

**A Review On Dual Fuel Mode Operation In Compression
Ignition Engine Fueled With Biofuels.**

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in

Mechanical Engineering

By

D. Clarence Raj. [Reg. No. 39150027]

G. Deva Dharshan. [Reg. No. 39150030]



DEPARTMENT OF MECHANICAL ENGINEERING

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119

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Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai 600119

www.sathyabama.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of D. Clarence Raj. Reg. No. 39150027. G.Deva Dharshan. Reg. No. 39150030. Who carried out the project entitled **“A Review on Dual Fuel Mode Operation in Compression Ignition Engine Fueled with Biofuels.”** Under our supervision from November 2022 to April 2023.

Internal Guide

Dr. J. Jayaprabakar M.E., Ph.D.,

Head of the Department

Dr. G. ARUNKUMAR, M.E., Ph.D.,

Submitted for Viva voce Examination held on 26.04.2023

Dr. J. HEMANANDH, M.E., Ph.D.,
Internal Examiner

Dr. J. JAYAPRABAKAR, M.E., Ph.D.,
External Examiner

DECLARATION

We D. Clarence Raj. (Reg. No. 39150027), G.Deva Dharshan. (Reg. No. 39150030) hereby declare that the Project Report entitled “**A Review on Dual Fuel Mode Operation in Compression Ignition Engine Fueled with Biofuels.**” Done by us under the guidance of Dr **J. Jayaprabakar M.E., Ph.D** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE: 26-04-2023

1)

Darshan

2)

Clarence

PLACE: CHENNAI

SIGNATURES OF THE CANDIDATE

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ABSTRACT

The use of inedible vegetable oils as an alternative fuel for diesel engine is driven by a fuel crisis caused by resource depletion and increased environmental problems including the great need for edible oil as food and the reduction of biodiesel production cost. In this a lot of inedible vegetable oils which can be exploited for substitute fuel as diesel fuel, seven vegetable oils, i.e., jatropha, karanja, mahua, linseed, rubber seed, cottonseed and neem oils were selected for discussion in this review paper. So far ethanol is also a biofuel with the production and sustainability of corn-based and sugarcane-based to present ethanol as a renewable and sustainable biofuel. The application of gasoline-ethanol blends in spark ignition engines and diesel ethanol blends in compression ignition engines is also addressed. Here we use blends of biodiesel and ethanol fuels, which must be a promising possibility. Ethanol potentially increases the thermal efficiency of internal combustion engines of compression ignition and reduces the NO_x emissions, but that biodiesel generally causes an increase in NO_x emission and a decrease in HC and CO emissions compared to diesel. For that here using the ethanol to kinetic mechanisms need improvement for high pressures and low temperatures. The journal Biofuels found that the greenhouse gas (GHG) emissions from corn ethanol are about 39% lower than gasoline on an energy equivalent basis. It was reported that a diesel engine without any modification would run successfully on a blend of 20% vegetable oil and 80% diesel fuel without damage to engine parts. The effect of the techniques on other emission and performance parameters were also discussed in detail.

Keywords: Inedible vegetable oils, Biodiesel, Ethanol, and CI engine, internal combustion engine, kinetic mechanisms, greenhouse gas, compression ignition.

TABLE OF CONTENT

Chapter no.	Title	Page no.
1	INTRODUCTION.	
	1.1. INTRODUCTION TO BIO-DIESEL.	8
	1.2. INTRODUCTION TO BIO – ETHANOL.	9
2	LITERATURE SURVEY.	10
3	AIM AND SCOPE OF THE PROJECT.	
	3.1. AIM OF THE PROJECT.	12
	3.2. SCOPE OF THE PROJECT.	12
4	METHODOLOGY.	
	4.1. MATERIALS.	13
	4.2. IGNITION COMBUSTION ENGINES	13-14
	4.3. BIO-DIESEL.	15
	4.4. PRODUCTION OF BIO-DIESEL	16
	4.5. FLOW CHART FOR THE PRODUCTION OF BIO-DIESEL.	17
	4.5. BIOETHANOL.	17
	4.6. PRODUCTION OF BIOETHANOL FROM SUGARCANE.	18
	4.7 BIOETHANOL BLENDS.	18
5	RESULTS.	19
6	CONCLUSION.	20
7	REFERENCES.	21-22

CHAPTER 1

INTRODUCTION

1.1 Introduction to Bio Diesel:

Biodiesel is a vegetable oil-based fuel that runs in the present diesel engines, without any modifications to the hardware biodiesel blends can be used in all compression-ignition (CI) engines that were designed to be operated on diesel fuel. It is cheaper than oil, sustainable, and nontoxic and does not produce acid rain. Bioethanol production capacity from sugarcane waste, having a potential of producing 41% of the global biofuel. Asia was also found to have the greatest potential in producing biofuels from biodiesel are the most popular biofuels that are being used as substitutes for regular gasoline and diesel. The quantity of agricultural waste and Garbage has significantly increased over the last few years.

Alternative fuels can reduce engine emissions as compared to crude oil products. The molecules of alternative fuels (such CH_3OH , $\text{C}_2\text{H}_5\text{OH}$, and CH_4 , etc.) are a lot simpler than those in gasoline and diesel (mixture of different molecules). Low C:H alternative fuels also burn more thoroughly after combustion. Fuel, which emits no hydrocarbons, is the cleanest fuel. Emissions from moving vehicles can be controlled more simply than emissions from a single factory. The United States produces biodiesel, which is utilized in conventional diesel engines and directly substitutes or increases the supply of conventional fossil diesel. Soybean biodiesel has a positive energy balance, which means that for every unit of fossil energy used over its lifetime, it produces 4.56 units of energy.

1.2. Introduction to Bioethanol:

Ethanol is also a biofuel with the production and sustainability of corn-based and sugarcane-based to present ethanol as a renewable and sustainable biofuel. The United States uses ethanol extensively, and more than 98% of fuel contains some ethanol. E10, which contains 10% ethanol and 90% gasoline, in Asia, India has consumed 4% ethanol and 96% gasoline is the most popular ethanol blend. For usage in flexible fuel cars, ethanol is also offered as E85 commonly known as flex fuel, a high-level blend with 51% to 83% ethanol, depending on location and season. Another blend, E15, is expanding its market share. Model year 2001 and newer illumination conventional gas vehicles are permitted to utilize it. When ethanol blended with gasoline for use as a vehicle fuel, it can offer some emissions benefits depending on vehicle type, engine calibration, and blend level. As with conventional fuels, the use and storage of ethanol blends can result in emissions of regulated pollutants, toxic chemicals, and greenhouse gases (GHGs).

CHAPTER 2

LITERATURE SURVEY

Shahir, S. A., Masjuki, H. H., Kalam, M. A., Imran, A., Fattah, I. M. R., & Sanjid, A. (2014) has studies on the Feasibility of diesel–biodiesel–ethanol/bioethanol blend as existing CI engine fuel: An assessment of properties, material compatibility, safety and combustion. Renewable and Sustainable Energy Reviews.

Nibin, M., Raj, J. B., & Geo, V. E. (2021) has done an Experimental studies to improve the performance, emission and combustion characteristics of wheat germ oil fuelled CI engine using bioethanol injection in PCCI mode.

Shekofteh, M., Gundoshmian, T. M., Jahanbakhshi, A., & Heidari-Maleni, A. (2020) has invested a review on Performance and emission characteristics of a diesel engine fueled with functionalized multi-wall carbon nanotubes and diesel–biodiesel–bioethanol blends.

Graboski MS, McCormick RL. Combustion of fat and vegetable oil derived fuels in diesel engines. Prog Energ Combust 1998

KHESHGI, H (2003) has invested on Greenhouse Gas Control Technologies and Greenhouse Gas Emissions from Bioethanol and Bio-Diesel Fuel Supply Systems.

Kaul S, Saxena RC, Kumar A, Negi MS, Bhatnagar AK, Goyal HB, et al. Corrosion behavior of biodiesel from seed oils of Indian origin on diesel engine parts.

Caligiuri, Carlo; Renzi, Massimiliano; Bietresato, Marco; Baratieri, Marco (2019) has done an Experimental investigation on the effects of bioethanol addition in diesel-biodiesel blends on emissions and performances of a micro-cogeneration system.

Asgar Asadi, Omid Nouri Kadijani, Mohammad Hossein Doranehgard, Mehdi Vahabzadeh Bozorg, Qingang Xiong, Mostafa Safdari Shadloo, Larry K.B. Li has done experimental investigation on Numerical study on the application of biodiesel and bioethanol in a multiple injection diesel engine.

Kwanchareon P, Luengnaruemitchai A, Jai-In S. Solubility of a diesel–biodiesel–ethanol blend, its fuel properties, and its emission characteristics from diesel engine.

Päivi A, Nils-Olof N, Mårten W, Marko M, Mikko M, Risto H, et al. Emissions from heavy-duty engine with and without aftertreatment using selected biofuels.

CHAPTER 3

AIM AND SCOPE

3.1 Aim of the project:

- Conventional usage of biodiesel-bioethanol blend as a fuel
- To reduce the carbon footprint of transportation and other industries, by making the most of our planet's carbon cycle.
- To Improve engine properties such as brake power, volumetric efficiency and engine efficiency etc.
- Restores lubricity and cleaner burning.
- To reduce the usage of crude oil and gasoline.
- As replacement for fossil fuels for transportation purposes.

3.2 Scope:

Biodiesel, which is regarded as an alternative fuel, effectively reduces the amount of polluting particles dispersed in the atmosphere as a result of emissions. Moreover, it's sustainable, it can be used in CI and SI engines often in their purest form or in combinations with other fuels. Biodiesel is a vegetable oil-based fuel that runs in the present diesel engines, without any modifications to the hardware biodiesel blends can be used in all compression-ignition (CI) engines that were designed to be operated on diesel fuel. It is cheaper than oil, sustainable, and nontoxic and does not produce acid rain. Bioethanol production capacity from sugarcane waste, having a potential of producing 41% of the global biofuel. The production and sale of bioethanol can generate a process of maximizing, and the

usage of ethanol blends in automobiles can significantly lower CO₂ emissions.

CHAPTER 4

MATERIALS AND METHODOLOGY

4.1 Materials:

- IGNITION COMBUSTION ENGINE.
- BIO-DIESEL.
- BIO ETHANOL.
- BLENDED MIXTURE.

4.2 IGNITION COMBUSTION ENGINES:

Internal combustion engines (ICEs) are the primary and leading source of power in vehicles. This energy can be used in both land and marine vehicles. Therefore, Compression ignition engine operation is fundamentally different from that of spark ignited engines in that the fuel is injected after compression and self-ignites due to the high gas temperature in the combustion chamber. This eliminates the problem of knocking, since only pure air is present in the cylinder during the compression stroke, and it allows significantly higher compression ratios to be used. Therefore, the 'Compression-Ratio' varies from 18:1 to 23:1, which depends on engine design & construction.

In the Compression Ignition only air is compressed by the piston and the fuel is injected into the chamber towards the end of the compression stroke. At this point the temperature of the air is high enough to cause the fuel to ignite spontaneously. The time interval between the start of injection of the fuel and ignition of the first portion of the mixture is typically 1 ms, this represents 12° of crankshaft rotation for an engine running at a speed of 2000 rev min⁻¹. At this sufficiently high temperature for self-ignition to occur. The mixing process between air and fuel is of critical importance to combustion. Most diesel engines are four strokes, but some very large, slow-speed diesel engines are based on a two-stroke cycle.

ENGINE MODEL:

Engine type	Gasoline
Displacement	499 cm ³
Working temperature	80°C
Number of cylinder	1
Number of Stroke	4
Bore x stroke	86x86
Maximum speed	6000 rpm
Idle speed	1500 rpm
Heating value	43500 kJ/kg
Fuel density	0.737kg/l
Torque maximum	27 Nm(3500 rpm)

4.2. Bio-Diesel:

When compared to petroleum goods, alternative fuels can lower engine emissions. Alternative fuels (such as CH_3OH , $\text{C}_2\text{H}_5\text{OH}$, and CH_4 , etc.) have considerably simpler molecules than gasoline and diesel (mixture of different molecules). Additionally, an alternative fuel with a clean burn that is produced locally from renewable resources is biodiesel. Although biodiesel doesn't include petroleum, it may be mixed with petroleum fuel in any quantity to make a biodiesel blend. Diesel engines may use it with little to no modification. The main benefits of biodiesel include its coherence, biodegradability, lack of toxicity, and lack of Sulphur and aromatics.

Vegetable oil, old cooking oil, yellow grease, and animal fat are better sources of biodiesel since they are highly biodegradable, non-toxic, and ecologically beneficial in addition to having lower NO_x emissions. Biodiesel is preferable from an environmental standpoint and may be used in diesel engines alone or blended with petroleum diesel fuel in any ratio, standard diesel fuel. The performance of diesel engines may currently be increased by roughly 30% by using turbochargers with intercoolers. Although it has a significant impact on diesel engine performance, turbochargers should not be utilized in biodiesel-fuelled engines. However, catalytic converters can be used to increase emissions performance. Additionally, a number of elements have a role in diesel engine exhaust emissions. Hydrogen Fuel, lubricating oil, engine conditions, technology for emission control etc.

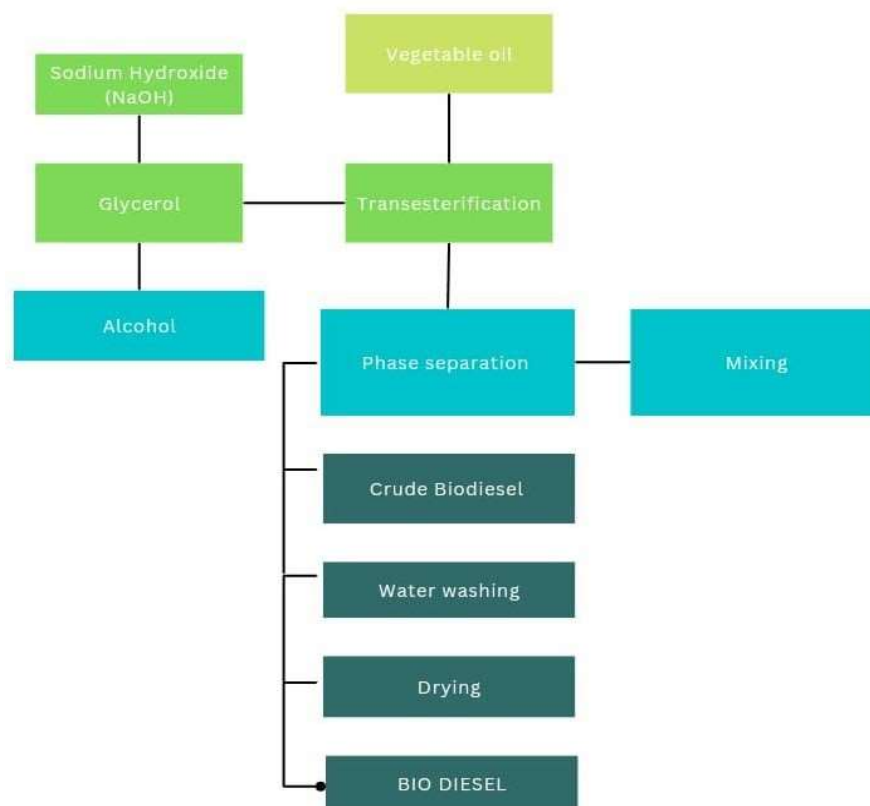
4.3. Production of Bio-Diesel:

The process of creating biodiesel through the transesterification and esterification of chemical reactions is known as biodiesel manufacturing. Short-chain alcohols are reacted with vegetable or animal fats and oils in this process typically ethanol. Use should be made of low molecular weight alcohols. Due to its low cost, ethanol is the most commonly utilised fuel, while ethanol can produce biodiesel at higher rates. Although both bases or acids can catalyse the transesterification reaction, bases are more frequently used. Compared to acid catalysis, this route has faster reactions and less affordable catalysts. Alkaline catalysis's drawback is that it is highly sensitive to both water and the free fatty acids found in the oils.

- Base Catalysis/Transesterification.
- Acid Catalysis.
- Enzymatic Conversion.
- Solid Catalyst.
- Non-Catalytic Conversion Techniques.
- Downstream Processing.

quantities and blended with fossil-derived fuel. Biodiesel has high biodegradability, low Sulphur content, low stability (addition of antioxidants, which can be enhanced), and high NO_x (nitrogen oxides) emissions when burned when compared to fossil fuel.

FLOW CHART OF PREPARATION OF BIO-DIESEL:



4.5. Bioethanol:

Asia was also found to have the greatest potential in producing biofuels from Bioethanol and biodiesel are the two most popular biofuels that are being used as substitutes for regular gasoline and diesel. In 2019–2020, Bangladesh imported 5.2 million metric Tons of petroleum products, worth 2.5 billion USD, and 50% of the imports were consumed by the transportation sector. Having limited natural oil reserves and being heavily dependent on oil imports, the country is vulnerable to shocks in the international oil market, which can jeopardize its consistent economy. [5] It is important to minimize CO₂ emissions from fuel combustion in automobile engines and switch to alternative and cleaner fuels to avoid the consequences of global warming. When considering the remaining global supply of fossil fuels like natural gas, the need for alternative fuels becomes more obvious.

4.6. Production of Bioethanol from sugarcane:

Ethanol may be produced using sugarcane bagasse as raw material through the Organosolv process with dilute acid hydrolysis, thus increasing ethanol production with the same cultivated sugarcane area. Using the software Associated with a specific Design, simulations of the synthesis of bioethanol from sugarcane juice and bagasse are performed in this study. The following is an example of a large-scale production facility: The raw material used to generate 1000 m³/day of ethanol is sugarcane juice. Pinch analysis is used to determine the minimum hot utility obtained with thermal integration of the plant, in order to find out the maximum availability of bagasse that can be used in the hydrolysis process, taking into consideration the use of 50% of generated sugarcane trash as fuel for electricity and steam production.

4.7. Bioethanol blends:

The methodology for diesel-biodiesel ethanol mixture involves various techniques to achieve the ideal solution. Some of the techniques adopted for the mixing of bioethanol with diesel are mentioned below:

1. One of the focuses was to control and maintain the temperature at which these fuel types are well mixed, since the synthetic diesel fuel temperature differs from that of biodiesel/ethanol. Therefore, obtaining a homogenous mixture of diesel-biodiesel-ethanol is very important and a wide variation in temperature would cause a fuel clog.
2. In a diesel-biodiesel-ethanol blends, ethanol has a characteristic 95% mass so the mixing is a challenge yet 95% ethanol makes the optimum fuel mixture to yields best physical and chemical properties. Although using this fuel mixture requires minor changes to the engine to suit the properties of ethanol. Even so, the diesel-biodiesel-ethanol mixture is hard to be used in compression-ignition (CI) diesel engines currently used nowadays.
3. To achieve higher performance from an injection type engine running on biodiesel mix, not only appropriate volumetric ratio of diesel-biodiesel-ethanol is required but stability of that mixture is also equally important.

CHAPTER 5

RESULTS

Bio-diesel and bioethanol are extracted and blended for engine testing and analysis. However, the experimental testing and analysis of this are yet to be executed. The upcoming tests to improve engine efficiency and performance are listed as follows:

Engine properties tested using the blend compared to that of diesel.

- Brake thermal Efficiency.
- Brake specific fuel consumption.
- Volumetric efficiency.
- Brake power.
- Engine efficiency.

Emission characteristics.

- Emissions of CO/CO₂.
- Emissions of Nitrogen oxides.
- Emissions of Unburnt hydrocarbons.
- Smoke opacity.

CHAPTER 6

CONCLUSION

The potential depletion of fossil fuels has motivated researchers to look for alternative fuels with efficiency comparable to those found for the current standard fuels. The current assesses the possibilities and expectations for using alternative fuels such as biodiesel and bioethanol in various contexts. We go into great length about the characteristics of various fuels and their use as a fuel. As fossil fuel substitutes, vegetable oils present a very promising operational framework.

Unburned hydrocarbons, carbon monoxide, particulate matter, and nitrogen oxides are all significantly reduced when biodiesel is used in a standard diesel engine. Different alternative fuels have been compared to conventional fuels, and it is obvious that the usage of blended fuels can greatly reduce the consumption of the rearmost. Since the majority of alternative fuels have characteristics similar to those of conventional fuels, the technology needed to manage them is already well-known. Thus, challenges are anticipated in the storage, delivery, and use of hydrogen as a fuel. There is also discussion of other technologies, such as substitutes for traditional fuels.

CHAPTER 7

REFERENCES

- [1] E. Atabani, A. S. Silitonga, I. A. Badruddin, T. M. I. Mahlia, H. H. Masjuki, and S. Mekhilef, “A comprehensive review on biodiesel as an alternative energy resource and its characteristics,” *Renewable and Sustainable Energy Reviews*, vol. 16, no. 4, pp. 2070–2093, May 2012, doi: 10.1016/J.RSER.2012.01.003.
- [2] Dr.Prathiba Barathi and Mrs. Nitheesha, *DIGITAL NOTES of ALTERNATIVE FUELS FOR I.C. ENGINES*, vol. 122. 2015.
- [3] Yoon SH, Hwang JW, Lee CS. Effect of injection strategy on the combustion and exhaust emission characteristics of biodiesel–ethanol blend in a DI diesel engine. *J Eng Gas Turbines Power* 2010;132:094503-1–3-3.
- [4] Sriwij. Int. Semin. Energy Environ. Sci. Technol. Palembang, Indones (2014).
- [5] Tang, Y., Xu, J., Zhang, J. & Lu, Y. Biodiesel production from vegetable oil by using modified CaO as solid basic catalysts. *J. Clean. Prod.* 42, 198–203 (2013).
- [6] K. Venkata Sundar Rao, S. N. Kurbet, and V. V. Kuppast, “A Review on Performance of the IC Engine Using Alternative Fuels,” *Mater Today Proc*, vol. 5, no. 1, pp. 1989–1996, 2018, doi: 10.1016/J.MATPR.2017.11.303.
- [7] Z. Wu, J. Wu, Z. Kang, J. Deng, Z. Hu, and L. Li, “A review of water-steam-assist technology in modern internal combustion engines,” *Energy Reports*, vol. 7, pp. 5100–5118, Nov. 2021, doi: 10.1016/j.egyr.2021.08.104.
- [8] R. D. Reitz et al., “IJER editorial: The future of the internal combustion engine:,” <https://doi.org/10.1177/1468087419877990>, vol. 21, no. 1, pp. 3–10, Sep. 2019, doi: 10.1177/1468087419877990.
- [9] R. Stone, *Introduction to internal combustion engines*. 1999.
- [10] J. Heywood, *Internal combustion engine fundamentals*. 2018.
- [11] A.M. Jodeiri, M. J. Goldsworthy, S. Buffa, and M. Cozzini, “Role of sustainable heat sources in transition towards fourth generation district heating – A review,” *Renewable and Sustainable Energy Reviews*, vol. 158, Apr. 2022, doi: 10.1016/J.RSER.2022.112156.

- [12] N. V. M. B. Talupula, P. S. Rao, B. S. P. Kumar, and Ch. P. raveen, "Alternative Fuels for Internal Combustion Engines: Overview of current research," *International Journal of Mechanical Engineering*, vol. 4, no. 3, pp. 20–29, Apr. 2017, doi: 10.14445/23488360/IJME-V4I4P105.
- [13] C. Bae and J. Kim, "Alternative fuels for internal combustion engines," *Proceedings of the Combustion Institute*, vol. 36, no. 3, pp. 3389–3413, Jan. 2017, doi: 10.1016/J.PROCI.2016.09.009.