

# Effect of Compression Ratio on Performance Characteristics of Diesel Engine Run by Biodiesel Derived From Neem & Pongamia

Rajeesh.S<sup>1</sup>, S V Prakash<sup>2</sup>, Nagesh S N<sup>3</sup> and Girish V Kulkarni<sup>4</sup>

Research scholar, Ramaiah Institute of Technology, Bangalore, VTU Belgaum, India<sup>1</sup>

Professor & Dean, Department of Mechanical Engineering, Sri Krishna Institute of Technology, Bangalore, India<sup>2</sup>

Assistant Professor, Department of Mechanical Engineering, Ramaiah Institute of Technology, Bangalore, India<sup>3</sup>

**ABSTRACT:** In this study, diesel, biodiesel blends of neem (NB) and biodiesel blends of pongamia (PB) were tested in a four stroke, single cylinder, variable compression ratio, water-cooled, 553cc capacity kirloskar AV-1 CI engine to investigate the engine performance and emission characteristics of the engine under five engine loads at the speed of 1500 rpm at different compression ratios 12:1, 15:1 & 17:1 respectively. Various blends of neem viz., NB10 (Diesel 90% and neem 10%), NB15 (Diesel 85% and neem 15%), NB20 (Diesel 80% and neem 20%) and NB25 (Diesel 75% and neem 25%) and various blends of pongamia viz., PB10 (Diesel 90% and pongamia 10%), PB15 (Diesel 85% and pongamia 15%), PB20 (Diesel 80% and pongamia 20%) and PB25 (Diesel 75% and pongamia 25%) biodiesels were tested in the engine. The output parameters like, Brake Power (BP), Indicated Power (IP), Specific Fuel Consumption (SFC), Mechanical Efficiency, Brake Thermal Efficiency (BTE) were analyzed. From the experiments it was observed that, the increased trend in BTE and reduced BSFC with increased compression ratio for all blends of biodiesels. The optimum BTE was showed for NB15 (Neem biodiesel blend) at CR 17:1 and 60% load in compared with all neem biodiesel blend. Similarly PB10 (Pongamia biodiesel blend) showed optimum BTE at CR 12:1 & 80% load in compared with all their respective biodiesel blends. The optimum BSFC was showed for NB15 (Neem biodiesel blend) at CR 12:1 and 60% load in compared with all neem biodiesel blend. Similarly PB20 (Pongamia biodiesel blend) showed optimum BTE at CR 17:1 & 60% load in compared with all their respective biodiesel blends. However at maximum compression ratio (CR 17:1) and maximum load (80%), NB10 and PB10 at exhibits better performance characteristics respectively in compared with all biodiesel blends.

**KEYWORDS:** compression ratio; neem; pongamia; engine performance and emission characteristics.

## I. INTRODUCTION

In today's world the Fossil fuels have given birth to the industrial revolution and subsequently, drive the modern world. With a staggering economy, climbing gas prices and global climate change, some researchers are exploring sources other than petroleum for fuel. Organic matter is one such source. Several attempts have been made to use edible and non-edible oils in compression ignition for different utilities. But developing countries cannot afford to use edible oils as a power source; but non-edible oils, such as Jatropa, Sweet sorghum, Cashew Nut Shell oil, etc can be strategically propagated. Pongamia pinnata (karanja) and Jatropa curcas (ratanjot) could form the basis of a self-sustaining agricultural platform that could breathe new life into villages. Materials like corn and soybeans have oil extracts that can be converted to ethanol or biodiesel. These and many other organic materials are more sustainable than petroleum, meaning they can be re grown and remain productive with less negative impact on our ecosystem.

Biodiesels are derived from edible oils and non-edible oils such as jatropa, pongamia, cashew nut shell liquid oil, mahua, cottonseed, soy bean, neem, sunflower, rapeseed, palm etc. Direct use of vegetable oils or animal fats as fuel can cause numerous engine problems like poor fuel atomization, incomplete combustion and carbon deposition formation, engine fouling and lubrication oil contamination, which is due to higher viscosity [2]. Hence the viscosity of vegetable oils can be reduced by several methods which include blending of oils, micro emulsification, cracking /

pyrolysis and transesterification [3]. Among this transesterification is widely used for industrial biodiesel production [4].

It is important for an alternative diesel fuels to be technically acceptable, economically competitive, environmentally acceptable and easily available. Among these alternative fuels, biodiesel and its derivatives, have received much attention in recent years for diesel engines. For all above reasons, it is generally not accepted that blends of standard diesel fuel with 10% or up to 20% biodiesels can be used in existing diesel engines without any modifications[5]. However major disadvantage of vegetable oil is its viscosity, which is considerably higher than that of mineral diesel. Because of high viscosity and low volatility of vegetable oils, the brake thermal efficiency of vegetable oils is inferior to those of diesel. This leads to problems of high smoke, HC and CO emissions. Due to some technical deficiencies, they are rarely used purely in unmodified diesel engines. They are generally used as a blend with conventional diesel fuel with low percentages.

In this work the different blends of biodiesel derived from neem and pongamia used in an unmodified diesel engine. The engine performance characteristics are evaluated at different compression ratio for a varying load conditions.

## II. MATERIALS AND METHODS

### 2.1 Test fuels

Transesterified biodiesel of blends B10, B15, B20 & B25 derived from neem and pongamia were procured from University of Agricultural Science, Gandhi Krishi Vignan Kendra, Bengaluru, India. In the present work, no modifications were done to IC engine for testing biodiesel. Hence, the blend ratio were chosen to B25 as per ASTM standards.

All biodiesel blends were tested for their basic properties such as CV, density, Kinematic viscosity, flash point and fire point. The tests were conducted at Sneha Test House, Bangalore, India, and a professional testing service provider.

The properties of biodiesels are listed in

Table 2-1 to  
Table 2-12

Table 2-1: Properties of the different blends of neem biodiesel

Properties	Diesel	Neem			
		NB10	NB15	NB20	NB25
Calorific Value (kJ/kg)	44800	41533	40946	40361	39775
Density kg/m <sup>3</sup>	840	841	844	846	850
Kinematic Viscosity (mm <sup>2</sup> /sec)	4	3.78	3.8175	3.855	4.96
Flash Point °C	61	57	59	62	65
Fire Point °C	65	67	71	74	78

Table 2-2: Properties of the different blends of pongamia biodiesel

Properties	Diesel	Pongamia			
		PB10	PB15	PB20	PB25
Calorific Value (kJ/kg)	44800	41784	41282	40777	40277
Density kg/m <sup>3</sup>	840	843	846	850	853
Kinematic Viscosity (mm <sup>2</sup> /sec)	4	4.3	4.75	5.2	7.2
Flash Point °C	61	65	66	67	68
Fire Point °C	65	69	71	74	76

### III. EXPERIMENTAL SETUP AND PROCEDURE

The experiments were carried out in the CI engine laboratory (Mechtrix engineers Pvt ltd, Bangalore, India) on an experimental test rig consisting of a water-cooled, single-cylinder, four-stroke, and stationary and constant-speed diesel engine connected to an eddy current dynamometer. It also includes the fuel system, the lubrication system and various sensors and instruments built into the data acquisition system to measure the load, air and fuel flow, exhaust gas temperature. The configuration allows the evaluation of thermal performance and engine emission components. The performance parameters are BP, SFC and Exhaust temperature. The thermocouples are located in the appropriate positions. The experimental setup consists the following major components.

Figure 3-1 shows the of schematic diagram of experimental setup and Table-3-1 shows the engine specifications:

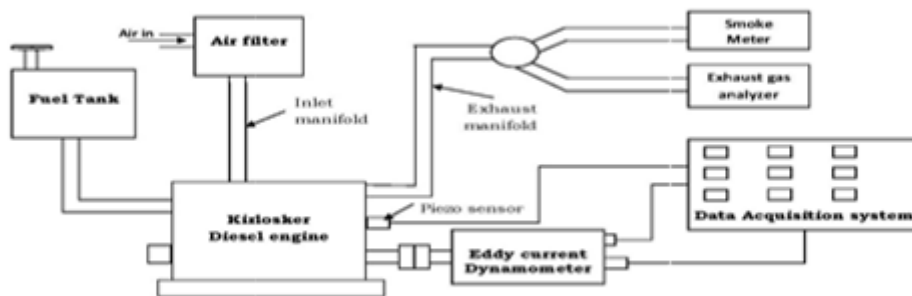


Figure 3-1: Schematic diagram of experimental setup.

Table 3-1: Engine specifications

Engine	Type - single cylinder, 4- stroke diesel, water cooled, VCR
Make	KIRLOSKAR AV-1.
Rated power	3.7 kW, 1500 rpm
Bore and stroke	85mm*110mm
Compression ratio	12:1 to 18:1
Cylinder capacity	553 cc
Dynamometer	Type eddy current, water cooled, with loading unit
Crank angle sensor	Resolution 1 Deg, Speed 5500 rpm with TDC pulse.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Load indicator	Digital, Range 0-50 Kg, 230V AC Supply
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Exhaust gas analyzer	Make – Smart cap Technologies, Five gas analyzer

The performance tests were carried on a single cylinder, four strokes and water cooled, kirloskar AV 1 diesel engine. The engine was directly coupled to an eddy current dynamometer. The engine was run at a constant speed of 1500 rpm. The cylinder pressure was measured by a Kistler piezoelectric sensor (Type 6056A). The pressure signals were amplified with a Kistler charge amplifier (Type 5011B) and analyzed with a combustion analyzer o obtain the heat release rate. A crank angle encoder was employed for crank-angle signal acquisition. Experiments were conducted at the engine speed of 1500 rpm and at five engine loads. In this study, the diesel engine was not modified during all the tests. Before each test, the engine was allowed to operate with the new fuel for twenty minutes to clean the fuel system which is used in the previous running. The data were recorded continuously for 5 min to reduce experimental uncertainties, and average values were presented.

#### IV. RESULTS AND DISCUSSION

Performance characteristics for the various load conditions at different compression ratios are analyzed and the results are presented in the following sections.

##### Performance Parameters

##### 4.1.1 Brake Thermal Efficiency (BTE)

Fig.4.1 to Fig.4.3. Shows the variation of brake thermal efficiency with respect to load for the tested fuels for different compression ratios 12:1, 15:1 and 17:1 respectively.

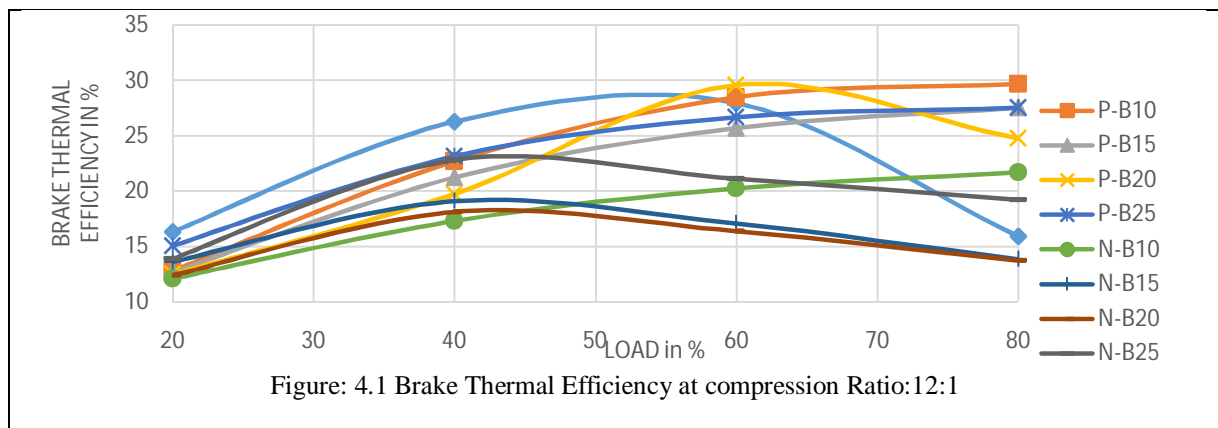


Figure: 4.1 Brake Thermal Efficiency at compression Ratio:12:1

It is observed from the figure.4.1 at compression ratio 12:1, as the load varies from 20%, the optimum BTE increased by 79.33% at 80% load for NB10, 40.4% at 40% load for NB15, 45.9% at 40% load for NB20 and 64.02% at 40% load for NB25 respectively. Similarly the optimum BTE increased by 132.0% at 80% load for PB10, 117.0% at 80% load for PB15, 136.8% at 60% load for PB20 and 82.1% at 80% load for PB25 respectively. This may be due to the lower heating value and inferior combustion of neem biodiesel in compare with pongamia biodiesel. Besides, the brake thermal efficiency of was higher than that of neem biodiesel fuel at full load (80% load).

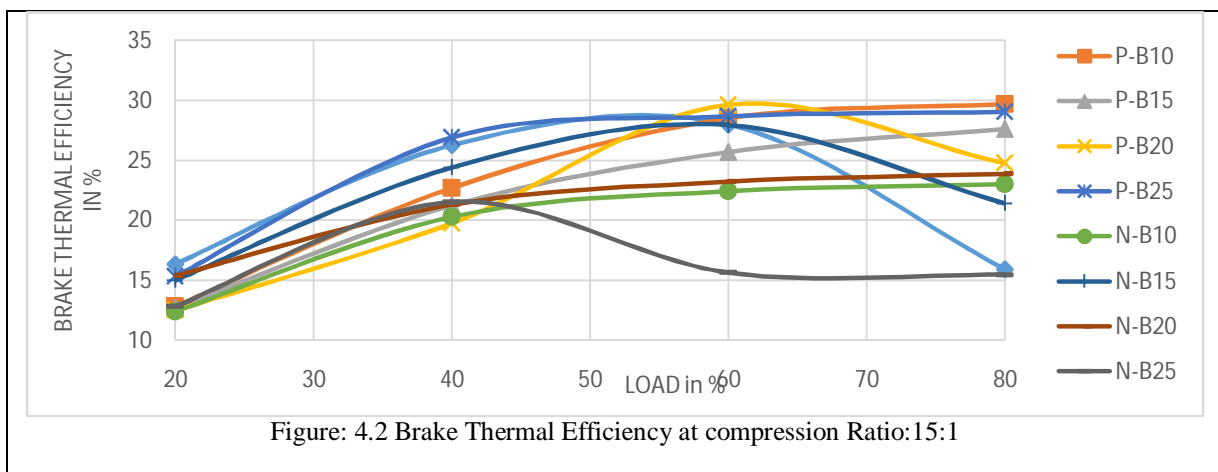
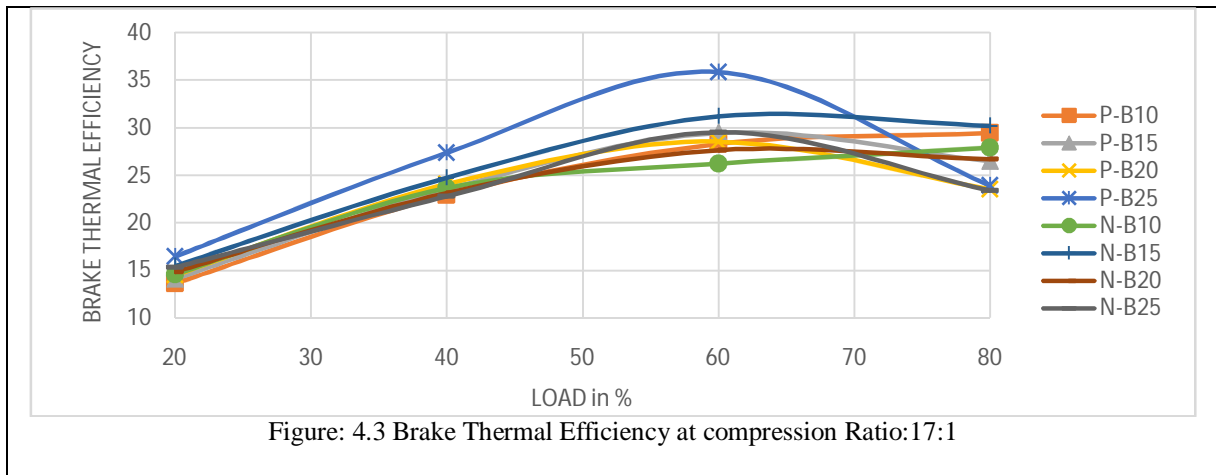


Figure: 4.2 Brake Thermal Efficiency at compression Ratio:15:1

It is observed from the figure.4.2 at compression ratio 15:1, as the load varies from 20%, the optimum BTE increased by 85.4% at 80% load for NB10, 86.0% at 60% load for NB15, 50.6% at 80% load for NB20 and 67.96% at 40% load

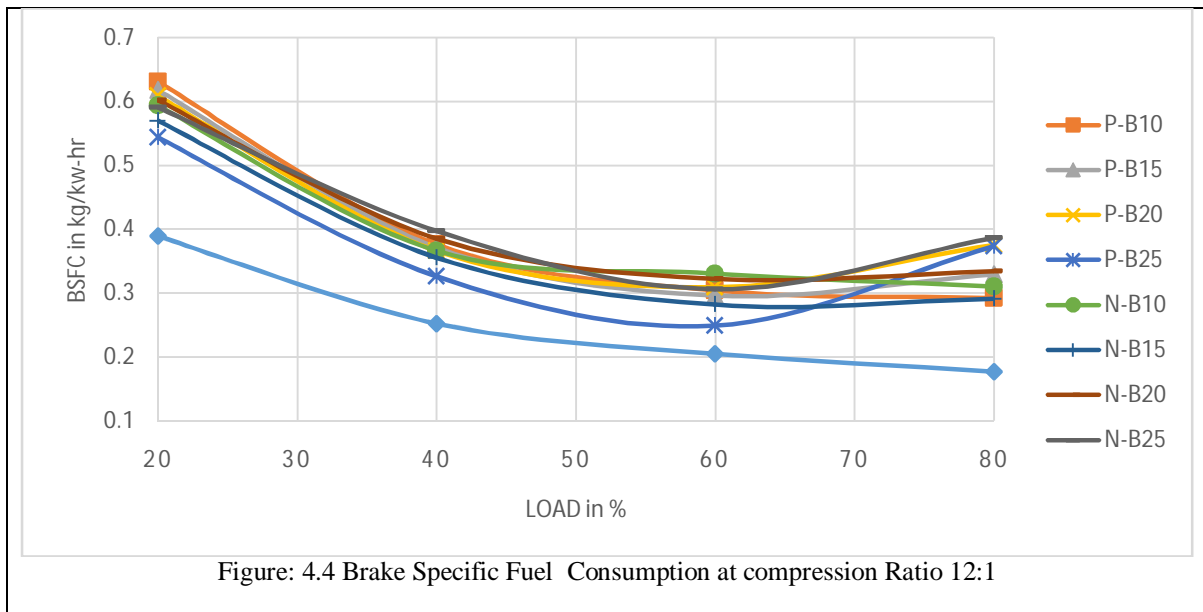
for NB25 respectively. Similarly the optimum BTE increased by 113.5% at 60% load for PB10, 105.0% at 60% load for PB15, 95.9% at 60% load for PB20 and 93.2% at 80% load for PB25 respectively. The brake thermal efficiency of pongamia biodiesel was higher than that of neem biodiesel fuel at 60% load.



It is observed from the figure.4.3 at compression ratio 17:1, as the load varies from 20%, the optimum BTE increased by 91.0% at 80% load for NB10, 102.0% at 60% load for NB15, 86.4% at 60% load for NB20 and 92.81% at 60% load for NB25 respectively. Similarly the optimum BTE increased by 116.9% at 60% load for PB10, 109.2% at 60% load for PB15, 96.5% at 60% load for PB20 and 118.9% at 80% load for PB25 respectively. The brake thermal efficiency of pongamia biodiesel was higher than that of neem biodiesel fuel at 60% load.

#### 4.2.2 Brake Specific Fuel Consumption (BSFC)

Fig.4.1 to Fig.4.3. Shows the variation of brake specific fuel consumption with respect to load for the tested fuels for different compression ratios 12:1, 15:1 and 17:1 respectively.



It is observed from the figure.4.4 at compression ratio 12:1, as the load varies from 20%, the optimum BSFC decreased by 47.69% at 80% load for NB10, 50.5% at 60% load for NB15, 46.4% at 60% load for NB20 and 48.10% at 60% load for NB25 respectively. Similarly the optimum BSFC decreased by 53.65% at 80% load for PB10, 52.08% at 60% load for PB15, 49.22% at 60% load for PB20 and 54.16% at 60% load for PB25 respectively. This may be due to the lower heating value and inferior combustion of neem biodiesel in compare with pongamia biodiesel. The brake specific fuel consumption of pongamia biodiesel was lower than that of neem biodiesel fuel at 60% load.

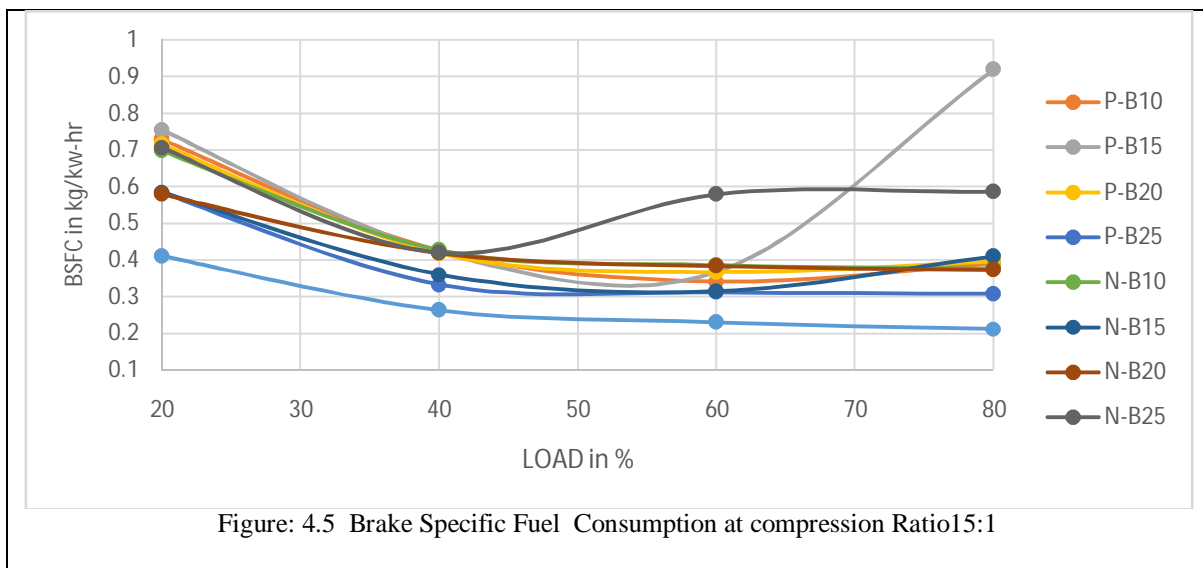


Figure: 4.5 Brake Specific Fuel Consumption at compression Ratio 15:1

It is observed from the figure.4.5 at compression ratio 15:1, as the load varies from 20%, the optimum BSFC decreased by 46.0% at 80% load for NB10, 46.25% at 60% load for NB15, 35.5% at 80% load for NB20 and 40.44% at 40% load for NB25 respectively. Similarly the optimum BSFC decreased by 53.22% at 60% load for PB10, 51.25% at 60% load for PB15, 48.72% at 60% load for PB20 and 47.26% at 80% load for PB25 respectively. The brake specific fuel consumption of pongamia biodiesel was lower than that of neem biodiesel fuel at 60% load.

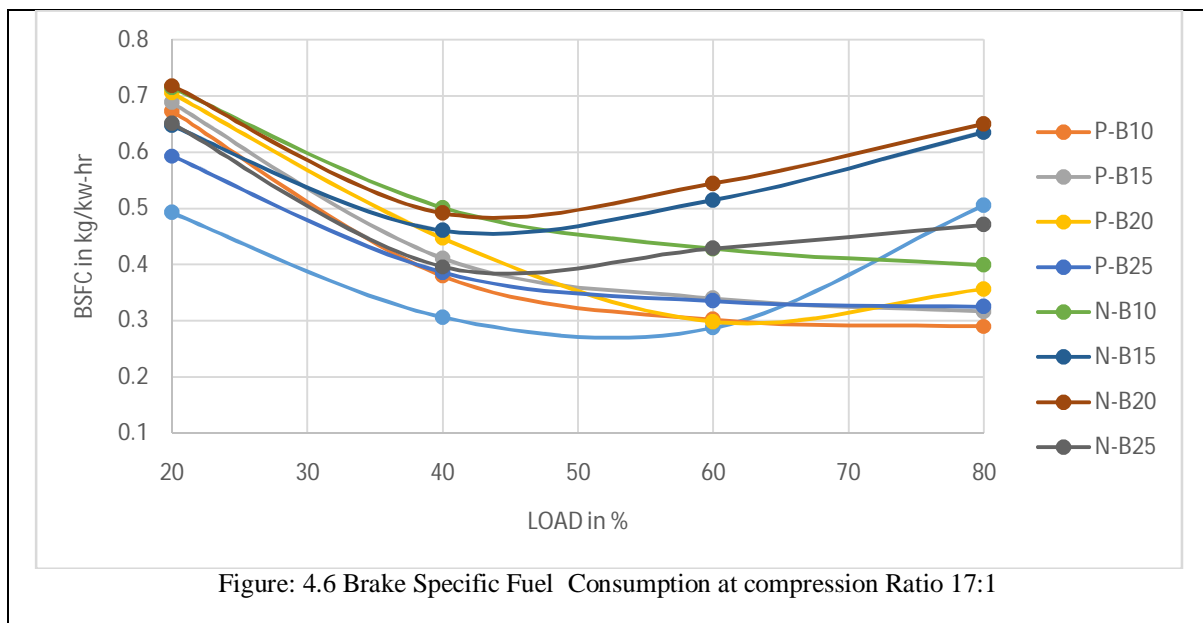


Figure: 4.6 Brake Specific Fuel Consumption at compression Ratio 17:1

It is observed from the figure.4.6 at compression ratio 17:1, as the load varies from 20%, the optimum BSFC decreased by 46.0% at 80% load for NB10, 28.8% at 40% load for NB15, 31.1% at 40% load for NB20 and 39.12% at 80% load for NB25 respectively. Similarly the optimum BSFC decreased by 56.81% at 80% load for PB10, 54.0% at 80% load for PB15, 57.7% at 60% load for PB20 and 45.35% at 80% load for PB25 respectively. The brake specific fuel consumption of pongamia biodiesel was lower than that of neem biodiesel fuel at 80% load.

## V. CONCLUSION

Based on the experimental results the performance characteristics of diesel engine using neem biodiesel and pongamia biodiesel fuels have been analysed and presented as follows.

- Compared with diesel fuel, the heat release rate of all biodiesels blends are lower than that of diesel fuel. This is due to the poor pre mixed combustion of biodiesels blends and lower calorific or heat value of the biodiesels.
- It is observed that, the BTE of different blends of pongamia biodiesels were higher than the neem biodiesels.
- The BTE were decreased as the blend ratio in pongamia biodiesel increased. The increase in blend ratio, decreases the calorific value of the fuel. But the BTE were increased for increase in blend ratio of neem biodiesel due to reduce in the density of the fuel.
- The BTE were decreased as the compression ratio of the engine increased. But the maximum BTE were observed at maximum load condition.
- It is observed that, the BSFC of different blends of pongamia biodiesels were lower than the neem biodiesels.
- The BSFC were decreased as the blend ratio in pongamia biodiesel increased and increase in blend ratio. The lower BSFC were observed for higher compression ratios at higher load.
- The neem biodiesel exhibits optimum BTE for NB15 blend at compression ratio 17:1 and at 60% load. Whereas the pongamia biodiesel exhibits for PB10 at compression ratio 12:1 and at 80% load.
- The neem biodiesel exhibits optimum BSFC for NB15 blend at compression ratio 12:1 and at 60% load. Whereas the pongamia biodiesel exhibits for PB20 at compression ratio 17:1 and at 60% load.
- If higher compression ratio and higher load considered as deciding factors for selection biodiesel for application, than the pongamia is the best choice.

On the whole the blends of neem biodiesel and pongamia biodiesel can be used as alternative fuels in conventional diesel engines without any major change in the engine.

## REFERENCES

1. World energy outlook 2016: International energy agency report, France
2. Gerhard Knothe, Jon Van Gerpen, Jürgen Krahl "The Biodiesel Handbook" AOCS Press Champaign, Illinois, 2005. (Handbook)
3. Bärbel Hahn Hägerdal, Michael E Himmel, Chris Somerville, and Charles Wyman "welcome to biotechnology for biofuels" Journal of Biotechnology Biofuels. Volume -1, 2008
4. Tilman Altenburg, Hildegard Dietz, Matthias Hahl, Nikos Nikolidakis " biodiesels in India Value chain organization and policy options for rural development", studies for German Development Institute (DIE) , 2009
5. Mustafa Balat, Havva Balat "A critical review of bio-diesel as a vehicular fuel" Energy Conversion and Management 49, Page 2727–2741, 24 March 2008. (Journal)
6. Y C Sharma & B Singh " development of biodiesel; Current Scenario" Renewable and sustainable energy reviews - 2008
7. Ulf Schuchardt, Ricardo Serchelia, and Rogério Matheus Vargas, Transesterification of Vegetable Oils: a Review, J. Braz. Chem. Soc., Vol. 9, No. 1, 199-210, 1998.
8. A. Siva Kumar, D. Maheswar, K. Vijaya Kumar Reddy, Comparison of Diesel Engine Performance and Emissions from Neat and Transesterified CSO Jordan Journal of Mechanical and Industrial Engineering Volume 3, Number 3, September 2009.
9. Internal combustion engines by Heywood text book,
10. Ganusov VV. Strong Inference in Mathematical Modeling: A Method for Robust Science in the Twenty-First Century. Frontiers in Microbiology, 7:1131, 2016
11. C H G Brito, C B Maia and J R Sodr , "A Mathematical Model for the Exhaust Gas Temperature Profile of a Diesel Engine", Journal of Physics: Conference Series 633, 012075, (2015)
12. Computational Methods For Fluid Dynamics text book by J. H. Ferziger & M. Peric
13. Computational Fluid Dynamics text book by John D. Anderson, Jr.
14. Krishna Kini H., Hanock S. Souza, N. Satheesh Kumar, "Investigation of Properties of Different Blends of Castor and Pongamia Biodiesels and Their Performance in a Compression Ignition Engine" Energy and Power, 6(1A): 8-14, 2016.
15. S. Naga Prasad , K. Vijaya Kumar Reddy, B.S.P. Kumar, E. Ramjee, O.D. Hebbel and M.C. Nivendgi, "Performance and emission characteristics of a diesel engine with castor oil" Indian Journal of Science and Technology, Vol.2 No.10, Oct 2009.



**International Journal of Innovative Research in Science, Engineering and Technology**

*An ISO 3297: 2007 Certified Organization*

*Volume 7, Special Issue 7, June 2018*

**One Day National Conference on "Recent Trends in Mechanical Engineering & Applied Sciences 2018"**

**(RTME & AS-2018)"**

**17<sup>th</sup> May 2018**

**Organized by**

**Department of Mechanical Engineering and Applied Science, Sri Krishna Institute of Technology, Bangalore, India**

- 16.Sangeetha Krishnamoorthi, K.Rajan , M.Prabhakar " Performance and Emission Characteristics of a Diesel Engine using Preheated Cashew Nut Shell Liquid (CNSL)-Diesel Blend" Vol.9, No.05 pp 338-345, 2016
- 17.S. Vedharaj, R. Vallinayagam, W. M. Yang, S. K. Chou, K. J. E. Chua, and P. S. Lee, "Performance emission and economic analysis of preheated CNSL biodiesel as an alternate fuel for a diesel engine," Int. J. Green Energy, vol. 12, no. 4, pp. 359–367, 2015.
- 18.Srinath Pai a, , Abdul Sharief b, Shiva Kumar c, Shree Prakash B d "A Study on Increased Fuel Injection Pressure Role in Promoting Biodiesel Blends Usage in a Diesel engine - A Review" Elsevier, 978-93-5107-222-5, Date :28-30 March, 2014
- 19.Sathyamurthy and S. Thiagarajan "Performance & Emission Characteristics of a Diesel Engine Fuelled with Pyrolysed Cashew Nut Shell Liquid (CNSL) Along with Oxygenates" Vol. 5 Issue 04, April-2016
- 20.G. Kasiraman, B. Nagalingam, and M. Balakrishnan, "Performance Improvement of A Diesel Engine Fuelled By Cashew nut Shell Oil on Blending with Oxygenates - An Experimental Study," vol. 6, no. 1, pp. 189–200, 2013.