ISSN: 2278-0181
Vol. 1 Issue 6, August - 2012

Experimental study on the performance of C.I diesel engine using plastic pyrolysis oil blends with pure diesel

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Abstract:

The performance of a constant speed, stationary diesel engine using plastic pyrolysis oil-diesel blends as fuel has been evaluated experimentally. The experiments were performed using 20% and 40% plastic pyrolysis oil- diesel blends .Diesel fuel was used as a basis for comparison. The effect of using different blends of plastic pyrolysis oil- diesel on engine brake power, brake thermal efficiency, specific fuel consumption, mechanical efficiency, volumetric efficiency and mass of fuel consumption were studied. The results indicates no significant power reduction in the engine operation on plastic pyrolysis oil –diesel blends (up to 40%) at a 20% level of significance .The volumetric efficiency decreased by up to 18.81%, brake thermal efficiency increased by up to 40% and mechanical efficiency increased by up to 0.09% with an increased blend of plastic pyrolysis oil- up to 40% in blends as compared to diesel alone.

Introduction

Plastic is the general common term for a wide range of synthetic or semi synthetic organic amorphous solid materials used in the manufacture of industrial products. Plastics are typically polymers of high molecular mass, and may contain other substances to improve performance and/or reduce costs. Monomers of Plastic are either natural or synthetic organic compounds. Plastics can be classified by chemical structure, namely the molecular units that make up the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, polyaddition, and cross-linking. Other classifications are based on qualities that are relevant for manufacturing or product design. Examples of such classes are the thermoplastic and thermoset, elastomer, structural, biodegradable, and electrically conductive.

Literature Survey

Experimental study of some performance parameters of a constant speed stationary diesel engine using ethanol-diesel blends as fuel [1].the experiments were performed using 5,10,15and 20%ethanol-diesel. Diesel fuel was used as a basis for comparison. The effect of using different blends of ethanol-diesel on engine horsepower, brake specific fuel consumption, brake thermal efficiency, the exhaust gas temperature were studied. The results indicate no significant power reduction in the engine operation on ethanol-diesel blends (up to 20%) at a 5% level of significance. Brake specific fuel consumption increased by up to 9% with an increase of ethanol up to 20% in the blends as compared to diesel alone.

An experimental study on performance and exhaust emissions of a diesel engine fuelled with tobacco seed oil methyl ester [2]. Tobacco seed oil is a non-edible vegetable oil; it can be utilized for biodiesel production as a new renewable alternative diesel engine fuel. In this study, an experimental study on the performance and exhaust emissions of a turbocharged indirect injection diesel engine fuelled with tobacco seed oil methyl ester was performed at full and partial loads. The results showed that the addition of tobacco seed oil methyl ester to the diesel fuel reduced CO and SO_2 emissions while causing slightly higher NO_X emissions. Mean while, it was found that the power and the efficiency increased slightly with the addition of tobacco seed oil methyl ester.

Physical, chemical and fuel related properties of tomato seed oil for evaluating its direct use in diesel engines [3].Oil was extracted from tomato seeds, tested for several important alternative fuel properties and compared with other vegetable oils. The oil yield of tomato seeds is about 35% on a dry weight basis. This vegetable oil has low volatility, low sulphur, low ash content, and high viscosity. Cetane number, density as well as the cold flow properties is similar to those of other vegetable oils. The fatty acid profile of tomato seed oil shows that there is a predominance of compounds containing an even number of carbon atoms, especially c16 and c18. The total saturated and unsaturated fatty acid composition is 18.28% and 81.72%, respectively, and the most abundant fatty acid (56.12%). This study indicates that tomato seed oil is a renewable energy source and a promising fuel substitute which could be used in the diesel engine to bring down the consumption of the convention of the conventional petroleum products.

Experimental evaluation of diesel engine performance and emission using blends of jojoba oil and diesel fuel [4].An experimental evaluation of using jojoba oil as an alternative diesel fuel has been conducted in the present work. Measurements of jojoba oil chemical and physical properties have indicated a good potential of using jojoba oil as an alternative diesel engine fuel .blending of jojoba oil with gas oil has been shown to be an effective method to reduce engine problems associated with the high viscosity of jojoba oil. Experimental measurements of different performance parameters at different load conditions over the engine speed range have generally indicated a negligible loss of engine power , a slight increase in brake specific fuel consumption and a reduction in engine NO_x and soot emission using blends of jojoba oil with gas oil as compared to gas oil. The reduction in engine soot emission has been observed to increase with the increase of jojoba oil percentage in the fuel reserved.

Investigation on the performance and exhaust emissions of a diesel engine using preheated waste frying oil as fuel [5].Waste frying oil a non-edible vegetable oil was used as an alternative fuel for diesel engine. The high viscosity of the waste frying oil was reduced by preheating it was determined that the waste frying oil requires a heating temperature of

135°c to bring down its viscosity to that of diesel at 30°c. The performance and exhaust emissions of a single cylinder diesel engine was evaluated using diesel, waste frying oil(without preheating) and waste frying oil preheated to two different inlet temperatures(75 and 135°c).the engine performance was improved and the co and smoke emissions were reduced using preheated waste frying oil. It was concluded from the results of the experimental investigation that the waste frying oil preheated to 135°c could be used as a diesel fuel substitute for short-term engine operation.

Pyrolysis

Pyrolysis is a process of thermal degradation in the absence of oxygen. Plastic & Rubber waste is continuously treated in a cylindrical chamber and the paralytics gases are condensed in a specially-designed condenser system. This yields a hydrocarbon distillate comprising straight and branched chain aliphatic, cyclic aliphatic and aromatic hydrocarbons. The resulting mixture is essentially the equivalent to petroleum distillate. The plastic / Rubber is pyrolysis at 370ºC -420ºC and the pyrolysis gases are condensed in a series of condensers to give a low sulphur content distillate.

Future prospects of pyrolysis technology:

Pyrolysis is a very promising and reliable technology for the chemical recycling of plastic wastes. Countries like UK, USA, and Germany etc have successfully implemented this technology and commercial production of monomers using pyrolysis has already begun there.

Pyrolysis offers a great hope in generating fuel oils, which are heavily priced now. This reduces the economical burden on developing countries. The capital cost required to invest on pyrolysis plant is low compared to other technologies. So, this technology may be the beacon light in the future to a world, which is now on the verge of acute fuel shortage.

Experimental summary

This is Single cylinder four stroke water cooled diesel engine,(make kirloskar) here the engine is mounted on a ms channel frame and is coupled to a brake drum, the belt is wound round the brake drum and is connected to the spring balances S1&S2.The load can be varied by rotating the hand wheel provided.

Engine Specifications

Engine : four stoke single cylinder
Make : kirloskar
Bhp : 5 hp
Rpm : 1500
Fuel : pure diesel and blends of plastic pyrolysis oil
Bore : 80mm
Stroke length : 110mm
Starting : cranking
Working cycle : four stroke
Method of cooling : water cooled
Method of ignition : compression ignition

Comparison of properties of WPPO, diesel

s.no	Properties	Wppo	diesel
1	**density@30°c in g/cc**	**0.7930**	**0.83 to 0.88**
2	**Ash content %**	**<0.01% wt**	**0.045**
3	**Calorific value kj/kg**	**41858**	**46500**
4	**Kinematic**	**2.149**	**5.0**

	viscosity(cst) @40^{0}c		
5	Cetane number	51	55
6	Flash point ^{0}c	40	50
7	Fire point ^{0}c	45	56
8	Carbon residue %	0.01	0.2
9	Sulphur content %	< 0.002	<0.035
10	Acidity mg KOH/gm	0.16	0.2
11	Pour point ^{0}c	-4	3 to 15

Observation tables

For pure diesel

Sl.no	Speed in (rpm)	Load in(kg)	Manometer Reading in (mm)		Time taken for 10 cc of fuel consumption (t) in (sec)	Rota meter reading	
			H_1	H_2		Rt_1	Rt_2
1	1500	O	43	53	66.52	120	110
2	1500	5	41	50	60.8	120	110
3	1500	10	40	51	57.07	120	110
4	1500	15	40	49	50.04	120	110

For 20%Plastic Oil& 80% Diesel

Sl.no	Speed in (rpm)	Load in(kg)	Manometer Reading in (mm)		Time taken for 10 cc of fuel Consumption (t) in (sec)	Rotameter reading	
			H_1	H_2		Rt_1	Rt_2
1	1500	O	10	45	76.5	120	110
2	1500	5	10	46	73.31	120	110
3	1500	10	10	47	70.52	120	110
4	1500	15	10	47	69.04	120	110

For 40%Plastic Oil&60% Diesel

Sl.no	Speed in (rpm)	Load in(kg)	Manometer Reading in (mm)		Time taken for 10 cc of fule Consumption (t) in (sec)	Rotameter reading	
			H_1	H_2		Rt_1	Rt_2
1	1500	O	10	45	88.35	120	110
2	1500	5	11	46	86.45	120	110
3	1500	10	11	47	85.12	120	110
4	1500	15	11.5	47	80.25	120	110

Results for pure diesel

s.no	1	2	3	4
Load(kg)	0	5	10	15
b.p(k.w)	0	1.317	2.630	3.950
Mfc(kg/hr)	0.450	0.497	0.529	0.604
Sfc(kg/kw hr)	0	0.377	0.2	0.152
v_a m^3/hr	22.56	21.98	21.98	21.68
V_s m^3/hr	24.75	24.75	24.75	24.75
η_v%	91.1	88.8	88.8	87.6
η_{bth}%	0	20.520	38.432	47.782

ISSN: 2278-0181
Vol. 1 Issue 6, August - 2012

F.P	1.5	1.5	1.5	1.5
ηmech%	0	46.00	63.68	72.42

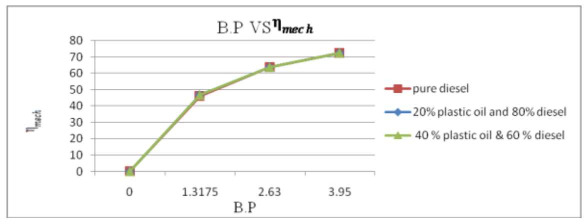
Results for 20% plastic oil and 80% diesel

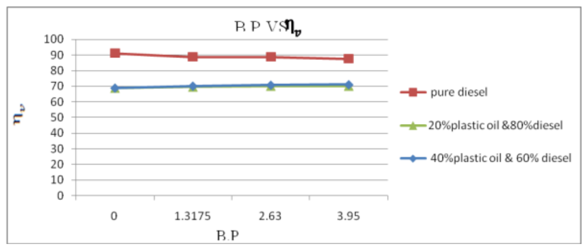
s.no	1	2	3	4
Load(kg)	0	5	10	15
b.p(k.w)	0	1.3175	2.63	3.952
Mfc(kg/hr)	.3952	.4129	.4288	.4380
Sfc(kg/kw hr)	0	.3131	.1627	.1108
v_a m^3/hr	17.05	17.2	17.357	17.35
V_s m^3/hr	24.75	24.75	24.75	24.75
η_v%	68.8	69.49	70.13	70.13
η_{bth}%	0	24.7	47.57	69.81
F.P	1.5	1.5	1.5	1.5
ηmech%	0	46.69	63.68	72.49

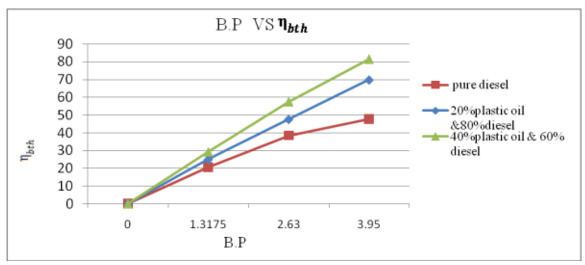
Results for 20% plastic oil and 80% diesel

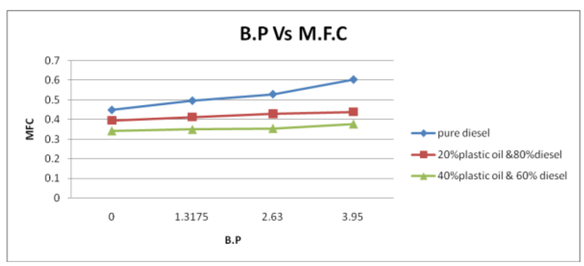
s.no	1	2	3	4
Load(kg)	0	5	10	15
b.p(k.w)	0	1.3175	2.63	3.995
Mfc(kg/hr)	.3422	.349	.355	.376
Sfc(kg/kwhr)	0	.266	.135	.095
v_a m^3/hr	17.05	17.35	17.50	17.58
V_s m^3/hr	24.75	24.75	24.75	24.75
η_v%	68.88	70.13	70.74	71.04
η_{bth}%	0	29.15	57.35	81.33
F.P	1.5	1.5	1.5	1.5
ηmech%	0	46.69	63.68	72.47

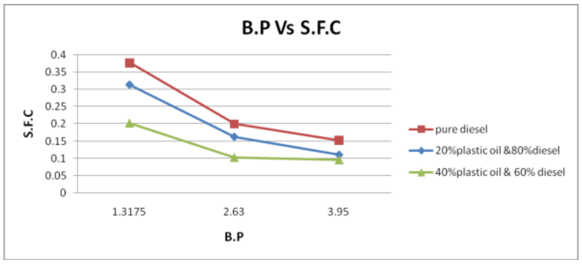
Graphs











Conclusion:

The results indicates no significant power reduction in the engine operation on plastic pyrolysis oil – diesel blends (up to 40%) at a 20% level of significance .The volumetric efficiency decreased by up to 18.81%, brake thermal efficiency increased by up to 40% and mechanical efficiency increased by up to 0.09% with an increased blend of plastic pyrolysis oil-up to 40% in blends as compared to diesel alone.

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