PRODUCTION OF BIODIESEL FROM DIFFERENT TYPES OF WASTE COOKING OIL SAMPLES AND ITS PERFORMANCE ANALYSIS IN DIESEL ENGINE

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Abstract
Producing energy is the most challenging part in today's world and due the depletion of non-renewable resources such as petroleum. The scenario is changing rapidly. Now the concept of green energy comes into the play. Biofuel is the one way of producing green energy with minimum carbon foot print. Biofuel can be derived from biological waste such as bio mass, waste cooking oil, municipal waste etc. Due to the increase in the demand of biofuel, biodiesel is considered to be the most prominent way for producing green energy among them. Biodiesel can be produced by various methods such as Transesterification and Pyrolysis. Among many alternatives for making of biodiesel by different feed stock, vegetable oil is basic and can be used for mass production process. Production of biodiesel by waste vegetable oil can be used in low grade field generators, engines, automobiles, furnaces, aviation industries etc. According to the present study the main emphases is given on producing biodiesel from different types of waste cooking oil samples such as rice bran oil, mustard oil, corn oil, canola oil, sunflower oil and analyzing the pros and cons of performance characteristics of biodiesel produced by testing it into a single cylinder four stroke Compression ignition (C.I.) engine. Moreover, the fuel properties and performances of biodiesel produced by different waste cooking oils and its blends with diesel fuel are discussed. Further, routes for upgrading biodiesel by various techniques have been mentioned.

Keywords: Trans-esterification, Pyrolysis, Compression ignition (C.I.) engine.

Introduction
The astonishing development in industrialization, transformation in lifestyle and the vehicular population has

led to a sudden increase in the consumption of non-Renewable resources which led to the depletion of petroleum-based oils(Agarwal, Gupta, & Kothari, 2011; Nigam & Singh, 2011). Currently, more than 80 % of the total energy demand of the world is being fulfilled by petroleum-based fuels, out of that 60 % is used in the vehicular sector(Almazan et al., 2008). Conventional fuels are very hazardous to the environment and known for polluting air, global warming, greenhouse gas emissions, larger emission of carbon dioxide, Sulphur dioxides and other toxic gases. This has resulted in increased research in alternative fuels and renewable sources of energy. Several alternatives of non-renewable sources such as hydro, wind, nuclear, solar, biofuel and biodiesel have been listed but still, all these are in the research and development. Consumption of fuels in very high demand is leading to advancement in green technology which will help to reduce pollution and the rising price of fuels(Banković-Ilić, Stamenković, & Veljković, 2012). The inventor of biodiesel engines, Rudolf Christian Karl Diesel (1858-1913) demonstrated the use of vegetable oils as a substitute for diesel fuel in the 19th century(Orchard, Denis, & Cousins, 2007). Biodiesel is a mono alkyl ester of fatty acid and derived from triglycerides molecule of vegetable oil or animal fats. When this triglyceride chemically reacts with alcohol in the presence of the catalyst (NaOH /KOH) then products comes fatty acid methyl ester (FAME) and glycerol. This FAME (biodiesel) is biodegradable and environmentally friendly which is less harmful than diesel and obtained from renewable sources like vegetable oils, animal fats, algae etc. There are crucial benefits over diesel petroleum like a significant reduction in greenhouse gas emissions, non-Sulphur emission, and non-carbon mono-oxide and low toxicity. Studies show that biodiesel combustion the carbon mono-oxide emission decreases by 46.7%, material particles by 45.2% and carbon dioxide by 68% compared to diesel fuel (Canice, M. 2007). Moreover, biodiesel returns about 90% more energy than the energy that is utilized to produce it(Muhammad F. 2015). In biodiesel production, all fatty acids sources can be used like animal fats or plant lipid. The utilization of these types of sources has given rise to certain concern as some of them are important food chain material(Kyriazis et al., 2009; Srinivasan, 2009). In other words, using human nutritional resources for the production of diesel may lead to the food availability problem and also it will not remain cost-effective. Bio-diesel from waste cooking oil is an innovative approach to produce alternative fuel. Using of biodiesel as a fuel in vehicles and industries results in the reduction of the shortage problem of petroleum diesel without harming the environment.

Biofuel is produced by several different processes like Transesterification, pyrolysis and Hydrothermal liquification but the most common and effective process is transesterification which refers to the interchanging of organic group of an ester with the organic group of alcohol in presence of catalyst. This reaction is also differentiated on the basis of catalyst used like acid, alkali or enzymes. Transesterification is used because the raw material for this process is easily available and cheap.

Blends of biodiesel and conventional hydrocarbon-based diesel are now being used for commercial a purpose that is for the use in diesel engines. In general, there a system known as the "B" factor to state the amount of biodiesel in any fuel mix [16] like B100 which refer 100% bio diesel, B50 which refers 50% bio-diesel and 50% diesel and B20 represents 20% Bio-diesel and 80% diesel. In the present paper, same system of representation has been used. Biodiesel has promising lubricating properties and cetane ratings compared to low Sulphur diesel fuels. ("Biodiesel" Retrieved 2017-12-22) Fuels with higher lubricity may increase the usable life of high-pressure fuel injection equipment that relies on the fuel for its lubrication. The approximate value of calorific value of biodiesel is about 37.27 MJ/kg (Board & City, 1907). Biodiesel contains no Sulphur, [19] and it is often used as an additive to Ultra-Low Sulphur Diesel (ULSD) fuel to aid with lubrication, as the Sulphur compounds in diesel provide much of the lubricity. The power output of biodiesel depends on its blend, quality, and load conditions under which the fuel is burnt.

Such comparable properties with less harmful emissions have turned the whole world's view towards the production and use of bio-diesel. Countries like United States, Brazil, China is leading in the list of production of bio-diesel. According to a report of World Economic Forum which shows the data of the United States Energy Information Administration, tells that United States produces 9,40,000 barrels a day in 2012.

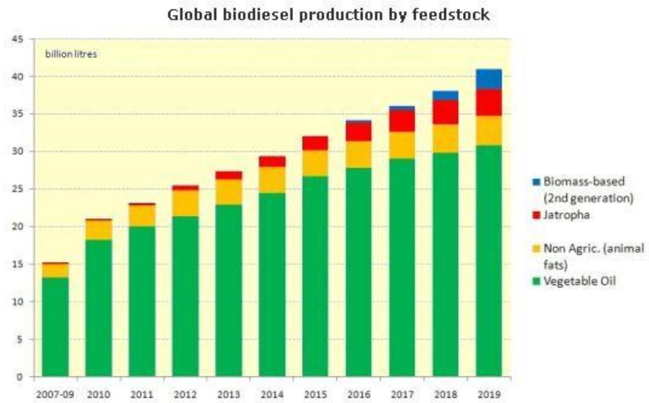


Fig. 1:- Global Biodiesel Production by feedstock (Author: Joe Myers is a Digital Content Producer at Formative Content).

As we can see from the fig. 1 the global production of biodiesel is increasing on a good scale also we can see that the major feedstock is vegetable oil (green portion in graph) which is responsible for production of biodiesel. 9, 40,000 barrels a day. Vegetable oil is easily available, high energy source and cost-efficient too. Approximately 28 billion litre biodiesel is produced in the year 2018. Apart from the vegetable oil, waste cooking oil is another promising raw material through which bio diesel can be produced. According to the survey conducted by our team in Delhi and National Capital Region (India) all the hotels, restaurants, small food vendor, college mess and canteens used different types of vegetable oil for cooking purposes. After the cooking the used vegetable oils are generally sold to the local farmers or the milkman. The milkman and farmers mix these used oil with the animal feed to increase the amount and butter of the milk

as per their locally developed concepts. But in real scenario, these used oils are saturated and very harmful to animal as well as for human being directly and indirectly.
This paper aims to sum up the one of the best solution for the end use of waste cooking oil. Paper presents the experimental investigation of the production of efficient grade bio-diesel from different used cooking oil samples, which can be used in diesel engine directly or in different ratios with diesel without any modification in Engine.

Methodology

Materials

For this experiment, we had collected multiple samples of used Edible oils from various canteens, mess and local food vendors. These Edible oils were used multiple times and contained with few food particles in it. These oils were filtered with sieve size of micron before making the Biodiesel. We used Methanol as separating alcohol and Potassium Hydroxide (KOH) as base catalyst. An induction pad with adjustable temperature was used. Weighing machine and glass beaker is used for the measurement of KOH and methanol respectively. A separation funnel is used to separate distilled biodiesel and glycerin.

Experimental Setup

The experimental setup is shown in fig 2. A single cylinder, four strokes, water cooled CI engine was used for study. The main parameters of engine are listed in the Table 1.

Table 1: main parameters of engine.

TECHANICAL SPECIFICATION		
PARAMETER	SI UNIT	DATA
MANUFACTURER	-	KIRLOSKAR
ENGINE TYPE	-	INTERNAL COMBUSTION
POWER OUTPUT	KW(HP)	5.2(7)
COOLING TYPE	-	WATER COOLING
ENGINE SPEED	RPM	1500
NO. OF CYLINDER	-	1
COMPRESSION RATIO	-	17.5:1
DISPLACEMENT VOLUME	LITER	0.661
INJECTION TYPE	-	DIRECT INJECTION

The engine was firmly established on the cemented platform and was attached with a control as well as monitoring panel. The monitoring panel were consists of tachometer reading, load indicator, temperature indicators and fuel consumption meter. Engine output shaft were attached with the Dynamometer. All the probes and all essential equipment's were attached as per the code IS 10000 of engine testing. The exhaust gas analyzer was separately available for the analysis of exhaust gases.

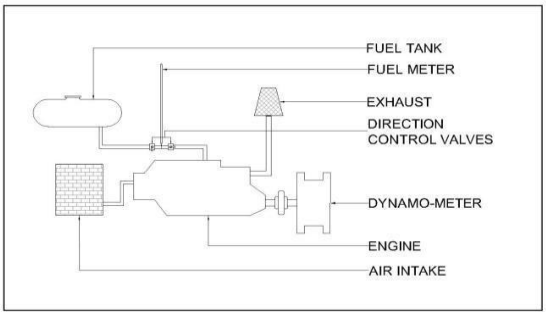


Fig. 2: Test rig for the testing of fuel.

Test Fuels

The test fuels utilized throughout the present experiments were named as followed:

B100 - The pure biodiesel obtained from Samples of corn oil, sunflower oil, Canola oil, mustard oil, rice brain oil

B50 **-** The mixture of sample biodiesels with the composition of 50% biodiesel and 50% of diesel oil.

B20 - The mixture of sample biodiesels with the composition of 20% biodiesel and 80% diesel oil.

Table 2: Percentage of diesel and biodiesel present in various testing samples.

Nomenclature	Volumetric percentage of Diesel	Volumetric percentage of Bio-Diesel
B-20	80%	20%
B-50	50%	50%
B-100	0%	100%

Fig. 4: Various oil samples.

Preparation of Bio diesel

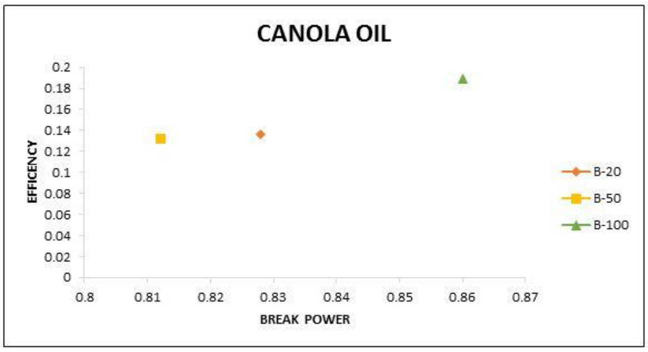
The production of the bio-diesel from used cooking oil may

be done by methods like esterification, trans-esterification.
The main problem which occurs with the used cooking oil is to reduce its viscosity, density and nitrogen emissions from it. it is observed that viscosity and density of the bio-diesel is much higher than the conventional diesel. Due to which the bio-diesel gelled in winter easily compared to conventional diesel. And apart from its gelling property it emits a higher concentration of nitrogen content in atmosphere compared to diesel.
After analyzing all the parameters, production of bio-diesel from used cooking oil by the process of transesterification is done. Transesterification is chemical process by which triglyceride lipid fat molecules can be shattered into four molecules using methanol (CH_3OH).
Used cooking oil has different physical and chemical properties as per requirements of the restaurants for different purposes. In this study, five different most commonly used oil samples are collected from restaurants and their properties like density, viscosity and emissions were determined, analyzed and compared with each other. And then form the samples of different used oils bio diesel had prepared at laboratory scale. For the preparing the biodiesel firstly by titration method the amount of methanol and Potassium Hydroxide (KOH) were calculated and found that for the present sample ----- litre and --- gram KOH are sufficient to separate the glycerin.
Used cooking oil samples were mixed with methanol (CH_3OH) in the presence of the strong base potassium hydroxide (KOH) as a catalyst one by one for all the five different oil samples. In this for process optimization, through-out the whole process ratio of the catalyst is kept constant with the ratio of the oil sample and methanol. Oil sample, methanol and KOH are taken in the ratio of 100:20:1. While considering the ratio, reaction time and temperature was not compromised. they were also considered as a factor for influencing the process. Every step was done very accurately and precisely. The reaction time and temperature were kept constant to 45 minutes and 333.15K respectively.
First, the used oil sample (500ml) is taken then filtered through a paper towel or cheese cloth-lined kitchen strainer resting on a clean pot or container. This method quickly clogs the pores of the paper towel with pieces of fried bits so that the oil strains through slowly.
After removing all the unwanted impurities, the oil was heated at a temperature of 373.15K, which evaporates the water content present in the oil. Then oil samples were maintained at a temperature in between 333.15K-353.15K up to 30 minutes so that it can dissolve easily with the mixture of methanol and KOH easily. Than 100 ml methanol (CH_3OH) is mixed with the 5gm of potassium hydroxide (KOH). KOH is used as a base catalyst just to make reaction faster. Further the obtained sample is mixed with the sample of used cooking oil which is filtered. After the mixing, the new sample is stirred continuously for 30 minutes. After this bio-diesel is kept for 48 hours for gravity separation of glycerol with waste cooking oil methyl esters. The obtained sample is separated in 2 layer of fluid and they both are different in colour and can be visible from the naked eyes. The 2 layers of fluid consist of bio-diesel and glycerol. The layer which is light in colour and upper side in the container is bio-diesel and the layer which is dark in colour and in the bottom of the container is glycerol. The glycerol forms the lower layer because of the higher density. Biodiesel separation methods are such as gravitational settling and decantation. Decantation is a process for the separation of mixtures of immiscible liquids or of a liquid and a solid mixture such as a suspension. The esters than washed by warm water (at 323.15K) and kept for 4 hours in separate container to remove catalyst and excess alcohol present in biodiesel.

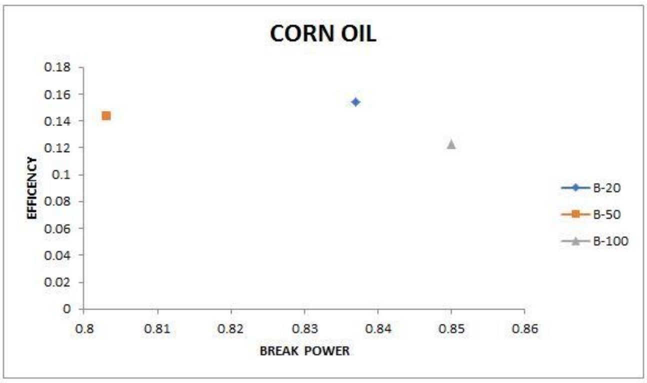
It was observed that different of used cooking oils were having varying quantity of bio-diesel and glycerin. It was observed that the oils were having higher density had more amount of glycerin in them.it was also concluded by (Singh, Kaur, & Singh, 2010) Bio diesel sample of different used cooking oils were collected in separate glass bottle, as shown in figure fig.5.

Fig. 5: Unseparated biodiesel from different oils.

After the study of experimental result, we have seen that different oils have different break power, BP efficiency according to the percentage of mixture of diesel with bio-diesel.
The following graph is the study of Comparison between break Thermal Efficiency and Brake power of different waste cooking oils at constant loads.



(A)



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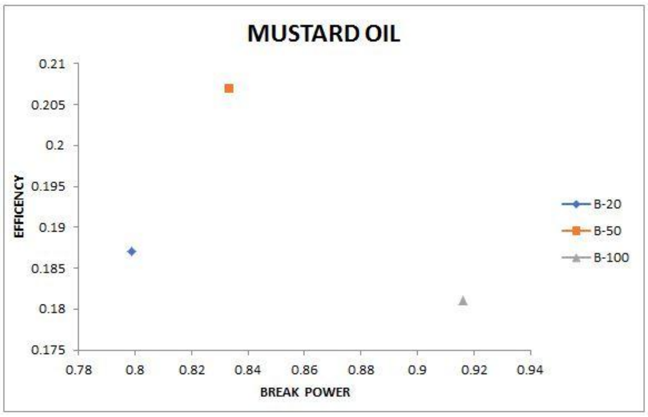

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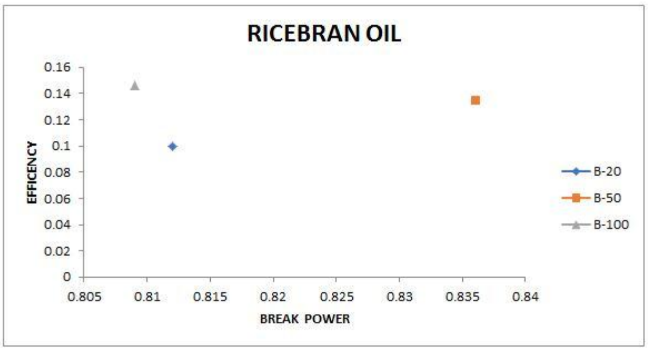

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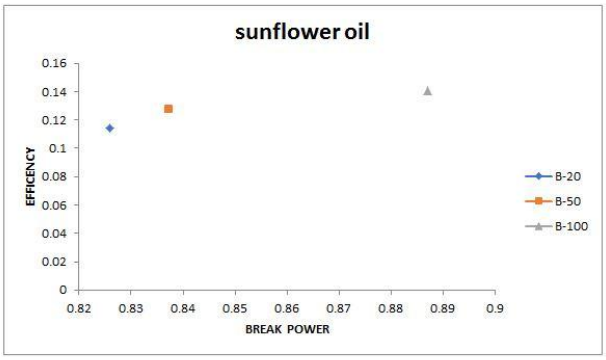
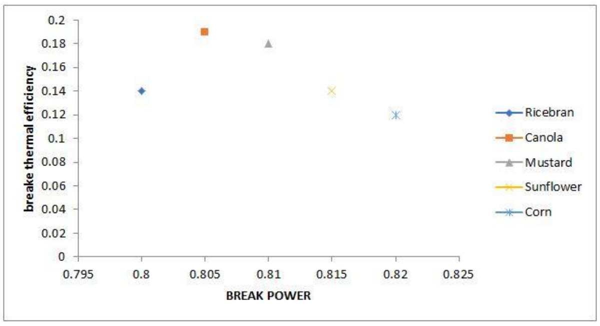


(E)

Graph 1: Comparison between break Horse power on different Fuel blend of different waste cooking oils at constant loads.



Graph 2: Comparison between break thermal efficiency and Brake power of different waste cooking oils at constant loads.

Result and discussion

Using transesterification to convert the used cooking oil into bio-diesel and using it as a fuel and comparing all its characteristics with the standard fuel. All the analysis shows that the different oil has different efficiencies when they are mixed in a certain ratio:

1. B-100 - 100% Bio-diesel
2. B-50 - 50% Diesel+50%Bio-Diesel
3. B-20 - 80%Diesel+20%Bio-diesel

Corn, Mustard, Canola, Rice Bran and Sunflower oils are studied.

The efficiencies of different fuel mixture are:

1. B-100
   a. Canola oil got the highest efficiency in B-100.
   b. Mustard oil got the lowest efficiency in B-100.
2. B-50
   a. Mustard oil got the highest efficiency in B-50.
   b. Sunflower oil got the lowest efficiency in B-50.
3. B-20
   a. Mustard oil got the highest efficiency in B-20.
   b. Rice bran oil got the lowest efficiency in B- 20.

In the process of transesterification apart from bio -diesel production glycerol is also produced and Mustard oil produced the maximum amount of the glycerol among all the oils.

Conclusion and future scope

After analyzing all the engine characteristics of the 5 oils it shows that all oils have given efficiency approximately same efficiency as the standard diesel fuel efficiency but apart from this some mixture of both fuels in a certain amount show very good results because they achieve a much higher efficiency than the normal diesel fuel and some are very low also. As we know that normal diesel fuel has an efficiency of around 30 to 35% in the diesel engines. After comparing all the data with the normal diesel, we found that mixture of different oil gives very different resus: Mustard oil with normal diesel in the 50-50 ratio gives the highest efficiency of 39.14% which was 9.14% more than the diesel fuel.

1. Rice bran oil with normal diesel in the 20-80 ratio gives the lowest efficiency of 21.42% which was 8.57% less than the normal diesel fuel.

And apart from the production of the fuel and glycerol from this process the emissions produced when bio-diesel is burnt in the combustion chamber are very less than the diesel fuel.

As we see that the rapidly growing population and industrialization in the world is making human life much easier and comfortable but on the other hand this leads to exploitation of natural resources and increase in the amount of pollution also. To fulfil the need of rapidly increasing population and expanding number of industries, we need resources in the large amount to satisfy the need but due to so much of extraction of them on daily basis their amount or quantity in the nature is decreasing day by day and that day is not too far when all these natural resources are exploited completely. At seeing the current scenario our main focus is to reduce the load on the natural resources by making or finding an alternative source of fuel which can fulfil the demand, without compromising with the properties and to reduce the amount of pollution in the atmosphere also. Electric vehicles were playing a big role in this but they have some sort of limitations due to which they were not used everywhere.

Electric vehicles have many advantages over diesel fuel like:

- Zero emissions.
- Minimal noise pollution and a quiet travelling experience.
- Presents a green image.
- Instant acceleration.

But still they lack in some properties which a diesel fuel can fulfil:

- Engines last longer than other.
- Higher torque or pulling power means mid-range acceleration of larger diesel cars is often better than sports cars. This pulling power is why diesel is used for commercial vehicles: it can pull much greater loads than any other option here

But due to the emissions produced by the diesel engine they are becoming harmful for the environment also. Considering the high level of emissions in the diesel fuel, bio-diesel is a new and innovative start which fulfils our diesel engine demand without compromising with the power output and also has fewer emissions than the diesel fuel. Using bio-diesel in replace of normal diesel has very positive effect on the environment but not in every aspect. Using bio-diesel reduces the emission of gases like CO (carbon monoxide), HC (hydrocarbons) but on the other hand it emits a large amount of nitrogen dioxide (NO_2).

Generally, NO_2 didn't affect the environment but it led to breathing problem in the humans. The epidemiological studies provide some evidence that long-term NO_2 exposure may decrease lung function and increase the risk of respiratory symptoms (Agarwal et al., 2011).

And bio-diesel suffers from a problem of gelling also in high altitude regions or in winter season. The gelling problem can be cured by adding kerosene which increases its cold floe operation ability which means that it can't gel in winter season and works like the normal diesel fuel.

References

[1] Agarwal, A. K., Gupta, T., & Kothari, A. (2011). Particulate emissions from biodiesel vs diesel fuelled compression ignition engine.
[2] Renewable *and Sustainable Energy Reviews*, *15*(6), 3278–3300.
[3] https://doi.org/10.1016/j.rser.2011.04.002
[4] Almazan, O., Venturini, O. J., Lora, E. S., Castillo, E. F., Escobar, J. C., & Yáñez, E. E. (2008). Biofuels: Environment, technology and food security. *Renewable and Sustainable Energy Reviews*, *13*(6–7), 1275–1287. https://doi.org/10.1016/j.rser.2008.08.014
[5] Banković-Ilić, I. B., Stamenković, O. S., & Veljković, V. B. (2012). Biodiesel production from non-edible plant oils. *Renewable and Sustainable Energy Reviews*, *16*(6), 3621–3647.
[6] https://doi.org/10.1016/j.rser.2012.03.002
[7] Board, N. B., & City, J. (1907). Biodiesel : a Technology , Performance , and. *Consultant*, (800).
[8] Kyriazis, J., Pimentel, D., Toth, M. A., McCormack, R., Marklein, A., Paul, G. S., … Krueger, T. (2009). Food Versus Biofuels: Environmental and Economic Costs. *Human Ecology*, *37*(1), 1–12.
[9] https://doi.org/10.1007/s10745-009-9215-8
[10] Nigam, P. S., & Singh, A. (2011). Production of liquid biofuels from renewable resources. *Progress in Energy and Combustion Science*, *37*(1), 52–68. https://doi.org/10.1016/j.pecs.2010.01.003
[11] Orchard, B., Denis, J., & Cousins, J. (2007). Developments in biofuel processing technologies. *World Pumps*, *2007*(487), 24–28.
[12] https://doi.org/10.1016/S0262-1762(07)70151-7
[13] Singh, B., Kaur, J., & Singh, K. (2010). Production of Biodiesel From Used Mustard Oil and Its Performance Analysis in Internal Combustion Engine. *Journal of Energy Resources Technology*, *132*(3), 031001.
[14] https://doi.org/10.1115/1.4002203
[15] Srinivasan, S. (2009). The food v. fuel debate: A nuanced view of incentive structures. *Renewable Energy*, *34*(4), 950–954.
[16] https://doi.org/10.1016/j.renene.2008.08.015
[17] https://www.biofuelsystems.com/biodiesel/information.html
[18] K. NanthaGopal ,Arindam Pal , Sumit Sharma , CharanSamanchi , K. Sathyanarayanan , T. Elango ; Alexandria Engineering Journal (2014) 53, 281–287.
[19] By Omidvarborna; et al. "Characterization of particulate matter emitted from transit buses fueled with B20 in idle modes". Journal of Environmental Chemical Engineering. 2 (4): 2335–2342. doi: 10.1016/j.jece.2014.09.020.
[20] "E48_MacDonald.pdf (application/pdf Object)" (PDF). astm.org. 2011. Retrieved May 3, 2012.
[21] Credit: BEEMS Module B4