ANALYSIS OF CARDANOL AS A SUBSTITUTE FOR DIESEL

Chandrasekaran.S

Assistant professor Vels University, Chennai, India.

ABSTRACT

The demand for alternate fuels used in the operation of I.C engine is met with CNSL (Cashew nut shell liquid) a by-product of cashew industry which is considered as an economically suitable for producing bio-diesel. Cashew nut shell liquid is obtained from the hard cashew nut shell, cardinal a natural phenol obtained from the pyrolysis of CNSL at reduced pressure. The viscosity of the cardinal is very high compared to that of diesel. The parametric characteristic of I.C engines with various injection timing and pressure using fuel as Cashew nut shell oil is found. Cashew nut shell liquid is being used in our Defence force heavy truck vehicle-SHAKTHIMAN.

1. INTRODUCTION

1.1. Need for Alternate fuel

The depleting reserves of fossil fuels, increasing demand for diesel an alternate source in their availability has emerged as initiatives to search for alternate sources of energy, so it can be supplement or replace fossil fuels. At present years, rather than using fossil fuels , researchers have focused their upon using the products of plant that is seed oil and fats extracted from plants, in that way the most commonly used alternated fuels for now is bio-diesel. Which is made up of fatty acid methyl esters(FAMEs) from oil seeds and fats. FAMEs bio-diesel is economically safe, non-toxic and biodegradable .Bio-diesel producing countries use edible fatty oils derived from rapeseed ,soybean, palm, sunflower, coconut, linseed etc., as a raw material but such types of edible oils are not possible to be used in India, due to the increasing supply and demand of these oils in India. Thus the increase in demand of such oils has put a stop for these oils to be used in making of Bio diesel. In a country like India, the use of only non edible oil is promoted for making Bio diesel in large quantity and planted on large scale on non cropped and waste lands.

1.2. Cashew Nut Shell Liquid

There are a large number of trees, shrubs and herbs which are present in India and that can be used as a Bio diesel fuel. Nearly 30 – 35 % CNSL is available in the shell where shell percentage 67% of nut. The cashew processing industries produce CNSL as a byproduct. Cashew nut shell undergoes various ethnical processing to obtain CNSL. At first, the heat obtained CNSL, the heating process leads to decarboxylation of anacardic acid to form Cardanol, this comprises of 10% cardol and 30% polymeric material and the remaining percentage is made up of substances. After heating process, distillation is done at a reduced pressure inorder to remove the polymeric material. Now the distilled CNSL consists of 78% Cardanol , 8% cardol, 2% polymeric material

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and remaining other substances. At this present commercial extraction process is carried out by boiling or heating CNSL upto 108 degree centigrade to obtain cardanol rich oil.

1.3.Cardanol

Cardanol is obtained from cashew Nut shell Liquid (CNSL) - a Monohydroxyl phenol having hydrocarbon chain in the Meta position.

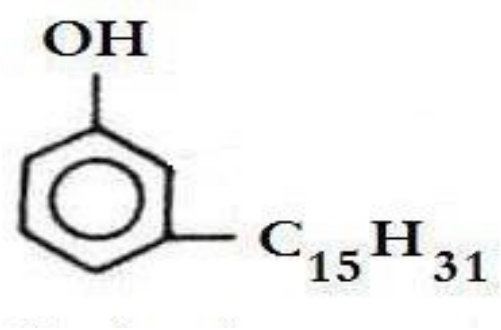


Figure 1: Structure of Cardanol

Cardanol is processed and extracted from CNSL with respective its fractional distillation at 200°C to 240°C with a pressure less than 5mm of mercury. Cardanol is renewable, cost effective and easily produced in many regions in India and Asian countries with the limited usage of diesel. These products extracted from Cardanol have many advantages over other substituted phenols. Therefore it is widely used in the manufacture of surface coatings, Insulating varnishes, oil and alcohol soluble resins, laminating resins, Rubber compounding, Azo dyes, etc. As the viscosity of Cardanol is very high (compared to diesel) in the present investigation.

2. RELATED WORK

A number of different oils have been investigated in recent years and their performances and emission characteristics have been compared with Diesel. Kasiraman et al [5] report that a blend of 70% CNSL and 30% camphor Oil give results similar to Diesel. Velmurugan et al [11] tested of commercial diesel fuel and biofuel from CNSL with ethanol as an additive (BDEB). Experiemental Investigation of CNSL as alternative was under taken by V.Palvannan et al and the first trial run with a maximum of 20% CNSL- diesel blend was successfully conducted on single cylinder CI engine. engine power output and smoke emissions are found to be satisfactory,then it was decided to to proceed further testing. Mallikappa et al [7] investigated the performance and emission characteristics with 0.5%, 10%, 15%, 20% and 25% blends of Cardanol and Diesel. They reported that up to 20% blends of cardinal bio fuels may be used in CI engines without any modifications.

Table 1:Fuel Properties

Sl. No.	Tests	Cardanol Oil (CNSL)	Diesel
1	Density @ 15°C (in gm/cc)	0.9331	0.84
2	Kinematic Viscosity @ 40 °	27.80 cst	4.59
3	Flash Point by PMCC method	168°C	50°C
4	Fire Point by PMCC method	182°C	68°C
5	Gross Calorific value in Kcal/Kg	9651	10152.89
6	Conradson Carbon Residue	0.55%	...

2.1. Testing setup of an engine

The diesel engine is a high rpm with four strokes, vertical and air cooled type. Loading by means of an electrical dynamometer. To find out the how much quantity of fuel is consumed per unit time is measured with the help of graduated burette which is located outer end of the fuel tank .An orifice meter with U tube manometer provided along with an air tank on suction line for measuring air consumption. An AVL 4.5 smoke meter is provided for measuring a FSN of exhaust gases. The rig is installed with AVL software for obtaining various curves and results during operation. A five gases and analyzer are used to obtain the exhaust gas combustion.

2.2. Engine specification

Table 2.1 Engine Specification

Sl. No.	Description	Specification
1	Engine make	Kirloskar oil engine
2	Engine model	TAF 1
3	Engine type	Four stroke, single cylinder, vertical, air cooled diesel engine.
4	Rated power	4.4 kW
5	Rated speed	1500 rpm
6	Bore diameter (D)	87.5 mm
7	Stroke (L)	110 mm
8	Compression ratio	17.5 : 1
9	Orifice diameter	13.4 mm
10	Coefficient of discharge	0.62

3. RESULTS AND DISCUSSION

The performance of emission & combustion test have been conducted on 4.4 kW constant speed diesel engine.The parametric study has been conducted using Cardanol as fuel.The parametric study have been conducted at various injector pressure 180 ,200 ,220 & 240 bar & timing 21°,23°,25° & 27° bTDC.Based on the experimental observations the following conclusions were drawn. At peak load among the combinations of injection parametric study 25° bTDC & 240 bar operations gives the best efficiency on par with Diesel. The summary results are presented.

3.1. Performance Characteristics

Table 3: Neat Cardanol at Injection timing 25° bTDc
Diesel at Injection timing 23° bTDC and injection pressure 200 bar

Fuel used	Injection timing	Load	Brake thermal efficiency				Brake power				Specific fuel consumption				Carbon monoxide			
			%				KW				Kg / KW hr				%			
			ηBT				BP				SFC				CO			
			Injection pressure				Injection pressure				Injection pressure				Injection pressure			
	deg	%	180	200	220	240	180	200	220	240	180	200	220	240	180	200	220	240
NEAT CARDANOL	25°	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0.13	0.24	0.13
	25°	25	13.691	14.603	13.064	14.254	1.170	1.170	1.165	1.165	0.651	0.610	0.682	0.625	0.13	0.10	0.11	0.10
	25°	50	20.052	21.543	20.052	21.825	2.280	2.290	2.280	2.270	0.444	0.414	0.444	0.408	0.10	0.06	0.08	0.08
	25°	75	24.837	25.175	24.115	26.461	3.360	3.360	3.360	3.330	0.359	0.354	0.369	0.337	0.09	0.08	0.11	0.08
	25°	100	23.344	23.706	23.989	24.268	4.340	4.360	4.340	4.320	0.382	0.376	0.371	0.367	0.38	0.24	0.45	0.42

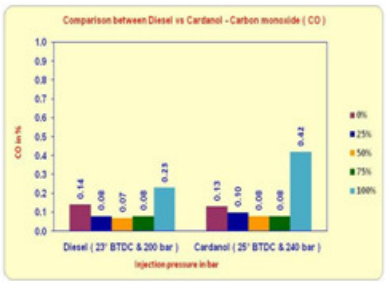
Table 4.Diesel and Cardanol

Injection timing	Load	Hydro carbon				Carbon di oxide				Oxygen				Nitrogen oxides				Filter smoke number			
		PPM				% in Vol				% in Vol				PPM							
		HC				CO2				O2				NOX				FSN			
		Injection pressure				Injection pressure				Injection pressure				Injection pressure				Injection pressure			
deg	%	180	200	220	240	180	200	220	240	180	200	220	240	180	200	220	240	180	200	220	240
25°	0	26	16	36	26	2.0	1.9	2.3	1.9	17.93	18.13	17.42	18.05	68	123	45	121	0.29	0.26	0.13	0.03
25°	25	25	14	21	18	2.9	2.8	3.2	2.9	16.74	16.85	16.13	16.8	244	282	222	293	0.49	0.55	0.46	0.44
25°	50	26	16	18	17	3.7	3.7	4.3	4.2	15.3	15.65	14.83	14.96	541	553	508	583	1.14	1.40	1.69	0.96
25°	75	25	20	18	18	5.1	5.7	5.5	5.4	13.9	13.09	13.27	13.26	820	889	610	759	1.44	2.37	1.84	1.56
25°	100	39	28	33	27	6.0	7.0	7.5	8.2	12.25	11.23	10.35	9.65	629	710	599	664	4.11	3.49	4.53	3.59

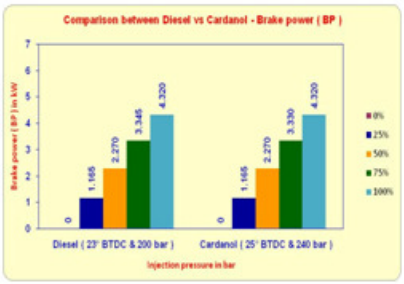
Fuel used	Injection timing	Load	Brake thermal efficiency	Brake power	Specific fuel consumption	Carbon monoxide	Hydro carbon	Carbon di oxide	Oxygen	Nitrogen oxides	Filter smoke number
			%	KW	Kg / KW hr	%	PPM	% in Vol	% in Vol	PPM	
			ηBT	BP	SFC	CO	HC	CO2	O2	NOX	FSN
			Injection pressure								
	deg	%	200								
DIESEL	23°	0	0	0	0	0.14	31	2.0	17.91	148	0.22
	23°	25	14.723	1.165	0.605	0.08	22	2.9	16.6	378	0.56
	23°	50	22.108	2.270	0.403	0.07	25	4.0	15.12	689	1.31
	23°	75	25.098	3.345	0.355	0.08	28	5.7	12.84	1255	1.92
	23°	100	24.600	4.320	0.362	0.23	36	7.2	10.92	1004	2.96
			Injection pressure								
	deg	%	240								
NEAT CARDANOL	25°	0	0	0	0	0.13	26	1.9	18.05	121	0.03
	25°	25	14.254	1.165	0.625	0.10	18	2.9	16.8	293	0.44
	25°	50	21.825	2.270	0.408	0.08	17	4.2	14.96	583	0.96
	25°	75	26.461	3.330	0.337	0.08	18	5.4	13.26	759	1.56
	25°	100	24.268	4.320	0.367	0.42	27	8.2	9.65	664	3.59

COMPARISON BETWEEN DIESEL VS NEAT CARDANOL

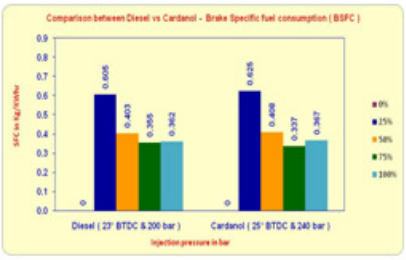
Graph-1



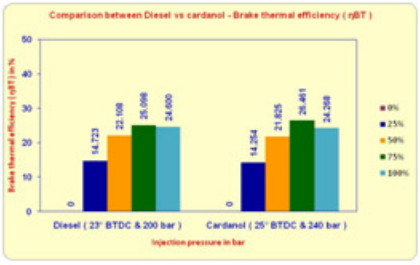
Graph-2



Graph-3



Graph-4



4. CONCLUSION

The CNSL oil is most useful non edible for the yield of bio diesel. Cardanol oil is used to used to run the multifuel engine which is extracted from the raw CSNL oil . Based on the experimental investigations carried out on the IC engine ,Cardanol oil can be used as alternative for diesel. From the experimental results it is recommended to use Cardanol 25° bTDC and 240 bar for improved performance.

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Author

S. Chandrasekaran, M.Tech(2nd yr), Bharath University, Chennai.