Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 5, May 2024

# Experimental Analysis of Diesel Additives and Pongamia Pinnata Methyl Ester in Direct Injection Diesel Engines

Krupali Jagadala
Department of Plant physiology College of Agriculture,
OUAT Chiplima Odisha-768026

Jibitesh Kumar Panda
Department of Mechanical Engineering,
Anurag University, Telangana-500088,

***Abstract—***
**The ongoing depletion of conventional fossil fuels, alongside escalating costs and the environmental burden from their pollutants, increasingly underscores the need for alternative energy sources. Pongamia Pinnata methyl ester, a non-edible and widely available option, presents a promising substitute. This detailed study examines its application in diesel engines, particularly when blended with diesel additives such as 2-EHN and ethanol. The research focuses on assessing how these blends perform in comparison to traditional diesel under a variety of engine load conditions. Blends were tested in proportions of 20%, 30%, and even a full replacement at 100%, analyzing key performance metrics such as brake thermal efficiency and indicated mean effective pressure. Results indicate that specific blends, notably B20 A1(5) A2(5) D70, B20 A1(10) D70, and B20 A2(10) D70, not only matched but frequently surpassed mineral diesel in performance under certain load conditions. Furthermore, emission tests revealed significant reductions in carbon dioxide, carbon monoxide, and nitric oxide emissions, enhancing the environmental benefit of adopting such biofuel blends in diesel engines.**
***Keywords-*** **Pongamia pinnata methyl ester, Performance, Emission, CO, NO, BTE**

## 1. INTRODUCTION

The growing environmental concerns and the ongoing depletion of fossil fuel reserves have driven increased scientific and engineering research into renewable alternatives. Biodiesel, particularly for use in diesel engines, has gained significant attention due to its promising results, as highlighted in numerous studies [1-4]. This focus is not only due to biodiesel's potential as a sustainable fuel but also because of its practical applicability in existing diesel engine technologies. Biodiesel is primarily produced from non-edible oil crops like rapeseed and sunflower, which are abundantly available and do not compete with food sources. This type of biofuel is generated through a process known as transesterification, which involves replacing one alcohol in an ester with another. This process is crucial as it reduces the oil's viscosity, improving its combustion properties to match those of conventional diesel, as indicated in Table 1.

The transition to biodiesel offers significant environmental benefits, including a reduction in greenhouse gas emissions and a lower dependency on depleting fossil fuels. Moreover, the use of biodiesel supports agricultural sectors and promotes the development of rural areas, making it a cornerstone in the strategy for achieving energy sustainability. The integration of biodiesel into the fuel system of diesel engines not only aligns with global environmental goals but also showcases the potential for renewable fuels to replace conventional fossil fuels effectively. RCOOR'+R''OH→ RCOOR'' +R''OH. Triglycerides, when exposed to an alkaline catalyst, undergo transesterification effectively at temperatures ranging between $60^0$ to $70^0$C. This chemical reaction is crucial for converting fats into biodiesel, a renewable fuel that can significantly reduce carbon dioxide emissions. The automobile sector, a major contributor to global CO2 emissions, stands to benefit from adopting biodiesel produced through this process. By integrating biodiesel into the fuel mix, the automotive industry can actively participate in reducing its environmental footprint. The successful transesterification of triglycerides not only supports the production of cleaner fuel but also aligns with broader efforts to combat climate change by lowering reliance on fossil fuels [4-6].

## 2. MATERIALS AND METHODS

### 1. Biodiesel properties

Before evaluating the performance and emissions characteristics of various fuel blends, it is crucial to understand the fundamental properties of the components involved. Detailed properties of Pongamia Pinnata, its methyl ester derivative, and conventional diesel fuel are systematically provided in tabular form. These tables, referenced in [13-15], offer comprehensive data including density, viscosity, calorific value, and flash points among others. Such detailed characterization is essential for assessing compatibility and performance implications when these fuels are used in diesel engines. By analysing these properties, researchers can better predict how these blends will behave under operational conditions, ensuring more accurate and reliable experimental outcomes.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 5, May 2024

TABLE I Properties fuels

| Properties | Ponagamia (SVO) | Pongamia Biofuel | Diesel |
|---|---|---|---|
| Density@ $15^0$ C | 0.9358 | 0.797 | 0.850 |
| Viscosity@ $40^0$ C | 38.8 | 7.0 | 2.6 |
| Flash Point | 212.0 | 97.8 | 70.0 |
| Cloud Point | 2.0 | -7 | -16 |
| Pour Point | -4 | -6 | -20 |
| Water Content | <0.05 | 0.03 | 0.02 |
| Acid Value | 16.8 | 0.42 | 0.35 |
| Calorific Value | 8742 | 3712 | 4290 |
| Cetane Number | 38.0 | 42.9 | 46 |

2. Diesel additive properties

TABLE II

| Properties | Unit | 2-EHN | Ethanol |
|---|---|---|---|
| Molecular weight | g/mol | 175.23 | 46.06 |
| Flash point | $^0C$ | 36 | 9 |
| Freezing point | $^0C$ | -45 | -114 |
| Boiling point | $^0C$ | 79.48 | 78.37 |
| Auto ignition temperature | $^0C$ | 130 | 425 |
| Density | gm/m3 | 0.96 | 0.48 |

3. EXPERIMENTAL SETUP AND PROCEDURE

The experimental apparatus utilized for the study comprised a precisely engineered setup featuring a single-cylinder, four-stroke diesel engine. This engine was meticulously connected to an eddy current dynamometer, which is renowned for its reliability in measuring torque and power under various load conditions. The system was designed to facilitate load adjustments ranging from 0% to 100%, allowing for a comprehensive assessment of engine performance across a spectrum of operating conditions. Key to the experimental design was the inclusion of a sophisticated measurement system for water flow, utilizing a rotameter to ensure accurate monitoring. This component was critical in maintaining the engine's thermal balance during the tests. Emissions testing was conducted using a state-of-the-art five-gas analyzer, capable of detecting and quantifying the levels of carbon monoxide (CO), nitric oxide (NO), and carbon dioxide (CO2) in the engine's exhaust gases. This analyzer was strategically installed at the exhaust outlet to capture real-time emission data, as represented in Figure 2 [6-9]. To manage the fuel supply, a glass burette was employed for the precise measurement of both biodiesel and diesel fuel volumes. This setup was complemented by a stopwatch, which played a crucial role in calculating the brake-specific fuel consumption (BSFC), a key metric in evaluating engine efficiency [11-13]. The engine was operated at a constant speed of 1500 rpm throughout the experiments. Notably, no alterations were made to the fuel injection timing, which was meticulously set at 23° before top dead center (BTDC) for both diesel and Pongamia Pinnata Methyl Ester (PPME). This consistency was vital for ensuring comparability of results across all fuel types tested.

The variety of fuel blends examined included pure diesel (D100), and several biodiesel blends such as B20 A1(5) A2(5) D70, B20 A1(10) D70, B20 A2(10) D70, B20 B80, and B100. These blends were tested under progressive load conditions from 0% to 100%, simulating real-world engine operations at a compression ratio of 17.5:1. Performance evaluations were executed using software from Apex Innovations Pvt. Ltd, designated as ENGINE SOFT, which enabled detailed analysis of engine output and efficiency. Additionally, the TESTO 350 gas analyzer provided further insights into the exhaust gas composition, complementing the data obtained from the five-gas analyzer [8-12]. This comprehensive setup not only facilitated a thorough understanding of the performance characteristics of the various fuel blends but also underscored the potential environmental benefits associated with the use of biodiesel in reducing harmful emissions. The rigorous testing regime ensured that the data collected was both robust and representative of each fuel’s performance under varied operational conditions.

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 5, May 2024

Fig.1 Experimental setup

Fig.2 Gas analyzer

4. RESULTS:

1. Performance analysis

A. Brake thermal efficiency

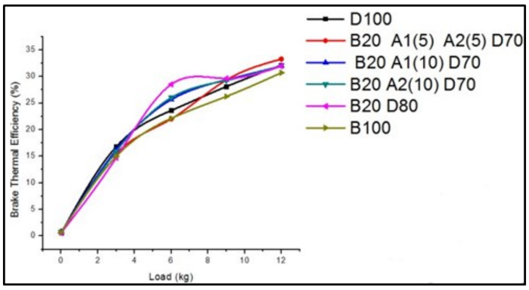


Fig3. bte vs. Load

B. Brake specific fuel consumption

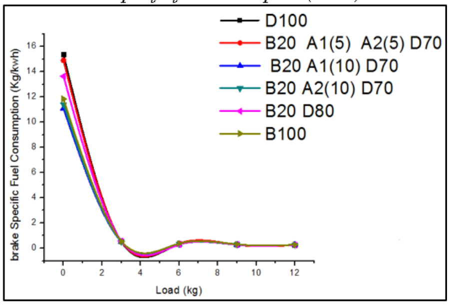


Fig4. bsfc vs. Load

C. Indicated mean effective pressure

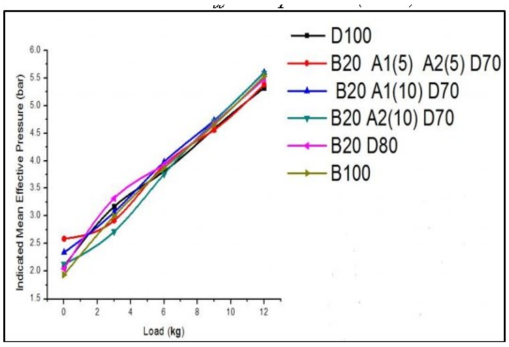


Fig5. imep vs. Load

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 5, May 2024

2. Emissions analysis

A. Carbon monoxide (CO)

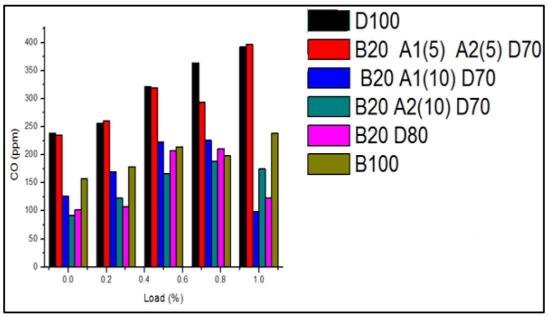


Fig6. CO vs. Load

B. Carbon dioxide (CO2)

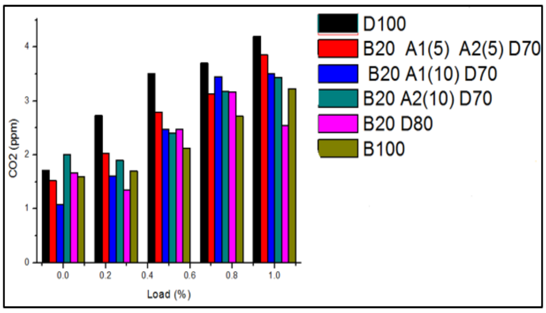


Fig7. CO2 vs. Load

C. Nitric oxide (NO)

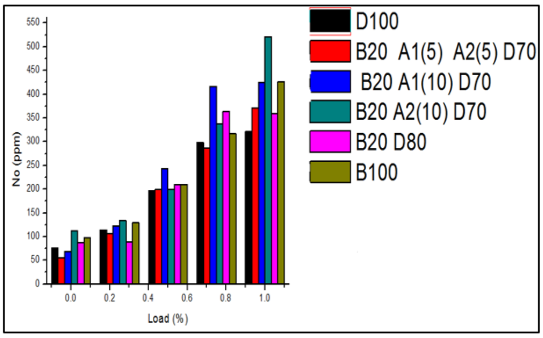


Fig8. NO vs. Load

5. CONCLUSIONS

This study focused on evaluating the performance and emissions of diesel blended with Pongamia Pinnata methyl ester, 2-EHN, and ethanol. The experimental results led to several key conclusions about the efficacy and environmental benefits of these biofuel blends in comparison to pure diesel:

- Pongamia Pinnata methyl ester, when combined with diesel additives such as 2-EHN and ethanol, demonstrates significant potential as a viable alternative fuel for Direct Injection (DI) diesel engines, requiring no modifications to the existing engine infrastructure. This finding presents a sustainable solution in the quest for reducing dependency on traditional fossil fuels and mitigating environmental impact.
- Among various blends tested, B20 A1 (5) A2 (5) D70 particularly stands out for its enhanced performance characteristics. This specific blend consists of 20% biodiesel derived from Pongamia Pinnata, supplemented with 5% of each additive, 2-EHN and ethanol, mixed into 70% standard diesel. The experimental results have shown that this blend not only maintains comparable fuel consumption to pure diesel under full load conditions but also improves brake thermal efficiency. The data, as illustrated in Figure 3, indicates a slight but noticeable improvement in thermal efficiency over pure diesel, suggesting that the blend is more efficient at converting fuel into energy.
- Moreover, the use of this biodiesel blend has been associated with a significant reduction in the emission of major exhaust pollutants such as carbon dioxide (CO2) and carbon monoxide (CO), as evidenced in Figures 6 and 7 respectively. These reductions contribute positively towards lowering the overall environmental footprint of diesel engines, which are traditionally known for their higher pollutant emissions.
- However, it's important to note that there is a slight increase in nitric oxide (NO) emissions with this blend, as shown in Figure 8. While this increase is modest, it highlights a common challenge associated with biodiesel usage, where certain emissions may not decrease uniformly across all categories. Despite this, the overall environmental benefits of using such a blend, particularly in terms of reducing greenhouse gases like CO2 and toxic emissions like CO, are considerable.
- The experimental analysis of both performance and emissions characteristics strongly supports the potential of B20 A1 (5) A2 (5) D70 to serve as a substitute for pure diesel in diesel engines. This blend not only enhances engine performance but also aligns with global environmental goals, offering a promising route towards cleaner, more sustainable diesel engine operations. These findings underscore the importance of continuing research and development in biodiesel fuels to optimize blends for both performance and environmental impact.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 5, May 2024

## 6. REFERENCE:


[1] Dr.G.R.Ksastry, Bio-diesel Bio-degradable Alternative Fuel for Diesel Engines .Readworthy Publications Pvt. Ltd. ISBN 13: 978-81-89973-50-6, ISBN 10: 81-89973-50-9

[2] A. Murugesan, C. Umarani, R. Subramanian, N. Nedunchezhian. Bio-diesel as an alternative fuel for diesel engines—a review. Renewable and Sustainable Energy Reviews 13 (2009) 653–662

[3] Avinash Kumar Agarwal, AtulDhar. Experimental investigations of performance, emission and combustion characteristics of Karanja oil blends fuelled DICI engine. Renewable Energy 52 (2013) 283e291

[4] Rosli Abu Bakar. Semin and Abdul Rahim Ismail. Fuel Injection Pressure Effect on Performance of Direct Injection Diesel Engines. American Journal of Applied Sciences, 2008 5 (3): 197-202.

[5] Ismet Celýkten. An experimental investigation of the effect of the injection pressure on engine performance and exhaust emission in indirect injection diesel engines.Applied Thermal.

[6] Venkateswarlu K., Murthy B, and Subbarao V. An Experimental Investigation on Performance, Combustion and Emission Characteristics of Diesel- Biodiesel Blends with Isobutanol as an Additive. SAE Technical Paper 2012-28- 0011.

[7] Manish Nandi, K. The Performance of Ditertiary- Butyl Peroxide as Cetane Improver in Diesel Fuels.ARCO Chemical Company, Newtown Square, PA 19073.

[8] Sathiyagnanam,A.P. Saravanan,C.G. and Dhandapani,S. Effect of Thermal-Barrier Coating plus Fuel Additive for Reducing Emission from DI Diesel Engine. Proceedings of the World Congress on Engineering, 2010, Vol II WCE 2010, June 30 - July 2, 2010, London, U.K.

[9] SundarRaj, C. Sendilvelan,S. and Arul,S. Performance of a Thermally Insulated Constant Speed Diesel Engine with Dioxane Blended Fuels. Global Journal of Researches in Engineering, 2010, Vol. 10 Issue 2 (Ver 1.0).

[10] Murat, Karabektas. And Murat, Hosoz. Performance and emission characteristics of a diesel engine using isobutanol– diesel fuel blends. Renewable Energy, 2009(Elsevier), Volume 34, Issue 6, Pages 1554-1559.

[11] VenkataSubbaiah,G. Raja Gopal,K. Syed AltafHussain. DurgaPrasad,B. and TirupathiReddy,K. RiceBran Oil Biodiesel As andditive In Diesel-Ethanol Blends For Diesel Engines. Ijrras, 2010, 3(3).

[12] AnandaSrinivasan, C. and Saravanan, C.G. Study of Combustion Characteristics of an SI Engine Fuelled with Ethanol and Oxygenated Fuel Additives. Journal of Sustainable Energy & Environment, 2010, 85-91.

[13] Venkanna, B.K. Swati B.Wadawadagi, Venkataramana Reddy,C. Effect of Injection Pressure on Performance, Emission and Combustion Characteristics of Direct Injection Diesel Engine Running on Blends of PongamiaPinnata Linn Oil (Honge oil) and Diesel Fuel. The CIGR Ejournal, 2009, Manuscript number 1316. Vol. XI.

[14] Wang,X.G. Zheng,B. Huang,Z.H. Zhang,N. Zhang,Y.J. and Hu, E.J. Performance and emissions of a turbocharged, high-pressure common rail diesel engine operating on biodiesel/diesel blends. Proc. IMechE Part D: J. Automobile Engineering, 2010, Vol. 225.

[15] Mustafa Canakci. CenkSayin.AhmetNecatiOzsezen and Ali Turkcan.Effect of Injection Pressure on the Combustion, Performance, and Emission Characteristics of a Diesel Engine Fueled with Methanol-blended Diesel Fuel.Energy Fuels, 2009, 23 (6), pp 2908–2920.