Performance and Emission Characteristics of DI Diesel Engine Using Cooking Oil With The Help Of SCR Technology

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Abstract: With abundance of forest and plant based non edible oils being available in our country such as jatropha, mahua and castor oils, an attempt has been made to use these as substituent of diesel. But vegetable oils are not compatible with regular diesel (C.I.) engines, mainly due to the high viscosity of vegetable oils. Hence in the research the problem has been overcome by reducing the viscosity and increasing the volatility. By careful review of literature and market survey I have come to the conclusion of selecting Mahua and Diesel oil blends. After successfully blending of biofuel after transesterification process we have tested its real application in a diesel engine. But before testing the Biodiesel in a C.I. engine we had make sure that the biodiesel derived from neutralized Mahua and oil is suited for use in diesel engines given that its kinematic viscosity, flash point, cloud point, and calorific value conform to the recommended international standards. So after this conformation we have carried out the performance analysis to get an idea about the practicality of the use of Mahua oil as an alternative fuel.

Key Words: Vegetable oils, Biofuel, Mahua tree, Diesel engines.

1. INTRODUCTION:

1.1 Introduction of CI Engines

Today’s diesel engines are well established as a serious and very promising powertrain solution in the world market. In the area of agriculture, diesels are the dominating power source especially for Tractors. This is due to the significant improvements of these engines, especially the DI ones, in combination with the absence of reliable and economic alternative solutions that would cover partially the demand in these areas. Moreover today’s technological status reveals clearly that diesel engines (and especially tractors) will remain the dominating power source in the agriculture sector for the short- and mid-term future. On the other hand, the most difficult task that have to overcome, is the further reduction of pollutant emissions, mainly NOx and particulates, to extremely low levels to meet future emissions legislation.

This could be faced today using two main technologies:

- Reduction of pollutant formation inside the combustion chamber
- Reduction using after-treatment technologies at the tail-pipe.

The basic mechanism involved in the formation of pollutants inside the DI diesel combustion chamber, is the mixing and combustion of injected fuel. From the literature survey during this project it is reported that any effort that results in the reduction of either NOx or Soot has a negative effect on the other especially.

1.2 Introduction to Combustion

In CI engine, only air is compressed through a high compression ratio raising its temperature and pressure to a high value. Fuel is injected through one or more jets into this highly compressed air in the combustion chamber. Here, the fuel jet disintegrates into a core of fuel surrounded by a spray envelop of air and fuel particles. The turbulence of air in the combustion chamber passing across the jet tears the fuel particles from the core. A mixture of air and fuel forms at some location in the spray envelope and oxidation starts.

1.3 ENGINE SPECIFICATIONS

Parameter	Specification
Engine type	DI, naturally aspirated, water cooled
Number of cylinders	1
Bore (mm)	87.5
Stroke (mm)	110
Displacement (cm^3)	661
Compression ratio	17.5
Maximu power (kW) at rated rpm	5.2
Rated rpm	1500
Injection pressure (bar)	220
Injection timing (°btdc)	23

1.4 Mahua Oil

Mahua oil is obtained from dried seeds of the mahua plant. Mahua plant is a large deciduous tree growing widely under dry tropical and sub tropical climatic conditions. It is an important tree for the poor, it is greatly valued for its flowers and its seeds. The tree has religious and aesthetic value in the tribal culture. The fruits ripen in June – July and fall off soon ripening. In northern India harvesting takes place between April and July. In southern India the harvesting period is between August and September. The tree starts giving flowers and fruits between 10to 15years after plantation. An average sized tree yields about 50 to 100 kg of flower in a season that lasts around a month. Mahua tree has an annual average yield of 62.5 kg of flower and 59 kg of gully as per one study. Collection of Mahua seed, which is also an important source of oil, is capable to generate employment worth 3 million person days a year. Mahua trees are widely grown in Uttar Pradesh, Madya Pradesh, Gujarat, South India, three district of Karnataka (Mysore, Tumakur and Bidar) and Monsoon forest of western Ghats.

1.4 Applications

It is used mostly in manufacturing of soaps, particularly the laundry field. It is also used for edible and cooking purpose. Refined oil is used in manufacturing of lubricating greases. The oil is used for candles a batching as a raw material for production of fatty alcohol and stearaic acid. The tribal commonly consume the tori oil that contains 40-45% oil. The oil cake is also used as pesticide and manure. It contains 16% of protein. The oil cakes are profitably utilized as biofertilizers or cattle feed or sold to solvent ex-traction plants, where still more oil is extracted.

Medically the tree is very valuable. Flowers are prepared to relieve coughs, biliousness and heart- trouble while the fruit is given in cases of consumption and blood diseases. Mahua flowers show anti-bacterial activity against Esche-richia coli. The honey from flowers is edible and reported to be used for eye. The bark is used in treating of rheuma-tism, ulcers, itching, bleeding and spongy gums, tonsillitis leprosy, heal wound, and diabetes mellitus. The root base is applied to ulcers.

1.5 Details of Constituents and Quality Characterristics

Mahua oil is obtained from the kernel of mahua seed (MadhucaIndica) and contains 50-55%oil. The unrefined but filtered crude mahua oil is greenish yellow in color. The oil itself contains a number of fatty acids similar to those in cooking oils such as oleic acid, linoleic acid, stearic acid and palmitic acid. The quality of oil ex-tracted from the seeds, depends largely on the conditions under which they have been stored. Even under the best conditions the concentration of fatty acid increases. The oil from fresh seeds has an acid value as low as 3.5.

1.6 Collection And Processing

Mahua seed is collected during May to July. In this season when Mahua tree flowers more, seed production is low. The villagers go to forests early in morning to collect fruits using bamboo sticks (or hand pick) to pluck the fruits. During a bumper season a person can collect up to 15 kg of tori per day. Local tribal use their indigenous knowledge for extraction of oil from seed. 250 ml of oil is extracted from 1 kg of seed. Oil is usually kept for domestic consumption. In the market they sell at Rs 8/- a kg. After collection of fruits, the seeds are separated from them and tribal people use the pulp for their food. After removal of pulp, seeds are washed and soaked in water for 3 days so that the seed coat softens. Thereafter the covering is removed either one at a time or many together by crushing the seeds through grind stones by applying minimum pressure. The seeds should be de-shelled by pressing and then dried to get the kernel. The amount of oil extracted depends on the efficiency of the equipment employed for crushing; it is 20-30% of the weight of kernels when crushed in ganas 34-37% in expellers and 40-43% when extracted by solvents. Fresh Mahua oil from properly storedseeds is yellow in color with unpleasant taste. Commercial oil is generally greenish yellow in colour with an offensive odour and disagreeable taste. Groups can set up advance dealing, directly with the oil expellers, if they are located nearby. Indigenous methods for oil expelling could be utilized and gully oil may be sold to soap manufacturers after vacuum purification. Mahua gully is prone to fungal attack if not preserved properly. It is kept in an airtight earthen pot with its mouth sealed or in baskets with wet mud and leaf coating. Mouth of the basket is covered with mahul or palas leaves. This indigenous technique is useful for storing the guli for sufficiently longer time before onset of monsoons.

1.6Production, Economic Aspects And Cultivation Package

Seeds that are procured during the months of June/July cultivate this tree. The fleshy pulp is separated and seeds sown in poly bags containing sand, soil and FYM. Germination starts after 15 days and continues till 40 days. They can then be transplanted in the field during the late rainy season after they are two-three months old. The growth of the seedling is slow during the first two years. Setting up a small size oil mill as a Small Scale Industry would cost Rupees 1 to 1.25 Lakhs (at 1997 prices) including filtration set up required at a central (may be a block) level. Khadi Village Industry Commission has schemes that could help setting up of a Small Scale Industry. Assuming that 3 kg of ripe gully will result in 1 kg of oil and average price of oil as Rupees 27 per Kg, the returns to the primary collector per kg of gully would be Rupees. 7per Kg again assuming a Rupees 2 per kg of processing cost of the gully. The current prices of oils for first grade is Rupees 2900 and oil second grade is Rupees 2850 for a quintal.

1.7Selective Catalytic Reduction

In the Selective Catalytic Reduction (SCR) process, NOx reacts with ammonia, which is injected into the flue gas stream before the catalyst. Different SCR catalyst systems based on platinum, vanadium oxide or zeolites have different operating temperature windows and must be carefully selected for a particular SCR process. Ammonia-SCR has been used for years in industrial processes, in stationary diesel engine applications, as well as in marine engines. Urea-SCR technology, using urea as the ammonia precursor, is being adapted for mobile diesel engines. The application of SCR for mobile diesel engines requires overcoming several problems, which are discussed later. However, SCR remains the only proven catalyst technology capable of reducing diesel NOx emissions to levels required by a number of future emission standards. Urea-SCR has been selected by a number of manufacturers as the technology of choice for meeting the Euro V (2008) and the JP 2005 NOx limits—both equal to 2 g/kWh—for heavy-duty truck and bus engines. First commercial diesel truck applications were launched in 2004 by Nissan Diesel in Japan [Hirata 2005] and by DaimlerChrysler in Europe.

SCR systems are also being developed in the USA in the context of the 2010 NOx limit of 0.2 g/bhp-hr for heavy-duty engines, as well as the Tier 2 NOx standards for light-duty vehicles. However, the US clean air authorities have voiced concerns about the SCR technology. From the regulatory perspective SCR poses enforcement problems, both in terms of ensuring that the reductant (urea) is available together with diesel fuel throughout the nationwide distribution network, and that it is always timely replenished by vehicle operators.

1.7 Reductants and Catalytic Reactions

1.7.1 Cerium

Ceria is a promising eco-friendly redox catalyst for a large number of industrial as well as lab scale reactions, especially for automotive exhaust gas conversion, hydrogen production, etc., because of its virtuous redox property. The most important feature associated with the ceria is that it stores the oxygen in aerobic conditions and releases the oxygen in anaerobic conditions in order to satisfy its stoichiometry. Due to its fluorite structure, the oxygen atoms in a ceria crystal are all in a plane with one another, allowing for rapid diffusion as a function of the number of oxygen vacancies. As the number of vacancies increases, the ease at which oxygen can move around in the crystal increases, allowing the ceria to reduce and oxidize molecules or co-catalysts on its surface. However pure ceria's oxygen storage capacity is limited because of lack of surface area at high temperatures due to nucleation and growth of crystallites of ceria within the pore. This limitation is overcome by addition of other earth metals such as zirconium.

1.7.2 Zirconium

Zirconium dioxide is one of the most studied ceramic materials.ZrO_2 adopts a monoclinic crystal structure at room temperature and transitions to tetragonal and cubic at higher temperatures. The volume expansion caused by the cubic to tetragonal to monoclinic transformation induces large stresses, and these stresses cause ZrO_2 to crack upon cooling from high temperatures. When the zirconia is blended with some other oxides, the tetragonal and/or cubic phases are stabilized. An effective dopant is cerium oxide. Zirconia is often more useful in its phase 'stabilized' state. Upon heating, zirconia undergoes disruptive phase changes. By adding small percentages of cerium, these phase changes are eliminated, and the resulting material has superior thermal, mechanical, and electrical properties. In some cases, the tetragonal phase can be metastable. If sufficient quantities of the metastable tetragonal phase is present, then an applied stress, magnified by the stress concentration at a crack tip, can cause the tetragonal phase to convert to monoclinic, with the associated volume expansion. This phase transformation can then put the crack into compression, retarding its growth, and enhancing the fracture toughness. This mechanism is known as transformation toughening, and significantly extends the reliability and lifetime of products made with stabilized zirconia.

1.7.2 REACTIONS TAKING PLACE

A number of chemical reactions occur in the ammonia SCR system, as expressed by Equations (1) to (5). All of these processes represent desirable reactions which reduce NOx to elemental nitrogen. Equation (2) represents the dominant reaction mechanism [Cho 1994]. Reactions given by Equation (3) through (5) involve nitrogen dioxide reactant. The reaction path described by Equation (5) is very fast. This reaction is responsible for the promotion of low temperature SCR by NO2 [Cooper 2003]. Normally, NO2 concentrations in most flue gases, including diesel exhaust, are low. In some diesel SCR systems, NO2 levels are purposely increased to enhance NOx conversion at low temperatures.

(1)$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$

(2)$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$

(3)$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$

(4)$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$

(5)$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$

It has been found that the above reactions are inhibited by water [Willi 1996]. Moisture is always present in diesel exhaust and other flue gases. To obtain valid results, water vapor should be always present in laboratory gas tests of SCR processes and in process modeling.

In case the NO2 content has been increased to exceed the NO level in the feed gas, N2O formation pathways are also possible, as shown in Equation (6) and (7) [Madia 2002].

(6)$8 NO_2 + 6 NH_3 \rightarrow 7 N_2O + 9 H_2O$

(7)$4 NO_2 + 4 NH_3 + O_2 \rightarrow 4 N_2O + 6 H_2O$

Undesirable processes occurring in SCR systems include several competitive, non-selective reactions with oxygen, which is abundant in the system. These reactions can either produce secondary emissions or, at best, unproductively consume ammonia. Partial oxidation of ammonia, given by Equations (8) and (9), may produce nitrous oxide (N_2O) or elemental nitrogen, respectively. Complete oxidation of ammonia, expressed by Equation (10), generates nitric oxide (NO).

(8)$2NH_3 + 2O_2 \rightarrow N_2O + 3H_2O$

(9)$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

(10)$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

Ammonia can also react with NO_2 producing explosive ammonium nitrate (NH_4NO_3), Equation (11). This reaction, due to its negative temperature coefficient, occurs at low temperatures, below about 100-200°C. Ammonium nitrate may deposit in solid or liquid form in the pores of the catalyst, leading to its temporary deactivation.

(11)$2NH_3 + 2NO_2 + H_2O \rightarrow NH_4NO_3 + NH_4NO_2$

Ammonium nitrate formation can be avoided by making sure that the temperature never falls below 200°C. The tendency of NH_4NO_3 formation can also be minimized by supplying into the gas stream less than the precise amount of NH_3 necessary for the stoichiometric reaction with NO_x (1 to 1 mole ratio).

(12)$NH_3 + SO_3 + H_2O \rightarrow NH_4HSO_4$

(13)$2NH_3 + SO_3 + H_2O \rightarrow (NH_4)_2SO_4$

1.8 Importance of SCR

SCR technology is one of the most cost-effective and fuel-efficient technologies available to help reduce diesel engine emissions. All heavy-duty diesel truck engines produced after January 1, 2010 must meet the new EPA standards, among the most stringent in the world, reducing particulate matter (PM) and nitrogen oxides (NOx) to near zero levels. SCR can reduce NOx emissions up to 90 percent while simultaneously reducing HC and CO emissions by 50-90 percent, and PM emissions by 30-50 percent. SCR systems can also be combined with a diesel particulate filter to achieve even greater emission reductions for PM. In the commercial trucking industry, some SCR-equipped truck operators are reporting fuel economy gains of 3-5 percent. Additionally, off-road equipment, including construction and agricultural equipment, must meet EPA's Tier 4 emissions standards requiring similar reductions in NOx, PM and other pollutants.

1.9 Usage of SCR

SCR has been used for decades to reduce stationary source emissions. In addition, marine vessels worldwide have been equipped with SCR technology, including cargo vessels, ferries and tugboats. With its superior return in both economic and environmental benefits, SCR is also being recognized as the emissions control technology particularly helpful in meeting the U.S. EPA 2010 diesel engine emission standards for heavy-duty vehicles and the Tier 4 emissions standard for engines found in off-road equipment.

1.10 Components of SCR

One unique aspect of a vehicle or machine with an SCR system is the need for replenishing Diesel Exhaust Fluid (DEF) on a periodic basis. DEF is carried in an onboard tank which must be periodically replenished by the operator based on vehicle operation. For light-duty vehicles, DEF refill intervals typically occur around the time of a recommended oil change while DEF replenishment for heavy-duty vehicles and off-road machines and equipment will vary depending on the operating conditions, hours used, miles traveled, load factors and other considerations.DEF is an integral part of the emissions control system and must be present in the tank at all times to assure continued operation of the vehicle or equipment. Low DEF supply triggers a series of escalating visual and audible indicators to the driver or operator. Once the tank reaches a certain level near empty, the starting system may be locked out the next time the vehicle is used, preventing the vehicle from being started without adequate DEF. A nationwide DEF distribution infrastructure has rapidly expanded to meet the needs of a growing SCR technology marketplace.

On-board tanks to store DEF are typically located in the spare tire area of passenger vehicles, while tractor trailers typically have a DEF tank alongside the diesel fuel saddle tank. Proper storage of DEF is required to prevent the liquid from freezing at temperatures below 12 degrees Fahrenheit, and most vehicle DEF dispensing systems have warming devices.

1.11 DEF

Diesel Exhaust Fluid (DEF) is a non-toxic fluid composed of purified water and automotive grade aqueous urea. DEF is available with a variety of storage and dispensing methods. Storage options consist of various size containers such as bulk, totes and bottles or jugs. The American Petroleum Institute rigorously tests DEF to ensure that it meets industry-wide quality standards.

DEF is available for purchasing at various locations like truck stops, truck dealerships and engine distributors which can be located using one of the below links. DEF tanks range in size from 6 to 23 gallons depending on the truck's application. The DEF tank fill opening is designed to accommodate a DEF fill nozzle to ensure only DEF is put into the tank. A diesel fuel nozzle will not fit into the DEF tank opening.

2. LITERATURE REVIEW:

2.1. SCR and Its field of usage

By Tang, T., Zhang, J D, SAE Technical Paper 2014-01, 2014
In this paper, we found out from our research about the various fuels where SCR can be used. It was very helpful in our project as it made clear about the fules we can use in our experiment. It also showed us that to meet the Euro VI regulations, the SCR system should achieve high NOx reduction efficiency even at low temperature

2.2 100% Vegetable oil as Potential Fuel Source

By The Southwest Research Institute, Reid et al. (1982)
This paper evaluated the chemical and physical properties of 14 vegetable oils. We learned from this paper that the oils behave very different from petroleum-based fuels. This change in behaviour was attributed to the vegetable oils' high viscosity.

2.3 Study of Cooking Oil at Different Blends

By Goering et al. (1981)
They studied the characteristic properties of eleven vegetable oils to determine which oils would be best suited for use as an alternative fuel source. We found out that of the eleven oils used, corn, rapeseed, sesame, cottonseed and soybean oils had the most favourable fuel properties.

2.4 Sunflower Oil as a Substitute

By Bruwer University (1980)
From this paper we studied about the properties of the sunflower oil. Upon various tests conducted on tractors with 100% sunflower oil, an 8% power loss occurred after 1000 hours of operation.

2.5 Rapeseed as Alternative Cooking Oil

By Schoedder (1981)
The test was done by using rapeseed oils as a diesel fuel replacement in Germany with mixed results. Short term engine tests indicated rapeseed oil had similar energy outputs when compared to diesel fuel.

2.6 Soybean Blends with Diesel

By Engelman et al. (1978)

From this paper we found out that the initial results of using the fuel were encouraging. The main conclusion was that the fuel can be used as an alternative for short period of time.

2.7 Vegetable Oil Blend with Diesel Oil

By Caterpillar (Barthalomew,1981)
This paper helped us to know the effects of the blend on the engines. We found out that small amounts of blend did not cause engine failure. The 20% vegetable oil fuel blends were better.

2.8 Mahua Oil with Diesel Blend Usage

By McDoennell (2000)

This Paper was useful the most as it helped us to study the properties of Mahua oil which were very encouraging and the best results were found from this oil.

3. OBJECTIVE:

The main objective of this project is to :-

1. Find an alternative fuel to the conventional fuels used in vehicles. We are basically trying to find a fuel that will replace diesel in the engines as we know their availability is decreasing rapidly.
2. Perform the tests using the oil on diesel engine. We are going to perform the tests on the engines using the alternative oil for checking its performance characteristics.
3. Check the performance characteristics of the oil and compare it with diesel fuel.
4. Check the emission characteristics of the oil and again compare them with diesel fuel.
5. Designing of Selective Catalytic Reduction. It will be used at the exhaust manifold while using vegetable oil.
6. Installing SCR on diesel engine and perform tests using vegetable oil.

4. METHODOLOGY:

1. Study is done on the basic concepts of diesel engine emissions and SCR
2. Emission test is done on the diesel engine without the use of SCR.
3. Blend of used engine oil with diesel is prepared and emission readings are taken.
4. Comparison of the emission results and brainstorming is done to select the best suitable catalyst to reduce the emission.
5. Design of CAD model of SCR.
6. Emission test is done on the diesel engine with the use of SCR.
7. Comparison is made on both the results obtained.
8. Final conclusion is made after analyzing the results.

5. SCR DESIGN CAD Model:

5.1 Shape of Catalytic Converter

The cylindrical shape was considered due to ease of fabrication, minimum assembly time, rigidity and easier maintenance.

5.2 SHELL DIMENSION

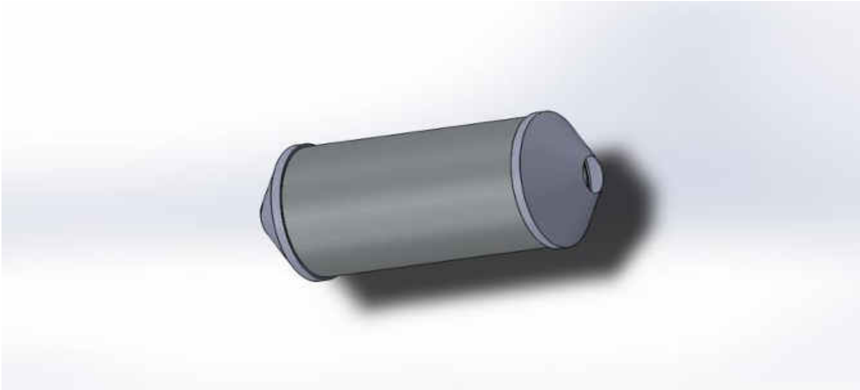
$V=3.14/4*D^2*L$

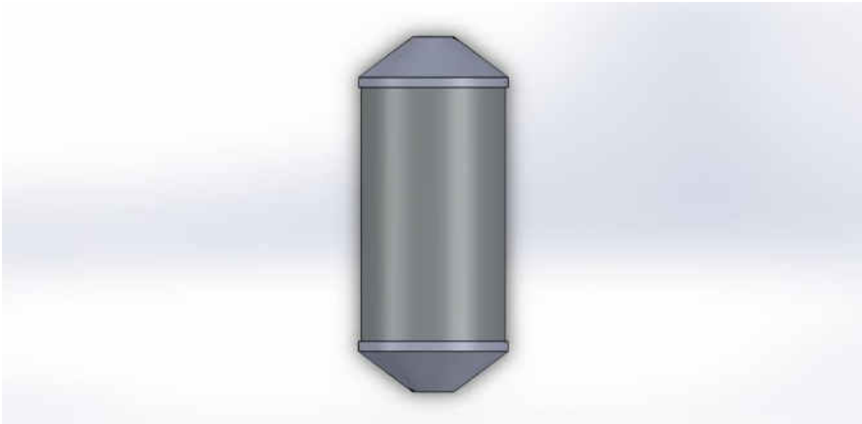
$L=2D$

$V=3.14/4*2*D^3$

D=13.4 CM

L= 26.8 CM





6. Properties Of the Oils:

6.1 Comparison between Diesel Oil, Mahua Oil blends with Diesel and Mahua Oil

Fuel	Fuel Viscosity mm2/s at 40oC	Calorific value MJ/kg	Density kg/m3 at 40oC	Flash point oC
B100	3.96	37.2	880	110
B60	3.92	38.6	868	96
B40	3.88	40	855	94
B20	3.84	41.6	843	90
DIESEL OIL	3.8	42.8	830	58
MAHUA OIL	18.4	36.1	918	207

7. EMISSION READINGS:

7.1 Diesel Emission Readings

LOAD	CO%	PPM HC	% CO2	%O2	PPM NOx	oC	SMOKE
0%	0.08	18	2.60	17.12	145	7.343	33.1
20%	0.08	14	2.90	16.62	182	6.545	42
40%	0.09	18	3.60	15.83	291	5.262	52.8
60%	0.09	17	4.10	15.27	411	4.622	61.5
80%	0.07	19	4.40	14.89	477	4.301	70.3
100%	0.06	22	4.80	14.09	554	3.882	78.3

These readings were calculated after performing the experiment. We noted these readings with the help of AVL meter. The readings were accurate and thus were helpful in finding out the graphs.

7.2 Diesel Emission Readings with 20% Blend

USED ENGINE OIL 20% BLEND WITH DIESEL FUEL								
WITHOUT CONVERTER								
LOAD	CO	HC	CO2	O2	Nox	SMOKE	BRAKE POWER	BSFC
%	%	ppm	%	%	ppm	%	kw	kg/kwhr
0	0.07	26	4.5	14.61	458	47.8	0.189	2.79
20	0.08	24	4.6	14.24	469	64.7	0.049	16.65
40	0.07	20	5.1	13.86	515	82.1	0.145	5.96
60	0.08	20	5.3	13.4	547	88.6	0.5	1.824
80	0.06	26	5.1	13.68	537	91.2	0.756	1.08
100	0.08	33	5.5	13.08	576	96.1	0.974	0.94

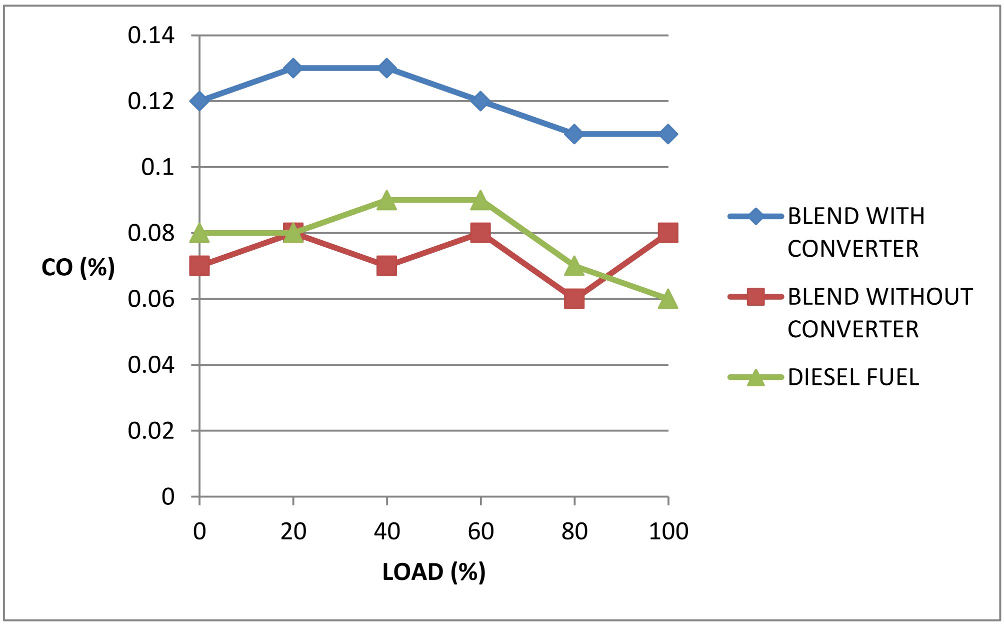
7.3 USED ENGINE OIL 20% BLEND WITH DIESEL FUEL WITH CATALYTIC CONVERTER

The following were the readings from the experiment :

LOAD	CO	HC	CO2	O2	Nox	SMOKE
%	%	Ppm	%	%	ppm	%
0	0.12	30	2.7	16.9	105	11.1
20	0.13	34	3.4	15.84	158	19.3
40	0.13	35	4.2	14.72	261	23.7
60	0.12	37	5	13.57	403	42.7
80	0.11	39	5.9	12.37	465	60.5
100	0.11	33	6.7	11.4	558	70.8

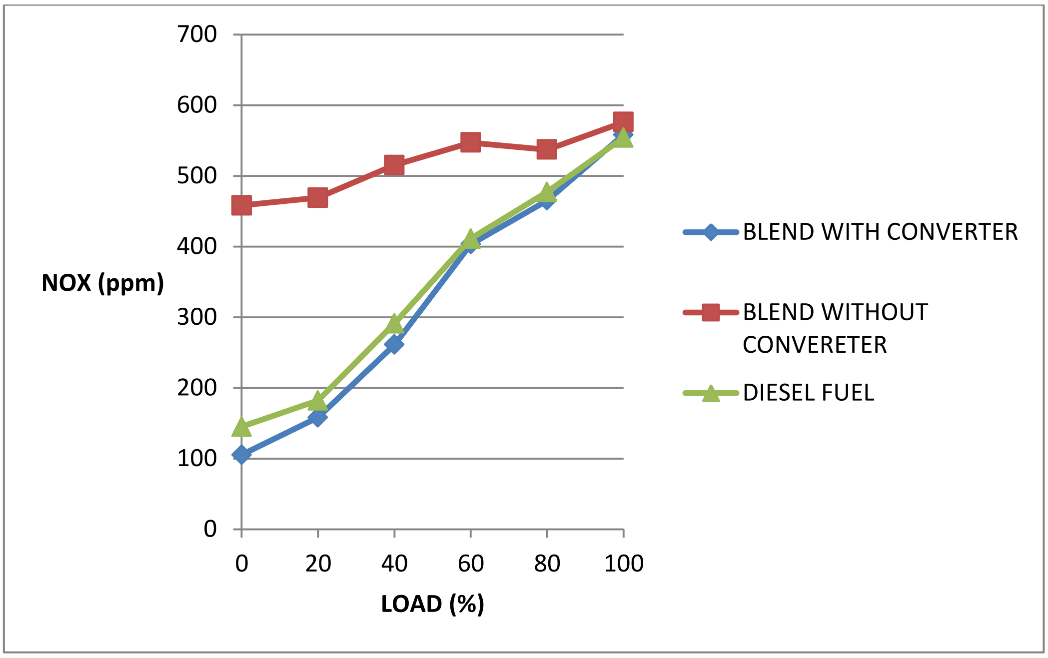
8. GRAPHS FROM THE READINGS:

8.1 For CO



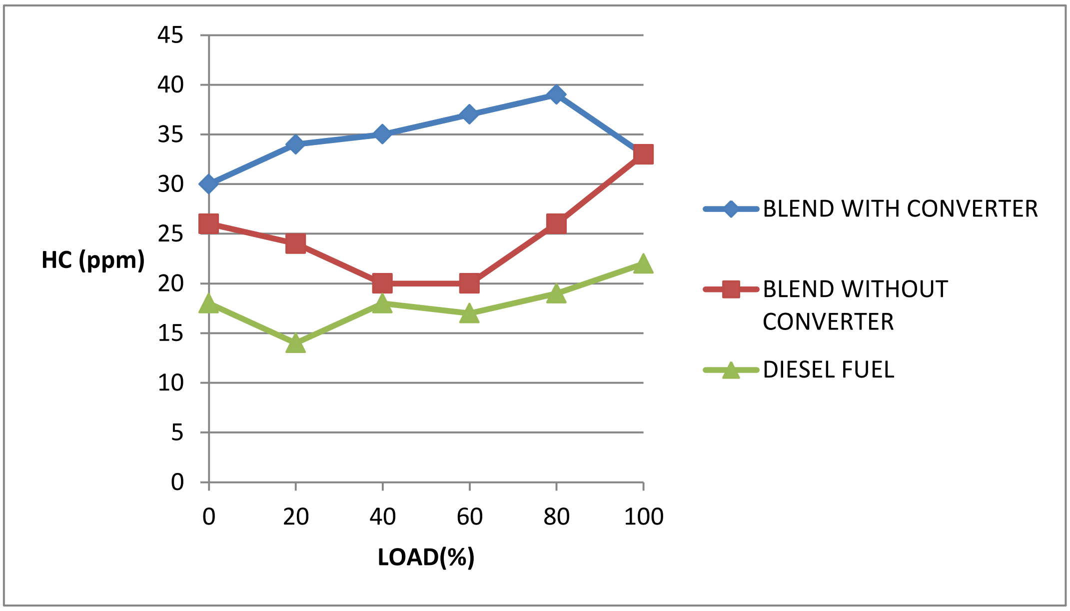
The effect of load on carbon monoxide (CO) emissions for diesel, neat Mahua biodiesel, and their blend were found. It can be seen from the graph above that the higher CO emissions were obtained with blends of Mahua biodiesel and diesel and neat Mahua biodiesel mode of operation.Higher Co emissions in the exhaust gas of the engine may be attributed to the polymerization that takes place at the core of the spray; this also caused concentration of the spray core and decreased the penetration rate.

8.2 For NOX,



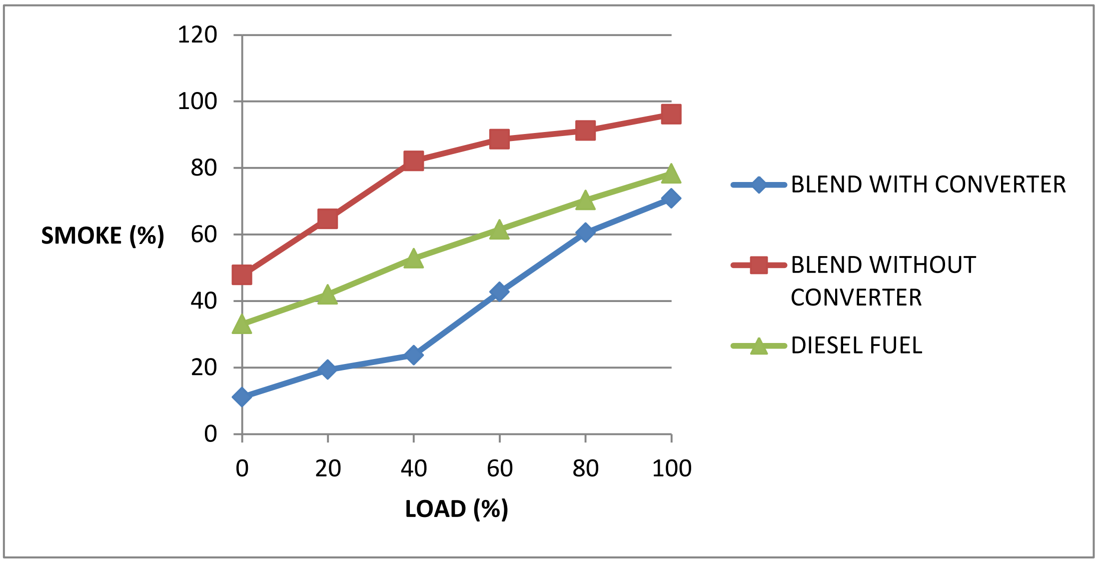
It was observed that no emissions were higher for neat Mahua biodiesel and blends compared to diesel at almost all loads. The increase in no emissions with increase in the proportion of Mahua biodiesel may be due to the delayed combustion. Also the higher oxygen content of biodiesels leads to more complete combustion resulting in greater combustion temperature peaks which caused higher no emissions.

8.3 For HC,



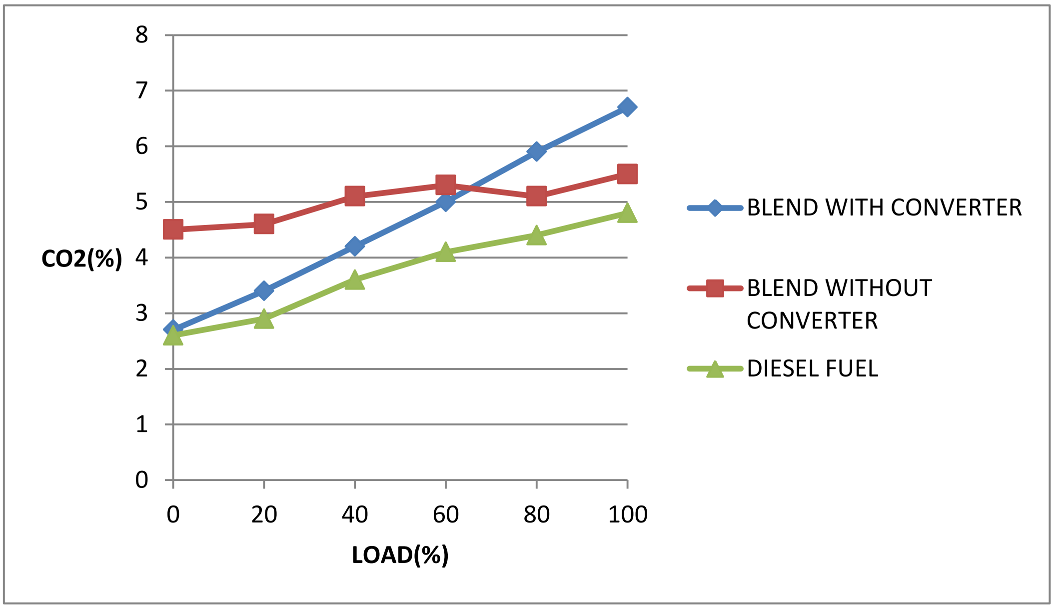
From the results found and the graph plotted above, it can be seen that the lower Hc emissions were obtained with blends of Mahua biodiesel-diesel and neat Mahua biodiesel mode of operation for loads above 40%.Lower Hc emissions in the exhaust gas of the engine may be attributed to the efficient combustion of Mahua biodiesel and blends due to the presence of fuel bound oxygen and warmed-up conditions at higher loads. Whereas at lower loads (up to 40%) higher Hc emissions were observed with blends of Mahua biodiesel-diesel and neat Mahua biodiesel operations. This is due to the reason that at lower loads the lower cylinder pressure and temperatures were experienced that was caused by lower rate of burning. This feature results in higher Hc emissions.

8.4 For Smoke %,



From the figure it follows that smoke opacity increases with increase in load. It is observed that smoke emissions are higher for neat Mahua biodiesel and blends compared to diesel oil. This may be due to heavier molecular structure, double bonds in vegetable oil chemical structure, and higher viscosity of Mahua biodiesel and their blends.

8.5 For CO2,



From the graph above, it was observed that the CO2emissions increases with the increase in blend of Mahua and diesel. The increase in this emission might be due to lower combustion rate at higher blends and loads due to low atomization of the fuel.

9. RESULTS:

1. The tests were performed with the help of Neat Diesel oil and Blends of Diesel with Mahua oil. It was found out that 20% Mahua Oil gave the best results with diesel blend. It can be used in engines but for short period of time.

By comparing the results obtained from the emission tests conducted above, we can conclude that the SCR system has reduced the emissions effectively and both the aims of the project are fulfilled.

2. Engine oil blend can be effectively used as fuel which reduces the environmental effects of the used engine oil.
3. By using the SCR system we are effectively reducing the emissions that are increased by the use of used engine oil blend of diesel.
4. Combining both the results, we have done significant progress in using the used
5. engine oil blend with vegetable oil and also reducing the emissions caused by the use of the blend attending to all the environmental concerns.

10. FUTURE SCOPE:

From this project, we have come to various conclusions that will be the key to using cooking oil in diesel engines in the future. They are :

1. Cooking oils can be used in diesel engines but few properties have to be taken into consideration.
2. Blends of cooking oil can be used in diesel engine.
3. Cooking oil is a very good alternative fuel and can replace diesel in the future.
4. The emission control will still be a problem in future but with a advancement in technology, they can be reduced and kept under control.
5. SCR technology is still new in market, but will play a major role in future for controlling the various emissions.

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