Journal of Mines, Metals and Fuels, *72(8): 829-842; 2024. DOI: 10.18311/jmmf/2024/35670*

INFORMATICS JOURNALS

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

An Experimental Investigation on Diesel Engine Performance by the Application of Dual Bio-Diesel Blends

Nitin Namdeo Pawar[1]*, Hameshbabu Nanwala[2] and A. M. Rathod[3]

[1]*Mechanical Department, Alamuri Ratnamala Institute of Engineering and Technology, Sapgaon, Thane – 421601, Maharashtra, India; nitinpawar1702@gmail.com*

[2]*Mechanical Department, Babasaheb Naik College of Engineering, Pusad, Kawadipur – 445215, Maharashtra, India*

[3]*Veermata Jijabai Technological Institute, Mumbai – 400019, Maharashtra, India*

Abstract

This paper investigates the feasibility of the Biofuel and diesel used in a proportionate mixture as a Biodiesel as a replacement for Diesel fuel. Biodiesel has gained significant attention in the power world as an alternative to biodiesel blends prepared in this study is 50% Neem and 50% Pongamia pinnate. During the study, the blends used for testing were B5%, B10%, B15% and B20% with a varying load condition of 3kg to 20kg in a single-cylinder diesel engine at rpm of 1600 with a load of 19.01kg. A pyrolysis method is used for making Biodiesel. The viscosity values of the Biodiesel blend lie in the range of 3.89 to 8.756 Nm/s^2 [1]. The performance of biodiesel has been analysed in terms of break power, indicated power, break and indicated thermal efficiency, mechanical efficiency, torque, specific fuel consumption, and volumetric efficiency. The parametric value of the all curve shows the increasing behaviour from lower to higher value. Volumetric efficiency shows only decreasing behaviour concerning load. The result shows the B5% blend is better in break power by 13.43% than a diesel at a load of 19.01kg. And specific fuel consumption. The torque generated is more efficient in B20% blends. Break thermal efficiency is proportional to the load of the engine. Indicated Thermal efficiency is much higher than diesel of B5% Biodiesel. The maintenance of a fuel pump is required regularly due to more viscosity problems.

Keywords: *Blends, Esterification, Neem, Pongamia pinnate, Specific Fuel Consumption, Torque*

1.0 Introduction

The researchers are continuously searching for alternatives to C12 fuels like diesel for heavy vehicles in transportation and off-road work. Developed and developing countries are facing major problems in the form of plastic waste of various categories like households use plastic waste, industry uses plastic waste, medical use plastic waste, etc. Many researchers have found that fuel will be a better alternative to diesel fuel[2,3]. An analysis was carried out comparing plastic and diesel as fuel. It has been found that some more work is required in the parameter of good spraying characteristics, injection, and burning issues throughout the ideal working of vehicle engine[4]. The author notes the necessity to enhance emission characteristics due to emission norms, indicating a need for improvements in this aspect alongside the advancements in the pyrolysis technology for plastic waste utilization[5]. Using a video cassette recorder engine evokes a prime resolution of speedy flame circulation due to incomplete combustion of fuel evoking a smoke of black colour[6]. A complete burning of fuel is necessary

**Author for correspondence*

to reduce emissions like particulate pollutants and conjointly improve the smoothness of the mixture. For that, some additives are mixed to fuel like diethyl ether and straight-chain pentsanol. It is found that the performance of the vehicle improves to optimum value by mixing suitable additives[7-9]. Pyrolysis is the process of thermally degrading long-chain compound molecules into shorter, simpler molecules under high temperature and pressure, and appears to be a viable method for repurposing plastic waste. This method can efficiently produce a substantial amount of plastic fuel, up to eighty times the volume of the petroleum traded through the World Trade centre. Furthermore, it minimizes environmental pollution, particularly when the plastic waste lacks sulphur and chlorine content. Nonetheless, efforts are underway to enhance the technology and transition it into a greener form. The organic oil produced can find applications in various sectors, such as automotive engines (e.g., diesel), power plants, and power generation. Additionally, the aerosolized by-product possessing significant heat value is also suitable for reutilization to meet overall power demands. Moreover, the process control is relatively simple and flexible; extensive sorting is not necessarily required. The tested single-cylinder diesel engine operates at 1500rpm with a compression ratio ranging from 16 to 18. The author concluded that optimal performance characteristics are achieved at a compression ratio of 17[10]. A testing has been done on a single-cylinder diesel engine with a fuel as fuel with additives of diethyl ether in the quantity of 5-15 %. It has been found that the rate of combustion is low, the intensity of smoke is high, and the rate of NOX generation increases[11]. One test has been carried out on a diesel fuel with a blend of methanol and additives (1-dodecanol) in various parameters. Also experimental investigation has been carried out fuel and diesel blends are compared to baseline mineral diesel. It has been found that plastic blend gives optimum results[12]. The authors worked on the density of diesel and plastic fuel. Successful completion of an experiment found that fuel density is 9300kg/m^3 [13]. Fuel is manufactured using a row material as low-density polyethylene. The two different feeds are used for manufacturing. The working temperature range is 500°C by using a kinematic equilibrium method. The production of fuel is obtained by the Pyrolysis method[14-16].

2.0 Experimental Setup

A total six number of thermocouples are placed at different locations on the experimental set are noted as follows:

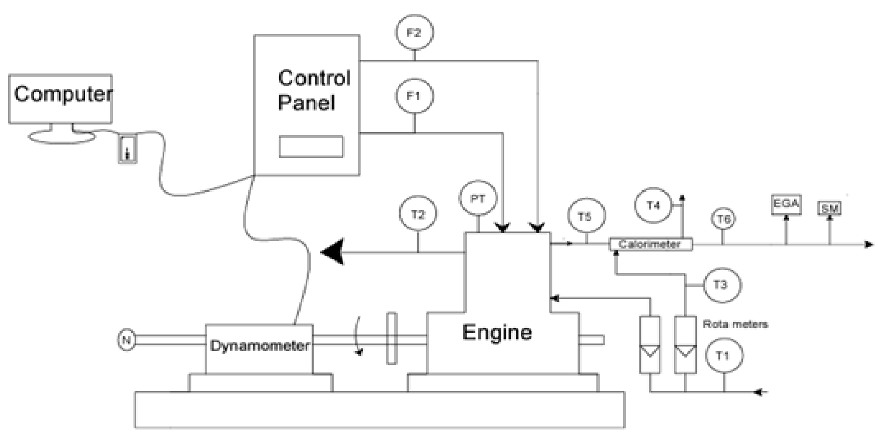


Figure 1. Block diagram of the test ring for biodiesel testing.

T1, T3: Inlet water temperature, T2: Outlet engine jacket water temperature, T4: Outlet calorimeter water temperature, T5: Exhaust gas temperature before calorimeter, T6: Exhaust gas temperature after calorimeter.

Table 1. Specification of single-cylinder diesel engine

Type	Kirloskar
Details	Single-cylinder, Four stroke, Diesel Engine
Bore and stroke	87x110mm
Compression ratio	18:1
Rated power	3.7kw at1500rpm.

Testing has been carried out on the single-cylinder Diesel engine experiential set-up specification as mentioned in Table 1.

The Test ring used for testing purposes is studied on the following parameter

2.1 Engine Details

Single cylinder diesel engine test set up under test is 3.50 kw power at a rated speed is 1500rpm. It is four strokes, constant speed, water-cooled engine. The test ring has a bore diameter of 87.50 (mm), a stroke length of a cylinder of 110.00 (mm), compression ratio of 18.00, swept volume of 661.45 (cc).

2.2 Combustion Parameters

Specific gas constant (kJ/kgK): 1.00, air density at 25°C (kg/m^3): 1.17, the value of the adiabatic index is: 1.41, contact entropy generation, single cycle engine.

2.2.1 Fuel Preparation

- **Preheating of Oil:** The neem oil and *Pongamia pinnate* oil were heated at 80°C for 30 mins using a Gallenkamp magnetic stirrer thermostat hotplate to reduce their viscosity.
- **Transesterification process:** A two-step transesterification was employed due to the high free fatty acid content of neem and *Pongamia pinnate* oils. The modified Hanny and Shizuko method involves acid transesterification followed by base transesterification.
- **Separation of bio-diesel from glycerine:** After the base transesterification process, the biodiesel is left to settle in a separating funnel for at least 24 hrs to ensure clear separation from the glycerin.
- **Bio-diesel washing and drying:** Warm distilled water at 50°C was added to the separated biodiesel

Figure 2. Photographic image of a test ring set up of a single-cylinder diesel engine.

and shaken vigorously. The water was then drained from the bottom of the separating funnel. This process was repeated five times until clear biodiesel was obtained. Anhydrous $CaCl_2$ was added to the biodiesel and gently heated at 50°C, then later removed to yield clean, dry biodiesel. The volume of biodiesel from each sample was measured, and the percentage yield was calculated.

2.3 Performance Parameters

Orifice diameter (mm): 20.00, Orifice coefficient of discharge: 0.60, Dynamometer has 185mm arm length, the fuel pipe diameter is 12.40mm, atmospheric temperature is 27°C , frequency of a test ring is 360, The fuel used in the test ring is diesel with a density 830kg/m^3, calorific value of fuel: 42000kJ/kg.

3.0 Testing and Data Analysis

The experimental investigation was carried out at different loads for a mixed blend of neem and *Pongamia pinnate*. The blends used are B5%, i.e., 5% biodiesel (50% neem and 50% *Pongamia pinnate*) and 95% diesel, B10%, i.e., 10% biodiesel and 90% diesel, B15%, i.e., 15% biodiesel and 85% diesel, B20%, i.e., 20% biodiesel and 80% diesel.

3.1 Diesel Fuel (100% Diesel)

The Report Date: Monday, May 09, 2022, Time: 11:41:36 AM
Organization: Alamuri Ratnamala Institute of Engineering and Technology, Sapgaon.
(An experimental investigation on diesel engine by dual biodiesel blend)
Nitin N. Pawar, Operator; Jagat Sing, Lab Assistant
Data File: TESTING-2.xlsx, Last Modified Date: Monday, May 09, 2022
Configuration File: VCR DIESEL.xls

Figure 3 shows the performance of the engine in terms of Indicated Mean Effective Pressure (IMEP), Break Mean Effective Pressure (BMEP) and Frictional Mean Effective Pressure (FMEP) at a load of 0.64kg, 3.2kg, 6.10kg, 9.230kg, 12.05kg and 15.22kg as well as a speed of Engine is 1601rpm, 1576rpm, 1569rpm,1560rpm, 1549rpm and 1540rpm. Break Means Effective Pressure gives more linear behaviour with the load.

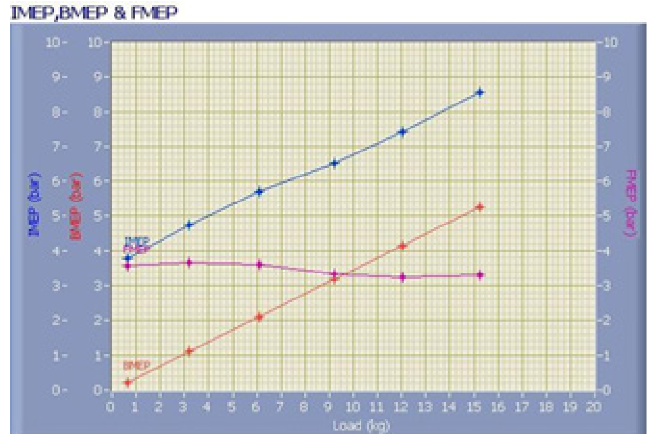


Figure 3. The relation between IMEP, BMEP and FMEP w.r.t. load.

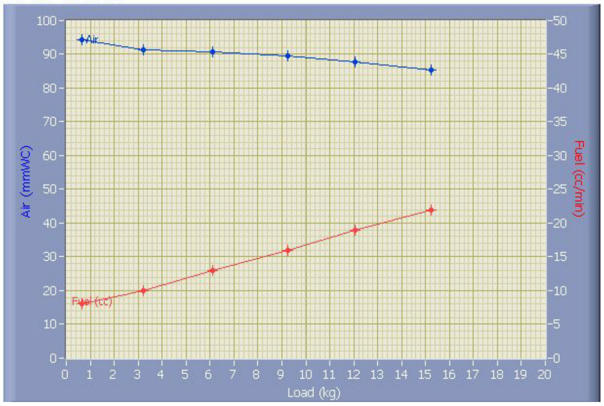
Figures 4(a, b) show the performance of the engine in terms of consumption of an engine in terms of air and fuel and specific fuel consumption. Figure No. 4(a,b) noted that maximum air consumption is 94.24mm/WC and fuel consumption is 8mL/cc at 1600rpm. Specific fuel consumption decreases rapidly in the first half of load increases then decreases slowly.

Figures 4(c, d) show the performance of the engine in terms of consumption of an engine in terms of air and fuel and specific fuel consumption. Figures 4(c, d) noted that maximum air consumption is 94.24mm/WC and fuel consumption is 8mL/cc at 1600rpm.

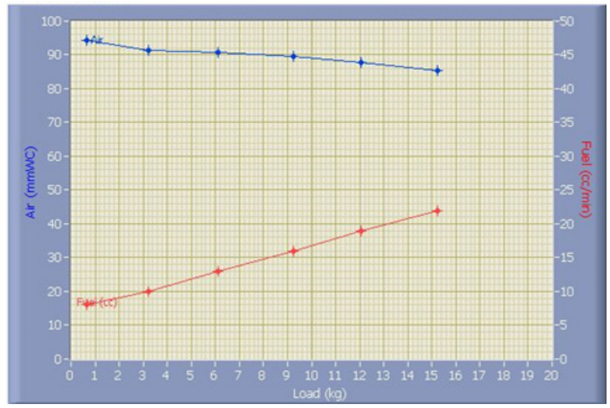
3.2 Blend of B5% (5% Biodiesel and 95% Diesel)

Figure 5 shows the performance of the engine in terms of IMEP, BMEP and FMEP at a load of 3.23kg, 6.20kg, 9.18kg, 12.15kg and 15.19kg as well as the speed of the engine is 1569rpm, 1564rpm, and 1556rpm, 1544rpm and 1530rpm. Break Mean Effective Pressure gives more linear behaviour with load at a blend of 5%.

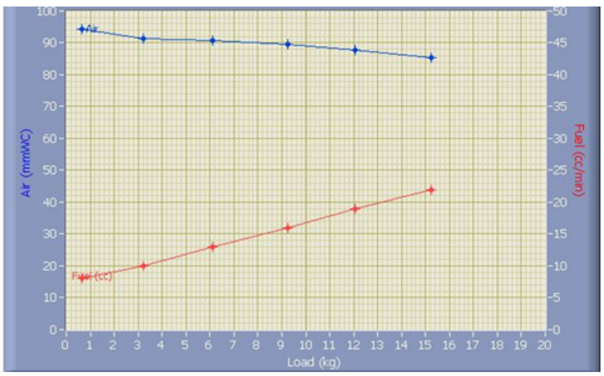
Figure 6(a, b) shows the performance of the engine in terms of the consumption of an engine in terms of air and fuel and specific fuel consumption. Figure 6 noted that maximum air consumption is 94.24 mm/WC and fuel consumption is 8mL/cc at 1600rpm. Specific fuel consumption decreases rapidly in the first half of load increases then decreases slowly.



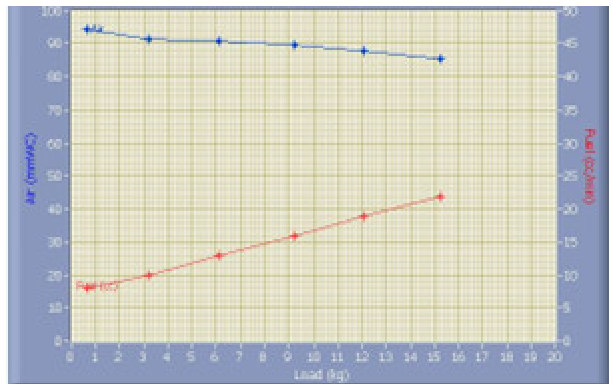
(a)



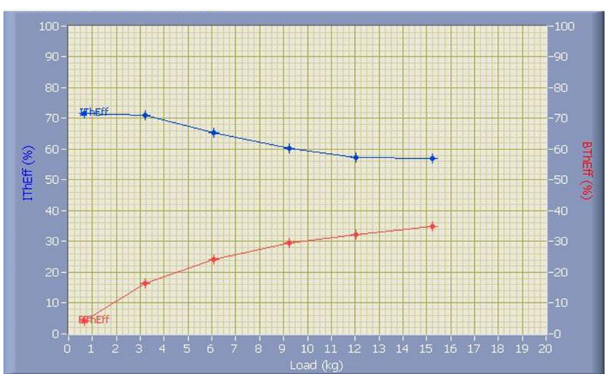
(b)



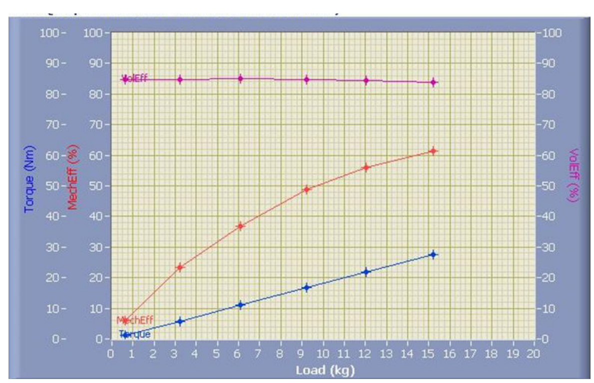
(c)



(d)



(e)



(f)

Figure 4. **(a)** Fuel and air consumption at different loads, **(b)** Fuel and specific fuel consumption at different loads, **(c)** The relations between fuel and air consumption at different loads, **(d)** The relation between fuel and specific fuel consumption at different load, **(e)** The relation between Indicated Power efficiency (IP), Break thermal efficiency (BP) w. r. t. load, **(f)** The relation between torque generated, mechanical efficiency and volumetric efficiency w. r. t. load.Figure 4(e) shows the performance of the engine in terms of IP and BP w. r. t. load at 0.64kg, 3.2kg, 6.10kg, 9.230kg, 12.05kg and 15.22kg as well as a speed engine is 1601rpm, 1576rpm, 1569rpm, 1560rpm, 1549rpm and 1540rpm. Figure 4(e) noted that efficiency first increases and then is constant. Figure 4(f) shows the performance of the engine in terms of Torque generated, mechanical efficiency and volumetric efficiency w.r.t. load. The graph concludes that volumetric efficiency changes are less and torque increases with an increase in load.

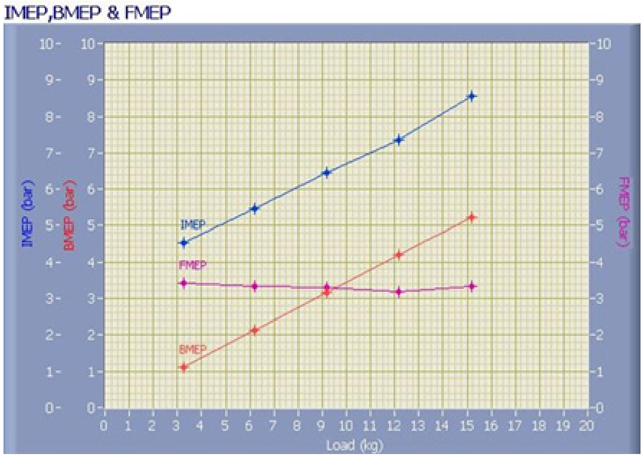


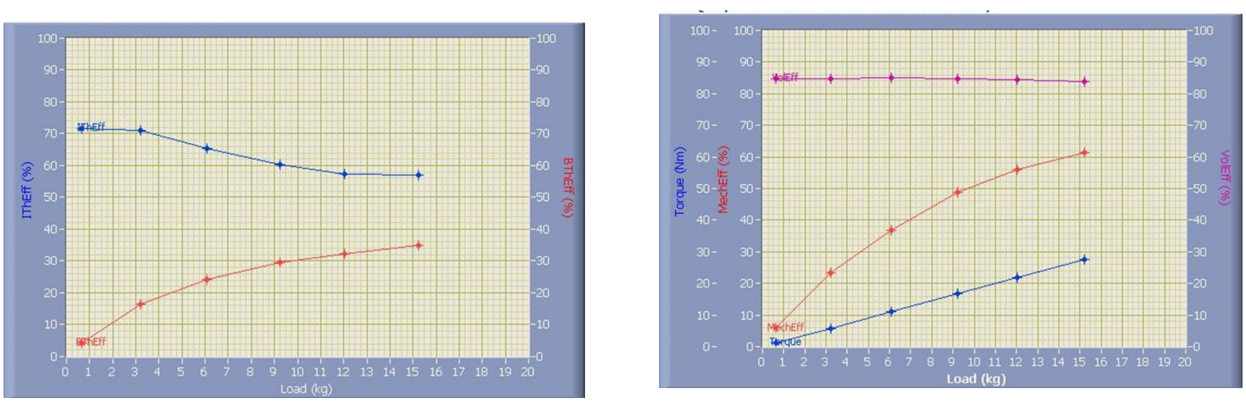
Figure 5. The graph shows the relation between IMEP, BMEP and FMEP w. r. t. load at 5% blend.

engine is 1569rpm, 1564rpm, 1556rpm, 1544rpm and 1530rpm. The graph concludes that volumetric efficiency changes are less and torque increases with an increase in load.

3.3 Blend of B10 % (10% Biodiesel and 95% Diesel)

Figure 7 shows the performance of the engine in terms of IMEP, BMEP and FMEP at a load of 0.28kg, 3.25kg, 6.10kg, 8.92kg, 12.92kg and 15.06kg as well as the speed of the engine is 1619rpm, 1584rpm, 1574rpm, 1563rpm, 1549rpm and 1534rpm. Break Mean Effective Pressure gives more linear behaviour with load at a blend of 5%.

Figures 8(a, b) show the performance of the engine in terms of consumption of an engine in terms of air and fuel and specific fuel consumption. Figures 8(a, b) noted that maximum air consumption is 94.24mm/WC and fuel consumption is 8mL/cc at 1600rpm. Specific fuel consumption decreases rapidly in the first half of load increases then decreases slowly.



(a) (b)

Figure 5. **(a)** The relation between IP, BP w.r.t. load, **(b)** The relation between torque generated, mechanical efficiency and volumetric efficiency w.r.t. load.

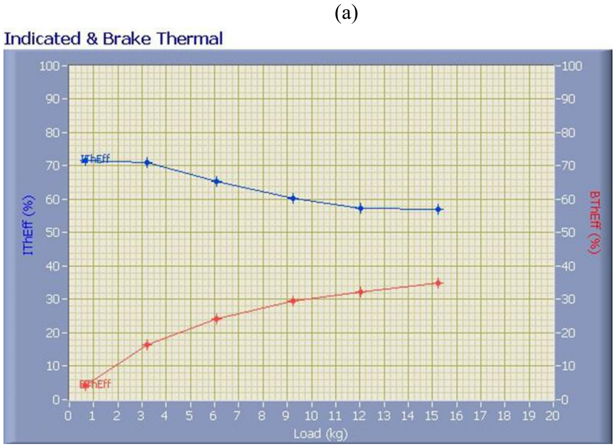
Figure 6(c) shows the performance of the engine in terms of IP and BP w. r. t. load at 3.23kg, 6.20kg, 9.18kg, 12.15kg and 15.19kg as well as the speed of the engine are 1569rpm, 1564rpm, 1556rpm, 1544rpm and 1530rpm. Figure 6(c) noted that efficiency first increases then constant

Figure 6(d) shows the performance of the engine in terms of torque generated, mechanical efficiency and volumetric efficiency w. r. t. load at 3.23kg, 6.20kg, 9.18kg, 12.15kg and 15.19kg as well as the speed of the engine is 1569rpm, 1564rpm, 1556rpm, 1544rpm and 1530rpm.

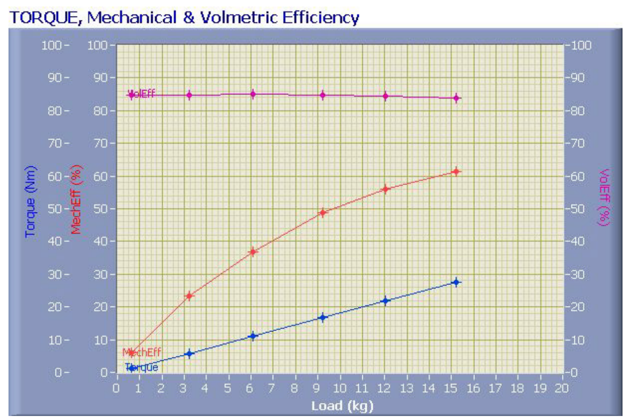
Figure 8(c) shows the performance of the engine in terms of IP and BP w. r. t. load at 0.28kg, 3.25kg, 6.10kg, 8.92kg, 12.92kg and 15.06kg as well as a speed of engine is 1619rpm, 1584rpm, 1574rpm, 1563rpm, 1549rpm and

(a)

(b)



(c)



(d)

Figure 6. **(a)** Fuel and air consumption at different loads, **(b)** Fuel and Specific fuel consumption at different loads, **(c)** IP, BP w. r. t. load at a blend of 5%, **(d)** Torque generated, Mechanical efficiency and volumetric efficiency w. r. t. load at blend 5%.

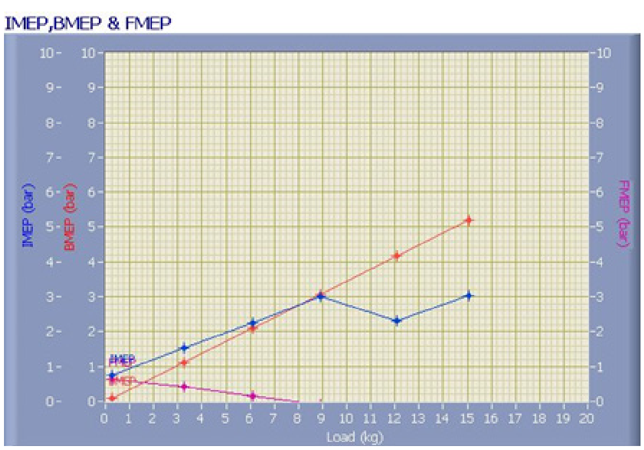
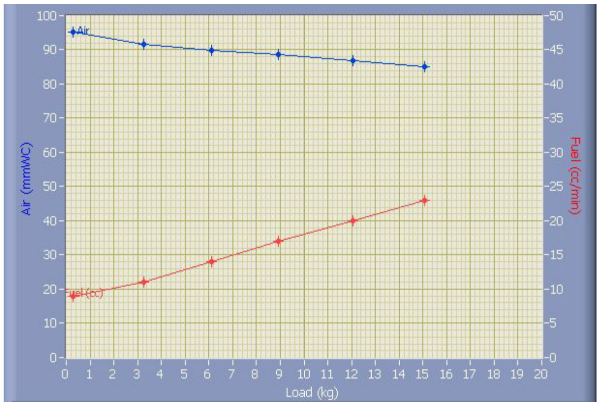
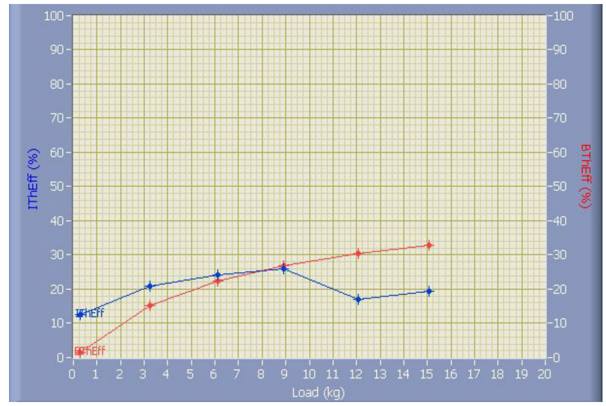


Figure 7. The relation between IP, BP w. r. t. load at a blend of 5%.

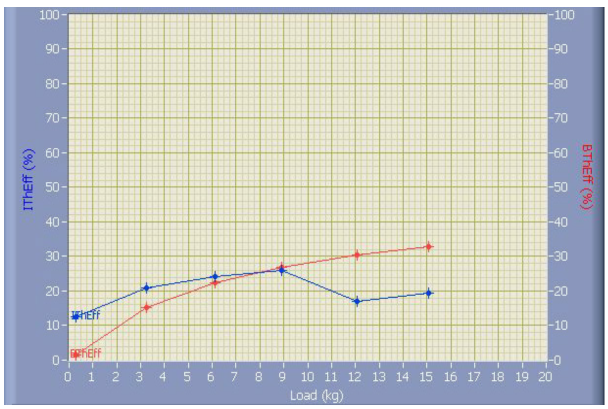
1534rpm. Figure 8(c) noted that efficiency first increases and then is constant.

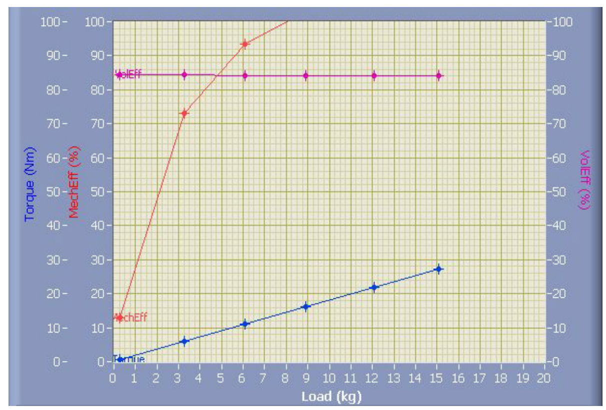
Figure 8(d) shows the performance of the engine in terms of torque generated, mechanical efficiency and volumetric efficiency w. r. t. load at 0.28kg, 3.25kg, 6.10kg, 8.92kg, 12.92kg and 15.06kg as well as a speed of engine is 1619rpm, 1584rpm, 1574rpm, 1563rpm, 1549rpm and 1534rpm. The graph concludes that volumetric efficiency changes are less and torque increases with an increase in load.





(a) (b)





(c) (d)

Figure 8. **(a)** Fuel and air consumption at different loads, **(b)** Fuel and specific fuel consumption at different loads, **(c)** IP, BP w. r. t. load at a blend of 5%, **(d)** Torque generated, mechanical efficiency and volumetric efficiency w. r. t. load at blend 5%.

3.4 Blend of B15 % (15% Biodiesel and 95% Diesel)

Figure 9 shows the performance of the engine in terms of IMEP, BMEP and FMEP at a load of at 0.28kg, 3.25kg, 6.10kg, 8.92kg, 12.92kg and 15.06kg as well as the speed of the engine is 1619rpm, 1584rpm, 1574rpm, 1563rpm, 1549rpm and 1534rpm. Break Mean Effective Pressure gives more linear behaviour with load at a blend of 5%

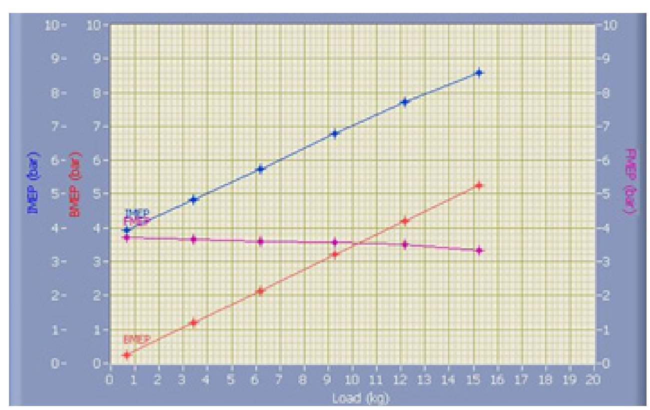
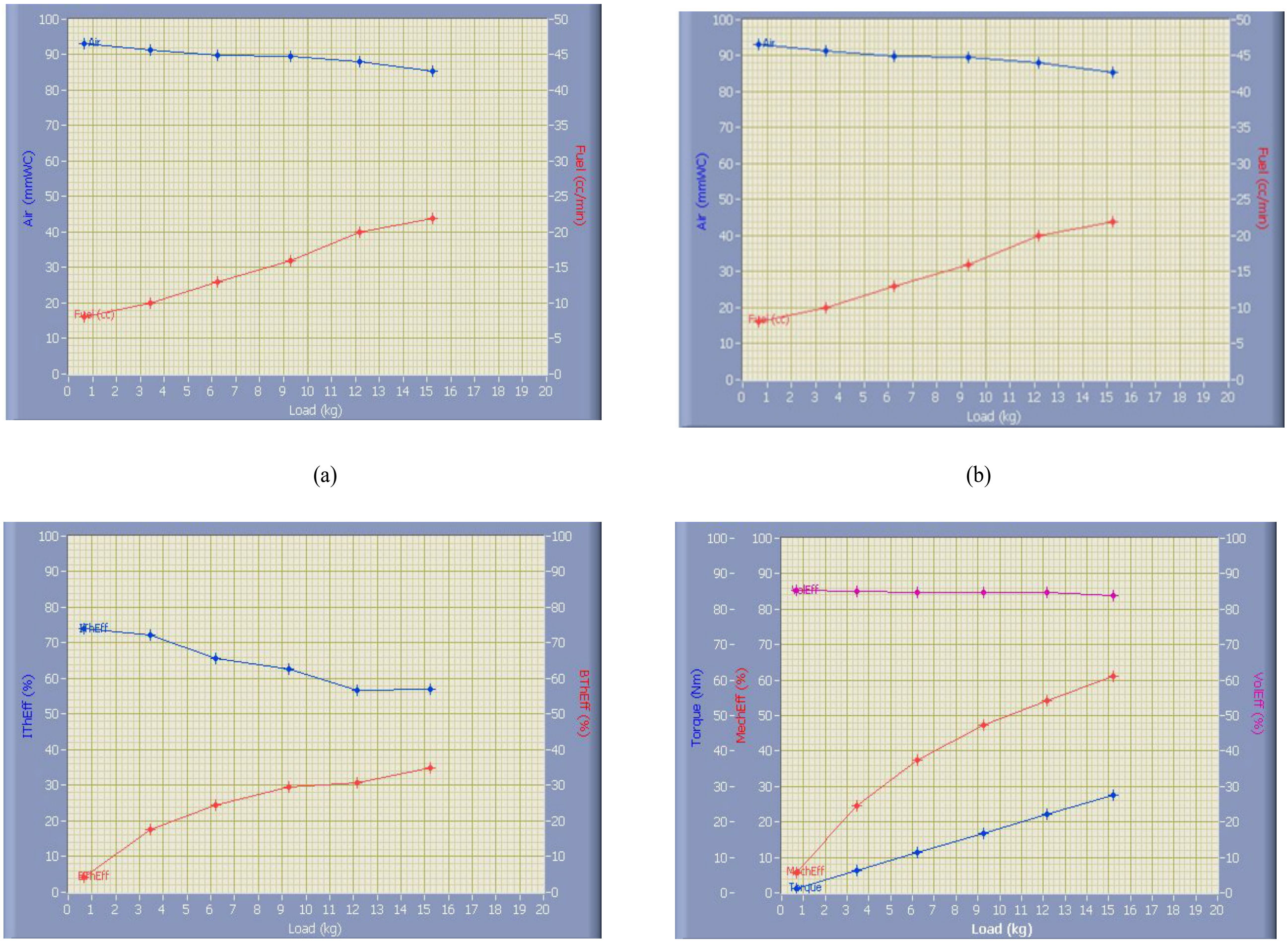


Figure 9. The relation between IP, BP w. r. t. load at a blend of 10%.



(a) (b)

(c) (d)

Figure 10. **(a)** Fuel and air consumption at different loads, Figure **(b)** Fuel and specific fuel consumption at different loads, **(c)** IP, BP w. r. t. load at a blend of 5%, **(d)** Torque generated, mechanical efficiency and volumetric efficiency w. r. t. load at blend 5%.

Figures 10(a, b) show the performance of the engine in terms of consumption of an engine in terms of air and fuel and specific fuel consumption. Figures 10(a, b) noted that maximum air consumption is 94.24mm/WC and fuel consumption is 8mL/cc at 1600rpm. Specific fuel consumption decreases rapidly in the first half of load increases then decreases slowly.

Figure 10(c) shows the performance of the engine in terms of IP and BP w. r. t. load at 0.28kg, 3.25kg, 6.10kg, 8.92kg, 12.92kg and 15.06kg as well as a speed of Engine is 1619rpm, 1584rpm, 1574rpm, 1563rpm, 1549rpm and 1534rpm. Figure 10(c) notes that efficiency first increases and then is constant.

Figure 10(d) shows the performance of the engine in terms of torque generated, mechanical efficiency and volumetric efficiency w. r. t. load at 0.28kg, 3.25kg, 6.10kg, 8.92kg, 12.92kg and 15.06kg as well as a speed of engine is 1619rpm, 1584rpm, 1574rpm, 1563rpm, 1549rpm and 1534rpm. The graph concludes that volumetric efficiency changes are less and torque increases with an increase in load.

3.5 Blend of B15 % (15 % Biodiesel and 95% Diesel)

Figure 11 shows the performance of the engine in terms of IMEP, BMEP and FMEP at a load of 0.64kg, 3.44kg, 6.21kg, 9.28kg, 12.17kg and 15.23kg as well as the speed of the engine is 1582rpm, 1572rpm, 1566rpm, 1562rpm, 1547rpm and 1539rpm. Break Mean Effective Pressure gives more linear behaviour with load at a blend of 5%

Figure 12(a) shows the performance of the engine in terms of IP and BP w. r. t. load at 0.64, 3.21 and 6.10 as well as the speed of the engine is 1582rpm, 1572rpm, 1566rpm, 1562rpm, 1547rpm and 1539rpm. Figure 12(a) notes that efficiency first increases and then is constant.

Figures 12(b, c) show the performance of the engine in terms of consumption of an engine in terms of air and

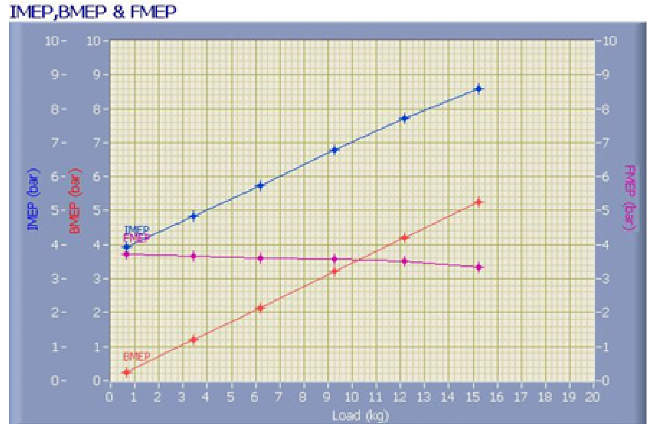
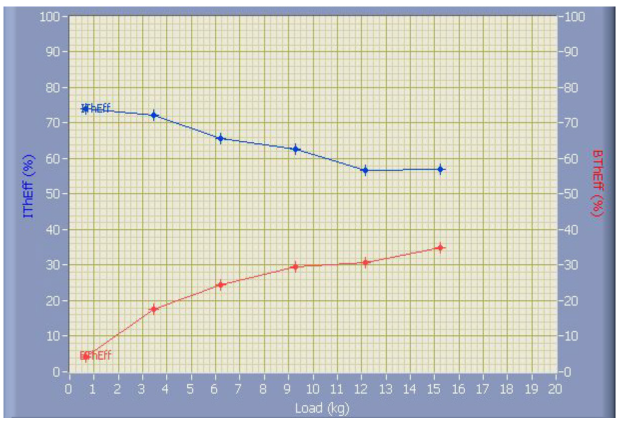
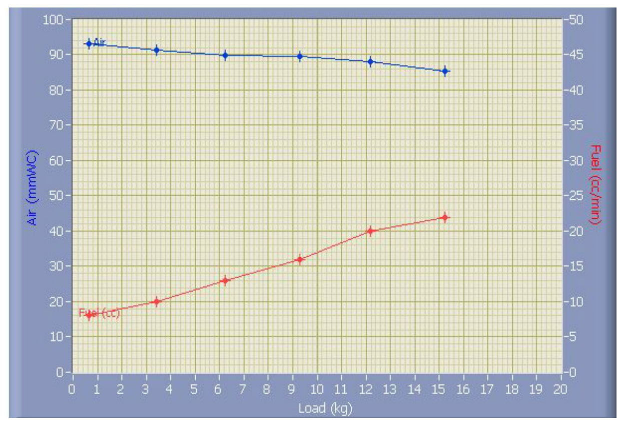


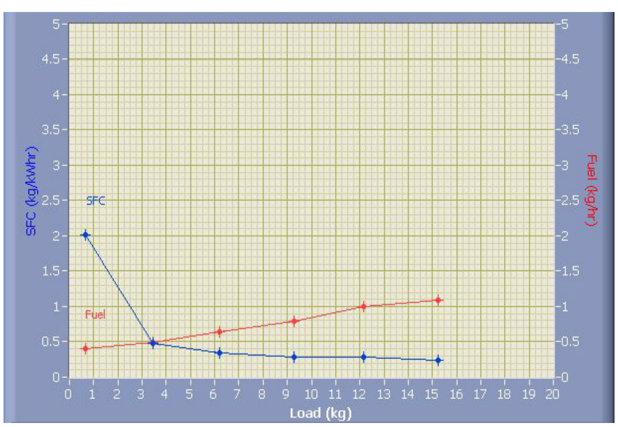
Figure 11 The relation between IP, BP w. r. t. load at a blend of 5%.



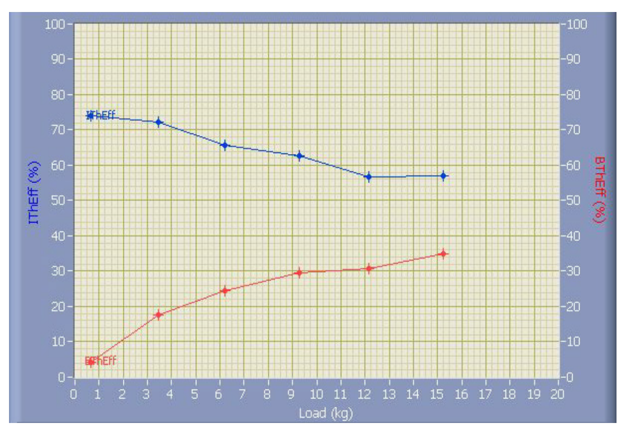
(a)



(b)



(c)



(d)

Figure 12. **(a)** IP, BP w. r. t. load at a blend of 5%. **(b)** Fuel and air consumption at different loads, **(c)** Fuel and specific fuel consumption at different loads, **(d)** IP, BP w. r. t. load at a blend of 5%.

fuel and specific fuel consumption. Figures 12(b, c) noted that maximum air consumption is 94.24 mm/WC and fuel consumption is 8 mL/cc at 1600rpm. Specific fuel consumption decreases rapidly in the first half of load increases then decreases slowly.

Figure 12(d) shows the performance of the engine in terms of IP and BP w. r. t. load at 0.64kg, 3.44kg, 6.21kg, 9.28kg, 12.17kg and 15.23kg as well as a speed of engine is 1582rpm, 1572rpm,1566rpm, 1562rpm, 1547rpm and 1539rpm. Figure 12(d) notes that efficiency first increases and then is constant.

3.6Blend of B20% (20% Biodiesel and 95% Diesel)

Figure 13 shows the performance of the engine in terms of IMEP, BMEP and FMEP at a load of at 0.66kg, 3.34kg,

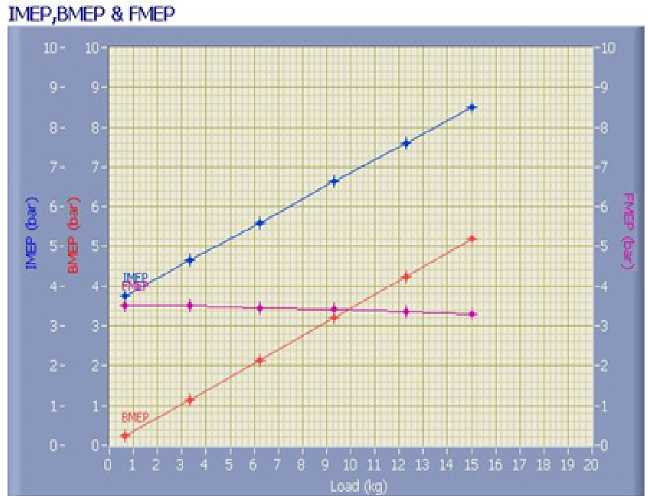
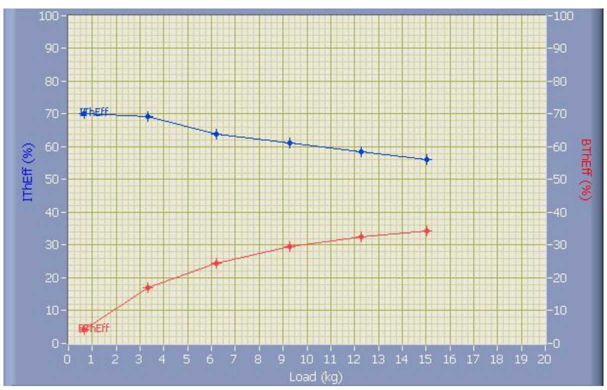
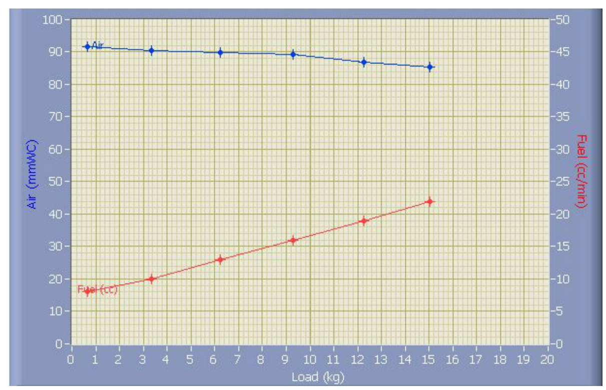


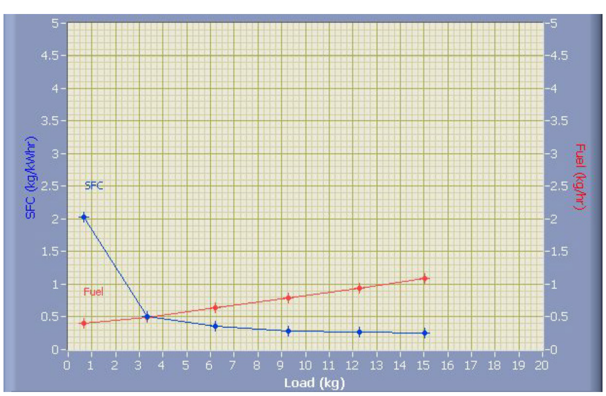
Figure 13 The relation between IP, BP w. r. t. load at a blend of 5%.



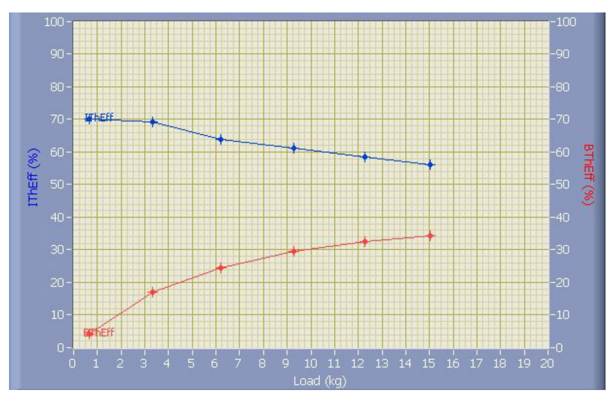
(a)



(b)



(c)



(d)

Figure 14. **(a)** IP, BP w. r. t. load at a blend of 5%. **(b)** Fuel and air consumption at different loads, **(c)** Fuel and specific fuel consumption at different loads, **(d)** IP, BP w. r. t. load at a blend of 5%.

6.21kg, 9.29kg, 12.28kg and 15.04kg as well as the speed of the engine is 1579rpm, 1569rpm, 1562rpm, 1555rpm, 1541rpm and 1535rpm. Break Mean Effective Pressure gives more linear behavior with load at a blend of 5%.

Figures 14(a, b) show the performance of the engine in terms of IP and BP w. r. t. load at 0.66kg, 3.34kg, 6.21kg, 9.29kg, 12.28kg, and 15.04kg as well as a speed engine is 1579rpm, 1569rpm, 1562rpm, 1555rpm, 1541rpm and 1535rpm. Figure14 (a) noted that efficiency first increases and then is constant.

Figures 14 (b, c) shows the performance of the engine in terms of consumption of an engine in terms of air and fuel and specific fuel consumption. Figures 14 (b, c) noted that maximum air consumption is 94.24mm/WC and fuel consumption is 8mL/cc at 1600rpm. Specific fuel consumption decreases rapidly in the first half of load increases then decreases slowly.

Figure 14(d) shows the performance of the engine in terms of IP and BP w. r. t. load at 0.66kg, 3.34kg, 6.21kg, 9.29kg, 12.28kg and 15.04kg as well as a speed of engine is 1579rpm, 1569rpm, 1562rpm, 1555rpm, 1541rpm and 1535rpm. Figure 14(d) notes that efficiency first increases and then is constant.

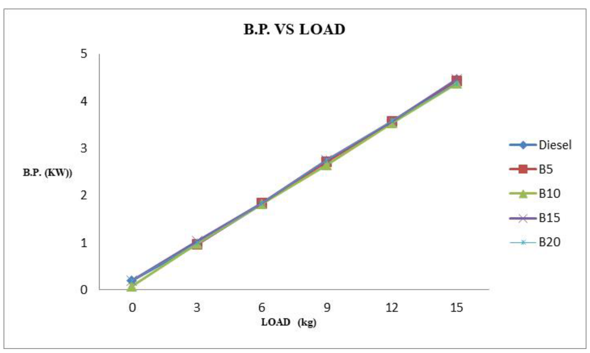
4.0 Results and Discussions

Figure 15(a) shows the engine performance on the parameter Break Power (BP) and load. It has been found that blends and Diesel are close to performance.

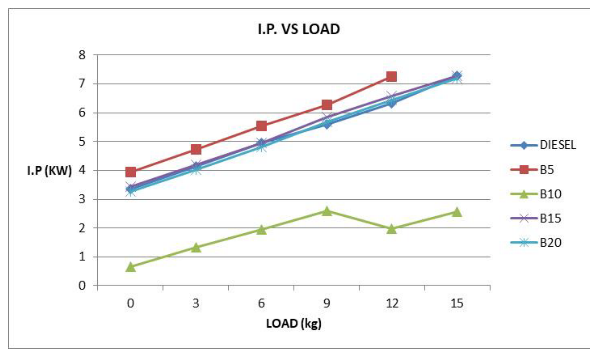
Figure 15(b) shows that the indicated power of blend B5 is greater than diesel and other blends.

Figure 15(c) shows the engine performance on the parameter break thermal efficiency and load. It has been found that B5 blends are more efficient than diesel and other blends.

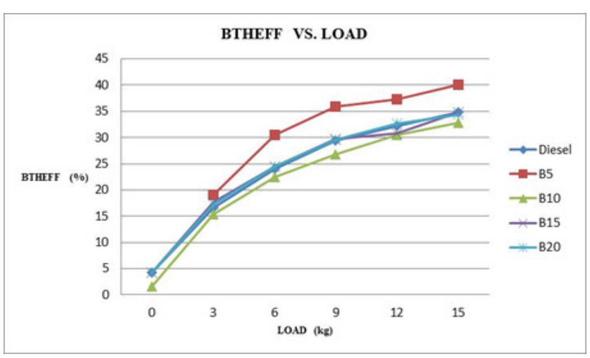
Figure 15(d) shows the engine performance on the parameter indicated thermal efficiency and load. It has been found that B5 blends are more efficient than diesel



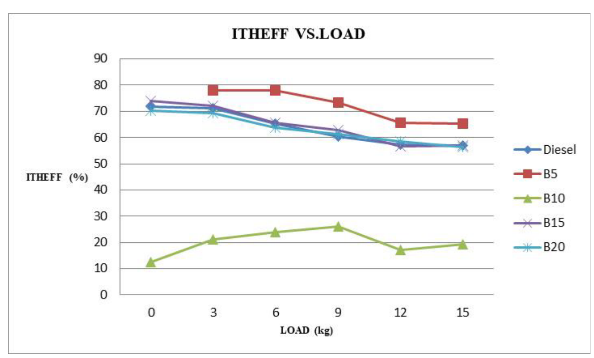
(a)



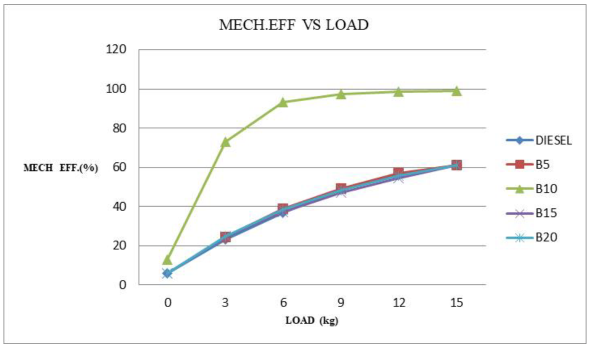
(b)



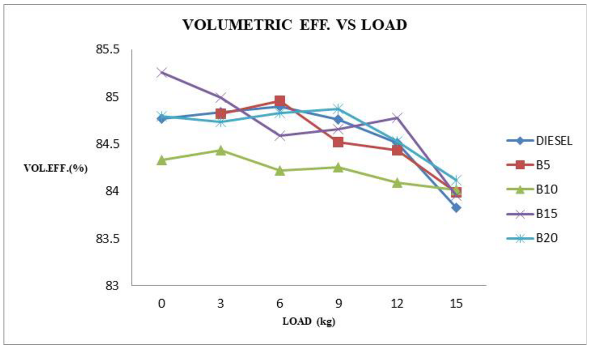
(c)



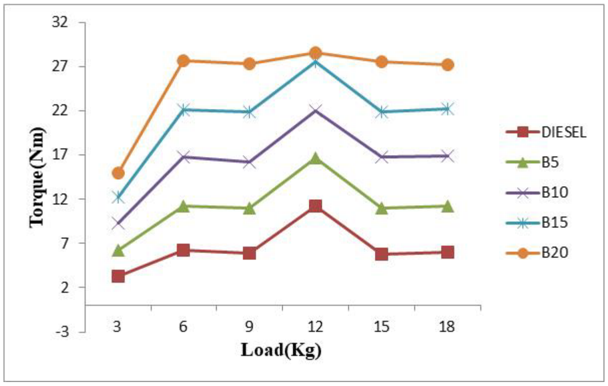
(d)



(e)



(f)



(g)

Figure 14. **(a)** 44. Break power and load of the engine, **(b)** Indicated power and load of the engine, **(c)** Break thermal efficiency and load of the engine, **(d)** Indicated thermal efficiency and load of the engine, **(e)** Mechanical efficiency and load of the engine, **(f)** volumetric efficiency and load of engine, **(g)** Torque and load of engine.

and other blends. It also concludes that B10 has a much different performance than other blends.

Figure 15(e) shows the engine performance on the parameter mechanical efficiency and load. It has been found that B10 blends are more efficient than diesel and other blends.

Volumetric efficiency is analyzed with the load of the engine in Figure 15(f). It states that volumetric efficiency varies concerning load and smoothly decreases in B20.

Figure 15(g) shows torque is analysis with the load of the engine and shows that torque efficiency varies concerning load and smoothly decreases in B20.

5.0 Conclusion

The conclusions derived from the aforementioned experimental study on a single-cylinder diesel engine indicate that the engine operates under varying loads (0.64kg, 3.2kg, 6.10kg, 9.230kg, 12.05kg and 15.22kg) using a combination of diesel fuel blended with neem and *Pongamia pinnata* (karanj) biodiesel in dual fuel mode, with corresponding graphical representations. The blend of biodiesel in dual fuel mode can be directly used in diesel engines without any engine modification.

The break thermal efficiency rises with B5% and stays consistent with B15 and B20 blends compared to the diesel engine.

As the engine load increases, the indicated thermal efficiency consistently declines. Notably, the indicated thermal efficiency surpasses that of the diesel engine for B15 and B20 blends.

On the same load condition the Mechanical efficiency and volumetric efficiency remain steady.

The reliance on diesel can be lessened by employing biodiesel in applicable scenarios, thereby benefiting both the environment and conserving foreign exchange reserves.

6.0 References

1. Abdelraziq IR. Biodiesel viscosity and flash point determination; 2015.
2. Arjanggi RD, Kansedo J. Recent advancement and prospective of waste plastics as biodiesel additives: A review. J Energy Inst. 2019; 93(3):1-19. https://doi.org/10.1016/j.joei.2019.08.005
3. Pawar NN, Jadhao KK. An experimental investigation of production of plastic fuel and blend with diesel fuel. Lect Notes Electr Eng. 2022; 976:211-20. https://doi.org/10.1007/978-981-99-0412-9_18
4. Arjanggi RD, Kansedo J. Recent advancement and prospective of waste plastics as biodiesel additives: A review. J Energy Inst. 2020; 93(3):934-52. https://doi.org/10.1016/j.joei.2019.08.005
5. Kalargaris I, Tian G, Gu S. Combustion, performance and emission analysis of a DI diesel engine using plastic pyrolysis oil. Fuel Process Technol. 2017; 157,108-15. https://doi.org/10.1016/j.fuproc.2016.11.016
6. Pradeep AP, Gowthaman S. Combustion and emission characteristics of diesel engine fuelled with waste plastic oil – A review. Int J Ambient Energy; 2019:1-19. https://doi.org/10.1080/01430750.2019.1684994
7. Milojević S, Pešić R. Determination of combustion process model parameters in diesel engine with variable compression ratio. J Combust. 2018:1-11.https://doi.org/10.1155/2018/5292837
8. Bridjesh P, Periyasamy P, Chaitanya AVK, Geetha NK. MEA and DEE as additives on diesel engine using waste plastic oil diesel blends. Sustain Environ Res. 2018; 28(3):142-7.https://doi.org/10.1016/j.serj.2018.01.001
9. Dhanasekaran M, Bhavan PS, Manickam N, Kalpana R. Physico-chemical characteristics and zooplankton diversity in a perennial lake at Dharmapuri (Tamil Nadu, India). J Entomol Zool Stud. 2017; 5(1):285-92.
10. Knothe G, Van Gerpen J, Krahl J. The biodiesel handbook. AOCS Publishing eBooks. AOCS Publishing; 2005. p. 1-328. https://doi.org/10.1201/9781439822357 PMCid:PMC550665
11. Sharma VK, Singh SK, Saraswat M. Effect of ratio of total valuem to clearance volume i.e. compression ratio on performance and emissions of diesel on a single cylinder four stroke VCR engine. Int J Emerg Technol Adv Eng. 2015; 5:94-102.
12. Kaimal VK, Vijayabalan P. An investigation on the effects of using DEE additive in a DI diesel engine fuelled with waste plastic oil. Fuel. 2016; 180: 90-6. https://doi.org/10.1016/j.fuel.2016.04.030
13. Agarwal AK, Sharma N, Singh AP, Kumar V, Satsangi DP, Patel C. Adaptation of methanol–dodecanol–diesel blend in diesel genset engine. J Energy Resour Technol. 2019; 141(10). https://doi.org/10.1115/1.4043390
14. Wami EN, Emesiobi FC, Ugoha VIP. Suitability of recycled waste plastic bags as aggregate for highway construction: The Nigerian experience. Nigerian Soc Chem Eng. 2004; 34:139-44.
15. Njiribeako IA, Kathleen EG. Management of non-biodegradable wastes in Nigeria. J Eng Manage. 2003; 4(2):9-12.
16. Abnisa F, Wan Daud WMA. A review on co-pyrolysis of biomass: An optional technique to obtain a high-grade pyrolysis oil. Energy Convers Manag. 2014; 87:71-85. https://doi.org/10.1016/j.enconman.2014.07.007