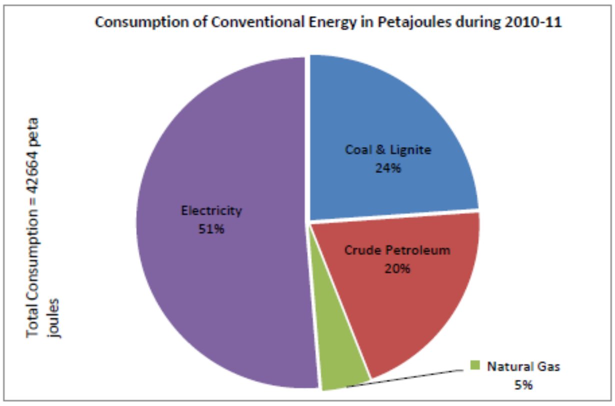

Figure 3: Conventional Energy sources in India

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat with an alcohol producing fatty acid esters.

Biodiesel is meant to be used in standard diesel engines and is thus distinct from the vegetable and waste oils used to fuel converted diesel engines. Biodiesel can be used alone, or blended with petrol / diesel. The "B" factor is commonly used to state the amount of biodiesel in any blended fuel mix. For example, 100% biodiesel is referred to as B100, and a mix of 20% biodiesel - 80% diesel is labeled bio-fuel B20. Biodiesel, when used in its pure form (B100) may require certain engine modifications to avoid maintenance and performance problems.

Recently, extensive research [3-8] has been done on the use of blends of fish oil biodiesel in compression ignition engines, and encouraging results are reported. Although the thermal efficiency is found to decrease a little, considerable improvements have been shown on the emissions front. In the present study, performance evaluation of fish oil biodiesel blends on a Conventional Diesel engine is attempted.

However, higher percentages of biodiesel imply lower volatility and higher viscosity of the vegetable oils. This might necessitate need for Low Heat Rejection Engines that can resist heat loss from the engine cylinder. The current scope of research is limited to studies on conventional engine using different fish oil blends and comparing the performance with pure diesel.

2. Fish Oil Blends as Biodiesel

Biodiesel is recognized as a clean alternative fuel or as a fuel additive, in view of the depleting fossil fuels, and in search of reducing pollutant emissions. Extensive research has been done on using Plant based biodiesel using Jatropha Oil, Pongamia Oil, etc., and the results have been encouraging too. But as cultivated land is too limited to grow plants sufficient to produce both food and biodiesel, non – land based water-borne living beings have been considered as an important source of biodiesel.

In the past couple of years concentrated efforts are being made to utilize discarded parts of mixed marine produce biodiesel [3]. It is a known fact that before the petroleum age, the world used whale oil for light and heat. In 2004 the Alaska Energy Authority (AEA) had partnered with Hawaiian firm to make biodiesel out of Fish Oil [2]. Twenty-one million gallons of fish oil are procured annually by Alaska's shore-based and floating fish processing plants-and-yet two-thirds (13 million gallons) are currently discarded.

Three different blends of 10, 20, and 30 % by volume of fish oil-biodiesel were used in another recent experiment [3] and it has been established that fish oil biodiesel is a better replacement for diesel without any engine modification.

Current research work has attempted using Fish Oil blends of 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100% by volume, using conventional engine.

The properties of Fish Oil and Diesel used in the experimentation in shown below:

Table 1: Fuel Properties

Property	*Fish-Oil*	*Pure diesel*	*UoM*
Gross Calorific Value	36180	44800	KJ/Kg
Density	923.60	820.00	Kg/cuM
Flash Point	> 300	72	Deg C
Viscosity (at 40 ^{0}C)	21.4	14.2	Centi-stokes

The interpreted values of Density and Calorific Values of different Fish Oil Blends are shown below in Figure-4 and Figure-5.

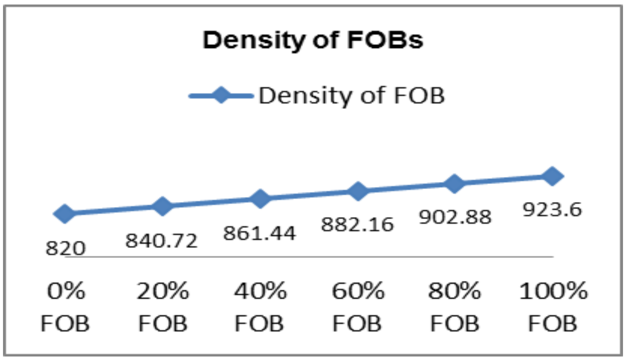

Figure 4: Density of different FO Blends

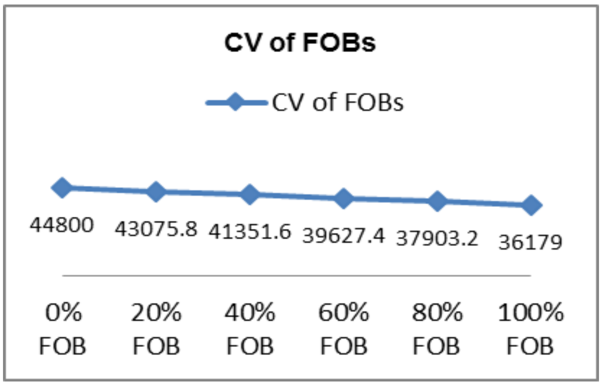

Figure 5: Cal Values of different FO Blends

3. Methodology

The experiments have been carried out on a single cylinder 4-stroke constant speed Diesel Engine, (a Conventional engine

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with conventional piston and liner). The test engine has an aluminum alloy piston with a bore of 80 mm, and a stroke of 110 mm. The rated output of the engine is 3.7 kW at a rated speed of 1500 rpm. The naturally aspirated engine is provided with a water cooling system with thermostats to measure inlet and out temperature.

Figure-6 depicts a snap-shot of the experimental set-up. The engine performance has been tested at varying loads using ten different blends of Fish Oil - Diesel, ranging from 0% to 100%. Fuel consumption has been measured by means of a burette measuring device, fitted to the fuel tank. Air consumption has also been measured using the air-box, orifice meter and a water tube manometer. The fish oil blends have been injected into the engine through conventional injection system.

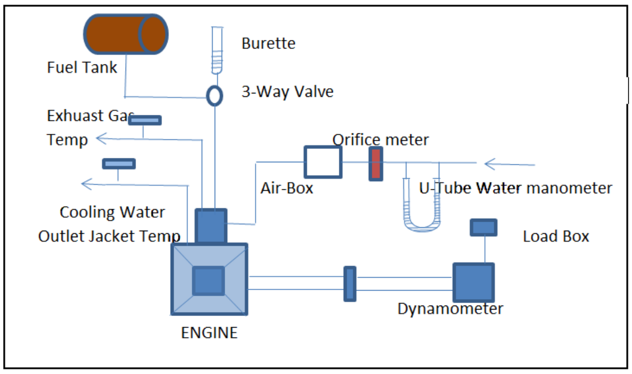

Figure 6: Experimental set-up used

The Calorific Value for each Fish Oil Blend (FOB) was mathematically computed, corresponding to the volumetric proportion of each blend used. Each of the ten blends was tested at different load conditions on conventional test engine. The results are compared with pure diesel operation tested on the same engine. Various performance parameters like Brake Thermal Efficiency, Specific Fuel Consumption, Exhaust Gas Temperature, have been measured for varying power outputs.

4. Results and Discussion

Table-2 depicts the comparative data on engine performance of different FOBs (Fish Oil Blends) on Conventional Engine. For ease of demonstration, only 5 representative FOBs - B20, B40, B60, B80 and B100 - are considered, and compared with the performance of pure diesel oil (B00).

Figure-7 shows a comparison of the Brake Thermal Efficiency of the Conventional test engine using Pure Diesel and five different FOBs, tested at rated load.

The analysis of the data indicates that the conventional Engine has its optimum thermal efficiency using 20% FOB, when compared to pure diesel.

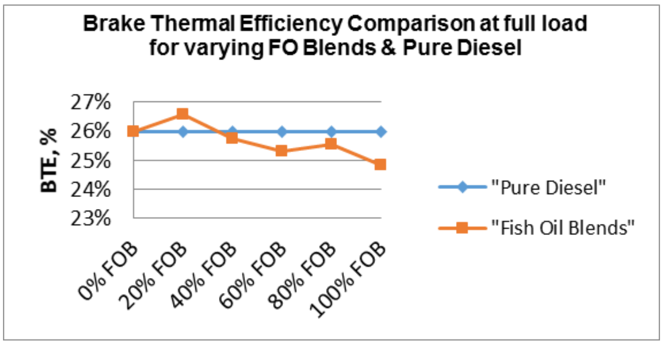

Figure 7: Brake Thermal Efficiency Comparison

Figure-8 shows the Specific Fuel Consumption of the Conventional test engine, using Pure Diesel and the five different FOBs, tested at rated load.

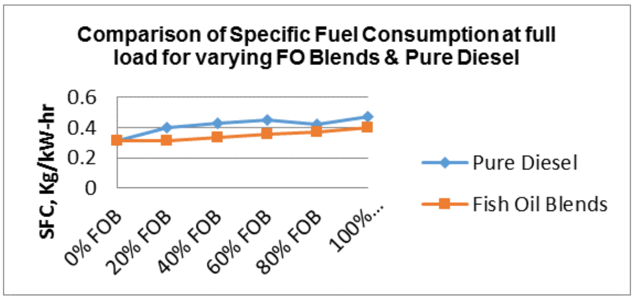

Figure 8: Sp. Fuel Consumption Comparison

Comparative study of the above data indicates that the conventional Engine has its optimum specific fuel Consumption using pure diesel and any Fish Oil blend (FOB) is understandably lower compared to pure diesel.

Figure-9 provides a snapshot of the Exhaust Gas Temperatures (EGT) for Conventional test engine using Pure Diesel and the five different FOBs, tested at rated load.

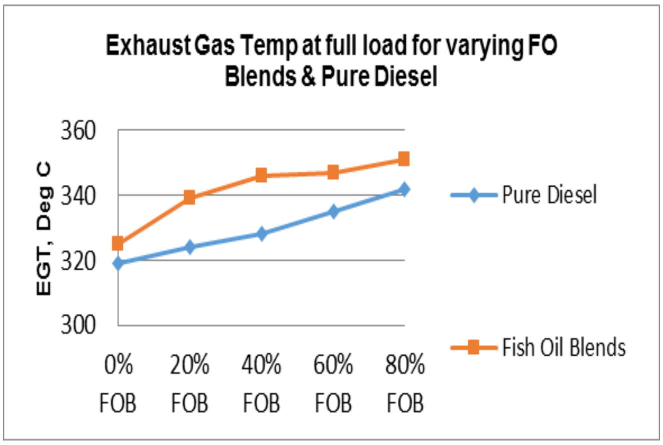

Figure 9: Exhaust Gas Temp. Comparison

An interesting observation that emerges is that the Exhaust Gas temperature increases with increase in Fish Oil Blend Percentage, when compared to pure diesel.

Figure-10 depicts the of the rise in the Cooling Water Outlet temperature, for Conventional test engine using Pure Diesel and the five different FOBs, tested at rated load.

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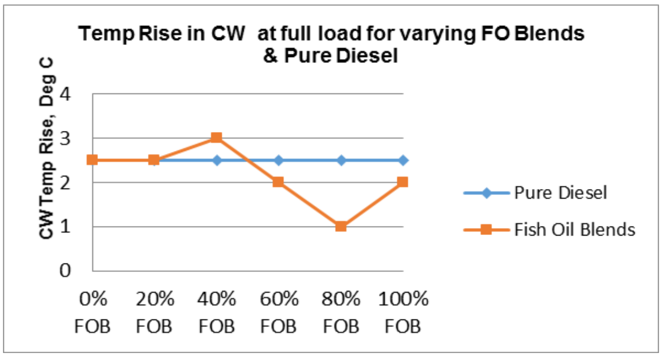

Figure 10: CW Outlet Temp. Comparison

Comparative study of the above data indicates that the conventional Engine has the same amount of deviation in Cooling Water temperature for pure diesel and 20% FOB, possibly, 60% & 80% FOB results could also be an experimental aberration.

5. Conclusion

1)Conventional diesel fuel can be successfully replaced by 100% Fish Oil without any engine modifications.
2)The experimental results show that the optimum engine performance for conventional engine is obtained with 20% Fish Oil blend.
3)Use of Fish oil blends as a biodiesel has certain practical limitations, particularly the stinking smell and the carbon deposits over the piston heads.
4)The literature studied also indicates that Methyl esterification of Fish Oil should be attempted in future studies.

6. Acknowledgements

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Annexure:

Table 2: Performance Parameters with varying Fish Oil blends using Conventional Engine

Experimental Results on Fish Oil blends using Conventional Single Cyl 4 Stroke Diesel Engine										
0% FOB (Pure Diesel)										
Sl No	Brake Power	Density	CV	Fuel Consumed	SFC	BTE	Heat Supplied	CWTi	CWTo	EGT
	BP	Kg/Cu M	KJ/Kg	(kg/hr)	(Kg/Kw-hr)	%	(kW)	Deg C	Deg C	Deg C
1	0	820	44800	0.49	0	0%	6.12	26	26	130
2	1.22558	820	44800	0.66	0.54	15%	8.16	26	26	158
3	2.5034	820	44800	0.89	0.36	22%	11.13	26	27	206
4	2.99301	820	44800	0.98	0.33	24%	12.25	26	28	235
5	3.61419	820	44800	1.14	0.31	26%	14.13	26	28.5	272
6	4.38622	820	44800	1.34	0.31	26%	16.70	26	28.5	318
20% FOB (Fish Oil Blend with Diesel)										
1	0	840.72	43075.8	0.46	0	0%	5.49	27	27	137
2	0.98339	840.72	43075.8	0.61	0.62	14%	7.24	27	27	158
3	2.24539	840.72	43075.8	0.84	0.37	22%	10.06	27	28	188
4	2.95863	840.72	43075.8	0.98	0.33	25%	11.68	27	28	229
5	3.60078	840.72	43075.8	1.16	0.32	26%	13.93	27	28.5	269
6	4.37521	840.72	43075.8	1.38	0.31	27%	16.46	27	29.5	319
40% FOB (Fish Oil Blend with Diesel)										
1	0	861.44	41351.6	0.50	0	0%	5.75	26	27	139
2	0.96264	861.44	41351.6	0.65	0.67	13%	7.42	26	27	164
3	2.2619	861.44	41351.6	0.91	0.40	22%	10.48	26	28	197
4	2.97825	861.44	41351.6	1.03	0.35	25%	11.87	26	28	229
5	3.68295	861.44	41351.6	1.24	0.34	26%	14.25	26	28.5	269
6	4.47252	861.44	41351.6	1.51	0.34	26%	17.38	26	29	324
60% FOB (Fish Oil Blend with Diesel)										
1	0	882.16	39627.4	0.60	0	0%	6.60	26	27	136
2	0.98819	882.16	39627.4	0.71	0.71	13%	7.77	26	27	157
3	2.21626	882.16	39627.4	0.96	0.43	21%	10.59	27	28	203
4	2.94271	882.16	39627.4	1.13	0.39	24%	12.48	27	28	235
5	3.59405	882.16	39627.4	1.32	0.37	25%	14.57	27	28	276
6	4.42746	882.16	39627.4	1.59	0.36	25%	17.48	27	29	328
80% FOB (Fish Oil Belnd with Diesel)										
1	0	902.88	37903.2	0.59	0	0%	6.22	27	29	133
2	0.96497	902.88	37903.2	0.71	0.73	13%	7.44	27	29	155
3	2.22169	902.88	37903.2	0.98	0.44	21%	10.37	28	30	193
4	2.96456	902.88	37903.2	1.12	0.38	25%	11.80	28	30	227
5	3.62124	902.88	37903.2	1.30	0.36	26%	13.69	29	30	263
6	4.371	902.88	37903.2	1.63	0.37	26%	17.11	29	30	335
100% FOB (Pure Fish Oil)										
1	0	923.6	36179	0.65	0	0%	6.55	28	29	129
2	0.93137	923.6	36179	0.74	0.79	13%	7.43	28	29	157
3	2.21626	923.6	36179	1.04	0.47	21%	10.44	28	29	193
4	2.92814	923.6	36179	1.19	0.41	25%	11.93	28	30	238
5	3.61218	923.6	36179	1.45	0.40	25%	14.53	29	30	278
6	4.371	923.6	36179	1.75	0.40	25%	17.59	29	31	342

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