ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Mechanical, Chemical and Materials Engineering

Testing the Performance of Cottonseed Biodiesel on Diesel Vehicle

A project submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Automotive Technology

Master of Science

in

Automotive Technology Teachers Education

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CANDIDATE'S DECLARATION

We hereby declare the work which is presented in the project entitle "*Testing the performance of cottonseed biodiesel on diesel vehicle*" in partial fulfillment of the requirements for the award of the degree of master of science in Automotive Technology Teacher Education is an authentic record of our own work carried out from February 2015 to May 2015 under the supervision of N.Ramesh Babu (Asso. Prof),Department of Mechanical and Vehicle Engineering, Adama Science and Technology University.

The matter embodied in this project has not been submitted by us for the award of any other degree or diploma. All relevant resources of information used in this thesis have been duly acknowledged.

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This is to certify that the above statement made by the candidates is correct to the best of my knowledge and belief. This project has been submitted for examination with my approval.

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Acronyms and abbreviation

ASTM	American society for testing and material
C	Carbon
CI	Compression ignition
CN	Cetane number
CO	Carbon mono oxide
CSME	Cottonseed methyl ester
CSO	Cottonseed oil
FFA	Free fatty acid
HHV	Higher heating value
IC	Internal combustion
KOH	Potassium hydroxide
Na_2SO_4	Sodium sulfate
NaOH	Sodium hydroxide
NO_X	Oxides of nitrogen
PM	Particulate matter
SME	Sunflower methyl ester
TDC	Top dead center
UHC	Unburned hydrocarbon
FAME	Fatty acid methyl ester
HC	Hydro Carbon
CO_2	Carbone dioxide
BTDC	Before top dead center
K	Potassium
Zn	Zinc
BD	Biodiesel
BSFC	Brake specific fuel consumption
RPM	Revolution per minute
SFC	Specific fuel consumption
MF	Mass flow rate
N	Engine speed

V	Vehicle speed
T_b	Brake torque
T_w	Torque at rear wheels
P_b	Brake power

ABSTRACT

Increasing cost of petroleum fuels, environmental threats from exhaust emissions and their depleting nature have generated intense international interest in developing renewable and alternative fuels for diesel vehicle. This study investigates the suitability of biodiesel derived from vegetable oil, particularly from cottonseed oil biodiesel on diesel vehicle. This project is aimed to conduct tests using blends of diesel and cottonseed oil (CSO) biodiesel in diesel. This project includes stages of producing cottonseed oil by mechanical pressing, converting cottonseed oil in to biodiesel by transesterification process, measuring the properties of biodiesel and testing the performance of diesel-biodiesel blends in diesel vehicle.

When producing biodiesel from CSO, the transesterification process is done, which is blended with petroleum diesel to have the properties of biodiesel is closest to that of conventional diesel for using of cottonseed biodiesel as alternative fuel without any modification with B20. B20 is 20% biodiesel and 80% petroleum diesel blend, such that the diesel engine does not need additional modification for this blend to be used.

The transesterifcation reaction is affected by molar ratio of glycerides to alcohol, catalysts, reaction temperature, reaction time and free fatty acids and water content of oils. The performance results of tested blend of fuel (B20) from cottonseed oil were compared to conventional diesel. As a result torque and power has less value than diesel which is the lower heating value in the biodiesel. But, the brake specific fuel consumption (BSFC) of blending fuel (B20) is higher which is due to the lower calorific values of biodiesel.

Keywords: Cottonseed oil, Transesterification, Biodiesel, Blend and Engine performance.

1. INTRODUCTION

1.1 Back-ground of the study

The increase of pollutant gasses and the rising cost of petroleum diesel are the major problems of the present day transportation sectors. This developing economy of Ethiopia has seen an major increase in transportation and releases lots of harmful pollutants and greenhouse gases. Conventional fuelled vehicles discharges significant amount of pollutants: such as; CO, UHC, $NO_{X,}$ smoke, etc which are harmful to the environment and human beings. Therefore, researchers are putting their effort in finding various alternative fuels of bioorganic as a replacement for conventional fuels. From various types of vegetable oils, it is possible to produce alternative fuels having similar characteristics to conventional diesel fuel. The high viscosity and low volatility of vegetable oils are the major problems for being use directly in diesel engine. These problems of vegetables oils can be reduced by transesterification process which helps in improvement of BSFC of diesel engines.

The modified vegetable oil produced after transeesterifiction process known as biodiesel is a potential alternative fuel for CI engine. Usage of biodiesel in engines considerable reduces the environmental pollution in solving the other problems like dependence on importation of oil etc. Cottonseed oil is one of the promising oil from which biodiesel can be produced to use in diesel engine [1]. The usage of biodiesel from cottonseed oil helps in reducing the consumption of petro diesel, reduces the dependence on importation oil and reduces the environmental pollution.

In this context, our project tries using of cottonseed oil biodiesel with conventional diesel in diesel engine to establish its performance behavior in diesel engines.

1.2 Statement of the problem

Use of petroleum fuel in ever growing transport sector is causing lots of pollution leading to global warming and other health problems of human beings. Also the petroleum reservoirs are going to finish in the near future. Dependence of the country on importation of oil is leading to the expense of lot of foreign exchange. So finding renewable, nonpolluting, home grown, cheap alternating fuel is on utmost necessity.

1.3 Objectives

1.3.1 General objective

The general objective of this project is to test the performance of cottonseed biodiesel in diesel engine.

1.3.2 Specific objectives

- To produce biodiesel from cottonseed oil by transesterification process
- To prepare diesel-biodiesel blends and characterize for their properties
- To conduct performance test with pure diesel and diesel-biodiesel blends in CI engine
- To compare the performance of pure diesel and diesel-biodiesel blends

1.4 Significance of the study

This project will indicate how and why the alternative fuels are used rather than pure petroleum fuel and will increase the interests in accepting alternative fuels by car manufacturers and owners. Using of the biodiesel in diesel engine has the following significance:

- Reduces the net emissions of greenhouse gasses.
- Reduces the importation of petroleum fuels.
- Encourages the agriculture with production of cotton seeds.
- Farmers get benefitted.

1.5 Limitation of the study

The project aims at reduction of NOx, UHC and other greenhouse gases however these gases are present in the exhaust gases from the biodiesel blend. The B20 diesel is more expensive compared to petroleum diesel at present, but the cost can be reduced by mass production of biodiesel.

2. LITERATURE REVIEW

2.1 Introduction

The increase of petroleum price and the environmental advantages, an alternative fuel as a blending of direct replacement for diesel fuel in vehicle engines i.e. Petro-diesel to bio-diesel. Biodiesel fuel is a renewable substitute fuel for petroleum diesel or petro diesel fuel made from vegetable oils or animal fats and it can be used in any mixture with petro diesel fuel as it has very similar characteristics but it has lower exhaust emissions. Also, Biodiesel, as an alternative fuel for internal combustion engines, is defined as a mixture of mono alkyl esters of long chain fatty alkyl acids (chain length C_{14}–C_{22}) derived from a renewable vegetable oil or animal fats which can offer benefits of in reduction of greenhouse gas emissions and a good lubricant (about 66% better than petro-diesel).The source of cottonseed oil is cottonseed, which is a crop by product. It is basically a triglyceride ester with a number of branched chains of 8-18 carbon atoms. It contains 85.3% fatty acids. A cotton seed biodiesel is a resource an alternative fuel derived from a vegetable oil which is blending with conventional diesel used in diesel engine has to high viscosity, low volatility and polyunsaturated character of vegetable oils. Therefore, using Vegetable oils in diesel engines can result in coking and trumpet formation on the injectors, carbon deposits, oil ring sticking and thickening and gelling of lubricating oil as a result of contamination by the vegetable oils. Also the cause of its high viscosity is resists the flow when it passes through the injection system. To solve these problem on vegetable oils such methods are applicable in the production of bio diesel fuel; preheating, blending and transesterification methods are used to reduce the viscosity and to produce biodiesel suitable for internal engine application i.e. diesel engine[2].

Now a day, improving the clean environment has become a great issue in the world's societies. The pollutants escaped from a transportation sector, such as; from vehicles is the most environmental pollutant and must be under control. Therefore, using cottonseed oil or biodiesel blended fuel can prevent the environment from pollution and the depletion of petroleum fuels simultaneously, also optimizing performance of the engine. Many researchers have been studied the performance of biodiesel on a diesel engine which is used as blended in different proportion of biodiesel in engine test. As our understanding from the review of the literature, that biodiesel blended fuels can effectively reduce the environmental pollution without any major modification to the design of the engine. Therefore, in this study we uses the cottonseed oil made from the product of cotton plant from vegetable oils or bio fuels which are further called biodiesel for the use of diesel engine. Finally, our intention in the project is testing performance of cotton seed biodiesel in diesel engine to address the environment free emissions from pollutant gasses and engine performance using of cottonseed biodiesel fuel.

2.2 Biodiesel

Biodiesel is a substitute of fossil fuel for diesel engine and defined as: a fuel comprised of mono-alkyl ester of long chain fatty acids derived from vegetable oils or animal fats. Biodiesel, also known as “mono-alkyl ester” is the product of the reaction of alcohol, such as methanol or ethanol with oil or fats (triglyceride) by transesterification reaction.

Biodiesel is a petroleum diesel alternative that is produced from vegetable oils and animal fats. Biodiesel is biodegradable and deemed to be less toxic than petroleum diesel. Biodiesel has slightly lower energy content than conventional diesel although this is not significant when operating vehicles on biodiesel blends [3].

Concerns about biodiesel raised by engine manufacturers in the World Wide Fuels Charter include; biodiesel may be less stable, so precautions should be taken to prevent problems from fuel oxidation, biodiesel requires special care at low temperatures to avoid viscosity problems and hence loss of fluidity special handling is required to prevent build-up of high water content and consequent risks of corrosion gum residue build-up may be higher than with conventional diesel, so detergents are recommended biodiesel may react adversely with natural and nitrite rubber seals and could dissolve paint coatings swapping between diesel and biodiesel could lead to greater residue build-up and these residues could block fuel filters. Biodiesel produced from different feed stocks can have significantly different fuel quality characteristics including cold flow properties, density and oxidation stability [4].

2.2.1 Types of biodiesels

There are different types of biodiesel which are derived from agriculturally cropped in different methods or from a different source of raw materials, such as; fuel from cotton seed oil, sunflower oil, jathropha oil, soybean, palm oil, seem seed and so on. From those, we are interested on biodiesel from cottonseed oil which is called cottonseed biodiesel [2]. Biodiesel fuel can be made from new or used vegetable oils and animal fats. Unlike fossil diesel, pure biodiesel is biodegradable, nontoxic and essentially free of sulphur and aromatics [5].

2.2.2 Advantages of biodiesel fuel

In IC engine, the thermal energy is released by burning the fuel in the engine cylinder. The combustion of fuel in IC engine is quite fast but the time needed to get a proper air/fuel mixture depends mainly on the nature of fuel and the method of its introduction into the combustion chamber. The fuel should there for satisfy the following performance
The advantages of vegetable oils as diesel fuel are:

- ✓ Ready availability.
- ✓ Renewability.
- ✓ Higher heat content.
- ✓ Lower sulfur content.
- ✓ Lower aromatic content.
- ✓ Biodegradability.
- ✓ Low toxicity.
- ✓ Biodiesel is safer to handle compared to standard diesel.
- ✓ Biodiesel can be easily blended with standard diesel
- ✓ Production and use of biodiesel accounts for significantly less emissions compared to standard diesel, approximately 78% less emissions compared to standard diesel.
- ✓ Biodiesel has very good lubricating properties, significantly better than standard diesel which can prolong engine's life [6].

The combustion process in the cylinder should take as little time as possible with the release of maximum heat energy during the period of operation. Longer operation results in the formation of deposits which in combination with other combustion products may cause excessive wear and corrosion of cylinder, piston and piston rings. The combustion product should not be toxic when exhausted to the atmosphere. These requirements can be satisfied using a number of liquid and gaseous fuels. The biodiesel from nonedible sources like Jatropha, Pongamia, Mahua, Neem etc. meets the above engine performance requirement and therefore can offer perfect viable alternative to diesel oil [7].

2.2.3. Disadvantage of biodiesel fuel

One of the problems encountered when using biodiesel is the increase in nitrogen oxides emissions which can result in the formation of smog and acid rain. Similarly, biodiesel when compared to petro-diesel have a lower energy output. In order to produce the same amount of energy, more biodiesels required than petro-diesel. Also, the use of valuable cropland to grow biodiesel crops could result to a rise in cost of food and further more leads to food scarcity.

- Higher viscosity.
- Lower volatility [6].

2.2.4 Characterization of vegetable oil

Vegetable oils provide engine performances similar to that obtained with diesel fuels. The following are the important characteristics of good vegetable oil required to substitute diesel fuel.

A. Ignition quality

Satisfactory diesel combustion demands self-ignition of the fuel as it is sprayed near TDC into the hot swirling compressed cylinder gas. Long ignition delay is not acceptable as it leads to knock. Therefore the cetane number of the substitute fuel should be high enough, which is a measure of knock tendency of the fuel. Satisfactory fuels must have a cetane number between 40 and 60.

B. Viscosity

Fuel viscosity plays an important role in the combustion of fuel used. The direct injection in the open combustion chamber through the nozzle and pattern of fuel spray decides the ease of combustion and thermal efficiency of the engine. Too low viscosity can lead to excessive internal pump leakage whereas system pressure reaches an unacceptable level and will affect injection during the spray atomization. The effect of viscosity is critical at low speed or light load conditions.

C. Heating value

Although the diesel combustion chamber system can accept wide variations in heating value, practical systems are only suitable when calorific value of the fuel is high. This helps to reduce the quality of fuel handled and maximizes the equipment operating range. It is always desirable for the vegetable oils to have a calorific value nearer to that of diesel.

D. Important temperatures

Pour point and cloud point are important for cold weather operations of the I.C. engine. For satisfactory working, the values of both should be well below the freezing point of the oil used. Flash point is an important temperature from a safety point of view. This temperature should be as high as practically possible. Typical values of commercial vegetable oils fuel range between 50 and 110 vs. Vegetable oil–diesel blend should not decrease the flash point temperature [8].

2.2.5 Compatibility of diesel powered engines with biodiesel blends

Although biodiesel can be used in most diesel engines with no modifications to the engine or the vessel's fuel system, it is highly recommended that you check with your manufacturer before using it. Some problems have been associated with its use in the environment, and your engine manufacturer can give you further guidance as to what biodiesel blends are acceptable for use and how to mitigate potential problems.

2.2.6 Raw materials of biodiesel

Commonly accepted biodiesel raw materials include the oils from soy, canola, corn, rapeseed, and palm. New plant oils that are under consideration include mustard seed, peanut, sun flower and cotton seed. The most commonly considered animal fats include those derived from poultry, beef, and pork. Cottonseed oils used almost entirely as a food material. Sesame, olive, and peanut oils can be used to add flavor to a dish. Walnut oil is high-quality edible oil refined by purely physical means from quality walnuts.

Algae can grow practically anywhere where there is enough sunshine. Some algae can grow in saline water. All algae contain proteins, carbohydrates, lipids and nucleic acids in varying proportions. While the percentages vary with the type of algae, there are algae types that are comprised up to 40% of their overall mass by fatty acids. The most significant distinguishing characteristic of algae oil is its yield and hence its biodiesel yield.

Biodiesel is produced by chemical purification of natural hydrocarbon products, for example vegetable oil, tallow, or cooking oil. The process is called esterification and produces a product containing about 10% oxygen. This product has similar properties to diesel and can be used in normal diesel engines. It can be used as a diesel (B100) or as a blend with normal diesel, normally at 20% (B20). Because the biodiesel is made from carbon taken out of the biosphere it adds no new carbon and so does not add to greenhouse gas emissions. Biodiesel is more expensive to produce than normal diesel at current crude prices unless the base stock is a waste material [9].

2.2.7 Properties of biodiesel

Biodiesels are characterized by their viscosity, density, cetane number, cloud and pour points, distillation range, flash point, ash content, sulfur content, carbon residue, acid value, copper corrosion, and higher heating value (HHV). The most important parameters affecting the ester yield during the transesterification reaction are the molar ratio of alcohol to vegetable oil and reaction temperature. The viscosity values of vegetable oil methyl esters decrease sharply after transesterification. The flash point values of vegetable oil methyl esters are significantly lower than those of vegetable oils. There is high regression between the density and viscosity values of vegetable oil methyl esters. The relationships between viscosity and flash point for vegetable oil methyl esters are considerably regular [10].

Table 2.1 Properties of biodiesel fuels

No	Property	Diesel	Cottonseed oil
1	Calorific Value	43,000 kJ/kg	39,648kJ/kg
2	Flash Point	44^0C	234^0C
3	Fire Point	49^0C	192^0C
4	Viscosity	0.278 poise	2.52 poise
5	Density	835 kg/m^3	850 kg/m^3

Physical properties of biodiesel fuels

The physical properties of biodiesel are similar to those of diesel fuels. Viscosity is the most important property of biodiesels since it affects the operation of fuel injection equipment, particularly at low temperatures when an increase in viscosity affects the fluidity of the fuel. High viscosity leads to poorer atomization of the fuel spray and less accurate operation of the fuel injectors. The lower the viscosity of the biodiesel, the easier it is to pump and atomize and achieve finer droplets [10].

A. Cetane number

The cetane number (CN) is based on two compounds, hexadecane, with a CN of 100, and heptamethylnonane, with a CN of 15.The CN is a measure of the ignition quality of diesel fuels, and a high CN implies short ignition delay. The CN of biodiesel is generally higher than conventional diesel. The longer the fatty acid carbon chains and the more saturated the molecules, the higher the CN. The CN of biodiesel from animal fats is higher than those of vegetable oils [11].

B. Cloud Point

While the Cloud Point must be reported, there are no minimum or maximum requirements. It is vital to understand the importance of this value in relation to the performance and handling of B100 at low ambient temperatures. The Cloud Point is the most conservative temperature at which components begin to precipitate from the fuel that may cause operability issues. Cloud Point results will vary significantly depending upon the feedstock from which the methyl ester was created.

C. Monoglycerides

Monoglycerides are partially converted fats and oils found within biodiesel. While not reported separately in the U.S., they are accounted for as part of the total glycerin. The monoglycerides formed as the result of different feed stocks have inherently different properties. They all have somewhat higher melting and Cloud Points, as opposed to the methyl esters. This may lead to the appearance of precipitates just above the reported Cloud Point. It has been shown that the presence of even small amounts of saturated monoglycerides will significantly raise the Cloud Point of biodiesel, while unsaturated monoglycerides will not. These saturated monoglycerides are one of the more common culprits in filter plugging. This material will appear as a thick, waxy coating. The monoglycerides formed from tallow or palm, or those that are saturated by nature, have significantly higher melting points that will require more diligence and more energy to dissolve back into solution. The monoglycerides derived from Soy and Canola are much less saturated, leading to considerably less impact on filterability.

D. Visual appearance

While there is no correlation between the color of biodiesel and its performance as a fuel, it is critical that the sample be free of un dissolved water, sediment and suspended matter. At room temperature, the sample should be clear and transparent. Any cloudiness or haze may be an indication of impurities or excess water that may be present.

E. Ash content

Abrasive solids or soluble metallic soaps may be present in diesel fuel. These ash forming materials can result in injector and fuel pump wear, as well as piston and ring wear, in the case of abrasive solids and engine deposits may also increase. The primary concern with soluble soaps is their contribution to engine deposit.

F. Flash Point

Flash point was measured using Pensky Marten's apparatus. The cup was rinsed, cleaned and dried before starting the test. The cup was filled up to the mark with the biodiesel sample and covered with the lid. Thermometer was inserted such that, the bulb got immersed in the sample and care was taken that stirrer would not touch the thermometer. The initial temperature of the sample was noted down. Heater was started and the power level was set such that temperature of sample rises at the rate of $3^{o}C$/min. The stirrer rotated at 2 rev/ sec. Test flame was applied by operating shooter. For every 2ºC rise in temperature, the test flame was brought near cup surface for observing the phenomenon. When flash appeared on the surface of cup, the temperature was noted down and taken as Flash point.

2.2.8 Biodiesel as a fuel additive

In most cases, the industry believes that blends up to 20% (B20) will cause no detriment to performance. B20 has proven to be a practical fuel that can be used in any diesel engine with few precautions or changes. However, most US auto, engine and fuel injection equipment companies strongly discourage the use of blends over 20%, mainly due to the possible impacts of higher blends on equipment and fuel systems that have not been thoroughly tested. There are additional concerns regarding the influence of the increased biodiesel content greater than 20% on cold flow properties, material compatibility, maintenance intervals, fuel stability, biological growth, energy content, emissions and overall handling [12].

2.2.9 Blending and storage

The blends were made on a volume basis and stored in glass bottles at room temperature and making sure that appropriately stored. Tests are done and blended by skilled person with professional understandings.

Biodiesel is safe to store and the properties of biodiesel should conform to respective standards after it has been stored for a long time. There are several key factors that need to be considered for the storage of biodiesel, including exposure temperature, oxidative stability, fuel solvency, and material compatibility. Poor stability can lead to an increased acid value and fuel viscosity and to the formation of gums and sediments. Biodiesel storage tanks made of aluminum, steel, Teflon, and fluorinated polyethylene or polypropylene should be selected. The tanks should minimize the possibility of water contamination and should be cleaned prior to use for biodiesel storage. [13].

2.2.10 Fuel quality

The quality of fuel used for in any motor vehicle engine is very important to its long life and the correct operation. But, if the fuel is not an appropriate or affects by temperature which is changes to from liquid to vapor incorrectly, drivability will be affected. Biodiesel is the name given to a variety of ester-based oxygenated fuels made from cottonseed oil, other vegetable oils, or animal fats. Because of having high viscosity and volatility of biodiesel, uses such method called transesterification, which gives for the purpose of reducing the viscosity and volatility. As a result, Esters have lower viscosities than the parent oils (cottonseed oil). Accordingly, this maintains the quality of cottonseed biodiesel fuel in improving the injection process and ensures better atomization of the fuel in the combustion chamber [10].

2.2.11 Biodiesel based fuels

Biodiesel has been approved by the US government to be added blended to petroleum diesel fuel in different concentrations.

B5: This label found on fuel pumps denotes a fuel blend of 5% biodiesel and 95% petroleum diesel.

B6-B20: These labels found on fuel pumps denote a fuel blend of 6-20% biodiesel to 94-80% petroleum diesel [14].

2.2.12 Effects of fuel quality

Biodiesel is an alternative fuel for diesel engines. The results show that compared to diesel fuel, all of the vegetable oils are much more viscous, are much more reactive to oxygen, and has higher cloud point and pour point. They also found that compared with diesel fuel, vegetable oils and their biodiesels offer lower engine noise, and lower smoke, HC, and CO, slightly higher NOx and higher thermal efficiency. In addition, 20/80 blend of biodiesel with diesel fuel offers better engine performance and lower emission [15].

2.2.13 Problems by using biodiesel fuel blends

Some common problems that have been experienced when using biodiesel fuel includes:

- Fuel line/filter clogging due to biodiesel's solvent properties
- Degradation of the vessel's rubber fuel lines and gaskets
- Voided engine warranties for use of biodiesel blends above what the manufacturer recommends [16].

2.2.14 Use of different blends of biodiesel

The use of blending of a cottonseed oil with conventional diesel in proportions is for the purpose of having suitable blending of a cottonseed biodiesel in self ignition engines. In general, the different blending percentages gives in reduction of emissions and lower engine noise in improving performance of cottonseed biodiesel at which proportion of blend does acceptable and which blend does meets to have same properties with conventional fuel [17].

2.2.15 Engine Performance with cottonseed biodiesel

The purpose of improving engine performance manufacturers adopts several new technologies such as; turbochargers, common rail systems, multistage injections and others. But this engine performance increment in many case caused a negative impact on emissions and this emissions must be regulated; as a result a solution could be found with the use of alternative fuels as renewing the fuel into bio fuels. From those the most common are: bio ethanol, vegetable oil and their derived methyl esters (biodiesel). Vegetable oils provide engine performances similar to that obtained with diesel fuels. All recommendations states that a vegetable oil blended with petroleum diesel which is cottonseed blended diesel to form a cottonseed biodiesel runs successfully for a diesel engine. The proportion of blend cottonseed biodiesel is 20% cottonseed oil and 80% petroleum diesel which shows a reduction in emission properties such as CO, CO_2, UHC and smoke opacity [18].

Engine Performance

Biodiesel produces about 3-5% less engine power and torque due to its lower value energy compared to diesel. It is expressed in terms of kWh/liter of fuel or as Brake specific fuel consumption (BSFC) in gm/kWh.

Deposit and Clogging

Deposits and clogging problems are widely reported and are generally attributed to sub standard quality of biodiesel or due to its less oxidation stability and therefore engine wear is relatively more when run on biodiesel.

Pollution from engine exhaust:

Biodiesel results in much less air pollution due to its higher oxygen content and absence of "aromatic compounds" and Sulphur. The NO_x tends to be slightly higher compared to biodiesel which can be minimized by proper engine timing.

Cold-weather performance

Diesel engines operated in cold weather experience the problems of clogging of the filters and/or choking of the injectors. The use of flow improving additives and "winter blends" of biodiesel and kerosene has proved effective in the operating range of climate temperatures B100 tends to operate well at temperatures down to about 5°C. Additives reduce the range by about 5-8^{0}C, while the winter blends have proved effective at temperatures as low as -20°C or below [4].

2.2.16 Biodiesel cost

The market price of biodiesel is heavily influenced by the cost of feed stocks such as cottonseed, canola, palm oil and soy beans. Biodiesel is currently effectively excise free compared with petroleum-derived diesel which has an excise of 18.43 cents per liter in a B5 blend this represents an excise advantage of almost 2 cents per liter however, biodiesel is generally cheaper than diesel off setting much or all of the excise advantage. The Ethiopian Government announced major changes in 2006 to move the fuel taxation system towards greater taxation neutrality between vehicle fuels. Biodiesel and other alternative fuels will continue to enjoy a significant excise advantage (50 per cent of the excise rate on an energy equivalent basis) compared to petroleum-derived diesel from July1, 2003 to July1, 2007, excise on biodiesel will be increased in five equal annual installments to 9.1 cents per liter, resulting in biodiesel having an ultimate excise benefit of 9.043 cents per liter in a B5 blend this represents an excise advantage of just over 1 cent per liter [19].

2.2.17 Benefits of biodiesel

The life cycle production and use of biodiesel produces approximately 80% less carbon dioxide emissions, and almost 100% less sulphur dioxide. Combustion of biodiesel alone produces over a 90% reduction in total unburned hydrocarbons, and a 75-90% reduction in aromatic hydrocarbons. Biodiesel further provides significant reductions in particulates and carbon monoxide than conventional diesel fuel. Neat biodiesel fuel is nontoxic and bio degradable. Catane number is significantly higher than that of conventional diesel fuel. Lubricity is improved over that of conventional diesel fuel [20].

2.2.18 Transesterification of reaction

In the transesterification of oils, triglycerides react with an alcohol, generally methanol or ethanol, to produce esters and glycerin. To make it possible, a catalyst is added to the reaction. The overall process is normally a sequence of three consecutive steps, which are reversible reactions.

$$
\begin{array}{ccccccc}
\mathrm{CH_2\text{-}OOC\text{-}R_1} & & & & \mathrm{R_1\text{-}COO\text{-}R'} & & \mathrm{CH_2\text{-}OH} \\
| & & & & & & | \\
\mathrm{CH\text{-}OOC\text{-}R_2} & + & \mathrm{3ROH} & \xleftrightarrow{\text{catalyst}} & \mathrm{R_2\text{-}COO\text{-}R'} & + & \mathrm{CH\text{-}OH} \\
| & & & & & & | \\
\mathrm{CH_2\text{-}OOC\text{-}R_3} & & & & \mathrm{R_3\text{-}COO\text{-}R} & & \mathrm{CH_2\text{-}OH} \\
\text{Glycerides} & & \text{Alcohol} & & \text{Esters} & & \text{Glycerin}
\end{array}
$$

Figure.2.1 Chemical reaction for biodiesel production

In the first step, from triglycerides diglyceride is obtained, from diglyceride, monoglyceride is produced and in the last step, from monoglycerides glycerin is obtained. In all these reactions esters are produced.

$$\text{Triglycerides (TG)+ROH} \xleftrightarrow{k_1} \text{Diglycerides (DG)+R'COOR}_1$$

$$\text{Diglycerides (DG)+ROH} \xleftrightarrow{k_2} \text{Monoglycerides(MG)+R'COOR}_2$$

$$\text{Monoglycerides(MG) + R'OH} \xleftrightarrow{k_3} \text{Glycerin(GL)+R'COOR}_3$$

Figure. 2.2 Steps involved in the transesterification process

The stoichiometric relation between alcohol and the oil is 3:1. However, an excess of alcohol is usually more appropriate to improve the reaction towards the desired product [21].

2.3 Producing biodiesel from cottonseed

The process of producing biodiesel is simple and of public domain. Basically consists in putting together the animal tallow or vegetable oil with an alcohol in a catalyst to have the process of transesterification, in which the oil is separated from the glycerin. The biodiesel comes as a new source of income for the cotton crop. However, compared to other crops, the cottonseed has a low yield of oil (15.2%). Thus, the yield of biodiesel from cottonseed is in the order of 160 liters per ton of raw material (seed).

2.3.1 Cotton production

Ethiopia has excellent cotton-growing conditions and a significant amount of land potentially suitable for cotton production. However, the current domestic cotton production is much below the potential which poses as a constraint with respect to backward integration of the country's textile and garment industry. Further, given the relatively limited use of pesticides and chemical fertilizers by Ethiopian smallholder farmers, Ethiopia has the potential to become a producer of organic cotton(22).

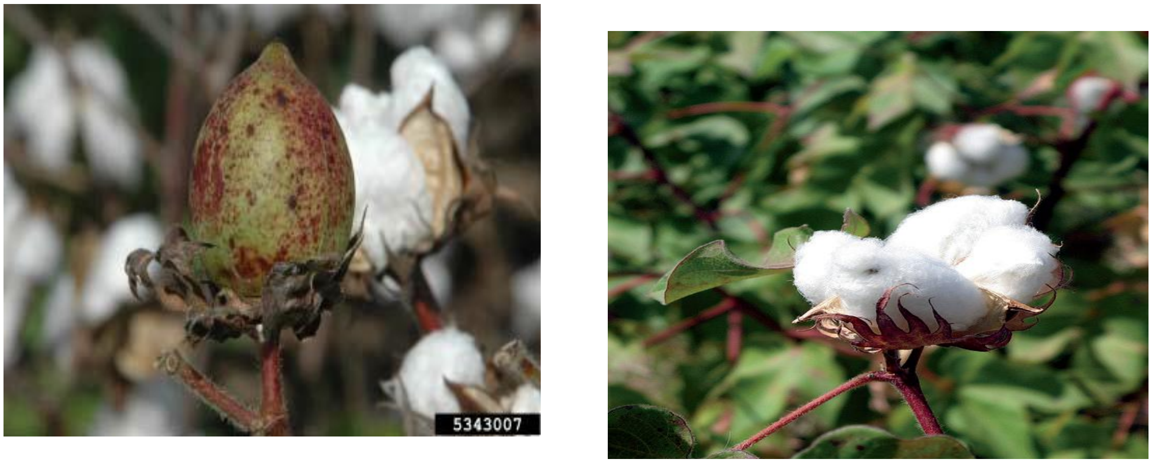

Figure.2.3 The unopened boll of cotton shown on left and an opened boll with exposed lint appears on the right.

2.3.2 Cottonseed

The cottonseed crop is a fast growing plant with long productive life span of 3-4 months, its ability to survive on drought and poor soils at average and high temperature up to 44°C and a low temperature of up to 4°C cotton was the third biggest of the crops grown worldwide [23].

Figure 2.4: Cottonseed with lint removed

2.3.3 Use of Cotton Seed Oil

Cotton seed oil (CSO) consists of triglyceride, diglyceride and monoglyceride esters possessing high molecular mass (852) that is the cause of its high viscosity which resists the flow particularly when it passes through the injection system [24]. Although the raw oil can be used as fuel in CI engines, yet it is not successful for long term running of engines.

However, the oil can be used as an alternative fuel after processing it chemically, by which the viscosity and specific gravity is reduced. A number of chemical processes are used to convert the raw oil into biodiesel. The most common method among them is transesterification [25].

The properties of biodiesel derived from cotton seed oil are comparable with those of diesel. The viscosity of cotton seed oil methyl ester is 3.75poise and its density is 0.87kg/m^3.

A. Use of Raw Cottonseed Oil

The chemical and physical properties of various vegetable oils and reported that almost all edible oils could be used as an alternative fuel for diesel engines. They further reported that the engine performance was disturbed when run it was run for longer time, using these oils. However the soybean, cottonseed, rapeseed, sesame, and corn oils have relatively better capabilities to be used as fuel. Biodiesel derived from cotton seed oil showed the acceptable results with reference to power and brake thermal efficiency. But the engine life was reduced and its fuel injection system started malfunctioning when it was run for longer duration using raw cotton seed oil.

B. Use of Processed Cottonseed Oil

The diesel engine with the blends transesetrified cottonseed oil and diesel with various proportions. The tested were carried out for about fifteen hours and the results with a 50% blend were most satisfactory for the performance of Cotton seed oil methyl ester (CSME) in a diesel engine. Those blends of CSME and diesel in various proportions and concluded that the optimum brake thermal efficiency can be obtained by using B30 and advancing the injection angle to 3-5º BTDC as compared to pure diesel (B0) [24].

They concluded that lower soot was produced using cottonseed oil as compared to sunflower oil. The CO and HC in exhaust emissions of for both of the fuels were reduced. The brake thermal efficiency and brake specific fuel consumption for sunflower and cotton seed oil was almost similar as that of diesel.

However there was significant decrease in CO but increase in NOx. Prepared biodiesel, using neat cotton seed oil and tested the engine performance and emissions using the biodiesel. The reduction of brake thermal efficiency which could be due to difference in spray pattern, calorific value, and incomplete combustion, as compared to diesel. A reduction in CO by 24% and increase in NOx by 10%, was noted when the engine was fed with B30. There was also minor decrease in HC and smoke opacity.

Methyl ester from cotton seed oil via a two-step transesterification and tested it in a ceramic coated and uncoated engine. The engine was run using the blends of diesel and cotton seed oil methyl ester with various ratios at different loads. The specific fuel consumption decreased up to 6%. The CO and smoke opacity was decreased by 18% and 8%. Fortunately the reduction in CO and smoke opacity was observed by 35% and 25% in ceramic coated engines respectively. Unfortunately increase in NOx was found by 4.5% with use of diesel and 7.3% with the use of biodiesel in ceramic coated and uncoated engines respectively, which could be due to increase in engine exhaust temperature.

2.3.4 Technologies in Biodiesel Production

There are three basic chemical processes used to produce biodiesel from oils and fats industrially. These processes can either be batch or continuous and are the following:

- ✓ Base catalyzed transesterification of the oil with alcohol (methanol).
- ✓ Direct acid catalyzed esterification of the oil with methanol.
- ✓ Conversion of the oil to fatty acids (acid pretreatment) and then to alkyl esters with acid catalysis.

Of the pro-mentioned methods available for producing biodiesel, transesterification of natural oils and fats is currently the method of choice. The purpose of the process is to lower the viscosity of the oil or fat. Transesterification is basically a sequential reaction (Figure 2.1). Triglycerides are first reduced to diglycerides, which are subsequently reduced to monoglycerides, which are finally reduced to fatty acid esters. The order of the reaction changes with the reaction conditions. The main factors affecting transesterification are the molar ratio of glycerides to alcohol, catalysts, reaction temperature and time, and free fatty acid and water content in oils and fats. Biodiesel as it is defined today is obtained by transesterifying triglycerides with methanol. Methanol is the preferable alcohol for obtaining biodiesel because it is the cheapest alcohol.

2.3.5 Oil from cottonseed

Biodiesel from used cottonseed oil was produced by reacting it with methyl alcohol in the presence of KOH. An experimental study was also carried out to examine the fuel properties, performance characteristics of different blends of used cottonseed biodiesel in comparison to diesel fuel. Performance characteristics like brake power, brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature of biodiesel blended fuelled C.I. engine were evaluated and compared with that by fuelling diesel while the engine running at no, part and full load condition. The objectives of this experimental study are to assess performance characteristics of a diesel engine when tested with selected fuels and compared with diesel as a reference fuel.

2.3.6 Biodiesel production processes

Biodiesel production from cottonseed oil was carried out for different parameters like catalyst type (NaOH and KOH), catalyst concentration (0.25%, 0.75% and 1.25%), Reaction time (0.5h, 1.5h and 2.5h) and Alcohol to oil ratio (1:1, 2:1 and 8:1).

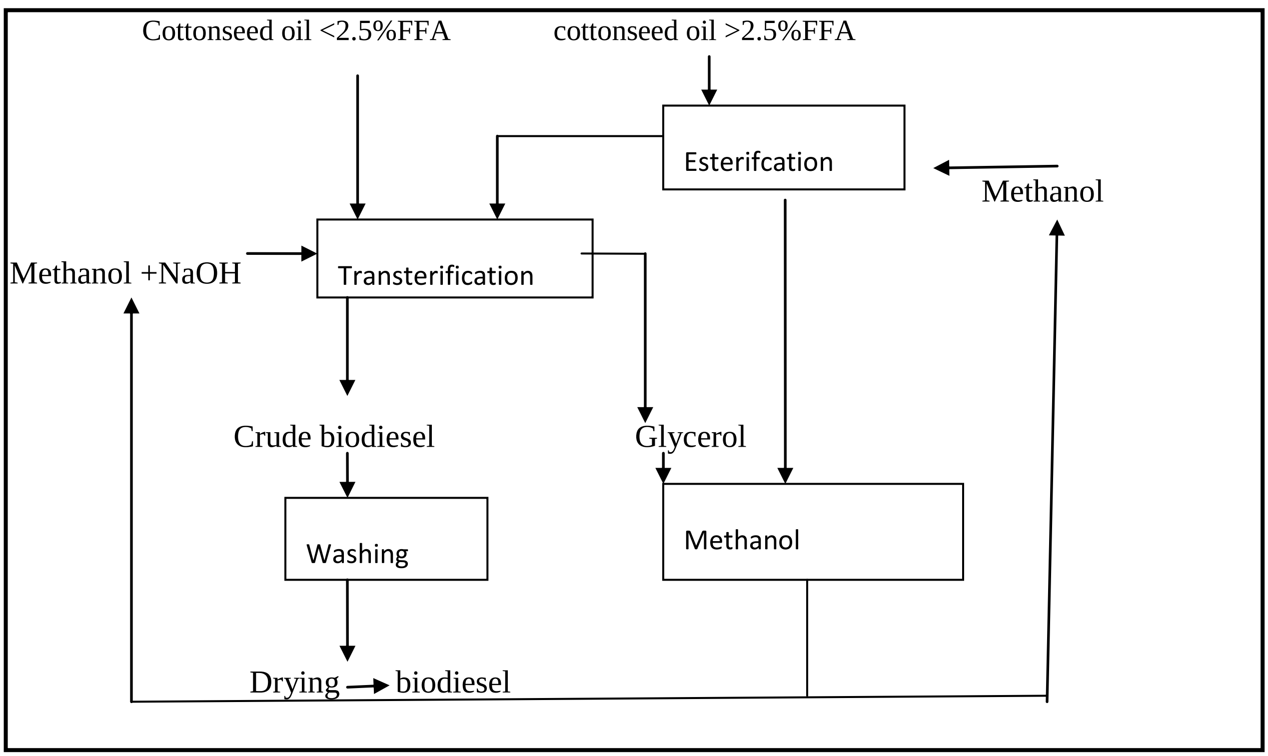

Figure.2.5 Flow chart of biodiesel production from cottonseed oil

Appropriate volume of methanol was measured and poured into a 250 ml conical flask as per the required ratio. The NaOH catalyst was weighed and mixed with methanol for about 15 to 20 minutes until all catalyst is dissolved. The flask was covered with aluminum foil during shaking to reduce the loss of alcohol by evaporation. The oil was preheated at temperature of 45ºC in water bath to melt coagulated oil molecules. 25 ml of heated oil was measured and poured into the conical flask, which already contained alcoxide mixture. This oil and alcoxide mixture was kept in shaker at 200 rpm and room temperature. After taking out from shaker, the product of the reaction was exposed to open air so that excess methanol gets evaporated. And then this mixture was allowed to settle using separating funnel for overnight. Crude ester was present at the top and glycerol at the bottom. Glycerol was removed and the biodiesel which was remaining in the separating funnel was collected and washed with water. Water and biodiesel was shaken gently for 1-2 minutes and then allowed to settle. It was washed several times until the washed water became clear. At the end, biodiesel was heated to remove any moisture content present after washing with water. For different parameters, the amount of ester produced was measured and the percentage of biodiesel yield was calculated by [(Volume of BD produced) / (Volume of oil used)] × 100 [11].

2.3.7 Other products of cottonseed oil

Various products can be derived from cottonseed of which cottonseed oil is very important. Crude cottonseed oil from the mill requires further processing before it is used in food. The first step in this processes refining. Treatment of the crude oil to produce refined grades is similar to that used for soyabean; it involves alkali refining to remove impurities, bleaching with activated clays and finally, steaming under vacuum conditions to remove traces of odors. The refining process also removes darker coloring materials present, leaving clear yellow oil.

Cottonseed oil finds application in the production of biscuits, crackers, doughnuts and potato chips and the preparation of ice cream substitutes (mellorines), in which process the oil replaces butter fat. Industrial uses of cottonseed oil include alkyl resins for interior paints, special lubricants and soft soaps [25].

2.3.8 Cottonseed yield

Cottonseed yield per hectare significantly increased when K was applied (by as much as 13.99%). Potassium would have a favorable impact on yield components, including number of opened bolls/plant and boll weight, leading to a higher cotton yield. The role of K suggests that it affects abscission (reduced boll shedding) and it certainly affects yield [6]. The elevated carbohydrate concentrations remaining in source tissue, such as leaves, appear to be part of the overall effect of K deficiency in reducing the amount of photsynthate available for reproductive sinks and there by producing changes in boll weight. Furthermore, K has an important role in the translocation of photo syntheses from sources to reproductive sinks [7]. Application of Zn significantly increased cottonseed yield per hectare, as compared with the untreated control (by 9.38%). Possible explanation of such results might be due the improvement of yield components due to the application of Zn. Zinc could have a favorable effect on photosynthetic activity of leaves [26], which improves mobilization of photosynthates and directly influences boll weight. Thus the number of retained bolls/plant and consequently cottonseed yield per hectare, would be increased.

Phosphorus application at all the three concentrations (600, 1200 and 1800 ppm as P2O5) also significantly increased cottonseed yield per hectare, where the three concentrations applied proved to excel the control (by 9.49-17.12%). Best yield was obtained at the high P2O5-concentration. Such results reflect the pronounced improvement of yield components due to application of P2O5 which is possibly ascribed to its involvement in photosynthesis and translocation of carbohydrates to young bolls. Phosphorus as a constituent of cell nucleus is essential for cell division and development of meristematic tissue and hence it would have a stimulating effect on increasing the number of flowers and bolls per plant(27).

2.4 Methods and devices for cottonseed oil extraction

2.4.1 Oil presses

Cotton is a tropical plant. Cottonseed oil is a vegetable oil extracted from the seeds of the cotton. After being freed from the linters, the seeds are shelled and then crushed and pressed or treated with solvents to obtain the crude cotton seed oil. Cotton seed oil is one of the most widely available oils and it is relatively in expensive.

The newest technology for oil pressing uses an expander, which helps release the oil and prepares the kernels for oil extraction. After the preparation step, the expanded collets are exposed to an organic solvent that dissolves out the oil. The mixture of oil and solvent is then put through a series of evaporators and stills to remove all solvent from the oil. The solvent is recovered and reused. Extracted kernels are put through a desolventizer to remove and recover the last traces of solvent. Meal produced by solvent processes usually contains 1-3% residual fat. Large, efficient processing plants of today employ the expander-solvent method to produce the highest quality products at the lowest cost [28].

2.4.2 Traditional methods

Traditional methods by which the oil is extracted from the cottonseeds by hand using simple implements are still practiced in rural and less developed areas.

2.4.3 Catalysts

Acid Catalyst: The use of an acid catalyst is observed to be more effective than alkali catalysts when the concentration of free fatty acids is high. Also the performance of the acid catalyst is not strongly affected by the presence of FFAs in the feedstock. In fact, acid catalysts can simultaneously catalyze both esterification and transesterification. Thus, a great advantage with acid catalysts is that they can directly produce biodiesel from low cost lipid feed stocks, generally associated with high FFA concentrations (low cost feed stocks, such as used cooking oil and greases, commonly have FFAs levels of >6%). However, Homogeneous acid catalyzed reaction is about 4000 times slower than the homogeneous base-catalyzed reaction. Acids used in the catalysis of the transesterification of biodiesels are usually either hydrochloric acid or sulfuric acid. Though these two acids are the most common, any Bronsted acid can be used in this reaction. The Biodiesel samples produced here are catalyzed using sulfuric acid.

Base catalyst: Transesterification reaction can be catalyzed by both homogeneous (alkalis and acids) and heterogeneous catalysts. The used alkali catalysts are NaOH, CH3ONa, and KOH for producing biodiesel. The alkali-catalyzed transesterification of vegetable oils proceeds faster than the acid-catalyzed. But the use of base catalyzed transesterification is only limited to oil having low water and FFA content. This reaction is the most widely used process for production of biodiesel worldwide. To keep check on the water and FFA content of the oil, they are first pretreated with an acid catalyzed transesterification process, which converts the FFA to esters [29].

2.4.4 Oil extraction

The cleaned seed meats are first passed through a series of pressure rolls to produce thin flakes, after which the flakes are under steam pressure, which ruptures the oil cells. Subsequently, the flakes are either pressed in hydraulic presses or processed in continuous screw type expellers which remove the oil under high pressure. There are various methods of extracting oil from oil producing seeds and these to a large extent determine the quality of the oil. The various methods include; mechanical extraction, traditional extraction, steam and high pressure method and solvent extraction.

The solvent extraction method is gaining acceptance, although not to as great an extent as in Soya bean oil production. Average yield of oil is about 16 - 17 percent of the cottonseed. Treatment of the crude oil to produce refined grades is similar to that used for soyabean; it involves alkali refining to remove impurities, bleaching with activated clays and finally, steaming under vacuum conditions to remove traces of odors (25).

2.4.5 Production process

Cotton seed oil is obtained from the processing of cottonseed, which is a byproduct of cotton production. Cotton is a crop, and the extracted cottonseed oil is considered a type of vegetable oil. Similar to other vegetable oils, cottonseed oil falls under the renewable biomass definition as being from planted crops and crop residues from existing agricultural land. At present production levels the national average is around 990 pounds of cottonseed produced per acre of cotton grown. Less than five percent of the seed must be set aside to plant the following year's crop. The remaining seed that is not needed for the next year's production to meet the cotton demand is used as raw material for the cottonseed processing industry or is fed to cattle, while a small amount is exported. Although not a primary product of cotton production, cottonseed brings additional value to the farmer as a secondary product. During recent years, the farm value of cottonseed has averaged about 15% of the total farm value of the cotton crop.

A. Water washing

Biodiesel must be washed to remove any remaining methanol, glycerin, catalyst, soaps and other impurities. Water used is warmed to about $45^{o}C$ and is passed through the esters to allow soluble material, excess catalyst and other impurities to stick to the water and be settled to the bottom of the vessel. The water is removed from the vessel periodically until the wash water drained out is clear or the pH of the biodiesel becomes relatively neutral.

Both glycerol and alcohol are highly soluble in water; water washing is very effective for removing both contaminants. It also can remove any residual sodium salts and soaps. The primary material for water washing is distilled warm water or softened water (slightly acidic). Warm water prevents the precipitation of saturated fatty acid esters and retards the formation of emulsions with the use of a gentle washing action. Softened water (slightly acidic) eliminates Calcium and Magnesium contamination and neutralizes any remaining alkali catalysts.

After washing several times, the water phase becomes clear, meaning that the contaminants have been completely removed. Then, the biodiesel and water phases are separated by a separation funnel or centrifuge. Moreover, because of the immiscibility of water and biodiesel, molecular sieves and silica gels, etc., can also be used to remove water from the biodiesel. The remaining water can be removed from the biodiesel by passing the product over heated Na_2SO_4 (25 wt. % of the amount of the ester product) overnight and then be removed by filtration.

However, there are many disadvantages to this method, including an increased cost and production time, polluting liquid effluent, product loss, etc. Moreover, emulsions can form when washing the biodiesel made from waste cooking oils or acidic feed stocks because of the soap formation [30].

B. Dry washing

The biodiesel washing sometimes leaves the biodiesel looking a bit cloudy. This means there's still a little water in it. It was heated slowly to 100^{o}C and held there until all moisture present was evaporated.

Dry washing used replacing the water with an ion exchange resin or a magnesium silicate powder in order to remove impurities. These two dry washing methods can bring the free glycerol level down and is reasonably effective for removing soaps. Both the ion exchange process and the magnesol process have the advantage of being waterless and thus eliminate many of the problems outlined above. Although the magnesol process has a better effect on the removal of methanol than the ion resins, none of the products from this process fulfill the limits specified in the EN Standard [30].

2.4.6 Mixing and neutralization

The purpose of mixing methanol with the catalyst is to produce methoxide which reacts with the base oils. Most of the catalysts (e.g. NaOH, KOH) are in solid form and do not readily dissolve into methanol, it is best to start agitating the methanol in a mixer and add the catalyst slowly and carefully. Once the catalyst completely dissolves in the methanol, the methoxide is ready to be added to the oil. Once the methoxide is added into the oil, a neutralization reaction will immediately start. Some alkali catalysts will react with rudimental acids during the pretreatment step or will react with the free fatty acids from the oil. Therefore, more catalyst needs to be added to complete the reaction [30].

3. MATERIALS AND METHODS

3.1 Project Design

The oil was interacted in Addis Modjo edible Oil complex in Modjo town (for producing crude oil from cotton seed, by mechanical pressing. Transterification and blending process was done in Chemistry department of ASTU. Performance test was conducted in automotive work shop of ASTU. In over the entire project includes the following activities.

- Seed preparation
- Production of oil from cottonseed which by using mechanical pressing.
- Production of biodiesel using transesterification process.
- Preparing diesel-biodiesel blends.
- Characterization of diesel-biodiesel properties.
- Conducting performance test.
- Comparing the performance of pure diesel and diesel-biodiesel blends.

3.2 MATERIALS

Table3.1 Materials used in transterification process

Sl.No	List of Materials
1	Cotton seed
2	Cottonseed oil
3	Methanol
4	KOH
5	Distilled water

Table 3.2 Vehicle specification

1	Engine model	Toyota 3L- 4122571
2	Stroke	4 stroke
3	Number of cylinder	4 cylinder
4	Transmission type	Manual
5	Fuel system	Diesel
6	Chassis number	LN 106-0136567

Also the equipment's that are used for in this project are the following.

Table3.3 Fuels and equipment used performance testing

S. No	List of Equipments
1	Chassis dynamometer
2	Magnetic stirrer with hot plate
3	Digital weighing scale
4	Glassware (Flasks)
5	Thermometer
6	Syringe

3.3 Methodology

It is mostly experimental based and includes the following stages. The procedure of each stage is given below.

3.3.1 Production of cottonseed

Before the oil is extracted from the seed; the raw cotton is collected from cotton ginning factory and separated the seed from the lint. Conventional diesel fuel purchased from fuel station in Adama and catalyst & alcohol was purchased from chemicals selling shops in Addis Ababa. After separating the process will be divided into two parts, such as;

- The lint will be baled and goes to textile industries for further processing
- The cottonseed goes to oil houses or factories and pressed by mechanical pressing machine for producing the oil.

3.3.2 Seed preparation

The processed raw cotton were requires for the preparation of seed by separating seed from lint; in the oil seed preparation which include; seed cleaning and seed drying.

3.3.3 Extraction of cottonseed oil

Oil was extracted at Addis Modjo edible oil factory by mechanical pressing. The amount of dried/ processed cotton seed from cotton ginning factory for oil extraction is 30 kg which were crushed/ broken into small pieces and pressed mechanically in the machine and finally 5 liter cottonseed crude oil was extracted.

The following are the major steps for extraction of cottonseed oil

1. The separated seed from lint and cleaned, crushed into small pieces.
2. The seed was poured into machine and pressed, and then oil was extracted.
3. The extracted oil was collected by using a plastic jerican.
4. After the collection of the crude oil, it is goes in to the chemistry laboratory for transesterification process.

3.3.4 Transesterification

Transesterification of cottonseed oil involves making triglycerides of cottonseed oil to react with methyl alcohol in the presence of a catalyst (KOH) to produce glycerol and fatty acid ester. Therefore, for this process we used for each sample was 2.5 gram of potassium hydroxide mixed with 30 ml of methanol and 150 ml of cottonseed oil (1:5 ratio) which is fully dissolved.

The transesterification process of producing cottonseed biodiesel:

1. 150 ml of cottonseed oil is measured and taken in a flask per sample.

Figure.3.1Measuring the sample oil

2. 30 ml of Methanol and 2.5 gm KOH were measured and taken into a flask for each sample.
3. Stirred the mixture until the KOH is fully dissolved in a Methanol.
4. Heat the crude oil to 65^0C.

Figure.3.2 Heating of cottonseed oil on magnetic stirrer hot plate

5. Pour the mixture (KOH and Methanol) in to the oil and stirred for 45 min.
6 Check the oil temperature.
7. Filter and pour the mixture in the decanter and keep for 24 hrs.
8. Two layers are formed in the decanter, *i.e*. bottom layer and top layer.
   - In the bottom layer – glycerol and fatty acid
   - In the top layer – ester (methyl ester)

Figure.3.3 Two layers of oil

9. Drain out glycerol and fatty acid from bottom layer through separator vessel.
10. Ester is remaining *i.e. biodiesel*
11. Wash the raw biodiesel using regular distilled water to remove impurities
12. Repeat washing process as required 3 times until water is mostly clears.
13. Biodiesel is allowed to settle until remaining water drops to the bottom.

Washing of bio- diesel is performed under the following steps;

- Water was heated at 50^0C
- One third volume of the biodiesel water was taken using syringe.
- The biodiesel was filled in a decanter and hung on stand
- By using the syringe, the water was sprayed to the oil slowly.
- The oil was left for 24 hrs hang in a decanter

- The water and soap settled at the bottom and was separated by opening the valve of the decanter

Figure 3.4 Washing of the oil

- The biodiesel was collected and heated by electric heater for 1hr at a temperature of 100^0C to evaporate the traces of water left during washing process

Figure.3.5 Heating and drying the biodiesel

14. Collecting the biodiesel and preparing for blending.

Figure.3.6 Collected bio-diesel

3.4 Blending of Biodiesel

The blends were made on a volume basis and stored in glass bottles at room temperature. The biodiesel which is prepared by transesterification process from cottonseed oil blended with conventional diesel fuel in proportion of 20% with 80% which is called B20, i.e. 20% biodiesel and 80% diesel fuel was conducted in diesel engine without any modification.

In this project the method used to blend the cottonseed biodiesel with conventional diesel fuel is splash mixing type rather than inline mixing type because, bio-diesel is slightly heavier than conventional diesel fuel (specific gravity 0.86 compared to 0.84 for diesel fuel). This allows use of splash blending by adding bio-diesel on top of diesel fuel for making bio-diesel blends. Bio-diesel should always be blended at top of diesel fuel. If bio-diesel is first put at the bottom and then diesel fuel is added, it will not mix.

3.4.1 Test fuels

The fuels used to test and blend in the experiment are: pure diesel and cottonseed biodiesel.

a. Pure diesel fuel　　b. Cottonseed biodiesel　　c. 20% biodiesel with 80% diesel blend

Figure 3.7 Fuels for test

Therefore blended fuels are; bio-diesel from cottonseed oil and conventional fuel at the proportion of only 20% with 80%. Such blending procedures are given below:

1. Collecting materials needed to blend the fuel.
2. Cleaning the materials used to blend.
3. Taking a cylindrical flask of one liter.
4. Preparing and measuring blends of 1000 ml in amount.
5. The blend B20 was prepared by taking 200 ml of biodiesel and 800 ml of petro diesel.
6. The blends were prepared by volume.

7. Stir while blending until it becomes homogeneous.
8. Checking phase separation of blend in graduated cylinder and keep this blend in the graduated cylinder for 24 hours to check whether it separates or not. It was kept in freezer at different temperatures to check for phase separation.
9. After the blend the fuel will be check its property and tests its performance

3.4.2 Characterization

Due to the time constraints only four properties of the biodiesel is measured in ASTU density (chemical engineering department), kinematic viscosity (material engineering department) and range of biodiesel (chemistry department).

Table3.4 Fuel characteristics

No	Property	Diesel	Cottonseed Biodiesel	ASTM Standard
1	Kinematic viscosity (mm^2/s) @ 40^0c	3.12	5.82	1.9 - 6
2	Density (kg/m^3) @ 15 ^0c	0.84	0.86	0.86 - 0.9
3	UV test (nm)	-	238	230 -270
4	Acidvalue(mg of KOH/g)	0.22	0.61	0.80

3.5. Performance testing

The performance of fuel was tested using chassis dynamometer in four stroke 3L diesel Toyota vehicle available in automotive work shop in ASTU. The blend of biodiesel is 20% (B20) and compares with pure diesel. The performance of the engine with blend of biodiesel and petro diesel can be evaluated by measuring torque, power and its fuel consumption at different speeds. The power and brake specific fuel consumption can be calculated.

Two sets of engine experiments were performed to evaluate the power. The experiments were conducted for conventional diesel 80% and 20% biodiesel blend. In all settings, the experiments were conducted as for the steps given below.

1. Fuel blends were prepared by volume.
2. The engine fuel tank was cleaned and filled with the fuel to be tested.

3. The engine was run with the test fuel for about five minutes to get warm up and stabilize.
4. After warming up the test was conducted for pure diesel engine at different test speeds then different parameters has been read from the dynamometer
5. And such parameters tractive force and power at the rear wheel were recorded at different speeds at equal intervals in the speed range.

3.5.2 Vehicle testing procedure

For obtaining the performance, the engine is started with diesel and the engine is in its appropriate operating condition by applying full throttle and reaches its maximum power. The vehicle was driven on the chassis dynamometer and the tractive effort (KN) and wheel power (KW) which is measured at test speed of starting from 25 Km/hr which is a minimum speed on the sun Road-a-Matic XII chassis dynamometer. The experiment was conducted in first gear, second gear, third gear, fourth gear and fifth gear. The time taken for the consumption of ten grams of fuel was recorded.

Experiments were performed with two different(with conventional diesel and with cottonseed biodiesel) fuels starting from 25 km/hr, 30 km/hr, 35 km/hr, 40 km/hr,…100km/hr with 5 km/hr intervals; of full load for different speed whose fuels were pure diesel and biodiesel (blend of 20% biodiesel with 80% diesel).

Therefore, in this experiment first the performance of conventional diesel fuel was tested and then the blended one.

3.6 Data collection

3.6.1 Primary data

Primary data was collected through interviews with Mr. Selemun (Head of Chemistry Department, ASTU) in extraction of biodiesel from edible oils, blending and its characterization. Similar information was gathered from contacts in Addis Modjo edible oil factory. Additional data were the results from laboratory transeterification experiments in the department of chemistry in ASTU and related chemical reactions.

3.6.2 Secondary data

In this data was gathered by reviewing the literature which are related with biodiesel production specifically from cottonseed about its oil extraction, transesterification process, blending with pure diesel and its performance.

4. RESULTS AND DISCUSSIONS

4.1 Extraction of cottonseed oil

Oil was being extracted from seed of cotton plant using mechanical press oil extraction method in Addis Modjo edible oil complex private limited company which is found in Modjo town. During the extraction of oil five litters (5 L) of oil is extracted from Thirty kilograms (30 Kg) of cotton seed. The oil extracted in percent is 17 % (v/w ratio).

4.2 Biodiesel Yield

The production of biodiesel was done by transesterification reaction process using alcohol and catalyst (methanol and KOH). After washing and neutralizing three times by heating distilled water at 50^0C. Finally, drying the biodiesel by heating at 100^0c and production yield is found to be 75 %.

4.3. Transesterification Process of cotton seed methyl ester

Transesterification of cottonseed oil is done to reduce its viscosity by separating glycerol content from it. The separation of glycerol is depends on by the parameters such as molar ratio, catalyst type, catalyst concentration, reaction time, reaction and temperature. Table below shows parameters used in this experiment.

Table 4.1Transterification process

Amount of cottonseed oil (ml)	Molar ratio	Concentration of catalyst & type (KOH) %	Concentration of alcohol & type (Methanol) in ml	Reaction time in minute	Reaction temperature in ^{0}c	Settling time in hr
150	1:5	1.7	30	60	65	24

The effect of KOH concentration was studied in the range of 1 - 2.5% (weight of KOH/weight of oil) which is taken in this experiment is 1.7 % getting 2.5 gm of KOH for 150 ml of the mixture. It was found that the ester recovery increases as the amount of catalyst decreased from 2.5-1%. Ester recovery decreases drastically as KOH concentration increases above 2.5% whereas ester recovery increase as KOH concentration reduces to almost 1%. This lesser recovery at high KOH concentration may possibly be due to high soap formation.

4.4 Performance Testing Result

Biodiesel from cottonseed oil was produced at the ASTU chemistry department laboratory which is replacement for conventional diesel fuel. Therefore the research was mainly concentrated on investigating engine performance at B20 blend ratio for five engine speeds by using Sun road –a- matic XII chassis dynamometer. As the initial step 20% of biodiesel were measured and mixed by splash method with petro-diesel to make a blend. Then, after blending the test is begin with pure diesel to compare with biodiesel by evaluating torque. The chassis dynamometer is capable of measuring the power output and tractive effort applied at the drive wheels.

When the performance is tested engine speed, brake torque, brake power and the flow rate of fuel are not registered directly. That means, brake torque is calculated from the wheel torque which is resulted from tractive force. Brake power was calculated from the wheel power and vehicle speed. Also the brake specific fuel consumption (BSFC) was calculated from the mass flow rate and brake power.

Tractive effort and wheel power

Tractive force is the force available at the contact between the rear wheel tires and road and which was recorded at the drive wheels on chassis dynamometer used to determine the torque produced by the engine. The measured value of tractive effort (F) in KN of diesel from chassis dynamometer is used for calculating the torque at the rear wheel and furthers also the brake torque. The measured values are listed in below table at different speed.

Table 4.2 Tractive effort for diesel fuel

Tractive force for Diesel (KN)				
Vehicle. speed (km/hr)	1st	2nd	3rd	4th
25	2.7	2	1.5	1.2
30	1.3	1.8	1.55	1.3
35	0.5	1.5	1.6	1.35
40		1.1	1.6	1.35
45		0.7	1.56	1.3
50			1.35	1.25
55			1.2	1.1
60				0.9
65				0.8
70				0.5

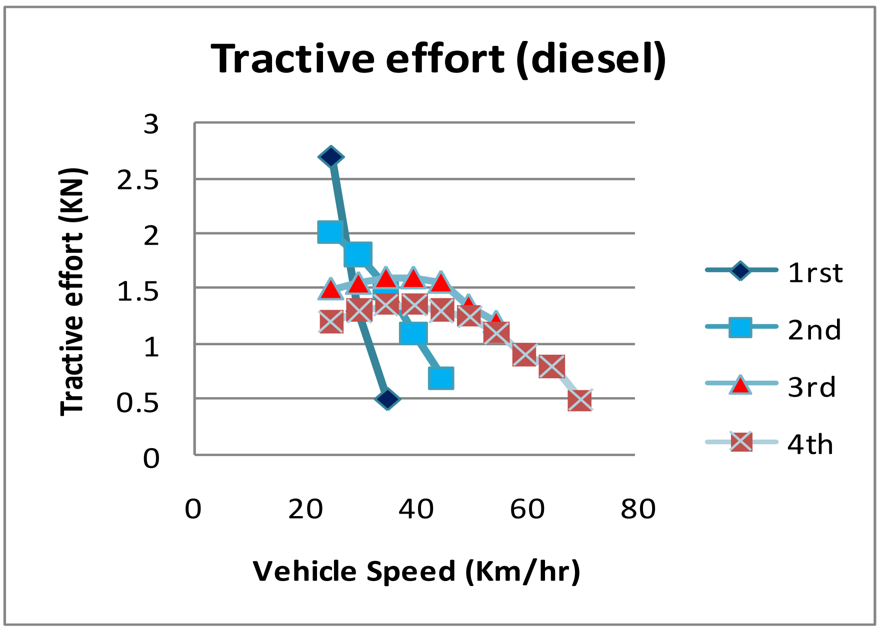

Figure.4.1 Tractive effort vs. vehicle speed for different gear ratios

Table 4.3 Tractive effort for blend fuel

Tractive effort for B20				
Vehicle Speed (Km/hr)	1st	2nd	3rd	4th
25	2.6	1.9	1.5	1.1
30	1.28	1.7	1.68	1.25
35	0.47	1.4	1.53	1.28
40		1	1.58	1.28
45		0.6	1.54	1.25
50			1.3	1.21
55			1.18	1
60			0.9	0.8
65			0.5	0.6
70				0.5

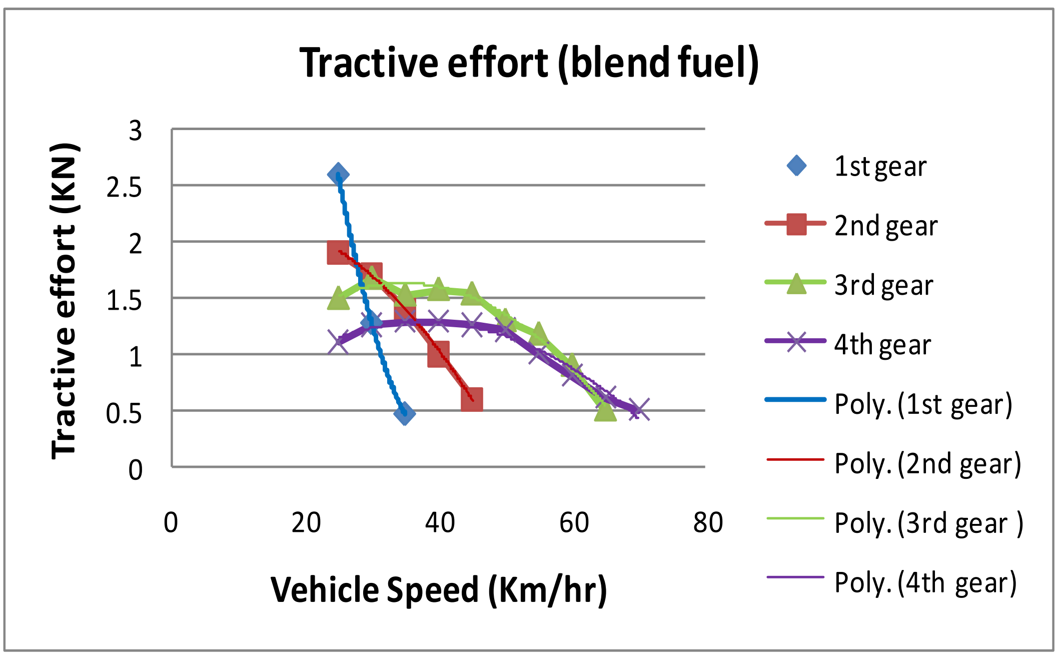

Figure.4.2 Tractive effort vs vehicle speed on blend fuel

This tractive force result used to calculate the wheel torque, which used further to find the brake torque using the following formula.

From equation

$$F = \frac{\boldsymbol{Tw}}{\boldsymbol{r}} \text{.................................} \quad (1)$$

$$T_w = F * r_w \text{.................................} \quad (2)$$

Where: T_w- wheel torque

F- tractive effort

r_w- wheel radius

Table 4.4 Wheel power for diesel fuel

Wheel power for diesel				
Vehicle .speed (Km/hr)	1st	2nd	3rd	4th
25	15	14		
30	16.5	16		
35	16	16.5	15.55	
40	14	17	16.5	14.5
45	13	17.2	16	15.2
50		15.5	16.2	16.4
55		15	15	16.2
60		14.5	14.68	15
65		12	14	13.75
70		10	13	12
75		8	12	11.25

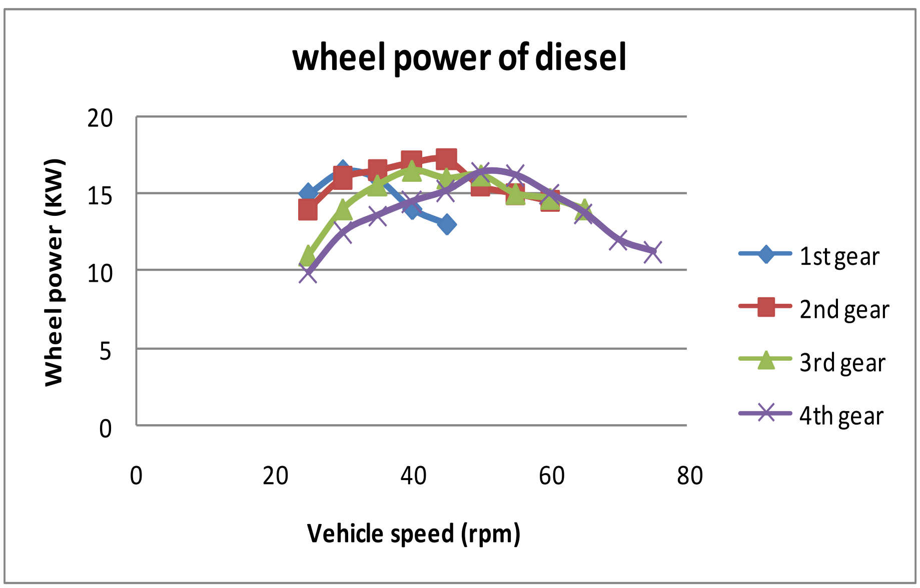

Figure.4.3 Wheel power vs vehicle speed of diesel fuel

Table 4.5 Wheel power of blend fuel

Wheel power for B20				
Vehicle speed (Km/hr)	1st	2^{nd}	3rd	4th
25	14	13.6		
30	15.5	15		
35	13	16	14.75	
40		16.5	15.85	13.5
45		16.45	16.45	13.65
50		16	16	13.5
55		15.5	15	13.5
60		14	14.5	12
65		11.8	13.89	11
70		9.5	12.65	10
75		8.3	11	9

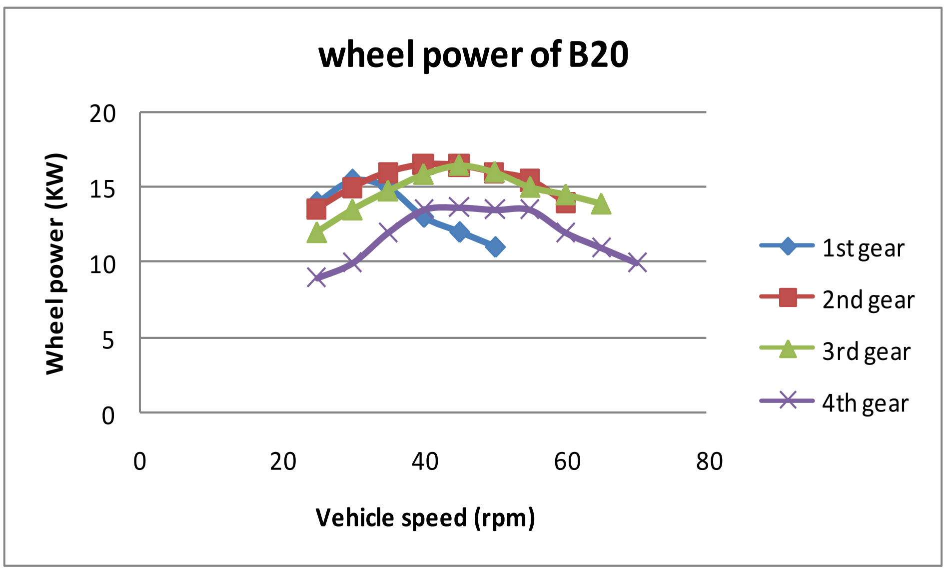

Figure.4.4 Wheel power vs vehicle speed for blend fuel

The above data was reads directly from the chassis dynamometer and shows the relationship between tractive effort and vehicle speed using different gear ratios. After plotting the curve of those values, it is used to calculate the wheel torque and brake torque. The registered wheel power is used to calculate the brake power, which is

$$Pb = \frac{Pw}{\eta t} \quad \text{(3)}$$

Where: P_b- brake power

Pw- wheel power

ηt - gear box efficiency

Table.4.6 Wheel torque of diesel fuel

Wheel torque of diesel (Nm)				
Engine speed (rpm)	1st	2nd	3rd	4th
3253.07	974.70	722.00	541.50	433.20
3903.68	469.30	649.80	559.55	469.30
4554.29	180.50	541.50	577.60	487.35
5204.91		397.10	577.60	487.35
5855.52		252.70	563.16	469.30
6506.13			487.35	451.25
7156.75			433.20	397.10
7807.36				324.90
8457.97				288.80
9108.59				180.50

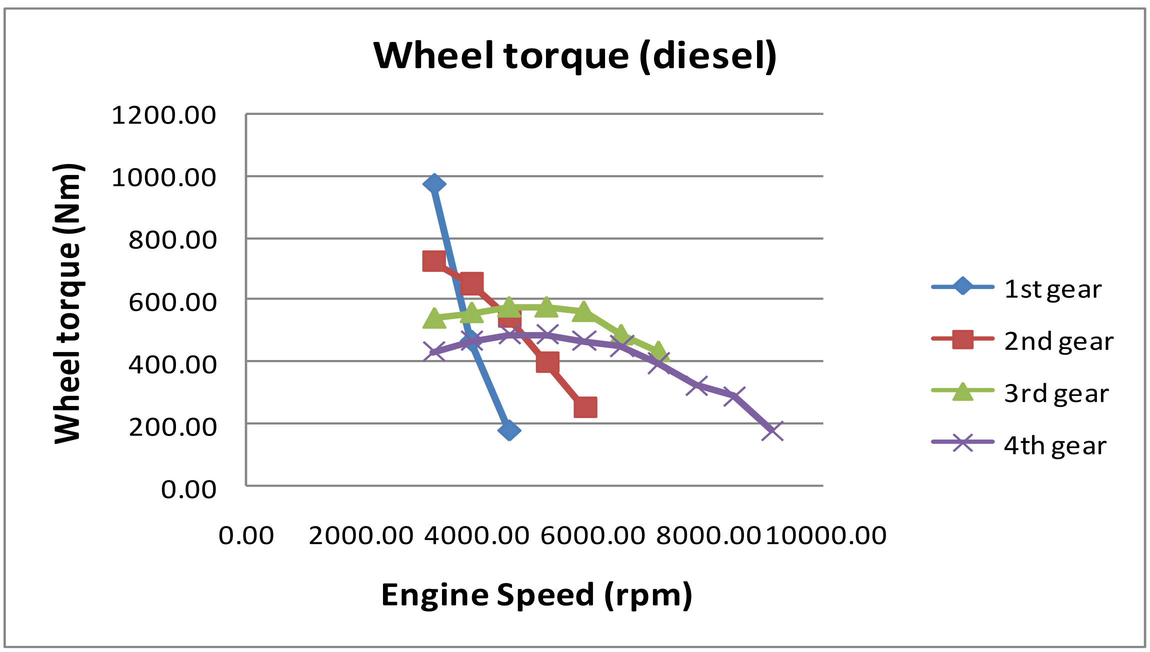

Figure.4.5 Wheel torque vs engine speed of diesel fuel

Table.4.7 Wheel torque of blend fuel

Wheel torque for blend fuel (Nm)				
E. speed (rpm)	1^{st}	2nd	3rd	4th
3253.067	938.6	685.9	541.5	397.1
3903.68	462.08	613.7	606.48	451.25
4554.293	169.67	505.4	552.33	462.08
5204.907		361	570.38	462.08
5855.52		216.6	555.94	451.25
6506.133			469.3	436.81
7156.747			425.98	361
7807.36				288.8
8457.973				216.6
9108.586				180.5

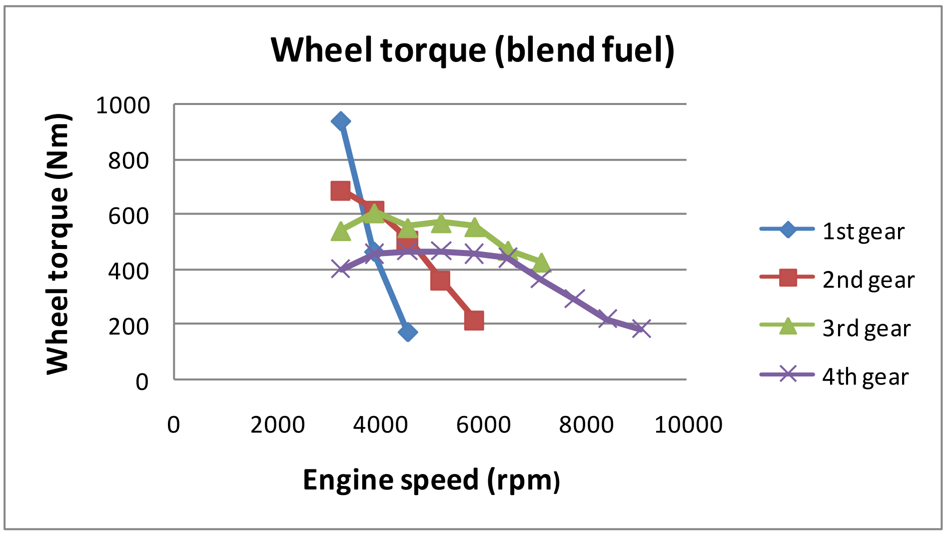

Fig 4.6 Wheel torque vs Engine speed for blend fuel

Brake torque (Tb)

By using equation (2) from the above and the calculated wheel torque, the brake torque will be finding by using below equation

$$T_w = (g.r \times a.r)\ \eta_t \times T_b \quad \text{...} (4)$$

$$Tb = \frac{Tw}{(g.r * a.r) * \eta t} \quad \text{...} (5)$$

Where Tw = torque at rear wheels

g.r = gearbox gear ratio

a.r = back axle ratio

ɳt = overall transmission efficiency

Tb = brake torque

The vehicle (Toyota Hilux model 3L engine) has a 5 speed transmission with the following gear ratios:

Table 4.8 vehicle gear ratio

Gear	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	Final drive
Gear ratio	3.901	2.432	1.654	1	0.812	4.544
Efficiency	0.80	0.825	0.85	0.87	0.90	0.92

The chassis dynamometer used for the test does not have engine revolution counter, it rather displays wheel speed in Km/hr. It is therefore necessary to calculate the engine speed (N) from the wheel speed.

The relationship between engine revolution (N) and vehicle speed (V) depends on the overall gear ratio. The engine revolution and vehicle speed can be related with the following expression:

$$\frac{2\pi N}{g.r*a.r} = \frac{1000\ V\ (\frac{km}{hr})}{60} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\mathrm{N} = \frac{\mathrm{V*g.r*a.r*1000}\ (\frac{\mathrm{rev}}{\mathrm{min}})}{CR*60} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$\mathrm{N} = \frac{2.65*\mathrm{V*g.r*a.r*}(\frac{\mathrm{rev}}{\mathrm{min}}}{\mathrm{r}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where CR = the driving wheel circumference in m = 2π x tyre radius (r)

N = the engine speed in rpm

g.r = gear box ratio

a.r = back axle ratio

r = the radius of the wheel is 0.361m

Therefore, using equation (8) calculating the speed in rpm and the vehicle is driven with diesel fuel in first gear with full throttle, the engine is running at its maximum speed. When the vehicle is driven by 25 km/hr, of first gear, the engine rpm is 3253.07 rpm. At 30 km/hr rpm reaches 3903.6 km/hr, and at 35 km/hr engine runs at 4554.3 rpm. As a result the tractive effort of the diesel cottonseed biodiesel increases when the vehicle runs with the second gear and as the vehicle speed increases the tractive effort will be decreases.

After the value of engine speed are found, brake torque versus engine speed graph having the following result will be constructed.

Table 4.9 Brake torque for diesel

Brake torque for diesel				
E. speed (rpm)	1st	2nd	3rd	4th
3253.07	74.71	49.59	92.13	95.38
3903.68	35.97	44.63	95.20	98.56
4554.29	13.84	37.19	98.28	101.74
5204.91		27.27	98.28	101.74
5855.52		17.36	95.82	99.20
6506.13			82.92	85.84
7156.75			73.71	76.31
7807.36				
8457.97				
9108.59				
9759.20				

Table 4.10 brake torque of blend fuel

Brake torque for blend fuel				
E. speed (rpm)	1st	2nd	3rd	4th
3253.07	38.97	47.11	56.34	69.95
3903.68	19.19	42.15	63.10	79.49
4554.29	7.04	34.71	57.47	81.39
5204.91		24.79	59.35	81.39
5855.52		14.88	57.84	79.49
6506.13			48.83	76.94
7156.75			44.32	63.59
7807.36				50.87
8457.97				38.15
9108.59				31.79
9759.20				

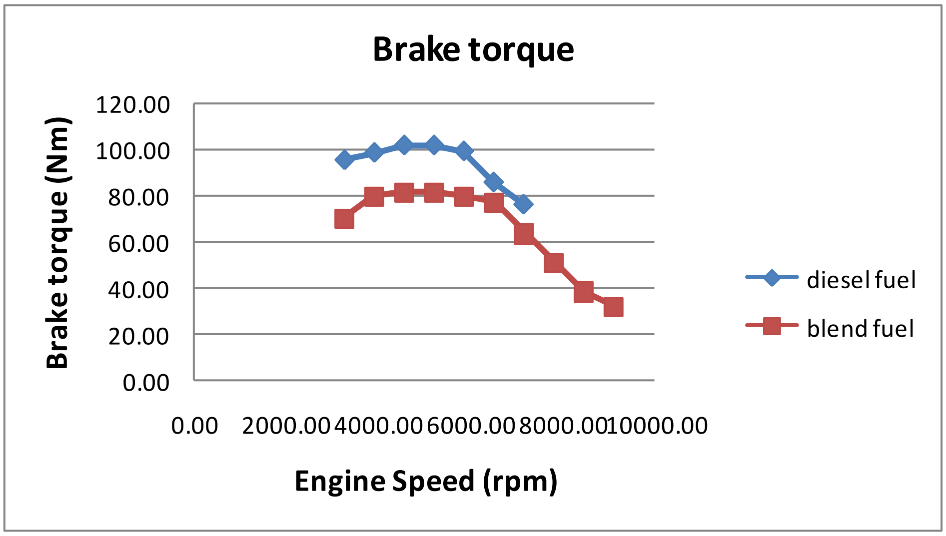

Figure.4.7 Brake torque for diesel and blend fuel vs engine speed

From the above curve observed that the torque increases with the increasing of speed up to 5204.91 rpm from about 101.74 Nm and decreasing further with increase in speed. Therefore the maximum torque has been achieved around 5204.91 rpm. It is similar for blend fuel (B20).

Brake power (P_b)

Table 4.11 Brake power for diesel fuel

Brake power for Diesel				
E. speed (rpm)	1st	2nd	3rd	4th
3253.07	20.38	18.45	14.07	13.45
3903.68	22.42	21.08	17.90	16.98
4554.29	21.74	21.74	19.88	18.48
5204.91	19.02	22.40	21.10	19.70
5855.52		22.66	20.46	20.65
6506.13		20.42	20.72	22.28
7156.75		19.76	19.18	22.01
7807.36		19.10	18.77	20.38
8457.97		15.81	17.90	18.68
9108.59		13.18	16.62	16.30
9759.20		10.54	15.35	15.29

Table 4.12Brake power for blend fuel

Brake Power for Blend fuel (Kw)				
E.speed (rpm)	1st	2nd	3rd	4th
3253.07	19.02	17.92	15.35	11.24
3903.68	21.06	19.76	17.26	12.49
4554.29	20.38	21.08	18.86	14.99
5204.91	17.66	21.74	20.27	16.87
5855.52		21.67	21.04	17.05
6506.13		21.08	20.46	16.87
7156.75		20.42	19.18	16.87
7807.36		18.45	18.54	14.99
8457.97		15.55	17.76	13.74
9108.59		12.52	16.18	12.49
9759.20		10.94	14.07	11.24

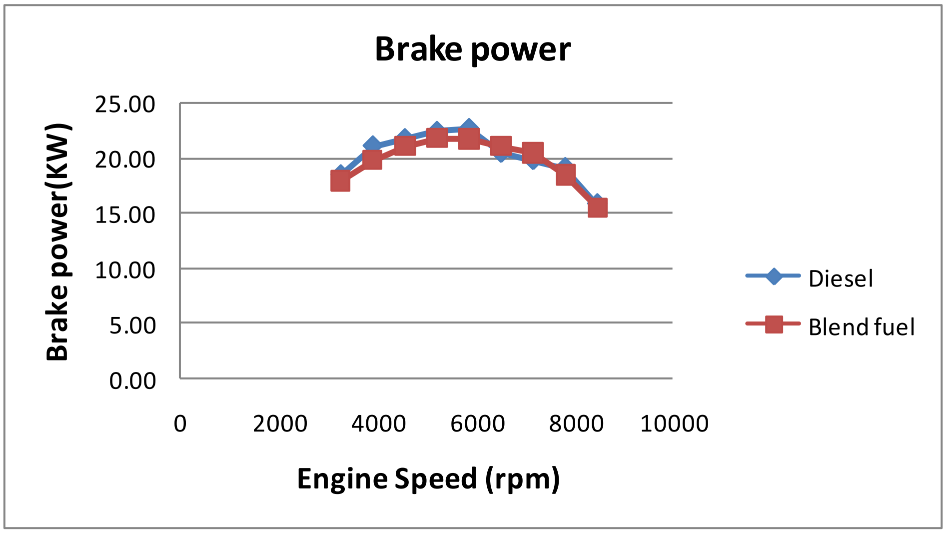

Figure.4.8 Brake power vs engine speed of Diesel and blend fuel

The above curve observed that the power with the blended fuel will be less as compared to conventional diesel fuel which is 22.66kN at 5855.52 Al so similar to blend fuel.

Brake specific fuel consumption (BSFC)

In engine tests, the fuel consumption is measured as a flow rate; mass flow per unit time (Mf) which is uses the specific fuel consumption (sfc) the fuel flow rate per unit power output.

$$\text{Specific fuel consumption (sfc)} = \frac{mass\ \ flow\ \ rate}{Power} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (9)$$

$$\text{Brake specific fuel consumption (bsfc)} = \frac{\text{mass flow rate}}{Brake\ \ power} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

For calculating the bsfc first the mass flow rate of the fuel is determined, the brake specific fuel consumption can be calculated using equation below.

$$\text{BSFC} = \frac{mf\left(\frac{gm}{se}\right) * 3600}{Pb}\left(\frac{gm}{kw\,hr}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (11)$$

Table.4.13. BSFC of diesel fuel

BSFC of diesel fuel (gm/kwhr)			
Engine Speed (rpm)	time (sec)	Mf	Bsfc
3253.07	16.50	0.61	176.38
3903.68	15.67	0.64	183.79
4554.29	14.50	0.69	146.13
5204.91	14.00	0.71	141.91
5855.52	13.75	0.73	137.87
6506.13	13.50	0.74	130.14
7156.75	13.00	0.77	136.82
7807.36	12.65	0.79	151.78
8457.97	11.75	0.85	178.23
9108.59	10.50	0.95	244.03
9759.20	10.75	0.93	

Table. 4.14. BSFC of blend fuel

BSFC of blend fuel (gm/kwhr)			
Engine Speed (rpm)	time (sec)	mf	bsfc
3253.06	13.26	0.75	241.48
3903.68	12.75	0.784	225.99
4554.29	11.84	0.84	202.80
5204.91	10.63	0.94	200.79
5855.52	10.03	0.99	210.46
6506.13	9.45	1.06	225.86
7156.75	10.35	0.96	206.22
7807.36	11.02	0.91	217.89
8457.97	12.05	0.83	217.38
9108.57	12.6	0.79	228.68
9759.2	13	0.77	246.27

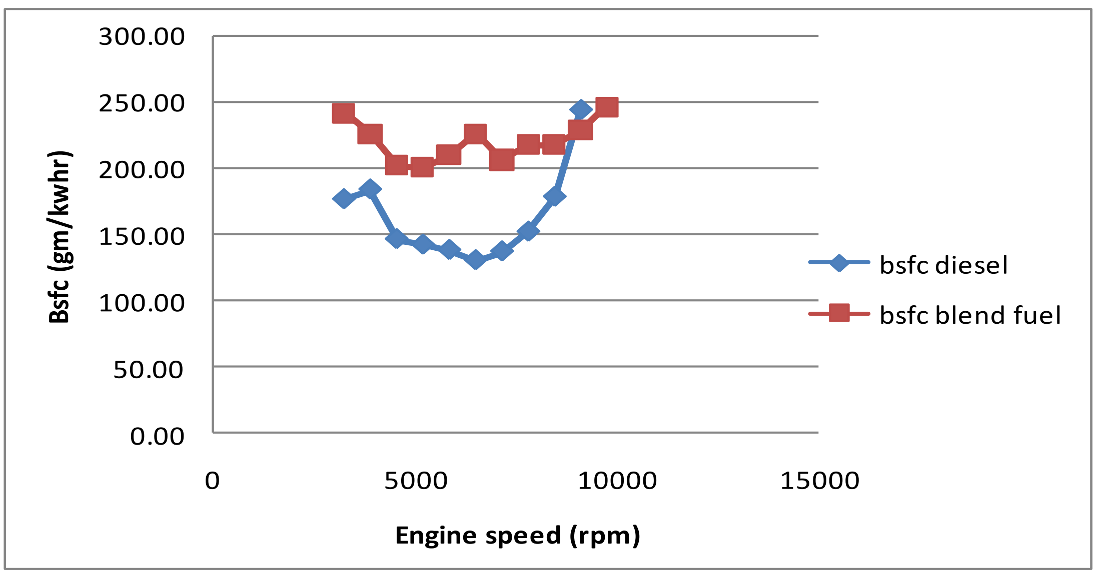

Figure.4.9 BSFC Vs engine speed of Diesel and blend fuel

The maximum BSFC of 244 gm/kWhr and the least bsfc of 130gm/kWhr is found at 9108 rpm & at 3253 rpm when the vehicle running with diesel fuel.

Performance curves

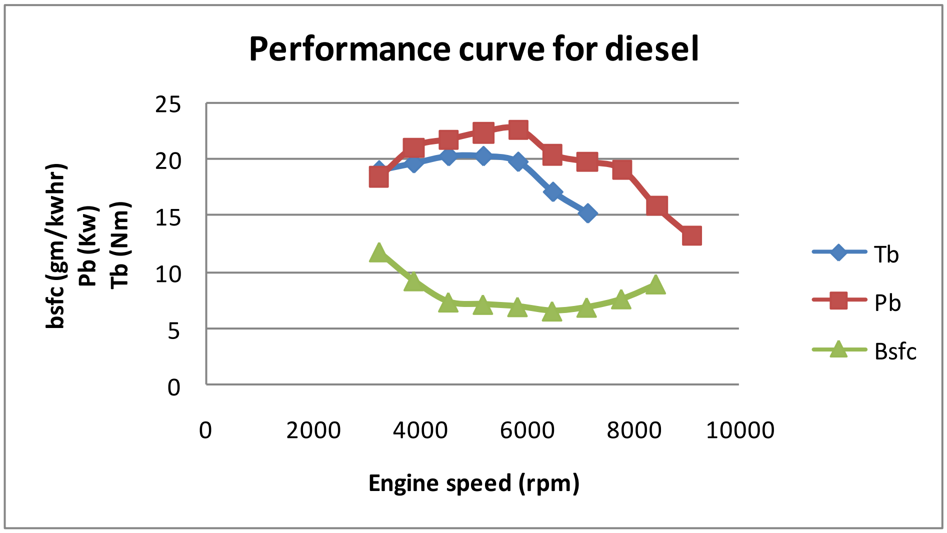

Figure 4.10 Performance curve of diesel fuel

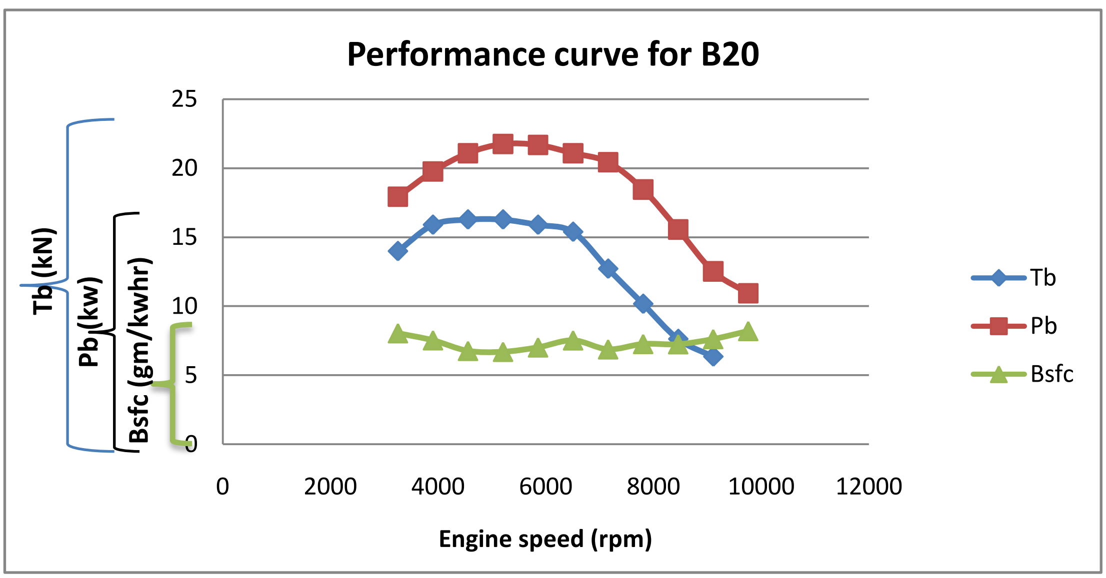

Figure.4.11 Performance curve for bend fuel

The above curves shows that the performance of fuel which is by comparing the conventional diesel with the blended fuel (cottonseed biodiesel). This comparison will be done by comparing the power torque, brake torque and fuel consumption with engine speed.

As a result the maximum torque brake and brake power decreases and brake specific fuel consumption is increases with the increase in engine speed. This is will be the reason for the high heating value with its high viscosity.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main aim of the study was to test the performance of diesel on vehicle with diesel-biodiesel as a fuel without any major modification. For starting purpose conventional fuel was used.

For oil extraction it is better to use mechanical pressing than chemical and enzymatic extraction. The mechanical extraction method is very much cheaper than the other extraction methods. As the amount of ethanol in B20 increases the performance of the fuel increases however using more than thirty milliliter of methanol per liter drops the viscosity of the fuel that could affect the lubrication property of the fuel on which the life of the fuel pump depends.

In this work transesterification reaction was carried using the cottonseed oil. The quantity of potassium hydroxide catalyst for optimal biodiesel yield of 75.5% was 2.5 gm per liter at reaction time of one hour, reaction temperature of 65^0C and volume ratio of oil to methanol as 5:1.The transesterifcation reaction is affected by molar ratio of glycerides to alcohol, catalysts, reaction temperature, reaction time and free fatty acids and water content of oils.

In conclusion the brake power of B20 is found to be lower than B0. This is because of the higher heating value of biodiesel.

5.2 Recommendations

The study of cottonseed oil has can be used as a resource to obtain biodiesel, which gives opportunities for generation of rural development and increasing income. So the development on additional fuel property blending conditions, engine performance and emission tests are necessary. Ethiopia is good in agricultural sector, the plantation coverage of cotton is located different areas i.e. Gondar metema, Humera, Afar... The performance test is done on a chassis dynamometer which is found in the department of Mechanical and Vehicle Engineering. The engine dynamometer is not functional but chassis dynamometer is functional, therefore the accuracy of the measurement is sufficient to measure different speeds and fuel consumption. The byproduct of cottonseed biodiesel could be used for different purposes. The cake used for animal feeds after mechanical pressing. The soap could be used as raw material for cosmetic industry. Therefore biodiesel industries shall use the byproducts in order to compensate the biodiesel price

5.3 Educational Implication

The objective of the National TVET strategy is to create a competent, motivate, adaptable and innovative workforce in Ethiopia contributing to poverty reduction and social & economic development through facilitating demand driven, high quality technical and vocational education and training, relevant to all sectors of the economy, at all levels and to all people in need of skill development transferring new technologies.

The industries are the stakeholders of the TVET institutions the progress has an impact on the outcome based training. So the industries and TVET linkage is very important to provide quality and outcome based training. The main objective of all technical and vocational education and training programs is the acquisition of relevant knowledge, practical skills and attitudes for gainful employment in a particular occupational area. The benefits of investing in vocational education and skills are, creating a qualified people with the knowledge and skills to contribute significantly to economic development, to be entrepreneurial, develop science and technology, and deliver basic services.

The objective of this project is to show how biodiesel can be produced from cotton seed and usage of biodiesel and diesel blends in diesel engine.

- Technological advance and progression.
- Effective labor training and re-training
- Reducing fuel importing
- Job opportunity gives to many people by participating biodiesel production.
- The capacity of industries are increase works by fuel

The institution should support the company or small enterprises by providing training for the workers to fill the skill gap. The TVET institution to provide improved curriculum for the next generation based on labor market especially on Biodiesel production and blending technology, and testing their performance in engine.

5.4 Future research

This project was done only with the bend of B20 and checks the performance comparing with the conventional diesel. The future will conduct with other bends by with or without the addition of additives which is improving the performance of cottonseed biodiesel as alternative fuel and increasing the production of cotton seed. The opportunities for expanded cottonseed biodiesel production are considering the high demand for petroleum products in the country.

As a result, the increased awareness of the negative environmental factors associated with petroleum fuels and a desire to move to renewable fuels, biodiesel production from cottonseed is growing significantly. However, it represents the fossil fuel which in the reduction of environmental aspects.

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APPENDIX - B

Interview questions

Questions asked during interview

1. What are the criteria's to extract oil from cottonseed?
2. Would you describe the process of cotton seed oil extraction?
3. What are the factors affects the extraction process?
4. Where is your source of raw material (cottonseed)?
5. What is the difference in the process of biodiesel to edible oil from cottonseed?
6. Would you tell us the distribution area of cottonseed biodiesel

APPENDEX-A

Cost analysis

S.No	Material	Unit	Qua ntity	Unit price	Total price
1	Cottonseed	kg	30	10	300
2	Methanol	liter	1	300.87	300.87
3	KOH	kg	0.5	660.87	660.87
4	Distilled water	liter	9	10	90
5	Diesel fuel	liter	19	15	285
6	Plastic reservoir	psc	3	15	45
7	Jerican (plastic)	psc	3	20	60
8	Transport cost	-----	-	------	1500
9	Labor cost	-----	-	-------	1600
10	Others	-----	-		500
11	Soap	litre		-	40
12	Rag	kg	2	20	40
Total					**5421.74**