ASSESSMENT OF THERMAL EFFICIENCY IN DIESEL ENGINE FUELLED WITH BIODIESEL BLENDS.

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Article History: Received: 12.12.2022 **Revised:** 29.01.2023 **Accepted:** 15.03.2023

Abstract

Aim: This work examines the brake thermal efficiency (BTE) of diesel engine runs by biodiesel and diesel blends comprising 20% of cashew nut shell oil (CNSO20D80) diesel blend by volume.
Materials and Methods: The test fuels were studied in a four-cylinder and four-stroke unmodified diesel engine at various operating conditions. CNSO20D80 was prepared by combining 80% neat diesel and 20% cashew nut shell oil with some SPAN 80 in it which acts as a surfactant. For each fuel 20 trails were considered based on the G-POWER calculator by having the alpha value 0.05 under 95% confidence level.
Results: The BTE at 100% load for CNSO20D80 is 26.56% while the BTE of the diesel is 29.5%. The obtained significance value for fuel trails is 0.029 which is a way less than 0.05, from this there is a significant difference between the fuel groups.
Conclusion: The thermal efficiency of the biodiesel is less than the diesel. There is a reduction of BTE by 9.96% for CNSO20D80 when compared to diesel. From this study it is concluded that diesel is more effective when compared to CNSO20D80.

Keywords: Cashew nut shell oil, Diesel engine, Diesel, Brake thermal efficiency, Biodiesel, Efficiency.

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1. Introduction

The usage of fossil fuels in the present scenario is increasing due to an increase in the usage of transport. It is a known fact that fossil fuels are non-renewable resources from nature. The increased usage of fossil fuels will bring fuel scarcity to the future economy. To overcome this scenario an alternative for fossil fuels needs to be found with better performances. Some literature states that biodiesel may act as an alternative for fossil fuels. Biodiesels are the renewable source obtained from nature. By the usage of biodiesel the pollution can be reduced upto a concentrated level, by which the engine performance can be optimized and can be increased in comparison to the diesel fuel (Vellaiyan, Subbiah, and Chockalingam 2019). The ratio of brake power output to heat input is known as brake thermal efficiency (National Research Council et al. 2015). The higher the brake thermal efficiency, the lower the fuel consumption, and greenhouse gas emissions. The break power of a heat engine as a function of the thermal input from the fuel is known as brake thermal efficiency (Sung and Chen 2015). Biodiesel made from a gradually different compound of wherewithal like the waste cooking oil, waste vegetables and animal fats, biodiesel is a renewable, clean- burning diesel (Heinberg and Fridley 2016). In this study CNSO is used as a biodiesel blend. CNSO is extracted from waste cashew nut shells. The usage of diesel engines cannot be eliminated as it acts as a major power source. The application of the research is minimizing the BTE of the diesel engine by the usage of CNSO20D80.

There are over 3,982 publications on this research in the science direct and there are 2,700 google scholars published on the brake thermal efficiency from the year 2015. In a research, diethyl ether blends BTE was found 29% and the diesel BTE is 31% done by the (al. 2017). For all loads the cashew nut shell oil BTE is lesser than the BTE of diesel because of the poor spray and no effective utilization of air caused in the incomplete combustion (Rajendran, Naushad, and Balakumar 2019). By the usage of the jatropha curcas ethyl ester blends by the (R. Kumar et al. 2014) the variation of BTE with respect to different fuels in different loads raises with load of all the blended fuel, but the brake thermal efficiency in the engine is improved by increasing the concentration of the ester in the blends (Saxena, Kumar, and Saxena 2019). Among these publications the paper by the balakumar stated that, for all loads the cashew nut shell oil BTE is lesser than the BTE of diesel due to the poor spray and no effective utilization of the air causing the incomplete combustion.

Our institution is keen on working on latest research trends and has extensive knowledge and research experience which resulted in quality publications (Rinesh et al. 2022; Sundararaman et al. 2022; Mohanavel et al. 2022; Ram et al. 2022; Dinesh Kumar et al. 2022; Vijayalakshmi et al. 2022; Sudhan et al. 2022; J. A. Kumar et al. 2022; Sathish et al. 2022; Mahesh et al. 2022; Yaashikaa et al. 2022). Inference from the previous studies conclude that the performance parameters of diesel engines were inspected for lower blends and loads. No significant studies were focused on evaluating the BTE on diesel engines with the CNSO20D80 biodiesel blends and higher loads. This research focuses on evaluating BTE of the 20% of the biodiesel blend at various loads.

2. Materials and Methods

The experimental investigation on the performance of the blend of cashew nut shell oil in CI engine was done in the Thermal engineering laboratory, Saveetha School of Engineering (SSE), Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai. The specifications of the CI engine are given in table 1. Totally two groups were considered: experimental group of cashew nut shell blend of 20% oil (B20) and control group consisting of neat diesel. From previous studies, the mean BTE and standard deviation values for the experimental group are 95% and 0.51 whereas for the control group the mean and standard deviation values are 95% CI and ±1.0 SD with the help of the G power calculator (Kang 2021).

The sample preparation, 5 liters of diesel was bought. The Diesel was bought from the nearby HP petrol pump near the SIMATS, thandalam, chennai. The properties of the neat diesel are mentioned in table 2 (properties of the diesel). Diesel is made by fractionally distilling crude oil between 200 and 350 degrees Celsius (392 and 662 degrees Fahrenheit) at atmospheric pressure.

The cashew nut shell oil was bought from the menaka chemicals, choolaimedu ,chennai. The common method used for the extraction of cashew nut shell oil was through mechanical pressing and transesterification, hot oil and roasting method. The cashew nut shell liquid as extracted has a strong vesicant dramatic action. It requires treatment to get rid of metallic impurities as well as traces of sulfur compounds. Cashew nut shell oil has innumerable applications, such as friction linings, paints, laminating resins, rubber compounding resins, cashew cements, polyurethane based polymers, surfactants, epoxy resins, foundry chemicals, and intermediates for chemical industry.

The properties of the cashew nut shell oil are presented in Table 2.

The CNSO20D80 is composed of cashew nut shell oil and the diesel with the ratio of 1:4. The addition of 80% diesel and 20% of cashew nut shell oil to form the composition of CNSO20D80. In this blend a small amount of SPAN 80 is added. The molecular formula of the SPAN 80 is CN24H4406. The boiling point of SPAN 80 is 463.5^{o}C, and it can be stored at room temperature.

The engine which is used in the process is a single cylinder 4 stroke engine, the bore length is 87.5mm, stroke length is 110mm, compression ratio is 16.5:1. The engine is powered by the 670 cc with a speed of 1500 rpm, lubrication used in the engine is SAE40 which is shown in the figure 1. The values and the readings were taken from the digital meter and the sensors fixed on the setup. The load was supplied in the form of hydraulic dynamometer loading. The engine was a water cooled system engine and the level of water was controlled accordingly. The difference between the CNSO20D80 and neat diesel values are noted in the table.

statistic analysis

IBM - SPSS applications are used to study the analytical table with the experimental table.5 (Watkins 2021). The test of the binary blend experimented with a single-cylinder CI diesel engine and thereafter it was compared with diesel fuel, which showed a confirmatory result condition when compared with diesel. IBM developed SPSS Statistics, a statistical software suite for data management, advanced analytics, multivariate analysis, business intelligence, and criminal investigation.

3. Result

When expressed, the thermal efficiency under the load from 0% to 100%, Efficiency is typically less than 100% because there are inefficiencies such as friction and heat loss that convert the energy into alternative forms. The BTE of diesel at 100% was calculated as 29.5% and the BTE of cashew nut shell oil obtained as 26.56%. The independence t test obtained significance is 0.029 this indicates there is significant difference between the fuels. Table 7. Is the tabulated significance value. Fig. 4. shows the graph comparing the BTE of the engine using both the fuels.

4. Discussion

The ratio of work production by heat produced in the IC engine is known as brake thermal efficiency (Ben Amar et al. 2021). The brake thermal efficiency obtained by the cashew nut shell is lesser than the brake thermal efficiency of the diesel. As the cashew nut shell oil has no sulfur, has a good lubricity and the biodegradability. The brake thermal efficiency obtained by the usage of CNSO20D80 at 20% load is 12.1% and the BTE of diesel is 14.47%, at 50% load the BTE of CNSO is 16.68% and the BTE of diesel is 21.74%, at 80% load the BTE of CNSO is 21.45% and the BTE of diesel is 25.53% and at 100% load is BTE of CNSO is 26.56% and the diesel's BTE is 29.5%. Previously the studies have been done by the use of CNSO with the blend of CNSO and DEE (diethyl ether) which resulted in the 2% more BTE than the diesel when compared to this research (A. Kumar et al. 2015) . The 30% proportion of biodiesel with 70% eucalyptus oil showed better performance than that of other proportions and it is an increase in BTE by 3% (Ellappan and Rajendran 2021) .

BTE depends on the increasing of the compression ratio and dilution of gasoline engines are both efficient ways to improve their thermal efficiency. The factors affecting this work are compression ratio, cut off ratio of the cycle, ratio of specific heats are the. The limitation of the work is production of CNSO because of the extraction period. The allowed values for compression ratio, heat transfer, friction, stoichiometry, peak cylinder pressure, and maximum pressure rise rate are among these constraints.

5. Conclusion

In this research the fuel from the waste cashew nut shells is used as a biodiesel blend and the BTE was lower when examined with the BTE of diesel. By this experiment the CNSO20D80 resulted in the less BTE and the neat diesel BTE is more when operated in the diesel engine. So the cashew nut shell oil cannot be used for obtaining the good BTE in the diesel engine when compared to the BTE of the neat diesel.

Declarations

Conflict of Interests

There is no conflict of interest in this manuscript

Author Contributions

Author SAF was involved in data collection,data analysis and manuscript writing. Author YD was involved in data validation and review of manuscripts.

Acknowledgement:

The authors would like to express their gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University)for providing the necessary infrastructure to carry out this work successfully.

Funding

We thank our financial sponsors for the following organizations for providing financial support.

1. Menaka chemicals.
2. Saveetha University.
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

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Tables and Figures

Table 1 specifications of engine.

S.NO	SPECIFICATION	RESULTS
1	BHP	10 (de rated)
2	No. of.. Cylinders	Four
3	Compression Ratio	23:1
4	Bore	73mm
5	Stoke length	88.9mm
6	Orifice diameter	20mm

7	Type of ignition	Compression ignition
8	Type of cooling	Water cooled
9	Type of starting	Self start
10	Method of loading	Hydraulic dynamometer
11	Speed	1500 rpm

Table 2. Properties of diesel.

S.no	**Specification**	**Value**
1	Density at 15^{o}C	0.8116
2	Flash point ^{o}C	59
3	Kinematic viscosity at 15^{o}C	4.6818
4	Conventional viscosity at 15^{o}C	1.321^{o}C
5	Freezing point, ^{o}C	-11
6	Pour point, ^{o}C	-2
7	Diesel index	30

8	Flame temperature, ^{o}C	2054

Table 3 : properties of CNSO.

SPECIFICATION	RESULTS
SPECIFIC GRAVITY AT 30 ^{0}c	0.950-0.970
Varrarity at 30 ^{0}c	550.0
Moisture % by weight max	1.0%
Matter insoluble in toluene %by weight max	1.08
Less in weight on heating% by weight max	2.0
Ash% by weight max	1.0
Iodine value min	1.0
Wifs method	250
Catalytic method	375
Viscosity at 30 ^{0}c cps min	30
Viscosity after acid washing at 30^{0}c cps min	200
Acid value max	14

Table 4. Specifications of the CNSO20D80

S.NO	SPECIFICATIONS	RESULTS
1	Saponification value	145-160

2	Water (kf)	Max 1%
3	Boiling point	463.43^0c
4	Color	Pale yellow
5	Solution form	Viscous liquid
6	Vapor pressure	Greater than 1.4 hpa (20^0c)
7	Refractive index	n20/D 1.48 (liter)
8	Flash point	Greater than 230 f
9	Specific gravity	0.986
10	Storage temperature	Room temperature
11	Acidic value	10 of maximum
12	Span 80 molecular formula	C24H44O6
13	Molecular weight	428.62

Table 5. Comparison of BTE using both CNSO20D80 and Diesel.

S.no	**CNSO20D80**	**Diesel**
1	26.56	29.5
2	25.3	30.45
3	24.49	27.5
4	25.34	28.89

5	23.5	26.45
6	26.56	29.5
7	25.3	30.45
8	24.49	27.5
9	25.89	28.89
10	26.46	26.45
11	24.3	29.5
12	25.3	30.45
13	24.49	27.5
14	23.87	28.89
15	24.64	26.45
16	25.4	29.5
17	25.3	30.45
18	24.49	27.5
19	23.5	28.89
20	26.99	26.45

Table 6. Group statistics mean standard deviation and standard mean error of both fuels.

Group	**N**	**Mean**	**Std Deviation**	**Std Error Mean**
BTE 1	20	25.1085	1.01536	0.22704
2	20	28.5580	1.46109	0.32671

Table 7. Independent T test significance value.

BTE	**F**	**Sig**	**t**	**df**
Equal variances	5.170	0.029	-8.670	38

assumed				
Equal variances not assumed			-8.670	33.881

Figure 1 the specifications of engine.

Figure 2 engine used for testing.

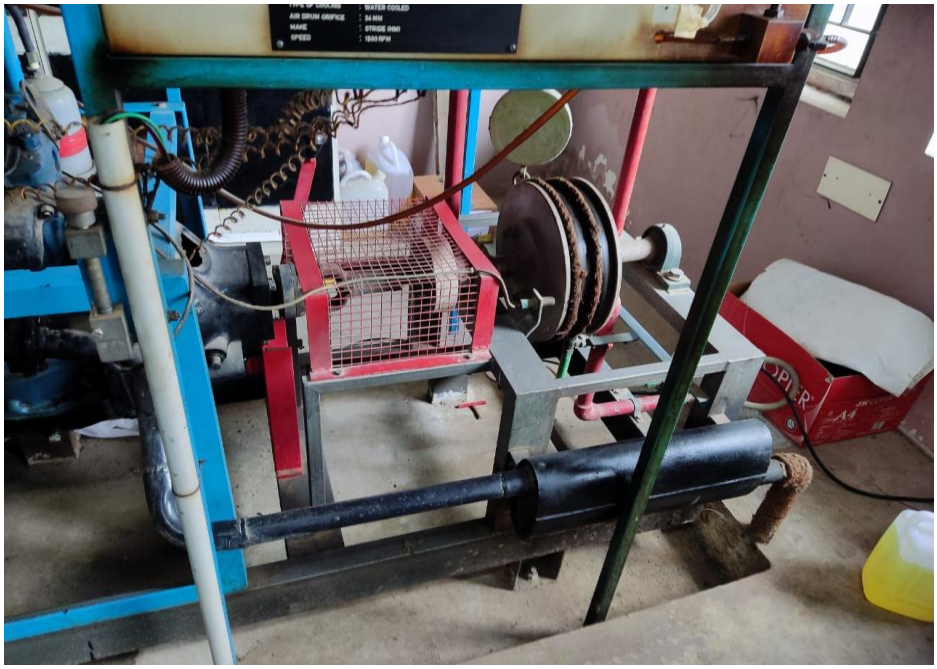

Figure 3 the loading mechanism.

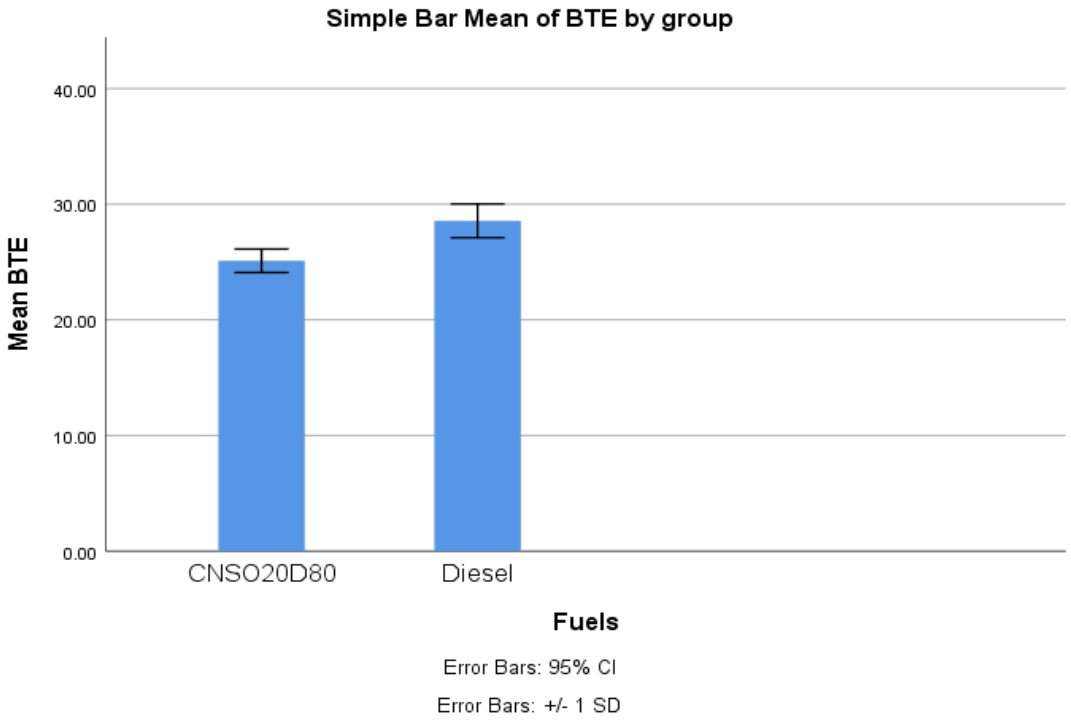

Fig. 4. Graph Of Brake thermal efficiency. On the X-axis the fuels are mentioned and on the Y-axis the mean of BTE is mentioned. The mean of BTE is compared in between the cashew nut shell oil and the diesel on the 100% load. The BTE of diesel is 29.5% and the BTE of cashew nut shell oil is 26.56%. The graph is made with the error bars 95% CI and the standard deviation of ± 1 SD.