economy and torque and would need higher injector size to obtain the same peak power. This problem is, however, of not much concern for blends lower than 5% [3].

The report is intended to provide a brief overview of the composition and properties of ethanol-diesel fuels. Also, comparative study of phase stability, the dependence of solubility on temperature (10, 20 and 30°C), and an evaluation of some basic fuel properties according to the ASTM of diesel-ethanol two component systems at different component concentrations was done.

## VI. EXPERIMENTAL PROCEDURE

### A. Materials used

The materials used for project work are Ethanol and Diesel as blends of various volumetric ratios. The ethanol (China Grade) used in the tests was limited to essentially anhydrous ethanol because other kinds of ethanol are not soluble or have very limited solubility in the vast majority of diesel fuels. The chemicals are of analytical grade and of good quality. Diesel used is acquired from the commercial supplier (HPCL). Glass wares used for the experimental work are lab scale and certified from the manufacturer. Various chemicals used are laboratory reagent grade from authorized manufacturer.

### B. Blending Procedure

The procedure for making the blend is as follows:-

1. Take the conical flask, measure the appropriate amount of diesel and pour into it.
2. Add respective amount of Ethanol into the Diesel for require % of the blend.
3. Close the conical flask and used the magnetic stirrer or the electric agitator for the proper mixing of the Ethanol. The main precaution has to take that while mixing it into diesel, the flask should be properly close so that air contact can be prevented.
4. Shaking is another option for the mixing of ethanol. It is carried for the time of 1-2hours for proper mixing.
5. The same procedure was carried out with other ratios of diesel and alcohol.

The blending of alcohol and diesel by this method is called “Splash Blending”.

## VII. RESULT AND DISCUSSION

### A. Effect on lubricity and viscosity

The viscosity of the Ethanol Diesel blend is measured in Oswald viscometer of type “A”. Experimental values of kinematic viscosity for various blends are shown in Table I. Figure 1 implies that viscosity of the Ethanol-Diesel blend decreases. As the increase in ethanol percentage in sample there is in decrease in kinematic viscosity of sample thus decreasing its lubricity action. Only 5% blend shows the kinematic viscosity in the diesel fuel specification.

TABLE I. KINEMATIC VISCOSITY OF ETHANOL-DIESEL BLENDS

Sample	Kinematic Viscosity at 40°C (centistokes)
Pure Diesel	2.8
5% Ethanol Diesel Blend	2.02
10% Ethanol Diesel Blend	1.95
15% Ethanol Diesel Blend	1.93
20% Ethanol Diesel Blend	1.81
25% Ethanol Diesel Blend	1.71

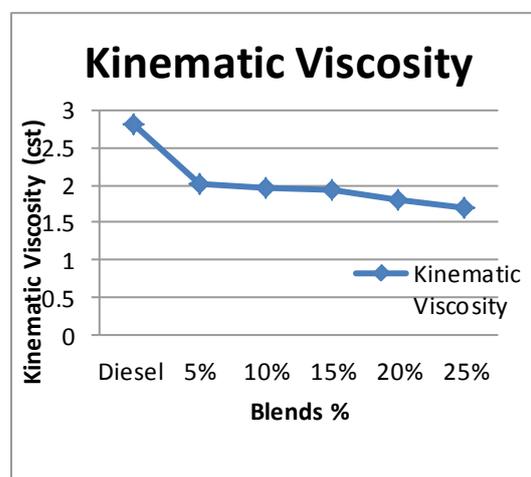


Figure 1 Kinematic viscosity Vs Blends of Ethanol Diesel Blends

### B. Effect on density, specific gravity and API gravity

The density of ethanol diesel blends is measured by gravity bottle at 15°C. Further, specific gravity and API gravity has been calculated. Experimental values of density, specific gravity and API gravity are shown in table II. The table II and figure 2 implies that the density and specific gravity of blends decreases with increase in ethanol

percentage. Whereas API gravity increases with increase in ethanol percentage. Due to addition of ethanol, the density of blend decreases thus making blends lighter.

TABLE II. DENSITY, SPECIFIC GRAVITY AND API GRAVITY OF ETHANOL DIESEL BLENDS

Sample	Density at 15°C in Kg/m <sup>3</sup>	Specific gravity	API Gravity
Pure Diesel	815	0.815	42.12
5% Ethanol Diesel Blend	812	0.812	42.76
10% Ethanol Diesel Blend	808	0.808	43.62
15% Ethanol Diesel Blend	805	0.805	44.27
20% Ethanol Diesel Blend	803	0.803	44.71
25% Ethanol Diesel Blend	801	0.801	44.93

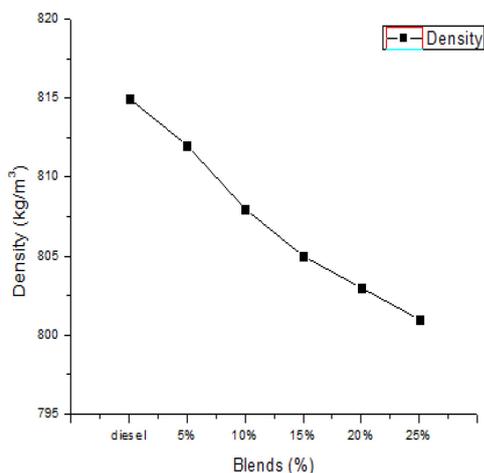


Figure 2 Density Vs Blends of Ethanol-Diesel

C. Effect on Flash Point

Flash point of blends was carried out in the Pensky Martin Flash point apparatus. The Experiments values of flash point for blends are shown in table III. After testing, it was found that the flash point of Ethanol–diesel fuel is mainly dominated by Ethanol. It seems from the figure 3 that the Ethanol-blend is having lower flash point means Ethanol-diesel blend can be used in cold climate purpose.

TABLE III. FLASH POINT OF ETHANOL DIESEL BLENDS

Sample	Flash Point in °C
Pure Diesel	46
5% Ethanol Diesel Blend	25
10% Ethanol Diesel Blend	21

15% Ethanol Diesel Blend	20
20% Ethanol Diesel Blend	20
25% Ethanol Diesel Blend	19

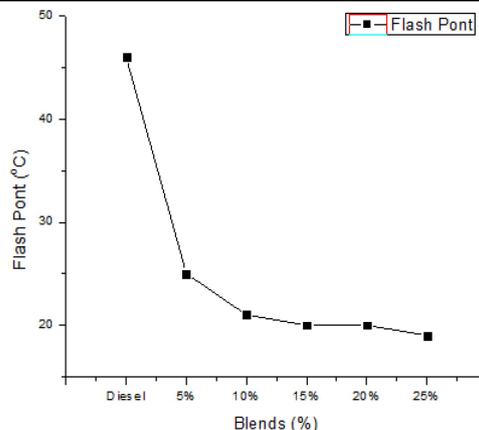


Figure 3 Flash Points of Ethanol Diesel Blends

D. Effect on ASTM distillation curve of Ethanol-Diesel Blends

The ASTM distillation was carried out in standard ASTM Distillation setup. ASTM distillation curve of diesel is compared with the curve obtained shown in figure 4. The boiling point of ethanol is below the lowest boiling fraction of normal diesel fuel. The addition of ethanol modifies the shape of distillation curve at temperatures below 200. The figure 4 shows that with addition of ethanol there is decrease in temperature range for lower percentage distillate.

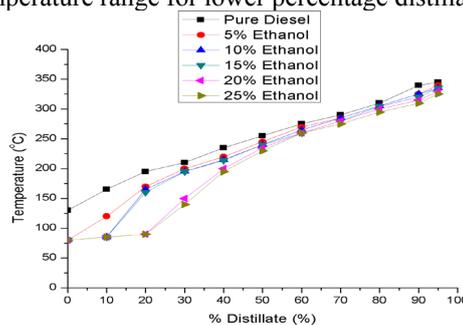


Figure 4 ASTM distillation graph of Ethanol-Diesel Blends

E. Effect on ASTM distillation curve of Ethanol-Diesel Blends

The Ethanol Blends were kept under the observation to check the stability of the fuel blend. Figure 5 shows the samples after phase separation. Experimental values are shown in table IV. It is observed from the figure 6 that the ethanol blends show phase separation as the quantity of ethanol increases. As the percentage of the ethanol increase in the diesel the stability of blend fuel decreases and

the phase separation occurs. For the 20% and 25% Ethanol Blend, it shows the immediate phase separation within few hours. Blend with 5% ethanol shows much more stability than the other blends.

Sample: Ethanol-Diesel Blend (Ethanol 5%, 10%,15%,20%, 25%)

Duration: 6 Days; Temperature range: 15 to 40 °C; Quantity of Samples each: 50 ml.

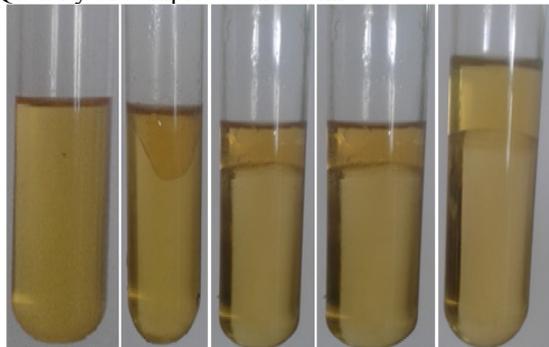


Figure 5 Photographic View of various Ethanol- Diesel Blends

TABLE IV. FLASH TIME DURATION FOR PHASE SEPARATION OF ETHANOL DIESEL BLENDS

5% Ethanol Diesel Blend	10% Ethanol Diesel Blend	15% Ethanol Diesel Blend	20% Ethanol Diesel Blend	25% Ethanol Diesel Blend
Phase separation after 4 days	Phase separation after 24 hours	Phase separation after 18 hours	Phase separation after 6 hours	Phase separation after 4 hours

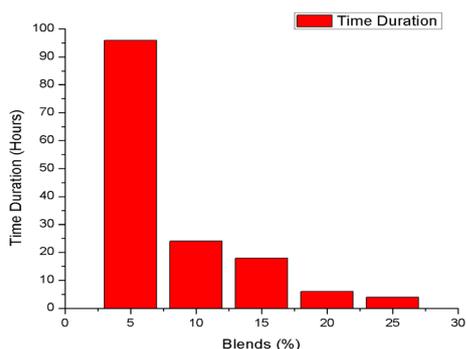


Figure 6 Graph of Time duration for phase separation of Ethanol Diesel Blends

F. Effect on Cetane Index

The Cetane index calculated from the four variable equations is calculated and shown in table VI. It shows that the value is decreasing with increase in the quantity of the Ethanol in the blend.

TABLE V. CALCULATED CETANE INDEX

Samples	Calculated Cetane Index
Pure Diesel	55.138
5% Ethanol Diesel Blend	53.34
10% Ethanol Diesel Blend	52.68
15% Ethanol Diesel Blend	52.12
20% Ethanol Diesel Blend	51.87
25% Ethanol Diesel Blend	51.58

VIII. CONCLUSION

This work was undertaken to study and compare the effects of different content of ethanol–diesel blend fuels. The diesel-alcohol fuel blends are very promising fuel alternative. The conclusion drawn from the results part are as follows:

- 5% Ethanol blends show much better fuel properties than other blends and are in comparative to pure diesel fuel properties. 5% Ethanol blend shows much better stability than the other blends. 5% blend shown phase separation after 4 days.
- 10% Ethanol blends show comparable fuel properties to pure diesel than other blends but shows poor stability. 10% blend shown phase separation after 24 hours.
- Further it is noted that water or moisture content and temperature impacts on face separation in ethanol diesel blends. Increase in water content quicker phase separation whereas increase in temperature prohibits phase separation.

The values of the produced diesel-ethanol sample for 5% and 10% blends are really promising and close to the value of a base diesel fuel for a better understanding of the behavior of blends containing ethanol.

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