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APPLICATION OF BIODIESEL PRODUCED FROM ARGEMONE MEXICANA OIL IN DIRECT INJECTION COMPRESSION IGNITION ENGINE

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Abstract- Now a day's biodiesel has become more attractive due to its environmental benefits and the fact that it is made from renewable resources. Due to high cost of biodiesel it is barrier to commercialization of the product. There are four methods to make biodiesel, direct use and blending, microemulsions, thermal cracking (pyrolysis), and transesterification. Due to low value of free fatty acid, single step transesterification of vegitable oils and animal fats for biodiesel production was done. In this research paper the experiments were conducted to determine the performance and emission characteristics of a single cylinder direct injection diesel engine operated on diesel/ biodiesel blends (B20, B40, B60, B80, and B100). The result shows that the maximum BTE was obtained for B20 blend which is 30.1% (more than diesel 27%). The BSFC for B20 was also similar to diesel fuel. The detail analysis of experimental result shows a significant decrease in the carbon monoxide (CO), hydrochloric acid (HC) and smoke. The result of experiments shows that the use of biodiesel produced from argemone mexicana methyl ester seed oil in diesel engine is a possible solution to a problem associated with diesel fuel.
Keywords: Argemone Mexicana, Biodiesel, Performance, Emission, Direct injection, Brake thermal efficiency (BTE), Brake specific fuel consumption (BSFC).

1. INTRODUCTION

Energy is an important part for the economic development of the Nation. Due to rapidly increasing demands of energy supply of fossil fuel source such as petroleum, coal and natural gas leads to increase the cost, decrease security, environmental degradation and their import bill [1]. India imported approx. 2/3rd of its petroleum requirements every year, which involved a cost nearly Rs. 81,000 crores in foreign exchange. Even 5% replacement of petroleum based fuel by bio-fuel can help India to save Rs.4000 crores per year in foreign exchange.

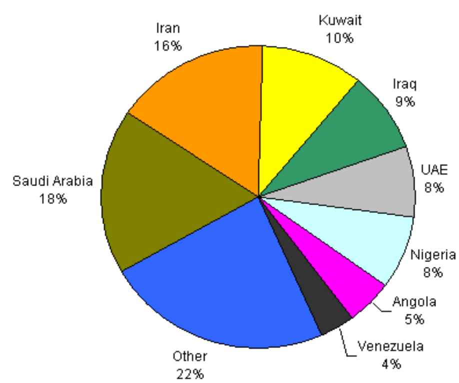

Fig.1.1: India's crude oil imports.

Hence biodiesel is an alternate renewable source for long period energy security. Biodiesel is a biodegradable, comparable heat of combustion, eco-friendly, renewable, contain molecular oxygen which helps in combustion of fuel, clean burning, have potential to significantly reduce harmful emissions and have low sulphur content [2-3]. Biodiesel (the mono alkyl esters) of long chain fatty acids typically made by chemically reacting lipids such as vegetable oils or animal fats with an alcohol producing fatty acid esters in the presence of catalyst for use in compression ignition engine. Transesterification of Vegetable oil to obtain biodiesel is a method in which the glycerol of triglycerides in oil reacts with a short chain alcohol in the presence of catalyst to form ester (FAME) and glycerol [4]. Argemone Mexicana oil (toxic and adulterer to mustard oil) is used as non-edible oil resource for the production of biodiesel. Argemone Mexicana oil belongs to papveraceae (poppy)

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family and its species belong to the mexicana prickly poppy. It is commonly known as Mexican poppy (English) and Satyanashi (hindi) in India. This plant have yellow flower, branching herb with yellow juice and height varies between 60-90 cm [5-6]. The leaves are simple, sessile, and spiny. The flowers are large, bright yellow coloured produced on terminal short leafy branches. The fruits are prickly capsules, oblong-ovoid, opening by 4- 6 walls with numerous black seeds. The leaves are used in treating wounds and skin diseases. The seeds are useful in skin diseases, leprosy, dental caries, and rheumatism. The latex is used in skin diseases, jaundice, and inflammations [7-8]. The argemone mexicana oil contain linoleic acid (54-61%), oleic acid (21-33%) and toxicity attributes mainly two alkaloids, sanguinarine and dihydro-sanguinarine [9]. The properties are compared with Diesel Fuel and show that argemone biodiesel meet the properties of diesel standard fuel.

Table 1.1: Fatty acid composition of argemone mexicana oil [10].

Fatty acid composition (%age)	Argemone oil
Oleic acid (C 18:1)	40.0
Linoleic acid (C 18:2)	36.6
Palmitic acid (C 16:0)	14.7
Stearic acid(C 18:0)	6.75
Palmitoleic acid(C 16:1)	1.3
Linolenic acid (C 18:3)	0.3
Arachidic acid (C 20:0)	0.3
Behenic acid (C 22:0)	0.2
Myristic acid (C 14:0)	0.1

O. P. S. Verma, et. al. [11] concluded thatin India, it is neither possible nor desirable to use the edible oils for biodiesel and thus, non-edible oils make the desirable feedstock for biodiesel. The Planning Commission has deliberately recognized this fact. In year 2004-05, the production of about 5 million tons of non-edible oils can meet the B10 blending objective only and it is likely to generate the revenues about Rs. 8000 crores annually with a potential of providing gainful employment to more than two million people. Arjun B. Chhetri, et. al. [12] showed that both edible and non edible oils have great potential to use as feedstock for biodiesel production, due to their high oil content. Based on Gas chromatography (GC) analysis, eleven types of FA were identified and quantified in soap nut biodiesel. Approximately 85% of the FA was found to be unsaturated. Similarly, six major FA were identified and quantified in jatropha oil biodiesel. Md. Nurun Nabi, et. al. [13] optimizes different parameters for biodiesel production and the performance study of a diesel engine with diesel biodiesel blends. The results showed that about 88% biodiesel production was experienced with 20% methanol, 0.5% NaOH catalyst and at 55°C. B.K.Venkanna, et. al. [14] has done experimental investigation on performance and emission characterization with the effect of injection timing and injection pressure on diesel engine, when fuelled with methyl ester of honge oil. The performance, emissions and combustion parameters of 20% honge oil and 80% diesel fuel (volume basis) were found very close to neat diesel fuel where as higher blend ratios were found inferior compared to neat diesel fuel. Y C Bhatt, et. al. [15] has done performance study with the effect of injection pressure and fuel temperature on diesel engine, when fuelled with methyl ester of honge oil. The brake specific fuel consumption increased with the increase in the concentration of KME in diesel and decreased with the increase in injection pressure and fuel temperature

The aim of this work is to - study the effect of diesel and biodiesel blends such as B20, B40, B60, B80, and B100 on commercial diesel engine in terms of performance and emission characteristics of diesel engine fuelled with neat biodiesel and its blends with diesel.

2. MATERIALS AND METHODS

2.1 Collection, extraction, purification of argemone mexicane oil

The seeds of Argemone Mexicane were collected from local market in Northern part of india, (Ropar Punjab). The fruits were dried, and dehulled to obtain the seeds. We have utilized magnet stirrer with hot plate acting as a biodiesel reactor. Accessories like capsule, thermometer, beakers, measuring cylinder, separating funnel, scales accurate to 0.1 grams etc. (All equipment were clean and dry) were used. Approximate amount of Argemone Mexicane, methanol and KOH (catalyst) available for biodiesel production were 10 liters, 4 liters, and 2 kilogram. Experimental set up for biodiesel production is shown in Figure 1.2.The oil was obtained from the seeds by the solvent extraction process using petroleum ether as a solvent (40–60°C) by soxhlet apparatus [16].

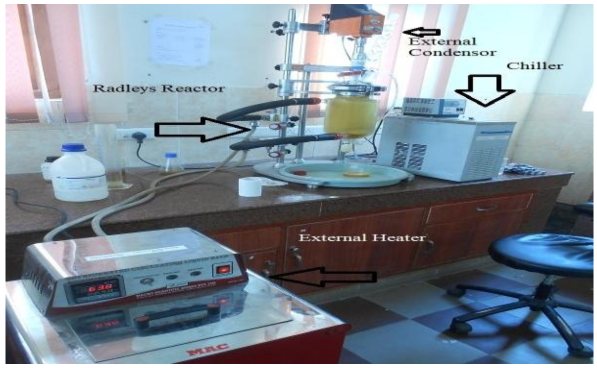

Figure 1: Experimental set up for biodiesel production.

Argemone Mexicana seeds were dried for 10 hours in an oven at 110°C for removing moisture.10 gram of seeds sample were placed on filter paper in the tube of soxhlet extraction apparatus and oil was extracted with petroleum ether at the rate of 151 drops per minute for 6 hour at constant heating and then allowed to cool and dismantle the extraction flask. Ether was evaporated on a water bath until no odour of ether remains and cooled at room temperature to obtain a weight of 3.5 gram oil.

2.2 Transesterification of oil

Transesterification is a process in which triglyceride present in oil react with an alcohol in the presence of strong acid or base, producing mixture of fatty acid methyl ester and glycerol.

2.3 Physico-chemical properties such as

the specific gravity and density were determined using the specific gravity bottle and were estimated using the equations below

SG =Mass of oil /Mass of a volume of water. Density = Mass of Biodiesel/Volume of Biodiesel. The chemical properties of a Argemone Mexicana oil, its ester and diesel were shown in Table 1.2.

Table 1.2: Chemical properties of a Argemone Mexicana oil, its ester and diesel.

Fuel properties	**A. Mexicana oil**	**A. Mexicana methyl ester**	**Diesel**
Saponification value (mg koh/g)	202.5	166.4	-
Peroxide value (meq/ kg sample)	150	130	0.2
Acid value (mg koh/g)	7.80	0.75	0.02
F.F.A. (oleic acid)	1.97%	-	-

3. RESULTS AND DISCUSSION

Production of Biodiesel for Argemone oil, Feedstock :Argemone Mexicana oil, Instrument: Redley reactor, Base catalyst: NaOH, KOH, NA metal of 1%, 1.52%, 2.1%, 2.51% w/w of oil Reactant : 1:6, 1:3, 1:9 (oil to methanol).

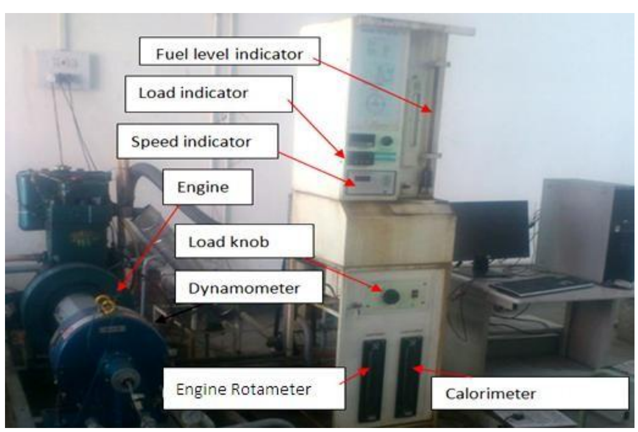

Fig.1.3: Arrangement of Experimental Test Rig.

Biodiesel Setup: The engine was directly coupled to generator and loaded by impedance as shown in Fig. 1.3.

Table -1.3: Engine Specification.

Engine	Kirloskar engine setup single cylinder, 4 stroke
Power rating	3.51KW
Engine speed	1500RPM
Cylinder bore	88 mm
Stroke length	110.00 mm
Swept volume	661.45 cc
Cooled type	Water cooled
Compression ratio	17.51
Dynamometer	Type eddy current , water cooled, with loading unit
Load indicator	Digital, supply 230 AC
Rotameter	Engine cooling 40-400LPH, Calorimeter 25-250 LPH

The results obtained from experimental work using diesel biodiesel blends in the engine at diff. loads.
Observation Tables for Performance and emissions of diesel /biodiesel blend in the engine:

For Neat Diesel

Load %	B.P.	B.T.E.	B.S.F.C	B.S.E.C	E.G.T.	C.O.	H.C	S.O.
0	0	0	-	-	74	0.05	28	5
25	0.97	14.8	0.58	25398.41	88	0.06	40	12
50	1.65	17.42	0.47	20836.12	112	0.07	52	20
75	2.20	21.57	0.38	15254.91	136	0.09	62	35
100	2.87	27.0	0.29	12939.52	166	0.13	70	50

For B20

Load %	B.P.	B.T.E.	B.S.F.C	B.S.E.C	E.G.T.	C.O.	H.C	S.O.
0	0	0	-	-	75	0.04	22	4
25	1.04	15.1	0.59	26212.32	90	0.04	33	9
50	1.70	18.6	0.48	21112.61	112	0.06	45	14
75	2.25	24.2	0.39	15999.11	140	0.08	57	22
100	3.00	30.1	0.30	13220.22	168	0.11	64	40

For B40

Load %	B.P.	B.T.E.	B.S.F.C	B.S.E.C	E.G.T.	C.O.	H.C	S.O.
0	0	0	-	-	77	0.04	22	5
25	1.02	12.83	0.65	28055.40	98	0.03	30	6
50	1.54	16.01	0.52	22479.41	120	0.05	38	8
75	2.10	19.89	0.42	18545.21	155	0.07	52	10
100	2.72	24.82	0.31	14503.62	176	0.10	56	27

For B60

Load %	B.P.	B.T.E.	B.S.F.C	B.S.E.C	E.G.T.	C.O.	H.C	S.O.
0	0	0	-	-	77	0.03	22	6
25	0.90	12.31	0.68	29170.61	99	0.03	32	8
50	1.35	14.83	0.57	24229.40	121	0.04	39	10
75	1.89	18.67	0.45	19269.22	160	0.05	44	14
100	2.45	22.14	0.38	16242.41	177	0.08	50	27

For B80

Load %	B.P.	B.T.E.	B.S.F.C	B.S.E.C	E.G.T.	C.O.	H.C	S.O.
0	0	0	-	-	82	0.02	20	8
25	0.72	12.33	0.69	29174.92	100	0.03	30	7
50	1.19	14.22	0.60	25349.52	128	0.04	34	10
75	1.78	17.57	0.48	20476.56	168	0.04	40	18
100	2.2	20.72	0.42	17899.64	184	0.07	45	30

For B100

Load %	B.P.	B.T.E.	B.S.F.C	B.S.E.C	E.G.T.	C.O.	H.C	S.O.
0	0	0	-	-	80	0.01	18	8
25	0.76	12.00	0.72	29993.21	100	0.02	27	7
50	1.11	13.89	0.62	25906.23	126	0.03	29	12
75	1.71	16.69	0.52	21560.64	166	0.04	35	15
100	2.10	20.10	0.45	17367.50	185	0.05	42	32

Effect of Biodiesel on Engine Performance

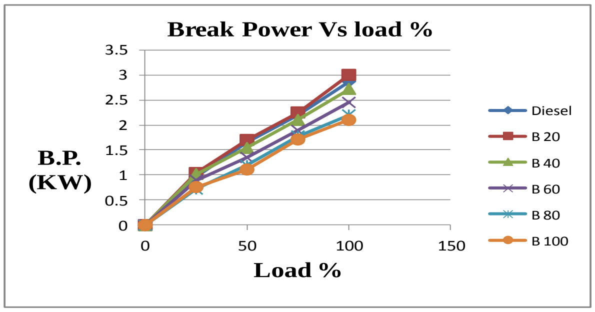

Figure 1.4: Effect on Brake Power.

The variation of Brake power with load for different fuel blends is shown in Fig.1.4. In all cases Brake power increases with increase in load and it is maximum for B20nblendnat full load.

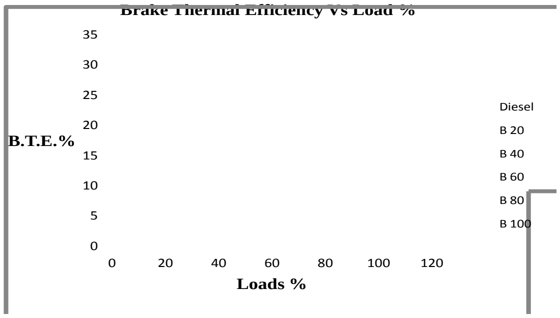

Figure 1.5: Effect on BTE

The variation of brake thermal efficiency with load for different fuels is shown in Fig. 1.5. In all cases, efficiency has increased with an increase in percent load. This was due to a reduction in heat loss and increase in power with increase in percent load. The maximum brake thermal efficiency was obtained to be 30.1% for B20, which was slightly higher than that of diesel (27%). The minimum brake thermal efficiencies obtained for B40, B60, B80 and B100 were 24.82%, 22.14%, 20.72% and 20.10%, respectively. This lower brake thermal efficiency obtained for B40–B100 could be due to a reduction in the calorific value and an increase in fuel consumption as compared to B20 and diesel fuel.

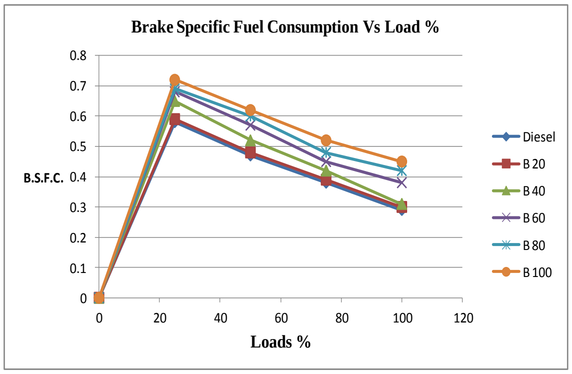

Figure 1.6: Effect on BSFC

The variation of brake-specific fuel consumption with load for different fuels is presented in Fig.1.6. For all fuels tested, brake-specific fuel consumption decreased with increase in load. One possible explanation for this reduction could be due to the higher percentage of increase in brake power with load as compared to fuel consumption. At higher loads, the brake-specific fuel consumption for B20 and B40 was close to the diesel. In case of B60–B100, the brake-specific fuel consumption was approximately 12–45% higher than that of diesel. This reverse trend was observed due to the lower calorific value with an increase in biodiesel percentage in the blends.

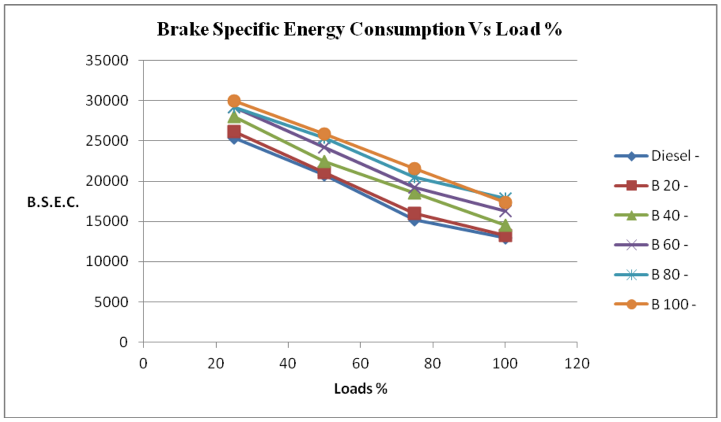

Figure 1.7: Effect on Brake specific energy consumption

The variation in Brake Specific Energy consumption (BSEC) with load for all fuels is presented in Fig. 1.7. In all cases, it decreased with increase in percentage load for all fuels. The main reason for this could be that percent increase in fuel required to operate the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads. The BSEC for B20 was observed closer to the diesel. In case of B40, B60, B80 and B100, the BSEC was higher than that of diesel. This reverse trend was observed due to lower calorific value with increase in biodiesel percentage in the blends.

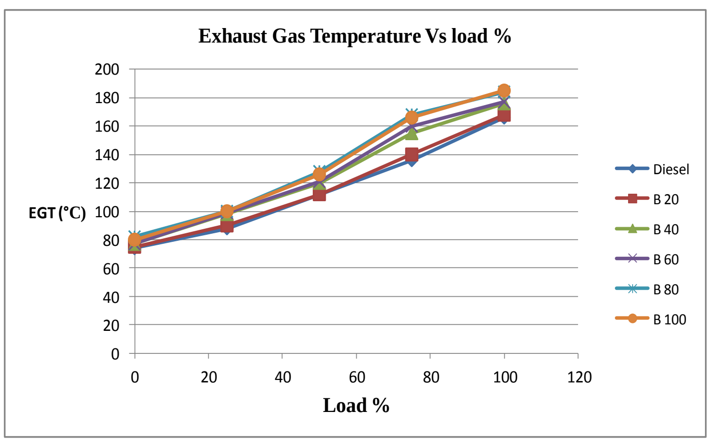

Figure: 1.8 Effects on Exhaust Gas Temperature

The variation of exhaust gas temperature with respect to applied load for different fuels tested is shown in the Fig.1.8.The exhaust gas temperature increases with increase in load for all tested fuels. The nitrogen oxides emission is directly related to the engine combustion chamber temperatures, which in turn indicated by the prevailing exhaust gas temperature. With increase in the value of exhaust gas temperature, NOx emission also increases which means, biodiesel fuelled engines has the potential to emit more NOx as compared to that of diesel fuelled engines.

Effect of Biodiesel on Engine Emission

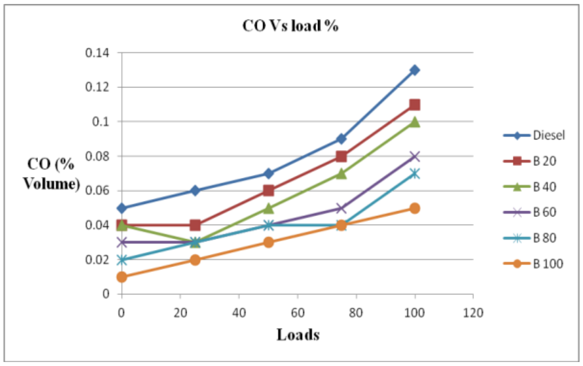

Figure 1.9: Effect on Carbon Monoxide

Variation of CO emissions with engine loading for different diesel biodiesel blends is compared in Fig.1.9. The minimum and maximum CO produced was 0.01–0.05 % for B100. These lower CO emissions of biodiesel blends may be due to their more complete oxidation as compared to diesel. Some of the CO produced during combustion of biodiesel might have converted into CO_2 by taking up the extra oxygen molecule present in the biodiesel chain and thus reduced CO formation. It can be observed from the Fig.1.9 that the CO initially remain linear with load and in later stage it increased sharply up to full load.

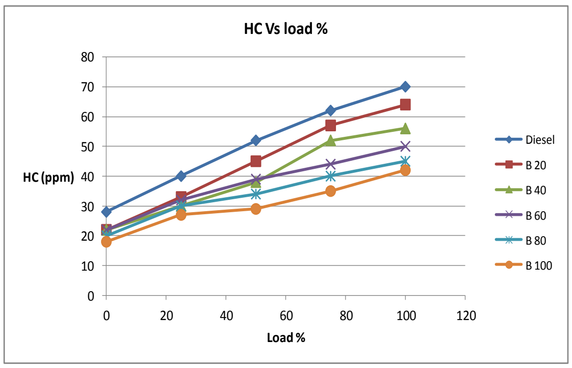

Figure 2.1: Effect on Hydrocarbon

Unburned hydrocarbon emissions result from incomplete combustion of hydrocarbon fuels. The unburned hydrocarbons and their derivatives that readily vaporize are termed as volatile organic compounds (VOCs) Fig 2.1 shows that with increase in injection pressure, hydrocarbon emission decreases for all load range.

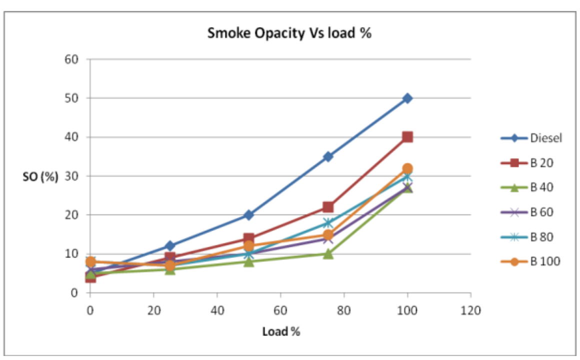

Figure 2.2: Effect on Smoke opacity

The variation of smoke opacity with respect to different fuels is considered, depicted in the diesel oil. Higher thermal efficiency indicates better and complete combustion of fuel. That is, lesser amount of unburnt hydrocarbons present in the engine exhaust emission. So, lower smoke density values are achieved with biodiesel blends as compared to that of the diesel. B40 blends gave smoke density of 27 % as compared to 50% in the case of diesel.
Experimental investigation shows that 20% Argemone oil methyl ester in the fuel blend (B20) can be used in C.I engine without any modification and without any adverse effect.

4. CONCLUSIONS

Following are the conclusion made on the basis of results:

1) Brake power and brake thermal efficiency has increased with an increase in load. The maximum brake thermal efficiency was obtained to be 30.1% for B20, which was slightly higher than that of diesel (27%).

2) Brake-specific fuel consumption (BSFC) and brake specific energy consumption (BSEC) decreased with increase in load. The BSEC for B20 was observed closer to the diesel. In case of B40, B60, B80 and B100, the BSFC and BSEC were higher than that of diesel.

3) There is a significant decrease in the HC emission level with blends of methyl ester of Argemone oil as compared to pure diesel operation. There is a reduction from 70 ppm to 42 ppm at the maximum power output for B100 fuel. Also B40 blends gave smoke density of 27% as compared to 50% in the case of diesel.

Finally it can be concluded that no problem was faced at the time of starting the compression ignition engine and the engine ran smoothly with Argemone Mexicane oil methyl ester and its various blends with diesel fuel. B20 can be used in C.I engine without any modification and without any adverse effect.

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