

A Comparative Study of Performance and Emission Characteristics of a Four Stroke Diesel Engine with Karanja and Cotton Seed Biodiesel Blended With Diesel

Dr. V. Naga Prasad Naidu¹, Prof. V. Pandu Rangadu², Dr. V.V. Prathibha Bharathi³

Principal, Intellectual Institute of Technology, Ananthapuramu, A.P, India¹

Professor, Department of Mechanical Engineering, JNTUACEA, Ananthapuramu, A.P, India²

HOD, Department of Mechanical Engineering, Malla Reddy College of Engineering, Hyderabad, A.P, India³

ABSTRACT: The gradual depletion of petroleum based fuels and the impact of environmental pollution led the researchers to search for an alternative fuels. One of the best alternatives is Biodiesels obtained from different vegetable oils. The present study focuses on comparison of performance and emission characteristics of a single cylinder four stroke diesel engine with two different biodiesels namely Karanja and Cotton seed biodiesels blended with diesel separately. The performance of the engine with biodiesel blend B20 as fuel is compared with the diesel fuel on the basis of brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature and emissions of hydrocarbons and oxides of nitrogen. This study reveals that the performance of the engine with these biodiesel blends differ marginally from diesel and hydrocarbon emissions are less than diesel. It is also observed that the cotton seed biodiesel blends are showing better performance and emission characteristics as compared with Karanja biodiesel blends.

KEYWORDS: Biodiesel blends, Cotton seed biodiesel, Karanja biodiesel, Performance and Emissions

I. INTRODUCTION

Today the world is facing the twin crises like the fossil fuel depletion and the global environmental pollution problems due to indiscriminate extraction and huge consumption of fossil fuel. A major solution to reduce these problems is to search for an alternative fuels like biodiesels, which are produced from vegetable oils. Over the last few years the biodiesel has gained as an important alternative fuel to diesel fuel [1] since they are renewable and can be produced in rural areas. The inventor of diesel engine Rudolf Diesel predicted that the plant based oils are widely used to operate diesel engine. The vegetable oil [2] has great potentials as alternative diesel fuel. Several researchers found [3] that the use of pure vegetable oils as fuel in diesel engine can cause numerous engine related problem such as injector choking, piston deposit formation and piston ring sticking due to higher viscosity and low volatility of vegetable oils. An effective method of using vegetable oils [4] in diesel engine is by modifying the vegetable oils into its monoesters (Biodiesel) by transesterification. Transesterification [5] of vegetable oil provides a significant reduction in viscosity, thereby enhancing their physical and chemical properties and improve the engine performance. Though the biodiesel has several advantages [6] over pure vegetable oil, it has disadvantages like low calorific value, higher viscosity and poor cold flow properties as compared with diesel. This drawback may be managed with the employment of blended fuel of biodiesel and diesel fuel.

II. LITERATURE REVIEW

Researchers from various parts of the world have carried out various experiments on a diesel engine with various biodiesels and its blends with diesel to evaluate the performance and emission characteristics.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

Yadav. D et al (7)] has conducted experiments on a CI engine with the biodiesel blends Neem biodiesel and investigated that the Neem blend B20 is showed the very close performance when compared to diesel.

Shruthi. H has conducted [8] experiments to analyze the performance of stationary single cylinder diesel engine running with Neem biodiesel mixed homogeneously with diesel at numerous proportions like 10% , 20% and 30% by volume and compared with diesel fuel. From the experimental results it's found that the brake thermal potency of the engine with this biodiesel blend B20 is nearer to the diesel and the carbon monoxide emission are reduced considerably whereas NOx increased slightly.

Agarwal. A.K et al (9) has investigated the effect of the Karanja biodiesel blends on the DI diesel engine and concluded that the Karnja biodiesel can be used as a partial substitute of diesel up to 20% (B20) without any major modifications in the existing engine.

Hadiya et al [10] has conducted experimental investigation on a four stroke CI engine with Cotton seed biodiesel and its blend with diesel. Four blends of Cotton seed biodiesel like B20, B40, B60 and B80 are employed in this experiment. From the experimental results it had been concluded that the combustion characteristics of the Cotton seed biodiesel blend B20 is followed closely with that of the diesel fuel.

III. MATERIALS & METHODS

In the present work engine tests were conducted with Karanja and Cotton seed Biodiesel blends separately to evaluate performance and emission characteristics. The performance of the engine with biodiesel blend B20 as fuel is compared with diesel fuel. Cotton [11] has long been known as nature's unique food and fiber plant. It produces both food for man and feed for animals in addition to a highly versatile fiber for clothing, home furnishings and industrial uses. Cottonseed oil [12] has a ratio of 2: 1 of poly un saturated to saturated fatty acids and generally consists of 65-70% unsaturated fatty acids including 18-24% monounsaturated (ole ic) and 42- 52% polyunsaturated (linoleic) and 26-35% saturated (palmitic and stearic). Karanja biodiesel is generated from karanja seeds of karanja tree. It is a medium sized tree and found throughout Asian country. The tree is drought resistant. Major manufacturing countries are East Indies, Philippines, and India. The oil content varies from 27-39%. Its cake is employed as chemical and plant food. Karanja Oil may be a non-edible oil of Indian origin. The plant is additionally said to be extremely tolerant to salinity and is observed to be grown in varied soil textures viz. stony, sandy and clayey. Karanja will grow in wet and also subtropical environments with annual low rain fall. This may be one of the reasons for wide availableness of this plant [13]. Karanja oil has been wide tested for insecticidal and antiseptic activity. In south a part of the Indian the karanja oil/cake also are used similarly like neem tree oil and organic fertilizer [14]. The seed oil has been utilized by the natives of Asian country for many years. Its maturity comes after 4 years of plantation. The oil expelled from the seeds is burned throughout the pageant of lighting to purify the surroundings. Such applications are at local or regional level and 94% of the oil from plant continues to be underutilized. The various properties [15] of the above bio diesels are presented in table 1.

TABLE- I
PROPERTIES OF FUELS USED

Properties	Cotton seed biodiesel	Karanja biodiesel	Diesel
Density (kg/m ³)	874	882	830
Calorific Value (kJ/Kg)	40600	39800	43000
Viscosity @40 ⁰ C(cSt)	4.34	5.43	2.75

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

Cetan Number	55	54	51
Flash Point (°C)	70-110	145	74

IV. TECHNICAL SPECIFICATIONS OF THE ENGINE

In this experimental work experiments were conducted on 4 stroke, single cylinder, C.I engine (Kirloskar Oil Engineers Ltd., India) of maximum power-3.68 KW with AVL smoke meter and Delta 1600 S gas analyser.

V. RESULTS AND DISCUSSIONS

A. Brake thermal Efficiency

The Figure 1 shows the variation of brake thermal efficiency of the engine with break power output. It is observed that the brake thermal efficiency of the engine increases with increase in load on the engine for all the fuel samples. In general the thermal efficiency depends on the combustion process which is a complex phenomenon that is influenced by several factors such as design of combustion chamber, type of injection nozzle, injection pressure, spray characteristics and fuel characteristics such as cetane number, volatility, viscosity, homogeneous mixture formation, latent heat of vaporization, calorific value etc. It is evident that diesel fuel has the higher brake thermal efficiency compared to biodiesel blends. It is also found that the cotton seed biodiesel blends has the highest thermal efficiency because of its calorific value and viscosity as compared with Karanja biodiesel blends. With the higher calorific value the amount of heat produced in the combustion chamber is more, further the combustion is complete and produced higher temperatures. The efficiency of the engine with diesel is 29.18%, Karanja biodiesel blend B20 is 27.82% and for the cotton seed biodiesel blend B20 it is 28.45% at 3/4th of rated load. It is observed that the brake thermal potency of the engine with Karanja biodiesel blends is lower than the cottonseed biodiesel blends.

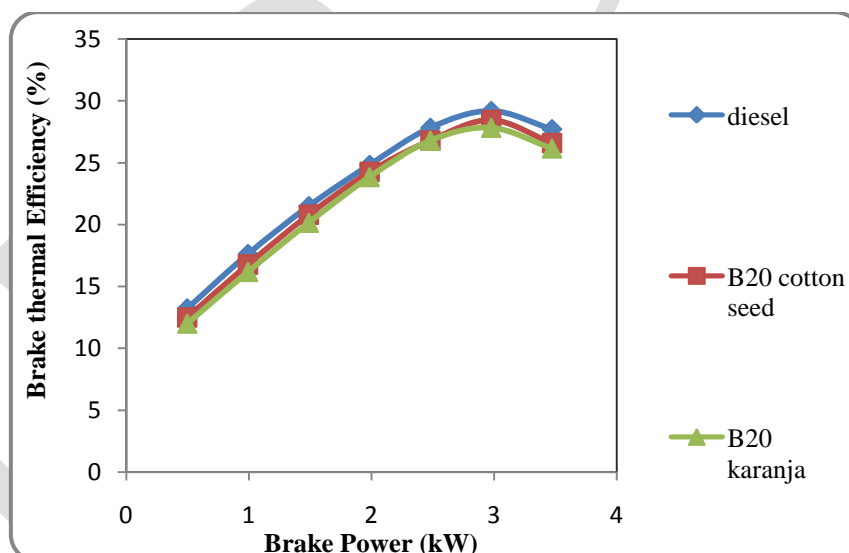


Figure 1: The variation of Brake thermal efficiency with brake power.

B. Brake specific Fuel Consumption

The variation of brake specific fuel consumption (BSFC) with break power is shown in Figure 2. The BSFC reduced with the load for all the fuels. The BSFC for all the biodiesel blends are higher than diesel fuel. The BSFC of cottonseed biodiesel blends are lower than the Karanja biodiesel blends. The specific fuel consumption is increased by 13.73% and 9.31% respectively with Karanja and cotton seed biodiesel blends compared with the diesel fuel. The BSFC is increased with increasing quantity of biodiesel in the blend because of the injection of less quantity of fuel due

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

to the higher viscosity and lower heating value. The oxygenated biodiesels may lead to the leaner combustion resulting in higher BSFC. It is also observed that the BSFC of the engine with Karanja biodiesel blends is higher than the cottonseed biodiesel blends.

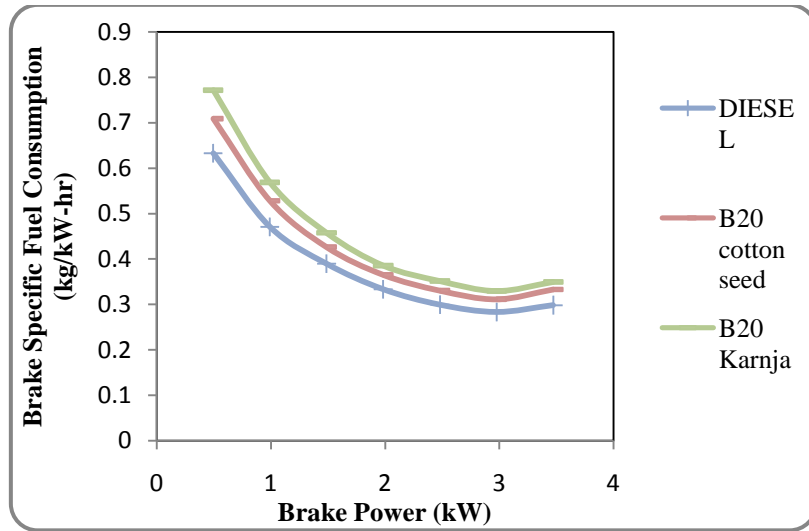


Figure 2: The variation of Brake specific fuel consumption with brake power.

C. Exhaust Gas Temperature

The Figure 3 shows the variation of exhaust gas temperature of the engine with break power output. The exhaust gas temperature in the combustion chamber depends on the calorific value, latent heat and viscosity of the fuel injected. The exhaust gas temperature was found to extend with increase in both the concentration of biodiesel within the blend and engine load. The rise in EGT with engine load is due to the actual fact that a more quantity of fuel is needed within the engine to get additional power required to take up conditional loading. For the diesel the exhaust gas temperature is low as compared with the biodiesel blends. The exhaust gas temperature for the diesel is 320°C, where as for Cotton seed biodiesel blend B20 and 332°C, for Karanja biodiesel blend B20 it is 334°C respectively at 3/4th of rated load. The exhaust gas temperature of Karanja biodiesel blends is slightly higher than the cottonseed biodiesel blends.

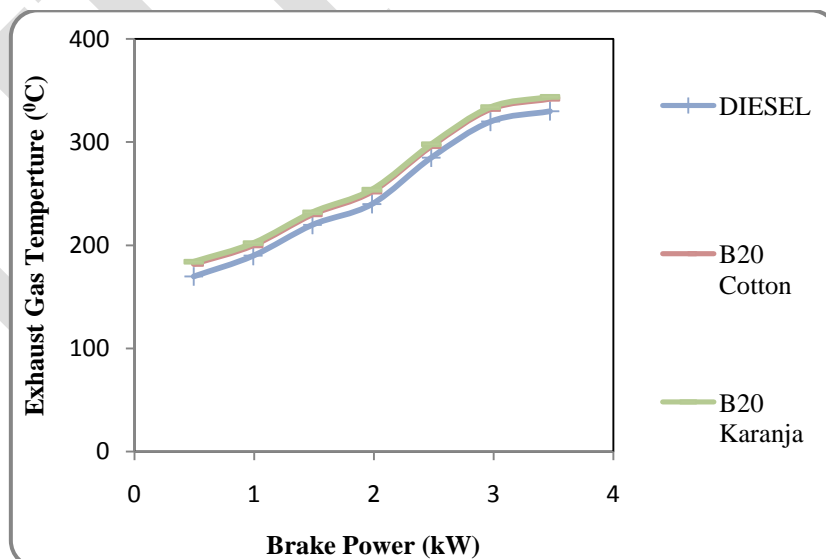


Figure 3: The variation of Exhaust gas temperature with brake power.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

D. Smoke Density

The variation of the smoke densities with power output is shown in Figure 4. The smoke opacity emissions increased with the increase of engine load. This is compensated up to certain extent due to the absence of aromatics and presence of inherent oxygen molecules in the biodiesel. These oxygen particles helps to promote stable and complete combustion by delivering oxygen to the combustion zone of burning fuel by reducing locally rich region and limit primary smoke formation and lower smoke emissions. Higher smoke emissions at higher loads may be due to poor atomization of biodiesel. When compared to diesel the increase in smoke emissions of biodiesel blends is higher due its high viscous nature. Due to higher viscosity of biodiesel the bigger size fuel molecules occurs and results in poor atomization of fuel.

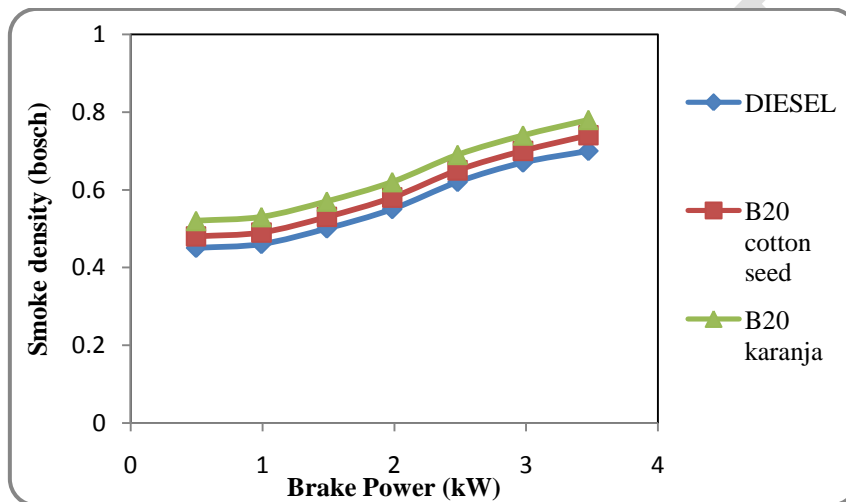


Figure 4: The variation of smoke density with brake power.

E. Hydrocarbon emissions (HC Emissions)

The variation of hydrocarbon emissions with break power is shown in Figure 5. The HC emissions depend upon mixture strength i.e. oxygen quantity and fuel viscosity in turn atomization.

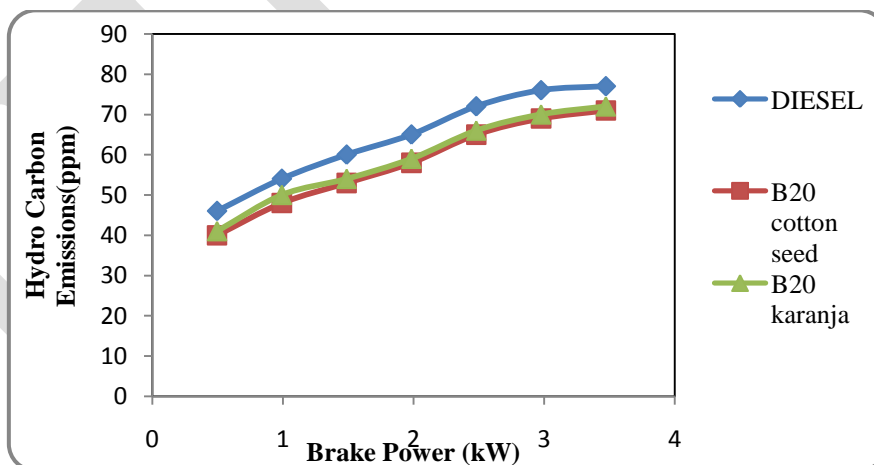


Figure 5: The variation of HC emission with brake power.

The HC emissions increase with increasing load as well as increasing the amount of biodiesel in the blend. There will be similar trends for all the fuels. Lower heating value of biodiesel leads to the injection of higher quantities of fuel for the same load condition. More the amount biodiesel leads to more oxygen availability, either inherent in fuel or present

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

in the charge. When compared to diesel, the oxygen availability in the biodiesels is more. So the HC emissions of the engine with biodiesel blends are less than diesel. The HC emissions of Karanja biodiesel blends are slightly higher than the cottonseed biodiesel blends.

F. Carbon Monoxide Emissions (co emissions)

The variation of carbon monoxide emissions for is illustrated in Figure 6. It has been observed that the CO emissions are inflated with increase in engine load for all fuel samples. The CO emission of the engine with diesel oil is higher than the Cotton seed and Karanja biodiesel blends. The lower CO emission of biodiesel compared to diesel oil is due to the presence of oxygen in biodiesel that helps in complete oxidization of fuel. The surplus oxygen offered within the biodiesel converts the some of the CO into carbon dioxide and thus the CO emission is reduced. The CO emission for diesel oil is 0.67% volume, for Cotton seed biodiesel blend B20 is 0.615% volume and for Karanja biodiesel blend B20 is 0.627% volume at $\frac{3}{4}$ th of rated load. The CO emissions of Karanja biodiesel blends are slightly higher than the cottonseed biodiesel blends.

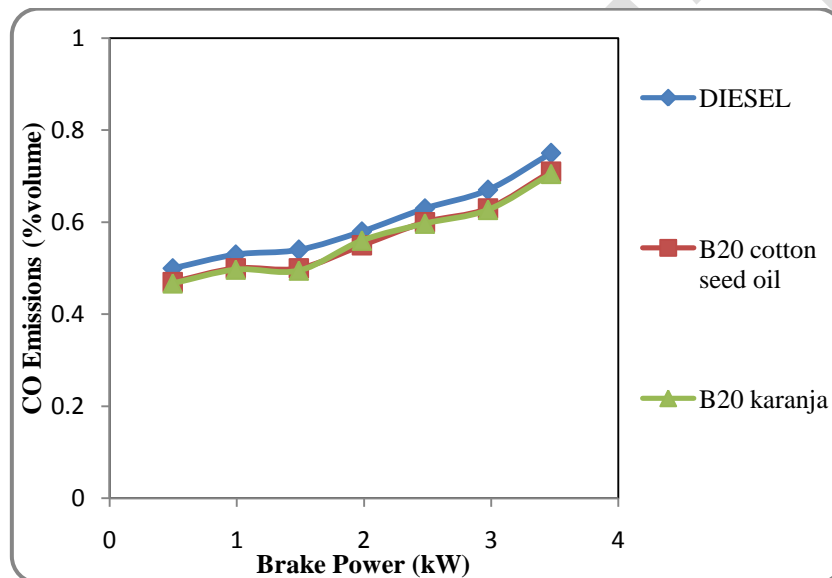


Figure 6: The variation of CO emission with brake power.

G. Nitrogen oxide Emissions

The variation of Nitrogen oxide emissions of the engine with diesel and biodiesels are illustrated in Figure 7. The NOx emission will increase with increase in load on the engine for each diesel and biodiesel blends. These higher NOx emissions could be due to the higher exhaust gas temperature at higher loads. The NOx emissions are slightly higher for Cottonseed biodiesel blends as compared with pure diesel. The rise of NOx emissions could also be related to the oxygen content of the biodiesel, since the biodiesel fuel provided extra oxygen for NOx formation. This one amongst the most reasons for the formation of higher NOx with the biodiesel blends as compared with pure diesel. The NOx emissions of Karanja biodiesel blends are slightly higher than the cottonseed biodiesel blends.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

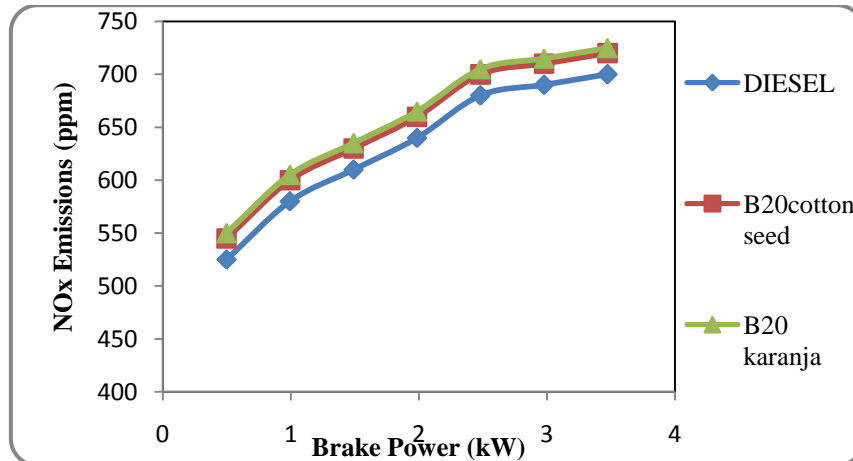


Figure 7: The variation of NOx emission with brake power.

VI. CONCLUSIONS

The following conclusions are drawn based on the experimental results of the above work:

- The brake thermal efficiency of the engine depends majorly on the heating value and viscosity. The brake thermal efficiency of biodiesel blends is lower than the diesel. The cotton seed biodiesel blends is having brake thermal efficiency higher than the Karanja biodiesel blends.
 - The BSFC of the engine with diesel fuel is lower than the biodiesel blends and the BSFC of cotton seed biodiesel blends is lower than the Karanja biodiesel blends.
 - The exhaust gas temperature of the engine with diesel fuel is lower than the biodiesel blends.
 - The CO and HC emissions of the engine with diesel fuel is higher than the biodiesel blends and the CO and HC emissions of cotton seed biodiesel blends is lower than the Karanja biodiesel blends.
 - The Smoke and NOx emissions of the engine with biodiesel blends are higher than the diesel.
- It is concluded that out of the two biodiesels cotton seed biodiesel is best as compared with Karanja biodiesel in terms of performance and emissions. So the cotton seed oil can be used as alternative to diesel.

REFERENCES

- [1] Cummins, C., Lyle, Jr. Diesel's Engine, Volume 1: From Conception to 1918. Wilsonville, OR, USA: Carnot Press, ISBN 978-0-917308-03-1. (1993).
- [2] Agarwal A.K and Das L.M, Bio diesel development and characterization for use as a fuel in CI engine, Transaction of ASME 123, pp.440- 447, 2001.
- [3] Senthil Kumar, M.; Ramesh, A.; Nalagingam, B., "Proceedings of the International Conference on WASTE to ENERGY," Jaipur, India, pp.85-92,2002,
- [4] Bari, S., Lim, T.H., Yu, C.W Effect of preheating of crude palm oil on injection system . (2002).
- [5] Scholl Wk, Sorenson CS "Combustion of soybean oil methyl ester in DI diesel engine". SAE 1983 930-934.
- [6] Sahoo PK, Das LM, Babu MKG and Naik SN, "Biodiesel development from high acid value polanga seed oil and performance evaluation in CI engine". Vol.86 issue.3, 448-454. 2007;
- [7] Dharmendra Yadav, Nitin shrivatsava and Vipin shrivatsava, Experimental investigation of performance parameters of single cylinder four stroke DI diesel engine operating on Neem biodiesel and its blends, International journal of Mechanical engineering and Robotic research, Voume:. 3, PP. 479-486. Oct-2012.
- [8] Shruthi, H.; Heroor; and Rahul Bhaeadwaj, SD., International journal of environmental engineering and Management Vol.4, Issue.5,pp 425-432,2013.
- [9] Avinash Kumar agarwal and Atul Dhar, Experimental investigations on the effect of Karanja biodiesel on engine performance, combustion and durability, in collaboration with Shell technology India PVT, Directions -2013, PP. 93-100.
- [10] Hadiya, J.P.; International Journal of Engineering Science and Research Technology, vol 2 , Issue.12, pp3444-3447. 2013.
- [11] Dinesh and Singh, Cotton Seed oil quality utilization and processing – CICR Technical bulletin No. 25.
- [12] Bhat, Y C.; Murthy, N.S.; and Datta, R.K., , Journal of Institute of Engineers (India) – AG, vol.85,pp 10 – 14, 2004.
- [13] Vivek; and Guptha, A.K., Journal of Scientific and Industrial research, Vol. 63, Issue 3,pp 39-47,2004,.
- [14] Material safety data sheet, National sourcing Oxford, CT USA, 1-3.
- [15] Report of the committee on Development of Bio fuels-Planning Commission, Government of India.