Analysis of Performance And Emission Characteristics of Diesel Engine Fueled With Diesel Blended With Biodiesels

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Abstract- *Biodiesels derived from vegetable oils and animal resources have been considered as a promising alternate fuel.Many researches were performed blending diesel with single biodiesel. Only very few works were done with the combination of two different biodiesel blended with diesel. In this experimental study, two Biodiesels from Castor Seed oil and Palm oil is blended with Diesel at various mixing ratio (CSME5PME5, CSME15PME5, CSME5PME15, CSME20PME0, CSME0PME20 and CSME10PME10). The fuel properties of the blends were tested for its acceptance in accordance with ASTM standards. The performance tests were done with the above blends at various loads with constant engine speed of 1500 rpm and the results were compared with diesel. The Brake power and Brake thermal efficiency are lower for other blends compared to CSME10PME10 blend however the Brake specific fuel consumption of other blends are higher than that of CSME10PME10 blend. This experimental analysis revealed that the combined blend of CSME10PME10 showed superior performance than the blends of CSME5PME5, CSME15PME5, CSME5PME15, CSME20PME0 and CSME0PME20.*

Keywords- Alternate Fuel, DI Diesel Engine, Castor Seed Oil Methyl Ester (CSME), Palm oil Oil Methyl Ester (PME), Performance Analysis

I. INTRODUCTION

Biodiesel, an alternative diesel fuel, is made from renewable biological sources such as vegetable oils and animal fats. It is biodegradable and non-toxic has low emission profiles and so is environmentally beneficial. The idea of using vegetable oil as fuel for diesel engines is not a new one. Rudolph Diesel used peanut oil as fuel in his engine at Paris Exposition of 1900. With the advent of cheap petroleum, appropriate crude oil fractions were refined to serve as fuel and diesel fuels and diesel engines evolved together. In the 1930s and 1940s vegetable oils were used as diesel fuels from time to time, but usually only in emergency situations. Recently, because of increases in crude oil prices, limited resources of fossil oil and environmental concerns there has been a renewed focus on vegetable oils and animal fats to make biodiesel fuels. Continued and increasing use of petroleum will intensify local air pollution and magnify the global warming problems caused by CO2. Bio-fuel is the non-toxic fuel, biodegradable and eco-friendly fuel used in diesel engines. Bio-fuel does not contain any Sulphur or aromatic compounds and its combustion results in lower emission of carbon monoxides, hydrocarbons and particulates. As fossil fuel reserves rapidly decline, renewable alternative fuels are more and more attractive. The various non-renewable and renewable sources of energy which support the reduction of demand for fossil fuel are:

Nuclear
Fuel
Solar Energy
Wind Energy
Tidal and Wave Energy
Geothermal Power

Bio FuelsThere are more than 350 oil bearing crops identified, among which only jatropha, pongamia, sunflower, safflower, soya bean, cottonseed, rapeseed and peanut oils are considered as potential alternative fuels for diesel engines. A lot of research work pointed out that biodiesel has received a significant attention and it is a possible alternative fuel. Biodiesel and its blends with diesel were employed as a fuel for diesel engine without any modifications in the existing engine.

Rajesh U Modi, Jayant Singh and TK Bhattacharya (2017) used cottonseed oil – ethanol fuel blends. These blends shows the acid value and carbon residue was more than that of diesel and the calorific value of the blends had nearest value while its flash point is higher than that of diesel fuel. But at higher concentration of ethanol in the biodiesel leads to the storage problems. Methyl ester of cotton seed oil obtained by trans-esterification process is found to be an alternative fuel for diesel.

Nidal H. Abu-Hamdeh, Khaled A. Alnefaie (2015), used Palm and Almond oil blends and illustrated the emissions and performance features of a single cylinder, naturally aspirated, diesel engine fueled with diesel–biodiesel blends were investigated in this study. Blends used were 10%, 30%, and 50% of almond biodiesel with diesel fuel, and 10%, 30%, and 50% of Cotton Seed oil biodiesel with diesel fuel. The blends and the diesel fuel were examined under various load conditions. A comparison between the almond biodiesel blends and Cotton Seed oil biodiesels reveal that the almond biodiesel, in general, performed better. Almond biodiesel resulted in improved performance over the load range considered as indicated by lower brake specific fuel consumption, higher thermal efficiency, and higher exhaust gas temperature. In terms of emissions, almond biodiesel resulted in lower carbon monoxide (CO), oxides of nitrogen (NOx), total particulate and unburned fuel emissions in the exhaust gas. Based on these results, it can be concluded that almond oil-blended fuel could be effective as an alternative fuel for diesel engines as compared to Cotton Seed oil biodiesel. This study opens the door for further research that could be conducted to reach clear cut conclusions and to give more details on the potential of a biomass (almond) as a fuel.

Mayank Chhabra, Ajay Sharma, Gaurav Dwivedi (2016), illustrated that 14 is the most optimum compression ratio for biodiesel prepared from the rice bran oil, because it has the lowest brake specific fuel consumption with highest break thermal efficiency. The BTE of CB10 and CB20 blend is almost similar to that of conventional diesel fuel at the CR of 12. At CR 14 maximum BTE was observed for CB10 higher than that at CR 14.

S. Madiwale and V. Bhojwani (2017), It is also recorded that the for all the blends of soybean oil biodiesel, the kinematic viscosities were found to be less than the palm, Jatropha and cotton seed oil blend of biodiesel. All blends of Jatropha oil biodiesel possesses the higher viscosities than blends of Palm, Cottonseed and Soybean oil biodiesel.

A.Mishra, G,S,Tiwari, S.Jindal, A.K.Mehta (2014),So we can conclude that rice bran biodiesel fuel properties of rice bran methyl ester and diesel were found comparable and within specified limits

K. Senthil Kumar., R. Thundil Karuppa Raj (2016), Effect of Di-Tertiary Butyl Peroxide on the performance, combustion and emission characteristics of ethanol blended cotton seed methyl ester fuelled automotive diesel engine, Energy Conversion and Management.

K. Srithar, K. Arun Balasubramanian, V. Pavendar, B. Ashok Kumar et al (2014), used Pongomia pinata oil biodiesel and mustard oil biodiesel as a fuel for Diesel engine. The author concluded the thermal efficiency and mechanical efficiency of mixing Blend A (PPME5%, MOME5%, D90%) were slightly higher than the diesel. Blend B (PPME10%, MOME10%, D80%) and Blend C (PPME20%, MOME20%, D60%) were very closer to the diesel values.

From the review of literatures, many works in the utilization of biodiesel as well as its blends in engines have been done. However, most of the literatures focused on single biodiesel and its blends. Very few experiments have been conducted with the combination of dual biodiesel and diesel as a fuel. So, the Cotton Seed oil and Rice Bran oil were selected for this current study which is easily and locally available. As a first level of experimentation, the properties of fuels in various combinations were found out in this work. In the second level performance analysis of a diesel engine with dual biodiesel and its blends and the results were compared with diesel.

The present study aims to investigate the mixing of Cotton Seed oil biodiesel and Rice Bran oil biodiesel as an alternate fuel for single cylinder four stroke Diesel engine.

II. MATERIALS AND METHODS

A. Biodiesel Production

The two biodiesels (Castor Seed oil and Palm oil oil) were produced by using the alkali catalyzed transesterification process with methanol and potassium hydroxide. The alcohol reacted with the triglycerides to form the mono-alkyl ester or biodiesel and glycerol. The simple equation of this process is shown below.

Triglyceride + Alcohol = Esters + Glycerol *B. Preparation of Blends*

The dual biodiesel blends were prepared in different proportions and the blends were prepared by volume basis. The biodiesel blended with diesel by volume as (CSME5PME5, CSME15PME5, CSME5PME15, CSME20PME0, CSME0PME20 and CSME10PME10) is prepared. As first 90%(800ml) of diesel fuel was taken in reactor vessel then 5 % (50ml CSME, 50ml PME) biodiesel was introduced in the same vessel. The mixture is then stirred (550rpm) at 40oc for 15min. The same procedure for

CSME15PME5, CSME5PME15, CSME20PME0, CSME0PME20 and CSME10PME10 blends.

B0 - Diesel 100%
Diesel 90% +CSME5%+PME5%,
Diesel 80%+ CSME15%+PME5%,
Diesel 80%+ CSME5%+PME15%,
Diesel 80% +CSME20%+PME0%,
Diesel 80%+ CSME0%+PME20%
Diesel 80%+ CSME10%+PME10%

B. Experimental Setup

The experiments were conducted on a single cylinder four stroke diesel engine with electrical loading and the performance characteristics were compared with diesel fuel. Tests were conducted at a constant speed and at varying loads for all dual biodiesel blends. Engine speed was maintained at 1500 rpm (rated speed) during all experiments. The experimental set up is shown in Fig.1 and the detailed engine specifications are also given in Table.1.

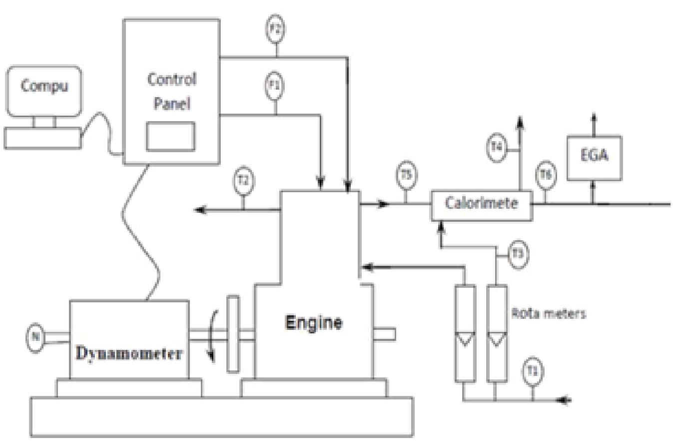

Fig. 1: Test Engine Setup.

Table 1: Test Engine Specification

Manufacturer	Kirloskar Oil Engines Ltd., India
Type of Engine	Direct Injection Diesel Engine
Number of Strokes	Four Stroke
Number of Cylinders	Single Cylinder
Cooling	Water Cooled
Engine Speed	1500 rpm, Constant
Rated Power	3.5 kW @ 1500 Rpm
Bore Diameter	80 mm
Stroke Length	110 mm
Type of Loading	Eddy Current Dynamometer
Method of Starting	Manual Cranking
Compression Ratio	16.5:1
Dynamometer Arm Length	0.095 m
Orifice Diameter	0.02 m

C. Fuel Properties

The various properties like kinematic viscosity, Density, calorific value, flash point temperature and fire point temperature of diesel fuel, biodiesels and two biodiesel mixed blends were determined by using ASTM methods.

PROPERTIES

Table:2 Properties of Diesel, Oils and Biodiesels

Properties	Diesel	Palm Oil	Castor Oil	PME	CSME
Flash Point (°C)	75	304	310	168	165
Fire Point (°C)	82	315	326	177	178
Kinematic Viscosity (CSt)	3.5	7.73	8.56	5.18	5.51

PERFORMANCE TEST

Time taken for 10 ml fuel consumption of diesel,

Table:2 Observation for diesel

S.No	Load (kg)	Speed(rpm)	Time taken for 10 ml fuel consumptions
1	0	1500	105
2	3	1500	90
3	6	1500	69
4	9	1500	54
5	12	1500	41

Table:3 Performance Characteristics for diesel

Brake power (kW)	Mass flow rate of fuel (kg/hr)	Heat input (kW)	BMEP (bar)	BSFC (kg/kW hr)	BTE (%)	IP (kW)	Mechanical efficiency (%)
0	0.29	3.44	0	0	0	0.5	0
0.44	0.33	4.0	0.64	0.76	10.94	0.94	46.77
0.88	0.43	5.24	1.27	0.49	16.78	1.38	63.73
1.32	0.56	6.69	1.91	0.42	19.70	1.82	72.50
1.76	0.73	8.81	2.54	0.42	19.94	2.26	77.85

Table:4 Observation for DIESEL + 5 PME + 10 CSME Blend

S.No	Load (kg)	Speed(rpm)	Time taken for 10 ml fuel consumption(s)
1	0	1500	103
2	3	1500	85
3	6	1500	66
4	9	1500	51
5	12	1500	39

Table:5 Performance Characteristics for DIESEL + 5 PME + 10 CSME blend

Brake power (kW)	Mass flow rate of fuel (kg/hr)	Heat input (kW)	BMEP (bar)	BSFC (kg/kW hr)	BTE (%)	IP (kW)	Mechanical efficiency (%)
0	0.29	3.51	0	0	0	0.5	0
0.45	0.35	4.11	0.65	0.79	10.92	1.25	35.93
0.89	0.46	5.29	1.28	0.51	16.75	1.69	52.57
1.32	0.59	6.85	1.91	0.45	19.33	2.12	62.34
1.78	0.77	8.96	2.58	0.43	19.91	2.58	69.04

Table:6 Observation for DIESEL + 5 PME + 15CSME Blend

S.No	Load (kg)	Speed(rpm)	Time taken for 10 ml fuel consumption(s)
1	0	1500	107
2	3	1500	83
3	6	1500	60
4	9	1500	48
5	12	1500	39

Table:7 Performance Characteristics for DIESEL + 5 PME + 15 CSME blend

Brake power (kW)	Mass flow rate of fuel (kg/hr)	Heat input (kW)	BMEP (bar)	BSFC (kg/kW hr)	BTE (%)	IP (kW)	Mechanical efficiency (%)
0	0.28	3.38	0	0	0	0.5	0
0.45	0.37	4.10	0.66	0.81	11.05	1.45	31.20
0.90	0.51	5.68	1.30	0.56	15.83	1.90	47.33
1.34	0.63	7.10	1.94	0.47	18.91	2.34	57.30
1.79	0.78	8.73	2.58	0.44	20.45	2.79	64.11

Table:8 Observation for DIESEL + 15 PME + 5 CSME Blend

S.No	Load (kg)	Speed (rpm)	Time taken for 10 ml fuel consumption(s)
1	0	1500	106
2	3	1500	85
3	6	1500	67
4	9	1500	50
5	12	1500	39

Table:9 Performance Characteristics for DIESEL + 15 PME + 5 CSME blend

Brake power (kW)	Mass flow rate of fuel (kg/hr)	Heat input (kW)	BMEP (bar)	BSFC (kg/kW hr)	BTE (%)	IP (kW)	Mechanical efficiency (%)
0	0.28	3.41	0	0	0	0.5	0
0.45	0.36	4.01	0.66	0.79	11.32	1.45	31.21
0.87	0.45	5.08	1.26	0.52	17.07	1.87	46.46
1.23	0.61	6.81	1.78	0.49	18.11	2.23	55.24
1.87	0.78	8.73	2.70	0.42	21.38	2.87	65.12

Table:10 Observation for DIESEL + 0 PME +20 CSME Blend

S.No	Load (kg)	Speed(rpm)	Time taken for 10 ml fuel consumption(s)
1	0	1500	101
2	3	1500	79
3	6	1500	66
4	9	1500	44
5	12	1500	40

Table:11 Performance Characteristics for DIESEL +0 PME + 20 CSME blend

Brake power (kW)	Mass flow rate of fuel (kg/hr)	Heat input (kW)	BMEP (bar)	BSFC (kg/kW hr)	BTE (%)	IP (kW)	Mechanical efficiency (%)
0	0.3	3.58	0	0	0	0.5	0
0.56	0.38	4.31	0.82	0.57	13.10	1.56	36.09
0.97	0.46	5.16	1.41	0.47	18.86	1.97	49.33
1.46	0.69	7.74	2.11	0.47	18.81	2.46	59.28
1.86	0.76	8.52	2.68	0.41	21.79	2.86	64.99

Table:12 Observation for DIESEL + 20 PME + 0 CSME Blend

S.No	Load (kg)	Speed(rpm)	Time taken for 10 ml fuel consumption(s)
1	0	1500	104
2	3	1500	85
3	6	1500	69
4	9	1500	43
5	12	1500	38

Table:13 Performance Characteristics for DIESEL + 20 PME + 0 CSME blend

Brake power (kW)	Mass flow rate of fuel (kg/hr)	Heat input (kW)	BMEP (bar)	BSFC (kg/kW hr)	BTE (%)	IP (kW)	Mechanical efficiency (%)
0	0.29	3.47	0	0	0	0.5	0
0.42	0.36	4.01	0.61	0.85	10.54	1.42	29.69
0.87	0.44	4.94	1.25	0.51	17.56	1.87	46.43
1.24	0.71	7.92	1.79	0.57	15.67	2.24	55.38
1.68	0.80	8.96	2.42	0.48	18.69	2.68	62.62

Table:14 Observation for DIESEL + 10 PME + 10 CSME Blend

S.No	Load (kg)	Speed(rpm)	Time taken for 10 ml fuel consumption(s)
1	0	1500	101
2	3	1500	83
3	6	1500	66
4	9	1500	49
5	12	1500	39

Table:15 Performance Characteristics for DIESEL +10 PME + 10 CSME blend

Brake power (kW)	Mass flow rate of fuel (kg/hr)	Heat input (kW)	BMEP (bar)	BSFC (kg/kW hr)	BTE (%)	IP (kW)	Mechanical efficiency (%)
0	0.30	3.58	0	0	0	0.5	0
0.88	0.37	4.10	1.27	0.42	21.34	1.88	46.70
1.57	0.46	5.16	2.27	0.29	30.37	2.57	61.05
1.88	0.62	6.95	2.71	0.33	26.99	2.88	65.23
2.99	0.78	8.73	4.32	0.26	34.20	3.99	74.92

III. RESULT AND DISCUSSION

A Brake Thermal Efficiency

The variations of brake thermal efficiency with respect to applied load are discussed for diesel, bio diesel-diesel blends in the following sections. The average brake thermal efficiency of B0, B5 & B10 were 28.06%, 27.66% & 26.61

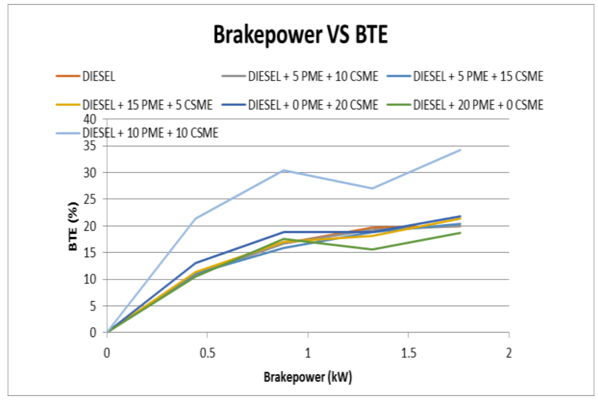

Fig. 2: Brake power Vs Brake Thermal Efficiency

Fig.2 shows the variation of brake thermal efficiency with applied load for B10, B20 blends in comparison with diesel. The brake thermal efficiency indicates the ability of the combustion system to accept the experimental fuel and provides comparable means of assessing how efficiently the energy in the fuel was converted into mechanical output. For all the blends, the brake thermal efficiency increases with increase in applied load. It is noteworthy to reiterate that the thermal efficiency of the engine relies on fuel consumption and calorific value of the fuel. The average Brake Thermal Efficiency B10 blend was found to be 4.64% higher than B20 blend and 1.88% lower than Diesel and so the percentage of diesel consumption (i.e., volume) can be reduced by 10% and 20% for B10 and B20 respectively.

B. Brake Specific Fuel Consumption

The Brake Specific Fuel Consumption (BSFC) values for every applied load were plotted for diesel, diesel-biodiesel blends. The average Brake Specific Fuel consumption of B0, B10 & B20 were 0.3137 kg/kW.hr, 0.3321 kg/kW.hr & 0.3590 kg/kW.hr. Fig.3 shows that, BSFC decreases with increase in load. BSFC of biodiesel blend B10 is similar to that of diesel when compared to B20. BSFC increases at higher concentration of biodiesel above 20%. Fig. 3: Load Vs Brake Specific fuel consumption

The average Brake Specific Fuel Consumption of B10 blend was found to be 8.59% lower than B20 blend and was slightly similar to that of Diesel.

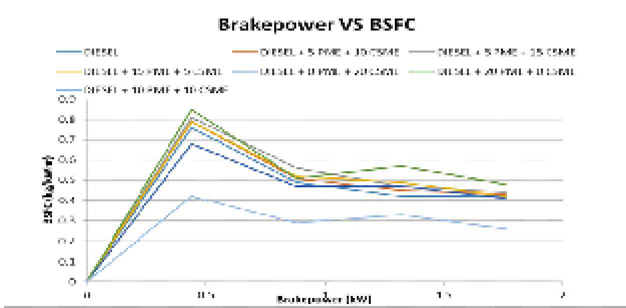

Fig 3:Brake power VS BSFC

C.Total fuel consumption

The Figure 4 shows the TFC values for every applied load were plotted for biodiesel diesel blend.

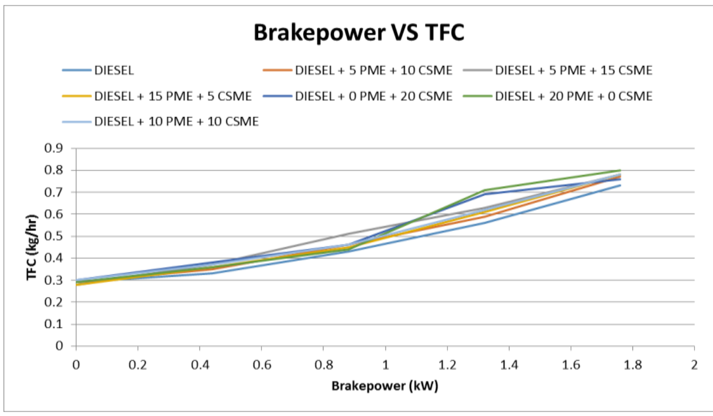

Fig 4:Brake power VS TFC

D. Mechanical Efficiency

The Figure 5 shows the mechanical efficiency values for every applied load were plotted for biodiesel diesel blend

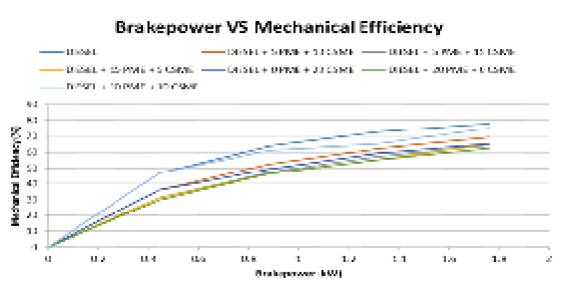

Fig 5:Brake power VS TFC

Fig. 5 shows that, Mechanical Efficiency of the 10 PME & 10 CSME increases with other percentage of PME & CSME blends

IV. EMISSION TEST FOR PURE DIESEL

EMISSION GRAPHS

1.HC EMISSION

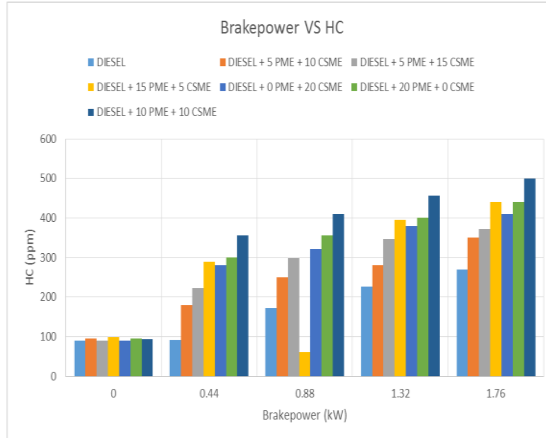

Fig 6:Brake power VS TFC

The figures 6 shows the variation of HC emission for the various PME & CSME biodiesel at different blend percentages and compared with the HC emission of base fuel diesel.

2. CO EMISSION

The figures 7 show the variation of CO emission for the various PME & CSME biodiesel at different blend percentages and compared with the CO emission of CO base fuel diesel

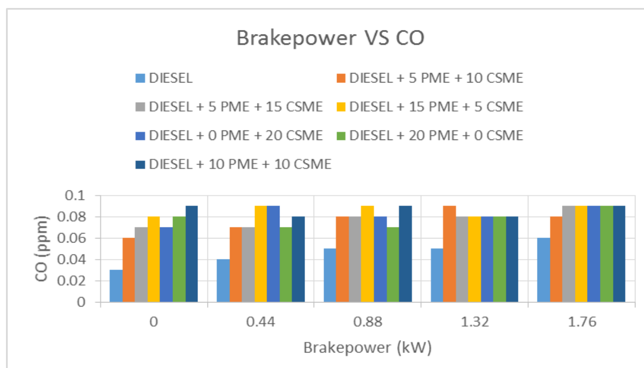

Fig 7:Brake power VS TFC

3.NO_X EMISSION

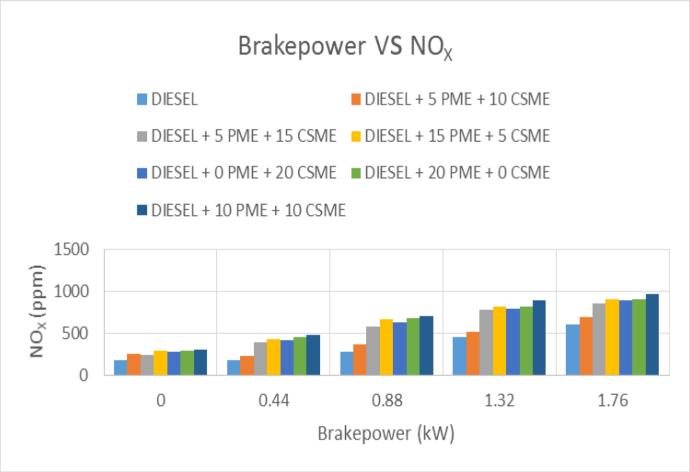

Fig 8:Brake power VS TFC

The figures 8 show the variation of NOX emission for the various PME & CSME biodiesel at different blend percentages and compared with the NOx emission of base fuel diesel.

V. CONCLUSION

In this experimental study, two Biodiesels from Palm oil and Casto seed oil blended with Diesel at various mixing ratio. The fuel properties of the blends were tested for its acceptance in accordance with ASTM standards. The performance tests were done with six blends at various loads with constant engine speed of 1500 rpm and the results were compared. The performance characteristics observed for 10PME10CSME blends are similar to that of diesel. The Brake power and Brake thermal efficiency are higher for 10PME10CSME blends compared to other blends however the Brake specific fuel consumption of 10PME10CSME blends are lower than that of other blends. This experimental analysis reveal that the combined blend of 10PME & 10CSME shows superior performance than the other blends of PME & CSME.

- ✓ Brake Specific Fuel Consumption (BSFC) of 10PME10CSME blend was found to be lower than other blends and was slightly similar to that of Diesel.
- ✓ Brake thermal efficiency of 10PME10CSME blend was found to be higher than other blends and lower than Diesel.
- ✓ Biodiesel up to 20% blend with diesel shows nearly equal performance characteristic compared with diesel. So 10PME10CSME blend could considered commercial application.
- ✓ Biodiesel up to 20% blend with diesel shows nearly equal emission characteristic compared with diesel. So 10PME10CSME blend could considered commercial application

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