INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

ANIMAL FATS FOR BIODIESEL PRODUCTION AND ITS IMPACT ON DIESEL ENGINE PERFORMANCE WITH ETHANOL-DIESEL BLENDS

MR. DARUNDE DHIRAJ S.[1], MR. PARDE GAURAV P.[2], MR. JOSHI ABHIJIT H.[3]

1. Asstt. Prof., IBSS College of engg., Mechanical Dept., Amravati, MH, India.
2. Asstt. Prof., IBSS College of engg., Mechanical Dept., Amravati, MH, India.
3. Asstt. Prof., IBSS College of engg., Mechanical Dept., Amravati, MH, India.

Accepted Date: 05/03/2015; Published Date: 01/05/2015

Abstract: Animal fat is one of the good triacylglycerol containing feedstock for the production of biodiesel. Mainly animal fats and vegetable oils are used for the production of biodiesel. Biodiesel which is defined as the mono-alkyl esters of vegetable oils or animal fats. Biodiesel is produced by Trans esterifying the animal fat with methanol under mild conditions in presence of NaOH as a base catalyst. This paper discuses fuel production, fuel properties, environmental effects including exhaust emissions and co-products. This also describes the use of glycerol which is the by-product in esterification process along with biodiesel. The impact of blending of biodiesel with ethanol and diesel on the diesel engine has described.

Keywords: Biodiesel, Animal Fats, Transesterification, Glycerine, Ethanol, Biodiesel, Petro-Diesel, Blends

Corresponding Author: MR. DARUNDE DHIRAJ S.

Access Online On:

www.ijpret.com

How to Cite This Article:

Darunde Dhiraj S., IJPRET, 2015; Volume 3 (9): 399-412

PAPER-QR CODE

INTRODUCTION

In the present days, use of fuel is picked its way of increase and price is also going to increase undoubtedly. So the use of present sources of petroleum becomes a serious issue. To provide the diesel fuel for diesel engines approximately not more than 40 years. Limited energy sources leads to the warning of potential lack of energy in the future. Approximately 1/3 of the petroleum fuels are consumed in the IC engines and exhaust gases emitted from these engines are one of the main reasons for the environmental pollution. In the last years, many studies on the IC engines aiming to reduce exhaust emissions have been carried out by changing operating parameters such as valve timing, injection timing, and atomization rate. At the same time, depletion of fossil fuels and environmental considerations has led to investigations on the renewable fuels such as ethanol, hydrogen, and biodiesel. Biodiesel derived from biological sources, among them lipid materials such as fats and oils have received increasing attention.

The increasing demand of petroleum in developing countries like China, Russia and India has increased oil prices. Besides, the combustion of petroleum based fuels causes environmental problems, which threaten wild and human life, impacts on the environment and human health. In addition, the combustion products causes global warming one of the most important today's world problem. The global warming is caused of emissions like carbon monoxide (CO), carbon dioxide (CO2), sulphur dioxide (SO2) and nitrogen oxides (NOx). In power system of using petroleum fuels, these components are emitted through the combustion process. Concerning environmental damage the transport sector has a clear responsibility. Its part in global warming potential has increased from year by year and now bigger than those of the domestic and industrial sector, while it highly constitutes the total emissions of this pollution type.

It was stated by Lloyd and Cackete (3) that diesel emission contributes to the development of cancer, cardiovascular and respiratory health effects; pollution of air, water and soil; soiling; reductions in visibility and global climate change. There are many works on reliable researching and implementation and useful results come to exist. The alternative fuels must be technically acceptable, economically competitive, environmentally acceptable and easily available. Research on biodiesel derived from vegetable oils and animal fats are being maintained to alternate this kind of fuels to petroleum based diesel fuel. It has been concluded by many studied that as an alternative engine biodiesel reduce the emissions of CO, (Hydrocarbons) HC, SO2, Polycyclic Aromatic Hydrocarbons (PAH), nitric Polycyclic Aromatic Hydrocarbons (nPAH) and particulate matter(PM) by NOx to increase in the exhaust as compared with diesel fuel (4,5,6). Though biodiesel has some attractive properties like higher cetane number, no aromatics, almost no sulphur, high oxygen(by weight), non-toxic, bio-degradable, high lubricant

ability (7,8,9) it has many properties need to improve such as Lower Calorific Value(LCV), Lower Effective Engine Power(LEEP), NOx emission, greater sensitivity to low temperature (9).

The sources of animal fat in our country are slaughterhouses, local stalls etc. In the mutton market lots of fats are available most of which results in non- edible and a waste product. This non-edible and waste fat can be used for the production of biodiesel which can be used as a blending fuel in neat diesel to replace that blended amount of diesel and it caused the engine to run with minor loss of energy but reduce harmful emission which can help in maintaining global climate. Particularly, we have used biodiesel as solvent to remove diesel-ethanol phase separation.

I. PRODUCTION OF BIODIESEL

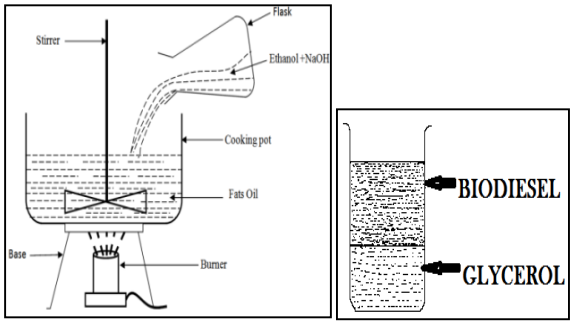

Fig.1 Production of Biodiesel

Biodiesel is produced from the triacylglycerol-containing material by means of a transesterification reaction. In this process, methanol and animal fats are mixed in the molar ratio of 6:1, heated at 60-650C for 1hr and the ambient pressure in the presence of catalyst such as NaOH/KOH. Before that, animal fat gets heated up to 105-1100C so that it will be converted into fat oil then in the separate flat bottom flask, alcohol and NaOH/KOH (2% of fat)are mixed, exothermic reaction take place. This mixer is then added to heated fat and keep it at 60-650C for about 15-20 minutes. After this, it is poured into a separator so that biodiesel and glycerol get separated as shown.

This biodiesel is used in diesel engine as a solvent in ethanol-diesel mixer for avoiding a phase separation. The increasing % of biodiesel in ethanol-diesel blends results in the little increase of emissions of NOx but it reduces the emissions of CO, HC, sulphur and particulate matter (PM) considerably. In this study, we blend 5-15% of biodiesel in ethanol (15-30%)-diesel blends.

The preparation of biodiesel by transesterification process can be shown as:

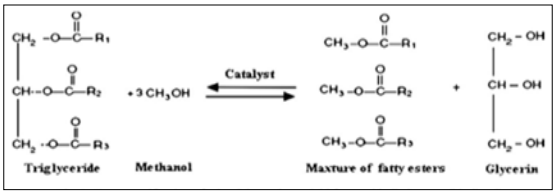

Fig. 2 Transesterification Process

Biodiesel is being produced from many of vegetable oils and animal fats. If it is produced from high quality edible oil and fats, it will resulted in high prices of raw material and biodiesel is more expensive than petroleum diesel fuel also shortage of edible oil for food purpose. Biodiesel may also be produced from less expensive animal fats including inedible tallow, pork lard and yellow grease. Animal fats are highly viscous and mostly in solid form at ambient temperature because of their high content of saturated fatty acids. The high viscous fuel lead to poor atomization of the fuel and result in incomplete combustion. Transesterification and emulsification are two main solutions that have appeared as effective methods for using animal fats in diesel engine. Animal tallow generated biodiesel offers a wide range of energy, environmental and economic advantage as stated by Nelon and Schrock (10).

USES OF GLYCEROL

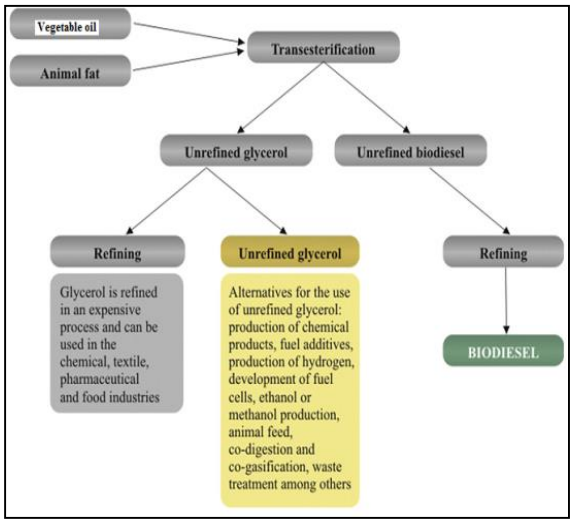

Fig. 3 Generation of glycerol and its alternative routes (ref.12)

As shown in the above figure, glycerol is obtained as a co-product in the transesterification process, refined and unrefined, can use in the manufacturing of a variety of products. Worldwide, the adoption of simplistic solutions in the management of by-products from

biodiesel production has led to a price reduction in the market, as glycerol is considered to be an unrefined raw material with a limited range of applications. The most common applications of glycerol use the purified or distilled form of this product. However, this process is expensive and economically unfeasible due to the lower price of raw glycerol.

Worldwide, the adoption of simplistic solutions in the management of by-products from biodiesel production has led to a price reduction in the market, as glycerol is considered to be an unrefined raw material with a limited range of applications. The most common applications of glycerol use the purified or distilled form of this product. However, this process is expensive and economically unfeasible due to the lower price of raw glycerol. Several alternatives have been identified for the use of unrefined glycerol. These include the production of chemical products, such as 1,2-propanediol, 1,3-propanediol, docosahexaenoic acid, glyceric acid, dihydroxyacetone and polymers, fuel additives, hydrogen production, development of fuel cells, and ethanol or methanol production among others. In general, the processes involved in these alternatives are still relatively new so their costs cannot yet be compared with the costs of glycerol purification or distillation a cost that is still considered to be high. Nevertheless, process such as are used in animal feed, co-digestion and co-gasification, and waste treatment, have potential to be adopted in the short term, as being part of a transitional scenario. In the medium and long term these alternatives should be replaced with alternatives that can provide more value-added products and lower environmental impacts. Finally, the present research reveals that the interest in this new research field, known as glycerol chemistry, has been increasing and consequently raising the possibilities for the use of unrefined glycerol, which may help consolidate the sustainability of the bio-fuel market in Brazil and in the world.

II. PROPERTIES OF DIESEL, ETHANOL AND BIODIESEL FUELS

TABLE I: DIFFERENT PROPERTIES OF DIESEL, ETHANOL AND BIODIESEL

Property	Diesel	Ethanol	Biodiesel
Heating value (kj/kg)	42700	29700	39858
Viscosity (time/200ml) (at 40°C)	37.89 sec	8.78	62.90
Density (kg/m^3) (15°C)	868.8	716.8	819.2 (20°C)
Cetane number	47	5-7	58.8
Flash point	60°C	14°C	195°C
Fire point	83°C	---	250°C
Cloud point	8°C	---	23°C
Pour point	-5°C	---	14°C

TABLE II: VISCOSITY AND DENSITY PROPERTIES OF THE FUEL BLENDS

Property	B5E15	B10E15	B15E15	B5E20	B10E20	B15E20	B5E30	B10E30	B15E30
Viscosity (time/200ml) (at 40°C)	*49.08*	*50.76*	*52.05*	*46.30*	*46.95*	*48.89*	*44.78*	*45.50*	*47.21*
Density (kg/m^3) (25°C)	*810*	*820*	*825*	*805*	*815*	*820*	*800*	*805*	*810*

As shown in table 1, the follow methyl ester showed lower density but it was increased more than diesel as temperature increased. It also showed higher viscosity, cetane number, flash point, but a lower heating value compared with diesel fuel. The residual alcohol can be removed from the ester by distillation to increase the flash point of esters (ref.). Biodiesel has lower heating value (about 7% less than diesel fuel), causes power loss. Therefore, it is necessary to increase the amount of fuel injected into the combustion chamber to produce same amount of power. As shown in table 1, tallow methyl ester has lower pour point, so it can not be used as a neat diesel fuel in cold weather conditions. For this conditions, blends can be used as it lowers the pour point.

III. EXPERIMEMTAL SET-UP

Experimental set-up for the use of biodiesel in diesel engine can be shown in the figure given below:

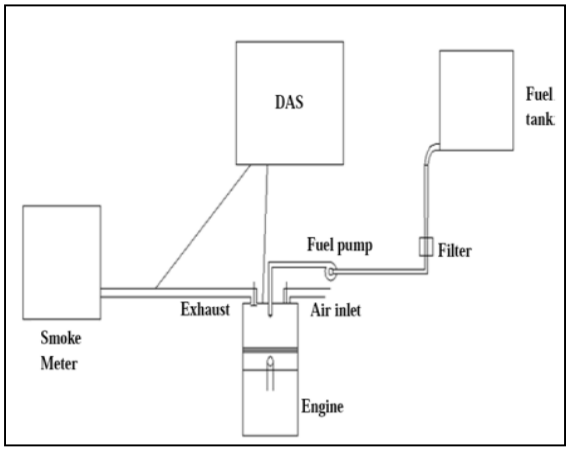

Fig. 4 block diagram of Experimental set-up

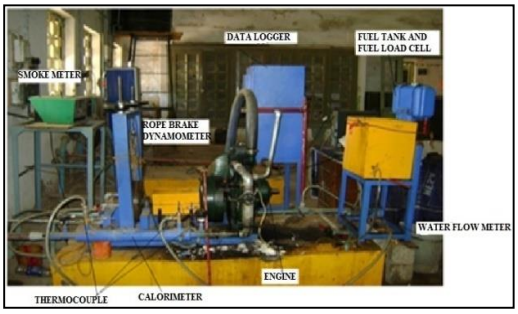

Fig. 5 Experimental set-up

As shown in the experimental set-up, blended fuel is supplied to the engine through filter and fuel pump. Data acquisition system (DAS) is used to take readings of speed, inlet pressure, temperature, etc. and show output on the computer monitor. Smoke meter gives smoke reading per minute. Emissions such as NOx, CO, HC, SO_2 can be measured with the help of exhaust gas analyzer (not shown in figure).

IV. RESULTS AND DISCUSSION

Performance Characteristics

This presents the results obtained from experimental data and these results are thoroughly discussed in subsequent sections. The main objective of the study was to fuel the diesel engine with biodiesel ethanol diesel- (BED) blend oils and compare the performance results with baseline data. Evaluate the performance of this alternative fuels on internal combustion engine and calculation of fuels consumption, power produced, brake specific fuel consumption, brake thermal efficiency.

- Brake Specific Fuel Consumption

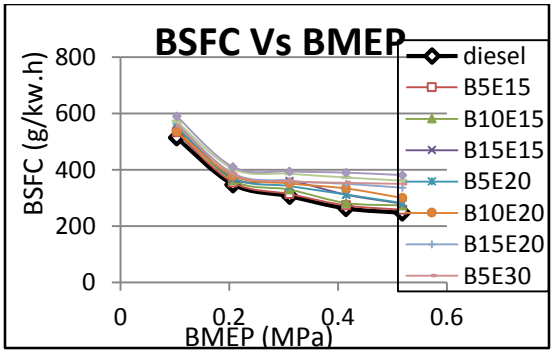

Fig. 6 Comparison of Brake specific fuel consumption Vs brake means effective pressure

Figure 6 shows the variation of BSFC with BMEP for different fuel blends. From the comparison of effect of BMEP on brake specific fuel consumption between diesel and for different blend, it is seen that brake specific fuel consumption decreases when the BMEP is increased for all operations of biodiesel, ethanol, diesel and their blends (BED). It can be observed that brake specific fuel consumption increases when blend is used for any given load.

The percent increase in specific fuel consumption was increased with decreased amount of diesel fuel in the blended fuels. This is mainly due to viscosity and lower heating value. As a result more, BED blend is needed to produce the same amount of energy due to its higher density and lower heating value in comparison to conventional diesel fuel. Again as bio- diesel blends have different viscosity than diesel fuel, so biodiesel causes poor atomization and mixture formation and thus increases the fuel consumption rate to maintain the power [1].

- Brake Thermal Efficiency

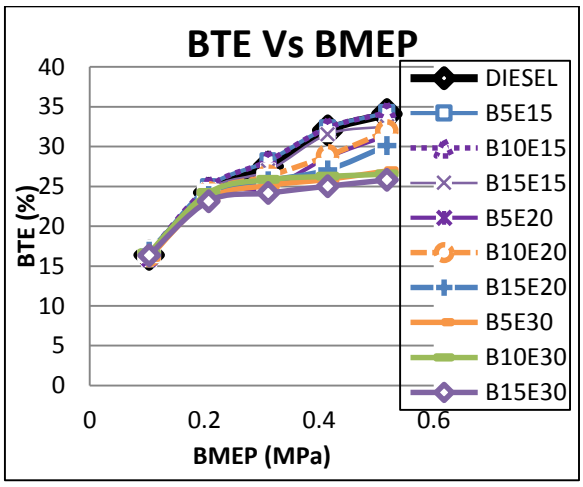

Fig. 7 Comparison of brake thermal efficiency vs. brake means effective pressure

Generally, BTE of diesel is higher than that of all other fuels due to its higher calorific value. All the blends shows comparable trend of BTE with diesel fuel. This may caused by the available oxygen content in the blend which improves the combustion process despite the fact that oxygenated fuel has lower heating value [3]. But the addition of ethanol reduces the viscosity which in turn increases the atomization [2, 4]. This leads to the enhancement of combustion. The blend B15E30 shows lower BTE than the other fuel blend. It's because of more oxygenation but lower calorific value than diesel.

- Exhaust gas temperature

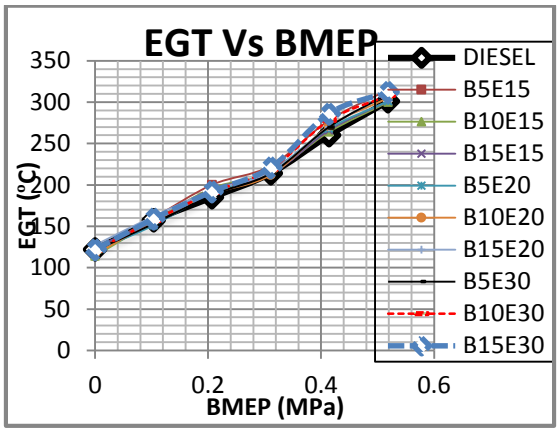

Fig. 8 Comparison of exhaust gas temperature vs. brake means effective pressure

EGT shows the burning efficiency. The EGT may be high due to the following reasons

- Complete combustion

- If the afterburning stages of combustion is longer or engine misfire took place or injection time is not proper.

For complete combustion fuel should be evaporated early as possible as and mixed with air. Ethanol has low viscosity [5]. When ethanol added to the diesel-biodiesel blend fuel evaporates faster and mixed with the air. It helps the combustion process. Ethanol blend has more oxygen content than other blend .It helps for better combustion. It may be one of the reasons for high EGT in ethanol blend.

Ethanol has low cetane number and high latent heat of vaporization. When Ethanol is added to the diesel –biodiesel blend reduces the cetane number is not adversely affect [6] but latent heat of vaporization reduces which results in lower heat release and affects the combustion process. At low load, the amount of fuel injected is less and in such case fuel evaporates early and also high cetane number plays a dominant role. Better combustion occurs.

But at high load, more fuel is injected .In such case higher latent heat of vaporization become the dominant factor. This fuel takes the heat from surrounding and in cylinder temperature decreases which increases the ignition delay period. This ignition delay may increases the mass of fuel in cylinder. This may cause longer after burning phase of combustion [7]. It may be

reason for high EGT in BDE. BDE showed the more EGT than other blend. It may be due to high latent heat of vaporization and more oxygen content.

- Smoke emission

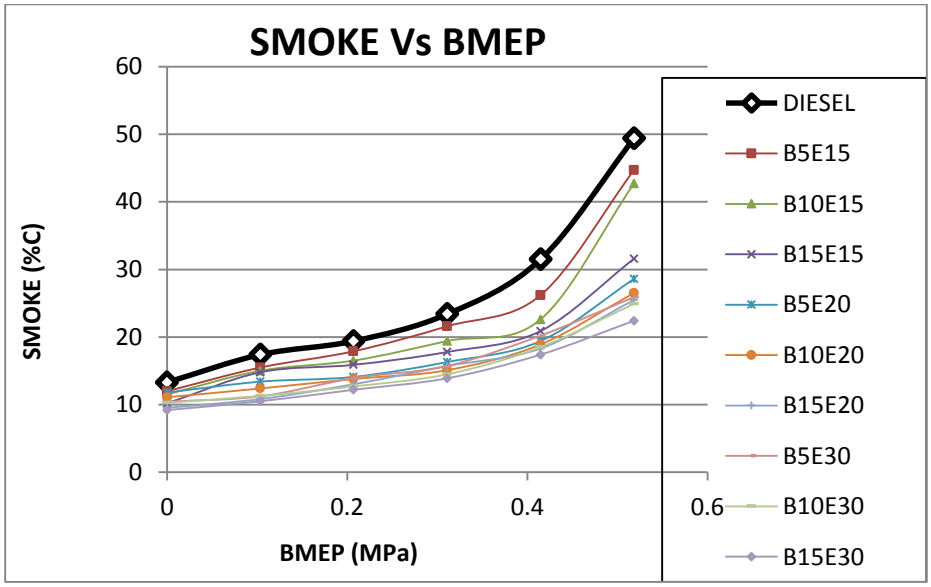

Fig. 9 Comparison of smoke vs. brake means effective pressure

The smoke opacity increased with the load for diesel fuel, biodiesel, diesel-biodiesel-ethanol blends. The smoke is formed due to incomplete combustion. It is obvious that the smoke emissions are reduced with BDE. The smokes Opacity reduced with increase of ethanol percentage in diesel-biodiesel-ethanol blends with diesel. This has been showed by previous study. This may be assisted by the presence of the fuel-bound oxygen of the ethanol. More oxygen in fuel blends will give more CO2 emission as a result of good combustion. It is seen that about 45-50% of smoke opacity decreased for E30 blends. B10E15 show lowest smoke at higher load or BMEP.

- Cold weather performance

Winter handling is a challenge for all biodiesel regardless of feedstock. Animal fat-based biodiesel has a higher cloud point that traditional plant-based biodiesel; however this does not have a substantial impact when blended with diesel.

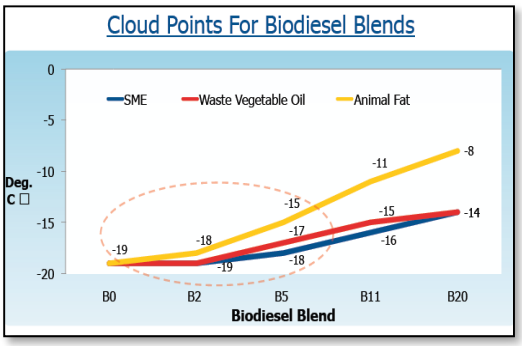

Fig. 10 Cold weather performance for bio-diesel fuels

COCLUSIONS

Study and experiments on the use of biodiesel, ethanol and diesel blends in order to minimize the use of petro diesel and search of renewable, alternative fuel on diesel engine, the following results are observed.

- The production of biodiesel from animal fats is a new option for vegetable oil biodiesel and can be efficiently and economically used in diesel engines.
- Animal fats biodiesel can be used as solvent or properties improver in alcohol and diesel blends.
- In India, its better option to use biodiesel produced from waste animal fats in order to overcome the problems related to diesel price increment.
- The experimental study of the addition of biodiesel and ethanol on engine performance and emissions of a biodiesel-ethanol-diesel blended fuel diesel engine, diesel-biodiesel-ethanol blends (BDE) show better stability and can be used in diesel engine without major modification.
- The BSFC of BDE blends are slightly lower than diesel.
- Biodiesel and ethanol having oxygen content, show excellent ability to eliminate smoke emissions, especially at high engine load.

ADVANCEMENT AREAS

- We can use animal fats biodiesel in diesel engine with turbo charging.
- Also CFD modelling and analysis on the combustion phenomenon of biodiesel in alcohol-diesel blends can be done.

REFERENCES

1. Gerhard Knothe, “Biodiesel and Renewable diesel: A comparison”, Progress in Energy and combustion science 36 (2010), 364-373.

2. Knothe G., Krahl J., Van Gerpen, J. editors. The biodiesel handbook; 2005. Champaign, IL, USA.

3. Lloyd AC, Cackette TA. Diesel engine: environmental impact and control. J Air Waste Manage Assos 2001; 51; 809-47.

4. Zheng M, Mulenga MC, Reader GT, Wang M, Ting DSK, Tjong J. Biodiesel engine performance and emissions in low temperature combustion. Fuel 2008; 87(6): 714-22.

5. Agarwal AK, Rajamanoharan K. Experimental investigation of performance and emissions of karanja oil and its blends in a single cylinder agricultural diesel engine, Appl Energy 2009; 86: 106-12.

6. Lin YF, Wu YPG, Chang CT. Combustion characteristics of waste-oil produced biodiesel/diesel fuel blends. Fuel 2007; 86: 1772-80.

7. Canakci M. Combustion characteristics of a turbocharged di compression ignition engine fuelled with petroleum diesel fuel and biodiesel. Bioresource Technol 2007; 98: 1167-75.

8. Lin CH, Lin HA, Hung LB. Fuel structure and properties of biodiesel produced by the peroxidation process. Fuel 2006; 85: 1743-49.

9. Kegl B. Biodiesel usage at low temperature. Fuel 2008; 87(7): 1306-17.

10. Nelson RG, Schrock MD. Energetic and economic feasibility associated with the production, processing and conversion of beef tallow to a substitute diesel fuel. Biomass Bioenergy 2006; 30: 584-91.

11. Vishal Mutreja, Satnam Singh, Amjad Ali, “Biodiesel from mutton fat using KOH impregnated MgO as heterogeneous catalyst”, Renewable Energy 36 (2011), 2253-2258.

12. Alexandre Bevilacqua Leoneti, Valquiria Aragão-Leoneti, Sonia Valle Walter, Borges de Oliveira, “Glycerol as a by-product of biodiesel production in Brazil: Alternatives for the use of unrefined glycerol,” Renewable Energy 45, pp.138-14 5, March 2012.

13. Metin Guru, Atilla Koca, Ozer Can, Can Cinar, Fatih Sahin, "Biodiesel production from waste chicken fat based sources and evaluation with Mg based additive in a diesel engine", Renewable Energy 35 (2010), 637-643.

14. Shaoyang Liu, Yifen Wang, Jun-Hyun Oh, Josh L. Herring, "Fast biodiesel production from beef tallow with radio frequency heating", Renewable Energy 36 (2011), 1003-1007.

15. Cenk Sayin, Kadir Uslu, Mustafa Canacki, "Influence of injection timing on the exhaust emissions of a dual-fuel CI engine", Renewable Energy 33 (2008), 1314-1323.

16. Cengiz Oner, Sehmus Altun, "Biodiesel production from inedible animal tallow and an experimental investigation of its use as alternative fuel in a DI diesel engine", Applied Energy 86 (2009), 2114-2120.

17. Cenk Sayin, Martin Gumus, "Impact of compression ratio and injection parameters on the performance and emissions of a DI diesel engine fueled with biodiesel-blended diesel fuel", Applied thermal engineering 31 (2011), 3182-3188.

18. B. K. Venkanna, C. Venkataramana Reddy, Swati B. Wadawadagi, "Performance, emissions and combustion characteristics of DI diesel engine running on rice bran oil / diesel fuel blend", International journal of chemical and biological engineering 2: 3 2009.

19. Lei Zhu, C. S. Cheung, W.G. Zang, Zhen Huang, "Effect of charge dilution on gaseous and particulate emissions from a diesel engine fueled with biodiesel and biodiesel blended with methanol and ethanol", Applied thermal engineering 31 (2011), 2271-2278.

20. Prommes Kwanchareon, "Solubility of a diesel–biodiesel–ethanol blend, its fuel properties, and its emission characteristics from diesel engine", Chulalongkorn University, Bangkok 10330.

21. Hadi Rahimi, Barat Ghobadian, Talal Yusaf C, Gholamhasan Najafi, Mahdi Khatamifar,"Diesterol: An environment-friendly IC engine fuel" Renewable Energy 34 (2009) 335–342.

22. Su Han Park, Junepyo Cha, Chank Sik Lee, "Impact of biodiesel in bioethanol blended diesel on the engine performance and emissions characteristics in compression ignition engine", Applid Energy (2012).

23. http://en.wikipedia.org/wiki/Ethanol

24. Biodiesel handling and use guide, fourth addition, National Renewable Energy Laboratory NREL/TP- 540-43672, Revised Jan.2009.