International Journal of Scientific & Engineering Research Volume 13, Issue 9, September-2022
ISSN 2229-5518

Experimental Investigation of Diesel and Pentanol Blends as a Fuel in Direct Injection Compression Ignition Engines

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Abstract— Increasing industries and vehicles has led to greater use of petroleum products. Because of fuel cost and stringent emissions norms, diesel has become an attractive, efficient and less expensive fuel compared to petrol. However, diesel engines are at a disadvantage because they produce higher level of NOx, which is a toxic emission. In the Diesel engine No_x formation is mainly due to lean A/F mixture; increase in engine temperature, fuel spray structure and also by poor quality fuel. This problems results in reduce the engine life time and efficiency of the engine. In my experimental setup Pentanol is blended with ester as a fuel and introduced in twin cylinder engine to reduce the HC and CO formation. Pentanol is the new generation bio-fuels it will give good efficiency and reduce the No_xformation. Regarding the particulate emissions, n-pentanol is found to be very promising in terms of reducing both the mass concentration and the particulate number concentration simultaneously. By using n-pentanol as a fuel in diesel engines the results to be achieved are efficiency – Not affected, Co_2, CO emission are almost same as diesel ,NO_xemission decreases.

Index Terms—

B20	-Blend of 20 percent bio diesel and 80 percent of diesel fuel
BMEP	-Brake Mean Effective Pressure
CN	-Cetane Number
DPF	-Diesel Particular Filter
ECU	-Electronic Control Unit
EGR	-Exhaust Gas Recirculation
HCCI	-Homogeneous Charge Compression Ignition
HRR	-Heat Release Rate
IMEP	-Indicated Mean Effective Pressure
LNT	-Lean NO_x Trap

1 INTRODUCTION

Internal combustion engines are seen every day in automobiles, trucks, and buses. There are basically two types of I.C. ignition engines, those which need a spark plug, and those that rely on compression of a fluid. Spark ignition engines take a mixture of fuel and air, compress it, and ignite it using a spark plug. In a spark ignition engine a spark plug is required to transfer an electrical discharge to ignite the mixture. In compression ignition engines the mixture ignites at high temperatures and pressures. The lowest point where the piston reaches is called bottom dead center. The highest point where the piston reaches is called top dead center. The ratio of bottom dead center to top dead center is called the compression ratio. The compression ratio is very important in many aspects of both compression and spark ignition engines, by defining the efficiency of engines. Compression ignition engines take atmospheric air, compress it to high pressure and temperature, at which time combustion occurs. Internal Combustion Engines

1.1 Compression Ignition Engines

Compression ignition engines differ from spark ignition engines in a variety of ways but the most obvious one being the way in which the air and fuel mixture is ignited. In a compression ignition engine there is no spark to create the flame but rather high temperatures and pressures in the combustion chamber cause a flame to initiate at different sites of the combustion chamber. Compression ignition engines are divided into direct and indirect ignition engines. Direct injection engines use pressures of up to 1000 bars to inject fuel into the combustion chamber. High pressure is needed because the heat addition process takes place at a compressed state, so in order for the fuel to inject well the pressure has to be greater than the one that has been accumulated through compression. There are several engineered direct injection combustion chambers. The direction of swirl is at a downward angle so that proper mixing can take place. The compression ratio for direct ignition engines is usually between 12: 1 and 16: 1. Indirect ignition engines have a pre-combustion chamber where the air to fuel mixture is first stored. The purpose of the separate chamber is to speed up the combustion process in order to increase the engine output by increasing the engine speed. In divided chambers the pressure required is not as high as the pressure required for direct ignition engines. The pressure required for both type of divided chambers is only about 300 bars.

1.2 Combustion In CI Engines

The main difference between combustion in CI and SI engines is the way in which combustion occurs. In SI engines the combustion process first occurs by igniting a homogeneous mixture using a spark plug. The main difference arises when the flame is initiated and the flame travels at a certain direction, dictated by the flame propagation, whereas combustion in CI engines there is no flame propagation with a direction. Combustion in a CI engine is a non-steady process where a non-homogeneous mixture is controlled through fuel injection. The mixture is non-homogeneous since air is the only substance being compressed until late in the compression stroke. Injection of the fuel occurs at about 15^0 bTDC and ends at about 5^0 aTDC. Following are the steps that the fuel goes through, after injection, in order to cause the proper combustion.

1. Atomization: the fuel droplets break into smaller droplets.

2. Vaporization: the small droplets of fuel vaporize in the chamber due to high temperatures. About 90% of the fuel injected into the cylinder has been vaporized within 0.001 second after injection."

3. Mixing: after vaporization of the fuel, the fuel mixes with the air to form a combustible air-fuel mixture.

4. Self-ignition: self-ignition usually starts around 8^0 bTDC, 6-8, after the start of injection, At this point some of the mixture will ignite. These small reactions are caused by high temperature within the chamber. They are exothermic and further raise the temperature of the combustion chamber.

5. Combustion: combustion finally takes place after the self-ignition of the air-fuel mixture, throughout the combustion chamber. At the time of combustion, around 70-95% of the fuel in the combustion chamber is in the vapor state. At this time many flame fronts develop at different places throughout the combustion chamber, with the aid of the self-ignited mixture. When all of the combustible air-fuel mixture has been used the temperature and pressure rise. The increase in temperature and pressure further increase self-ignition points and combustion increases. Throughout this process liquid fuel is still being injected into the combustion chamber. The amount of fuel that is injected dictates the rate of combustion since the fuel has to be atomized, vaporized, and mixed and finally combusted.

1.3 Pentanol description

1-Pentanol, (or n-pentanol, 1-pentanol), is an alcohol with five carbon atoms and the molecular formula $C_5H_{11}OH$. 1-Pentanol is a colorless liquid with an unpleasant aroma. It is the straight-chain form of amyl alcohol, one of 8 isomers with that formula the hydroxyl group (OH) is the active site of many reactions. The ester formed from 1-pentanol and butyric acid is pentyl butyrate, which smells like apricot. The ester formed from 1-pentanol and acetic acid is amyl acetate (also called pentyl acetate), which smells like banana. Pentanol can be used as a solvent for coating CDs and DVDs. Pentanol has all the properties necessary to replace gasoline as an internal combustion fuel.Pentanol can be prepared by fractional distillation of fuel oil. To reduce the use of fossil fuels, research is underway to develop cost-effective methods of producing (chemically identical) bio-pentanol with fermentation.2-Pentanol features a hydroxyl group attached to the carbon atom directly preceding the last one on either end of the carbon chain. It is used as a solvent and precursor in the production of different organic chemicals. It is often mixed with other alcohols in industrial-grade amyl alcohol solutions. 3-pentanol is an isomer where the hydroxyl group is attached to the middle atom in the carbon chain. The isomers of pentanol are prepared through the fraction distillation of fuel oil.

1.4 Fuel Blends Properties

Fuel properties of pentanol/diesel fuel blends. The tested fuels were straight diesel fuel (D100), 10% pentanol/90% diesel fuel blend (v/v) (P10), 15% pentanol/ 85% diesel fuel blend (v/v) (P15), 20% pentanol/80% diesel fuel blend (v/v) (P20) and 25% pentanol/75% diesel fuel blend (v/v) (P25). Kinematic viscosity (m) was measured with a Cannon-Fenske viscometer, flash point (FP) was measured with a closed cup Penski–Martens tester, cold filter plugging point (CFPP) was measured with an ISL device, density (q) was measured with a Proton hydrometer and higher heating value (HHV) was evaluated with an IKA C-200 calorimeter.

2 Objectives and Methodology

2.1 Objectives

To increase the operational range of an internal combustion diesel engine especially at higher loads through direct injection of n-pentanol and diesel in to the combustion chamber, by varying the proportion of high reactivity fuel at lower load conditions and low reactivity fuel at higher load conditions respectively.

To reduce the specific fuel consumption of diesel the n-pentanol directly injected as a main injection and diesel as a pilot injection

To make an effort to achieve an increased overall thermal efficiency the fuel is not blend together but injected directly in to the combustion chamber to increase the combustion efficiency and thus converting fuel's chemical energy to heat energy.

To achieve reduction in tail pipe emission (like soot, NO_x, HC and CO) compared to internal combustion diesel engines and specifically to minimize emissions of the global pollutant CO_2, HC, low temperature lean operation will ensure simultaneous reduction of NO_x as well as Soot, and lower the fuel consumption lower will be the CO_2 emissions.

Direct displacement of petroleum through optimized n-pentanol and diesel combination and improved engine-system efficiency. Use of n-pentanol and other renewable fuels will reduce the dependence on fossil fuels.

2.2 Expertimental Setup

The KirloskarAV1 5hpWater-Cooled base Engine is installed with dynamometer. The diesel injector is used for normal pilot diesel injection and the blended n- pentanol injected in the same injector. The sensors like temperature and operation sensor are fixed in the engine the fuels injection will vary according to the feedback signal received from the sensors.

The engine equipped with extensive instrumentation to enable detailed analysis of combustion, performance and emissions all being vital for understanding the effect of fuel on combustions and emissions.

The temperature will be reduced by many K type thermocouples. Thermocouples are positioned at various points in the Exhaust manifold, water intake pipe, water exhaust pipe. The thermocouples are connected to temperature indicator. A dynamometer is a load device which is generally used for measuring the power output of an engine. Several kinds of dynamometers are common, some of them being referred to as "breaks" or "break dynamometers": dry friction break dynamometers, hydraulic or water break dynamometers and eddy current dynamometers.

Eddy current dynamometers are electromagnetic load devices. The engine being tested spins a disk in the dynamometer. Electrical current passes through coils surrounding the disk, and induce a magnetic resistance to the motion of the disk. Varying the current varies the load on the engine.

The dynamometer applies a resistance to the rotation of the engine. If the dynamometer is connected to the engine's output shaft it is referred to as an Engine Dynamometer. When the dynamometer is connected to the vehicles drive wheels it is called a Chassis Dynamometer. The force exerted on the dynamometer housing is resisted by a strain measuring device (for example a strain gage).

3 Observation

In this experimental setup the pentanol is blended with diesel in different ratio (1:1, 5:1, 10:3 & 2:1) the reading was observed. The injection of fuel is made in conventional method. The observation of performance and exhaust emission of the testing engine are as follows.

In this observation the testing engine was run by diesel fuel to observe the performance and emissioncharacteristics. The testing engine runs in 100% diesel fuel

In this observation the testing engine was run by Pentanol blended with diesel fuel to observe the performance and emission characteristics. The testing engine runs in 80% of diesel and 20% of Pentanol are blended are used as a fuel

In this observation the testing engine was run by Pentanol blended with diesel fuel to observe the performance and emission characteristics. The testing engine runs in 70% of diesel and 30% of Pentanol are blended are used as a fuel.

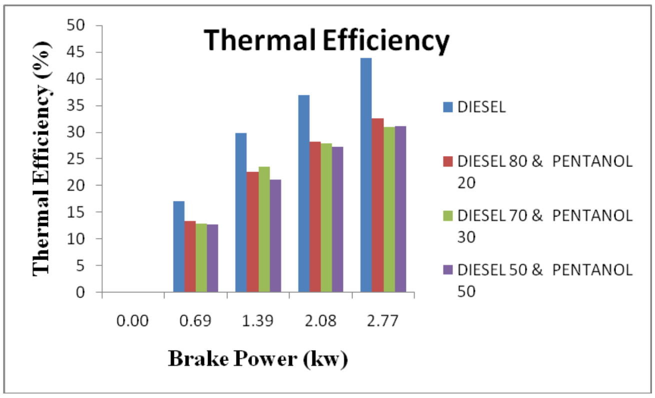
In this observation the testing engine was run by Pentanol blended with diesel fuel to observe the performance and emission characteristics. The testing engine runs in 50% of diesel and 50% of Pentanol are blended are used as a fuel

4 Result And Analysis

By the observations and readings of the performance for the testing engine with the diesel and pentanol blend are used as a fuel in different ratio the results comparison are as follows

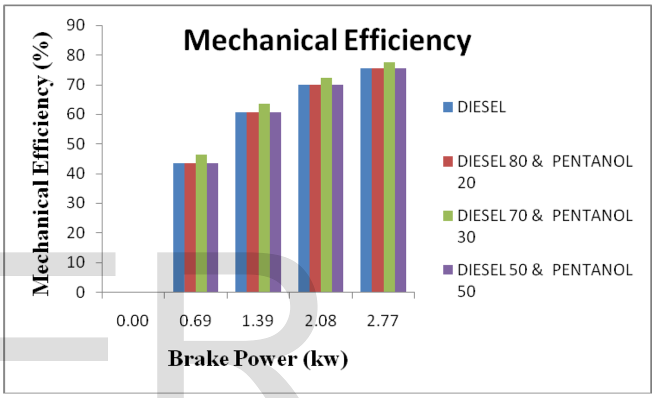
4.1 Comparison Of Efficiency

A.Thermal Efficiency



In the observation the blended diesel and pentanol fuel the thermal efficiency is decreasing.

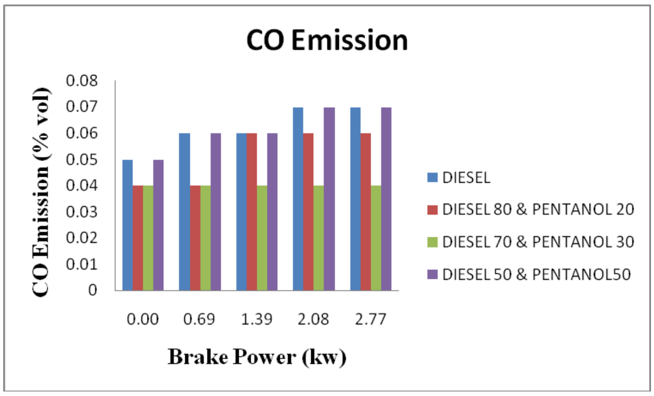
B.Mechanical Efficiency



In the observation the blended diesel and pentanol fuel the Mechanical efficiency has no change.

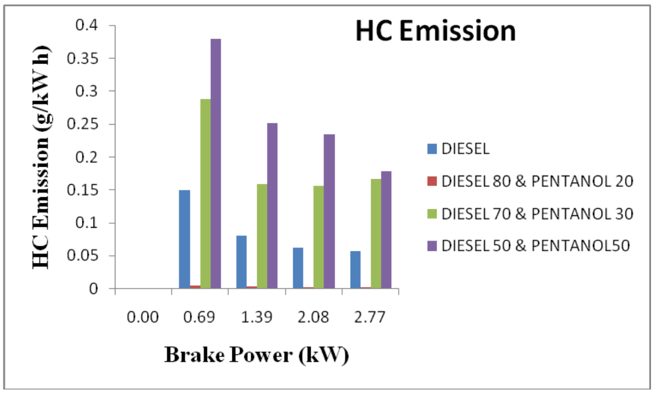
4.2 Comparison Of Emission

A.Comparison Of Co Emission



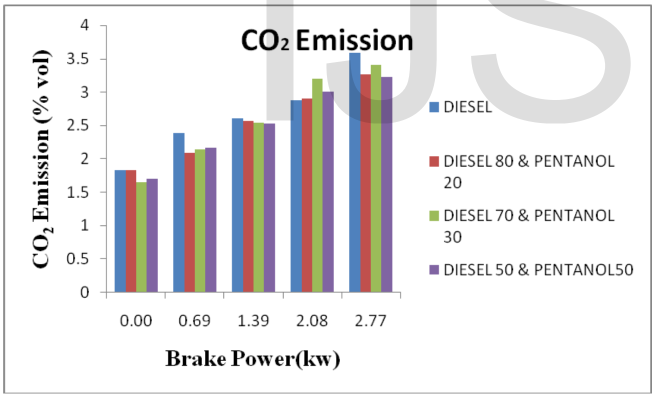
By this observation the Co emission for diesel fuel is constant but the diesel and pentanol blended fuel is varies corresponding to the ratio of blend the 2:1 ratio blended fuel emits more Co emission.

B.Comparison Of HC Emission



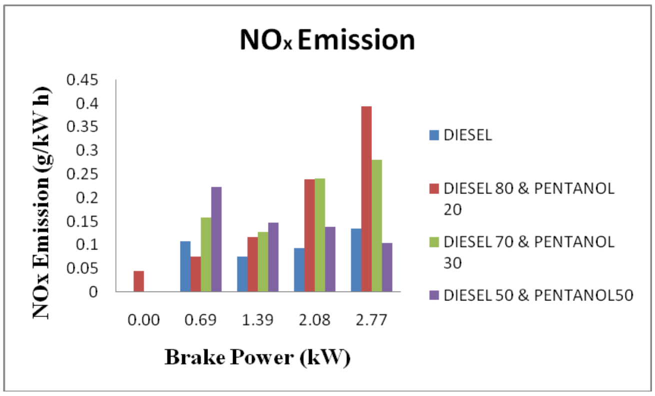
By this observation the HC emission for diesel fuel is constant but the diesel and pentanol blended fuel is varies corresponding to the ratio of blend the HC emission is keep on decreasing when the brake power increased.

C.Comparison Of Co_2 Emission



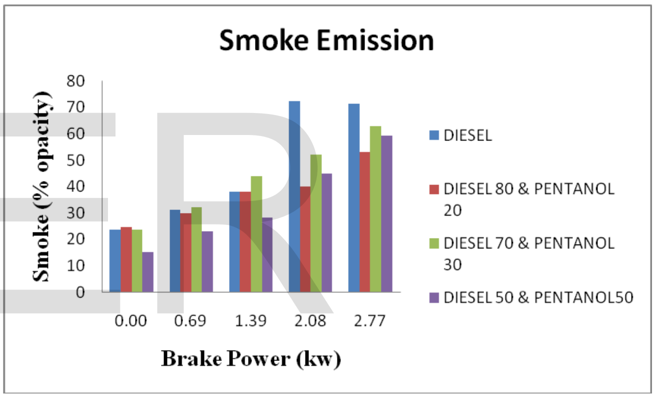
By this observation the Co_2 emission for diesel fuel is increasing but the diesel and pentanol blended fuel is varies corresponding to the ratio of blend the 2:1 ratio blended fuel emits less HC emission than the diesel fuel at full load .

D. Comparison Of No_x Emission



By this observation the NO_x emission for diesel fuel is increasing at full load but the diesel and pentanol blended fuel is varies corresponding to the ratios; the blended ratio of 10:3fuels emits moreNO_x emission than the diesel, at the full load condition of diesel and pentanol blends the NOx emission decreased.

E. Comparison Of Smoke Emission



By this observation the Smoke emission for diesel fuel is increasing at full load but the diesel and pentanol blended fuel is varies corresponding to the ratios. In this by using blended pentanol fuel smoke emission is very less than the diesel fuel.

5 Conclusion

Experimental investigation was carried out in a single cylinder direct injection combustion ignition engine with various ratios of diesel and pentanol fuel blend the following are the observations.

- When the brake power increased smoke emissions are very much lesser when compare with the 100% diesel fuel.
- When the brake power increased carbon dioxide emissions are reduced when compare with the 100% diesel fuel.
- When the brake power increased carbon monoxide emissions are competitively same as the diesel fuel.

- When the brake power increased nitrogen oxide emissions are more at 75% of load and it slightly gets decreased at full load condition.
- When the brake power increased hydro carbon emissions are decreased in diesel and pentanol blends.
- There is no change in thermal and mechanical efficiencies.
- When the various ratios of diesel and pentanol blends are injected in the testing engine the engine speed is not varying.

6 Acknowledgments

I would like to express my profound sense of gratitude to **Dr. M.R.SWAMINATHAN**, Assistant Professor, Internal Combustion Engineering Division, Department of Mechanical Engineering, Anna University for his timely suggestion and valuable guidance. I am intensively grateful to him for his encouragement to take up this project. I express my sincere thanks to him for his dynamic inputs.

I sincerely thank **Dr. G.NAGARAJAN**, Professor and Division Head, Internal Combustion Engineering Division, Department of Mechanical Engineering, Anna University for his constructive inputs and for his abundant encouragement.

I extend my gratefulness to **Dr. B.MOHAN**, Professor and Head, Department of Mechanical Engineering, College of Engineering, Guindy, Anna University for extending the amenities in the department.

I thank **Mrs. MEENAKSHI**Assistant Professor, Department of Chemical Engineering, International Maritime Academy, Chennai. For her technical support. I express my profound gratitude to all staff members of Internal Combustion Engineering Division, Anna University, and Chennai for their kind help during the course of my project work. Finally I thank one and all who have helped me directly or indirectly during the course of my project work.

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