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A REVIEW PAPER ON PERFORMANCE AND EMMISSION ANALYSIS OF FOUR STROKE CI ENGINE OPERTING ON USED COOKING OIL

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ABSTRACT :- *The rising demand in vehicles, rising fuel prices and extinction of conventional crude derivatives has created an urge to implement an alternative fuel in a vehicle. Due to increased adaptability and refined diesel engines, the acceptance and sales of diesel vehicles has hiked. The environmental concerns of pollution have struck an alarming concern for the users and non-users of vehicles Cooking Oils have a great potential to be used as a substitute of Diesel with little or no loss in power and considerable decrement in the emission levels. Used Cooking Oils (UCOs) can be got at a cheap price or free from homes, hotels and food industries. Therefore, UCOs can be implemented into a CI Engine as a substitute of Diesel which would thereby decrease the running cost of the vehiclethe brake thermal efficiency, exhaust gas temperature, specific energy consumption, carbon monoxide, unburned hydrocarbon of the used cooking oil were measured and compared with diesel. it produces higher specific fuel consumption and lower engine efficiency than diesel. On other side, the carbon monoxide, unburned hydrocarbon were reduced than diesel. From the results, it has been identified that the used cooking oil is recommended fuel for diesel engine as alternative fuel.*

KEY WORDS: Used cooking oil,Alternative fuel, Diesel engine,engineperformance, exhaust emissions

INTRODUCTION

An enormous increase in the number of automobiles in recent years has resulted in greater demand for petroleum products. With crude oil reserves estimated to last only for a few decades, therefore efforts are made on way to research on alternative to diesel. Depletion of crude oil would cause a major impact on the transport sector. Fossil fuels play the significant role in development of country. Continuous supply of fuel with increasing rate should be ensured to sustain and further development of country. Recently, significant problems associated with fossil fuel like short supply, drastically increasing price, non-renewability, contamination of environment, adverse effect on bio systems compiles researcher to search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency, and environmental preservation has become highly pronounced in the present context. Energy conservation is important for most of the developing countries, including rest of world. The rapid depletion in petroleum reserves and uncertainty in petroleum supply due to political and economic reasons, as well as, the sharp escalations in the petroleum prices have stimulated in search for alternatives to petroleum fuels. The situation is very grave in developing countries like India which import 70% of the required fuel, spending 30% of her total foreign exchange on oil imports. [1] In view of this, researcher found and analyze many energy sources like CNG, LNG, LPG, ethanol, methanol, hydrogen, bio-diesel and many more. Among these alternative fuels, India is having significant scope for development of bio fuel. Diesel engines are major source of transportation, power generation, marine application, agriculture vehicles etc. Bio-diesel is widely accepted as comparable fuel to diesel in compression ignition engine. It offers advantages like higher cetane number, reduced emissions of particulates. Moreover, transportation and agriculture sector depends on diesel fuel therefore, it is essential that alternatives to diesel fuels must be developed. In the view of these, vegetable oils like palm oil, cotton seed oil, Neem oil, pongamia oil are considered as alternative fuels to diesel which are promising alternatives. [1]

ALTERNATIVE FUELS

Natural gas is a mixture of hydrocarbons-mainly methane and is produced either from gas wells or in conjunction with crude oil production. Due to its lower energy density, for use as a vehicular fuel, it is compressed to a pressure of 200 to 250 bar to facilitate storage in cylinders mounted in vehicle and so it is called Compressed Natural Gas. Gross production of natural gas in India at 47.51 billion cubic meters during 2009-10 is 44.63% higher than the production of 32.85 billion cubic meters during 2008-09. India has total reserves (proved & indicated) of 1437 billion cubic meters of natural gas as on 1.4.2010. This enormous reserve of natural gas makes it a long-term substitute fuel for use in petrol & diesel engines.

LNG is a hydrocarbon mixture contains mainly methane, ethane, propane, butane and pentane. LNG is produced by cooling natural gas to its boiling temperature of -161.5˚C to eliminate low calorific value, storage and safety problem of natural gas [2]. Very high volumes of natural gas can be transported from one country to another (long distance) with low cost in form of LNG. Scarcity of LNG and complication associated to produce and stores LNG restricted its use in automobile. During 2009-10 India has imported 8.83 Million tonnes of LNG.[1].

LPG is composed primarily of propane and butane with smaller amounts of propylene and butylene. LPG is produced by crude oil refining. LPG is also produced during natural gas refining as by product. In India, production of LPG during 2009-10 was 6.51 and 2.21 million tons by refining of oil and from natural gas [1]. Due to high calorific value of the LPG it is filled in cylinder with moderate pressure of 10-15 bar.[2]Reduction in emissions, very less carbon build-up increases life of engine parts like spark plugs, little or no damage to soil or water if it is spilled, rapid evaporation, higher octane number are some of the advantages of LPG fuel. It is generally used in gasoline fuel vehicle with addition of gas kit to engine. Short supply of LPG, due to main use as cooking gas, inhibits use of LPG as alternative fuel. India is the largest producer of sugar in the world. In terms of sugarcane production, India and Brazil are almost equally placed. India is currently producing stocks of over 10 million tons since 1999-2000[3] Correspondingly, molasses production has also increased. According to MPNG, 5% ethanol blends on all India bases would require 500 million liters [3]. The current production of molasses and alcohol would be adequate to meet this requirement after fully meeting the requirement of chemical industries. It is estimated that about 300-million-liter capacity would have been created for the production of anhydrous alcohol [3]. Ethanol is used as an automotive fuel by itself and can be mixed with gasoline to form what has been called "gasohol" or can be mixed with diesel to form diesohol or E-diesel. Because the ethanol molecule contains oxygen, it allows the engine to more completely combust the fuel, resulting in fewer emissions.

COOKING OIL

Cooking oil is plant, animal, or synthetic fat used in frying, baking, and other types of cooking. It is also used in food preparation and flavoring not involving heat, such as salad dressings and bread dips, and in this sense might be more accurately termed edible oil. Cooking oil is typically a liquid at room temperature, although some oils that contain saturated fat, such as coconut oil, palm oil and palm kernel oil are solid.

The idea of using vegetable oil for fuel has been around as long as the diesel engine. Rudolph Diesel, the inventor of the engine that bears his name, experimented with fuels ranging from powdered coal to peanut oil. In the early 20th century, however, diesel engines were adapted to burn petroleum distillate, which was cheap and plentiful. In the late 20th century, however, the cost of petroleum distillate rose, and by the late 1970s there was renewed interest in biodiesel. Commercial production of biodiesel in the United States began in the 1990s.

The most common sources of oil for biodiesel production in the United States are soybean oil and yellow grease (primarily, recycled cooking oil from restaurants). Blends of biodiesel and petroleum diesel are designated with the letter “B,” followed by the volumetric percentage of biodiesel in the blend: B20, the blend most often evaluated, contains 20 percent biodiesel and 80 percent petroleum diesel; B100 is pure biodiesel. By several important measures biodiesel blends perform better than petroleum diesel, but its relatively high production costs and the limited availability of some of the raw materials used in its production continue to limit its commercial application.

`COOKING OIL TYPES		
Almond	Mustard Oil	Olive oil
Corn oil	Soybean oil	Macadamia oil
Butter	Diacylglycerol oil	Margarine
Ghee	Olive oil	Pumpkin seed oil
Sunflower oil	Palm oil	Tea seed oil
Coconut Oil	Peanut oil	Walnut oil
Hemp oil	Flaxseed oil	Canola Oil
Lard	Grapeseed oil	

LITERATURE REVIEW

E. Griffin Shay(1993) et. al. has obtained some results by using vegetable oils and their derivatives as fuel in compression ignition engines and has examined opportunities for their broader production and use. It is observed that coconut oil has been successfully used as a diesel fuel in many coconut-producing Pacific countries. The low sulfur content of biofuels results in little or no SO emissions, the precursor of acid rain. The use of biofuels can reduce the amount of fossil fuels and the NO_X SO_X, and unburned hydrocarbons they produce.

John N. CouplandD. Julian Mcclements,etal(1997) provided different properties of various oils as follows

Oil	c ($m \cdot s^{-1}$)	α ($Np \cdot m^{-1}$) (2 MHz)	Cp ($J \cdot kg^{-1} \cdot {}^{\circ}C^{-1}$)	ρ ($kg \cdot m^{-3}$)	η ($mPa \cdot s$)	B ($\times 10^{-4} \cdot {}^{\circ}C^{-1}$)	τ ($W \cdot m^{-1} \cdot {}^{\circ}C^{-1}$)
Water[6]	1482.7[7]		4.176	998.2	1.00	2.07	0.604
Sunflower	1471.6[8]		2.197[11,c]	919[16]	47[i]	6.61[16]	
Corn	1469.5[8]		1.956[12,c]	920[17,f]	64.5[i]	7.22[17,f]	
Olive	1464.0[8]	6.5[9,b]	1.895[11,c]	915.8[18]	92.0[i]		0.166[22]
Rape	1468.4[8]	3.6[9,b]	1.834[11,c]	911.4[17,f]	73[19,f]	7.19[17,f]	0.160[23]
Cotton			1.916[13,d]	918.7[18]	51[18,g]	7.30[21]	0.172[13,d]
Peanut	1465.9[8]	6.0[9,b]		913[16]	74[i]	6.52[16]	0.17[23,h]
Palm	1459.3[8,a]		2.000[14]	919[18]	85[14]		
Safflower	1471.4[8]	4.0[9,b]		922.0[9,b]		65[i]	
Soy	1469.8[8]	4.9[10]	1.917[15,e]	922.8[17,f]	59[19,f]	7.24[17,f]	

DamingHuan(2012)et al review the history and latest developments of Biodiesel, including the different types of biodiesel, the characteristics, processing and economics of Biodiesel industry.
Biodiesel can replace fossil fuel as a “clean energy source”. It can protect the environment by reducing CO_2 , SO_2 , CO, HC. To Reduce the cost of bio-diesel production one way is that using less Expensive feedstock containing fatty acids such as non-edible oils, animal fats and oils, recycled or waste oil and by-products of the refining vegetable oils, microalgae.

Dr. B. Balakrishna, **et.al(2012**) has given some problems and possible solutions for using vegetable oil as fuel in CI Engines. Kinematic viscosity of vegetable oil is several times greater than for diesel oil which leads to pumping and atomization problems in the normal diesel fuel injection system, which creates filter plugging and cold starting high carbon residue causes heavy smoke emission and carbon deposition on the injection nozzle tips and in the combustion chamber. Particulate emissions of vegetable oils are higher than that of diesel fuel with a reduction in NO_x. Vegetable oil methyl esters gave performance and emission characteristics comparable to that of diesel. Hence, they may be considered as diesel fuel substitutes.

Osmano Souza Valente,**Vanya Márcia Duarte Pasa, Carlos Rodrigues Pereira Belchioret al(2010)**presented the physical–chemical properties of fuel blends of waste cooking oil biodiesel or castor oil biodiesel with diesel oil.Also, Fuel density and viscosity were increased with increasing biodiesel concentration, while fuel sulfur content was reduced. Fuel blends with up to 20% waste cooking oil biodiesel or 35% castor oil biodiesel concentration in N. 2 diesel fuel will meet present specifications for biodiesel density, kinematic viscosity, and with regard to cetane index calculated from the distillation temperatures. the fuel blends with waste cooking oil biodiesel or castor oil biodiesel concentration up to 3% or 5% in N. 2 diesel fuel, respectively, comply with the European specification for biodiesel.

M.S. GAD F. K. El-Baz and O. S. El. Kinawy, et al (2015) Biodiesel is an environmentally friendly renewable resource of energy and can be produced from used cooking oil (UCO) by trans esterification process experiment is done on in a four stroke, single cylinder, diesel engine at a constant speed of 1500 rpm and variable loads. Diesel- UCO biodiesel blends of 10 and 20% was prepared.Biodiesel blends B20 and B10 showed decrease in engine thermal efficiency about 3.5 and 2.5%, respectively in comparison with diesel fuel.

At full load, the values of CO emissions for diesel, B10 and B20 fuels were 6.5, 6.3 and 6.2, respectively
At full load, the maximum values of HC emission for diesel, B10 and B20 fuels were about 32, 27and 23 ppm, respectively.

At full load, the decrease of CO emissions for B20 and B10 in comparison with diesel fuel was about 6 and18%, respectively. Diesel- biodiesel blends showed increase in fuel consumption due to the lower heating value of the biodiesel. B20 and B10 showed an increase of 2.6 and 1.4 %, respectively in fuel consumption compared to diesel fuel. Biodiesel blends B20 and B10 showed increase in specific fuel consumption about 2.2 and 1.3%, respectively in comparison with diesel fuel.

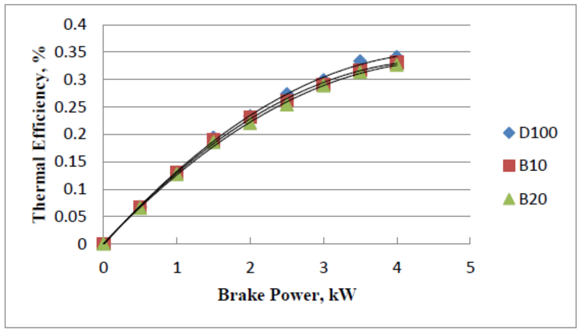

Figure 1.1 Variation of thermal efficiency with Brake Power for biodiesel blend

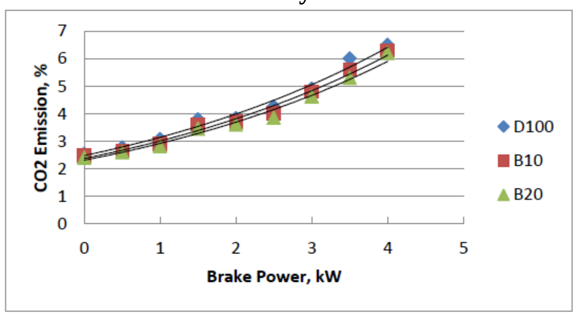

Figure 1.2 Variation of CO_2 with Brake Power for biodiesel blend

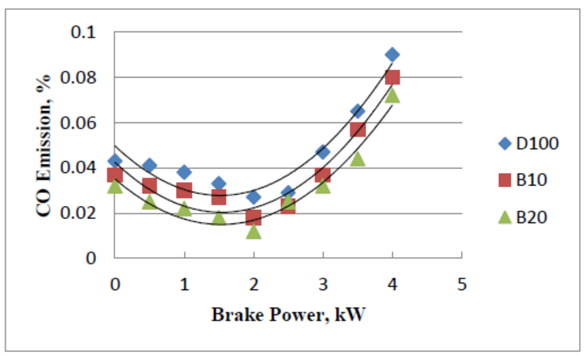

Figure 1.3 Variation of CO with Brake Power for biodiesel blend

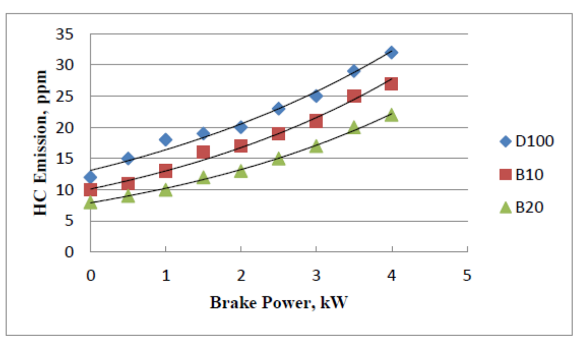

Figure 1.4 Variation of CO with Brake Power for biodiesel blend

Md. Isa Ali, A. Shahrir, et al(2015)carried out that untreated waste cooking oil (UWCO) was used as an alternative fuel for a diesel engine. The blends of varying proportions of UWCO and diesel were prepared, analyzed and compared with diesel fuel. Normally, cooking oils are originated from vegetable oils and are used for cooking or food frying purposesUCO has a potential to be substituted to Diesel Blends of 5% to 40% completely matched to Diesel.Use of 30% UCO improved the BP with CO and NOx reduced.The performance of the engine using blends of UWCO was evaluated in a four-cylinder diesel engine and compared with the performance obtained with diesel. Significant improvement in the engine performance was observed.

Engine parameters Cooling Water	**Specifications**
Type	**Kirloskar**
Number of cylinders	**Single**
Cycle	**Four stroke**
Cylinder diameter (mm)	**85**
Piston stroke (mm)	**110**
Compression ratio	**17.5:1**
Governing speed	**1500 rpm**
Rated power (HP	**6.5**

Ibrahim ThamerNazzal et al(2011) investigated the effects oils vegetable blends on the performance of single cylinder compression ignition. Following results were obtained:
Exhaust temperature and brake power are decreased with using the oils diesel blends samples (10% olive oil – 90% diesel blends), (10% sunflower oil- 90% diesel blends) , and (10% corn oil- 90% diesel blends) respectively due to the increase in the heat of vaporization fuel blends .Also, it should be noticed that (10% corn oil- 90% diesel blends) seemed to perform better than (10% sunflower oil - 90% diesel blends) while the (10% olive oil - 90% diesel blends) is smaller in term brake power and exhaust temperature. The lower cetane number also has the effect of increasing the ignition delay, thus brake power decreases for all the vegetable oil - diesel blends.

Sumedh Ingle,vilasnandedkar, madhavnagarhalliet al(2012) studied the prospects and opportunities of using methyl esters of palm oil as fuel in an engine.
At full load, B20 at 60^0C shows the lowest brake specific energy consumption of all the blends but is greater than that of dieselThe exhaust gas temperature increases with increase in brake mean effective pressure up to full load (BMEP 5.53 bar). Neat diesel at 60oC shows the highest exhaust gas temperature at full load. This may be due to chemical composition of palm oil biodiesel, which promotes the combustion process.

K. Nantha Gopal,arindam pal, sumitsharma, charansamanchi, K. Sathyanarayanan, t. Elango,et al (2014) investigated emissions and combustion characteristics of a CI Engine fuelled with WCO methyl ester and diesel blends and the results obtained are as follows: The diesel engine can perform satisfactorily on biodiesel and its blends with the diesel fuel without any engine modifications. The SEC increases with change in percentage of biodiesel in the blends due to the lower heating value of biodiesel. It is also observed that there is significant reduction in CO, UBHC and smoke emissions for biodiesel and its blends compared to diesel fuel. However, NO emission of WCME biodiesel is marginally higher than petroleum diesel.

K. Muralidharan et al (2011) reviews a single cylinder four stroke variable compression ratio multi fuel engine when fueled with waste cooking oil methyl ester and its 20%, 40%, 60% and 80% blends with diesel are investigated. Experiment has been conducted at a fixed engine speed of 1500 rpm, 50% load and at compression ratios of 18:1, 19:1, 20:1, 21:1 and 22:1. The brake thermal efficiency of the blend B40 is slightly higher than that of the standard diesel at higher compression ratios. Due to the lower heating value of the blends and unstable combustion the brake power decreases. The CO and HC emission of the blend B40 is closer to the standard diesel and it is very higher at compression ratio 21. The CO2 emission is also lesser at the same conditions.

Mohammed EL_Kassaby, Medhat A. Nemit_allah et al (2013) carried out that Wasted cooking oil from restaurants was used to produce neat (pure) biodiesel through transesterification, and then used to prepare biodiesel/diesel blends. The effect of blending ratio and
compression ratio on a diesel engine performance has been investigated.biodiesel could be safely blended with dieselfuel up to 20% at any of the compression ratio and speed tested for getting almost the same performance and emission as that with diesel fuel. On an average, the CO2 emission increased by 14.28%, the HC emission reduced by 52%, CO emission reduced by
37.5% and NOx emission increased by 36.84% when compression ratio was increased from 14 to 18. In spite of the slightly higher viscosity and lower volatility of biodiesel, the ignition delay seems to be lower for biodiesel than for diesel. On average, the delay period decreased by 13.95% when compression ratio was increased from 14 to 18. In general, increasing the compression ratio improved the performance and cylinder pressure of the engine and had more benefits with biodiesel than with high pure diesel.

K. Srinivas, N. Ramakrishna, Dr. B. Balunaik , Dr. K. kalayaniradha. et al (2013) carried out experimental investigation on computerized four stroke single cylinder diesel engine with Ethanol and Ethyl Hexyl Nitrate (EHN) as additives to the diesel-biodiesel blends. Ethanol was added as 5% and 10% by volume to the diesel-biodiesel blends and Ethyl Hexyl Nitrate (EHN) was added as 0.5% and 1% to the diesel-biodiesel blends.Brake thermal efficiency increased with all blends when compared to the conventional diesel fuel. There was a 0.175% increases in brake thermal efficiency with Additive to blend for B20 at full load. The Brake specific fuel consumption is increased with the blends when compared to diesel. CO and HC emissions are decreased significantly with the blends when compared with diesel.From the above analysis the blend B20+Additive shows the better performance and emissions compared to other blend(B20,B30,B40 ,B30+Additive, B40+Additive) and diesel. So the B20+Additive blend can be used as an alternative fuel in DI diesel engine.

CONCLUSION

The fact that conventional fuels are getting costlier, and it also more pollution supportive and extinct. So, there is rise in demand of alternative fuel. Cooking oil is having a lot of potential for replacing conventional fuel. Difficulties experienced in implementing cooking oil as a substitute of Diesel is high density, high viscosity, low volatility, foul smelling of oil. Use of cooking oil creates no or less SOxPollution Various comparative properties of Cooking/Vegetable oils were defined. The storage capability of Cooking Oil was tested and found out that long term storage of oil may degrade the quality of fuel, however possibility is there to store the Cooking oils for a short period of time. UCO has a potential to be substituted to Diesel Blends of 5% to 40% (Only Done up to B40) completely matched to Diesel. When used cooking oil is used, CO, CO2, NOx, SOx, HC emissions decreases.CO emissions decrease from 8% to 18% with used cooking oil blends. Blending methanol with UCO decreases NOx withslight increase in CO. And with Increase in Compression ratio 14 to 18 it gets almost the same performance and emission as that with diesel fuel. On an average, the CO2 emission increased by 14.28%, the HC emission reduced by 52%, CO emission reduced by37.5% and NOx emission increased by 36.84%.so it has been identified that used cooking oil is recommended as a alternative of diesel fuel.

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