ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Mechanical, Chemical and Materials Engineering

THE EXPERIMENTAL INVESTIGATION ON PERFORMANCE OF COTTON SEED BIODIESEL WITH NANO ADDITIVE IN SINGLE CYLINDER DIESEL ENGINE

A Thesis Submitted In Partial Fulfillment of the Requirements for the Award of the Degree of Master of Science in Automotive Engineering

by

Megersa Lemma

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MECHANICAL SYSTEMS AND VEHICLE ENGINEERING PROGRAM

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APPROVED BY BOARD OF EXAMINERS

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in a thesis work entitled "**The Experimental Investigation on Performance of Cotton Seed Biodiesel with Nano Additive in Single Cylinder Diesel Engine**" in partial fulfillment of the requirement for the award of the degree of Masters Science in Automotive Engineering is an authentic record of my own work carried out from February, 2018 to September, 2018 under the supervision of Mr. N. Ramesh Babu (Assistance Professor), Department of Mechanical and Vehicle Engineering, Adama science and Technology University, Ethiopia.

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

<u>Megersa Lemma Hunde</u>	______________	______________
Student	Signature	Date

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

<u>N.Ramesh Babu (Assistance Prof.)</u>	______________	______________
Advisor	Signature	Date

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ACRONYMS AND SYMBOLS

Al_2O_3	Aluminum oxide
ASTM	American Standards Testing and materials
B0	pure diesel
B10	10% Cotton seed biodiesel + 90% diesel
B20	20% Cotton seed biodiesel + 80% diesel
B20+CeO_2	20% Cotton seed biodiesel + 80% diesel + Cerium Oxide
B25	25% Cotton seed biodiesel + 75% diesel
BSEC	brake specific energy consumption
BSFC	Brake specific fuel consumption
CeO_2	Cerium oxide
CO	Carbon monoxide
CSME	Cotton Seed Methyl Ester
CuO	Copper oxide
FeO_2	Ferrous oxide
FFA	Free fatty acid
Kg	Kilogram
Km/hr	Kilometer per hour
KOH	Potassium hydroxide
Kpa	Kilo Pascal
Mg	Milligrams
Mm	Millimeters
NOX	Oxides of nitrogen
NP	Nano particle
PPM	Parts per million
TiO_2	Titanium di-oxide
UBHC	Unburned hydrocarbon
ZnO	Zinc oxide
ZnO_2	Zink peroxide
BMEP	Brake means effective pressure

CRDI	Common ray direct injection
CRFI	Common rail fuel injection
CNTS	Carbon nanotubes
MWCNT	Multi walled carbon tube
HOME	Hinge oil methyl ester
SWNT	Single-walled nanotubes
KME	Karanja methyl ester
CSO	Cotton seed oil
TIDI	Textile industry Development Institute
GOE	Government of Ethiopian
CO_2	Carbon dioxide
O_2	Oxygen
BET	Brake thermal efficiency

ABSTRACT

Biodiesel made from the vegetable oils found to check one among the most process alternatives to petro diesel in solving the issues like depletion of petroleum sources, environmental pollution etc. For a country like Ethiopia with large trade gas-producing home grownup with ecofriendly fuel is an urgent necessity. For Ethiopia with wide cultivation of cotton seed oil would be a really smart inedible feedstock for preparation of biodiesel. Far more work is reviewed to understand biodiesel behavior under varied designs of engines, before its commercialisation. Biodiesel has several drawbacks like higher viscosity, low calorific value, cold flow issues, higher emission, shorter storage life etc. In recent days with the development of nanotechnology, addition of nano particles for improving the performance of fuels attracting the attention of researchers. Thus during this work it's aimed to test the performance of cotton seed oil biodiesel with cerium oxide (CeO_2) nano particles as additive. This work goes through the varied stages like production of biodiesel, admixture of nano particles within the biodiesel-diesel blends in different proportion using ultrasonicator. The other was, testing the effect of nano additives on physichemical propertis of the fuel blend, testing the stability of fuel blend with nano particles, testing the performance and testing exhaust emission in diesel engine. The blend were ready as B10 (90% diesel and 10% biodiesel in volume), B20 (80% diesel and 20% biodiesel in volume), B20+50ppm (80% diesel and 20% biodiesel and 0.05 gm/l cerium oxide) in volume, B20 + 100ppm (80% diesel and 20% biodiesel and 0.1 mg/l cerium oxide) in volume, B25 (75% diesel and 25% biodiesel) in volume. From the performance test results, the cotton seed oil fuel blended with cerium oxide shows 4.5kW, 4.68kW, 18.43Nm and 18.52Nm with increasing point of brake power, brake torque. Also from characteristic's test, its viscosity was 3.67cSt for biodiesel. Addition of CeO_2 improves exhaust emission compared to pure diesel (B0). The brake specific fuel consumption of cotton seed fuel blended with cerium was decreased compared to the diesel. Generally, it may be concluded from the experimental investigations that the cotton seed oil fuel blended with cerium oxide nanoparticle can become an alternative source of fuel and Optimum blend fuel will be found for replacement of petro diesel in the future.

Keyword: *Biodiesel,* ***CeO_2*** *Nanoparticles, Ultrasonicator, Stability of the blend, Performance and Emission.*

CHAPTER ONE

1 INTRODUCTION

1.1 Background of the Study

The growing industrialisation and motoralisation of the world has led to a step up for the demand of petroleum-based fuel. The petroleum based fuels are obtained from restricted reserves. These finite reserves are highly targeted in certain areas of the world. Therefore, those countries not having these resources face energy/foreign exchange crisis, principally because of the import of crude petroleum. Hence, it's necessary to appear for alternative fuels which might be produced from resources accessible domestically among the country such as alcohol, biodiesel, vegetable oils etc. [1]. To solve this issue, many researchers established with results that biodiesel is an alternate fuel.

It’s evident that two things are necessary, one is process of vegetable oil to biodiesel and the alternative is testing obtained biodiesel in diesel engine for its compatibility as fuel to diesel engine particularly the blend percentage which will offer results almost like diesel. Biodiesel is outlined as mono-alkyl esters of long chain fatty acids derived from renewable biolipids via transesterification method, that conform to ASTM D6751 specifications to be used in diesel engines [2]. The method of elimination all glycerol and fatty acid from the vegetable oil within the presents of catalyst are called as transesterification. It’s basically a written record reaction. Triglycerides are first reduced to di glycerides. The di glycerides are afterwards reduced to mono glycerides. The mono glycerides are finally reduced to fatty acid esters [2].

The properties of biodiesel typically has higher density, viscosity, cloud point, cetane number, lower volatility and heating value The properties of biodiesel typically has higher density viscosity cloud point cetane number lower volatility and heating value compared with diesel fuel that affecting on engine performance and emissions. However, using optimised blend of nano particles and diesel will help to reduce these high properties or its blends could also be used in the present diesel engines with very little or no modification to the engine [3, 4]. With the following goals and method this work has been completed through fuel additives (nanofuel). Nanofuel could be a renewable and ecofriendly alternative diesel fuel for CI engine. What are more additives are an important a part of these days fuels, along with the carefully developed fuels composition. They contribute to efficiency responsibility associated long lifetime of an engine like using optimised blend of nano particles and diesel rather than conventional diesel fuel considerably reduces emission of particulate matters (PM), carbon monoxide (CO), sulphur oxides (SOx), and unburned hydrocarbons (HC). With the utilization of fuel additives within the blend of nanoparticles and diesel improves performance, combustion and additionally improves fuel properties that enhance the combustion characteristics. The impact of mixture of cerium oxide (CeO_2) and carbon nanotube (CNT) in single cylinder four-stroke water-cooled inconstant compression ratio engine using castor biodiesel blend with ethanol. When blended at 25ppm, 50ppm and 100 ppm of 32 nm sized CeO_2 and 100 nm sized CNT, brake thermal efficiency and cylinder pressure is increased. Moreover, such a blend of nano particles resulted in forward-looking peak pressure incidence with cleanser combustion means reducing emission [4]. In several countries varied oils are used as raw materials for biodiesel production as a result of its availableness. Soybeans are commonly used in the USA. In Malaysia and Indonesia the palm oil was used as major biodiesel supply. In Europe, rapeseed was the most common based oil used in biodiesel production. In Asian country and Southeast Asia, the Jatropha tree is employed as a major fuel supply [5].

In Ethiopia in keeping with “The Biofuel Development & Utilization Strategy” the biodiesel that's to be created from Jatropha carcass, cotton seed, caster bean, and palm tree aimed to make sure use of biodiesel for transportation, a high dosing level of blend, substitute biodiesel for domestic preparation and lighting fuel, etc. The researchers are targeted on single biodiesel with Nano fuels blends like soybean oil, rapeseed oil, pongamia pinnata oil, Cotton seed oil, Neem oil, Castor oil, Mahua oil, Mahua oil,jatropha oil, lineed oil, rice bran oil etc. and its blended with diesel[6]. From the previous literatures studies, many researchers work on the consumption of biodiesel and it was blends in diesel engine. It’s evident that single biodiesel supply acceptable engine performance and exhaust gas for diesel engine operation. This work study was designed to analyze the result of CSME blended with diesel beside cerium oxide (CeO_2) nanoparticle on the performance and exhaust gas characteristics of diesel motor. For investigation varied blends of cotton seed biodiesel with diesel were taken. The cerium oxide (CeO_2) nano particle was added with various proportions.

1.2 The requirements and use of nanoparticles

Nano-additives are considered as a propitious fuel-borne catalyst to improve the fuel properties, owing to their enhanced surface area/volume ratio, quick evaporation and shorter ignition delay characteristics. The size of nanoparticles varies from 1 to 100 nm [7]. Following are the main requirements of nano additive particles as fuel additive:

- The nanoparticles act as catalyst should reduce exhaust emission as well as increase the oxidation intensity in the engine and in the particulates filters.
- It should maintain the typical operational characteristics of engine.
- The stability of additive in the fuel must be retained under all operational condition.
- Addition of nanoparticles must not affect chemical stability of mixture under all conditions.
- It should not affect working effectiveness of particulate filters.
- It should reduce specific fuel consumption and increase thermal efficiency for constant power. The type of nanoparticles is given in table1.1 below

Table 1.1 Type of nanoparticles for IC engine application

Sr. No.	Type	Example
1	Metal based nanoparticles	Aluminum, iron, boron and ferric chloride
2	Metal oxide nanoparticles	CeO_2, Al_2O_3, TiO_2, MnO, CuO
3	Magnetic Nano fluid particles	Fe_3O_4
4	Carbon nanotube particles	Single walled and multi walled CNT

The performance and emission characteristics of diesel engine with diesel-blended biodiesel with the addition of nanoparticles were investigated. Because of the presence of nanoparticles, the performance and emission characteristics of CI engine wherever higher than the base fuel. The Al_2O_3, Al, Ferro fluid, CeO_2 nanoparticles additionally with base fuel showed higher BSFC reductions than all alternative nanoparticles. Addition of excess or lesser amount of nanoparticle with the diesel or diesel blend didn't make any effect on fuel chemical reaction. Adding the nanoparticles with lower calorific value fuels can facilitate in improving the fuel properties and thereby, improves the performance of CI engine [7].

1.3 Nanoparticles as a fuel additive

Nanoparticles acts as a fuel accepted catalyst that improves specific properties of fuel once value-added to the base fuel depending upon the dosage level of it (i.e., flash point, fire point, kinematic viscosity, heating value and cetane number) [7]. This can be because of its better thermo physical properties. Particles that have size in between one nm to one hundred nm are thought-about as nanoparticles.

1.4 Preparation of Nano fluid

Nanoparticle blended biodiesel is prepared by mixing nanoparticle with the help of an ultrasonicator shows that Fig1.1. The ultrasonicator method is that the best suited technique to dissolve nanoparticle within the base fuel. The nanoparticles are weighted to predefined mass fraction say 50 ppm, 100 ppm, and dissolve within the seeds biodiesel that's methyl ester with the help of ultrasonicator set at a frequency of 40 kHz for 30 minute. The stability of nano fluid is increase by ultrasonic bath stabilization or by adding chemical agent within the fluid. This mix preparation of nano particles with synthesis of nano fluid that nano particles are directly prepared by leaving a layer of nano particles (liquefied chemical technique). The collection of nanoparticles is reduced and stability of fluids is increased. The most restriction of this technique is that it's most popular preparation and economical [8].

Figure 1.1 Nano fluid preparation, Ultrasonicator.

1.5 Statement of the problem

At present, due to industrial revolution and high population growth, the demand of fossil fuel is increasing rapidly. The use of alternative sources as energy from biodiesel fuel blend is attention towards the development of fuel in order to replace the fossil fuel. Biodiesel offer a very promising alternative to diesel oil since they are renewable and have similar properties. However as different researches had been carried out on fuel blends, biodiesel has low engine performance and high viscosity that might effects on IC engine during injection in combustion. In recently, due to the environmental worries about air pollution caused by the combustion of fossil fuels as automobile users and industry increase the exhaust emission increases. Again due to the price of fossil fuel increase many countries like Ethiopia are facing a foreign exchange crisis, mainly due to the import of crude oil like Ethiopia country. Here, for these stated problems, diesel-biodiesel blend fuel within nano particle additives blend had being a solution by improving engine performance, characteristics, and exhaust emission. The aim of this thesis work is also consequently to conserve petroleum fuels for future and to eliminate the above-mentioned limitations fuel.

1.6 Objectives

1.6.1 General objective

The objective of this thesis work is to investigation on performance of cotton seed biodiesel with nano additive in diesel engine.

1.6.2 Specific objectives

The specific objective of this thesis work was as follows:

- To produce cotton oil methyl ester by transestrefication method
- To prepare homogeneous blend of diesel biodiesel and nanoparticle using ultrasonicator.
- To characterize the properties of fuel blends.
- To test and analysis of performance of diesel and fuel blended in diesel engine.
- To test and analysis of emission characteristics of diesel and fuel blended in diesel engine.

1.7 Significance of the project

- It helps to produce low cost, locally accessible energy to catalysis the experienced socioeconomic development method and improve engine performance, as well as exhaust
- Give substitute/supplemental energy for diesel engines.

- Supply an efficient low cost strategy for importing substitution of fossil fuel.
- Evolved a mechanism for a lot of balanced distribution of energy and alternative developmental advantages

1.8 Beneficiaries

The beneficiaries of this work studies are: Society, automobile industries, vehicle owners, and country as the whole.

1.9 The scope of this thesis work

The scope of this project is the experimental investigation on performance diesel engine using nano additives in diesel and cottonseed biodiesel. Extracting the oil from cotton seed and producing the biodiesel. To see the possibility and advantages of cotton seed diesel-biodiesel blends with cerium oxide nanoparticle. The characterization is the activity included in this work. At the last, this work concerns with the blending of biodiesels with the conventional diesel (petro diesel) to investigate the performance and emission analysis of the diesel engine compared to the performance of diesel engine fueled. The fuel samples were only studied for B0, B10, B20, B25, B20 + 50ppm CeO_2 and B20 + 100ppm CeO_2. Under this experimental investigation of the performance (i.e., engine brake power, engine brake torque, brake specification fuel consumption) and emission analysis (i.e. Carbon monoxide, Carbon dioxide, Hydrocarbon and Oxygen) concerned with variation of engine speed testing.

1.10 Limitations of the Study

There were some challenges faced during this thesis works. Thus challenge were lack of laboratory material equipment, engine dynamometer test and lack of the vehicle. The characterizations of the biodiesels were done for only certain properties (viscosity, density @15^0C, density @ 20^0C, total acidity, cloud point, and flash point) due to the budget constraints whereas, engine performances were done only, for engine brake power, engine brake torque and brake specific fuel consumption due to engine test. Additionally, emission characterestrisation test were done for carbon dioxide (CO_2), carbon monoxide (CO), unburned carbon (HC), and oxygen (O_2) only. NOx could not be measured due to lack of instrument.

1.11 Organization of the thesis work

The structure of this work is as follows:

Chapter one: It covers the necessary background of the study. Also it describes about statement of problem, objectives, scope, limitations, significance, nano particles and organization of thesis are included in this chapter

Chapter two: it is related to literature review and problem formulation. The literature review stated in five parts, which presents about the project works, based nano particles.

Chapter three: this chapter deals with methodology of the work. First of all, the cotton seed oil will be extracted. Then from crude oil biodiesel will be produced throughout transestrification method and its ester was blended fuel with nano additives will be prepared.

Chapter four: this chapter describe the performance testing of blended fuel will be done on diesel engine and discussion will be prepared on the results of performance, characteristics, emission and evaluation of cotton seed biodiesel for diesel obtained.

Chapter five: it is the last chapter and explains the conclusion and recommendation for future projects will be offered, summary of finding. At the last the references and appendix will be stated.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Introductions

A literature review was conducted from journals, reports, conferences and Books with several research papers were studied to formulate the problem and the research topic is related to the nanofuels. In this chapter section lot of research papers were studied that are interrelated to synthesis of nanoparticles, addition of nanoparticles to the diesel-biodiesel blends, effect of nanoparticles on fuel properties, effect on combustion performance test and emission characteristics test. Some papers were reviewed related to the biodiesel producing, engine performance test and emission characteristics test. The nanofuels were prepared by adding nanoparticles to the diesel-biodiesel blends. The literature was categorized as following.

2.2 Categorization literature review

Literature review was divided into the following five main categories. Such as:

1. Related literature reviews of this thesis work.
2. Previous experimental studies of fuel additives and its importance.
3. Biodiesel definition and its feedstock's.
4. Trans-esterification of biodiesel and chemistry of Trans-esterification process.
5. Characterizations and specification of biodiesel standards.

2.2.1 Related to literature reviews of this thesis work

Many researchers established with results that biodiesel is an alternate fuel. Now a day the rapid growth in industrialisation has created the transportation sector of a powerful importance. This transportation sector is dependent upon availability of fuel i.e. petrol-diesel and require it in abundant for its sustainability. Hence there's ever growing need of the fossil fuel and it need to be happy. However due to their restricted resources and increased demands has made the costs of those fuels increase continuously. Except for these higher prices, this fossil fuelled vehicle has led to increase the pollutants like greenhouse emission, NOx, lead, soot, and degrades the environment. During this context, biodiesel has emerged jointly of the foremost potential renewable energy to replace current commercial diesel. Also, it's renewable, biode-gradable and non-toxic fuel which may be simply created through transesterification reaction. However, such biodiesel primarily based fuel cannot directly use in diesel engine due to high ignition delay, low cetane number, high brake specific fuel consumption (Bsfc), little calorific value, and low brake thermal efficiency (BTE). It had been reportable that by addition of nanoparticles to the fuel, the performance and emission characteristics of the diesel engine may be improved.

Sajith et al. [9] studied the effect of treating level starting from 20ppm to 80ppm of CeO_2 Nano particles in biodiesel resulting from jatropha, on a single cylinder water-cooled direct injection diesel engine working at 1500 rpm. The scale of Nano particle remained 10 to 20 nm, 99.9% purity and density was 7.13g/ml. under this studied, emission characteristics, performance, and also the physiochemical properties were measured. The results concluded that an average reduction of 25 to 40^0c within the hydrocarbon emission was obtained for the additive treating level starting from 20 to 80 ppm of the fuel additive. The NOx emission was found to be generally reduced by 30 minutes on the addition of cerium oxide (CeO_2) Nano particle to biodiesel with treating level of 80 ppm. Here the decreasing effect of the fuel additive on carbon monoxide emission wasn't thus outstanding.

Karthikeyan et al. [10] piloted the experiments of Promolin Stearin wax oil B20, biodiesel – diesel blended with the particle size of the zinc oxide (ZnO) was less than 100nm and meditation was changing 50 ppm and 100 ppm for three vary loads, such that heavy, medium, and low at valued speed of 1500 ppm with injection pressures of 220 bar, on a single cylinder direct injection diesel engine. The conducted studying was to test engine performance test and emission characteristics. The result was concluded that ZnO additive did not detect any significant improved all properties except calorific value of the blends. The HC and CO had appreciably declined with increased in the dosing level of the nano particle as compared to B20. But, the NOx emission of all blended diesel-biodiesel did not significant effect.

Karthikeyan et al. [11] studied the experiments canola methyl ester biodiesel with Zink oxide (ZnO) nano particles additives on single cylinder direct injection diesel engine working at constant speed of 1500rpm. The size of this nano particle was 100nm and meditation with 50ppm and 100ppm. Their experimental were included various blends of fuels (i.e, B20+D80, B20+D80+50ppm ZnO, B20+D80+100ppm ZnO) in diesel engine. They conclude that, there are some improvements in calorific value and kinetic viscosity. From three blends B20+D80 with 100ppmZnO nano additives was released greatest heat 95.93 kj/m^3deg. The bsfc was increased as the dosing level increased and high brake thermal efficiency (BTE) was shown improving development. Also they conclude that minimum HC and CO determined with ZnO blend fuel compared to B20. But NOx emission was increased with ZnO blended fuel nano particles.

Selvan et al. [12] studied that the emission characteristics, engine performance test, and combustion using cerium oxide (CeO_2) nano particles at various compression ratio engine. The sizes of nano particle of 25 ppm, 50 ppm, 100 ppm were mixed with Diesterol at every of them and Carbon Nanotubes. Castor methyl ester biodiesel was acts as taking agent for diesel and ethanol those were incompatible in one another. All parameters like performance, emission and combustion were taken at optimum compression ratio of 19.1 whereas the load is taken at totally different condition. The results displayed that, the CeO_2 nano particles donates O_2 that helps in oxidation and reduction of CO and NOx since carbon nanotube decreases ignition delay and radical the peak heat release. In to this addition, CeO_2 delivers further energy to burn off carbon deposits within energy cylinder. In order that carbon nanotube was decreases delay ignition and advanced heat releases.

Rao et al. [13] analyzed that the emission characteristics, engine performances, diesel and diesel–biodiesel blends (eucalyptus oil) on single cylinder four stroke compression ignition diesel engine using cerium oxide (CeO_2) nanoparticles. The CeO_2 nano particles added to the pure diesel and B20 by volume. the size of nano particle is 100nm, with mixed properties of 20 ppm, 40 ppm, and 60 ppm to B20 (i.e, B20+20ppm, B20+40ppm, B20+60ppm of CeO_2). Their result were plotted against the load and determined that the BTE was shown improving trend with the nonfuels at B20. The result shows that addition of CeO_2 nanoparticles helped to reduce NOx, CH and CO. But, at full load the least Bsfc was reported as 0.268 kg/w-hr for B20+60ppm.

Krthikeyan et al. [14**]** studied that the experiment performance of grape seed biodiesel methyl ester with additives of Zink oxide(ZnO) nanoparticles on single cylinder four stroke vertical diesel engines at constant speed of 1500rpm. The ZnO nanoparticles were distributed to the B20 within the concentration of 50 ppm and 100 ppm. The typical size of nanoparticle was 100 nm and the compression ratio with injection timing was 17:1 and 23.4 bar for the test. The stability of nanoparticle is added blend was using mechanical trouble maker and ultrasonicator. The fuel physicochemical properties were measured and specially affected the BSFC and BTE. The results of addition ZnO nano particles to the blending diesel-biodiesel were improve Bp, BTE, and BSFC. But, while not fuel additives of nanoparticle the exhaust gas emission was slightly exaggerated then the biodiesel blend B20. Similarly, slightly HC and CO trend was observed. But, hither CO_2 and NOx were observed nanoparticles added fuel compared to B20.

Shaafi et al. [15] studied that, investigated emission characteristics and engine performance of two blends (i.e., B20 of diesel-soybean biodiesel blend and diesel-soybean biodiesel–ethanol blends with aluminum additives nanoparticles (Al_2O_3) 100mg/l with 1 chronicles isopropanol (B15E4Sl+100ml/l Al_2O_3) on natural aspirated, air cooled single cylinder at constant speed compression ignition engine and Al_2O_3 nanoparticles were adscititious to blends with facilitate of ultrsonicator. The results showed that the higher cylinder pressure and heat release rate was observed showed that higher cylinder pressure and heat release rate was observed for Al_2O_3 nanoparticles blend as compared to pure diesel. Also BTE was measured 17.9% increased then pure diesel. But, BSFC 11.46% and exhaust gas temperature declined once more as compared to pure diesel. Further, soybean biodiesel with Al_2O_3 nanoparticles provided in decreasing UBHC, CO_2, and CO. But, NOx exhaust emission was increased 9.9% then pure diesel.

Arul et al. [16] they studied that, the investigation of emission characteristics and performances of pure diesel and diesel-biodiesel blend and ethanol blends with 25 ppm cerium oxide (CeO_2). The size of fuel additives was 32 nm on a single cylinder 4-stroke water cooling engine at the compression ratio 19. The stage separation between diesel and ethanol was prevented by adding biodiesel. All the results were designed against brake mean effective pressure (BMEP) and also the least bsfc was observed for CeO_2 blended whereas the higher BTE measured for neat diesel. Additionally the highest peak pressure 10.2Mpa for neat diesel-biodiesel blends with CeO_2. Adding of CeO_2 decreased HC, and CO emission gas in comparison to neat diesel. But, NOx higher for fuel blended and reduced for neat diesel

Syed et al. [17] experimented, the effect of aluminum oxide nanoparticles (Al_2O_3) and iron oxide nanoparticles (Fe_2O_4) with performance and emission characteristics on single cylinder CRDI diesel engine fuel blended with Mahua methyl ester B20. The concentrations of nanoparticles added to B20 in proportion were 40ppm and 80ppm by helping of ultrasonicator and mechanical homogenizer. The result was concluded that, Al_2O_3 nanoparticle fuel integrated shows Bsfc was belittled once compare with Fe_2O_4 nanoparticles integrated fuel. just in case of B20+ Al_2O_3 40ppm the BTE was decreased up 0.8% whereas just in case of B20+ Fe_2O_4 40ppm BTE was accrued up 4.3% as compare to neat diesel. The other results were CO emission was reduced up

17% and 19% B20+ Fe_2O_4 40ppm and B20+ Al_2O_3 40ppm whereas the CO emission was reduced regarding 18 and 200th for both B20+ Al_2O_3 80ppm and B20+ Fe_2O_4 80ppm. But, the addition of nanoparticles to this B20 observed as increased of NOx emission. additionally the had studied the effect of zizipus jujube methyl ester blended with diesel fuel on the performance, combustion and exhaust emission characteristics in single cylinder, common rail direct injection (CRDI) systems by supporting diesel engine with Al_2O_3 nano particles 25 ppm and 50 ppm. To blend these nanoparticles the help of a mechanical homogenizer and ultrasonicator was used. The entire graph was drawn against brake power. This blend fuel shows a major reduction of BSFC and exhaust emission. The HC and smoke emission decreased up to 13.459 g/kWh and 79 g/kWh to 8.599 g/kWh respectively. At the last nano particles had dominant effect on BTE and release heat rates [17].

Prabhu et al. [18] they'd reported that the result of titanium oxide (TiO_2) nanoparticle with B20 (Neem methyl ester biodiesel) blended the concentration of 250 ppm and 500 ppm on ignition and emission characteristics in single cylinder four stroke diesel engine. The sizes of nanoparticles were between 1-100nm and ultrasonicator method was used to stabilizer the nanofuel. B20+250ppm TiO_2 nanoparticle showed that BTE was increased up 1.32% as compared B20+500ppm TiO_2 nanoparticle at full load condition. The CO and HC emission was reduced up to 20% and 17.5% with B20+250ppm TiO_2 nanoparticle since increased for B20+500ppm TiO_2 nanoparticle. However the NOx was increased up to 5% and other smoke was declined up to 27% for B20+250ppm TiO_2 when compared with B20+500ppm TiO_2 nanoparticle and without blended B20 at full load situation.

BanaPurmath et al. [19] studied the experimental on emission characteristics, performance and performance with Hinge oil methyl ester (HOME) biodiesel fuel blended with multi walled carbon tube (MWCNT) at 25 ppm and 50 ppm concentration in single cylinder four stroke direct injection diesel engine. The typical sizes of nanoparticles were 10-30nm and neat diesel was used for baseline knowledge generation for experimentation purpose. The entire test was accompanied at constant speed of 1500rpm and by varied the load. The result was determined improved for BTE at home –MWCNT blended fuel and the maximum BTE HOME50-MWCNT was 25% since 24-karat gold for HOME25-MWCNT as compared 23rd for HOME and 28% for pure diesel. Fuel blended reduced the smoke opacity as compared to HOME. The NOx emission for HOME25-MWCNT was at 600rpm since 750 rpm for HOME50-MWCNT compared to 580 rpm for HOME and 800 rpm for pure diesel at 80% load.

2.2.2 Previous experimental studies of fuel additives and its importance

Fuel additives are organic based or metal based substances that are simply soluble in fuel and its main purpose is to improve, support and supply useful characteristics to the fuel without affecting the performance and combustion parameters. The fuel additives are added in smaller quantities ranging between 100 ppm to many thousand ppms. They're broadly classified as industrial plant products, distribution system products, and automotive performance improvement products. they're again divided into following categories specifically antioxidants, cetane improvers, anti-knocking agents, anti-freezing agents, stability improvers, additives to prevent corrosion, cold flow improvers, fuel borne catalysts, anti-wear agents, etc. to understand the aims of this planned research, these previous experimental studies of fuel additives topics were explored: The following main point were the previous experimental studied on fuel additives of nano particles.

2.2.2.1 Effects of metal based nano additives on performance and emission

Metal nanoparticles such as aluminum, iron, boron and ferric chloride are used as catalyst in CI engine to encourage complete combustion and reduce HC and soot emissions by oxidizing HC, CO and particulate matter (PM) to CO_2. These types of nanoparticles also are used to reduce emission by reacting with water vapor within the exhaust to produce highly hydroxyl radicals. Additionally used to improve BTE and reduce of fuel consumption.

Kao et al. [20] discovered that influence of aqueous aluminum nanofluel (AN) combustionin diesel fuel using single cylinder four stroke engine with the average sizes an nanoparticles was about 40-60nm. Here the result displayed that hydrogen burns in diesel engine within the presence of an active an and it show that BTE, BSFC for AN+D was lower than that of diesel fuel (D) at engine speed fewer than 1800rpm. The blended particular measure of diesel was only not reduction of fuel consumption; it's additionally improved the exhaust emission concentration from diesel engine.

Kannan et al. [21] evaluated that, on combustion, emission characteristics, and performance of direct injection diesel engine operated at a constant speed of 1500rpmat different in operation condition with the addition of ferric chloride (Fe_2Cl_3) as Fuel Bome Catalyst (FBC) in waste preparation palm oil based mostly biodiesel. The Fe_2Cl_3 added in biodiesel at an amount of 20mol/L and the test result concluded that, the addition of FBC in biodiesel increased cetane number and calorific value of fuel. The added biodiesel showed BSFC of 0.4 kg/kWh at 220 bar, 230 BTDC and 0.3 kg/kWh at 280 bar, 25.50 BTDC respectively compared with biodiesel at the same in operation conditions. Additionally the addition of FBC decreases CO, HC, and smoke emission up to 52.6%, 26.6%, and 6.9% respectively whereas NOx and CO_2 increased with added of FBC. But, BTE was increased up to 6.3%. In another ways in which, FBC supplementary biodiesel was showed higher cylinder gas pressure and shorter ignition delay at optimized operation conditions.

2.2.2.2 Effects of metal oxide Nano additives on performance and emission

Metal oxide nano additives normally acts as associate degree oxidation catalyst as they delivered oxygen for oxidation of UHC, and CO whereas absorbs O_2 for reduction of NOx. Such metal ano additives like CeO_2, TiO_2, ZnO, MnO, Al_2O_3, and CuO are used as combustion catalyst in diesel engine to say no emission and gate optimum performance.

Fangsuwannarak. et al. [22] considered modification of engine performances and emission characteristics test on properties of palm biodiesel with blended of TiO_2 nanoparticles in diesel engine. TiO_2 nanoparticles were added in fraction of 0.1% 0.2% by volume. The result indicated that, all biodiesel fuel added with 0.1% TiO_2 obtained the higher brake power (Pb), wheel power (Pw), and engine torque (Te) as compared all biodiesel without 0.1% TiO_2. Additionally to the present, 0.2% TiO_2 will increase the specific fuel consumption and CO, CO_2, and NOx are considerably reduction with this additives nanoparticle.

2.2.2.3 Effects of organic nano additives on performance and emission

Yang et al. [23] attended experimentation on performance and emission properties with emulsion fuel 82.4% diesel, 5% water, and 12.6% nano organic additives in four cylinder diesel engine with common rail fuel injection (CRFI). The determined results showed that, improved BTE will observe with emulsion fuel due to the effect of micro-explosion of water precipitations. The other better one was reduction of NOx and the ignition delay of emulsion fuel was somewhat strong than the pure diesel. However the combustion period was shorter.

2.2.2.4 Effects of magnetic nano additives on performance and emission

Magnetic nanofluid (ferro fluid) was a suspension of ferro magnetic nano particles within transporter fluid like water or an organic solvent. The other most significant structures of ferrofluid were their stability which suggests particles within the fluid don't agglomerate and phase-separate even within the presence of powerful (strong) magnetic fields.

Nasrin et al. [24] studied experimental on the effect of magnetic ferrofluid (Fe_3O_4) nanoparticles in single cylinder direct injection diesel engine. The Fe_3O_4 nanoparticles were distributed with 0.4 vol and 0.8 vol center of attention. The result indicates that, the Fe_3O_4 nanofluid fuel with nano particle concentration of 0.4% better observation than 0.8 vol Fe_3O_4. This implies the selection of the suitable dosing of nanoparticle should be considered. The NOx and SO_2 emission reduced intensely, whereas CO emission and smoke opacity increase unusually with increasing the dosing level of nanoparticles.

2.2.2.5 Effects of carbon nanotube additive on performance and emission

Carbon nanotubes (CNTS) are allotropes of carbon with cylindrical nanostructure called graphene cylinder and it’s known as wonder material of 21st century. They are also classified into two like single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs). SWNTs have single layer of graphene cylinder whereas MWNTs have two or more than two layer of graphene cylinder

Ghanshyam et al. [25] investigated on performance and emission characteristics in single cylinder, air cooled diesel engine on Karanja methyl ester (KME) blends with multi-walled carbon nanotube (MWCNTs). The MWCNTs are blended with KME biodiesel (B) and diesel (D) in three different proportions of 50ml/L, 100ml/L and 150ml/L. The test result showed that the BTE for diesel and biodiesel was 29.13% and 23.30% respectively whereas, D+MWCNT150 and KME+MWCNT150 was 32.92% , 27.48% respectively and also these blended fuel had HC emission of 23.07% and 27.58 respectively as compared to pure biodiesel. Once more there's also a reduction of CO emission of 35.13% and 38.89% as compared to neat biodiesel respectively at full load. But, there was slight increase in NOx and CO_2 with MWCNTs blended KME and D.

2.2.2.6 Effects of mixed nano additives on performance and emission

These types of mixed nano additives were used to investigate in performance, emission characteristics etc. on CI engines.

Mehrdad et al. [26] determined that experimental investigation on performance and emission characteristics with adding mixed nanoparticles (CeO_2+MWCNTs) in B15 and B20 on diesel engine. The mixture of nanoparticles was added in dosing level of 30ppm, 60ppm and 90ppm. On B20+90ppm of hybrid of nano catalyst, the maximum pb and Tb were at 7.81% and 4.91% respectively. BSFC also reduced by 4.50% compared to B20 only. Due to unique O_2 absorption and donation properties of CeO_2 additives of CO, HC, Nox and soot reduced. On B20+90ppm of hybrid of nano catalyst, the maximum reduction of CO, HC, NOx, and soot emission are 18.9%, 38.8%, 71.4% and 26.3% respectively

Mozhi et al. [27] studied experimental investigation of performance and emission characteristics of vary common ray (VCR) engine at optimum compression ratio of 19.1 by using diesterol (diesel-castor iol biodiesel-ethanol) blend with (CeO_2 –CNT) blends. The CeO_2 –CNT blends concentrations were varied of every 25 ppm, 50 ppm and 100ppm added with diesterol blends. These diesterol blends increased BTE up to 7.5%. Additionally it reduced the HC and smoke emission up to 7.2% and 47.5% respectively as compared to diesterol blend without CeO_2 –CNT. But, NOx was slightly increased CeO_2 –CNT blended.

2.2.3 Biodiesel definition and its feedstock's

2.2.3.1 Biodiesel definition

Biodiesel production could be a very new and industrial zone for researchers due to the importance that it's winning every day because of the increase within the petroleum price and the environmental advantages. The foremost promising alternative diesel fuel, has received considerable attention in recent years due to its following merits like biodegradable, renewable, non-toxic, a less important amount emission of smokes and particulate contaminants with higher cetane number than normal diesel. additionally, it meets the increasing demands of world energy that, in a large degree, is dependent on petroleum based mostly fuel resources, which is able to be depleted within the predictable future if the present configuration of energy consumption continues. Biodiesel is that the name of an unpolluted burning mono-alkyl ester-based oxygenated fuel made up of natural, renewable sources like new or used vegetable biodiesel oil and animal fats [28]. it's also outlined as mono-alkyl esters of long chain fatty acids derived from renewable biolipids via transesterification method, that conform to ASTM D6751 specifications to be used in diesel engines. “Bio” symbolizes the renewable and biological source in distinction to petroleum-based diesel fuel and “Diesel” denotes to its use in diesel engines [29]

2.2.3.2 Sources and Feedstock’s of Biodiesel

The potential feedstocks for biodiesel production are edible (first generation feedstocks) and inedible vegetable oils (second generation feedstocks), wasted oils and animal fats. First-generation biofuels are directly concerning a biomass that's generally edible, and are sometimes created from edible oils [30]. Second-generation biofuels are fuels that are created from a large array of various feedstocks, starting from lignocellulosic feedstocks to municipal solid wastes. Third-generation biofuels are concerning alga that are considered as rising inedible oil sources of growing interest due to their high oil content and rapid biomass production however may also to a confident amount be joined to utilization of CO_2 as feedstock [30, 32]. Biodiesel is an alternative diesel fuel that is prepared from vegetable oils and animals fats. Biodiesel is produced from great free fatty acid feedstocks such as recycled oils and fats. Vegetable oils and animal fats are triglyceride molecules in that three fatty acid collections are esters connected to unique glycerol molecule [32]. Table five shows main groups and types of oils that would be utilized in biodiesel production [32].

Table 2.1 Oil species for biofuel production [32]

	Oil species for biodiesel production	
	1. Major oils sources	Coconut (Copra), corn (maize), cotton seed, canola (a variety of rapeseed), olive, peanut (groundnut), sunflower, sesame, and soybean.
	2. Nut oils sources	Almond, cashew, hazelnut, macadamia, pecan, pistachio, and walnut.
	3. Other Edible oils sources	avocado, bay laurel, beech nut, ben, borneo tallow nut, carob pod (algarroba), cohune, coriander seed, flax, grape seed, hemp, kapok seed, lallemantia, lemon, macauba fruit meadowfoan seed, mustard, okra seed , perilla seed, pequi, , pine nut, poppy seed, prune kernel, (guizotia abyssinica seed or Niger pea), rice bran, tallow, tea (camellia), (silybum marianum seed), and wheat germ
	4. Non-edible sources	Algae, babassu tree, copaiba, honge, jatropha or ratanjyote, jojoba, karanja or honge, mahua, milk bush, nagchampa, neem, petroleum nut, rubber seed tree, silk cotton tree and

Vegetable oils are a renewable and possibly unlimited supply of energy with energy comfortable getting ready to diesel fuel. Renowned oils and fats contain large numbers of free fatty acids. The merits of vegetable oils as diesel fuel are liquidity, ready availableness, renewability, lower sulfur and aromatic content, and biodegradability. The main demerits of vegetables oil as diesel fuel are high viscosity, lower volatility, and the reactivity of unsaturated hydrocarbon chain [32].

2.2.3.3 Biodiesel improves engine operation

As diesel engines performance depends on lubricates of the fuel it helps to stay moving components, especially fuel pumps, from wearing prematurely. It additionally provides horsepower, torque, and mileage like standard diesel. Even in very low meditations, biodiesel increases fuel lubricity and raises the cetane variety of the fuel. Biodiesel is healthier for vehicles' engine than conventional diesel. Simply 1% of biodiesel added to petrodiesel is enough to increase lubricity to 65%, reduce mechanical problems and enhance the life and efficiency of engine. As biodiesel have nearly no sulfur or aromatics thus use of biodiesel in actual diesel engine results in decline of unburned hydrocarbon, carbon monoxide and particulate matter (PM) [32].

2.2.3.4 Biodiesel as a Fuel

The best method to use vegetable oils as fuel is to change it in to biodiesel. Biodiesel is that the name of a clean burning mono-alkyl ester-based oxygenated fuel prepared from natural, renewable sources such as new or used vegetable oils and animals fats [33] biodiesel is produced by transestrification reaction of vegetable oil with little molecular weight alcohols, like ethanol or methanol [34]. The properties of biodiesel typically has higher density, viscosity, cloud point, cetane number, lower volatility and heating value related to diesel fuel that affecting on the engine performances and exhaust emissions. However, neat biodiesel or its blends could similarly use in the obtainable diesel engines with very little or no modification to the engine [35, 36]. Biodiesel has no petroleum products; however it's well-matched with conventional diesel and may be blended in any proportion with mineral diesel to form a stable biodiesel blend. The volume of blending with petroleum diesel is denoted as 'Bxx', where xx shows the amount of biodiesel within the blend (i.e. B10 blend is 10% biodiesel and 90% diesel). It will be used in diesel engines with no major modification within the engine hardware

2.2.3.5 Performance of diesel engine with biodiesel fuel

Literature survey reveals that biodiesel perform satisfactorily throughout diesel engine operation. And B20 blend provides the fuel economy nearly the same as the diesel. Due to its high lubricity, it causes less corrosion and tear to engine part. Various studies have are reported on the performance and emission of CI engines, fuelled by B100 biodiesel similarly as its blends with diesel. It oxygenated nature results in a lot of complete combustion, resulting in lesser emission because of higher combustion temperature. The biodiesel blends with diesel offer performance the same as diesel because the fuel properties of biodiesel and diesel are almost same as seen from data agreed intable3 that shows that the cetane number, flash purpose and lubricity of biodiesel are higher since the calorific value is lower. The following parameters are used to evaluator the performance of diesel engine using biodiesel and its blends [36].

2.2.3.6 Profile of Cotton seeds

Cotton lint is that the most vital vegetable fiber within the world these days and is plain-woven into fabrics, either alone or combined with different fibers. The invention of the saw gin and the development of the manufacturing plant system, along with the convenience of production and adaptableness to machine manufacture, caused a rapid growth within the use of cotton; by 1890 it providing 78.6 % of the world's textiles fabric, growing to 84.2 % within the period 1924 – 1928. India is fifth largest cotton manufacturing country in the word, the 1st four being the U.S, China, Russia, and Brazil. Our country produces about eighty nine of the globe cotton [37]. Oilseed oil has a red-brown color because of the presence of pigments, the most important being gossypol. Gossypol is famous to have antioxidant properties which will potentially growth the shelf life of the biodiesel oil and biodiesel [38]. CSO a rich vegetable oil gained from the seeds of the cotton plant (Gossypium) by pressing machine or extraction. The specific part of CSO is that the pigment gossypol. The gossypol contented defines the color and value of the oil. The darker color and more stable is that the biodiesel. Unrefined cottonseed oil could be a reddish-brown liquid, sometimes nearly black in color, with a unique odor and bitter taste

2.2.3.7 Availability of cotton seed in Ethiopia

At present, the government of Ethiopia doesn't seem to be maintaining official cotton production statistics. One attainable reason for this absence of information might be the recent transfer of the cotton production one unit from the ministry of agriculture to the Ministry of industry. However, GOE and industry sources typically agree that production is insufficient to stay pace with rising demand. Similarly, these bases approve that 2014/15 (Aug-Jul) production is between 40,000 to 50,000 metric tons, that was the equivalent to 184,000 to 230,000 480 lb. In keeping with information provided by the Textile industry Development Institute (TIDI), there are seven ginning operations with a collective capability of at least 276,000 bales (60,000 metric tons), [39]. Taking this into consideration, post forecasts total 2014/15 production at 184,000 bales (40,000 metric tons), up nearly 10,000 bales from the official Department of Agriculture estimate for this period. For 2015/16, production is predicted to climb slightly to 200,000 bales (43,500 metric tons). These expected will increase are primarily attributed to the gradual growth within the land area of land planted in cotton, that is currently calculable at 130,000, and 135,000 hectares for 2014/16135,000 hectares for 2014/15 and 2015/16. Again, since there are currently no official estimates for area planted in cotton, post is extrapolating from the GOE's earlier-reported statistics [39].

2.2.3.8 Biodiesel Production Process

Biodiesel contains of fatty acids methyl Esters (FAME) and is made by the chemical reaction of oils and fats with mono alcohols, usually like methanol. A catalyst likes sodium hydroxide or potassium hydroxide and/or methylate, are used to accelerate the formation of alkyl esters. This production method is mostly denoted to as transesterification. This section can describe the method of biodiesel production from vegetable oil wherever the triglyceride oil is broken into alkyl (biodiesel) and glyceron by reaction with mono-alcohol. The biodiesel glyceron phases are separated and refined. Production processes contain a similar stage, regardless of the production scale, though the variations in instrumentality could also be important. The production method will occur within the following steps:

1. Mixing of alcohol and catalyst: The catalyst is often sodium hydroxide or potassium hydroxide that dissolves within the alcohol by using a normal agitator or mixer throughout the reaction. The alcohol and catalyst mix then charge into a closed reaction vessel and also the oil or fat is added.

2. Separation: once the reaction is completed, there exists glycerol and biodiesel formation. Each has a major quantity of the excess alcohol that was used in the reaction that is in need of being recovered. The reacted mixture is sometimes neutralized at this step if the essential media that's caused by alkali hydroxide is occurred. The glycerol part is much heavier or denser than

biodiesel part, making biodiesel to be lifted or floated. The two productions may be separated by gravity using settling vessel. The glycerol is settling at the bottom of the settling vessel and biodiesel is drawn off at the top. In some cases, a centrifuge is used to separate the two materials quicker by screening each phases. During this section glycerine and biodiesel are separated. The reacted combination is sometimes neutralised at this step.

3. Alcohol removal. Methanol (MeOH) may be a basic alcohol used in excess in transesterification of triglycerides to provide biodiesel fuel at a present of catalyst and it was called wood alcohol. It’s lightweight, volatile and colourless. MeOH is considering as a protected fuel. However, it's after all combustible burns with an invisible flame and its biodegradable quickly in comparison with petroleum fuels. MeOH may be a polar liquid at ambient temperature (25^0C), in spite of his ability of attracting water molecular in stored case; it still has bad solubility in water and petrol or organic compounds [40]. The extra alcohol in each part may be removed by drying meanwhile the glycerine and biodiesel phases are separated

4. glycerine Neutralization. The glycerine by-product contains often unused catalyst and soaps that are neutralised by adding an acid and sent lately to storage for crude glycerol. The glycerol may be uses for preparation of cosmetics and medication [41].

5. Methyl group ester washing and drying after the Biodiesel is separated from the glycerol; it's normally pure by washing gradually with warm water to remove residual catalyst, alcohol or soaps to form additional pure. The washed biodiesel wants drying to remove trace impurities. In some processes washing step isn't necessary depending on the standard of biodiesel made.

6. Product Quality. The finished biodiesel should be analysed to make sure it meets any needed specifications. The most important aspects of biodiesel production:

- Complete Reaction
- Removal of Glycerine
- Removal of Catalyst
- Removal of Alcohol
- Absence of Free Fatty Acids

2.2.4 Trans-esterification and chemistry of transesterification process

Transesterification is that the reaction of vegetable oil or animal material with an alcohol, in most cases methanol, to make esters and glycerol. The transesterification reaction yield with or while not a catalyst by using primary or secondary monohydric open-chain. Additionally transesterification was known as alcoholysis that the movement of alcohol from an ester by alternative alcohol during a method likes hydrolysis except that an alcohol is used than water [42, 43]. This has been wide used to decrease the viscosity of the triglycerides. The transesterification is usually; the reaction temperature closes to the boiling point of the alcohol is recommended. However, the reaction may even be agreed at room temperature. The reactions can observed at low temperatures (~60^0C) and at modest pressures (2 atm, 1 atm = 101.325 kPa). This has been commonly used to decrease the viscosity of the triglycerides [43]. The Trans esterification is denoted as equation (2.1, 2.2, 2.3, 2.4, 2.5, and 2.6) below.

$$\underset{\text{Ester}}{RCOOR^1} + \underset{\text{Alchol}}{R^2OH} \xLeftrightarrow{\text{Catalyst}} \underset{\text{Ester}}{RCOOR^2} + \underset{\text{Alchol}}{R^1OH} \qquad 2.1$$

If methanol is used in this process then it is called methanolysis. Methanolysis of triglycerides represented in (Eq 2.2).

$$\begin{array}{l} CH_2\text{-----}OCOR^1 \\ \mid \\ CH\text{—-}OCOR^2 \\ \mid \\ CH_2\text{----}OCOR^3 \\ \text{Triglyceride} \end{array} + \underset{\text{Methanol}}{3CH_3OH} \xLeftrightarrow{\text{Catalyst}} \begin{array}{l} CH_2OH \\ \mid \\ CHOH \\ \mid \\ CH_2OH \\ \text{Glycerol} \end{array} + \begin{array}{l} R^1COOCH_3 \\ \\ R^2COOCH_32 \\ \\ R^3COOCH_3 \\ \text{Methyl Ester} \end{array} \qquad 2.2$$

2.2.4.1 Chemistry of Trans-esterification process

Transesterification of triglycerides produce fatty acid alkyl esters and glycerol. The glycerol layer settles down at the bottom of the reaction vessel. Triglycerides, diglycerides and monoglycerides are the intermediates in this process.

2.2.4.2 Kinetic of transesterification reaction

Biodiesel is produced by a chemical a reversible chemical reaction of three mole of alcohol methanol withone mole triglycerides (TG) to produce one mole glycerol and three moles of FAME:

A (TG) + 3B (MeOH) = C (Glycerol) + 3D (FAME 2.3

The reaction as shown down is reversible; it takes place at three different steps which starts with triglycerides conversion to dig-glycerides and FAME follows by the second and third steps to produce mono glyceride and glycerol respectively and FAME [44]. The mechanism of transesterification is described in Eq. (2.4).

Triglyceride + R´H3OH ↔ diglyceride + FAME 2.4

Diglyceride + R´H3OH ↔ monoglyceride + FAME 2.5

Monoglyceride + R´H3OH ↔ glycerol + FAME 2.6

Transesterification is one of the reversible reactions and proceeds essentially by mixing the reactants. However, the presence of a catalyst (a strong acid or base) accelerates the conversion.

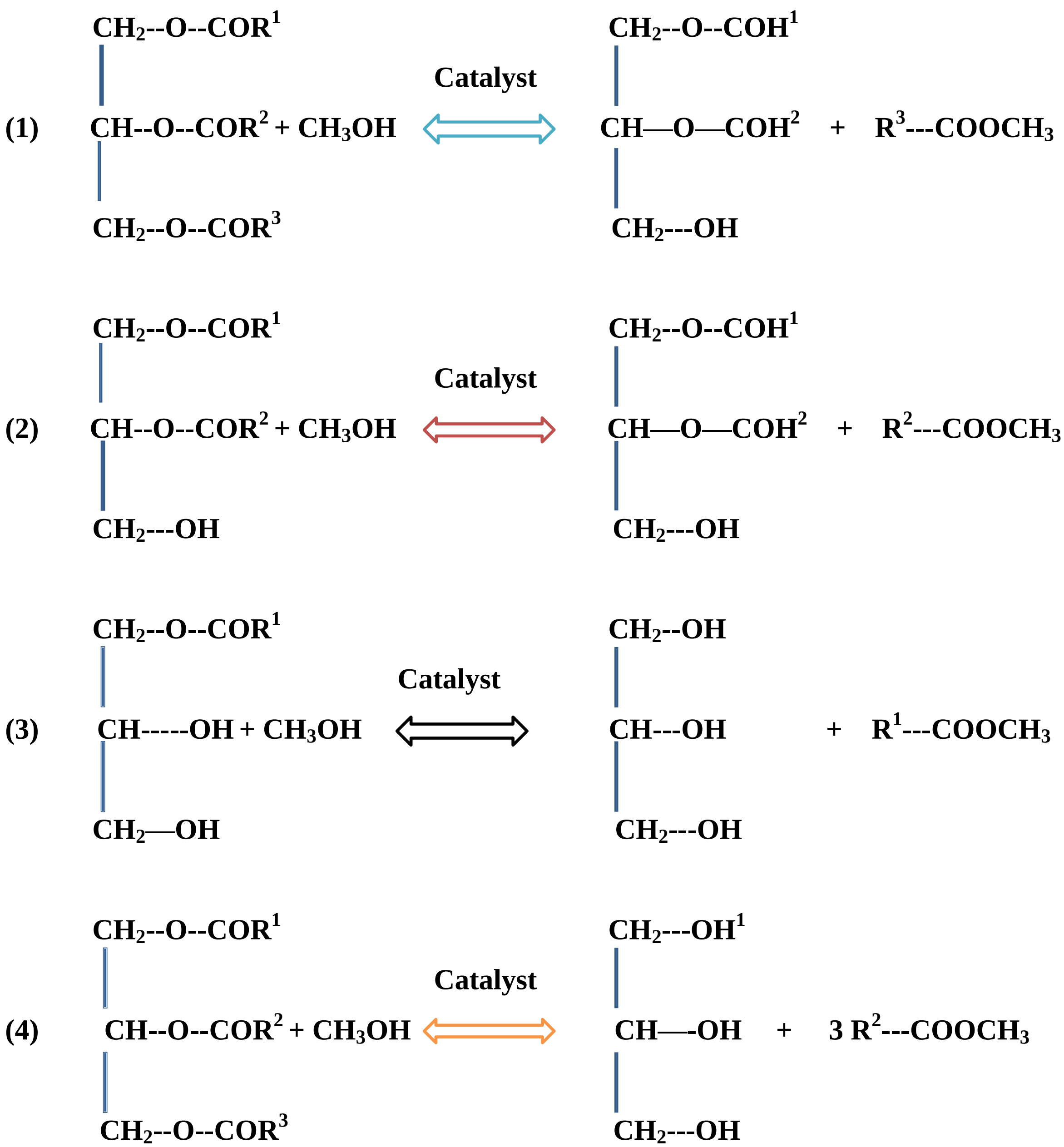


Figure 2.1 Reaction scheme showing the transesterification of triglycerides with methanol [45].

2.2.4.3 Variables affecting on reactions conditions of transesterification

The produce of biodiesel within the method of transesterification is affected by many method parameters or variables. The foremost significant variables affecting the produce of biodiesel from transesterification are; the reaction temperature, molar ratio of alcohol and oil, catalyst, reaction time, presence of moisture and FFA [46, 47].

2.2.4.4 The water and free fatty acid (FFA) contents

The water and FFA substances are essential factors for transesterification reaction. Base-catalysed transesterification reaction needs water free and low acid value (< 1%) raw materials for biodiesel production. If the oil samples have high FFA content (more than 1%) then the reaction wants a lot of alkali catalyst to neutralise the FFA. Presence of water provides larger negative impact than that of FFAs as a product of water can reason soap establishment and frothing which might cause increase in viscosity. FFA and water continuously yield negative result throughout transesterification and causes soap formation and consumes the catalyst that results in reduction of catalyst effect. Water and FFA additionally results in the reduction of methyl ester [47].

2.2.4.5 Reaction Temperature

The rate of reaction is strongly subjective by the reaction temperature. However, given enough time, the reaction can go ahead to near completion even at room temperature. For instance higher reaction temperature would be rise the reaction rate and shortened the response time because of the reduction in viscosity of oils. However, Leung and Guo [47] reported that increase in reaction temperature beyond the greatest level results in decrease of biodiesel yield, as a result of higher reaction temperature speed up the saponification of triglycerides. Commonly the transesterification reaction temperature would be below the boiling point of alcohol (60 -70^0c) to prevent the alcohol vaporization. The range of greatest reaction temperature could vary from 50^0c to 60^0c depends upon the oils or fats used [47]

2.2.4.6 Catalyst Concentration (Chemical Reaction)

The alcohol and catalyst mixture is then stimulating into a closed reaction vessel and similarly the oil is added. The reaction system is completely closed to the atmosphere to prevent the loss of alcohol, since it simply evaporable. The reaction mixture is unbroken simply close to the boiling point of the alcohol (~60^0c) to speed up the reaction. Excess alcohol is generally used to ensure total conversion of the oil to its esters as there's no problem of recovering of the alcohol for later use once usage. Biodiesel formation is additionally affected by the concentration of catalyst. Most typically used catalyst for biodiesel production is sodium hydroxide (NaOH) or potassium hydroxide (KOH) [47]. A concentration of NaOH within vary of 1.0–1.4% (w/w) has been found to supply 90–98% conversion from jatropha oil to methyl ester. As for the concentration of KOH starting from 0.55 to 2.0% (w/w), 95–99% of jatropha biodiesel has been obtained [47]. However, the yield of biodiesel was reduced if the alkali catalysts were additional beyond their optimum concentration. As a result of addition of excess amount of alkali catalyst react with triglycerides to make a lot of soap [47]. Freedman et al. [48] found that sodium methoxide was more effective than sodium hydroxide due to the reduced quantity of water made upon mixing sodium hydroxide with methanol. Because the catalyst concentration will increase, the conversion of triglycerides yield of biodiesel also increased.

2.2.4.7 Effect of molar ratio of alcohol

This is one among the most important factors which will have an effect on the ester yield. It's related to the kind of catalyst used, depending on that, the optimum value for the method is obtained. Higher molar ratios provide a higher ester yield in an exceedingly shorter time. Usually, once using acid catalysts higher molar ratios are required, most likely as a result of the use of acid catalysts is related to oils with high FFA contented [47]. Once rapeseed oil is transesterified by means of NaOH as a catalyst, the optimum molar ratio is 6:1. The molar ratio of alcohol was acting as important role in biodiesel yield. Normally the transesterification reaction needs three mole of alcohol for one mole of triglycerides to three mole of fatty acid ester and one mole of glycerol. Excess amount of alcohol will raise conversion of fats into esters within a short time [47]. That the produce of biodiesel will increase with increase within the meditation of alcohol up to assured concentration. But more increase of alcohol content doesn't rise the produce of biodiesel however it additionally increase the cost of alcohol recovery [48]. The molar ratio is associated closely with the kind of catalyst used. For base-catalyzed transesterification wherever the free fatty acids are under 1 chronicles when pretreatment, a molar ratio of methanol to oil of 5:1 or 6:1 is sufficient. However, wherever the percentage of FFAs in oils is high a molar ratio as high as 20:1 or 24:1 is required once using acid-catalyzed transesterification [48].

2.2.4.8 Reaction Time

Freedman et al [48] ascertained the rise in fatty acid esters conversion when there's a rise in reaction time. The reaction is slow at the start because of mixing and dispersal of alcohol and oil. At the moment the reaction takings very fast but the maximum ester conversion was achieved within < 90 min. more increase in reaction time doesn't increase the yield product i.e. biodiesel/mono alkyl ester [48, 49]. Besides, longer reaction time results in the reduction of finale produce (biodiesel) because of the reversible reaction of transesterification resulting in loss of esters similarly as soap formation [49].

This parameter is very affected by the type of catalyst used; totally different catalysts would require different concentrations. Even if they belong to a similar group (as within the case of potassium hydroxide and sodium hydroxide), totally different concentrations are going to be essential to achieve a similar yields. Therefore, the optimum value for each catalyst ought to be determined by titration. If the quantity of catalyst is over the optimum, there will be a decrease within the yield of methyl esters because of the formation of soap in presence of high amount of catalysts, which except for lowering the yield will increase the viscosity of the reactants [50].

2.2.4.9 Mixing of alcohol and catalyst

Mixing is essential for the reaction to require place while not mixing, the reaction only happens within the interface between the methanol and therefore the oil and it's very slow to be viable. Therefore, a mixing device is required within the reactor used for the process [51]. This typical method is especially done by mixing alkali hydroxide (commonly KOH and NaOH) with common alcohols (methanol and ethanol) within the mixer with standard troublemaker to facilitate the blending. Alkali hydroxide is dissolved within the alcohol to supply alkoxide solution.

2.2.5 Characterizations, Properties and Specification of Biodiesel Standards

2.2.5.1 Biodiesel Properties

1. Flash point: The instability of biodiesel is very low, and accurately produced biodiesel offerings negligible risk for treatment and safety. Flash point is outlined because the lowest temperature improved to a barometric pressure of 101.3 kPa (760 mmHg); at that request of an ignition supply causes the vapors of a sample to ignite below specified conditions of test. For biodiesel, this test could be a measure of remaining alcohol and cause for flammability grouping of materials.

2. Water and Sediment: Water and Sediment could be a test that determines the capacity of free water and residue in medium liquid fuels having viscosities at 40 °C within the range 1.0 to 4.1 mm2/s and densities in the range of 700 to 900 kg/m3. This test could be a measure of cleanliness of fuel. For biodiesel, this test is defining factor of occurrence of free water droplets and residue particles.

3. Kinematic viscosity: Kinematic Viscosity outlined because the struggle to flow of a fluid below gravity. It's a basic design specification for fuel injectors used in diesel engines. For biodiesel it's fast and simple method for estimating the degree of completion of batch reaction.

4. Sulfates Ash: Sulfated Ash is that the residue remaining after a fuel sample has been carbonized, and the remainder later on preserved with sulfuric acid and heated to a constant weight. This test monitors the mineral ash residual when fuel is burned. For biodiesel, this test is a very essential indicator of the amount of residual metals within the fuel that hail from from the catalyst used in the esterification method.

5. Sulfur: This method covers the purpose of total sulfur in liquid hydrocarbons, boiling within the vary from just about 25 to 400 ^{0}C, with viscosities between almost 0.2 and 20 cSt (mm^2/s) at room temperature. Biodiesel feedstocks generally have little sulfur; however this test is an indicator of contamination of protein material and/or carryover catalyst material or neutralization material from the production process.

6. Copper Strip Corrosion**:** Copper Strip Corrosion is used for detection of the corrosiveness to copper of fuels and solvents. This test screens the presence of acids within the fuel. For B100, the foremost likely source of a test failure would be too much free fatty acids that are explained in according to with an extra specification.

7. Cetane number: it's an evaluation of the ignition performance of a diesel fuel obtained by comparison it to location fuels in a very standardized engine test. This test may be evaluated how simply the fuel can ignite within the engine. For biodiesel, the cetane number is rarely a problem as results of all of the common fatty acid esters have cetane numbers near or above 47.

8. Cloud Point: CP isn't restricted in D6751 however is an important operability parameter that has to be reportable. The CP is that the temperature wherever the fuel initial begins to make crystals and is used to predict cold weather operability. For biodiesel, the CP is especially necessary as an effect of biodiesel is almost continuously blended with petroleum diesel, and therefore the CP of the biodiesel can have a significant impact on the ultimate blend properties.

CP is decided by the FAME profile content of the biodiesel, with higher levels of saturated FAME was increasing CP. It's the temperature at which a cloud of wax crystals initial seems in a very liquid when it's cooled down below specific conditions. The CP may be an important factor in cold weather performance for all diesel fuels. For biodiesel, cloud point is often more than the CP of conventional diesel. It will then be modified in following ways in which to get the lower cloud point. These are:

- The use of additives that retard the formation of solid crystals in the B100 by various mechanisms.
- The blending feedstock that is relatively high in saturated fatty acids with feedstock that have lower saturated fatty acid content.

9. Carbon Residue: In oil production, the part left behind after a sample has been subjected to thermal decomposition, is that the carbon residue. The carbon residue could be a measure of how much residual carbon remains after combustion. The test essentially involves heating the fuel to a high temperature within the absenteeism of oxygen. The most common reason behind excess carbon residues in biodiesel is an excessive level of total glycerine.

10. Acid Number: The acid number of biodiesel would be low to confirm no residual FFAs or process acids are present within the fuel. The presence of excess acids will cause corrosion and deposits in fuel systems. It’s the amount of base, expressed as milligrams of NaOH per gram of sample, needed to measure a sample to such that finish point. The acid number could be a direct measure of FFAs in B100. The FFAs will cause corrosion and should be an indication of water within the fuel.

2.2.5.2 Biodiesel Specifications

The American Society for Testing and Materials International (ASTM) specification for biodiesel (B100) is ASTM D6751-02. Also, the European standard (EN 14214) is accepted by all 31 member states of the European Committee for Standardization of biodiesel (B100). A number of the test methods listed in it perform over one role. These ways measure that the fuel performs same as supposed in CI engines and as tests to confirm that the manufacturer produced a high quality B100 [2]. Every of those properties and the test process used to measure it are in brief represented below.

Table 2.2 Specifications Properties of biodiesel according to ASTM standards [2]

Properties of biodiesels	Units	ASTM D-6751		EN 14214	
		limits	test methods	Limits	Test methods
kinematic viscosity (40^{o}c)	mm^2/s	1.9-6.0	D445	3.5-5.0	EN ISO 3104
Density (15oc)	kg/m^3	N/S	N/S	860-900	EN ISO 3675
Ester content	mass%	N/S	N/S	96.5 min	EN 14103
Cetane number	-	47min	D613	51 min	EN ISO 5165
Flash point	^{o}c	130min	D93	120 min	ISO/CD 3679
Water content	volume %	0.050 max	D2709	500 max	EN ISO 12937
Sulphated ash	mass %	0.020 max	D874	0.02 max	ISO 3987
Copper corrosion	grade	No.3 max	D130	No.1	EN ISO 2160
Acid number	mg KOH/g	0.80 max	D664	0.5 max	EN 14104
Iodine number	-	N/S	N/S	120 max	EN 14111
Oxidative stability (110oc)	h	N/S	N/S	0.8 max	EN 14112
Oxygen content	%	N/S	N/S	N/S	N/S
High calorific value	MJ/kg	N/S	N/S	N/S	N/S
Free glycerol	mass %	0.020 max	D6584	0.020 max	EN 14105
Total glycerol	mass %	0.240 max	D6584	0.25 max	EN 14105
Phosphorous content	mass %	0.001 max	D4951	10 max	EN 14107

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Material

In order to successfully accomplish the overall moreover as specific objectives of the study there would be a mixture of materials and methods meant to use. These are the extraction of the oil from the Cotton seed, production of biodiesel from the extracted oils, characterizing the properties of the biodiesel produced, additives Cerium oxide nanoparticle, blending, exhaust emission analyses and performance testing of the blending fuels within the diesel engines. The materials needed for the execution of this work are listed within the following tables.

Table 3.1 The materials used for production of biodiesel

Sr. No.	Types of Materials required	Units	Quantity
1	Cotton seed oil	Kilo grams	300
2	KOH	Gram	1000
3	Methanol	Liter	10
4	Magnetic stirrer	Pcs	1
5	Beakers (diffirent sizes)	Pcs	10
6	Distilled water	Liter	20
7	Nanoparticles	Grams	0.15
8	Aluminum foil	Inch	4
9	Conical flasks	Pcs	6
10	Stand funnel separators	Pcs	3
11	Ultrasonicator	-	1

3.2 Collection of Materials

The cotton seed was obtained from awash. Methanol, potassium hydroxide, and distilled water were purchased from chemical marketing and suppliers companies (Ranchem chemicals Plc, Addis Ababa) for laboratory scale amount. Cerium oxide (CeO_2) nanoparticle was buying from India; diesel fuel was purchased from Oil Libya Adama. All chemicals used for the research were analytical grade. Additional materials were used for this research: volumetric flasks, beakers, measuring cylinders, separator funnels, protecting equipment's, single cylinder engines of diesel vehicle, CT 110 Test Stand for Small Diesel Engine, thermometer, and hot plate with magnetic stirrer, The amount measuring devices, oven, Aluminum foil, and digital balance.

3.3 Methodology of the this thesis work

The methodology of this thesis work were gathering laboratory scale production of biodiesel from Cotton seed oil, methanol, and potassium hydroxide catalysis through transesterification methods, additive of cerium oxide (CeO_2) Nanoparticle. Characterisation of fuel blended tested at Ethiopian petroleum supply and enterprise while the performance and exhaust emission tested at Dilla University Mechanical Engineering workshop on CT 110 Test Stand Diesel Engine (single cylinder, 4-stroke engine).

3.4 General Method to Conduct the Experiment

This thesis work was conducted mainly based on the following experimental procedures shown within the following methods. These are the extracting of oil, preparation of methoxide, transesterification reaction, preheating of oil to remove the water, separation of glycerine from the biodiesel, biodiesel washing, drying to remove remaining water and alcohol within the biodiesel, characterization, blending, exhaust emission analyses and performance testing of the cotton seed biodiesel blended with petroleum diesel. Fig.3.1 shows that the overall methodology of this thesis works. But for cotton bio diesel extraction, the next flow chart and procedure was performed clearly (Fig.3.2).

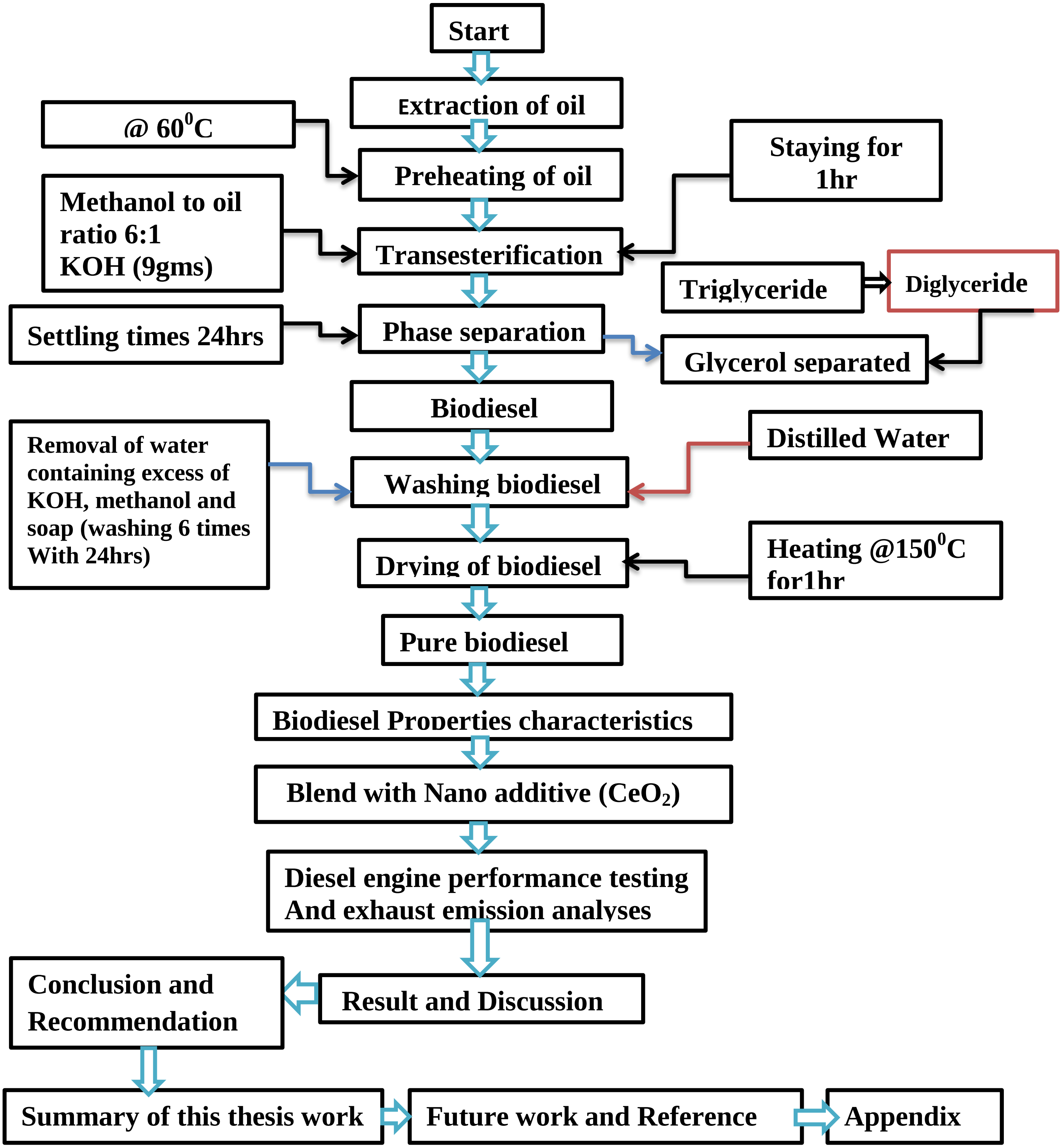


Figure 3.1 Flow chart of the methodology

3.5 Extraction of Cotton seed oil

The raw Cotton seed were obtained from cotton ginning factory Awash and separated the seed from the lint before the oil extracted from the seed. The lint goes to textile industry and therefore the seed for the oil extraction to Hundaf Engineer Food oil production Plc. There are some core procedures to extracting this crude oil from cotton seed. Initially collecting of all cotton seeds, de hulling and separation of the hulls (husk), cleaning the seed and drying, mechanical press, heat treatment and cooking, filtering. We are able to understand so extracted procedure in Hundaf Engineer oil Food production Plc, from fig.3.54.

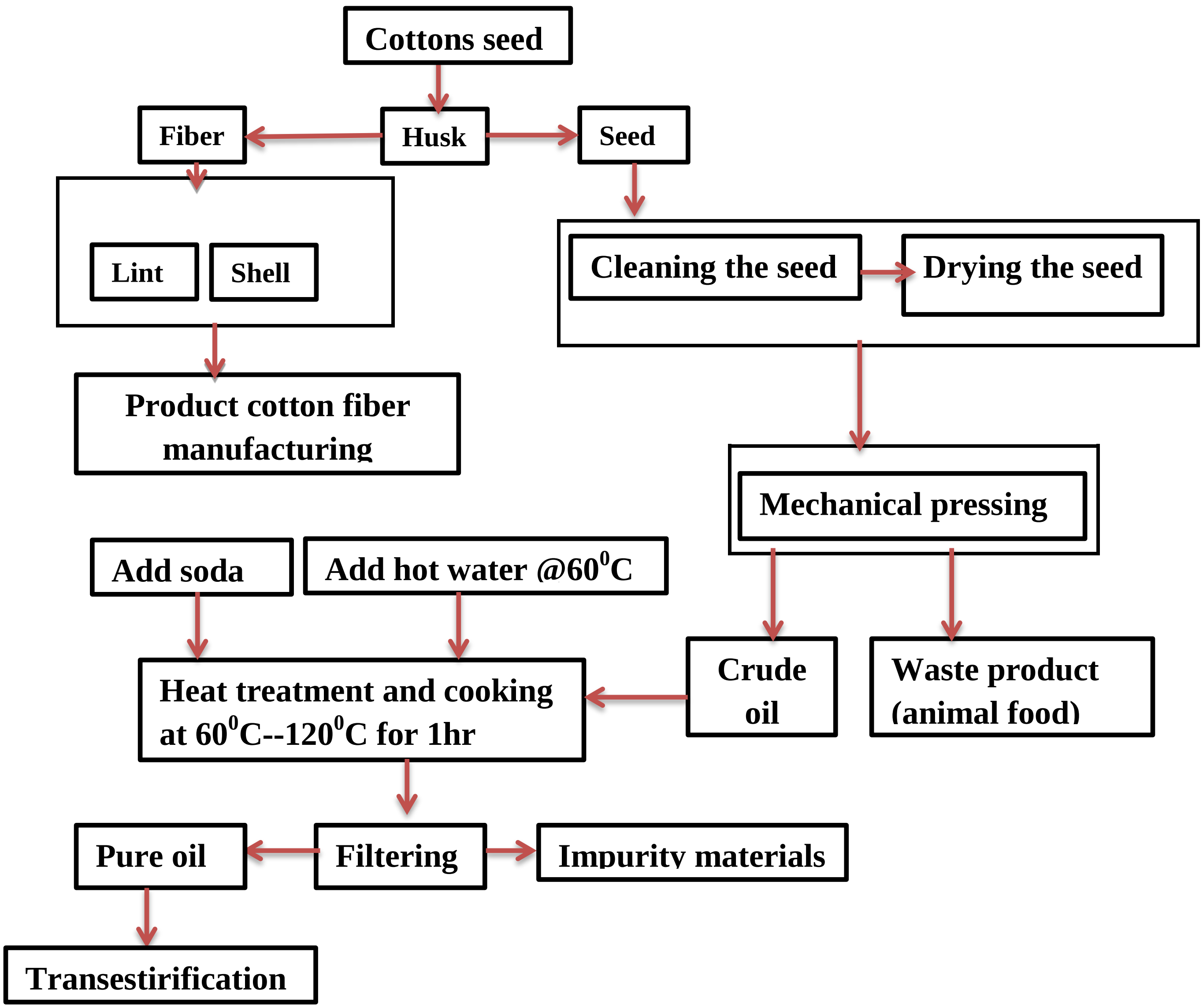


Figure 3.2 Cotton seed extraction procedures

1. De hulling and separation of the hulls (husk): collected cotton seed was prepared. Then by using hulls (husk) method separate seeds from fiber were prepared before the machine was starts. Cleaning the seed and drying: The raw material cotton seed was sent to pre cleaner to remove foreign matters; stones, dust, impurities and drying for simplify pressing the seed.

2. Mechanical press: At this stage, the seed was sent for screw pressing, screening and pumping. Here the cotton seed was compressed. The crude oil was extracted and also the cake (wastage products) part separated through screw passing. Finally, the oil was collected within the oil container or tank whereas the wastage product was used as animal's foods.

3. Heat treatment or cooking: The flaked or decorticated oil seed poured into the cookware, the preparation was carried out at temperature of 60-120^{0}C by steam and also the time taken for cooking 1hr. the aim of this work is to regulate the moisture content of the seed (3-6%), coagulate (settle) protein and makes the oil semipermeable to the flow oil, reduce viscosity of oil, removing impurity, and destroy catalyst action to prevent growth of mould and bacteria.

4. Filtering: once more clean oil was filtered to separates the oil from impurity. This was the last extraction of cotton seed procedures. In generally as we have a tendency to seen from fig.3.3 to obviously understand the process of extraction cotton seed oil with totally different view of machine was shown. There are three main methods used to extraction of oil.

1. Mechanical extraction: Mechanical extraction the technique of oil extraction using mechanical presses is that the most standard practice. During this kind, either a manual ram press or an engine driven screw press may be used. It's been found that, engine driven screw press will extract 68–80% of the accessible oil whereas the ram presses only achieved 60–65%

2. Solvent extraction (chemical extraction): Solvent extraction is that the technique of removing one constituent from a solid by means that of a liquid solvent. It is also referred to as leaching.

3. Enzymatic extraction: enzymatic oil extraction technique has emerged as a promising technique for extraction of oil. During this method appropriate enzymes are wont to extract oil from crushed seeds. The following fig.3.3 was shown clearly the way to extract the cotton seed crude oil. The amount of oil extracted was calculated as follows:

$$\%_{Oil} = \frac{Mass\ of\ oil}{Mass\ of\ seed} \times 100 \qquad 3.1$$

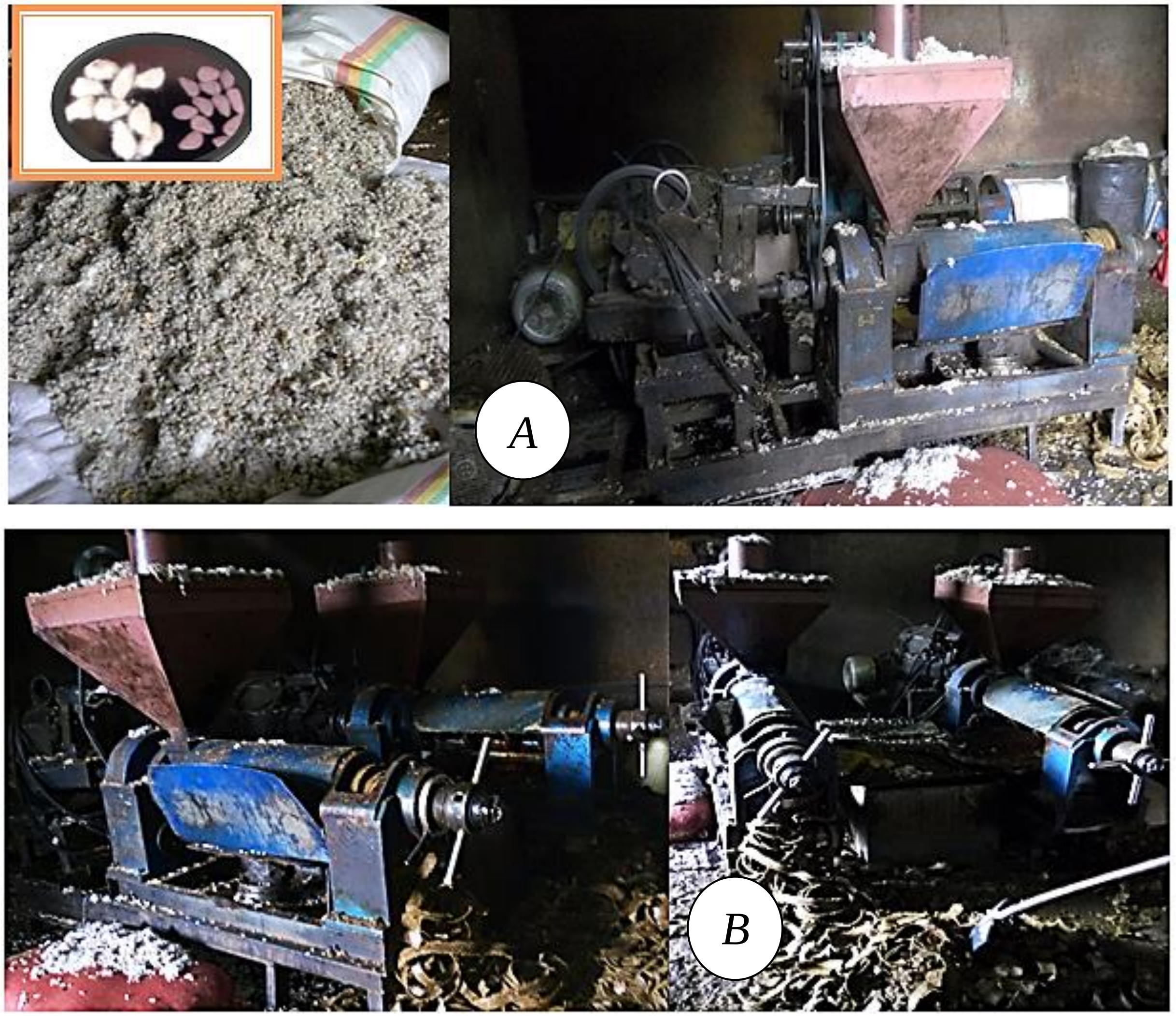


Figure 3.3 (*a* and *b*) shows the way to extract crude oil from cotton seed by screw pressing

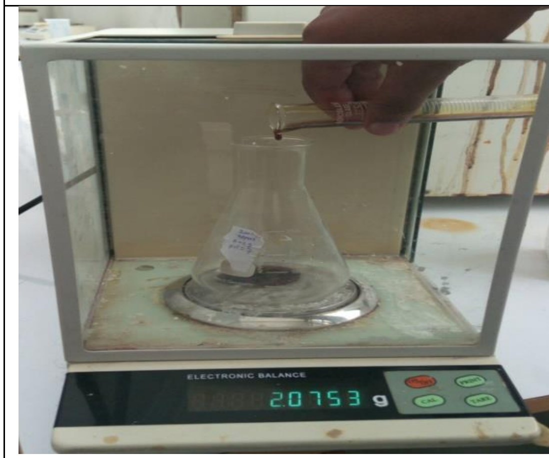
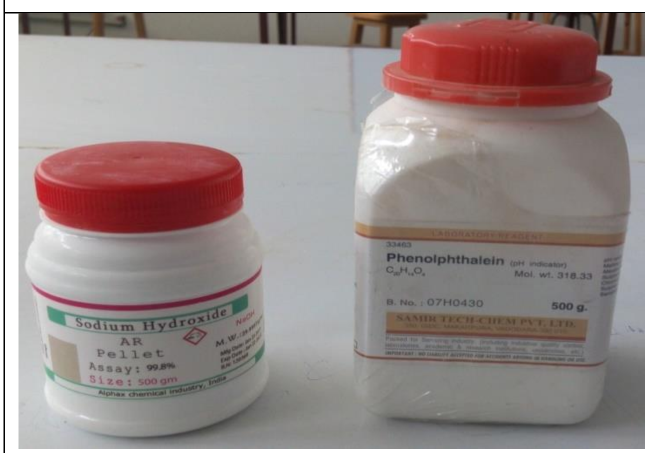
After the crude oil was collected through the procedure found on fig.3.3 above, the transestification was done at Adama Science and Technology University, Chemistry Department Laboratory.

3.6 Determination of acid value

3.6.1 Titration

In order to determine the percent of FFA within the oil, a process called titration is used. The vegetable oil is first mixed with methanol. Next, a mixture of sodium hydroxide (NaOH) and water is added till all of the FFA has been reacted. This can be confirmed by checking the pH of the mixture

Table 3.2 Materials used to make Titration for the cotton seed biodiesel

Lists of Materials	Descriptions
 Electro Balance	- Electro Balance is statistical calculation and density determination function of percent mode (%), density mode (DS) and gram mode (g) units. - It uses an electromagnet to generate a force to counter the sample being measured and output the result by measuring the force needed to achieve balance. Precision for 0.0000gm.
 Burette titration	A burette (also buret) is laboratory equipment used for the dispensing variable amount of a chemical solution and measuring that amount at the same time. It is a long, graduated glass tube, with a stopcock at its lower end and a tapered capillary tube at the stopcock's outlet. The flow of liquid from the tube to the burette tip is controlled by the stopcock valve.
 Sodium Hydroxide (a) phenolphtelein (b)	A, (NaOH): Are an inorganic compound and a white solid ionic compound. It is a highly caustic base and alkali that decomposes proteins at ordinary ambient temperatures and may cause severe chemical burns. It is highly soluble in water, and readily absorbs moisture and carbon dioxide from the air. B, phenolphtelein: is a chemical compound that used as an indicator in acid base titration. Its application was used to turns colorless into acidic solution and pink in base solutions.

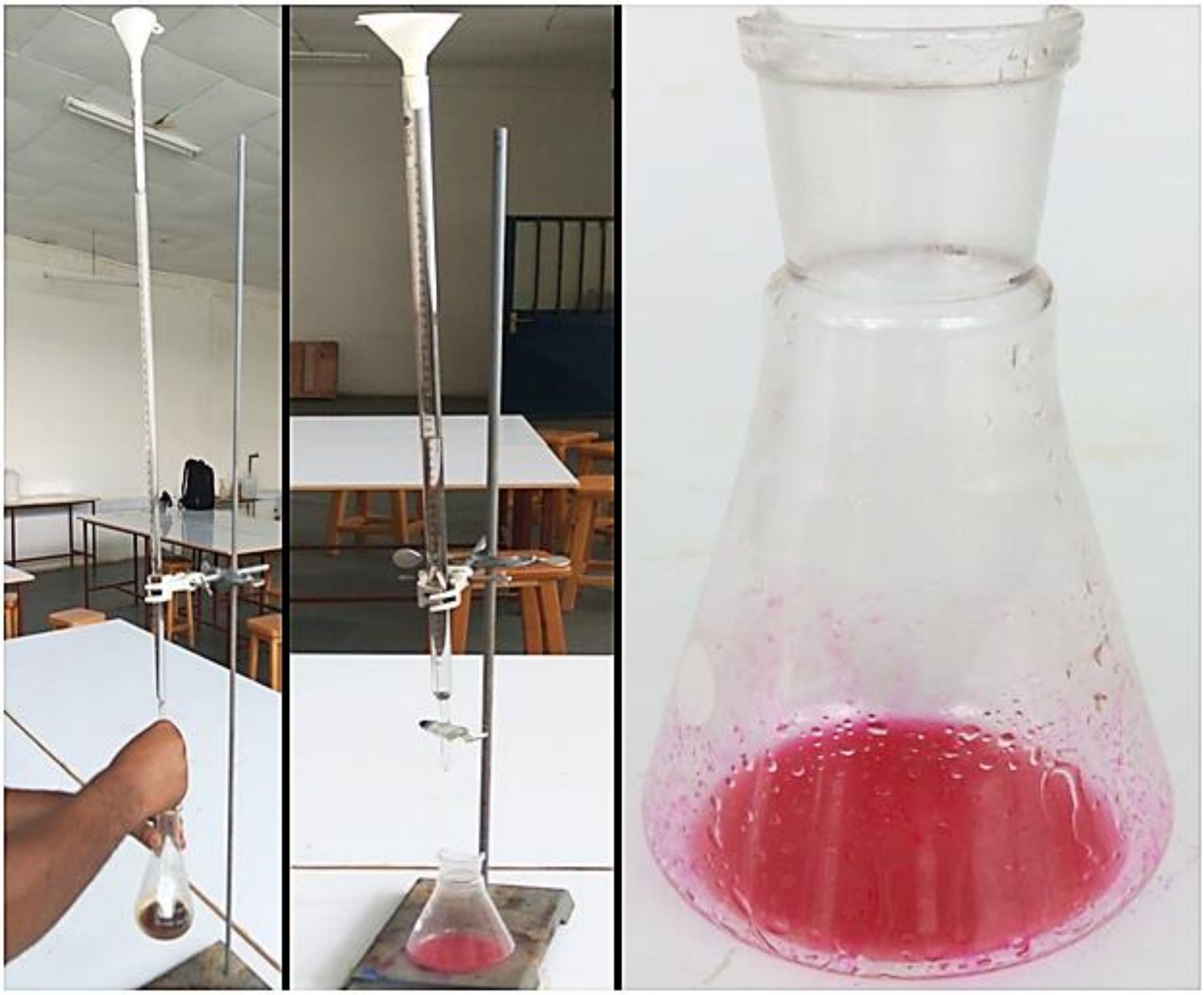


Figure 3.4 Making titration to calculate FFAs in the oil (pink color obtained)

If the oil samples have high FFA content (more than 1%) then the reaction wants a lot of alkali catalyst to neutralize the FFA. The aim was to find the FFA and extract biodiesel from the vegetable oils by base catalyzed transesterification method.

$$\text{Acid Value} = \frac{V \times N \times 39.9}{mass\ of\ the\ sample} \qquad 3.2$$

Whereas, V= Volume of NaOH consumed in titration

N = Normality of NaOH and 39.9 mass weight of NaOH

$$\text{Acid Value} = \frac{0.3 \times 0.5 \times 39.9}{5} = \frac{5.985}{5} = 1.2$$

$$\%\text{FFAs} = \frac{1.2}{2} = 0.59$$

From this acid value calculation, the value of FFAs result was less than 1.

FFAs < 1, therefore the transestirification process method was taken place to prepare biodiesel.

The procedures to make titration are as following.

1. Place 10mL of ethanol in a 50mL flask mix with phenolphtelein indicator
2. Check the color by paper indicator.
3. Pour 100mL of distilled water in 500mL flask and mix with 5gms of sodium hydroxide.
4. Placing 15ml of this mixed distilled water with sodium hydroxide into biuret pipette
5. Add the pH scale indicator solution drop by drop into 50ml flask.
6. Titrate (till the oil changes to pink color).
7. To gate accurate titration, repeat step 4 and 5 above again and drop at a time into measured oil.
8. Titrate the sample (i.e. the color should be pink) look it on figure 3.4
9. After this all procedure calculate the amount of FFAs found in cotton seed oil by using above equation (Eq. 3.2).

3.7 Laboratory preparation of biodiesel (Transestirification methods)

The transesterification reaction of Cotton seed oil was carried out at Adama Science and Technology University, chemistry department laboratory. The following fig. 3.5 shows that the transestrification reaction of cotton seed oil to making CSME and the various steps adopted in preparation of biodiesel from Cotton seed are listed as below.

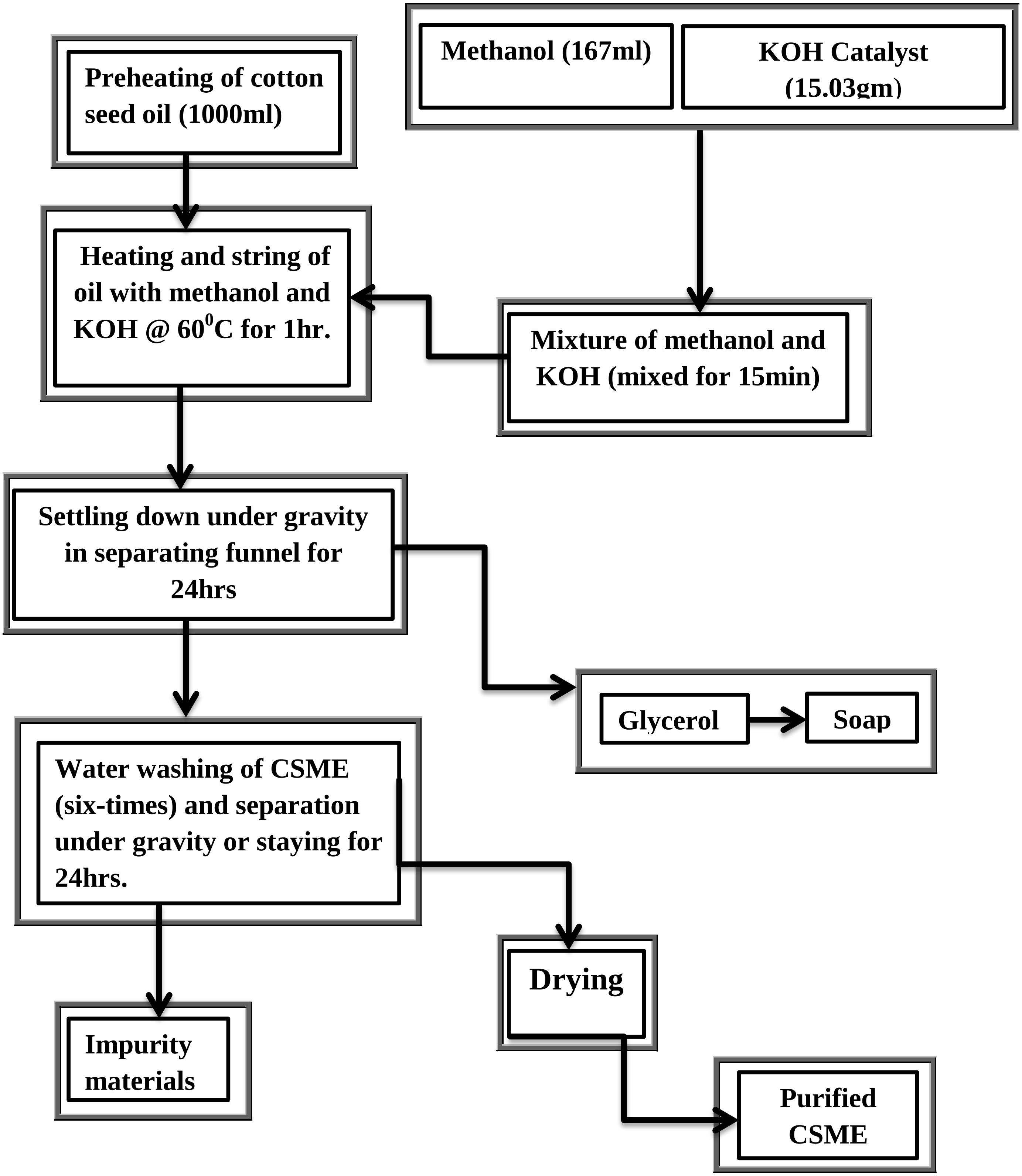


Figure 3.5 Flow charts of transestirification procedures

Step 1: first of all the required Cotton seed biodiesel oil was prepared. 600ml of oil was measured and poured into beaker and preheated to temperature of 60^0C for 1hr. to remove the water (fig.3.5).

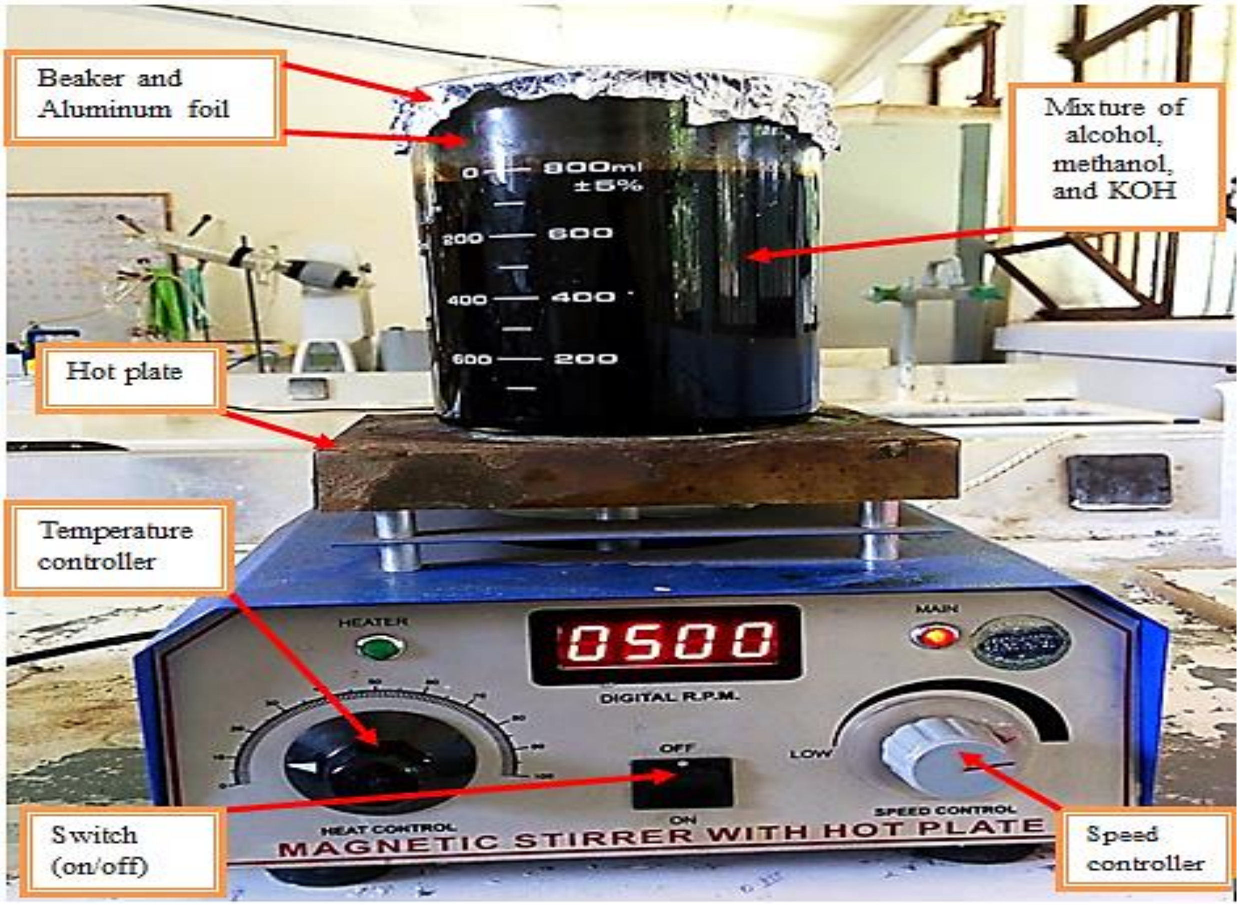


Figure 3.6 Preheating of the oil

Step 2: the solution of potassium methoxide was prepared in volumetric flask using 9 gm of KOH (i.e., catalyst concentration of 9gm) and 100 ml of methanol (i.e., mole ratio of oil to methanol of 1: 6). the solution was properly stirred till potassium hydroxide pellet was completely dissolved (i.e., a minimum of for 12 minutes) (fig.3.6).

Figure 3.7 Measuring potassium hydroxide

Step 3**:** the potassium methoxide solution was then poured into the warm oil at 60^{0}C and stirring speed at 500 rpm smartly (for 60 minutes) using a magnetic stirrer with hot plate (look step1). Throughout the transesterification reaction the mixture of Cotton seed oil and methoxide were coated by aluminum foil to prevent the loss of methanol since its boiling point was closer to 60^{0}C.

Step 4: the next procedure was the mixture must been allowed to settle for 24 hours during a separating funnel to separate glycerol from methyl ester. Gravity separation makes glycerine at bottom and biodiesel is easy to visible as glycerine can settle and might be drawn off the bottom of the reactor. We can identify from each other on fig.3.7 and fig.3.8 below.

Figure 3.8 Allowing the mixture for 24 hours.

Step 5: The biodiesel was then poured into a separate beaker, whereas the lower layer (which contains of glycerol and soap) was collected from the bottom of the separating funnel (fig.3.8).

Figure 3.9 Separated glycerol from methyl ester (ME)

Step 6**:** Separated glycerol and biodiesel before washing. Efficient separation of glycerol from biodiesel maybe reduces the amount of glycerine and catalyst in methyl ester after MeOH recovery (fig.3.9).

Step 7: Water washing is that the most flexible way to purify biodiesel. Warm distilled water (50% v/v at 55^0C,) was then used to wash the biodiesel to remove any excess glycerine and soap that stay within the funnel. This was done till the clear water was seen below the biodiesel in the separating funnel (fig.3.10).

Figure 3.10 Separated glycerol and biodiesel before washing

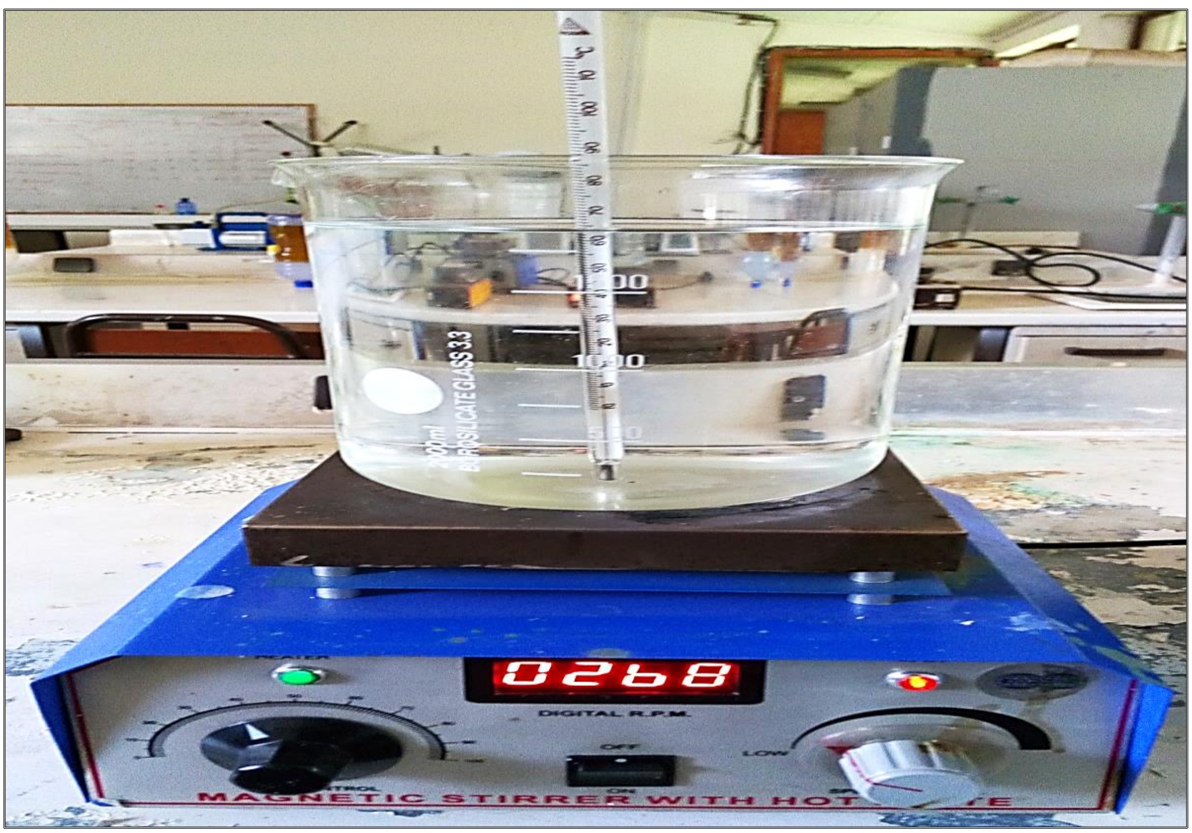


Figure 3.11 Warming distilled water before poured into biodiesel

Step 8: now the methyl ester was washed and boiled to remove the excess methanol, KOH, and other impurities and most yield 87.4% was obtained. At this step at least we've 6 steps to clean biodiesel. Keeping the methanol liquid and diluted in water makes water washing the safest way to clean biodiesel. Impurities migrate from the biodiesel to the water through the boundary layer over time. This method takes place to 24 hrs to saturate the water with contaminants (fig.3.11).

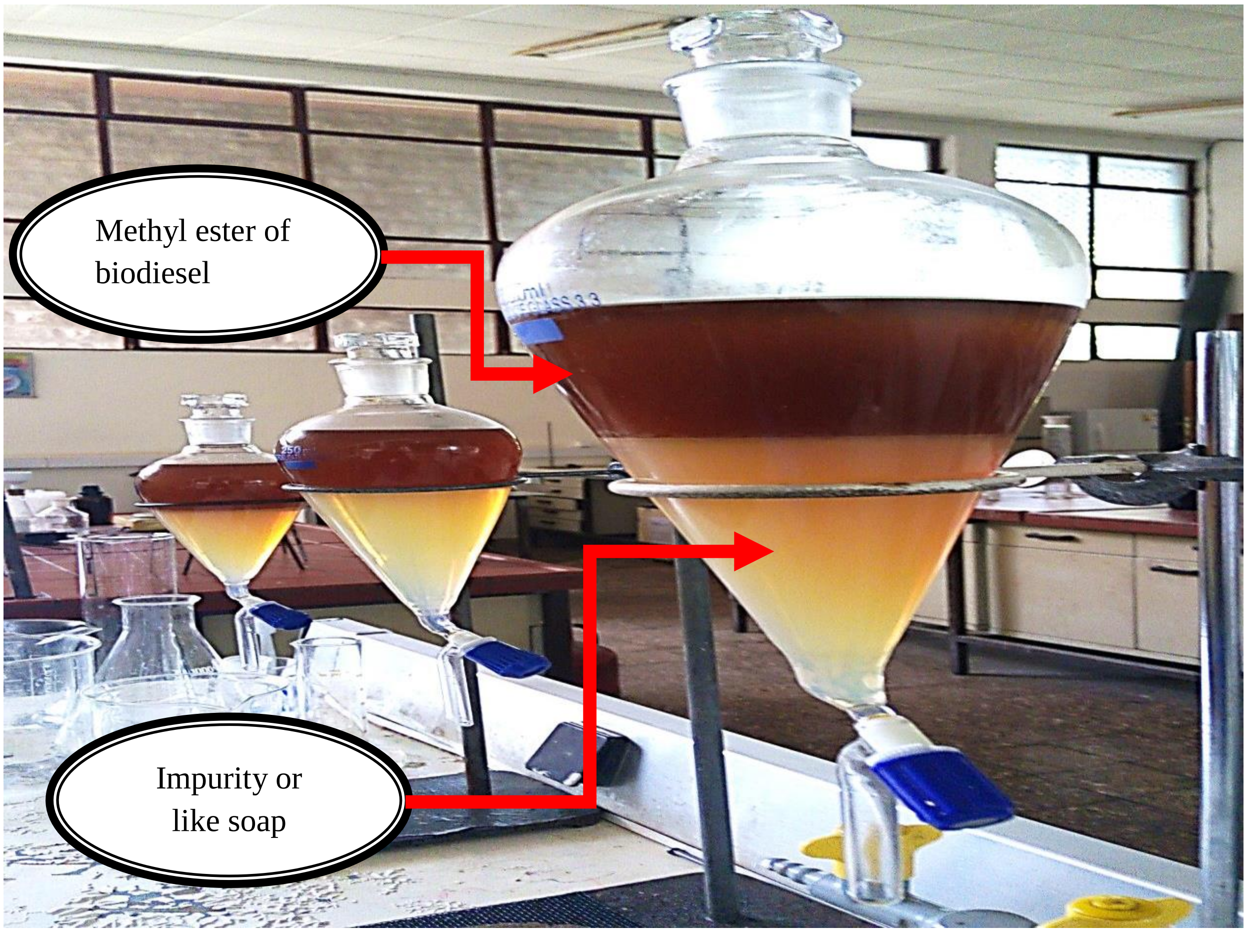


Figure 3.12 The first step of washing biodiesel (shows the soap was partially separated).

The amount of soap residue in purified biodiesel was considerably decreased when using all steps of washing (fig.3.12).

Regarding to washing analysis, the washing temperature and also the amount of wash water have a major effect on the level of soap residue in the final product. Keeping the water temperature at 60^0c and half amount of water to oil was separate soap from oil. Look fig.3.13 below; at this washing step the soap (impurity) slightly come too settled down.

Figure 3.13 The second step of washing biodiesel

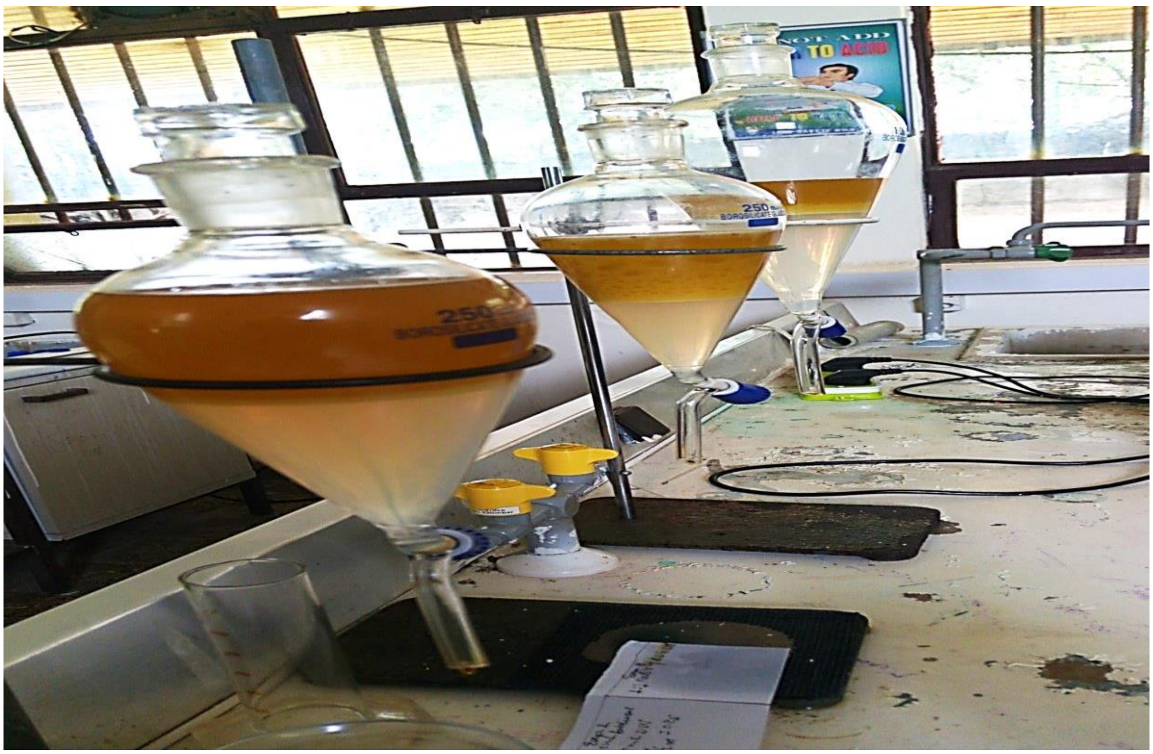


Figure 3.14 The third step of washing biodiesel

From fourth steps of washing biodiesel, we've seen that the soap was nearly going too purified and additionally the oil become brightly and separate from impurity materials (fig.3.14).

Figure 3.15 The fourth of step washing biodiesel

Now, this step of washing biodiesel (fig.3.15) was clearly visibly that the water was settling at the bottom and oil was at the top. Actually the alcohol and catalyst present within the ester (biodiesel) were removed.

Figure 3.16 The fifth step of washing biodiesel

The following washing steps were the last washing of biodiesel such as water and the ester were utterly separated from each other. Fig.3.17. show that purified water and it had been removed from the ester before used.

Figure 3.17 The sixth step of washing biodiesel

Step 9**:** The washed Cotton biodiesel (ester) was dried by placing it on a hot plate for 1hr at 140^{o}C. Then the amount of biodiesel collected was measured and yield of biodiesel was calculated (fig.3.17).

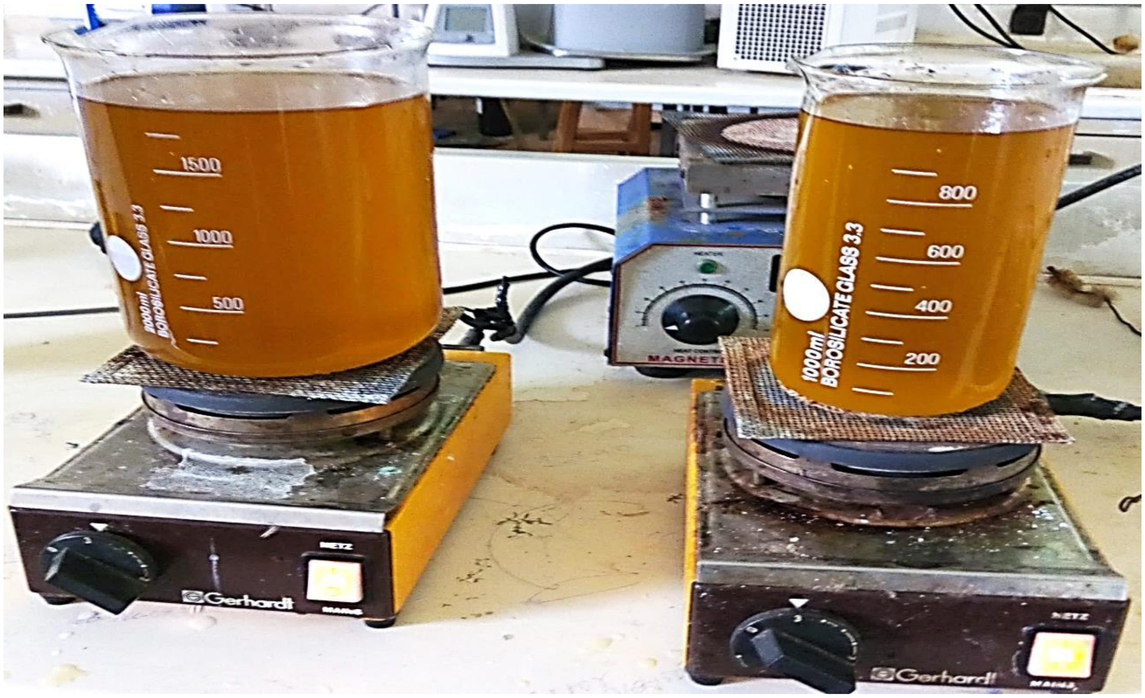


Figure 3.18 Before heating and drying collected biodiesel

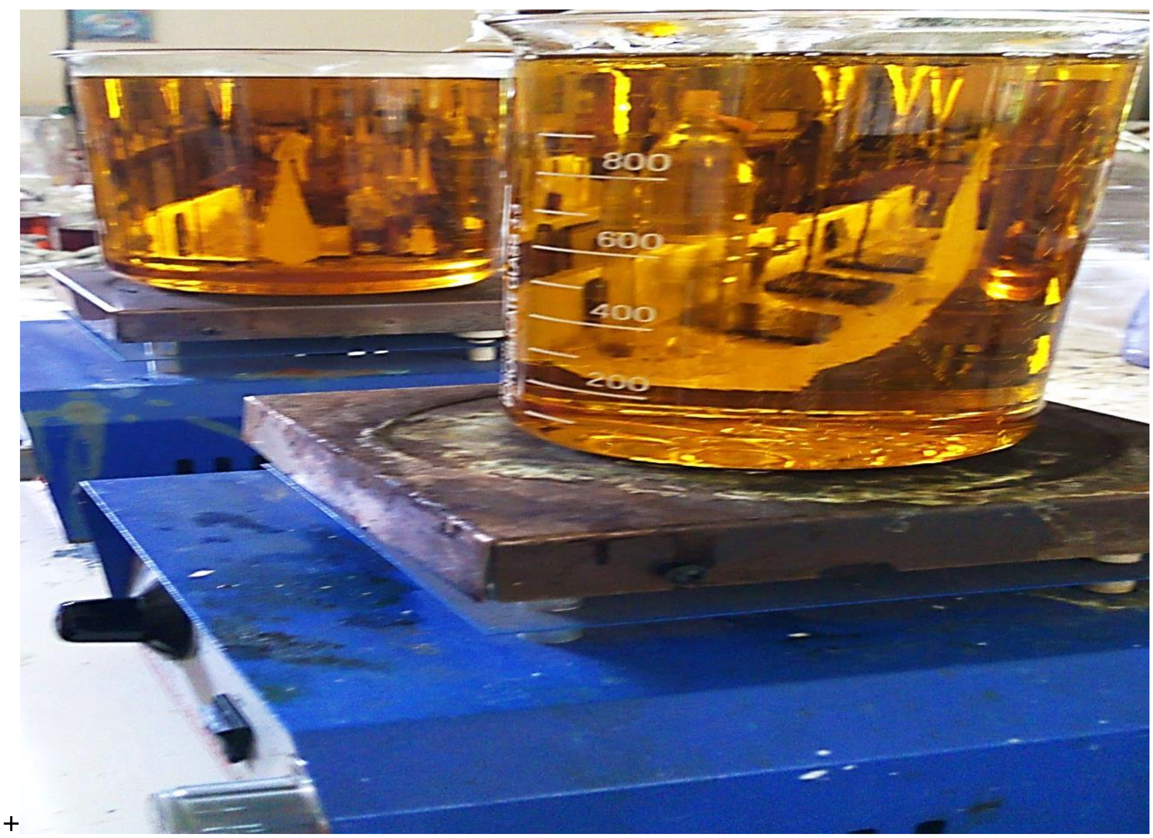


Figure 3.19 After heating and drying collected biodiesel

Figure 3.19, shows that the final collected pure biodiesel after dried. Generally following all the above procedure listed, we will pure produce biodiesel fuel.

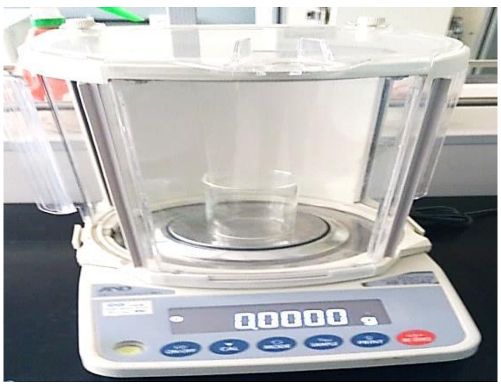
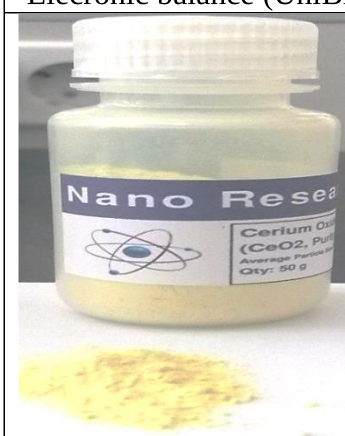
Figure 3.20 The final collected biodiesel and ready to use into the engine

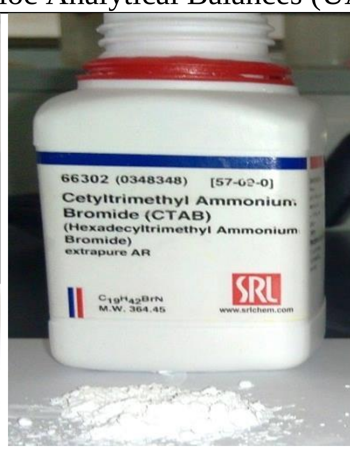
3.8 Preparation of Nano particle

Preparation of nano additive (in case of this thesis work) cerium oxide nano particle was prepared carefully with keeping its from air contamination, mixing water, light, and etc. this is because of the fact that nano additives were considered as a propitious fuel-borne catalyst to improve the fuel properties. Due to this, if it has some contamination may be it doesn't react as well as not simply mix with fuel. Also it was settled at the bottom during mixing with blend fuel. Materials used for preparation of Nano particle are listed in table 3.3 below.

Table 3.3 Material used for preparation of Nano particles

<table>
<tr><th>Lists of Materials</th><th colspan="2">Descriptions</th></tr>
<tr><td rowspan="8">

Ultrasonicator machine</td><td colspan="2">Ultrasonicator machine is used for blending process of Nanoparticles and vibrating at low, medium, and high amplitude at a frequency of 20 to 100 kHz.
Specifications</td></tr>
<tr><td>Model</td><td>UC-20</td></tr>
<tr><td>Cleaning capacity</td><td>50W</td></tr>
<tr><td>Heating capacity</td><td>100W</td></tr>
<tr><td>Temperature</td><td>0---800C</td></tr>
<tr><td>Time setting</td><td>1---99min</td></tr>
<tr><td>Volume</td><td>10L</td></tr>
<tr><td>Frequency</td><td>40kHz</td></tr>
<tr><td>
Elecronic balance (UniBloc Analytical Balances (UAB))</td><td colspan="2">UAB: - often called a "lab balance" is a class of balance designed to measure small mass in the sub-milligram range. They use an electromagnet to generate a force to counter the sample being measured and output the result by measuring the force needed to achieve balance.(0.00001gm)
Weighing a liquid, powder, or granular substance at high accuracy
And optimum performance and large easy to read display.</td></tr>
<tr><td>



Nano Particle (a) CTAB. Powder (b)</td><td colspan="2">A. Cerium oxide CeO_2 alpha, 1-30 nm, purity 99% was purchased from Nano laboratory India.
B. (CTAB): Cetyle trimethyl ammonium bromide is quaternary ammonium surfactant. Surfactants play a key role in nanoparticle synthesis by adsorbing to the surface of the forming nanoparticle, lowering its surface energy and help to prevent collection.</td></tr>
</table>

3.9 The methods to prepare Nano particles

There are three main methods with their sub procedure to prepare Nano particles

i. Starting the ultrasonic cleaning function

- First of all the recommended diesel-biodiesel blend samples (B20+50ppm and B20+100ppm) selected.
- Fill the cleaning tank with water, at least half full.
- Connect the ultrasonic cleaner to the power supply system.
- Set the cleaning time by means of the “timer setting” keys, up (increase time till 60min).
- Press the “cleaner on” key to start cleaning. The remaining cleaning time is displayed in the timer display in minutes and seconds.

ii. Starting the heating function

- Set the temperature by means of the “temperature setting” keys, down (decrease till room temperature).
- The Nano particles are weighted to predefined mass fraction say 50 ppm and 100ppm (0.05gms of CeO_2 + 0.1gms of CTAB and 0.1gms of CeO_2 + 0.2gms of CTAB) are prepared.
- 100ml of diesel-biodiesel mix was measured and poured into the beaker. Then stirring with 300rpm approximately at room temperature for 15minutes (i.e., for B20+50ppm, B20+100ppm respectively) shown on figure 3.21 below.

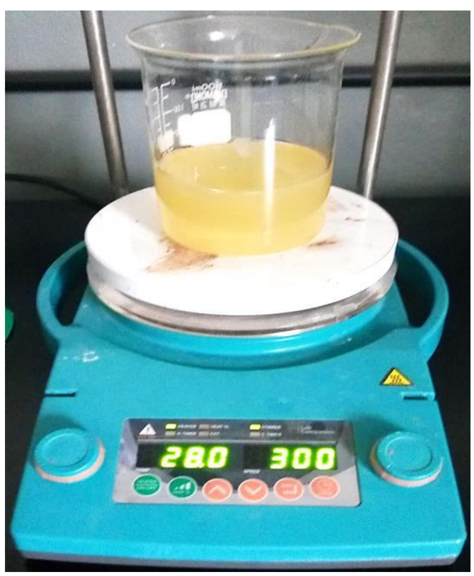


Figure 3.21 Preparing Cerium Oxide Nano particles

iii. Press the "heater on" key to start the heating function

- 4. 900ml diesel-biodiesel blend and 100ml prepared Nano particles poured into the bottle for (B20+50ppm sample). Again repeat same procedure for diesel-biodiesel blend for B20+100ppm sample and with the aid of ultrasonicator set at a frequency of 40 kHz for 30 min.

Figure 3.22 Ultrasonicator sated at a frequency of 40 kHz for 30 min.

3.10 Characterization of Cotton Seed Biodiesel

Characterization is that the process of determining physico-chemical properties of petroleum products and non-petroleum product like diesel-biodiesel blends. Thus before testing the performance and emission of this biodiesel blend it's very important to check physicochemical properties. During this study characterization of biodiesel was done in partial that's only for density, viscosity, flash point, total acidity, cloud point and at Ethiopian petroleum offer enterprise laboratory. The test was done as per the procedure of the enterprise in reference to ASTM methods with no involvement of the researcher. The sample drawn for characterization was only Cotton biodiesel (B100), 10% CSME + 90% Diesel (B10), 20% CSME + 80% Diesel (B20), 25% CSME + 75% Diesel (B25). The cottonseed oil biodiesel is used to prepare the blends and cerium oxide (CeO_2) is used as Nano additive and is employed in different proportions. The proportion of diesel fuel and biodiesel blends ratio is given blow in table 3.4.

3.11 Cotton Seed Biodiesel Blend Preparation

Cotton Seed Biodiesel may be blended with petrol diesel in any proportion, with B5 (5% biodiesel and 95% diesel) and B20 (20% biodiesel and 80%diesel) being the most common. No vehicle alternations are necessary if blended at levels of B20 or lower, although original equipment manufacturers have varied policies approving different blends to be used in their vehicles. the following are the fuel samples, Diesel, B10 (90% diesel and 10 % biodiesel in volume), B20 (80% diesel and 20 % biodiesel in volume), B20+50ppm (80 % diesel and 20 % biodiesel and 0.05 gm (50 mg/l) cerium oxide) in volume, B20 + 100ppm (80 %e diesel and 20 percentage biodiesel and 0.1 gm (80 mg/l) cerium oxide) in volume, B25 (75 % diesel and 25 % biodiesel in volume) in volume severally and the total number of experimental tests are 5 with 42 engine parameters tests. In this study only B20 (20% biodiesel and 80 % diesel fuel) with cerium oxide nano particle was being used in a conventional CI engine for the comparison. These are pure diesel (B0); cotton seed biodiesel blends (B20) plus B20 + 50ppm CeO_2 and B20+100ppm CeO_2 and fuel blends were prepared by volume as shown in the table 3.4 below

Table 3.4 Preparations of fuel blend by volume

S.No	Fuel type	Petro diesel	Cotton Seed biodiesel	Nano Particles	Total
1	B0	2000ml	-	-	2000ml
2	B10	1800ml	200ml	-	2000ml
3	B20	1600ml	400ml	-	2000ml
4	B25	1500ml	500ml	-	2000ml
5	B20+50ppm	1600ml	400ml	50ppm of CeO_2	2000ml
6	B20+100ppm	1600ml	400ml	100ppm of CeO_2	2000ml

Figure 3.23 Types of fuel blends

3.12 Engine Performance Testing

The performances and exhaust gas emission test were conducted at the Mechanical and Vehicle Engineering work shop of Dilla University. Engine performance was measured through CT 110 Test Stand for Small Combustion Engine. The CT 110 Test Stand for Small Combustion Engines facilitates experiments on combustion engines on the consumption of air for combustion and fuel consumption. In addition, measured values on the load behavior and speed of the engines under test are provided. Apart from the CT 110 test stand, a functional experimental setup must include at least one engine (e.g. CT 100.20). Once the engine is placed in the test stand, experiments for plotting engine performance can be performed. For this purpose the combustion engine is connected to the asynchronous motor, which is operated as a dynamometric brake. A part from measurements on the consumption of fuel and combustion air, the Test Stand for Small Combustion Engines is used in experiments to measure the torque and speed on the engines employed. The relevant measured values are indicated on clear displays.

A vibration-damped base plate is provided as a mounting for the engines. The asynchronous motor, which functions as a dynamometric brake, is equipped with a frequency converter. This facilitates the injection into the mains of the electrical energy gained when the asynchronous motor is used as a brake. Injection is performed using a powerful power return unit. Power is transmitted between the engine and braking device via an elastic claw coupling. The schematic of the CT 110 Test Stand for Small Combustion Engine test set up schematic were found on Appendix-A. Table 3.5 below shows the specification of the engine test stand for single cylinder engines (CT 110 Test Stand for Small Combustion Engine) which used for performance and exhaust emission test.

Table 3.5 T CT 110 Test Stand for Small Combustion Engine specification

Sr.No.	CT 110 Test Stand for Small Combustion Engine specification and Technical Data	Dimensions
1	Engine model	1B30-2
2	Number of cylinders	1
3	Length x Width x Height	370 mm x 330 mm x 450 mm
4	Company	Hatz
5	Weight	35 kg
6	Fuel	CT 100.22 Diesel
7	Bore	80 mm
8	Stroke	69 mm
9	Crank length	34.5 mm
10	Rod length	114.5 mm
11	Output power at 3500 min-1	5.5 kW
12	Oil capacity	1.1 L
13	Stop solenoid	12 V
14	Compression ratio	22: 1
15	Engine type	Air-cooled single cylinder 4-stroke Diesel Engine

3.13 Exhaust gas analyzer (Infralyt smart)

The Infralyt Smart modular gas analyser has been specially designed and manufactured to accurately measure specific gas components of the exhaust of petrol engine vehicles (with or without catalyst) in any situation where the composition needs to be determined.it can be used for;

- General vehicle servicing
- Statutory testing to the prescribed limits
- Emissions enforcement
- Training
- Tuning engines

The Infralyt Smart equipped with an integrated revolution counter and oil temperature measuring device can be used to:

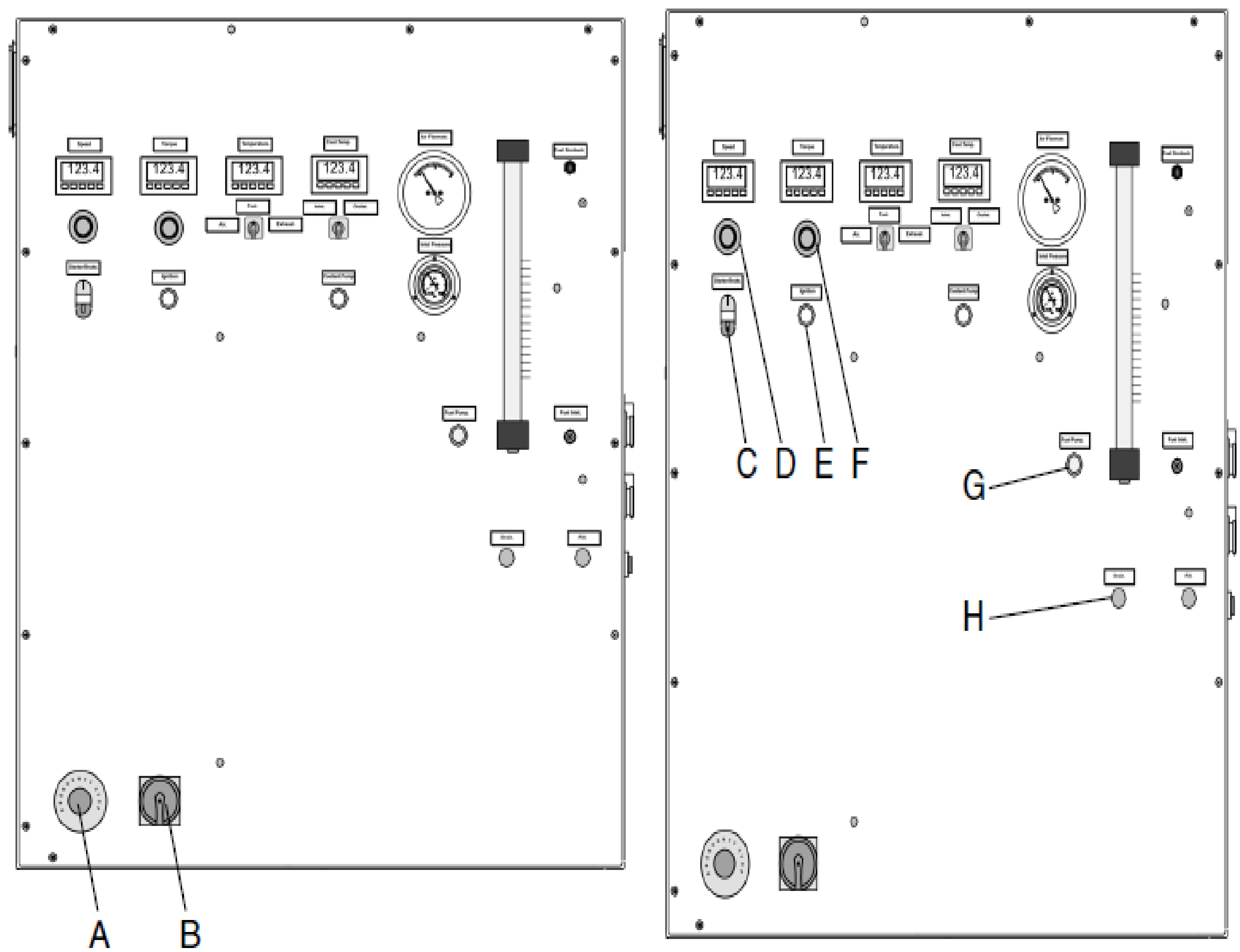
- Accurately monitor the CO levels and air/fuel ratio (Lambda) prescribed by legislation
- Carry out rapid fault diagnosis on engines using the composition of the exhaust gas and other measurable factors
- To analyses the fuel mixture
- To assist with ignition timing and valve adjustment

- To measure engine speed and oil temperature on 2 and 4 stroke engines using a variety of probes/sensors

To simply understand and operate the exhaust gas analyzer, its components thus schematic represented by number were named as following on Appendix-B Experimental test set up of CT 110 Test Stand Diesel Engine. During experiments, the test stand is used to display torque, speed, and various temperatures and to perform consumption measurements for combustion air and fuel on the engine being tested. The desk top computer connected engine test measures the output results of engine performance and gas Analyzer records output emission test. The total output measurements were mechanical efficiency, thermal efficiency, brake power, brake torque, brake fuel specific consumption, exhaust gas etc. But, on this thesis work, the output measurements were only exhaust gas, brake torque, brake fuel specific consumption, and brake power.

3.14 Experimental procedure

- First of all; prepare all material that was used to adjust the CT 110 Test Stand Diesel Engine.
- The test was start with pure diesel fuel (B0) and followed by poured biodiesel-diesel blended sample (i. e, B10, B20, B25, B20+50ppm and B20+100ppm) into the fuel tank step by step to test and record accuracy result on output.
- Connect CT 110 Test Stand Diesel Engine to the mains electricity sources. All connections between the engine and the test stand must be set up. The air hose and exhaust hose must be connected, and the outlet of the exhaust hose must be outdoors
- The engine is fitted with a temperature sensor cable to measure the exhaust gas temperature.
- For this purpose, the combustion engine is connected to the asynchronous motor in the CT110, which is operated as a braking device. All tests were subjected to full loading.
- Now, the engine is started using the braking device in the CT 110 with the asynchronous motor operating as a starter motor or simply Turn on the master switch (**B**).
- Allow the engine to warm up without load for approximately 5 minutes and Check that the EMERGENCY STOP (**A**) is released. To release, pull the button until it clicks into place.
- Before starting the engine, the fuel line to the engine and the measuring tube on the CT 110 test stand must be filled so that top up fuel using the button (**G**).



(a) *(b)*

Figure 3.24 (a, b) shows that ON & emergency STOP and speed regulator

- Set the speed adjusting knob (**D**) for the asynchronous motor to approx. "5" and Set the torque adjusting knob (**F**) to a maximum torque of "10".
- Turn on the ignition with the push button (**E**) and Turn on the asynchronous motor by pressing the "Starter/Brake" button (**C**) (green) on the CT 110 test stand.
- When the C engine starts up, turn off the asynchronous motor with the "Starter/Brake" (**C**) (red) button. Here that the C engine now runs at idle speed.
- Full and partial load characteristic curves are to be recorded on the engine.
- The measurement time is about 10 s of the full load (for the stabilization of speed and result reading) for each measurement point (an individual value of speed).
- The experiment result was conducted, and recorded through on desk top computer with exhaust analyzer displayed.

- For accuracy of the measurement the test was repeated two times for each tested fuel samples.

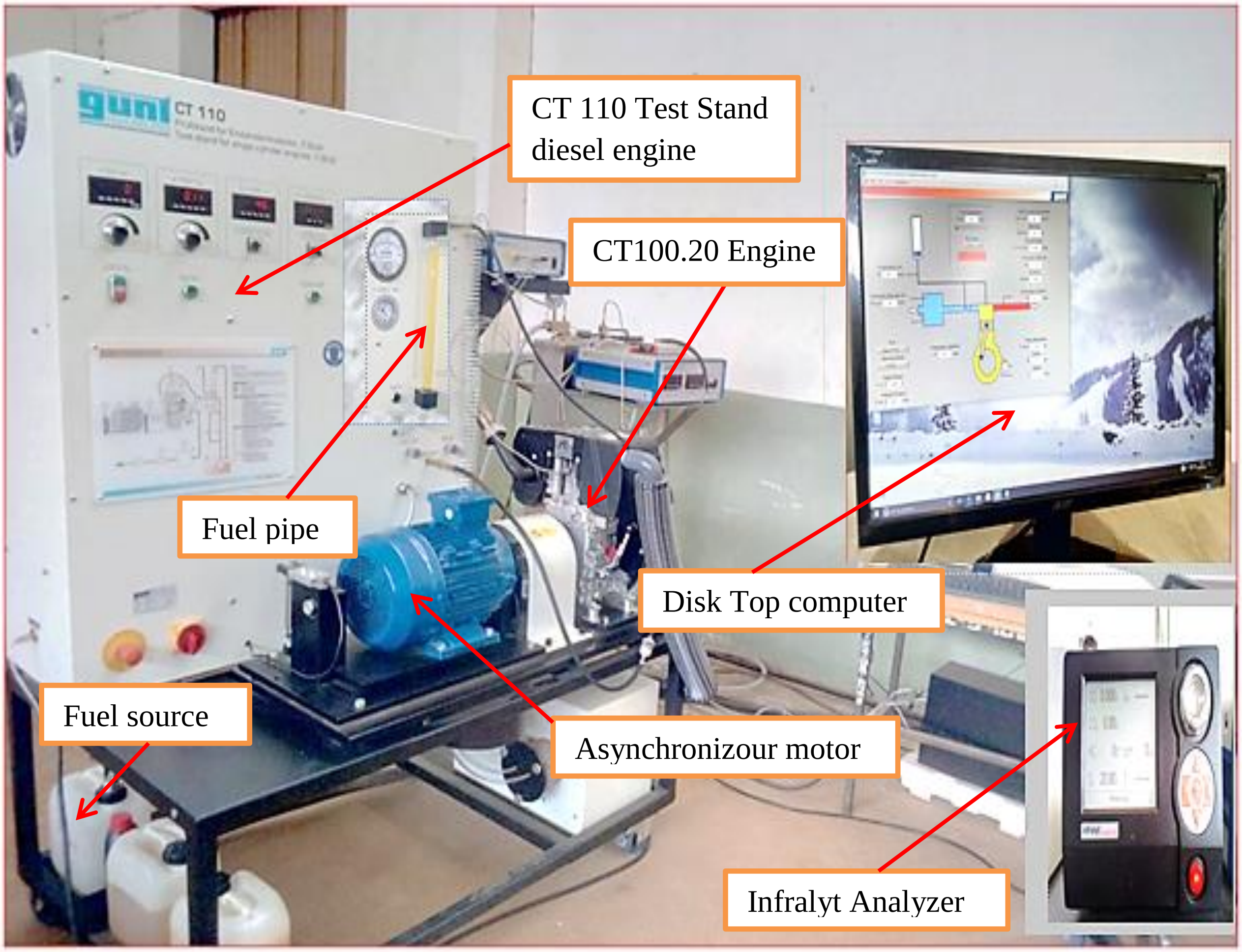


Figure 3.25 Installed CT 110 Test Stand Diesel Engines

3.15 Data Analysis

From the experiment Test Stand for Small Combustion Engine exhaust gas, brake torque, brake fuel specific consumption, and brake power data were directly collected from recorded through on desk top computer with exhaust analyzer displayed. These data were tabulated in accordance with specified engine speed and converted into brake power and brake torque of the engine relative to the engine speed.

i. Brake Power (Pb): is the net power available at the 'Flywheel' (at crank shaft). The output power can be calculated and can be plotted as a curve on a graph for the different speeds. To record the output power curve related to the full load characteristic curves, with the engine running the speed regulator is set to the maximum amount of fuel. Using the dynamometer on the CT 110 test stand, the engine is then loaded by turning the speed potentiometer to maximum.

$$P_b = M_L \times 2\,\pi \times n \qquad 3.4$$

Where: P_b = brake power (kW), n = engine speed (rpm) *and* M_L = engine load

ii. Brake Torque (Tb): is the torque available at the ‘Flywheel’. By reducing the speed set on the potentiometer in steps, torque values are displayed on the CT 110 test stand from which the output power curve can be drawn up.

$$T_b = \frac{\dot{m}_b}{p}\,, \quad \frac{gm}{se}/\mathrm{kW} \qquad 3.5$$

Where: T_b = brake power, $\dot{m}_b$ = mass flow rate of fuel and p= density of fuel.

iv. Brake Specific Fuel Consumption (Bsfc): bsfc was defined as the amount of fuel required to be supplied to engine to develop 1kW of power per hour at crankshaft. It’s the ratio of the amount of fuel consumed by the engine in gram per hour (gm/hr) to a unit brake power of the engine in ‘kW’. Since the measurement was taken by volumetric flow rate, mass flow rate of the fuel was obtained by multiplying with its density. Adjusted using the speed potentiometer on the CT 110 test stand whilst the engine load is 0 (torque display at 0). The load on the engine is then increased in evenly spaced steps using the speed regulator on the engine whilst the speed is maintained constant, i.e. the speed is readjusted on the test stand. Measured values for the fuel consumption are recorded; the consumption is measured at the measuring tube on the test stand using a stopwatch. For each value set for the torque, the time that it takes until the liquid level drops from one mark to the next is measured on the stopwatch (1cm drop on the scale corresponds to 5.1cm^3 fuel consumed). The conversion is performed using the formula:

$$b_e = \frac{\dot{m}_b}{P} \times 2\pi \qquad \frac{(\frac{gm}{se})}{kW} \qquad 3.6$$

But for $\dot{m}_b = \dot{\upsilon} \times \rho_{fue}$

Where: b_e = brake specification of fuel consumption (g/kWh), $\dot{m}_b$ = mas flow rate (kg/h), P = brake power (kW), $\dot{\upsilon}$ = volumetric flow rate (m^3/h) which given as brake specification of fuel consumption and ρ_{fue} = density of fuel, (kg/m^3)

3.16 Measurement of exhausts emission

The substances which are emitted to the atmosphere from any opening of the exhaust part of the engine are called as exhaust emissions. If combustion was complete and the mixture is stoichiometric the product of combustion would consist of carbon dioxide (CO_2) and water and water vapor only. However, there is no complete combustion of fuel and hence the exhaust gas consists of variety of components….most important of them are carbon monoxide (CO), unburned hydrocarbons (UBHC) and nitrogen (NOx). But the measurement of NOx is not included in this work due to the engine test of NOx installation problem.

CHAPTER FOUR

4 RESULT AND DISCUSSION

4.1 Extraction of Cotton seed oil

The amount of oil extracted from the seeds was calculated according to the formula given in the methodology (Eq.3.1). The machine extracts about 48% (v/v ratio) of cotton seed oil. The amount of processed cotton seed for oil extraction was 300kg that were broken into small items and pressed automatically within the machine. There are two outlets, by initial outlet the crude oil found and by alternative outlet the cake or residue or wastage product removes. Finally, from these 300kgs of cotton seed, 48Ls, crude cotton seed oil was extracted and 216kgs of cake was produced. This work was done at Holeta, Hundaf Engineer Food oil production Plc.

4.2 Biodiesel yields

The biodiesel production was done by transestrification reaction process using methanol alcohol and KOH catalyst. When washing six times by distilled water and drying biodiesel production yield was found to be 87.4% yield obtained. The following table 4.1 was shown that the reaction condition and biodiesel yield.

Table 4.1 Reaction condition and biodiesel yield.

Sample name	Molar ratios	Oil sample (ml)	Methanol (ml)	KOH (%w/v)	Reaction temp. (^{o}c)	Reaction time (minutes)	Yield (%)
Cotton seed	1:6	600	100	0.09%	60	60	87.4

The amount of biodiesel made and byproducts of biodiesel production in one liter unit is listed below. Table 4.2 below contains amount of raw material needed and also the amount of final product obtained.

Table 4.2 Shows that biodiesel production in one liter unit

Oil	Quantity used	Methanol used	FFA content	KOH Used	Biodiesel obtained	Glycerol obtained
Cotton seed	1000ml	167ml	0.59%	15.03gms	874ml	284ml

4.3 Characterization Result

Characterization was done to know the properties of the biodiesel produced whether it satisfies the ASTM standards for biodiesel prior to testing its performance in the existing diesel engines without doing any modification. The characterization results of the biodiesel produced from cotton seed oil and blend fuels that were certified from Ethiopian petroleum supple enterprise's shown in the table 4.3 (or in Appendix-D). From table 4.3, the density of blend fuels such that, B10, B20, and B25 increased while B20+50ppm CeO_2 and B20+.100ppm CeO_2 decreased in the results. The density observed by nano particles (i.e.50ppm CeO_2 and 100ppm CeO_2) blend fuels were decreased than other three blend fuels as compared. These density results were similar within the range given by Europe standard (EN 14214). The viscosity of cotton seed biodiesel was nearly same with diesel, also satisfied the ASTM standard Europe standard (EN 14214). The flash point for B20+.100ppm CeO_2 and B20 were similar to each other whereas, B25 was higher than other fuel blends. B20+50ppm CeO_2 had more flash point than B20+.100ppm CeO_2 as compared. From this result, B25 fuel bled has higher flash point then other. On other way, B20 fuel blend has lower cloud point than other fuel blend while B20 fuel blend had higher cloud point. But in case of fuel blend with 50ppm CeO_2 and 100ppm CeO_2 has same results of cloud point. In addition to these, total acidity was increased in all cases. In generally when we conclude these properties of biodiesel produced and blends fuels found within the ranges or obeying the ASTM standards Europe standard (EN 14214) rules. Since the fuel with flash point more than 66^0c is considered as a safe, the results of all samples of biodiesels are considered to be safe to store and to use in the engine.

Table 4.3 The properties of biodiesel produced and blend fuels

SN.	properties	Test method ASTM	EPSE Diesel limits	Results					
				B100	B10	B20	B25	B20+ 50ppm CeO_2	B20+ 100ppm CeO_2
1	Density@15^OC (g/ml)	D4O52	Report	0.8563	0.8425	0.8467	0.8488	0.8477	0.8464
2	Density@20^0C (g/ml)	D4052	Report	0.8465	0.8389	0.8432	0.8454	0.8442	0.8458
3	Flash Point (PMCC, ^0C)	D93	Min.60	182	85	86	89	87	86
4	Cloud point (^0C)	D2500	Max.+5	+3	+1	-1	+2	+1	+1
5	Total acidity (mgKOH/g)	D974	-	0.0985	0.0852	0.1009	0.0918	0.0930	0.1005
6	Viscosity@40^0c (cSt)	D445	1.9-6	3.67	3.29	3.32	3.33	3.32	3.31

4.4 Engine Performance characteristics Vs engine speed (rpm) Graphs

Performance characteristics Vs engine speed graph establishes performance test results. However, the graph also provides concise explanation of each engine test movement of performance and characteristics. The engine performance was measured in terms of brake power, brake torque and brake specific fuel consumption by using the formula given in chapter three (i.e., Eqns. 3.4, 3.5, and 3.6). In this section all blends of the engine performance and emission test results were compared with standard diesel fuel.

1. Engine Brake Power (KW); the output power can be calculated and plotted as a curve on a graph for the different speeds. According to the formula give in the methodology (see Eq.3.6), The brake power founded relative to the engine speed for all tested fuel samples collected from the CT 110 Test Stand Diesel Engine are given in table 4.4 below.

Table 4.4 The output brake power data recorded from CT 110 Test Stand Diesel Engine

Sr.No	Engine Speed(rpm)	Engine Brake Power (KW)					
		1	2	3	4	5	6
		B0	B10	B20	B25	B20 + 50ppm CeO2	B20 + 100ppm CeO2
		Pb	Pb	Pb	Pb	Pb	Pb
1	1553	2.76	2.71	2.62	2.48	2.68	2.74
2	1800	3.25	2.82	2.74	2.57	2.90	3.08
3	2050	3.72	3.54	3.43	3.41	3.55	3.55
4	2305	4.01	3.83	3.71	3.64	3.71	3.98
5	2548	4.53	4.22	4.21	4.02	4.33	4.47
6	2808	5.18	4.67	4.60	4.31	4.53	5.21
7	3040	3.62	3.50	3.45	3.35	3.51	3.52

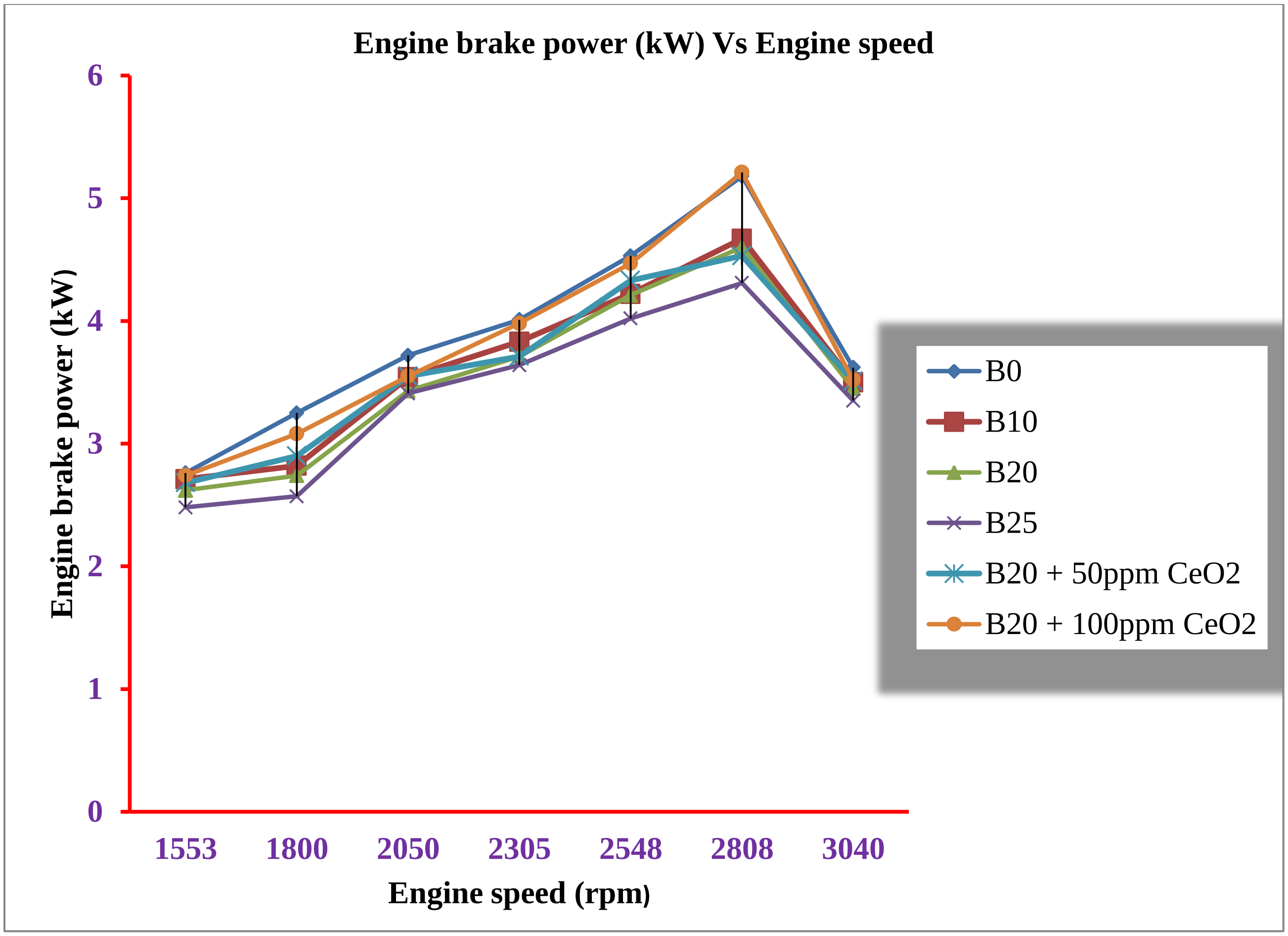


Figure 4.1 Variation of Brake power (kW) with Engine speed (rpm)

From the figure 4.1 above the maximum brake power produced by B0 (petro diesel) is 5.18 kW at engine speed of 2808 rpm. Also, the maximum brake powers for all fuel samples were taken place at engine speed of 2808 rpm. The curve shows that at lowest engine speed the brake power is lower, but as the engine speed keep increasing the brake power was also increased until it reaches its maximum and then start to fall down at higher engine speed. The higher value of brake power for B0, B10, B20, B25, and B20 + 50ppm CeO_2, B20 + 100ppm CeO_2, at this point were 5.18kW, 4.67kW, 4.60kW, 4.31kw, 4.53kW, and 5.21kW respectively. B20 + 100ppm CeO_2 had higher Brake power than other fuel blended, this may be due to cerium oxide nanoparticles additives. From this graph we have to understand that biodiesel blend fuel with Cerium Oxide (B20+100ppm CeO_2) additive had more brake power than B20 + 50ppm CeO_2 as compared.

2. Engine Brake Torque (Nm): the brake torque or engine torque was calculated based on the formula give in the equation (3.5) of the methodology. By reducing the speed set on the potentiometer in steps, torque values are displayed on CT 110 test stand from which the output power curve can be drawn up.

Table 4.5 The output brake torque data recorded from CT 110 Test Stand Diesel Engine

Sr.No	Engine Speed(rpm)	Engine Brake Torque (Nm)					
		1	2	3	4	5	6
		B0	B10	B20	B25	B20 + 50ppm CeO_2	B20 + 100ppm CeO_2
		Pb	Pb	Pb	Pb	Pb	Pb
1	1553	15.12	15.03	14.89	14.75	14.99	15.11
2	1800	16.02	15.91	15.73	15.47	15.89	15.99
3	2050	16.87	16.67	16.23	16.21	16.58	16.71
4	2305	17.05	16.88	16.53	16.44	16.87	16.95
5	2548	18.48	18.35	18.12	17.83	18.43	18.52
6	2808	14.81	13.98	13.77	13.36	13.78	14.03
7	3040	13.02	12.71	12.63	12.51	12.68	12.76

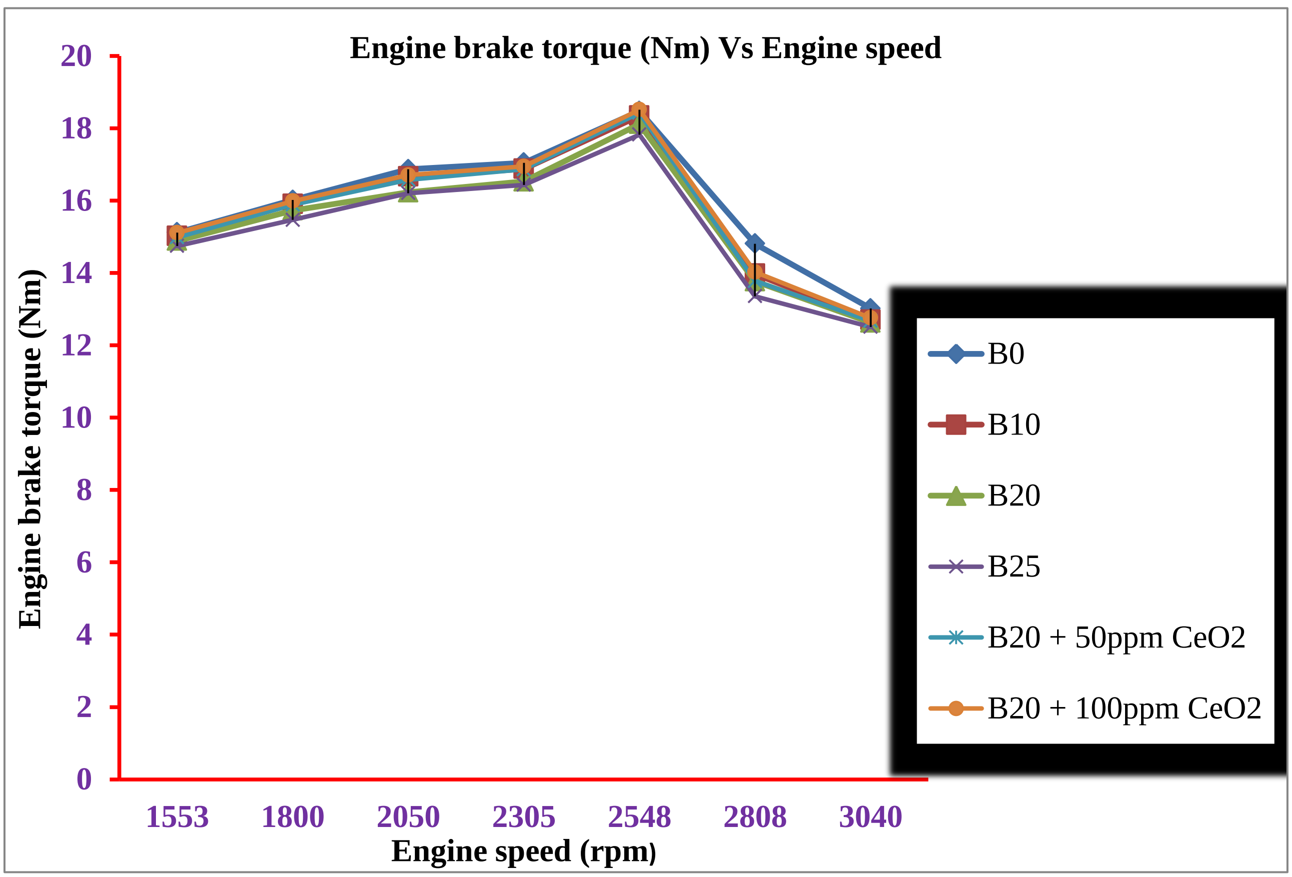


Figure 4.2 Variation of Brake torque (Nm) with Engine speed (rpm)

From fig 4.2 above the maximum engine brake torque produced by B0 (petro diesel) was at 2548Nm engine speed. Similarly, the maximum brake torques for all fuel samples were taken place at engine speed of 2548 rpm. The graph shows that at lowest engine speed the brake power is lower, but as the engine speed keep increasing the brake power was also increased until it reaches its maximum engine speed (2548 Nm) and then start to fall down at higher engine speed. At the maximum engine speed (2548Nm) the brake torque for all fuel samples (i, e. B0, B10, B20, B25, and B20 + 50 ppm CeO_2, and B20 + 100 ppm CeO_2) were 18.48 Nm, 18.35 Nm, 18.12 Nm, 17.83 Nm, 18.43 Nm, and 18.52 Nm respectively. Here also, B20 + 100 ppm CeO_2 had higher brake torque than other fuel blended, this may be due to cerium oxide nanoparticles additives. Within this reason out, the B20 + 100 ppm CeO_2 nanoparticle fuel blend had higher brake torque than B20 + 50 ppm CeO_2 nano particle fuel blend and drops from certain point as compared. The other reason for brake torques drops off at lower engine speeds is due to heat losses. The percentage heat rejected to coolant is more at lower speed. When engine is running at low speed, there is a relatively longer time for heat conduction to engine parts and then to the coolant; this will reduce the heat available for doing work. But as engine speed increases there is a relatively shorter time for heat loss and torque reduction due to heat loss will be minimal, thus brake torque rises up to 2548 rpm engine speed. Starting from this point the brake torque was drops until certain point.

3. Brake Specific Fuel Consumption (Bsfc) (kg/kWh): the Bsfc of bio diesel engine depend mainly on the relationship between the volumetric fuel injection system, viscosity, fuel density, and energy contents. Table 3.6 below shows that the output data recorded from CT 110 Test Stand Diesel Engine. The volume flow rate of the fuel was converted into the mass flow rate ($\dot{m}f$) by multiplying with the fuel density and the brake specific fuel consumption (Bsfc) of the engine at each speed was calculated based on the formula given in the methodology (Eq.3.6).

Table 3.6 the output *Bsfc* data recorded from CT 110 Test Stand Diesel Engine

Sr.No	Engine Speed(rpm)	Brake Specific Fuel Consumption (bsfc) g/kWh					
		1	2	3	4	5	6
		B0	B10	B20	B25	B20 + 50ppm CeO_2	B20 + 100ppm CeO_2
		bsfc	*bsfc*	*bsfc*	*bsfc*	*bsfc*	*Bsfc*
1	1553	0.357	0.332	0.343	0.342	0.331	0.329
2	1800	0.326	0.312	0.318	0.317	0.309	0.307
3	2050	0.311	0.295	0.297	0.306	0.289	0.284
4	2305	0.299	0.279	0.28	0.287	0.269	0.265
5	2548	0.297	0.278	0.266	0.291	0.277	0.263
6	2808	0.332	0.321	0.331	0.325	0.315	0.301
7	3040	0.347	0.355	0.356	0.368	0.347	0.327

Brake specific fuel consumption is better parameter to compare the performance of an engine when different biodiesel blend were used. Fig 3.6 below was shows that the brake specification fuel consumption with engine speed for neat diesel, biodiesel blend fuel and biodiesel blend fuel plus cerium oxide nano particles. This graph shows that at lowest engine speed (from 1553 rpm to 2548rpm) the brake specific fuel consumption (*Bsfc*) was decreased. However, as engine speed increasing from 2548rpm the Brake specific fuel consumption (Bsfc) was smoothly increased. At an engine speed 2548rpm, the lowest *Bsfc* fuel blend sample was within cerium oxide (B20 + 100 ppm CeO_2). All diesel biodiesel fuel blends have lower brake specific fuel consumption (*Bsfc*) than neat diesel. But at engine speed was 2808 rpm become decreasing. This was due to the fact that the neatly diesel has higher heating value then biodiesel as compared.

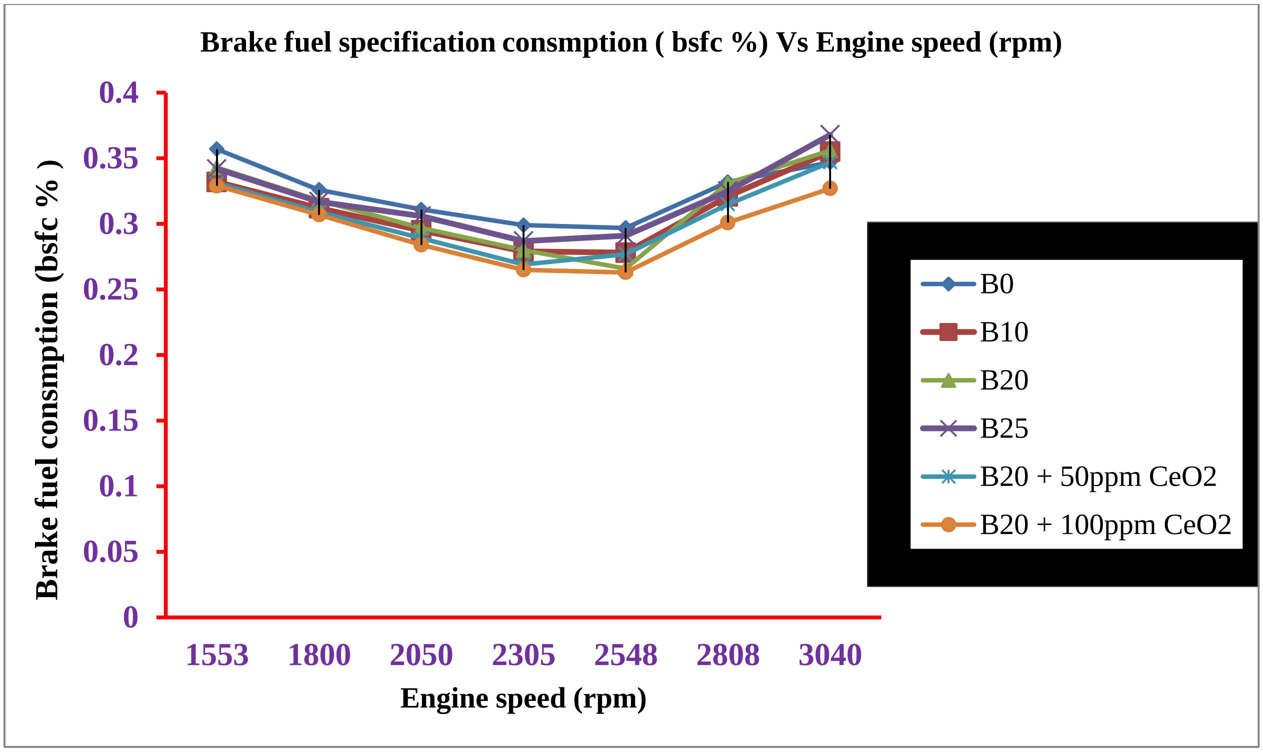


Figure 4.3 The variation of brake specific fuel Consumption (kg/kWh) with engine speed (rpm)

4.5 Result from Exhaust Emission Tests

In this section the result of emission test conducted the CT 110 Test Stand Diesel Engine and the full data was recorded in the following tabular within their graph representation. The main emission test discussed were carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC) and oxygen (O_2).

1. Emission test for carbon monoxide (CO %): Carbon monoxide (CO) are plotted for diesel and diesel biodiesel fuel blended with cerium oxide nano additives as shown in fig.4.4 while the output results were recorded in table 4.7 from CT 110 Test Stand Diesel Engine. This emission was formed due to incomplete combustion of fuel process like insufficient air supply to the systems.

Table 4.7 CO (%) emission data recorded from CT 110 Test Stand Diesel Engine

Sr.No	Engine Speed(rpm)	Emission test for CO (%)					
		1	2	3	4	5	6
		B0	B10	B20	B25	B20 + 50ppm CeO_2	B20 + 100ppm CeO_2
1	1553	0.075	0.065	0.065	0.069	0.069	0.064
2	1800	0.064	0.065	0.064	0.069	0.065	0.063
3	2050	0.063	0.064	0.061	0.065	0.063	0.062
4	2305	0.069	0.069	0.062	0.068	0.063	0.061
5	2548	0.076	0.077	0.073	0.082	0.073	0.072
6	2808	0.089	0.095	0.083	0.094	0.083	0.084
7	3040	0.097	0.092	0.085	0.099	0.084	0.082

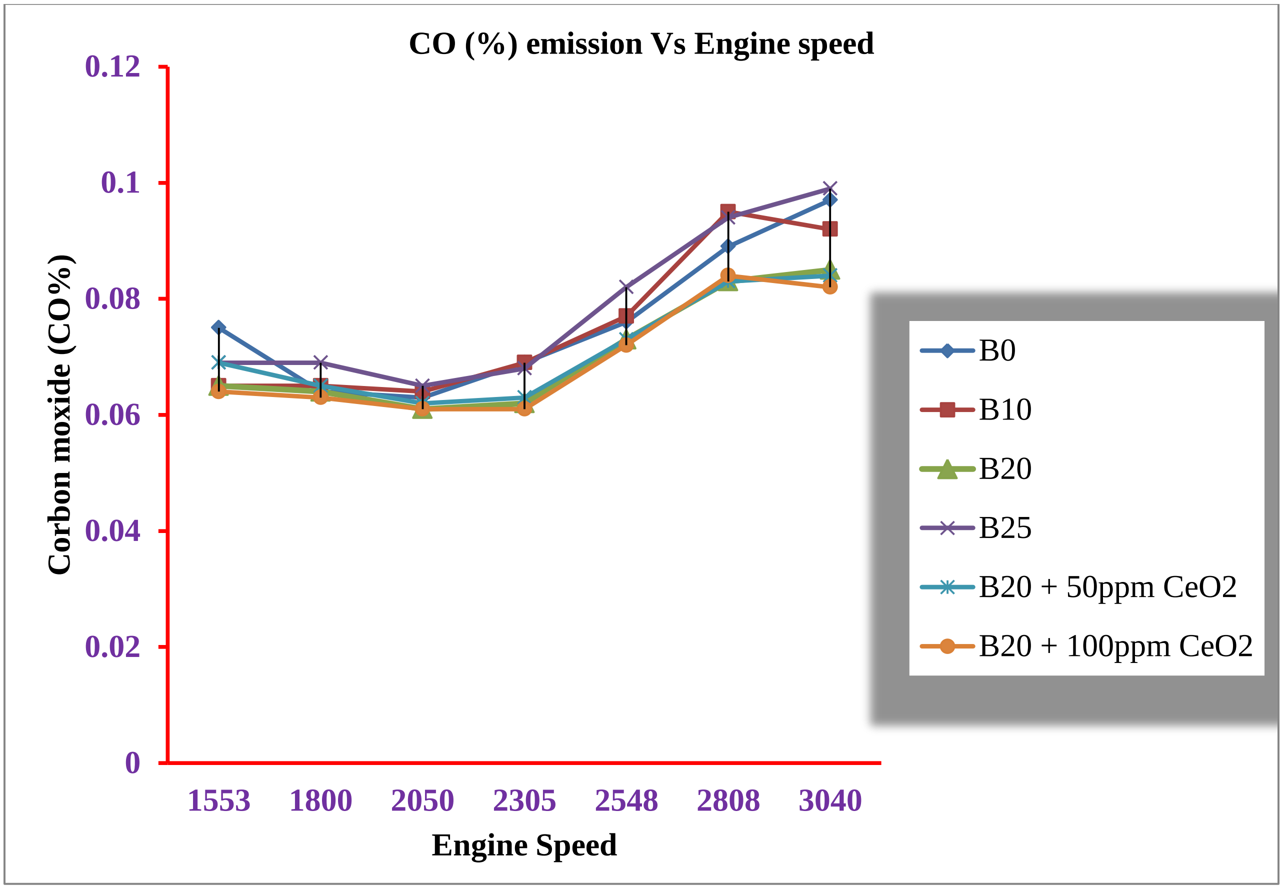


Figure 4.4 Variation of carbon mono oxide (%) respect to engine speed (rpm)

Fig 4.4 shows that carbon monoxide increases with pure diesel as engine speed increases whereas in diesel biodiesel fuel blend smoothly increases but, consequently fail down at engine speed was 2808 rpm especially with cerium oxide nano particles. The lower percentage of carbon monoxide was occurs in B20, B20 + 50ppm CeO_2 and B20 + 100ppm CeO_2 respectively. Again the lowest percentage of CO was occurred within B20 + 100ppm CeO_2. This was due to the addition of cerium oxide nanoparticle to diesel biodiesel fuel blended. Therefore, the availability of cerium oxide nanoparticle in diesel biodiesel fuel blend was leads to better combustion and reduces carbon monoxide emission by 6.1% obtained with the blend fuel B20 + 100ppm CeO_2.

2. Emission test for carbon dioxide (CO_2 %): When sufficient air supply to the combustion of fuel process Carbon monoxide was change to Carbon dioxide (CO_2) and also since biodiesel had enhanced oxygen content CO was simply converted to Carbon dioxide (CO_2)

Table 4.8 CO_2 (%) emission data recorded from CT 110 Test Stand Diesel Engine

Sr.No	Engine Speed(rpm)	Emission test for CO_2 (%)					
		1	2	3	4	5	6
		B0	B10	B20	B25	B20 + 50ppm CeO_2	B20 + 100ppm CeO_2
1	1553	2.53	2.38	2.47	2.52	2.32	2.28
2	1800	2.55	2.35	2.33	2.48	2.36	2.26
3	2050	2.59	2.34	2.32	2.46	2.37	2.28
4	2305	2.62	2.55	2.51	2.58	2.46	2.37
5	2548	2.79	2.73	2.69	2.76	2.58	2.45
6	2808	2.94	2.79	2.83	2.88	2.72	2.61
7	3040	3.31	3.1	3.01	3.23	3.01	2.89

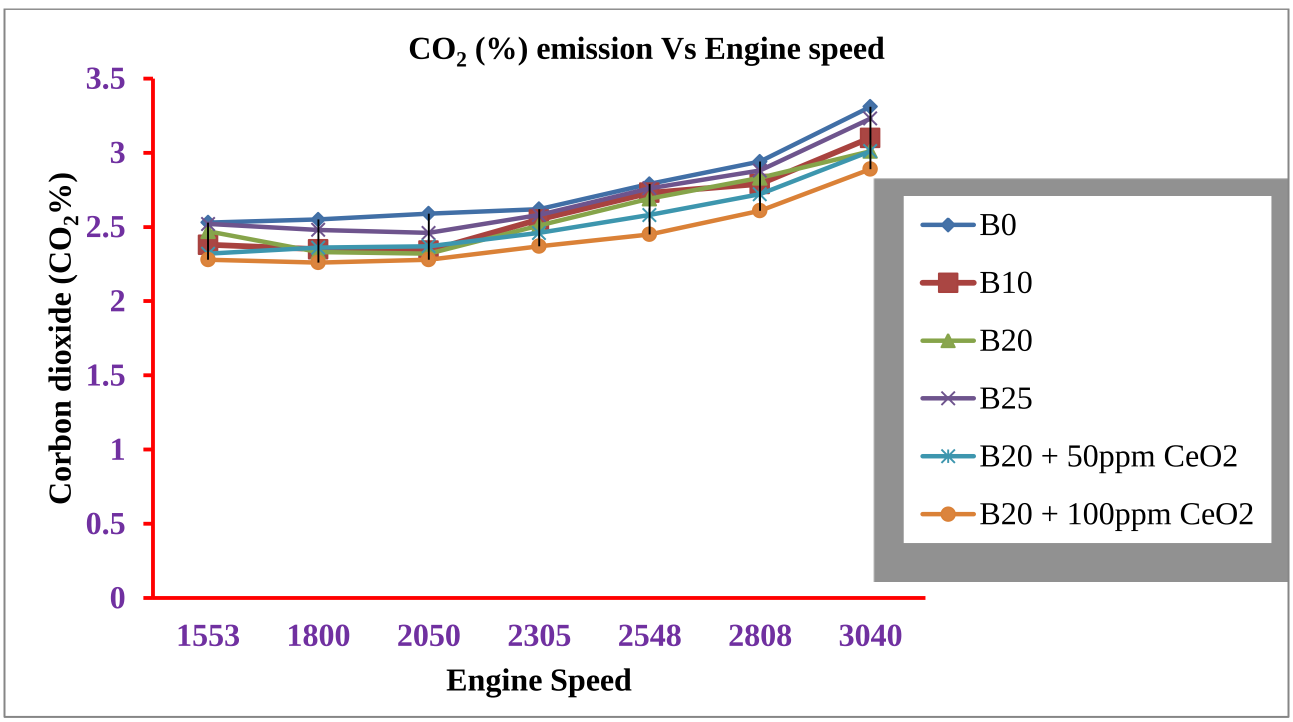


Figure 4.5 Emission test for Hydrocarbon (HC (ppm))

From fig.4.5 it can be seen that CO_2 emission compared to diesel fuel decreased for all biodiesel blend. Especially in B20 + 100ppm CeO_2 the reduction of CO_2 are more than others blends. The decline of CO_2 at low engine speed 1553 rpm is 2.53%, 2.38%, 2.47% 2.52%, 2.32% and 2.28% respectively compared to diesel. Here the value of CO_2 is 2.28% at this engine speed. This may be due to the fact that biodiesel has lower elemental carbon to hydrogen ratio than diesel fuel. The burning of blend fuels with air will therefore form lower emission than diesel fuel. But as engine speed increasing the CO_2 also increased

3. Emission test for hydrocarbon (HC) (ppm): The variation of hydrocarbon (HC) emission with respect to engine speed (rpm) was clearly indicated in fig.4.6 and the HC emission analysis data was recorded from the CT 110 Test Stand Diesel Engine in table 4.9 below. Fig 4.6 shows that the addition of cerium oxide with fuel blends would be result in decreasing hydrocarbon emission except B25 Ruther's than pure diesel. At lower engine speed the HC emission increases but as engine speed keeps slightly increases, the HC was increased. In this case, B20 + 50ppm CeO_2 and B20 + 100 ppm CeO_2 fuel blends had less HC emission then others as compared respectively, but B20 + 100 ppm CeO_2 the most HC emission reduction than all of fuel sample listed in table 4.9 above when compared to other fuel blends. The reason behind was due to increasing the amount of cerium oxide nanoparticles and high gas temperature in combustion of fuel.

Table 4.9 the variation of hydrocarbon (HC) emission taken from CT 110 Test Stand Diesel Engine

Sr.No	Engine Speed(rpm)	Emission test for HC (ppm)					
		1	2	3	4	5	6
		B0	B10	B20	B25	B20 + 50ppm CeO_2	B20 + 100ppm CeO_2
1	1553	14	15	15	16	14	13
2	1800	13	14	14	15	13	12
3	2050	13	13	13	15	13	12
4	2305	13	13	14	15	13	12
5	2548	14	14	14	16	14	13
6	2808	15	16	15	17	15	14
7	3040	18	19	17	20	17	16

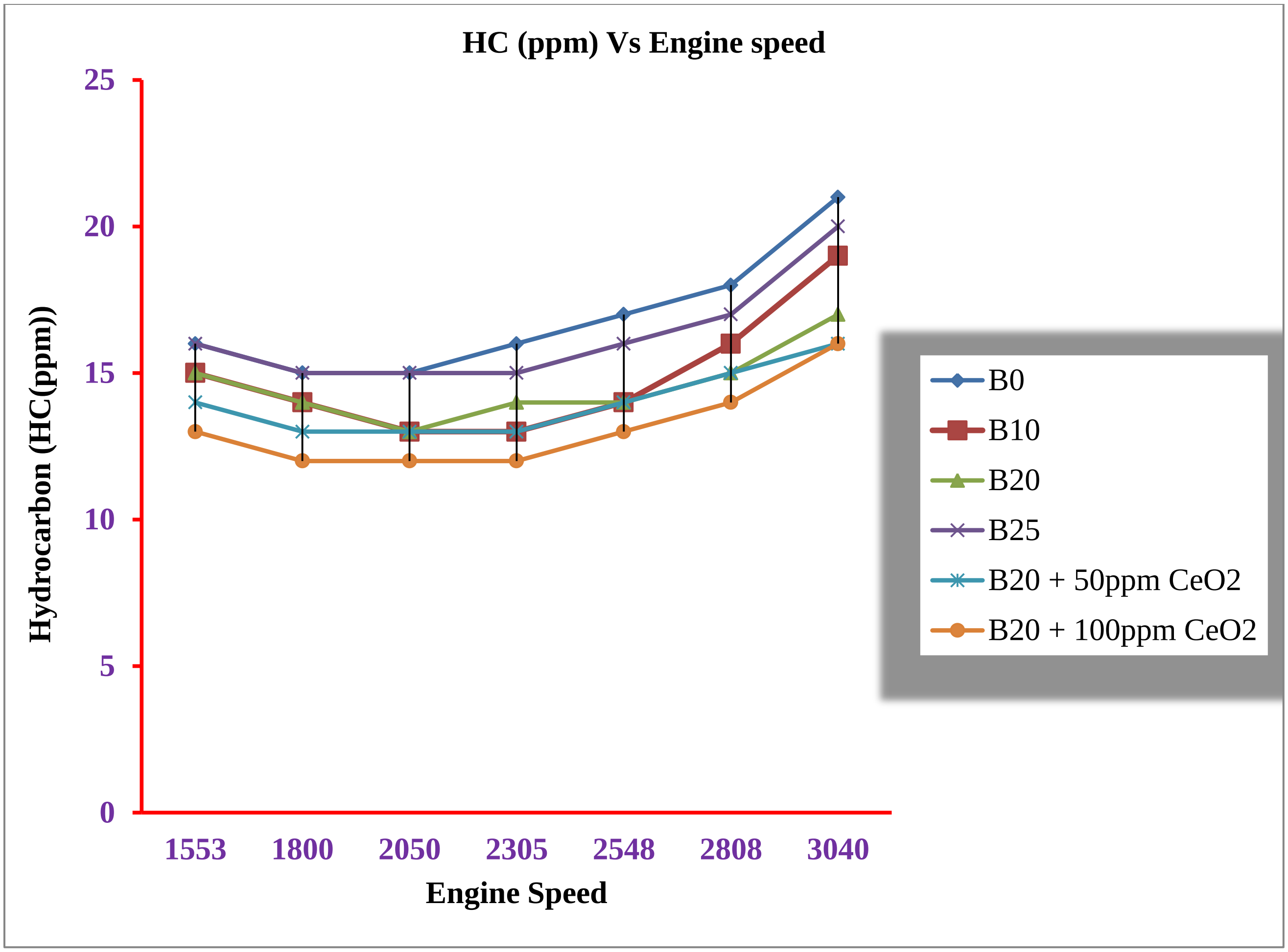


Figure 4.6 Variations of Hydrocarbon (HC) respect to Engine speed (rpm)

4. Emission test for O_2 (%): In this emission result we can discussed as following with graph explanation. As we seen from fig 4.7 that oxygen (O_2) emission for the fuel blended of biodiesel was higher than that of pure diesel. The reason was biodiesel contain more of an oxygenated and contain more of oxygen about 11% by weight. The higher oxygen ($O_{2)}$ emissions contain leading to the complete combustion. The oxygen (O_2) in case of fuel blended with cerium oxide nano particle somewhat higher than other, especially on fuel blended with B20 + 100ppm CeO_2 nano particles. The values were 17.56%, 17.55%, 17.49 %, 17.33%, and 17.29%. 17.18%, 16.99% for engine speeds 1553 rpm, 1800 rpm, 2050 rpm, 2305 rpm, 2548 rpm, 2808 rpm, and 3040 rpm respectively. Also we can write their values for others depending on data recorded in table 4.10 given above. In generally, diesel biodiesel bend with cerium oxide (B20 + 100ppm CeO_2) had higher oxygen contents then other diesel biodiesel fuel blended. Also we can write their values for others depending on data recorded in table 4.10 given below. In generally, diesel biodiesel bend with cerium oxide (B20 + 100ppm CeO_2) had higher oxygen contents then other diesel biodiesel fuel blended.

Table 4.10 the variation oxygen (O_2) emission data taken from CT 110 Test Stand Diesel Engine.

Sr.No	Engine Speed(rpm)	Emission test for O_2 (%)					
		1	2	3	4	5	6
		B0	B10	B20	B25	B20 + 50ppm CeO_2	B20 + 100ppm CeO_2
1	1553	16.99	17.65	17.68	17.43	17.58	17.56
2	1800	16.97	17.55	17.54	17.39	17.59	17.55
3	2050	16.85	17.46	17.39	17.27	17.38	17.49
4	2305	16.79	17.32	17.28	17.14	17.32	17.33
5	2548	16.52	17.02	17.17	17.06	17.19	17.29
6	2808	16.38	16.91	17.12	16.93	17.01	17.18
7	3040	16.21	16.69	16.79	16.87	16.87	16.99

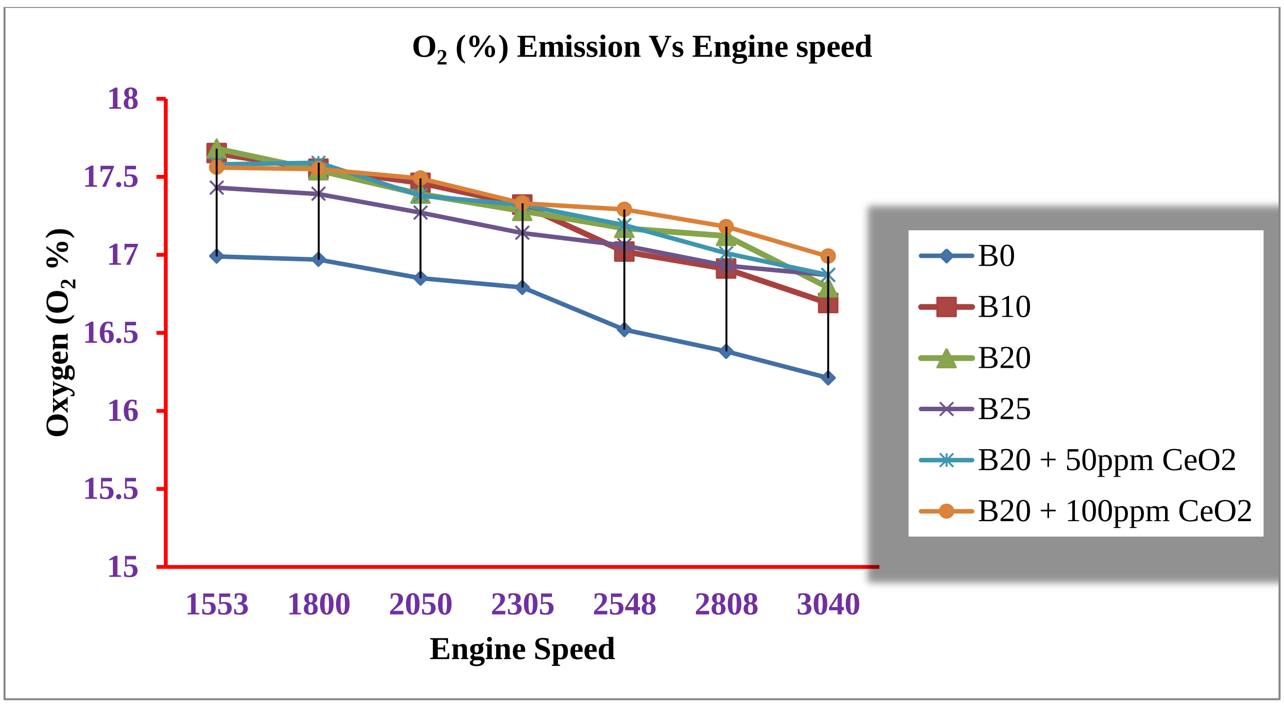


Figure 4.7 Variations of oxygen (O_2) respect to Engine speed (rpm)

CHAPTER FIVE

5 CONCLUSION AND RECOMUNDETION

5.1 Summary of finding

This section sets out the major findings resulting from this research and generalized as following. The Cotton seed were obtained from cotton ginning factory. The oil was extracted from the seed at Hundaf Engineer Food oil production Plc. There are certain core procedures to extract the crude oil from cotton seed. The seeds were crushed into small and pressed automatically within the machine. Finally, from these 300kgs of cotton seed, 48Ls of crude cotton seed oil was extracted and 216kgs of cake was produced.

Transestrification is a process of reaction vegetable oil or animal material with an alcohol (methanol) and KOH to make esterification (ester and glycerol). The aim of this method is to reducing the FFAs found in cotton seed biodiesel and the result obtained were the best for this study.

In this thesis work, since the transestrification, washing and dry of biodiesel carefully capable the last results had better evaluations. In other ways, this reaction of cotton seed biodiesel affected by water, FFAs, reaction temperature, catalyst concentration, molar ratio, ,reaction time, and mixing problems. However, by avoiding these all variable affect the biodiesel, we had gate the appreciable value for acid reduction, reducing the viscosity (3.67 cSt) of cotton seed biodiesel almost nearly to petro diesel viscosity.

The other considerable in this study work value was addition of Nanoparticles on fuel blended (B20 + 50ppm CeO_2 B20 + 100ppm $CeO_{2)}$ had best causes to improve the fuel properties, engine performance and exhaust gas emission. From the typical nano particles, CeO_2 used as catalyst should reduce exhaust emission as well as improved brake power, brake torque, and brake specific fuel consumption in single four stroke diesel engine. The results measurements from exhaust emission for CO, CO_2, HC, and O_2 had better values on experimental tests. Ingeneraly, it is commendable note that at this stage, bearing in mind exhaust emission, engine performance and fuel consumption, the addition of nano particle on fuel blended by using ultrasonicator mixing process must assisted and better option for diesel engine whatever for IC engine.

5.2 Conclusion

1. The overall studies based on extraction, production of biodiesel, characterization, engine performance test, exhaust emission test, diesel biodiesel blends with cerium oxide nano particles were carried out. The performance and exhaust emission tests were done on single cylinder four-stroke CT 110 Test Stand (Bio) Diesel Engine and characterization test was done at Ethiopian petroleum supply enterprises. Based on these results the following conclusions have been drawn.

- The oil extracted from cotton seed from 100kg was 16L by (v/v) and wastage product was 72kg. The wastage product was used for animal food.
- The biodiesel yield from 1L was 874mls and around 360ml make glycerol
- The glycerol made from biodiesel was used to soap production.
- Diesel biodiesel blend fuel (i.e., B20 + 50ppm CeO_2 and B20 + 100ppm CeO_2) prepared.
- Biodiesel produced from cotton seed oil is completely miscible with nano additive (CeO_2) and also with diesel fuel thus allowing the use of blends of diesel and biodiesel in any percentage.
- The characterization of biodiesel produced was shows low viscosity (i.e., 3.67cSt, 3.29cSt, 3.32cSt, 3.33cSt, 3.32cSt, and 3.31cSt for biodiesel, B10, B20, B25, B20 + 50ppm CeO_2, and B20 + 100ppm CeO_2 respectively). These results were nearly to diesel and confirm the pure diesel standard (ASTM D6751).
- The other properties of biodiesel and diesel biodiesel blend with nano particles (CeO_2) were, they had high flash points, and low cloud points.

2. Depending on engine performances and exhaust emission tests, it can be concluded that diesel biodiesel fuel blends with CeO_2 can be used satisfactorily in diesel engine without any modifications system.

- Brake power and brake torque produced by B20 + 50ppm CeO_2 and B20 + 100ppm CeO_2 were higher than that of other blends B10, B20, and B25. But when we compare each other, B20 + 100ppm CeO_2 has higher brake power and brake torque produced. The brake power and brake torque produced by B20 + 100ppm CeO_2 was 5.21kW and 18.52kW higher than that of petro diesel (B0), respectively.
- The Brake power and brake torque gets reduced and brake specific fuel consumption increased as the percentage of biodiesel in the fuel blend increased. This was due to the fact that biodiesel has low heating value then pure diesel as compared.

- The biodiesel blend fuel and biodiesel blend fuel within the additive of cerium oxide (CeO_2) nano particle produces lower exhaust emission (i.e., drop within CO, CO_2, HC while increased in O_2) as compared to pure diesel. The reason was maybe due to biodiesel content more of oxygenated, had sufficient oxygen and less carbon molecules. More oxygen content in the biodiesel results was better to facilitate combustion and increases the combustion chamber temperature in the systems.
- Generally for this thesis work, biodiesel produced from cotton seed and diesel biodiesel fuel blend with cerium oxide (CeO_2) nano particle through the experimental investigations it can be used without engine modification. Specially, the result fuel blend for B20 + 100ppm CeO_2 since its engine performance test, characterizations and exhaust emission tests were related to conventional petro diesel.

5.3 Recommendation

In this thesis work, the characterizations were only carried out for viscosity, density, cloud point, and flash point and total acidity of biodiesel and its blend fuel with cerium oxide (CeO_2) nano particles. Also, the performances test, and exhaust emissions tests were carried out only for engine brake power, engine brake torque, brake specification fuel consumption; and CO, CO_2, HC, and O_2. To have a better comparison the characterization for all properties, performances test, and exhaust emissions tests should be approved out.

Its glycerol which is obtained as a byproduct during transesterification process is a very valuable product. So it is recommended to find the ways to refine the crude glycerol obtained and use for different purpose like making soap. Also it’s recommended that to use biodiesel blend with ano additive to save environmental exhaust gases, and the government has to encourage using the biodiesel fuel blends.

Department of Mechanical and Vehicle engineering must have to establish the engine testing facilities for future research work on alternative fuels.

5.4 Future work

In this experimental investigation study was conducted only for B20 blend with nano additive, so that the work is to be extended to higher blend to understand the overall behavior of cotton seed biodiesel other nano additive like Al_2O_3, ZnO, and MnO

Also the researcher had to be done the effect of nano additives on cotton biodiesel by varying the engine parameters like compression ratio, injection pressure, and injection timing. The other most important future work would be studying of Error analysis for this blend fuel should be carried out as comparing.

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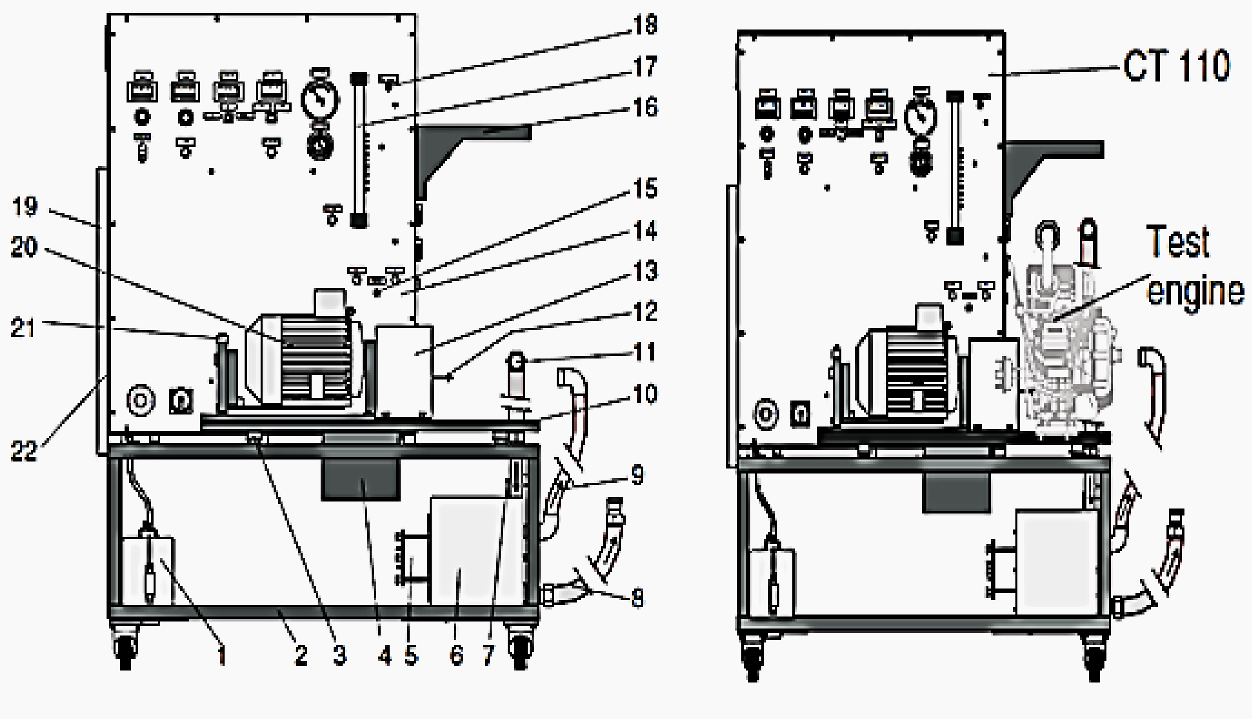
APPENDCIES

APPENDIX-A

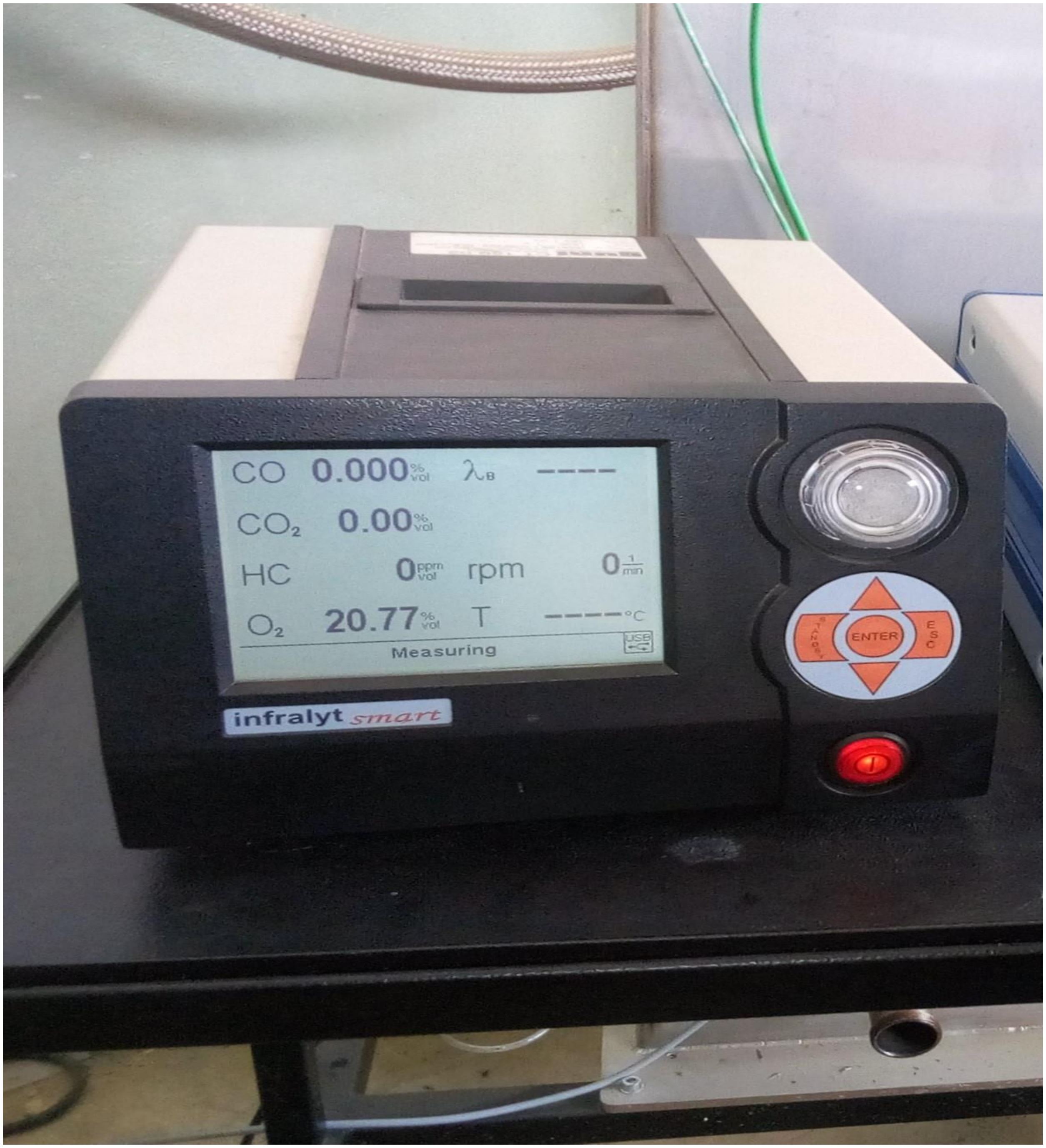


(a) (b)

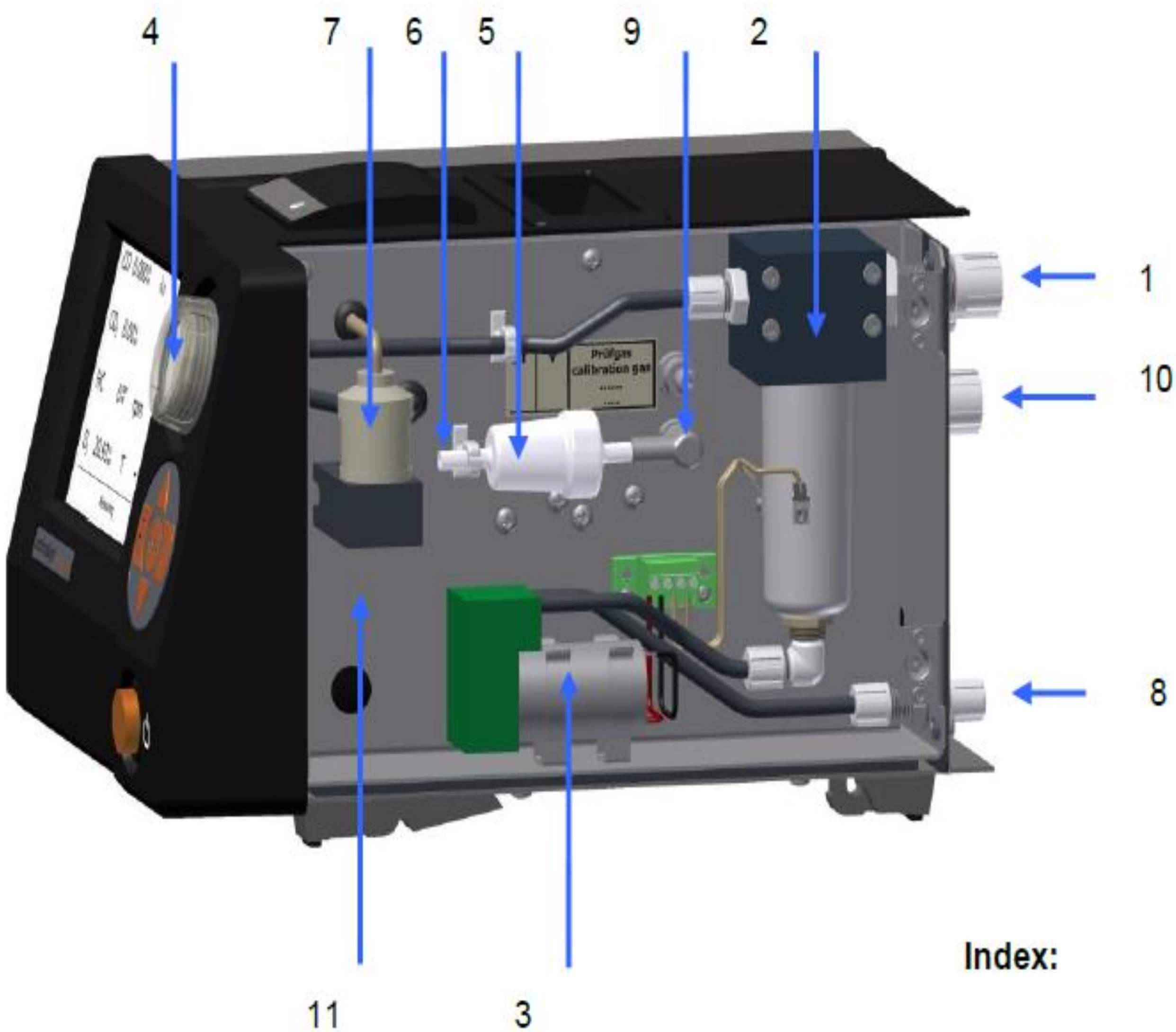
1. Fuel tank with pump
2. Mobile laboratory trolleys
3. Vibration attenuator
4. Damping mass
5. Air filter
6. Quieting vessel
7. Air measurement temperature sensors
8. Exhaust pipe
9. Air hose
10. Base plate
13. Coupling guard

12. Vacuum measuring hose
11. Exhaust pipe to engine
14. Display and control panel
15. Fuel line connection
16. Mounting, e.g. for CT113
17. Fuel measuring tube
18. Return line connection (diesel)
1.9. Transport protection
20. Asynchronous motor
21. Force sensor (torque)
22. USB-connection

APPENDIX-B



Infralyt Smart Analyzer (Exhaust Gas Analyzer) which is The Smart equipped with an integrated revolution counter and oil temperature measuring device.



Internal operation system of Infralyt Smart Analyzer (Exhaust Gas Analyzer)

1. Sample gas input
2. Condensate separator
3. Condensat pump
4. Front filter
5. Charcoal filter
6. Input zero gas

7.Oxygen O2 sensor

8.Outlet condensate

9.Input calibration gas

10.Input leak test

11. NO sensor (optional)

APPENDIX-C

It shows that the way how to extraction of cotton biodiesel and preparation of nano particlies.

APPENDIX-D

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251- (0)11 - 55179 56
251 - (0)11 - 5541905
Email – eth-petroleum@ethionet.et

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ETHIOPIAN PETROLEUM SUPPLY ENTERPRISE

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(251) – 011 – 5541904,
P. O. Box 3375
Addis Ababa - Ethiopia

Ref. No. 078/6-1-3-4-4/2010
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አዳማ ሳይንስና ቴክኖሎጂ ዩኒቨርስቲ
ለመካኒካል ሲስተምስ እና ቬይክል ኢንጂነሪንግ ዲ/ት
<u>አዳማ</u>

በቀን 19/10/2010 ዓ.ም በቁጥር MSVE/0179/3/2010 በተፃፈ ደብዳቤ ተማሪ መገርሳ ለማ በምርምር ያመረቱትን የባዮዲዝል ናሙና የላቦራቶሪ የጥራት ፍተሻ እንድንሰራላቸው በጠየቃችሁት መሰረት የፍተሻው ውጤት እንደሚከተለው ቀርቧል፡፡

SN.	properties	Test method ASTM	EPSE Diesel limits	results					
				B100	B10	B20	B25	B20+ 50ppm CeO_2	B20+ 100ppm CeO_2
1	Density@15°C (g/ml)	D4052	Report	0.8563	0.8425	0.8467	0.8488	0.8477	0.8464
2	Density@20°C (g/ml)	D4052	Report	0.8465	0.8389	0.8432	0.8454	0.8442	0.8458
3	Flash Point (PMCC, °C)	D93	Min.60	182	85	86	89	87	86
4	Cloud point (°C)	D2500	Max.+5	+3	+1	-1	+2	+1	+1
5	Total acidity (mgKOH/g)	D974	-	0.0985	0.0852	0.1009	0.0918	0.0930	0.1005
6	Viscosity@40°c (cSt)	D445	1.9-6 mm^2/s	3.67	3.29	3.32	3.33	3.32	3.31

Remark- The test results of the above parameters are satisfying the diesel specifications.

Liability

Ethiopian Petroleum Enterprise, its Laboratory, its Servants or agents Shall not be held liable for any damages, loss, claims or expenses direct or indirect howsoever caused, arising in connection with the laboratory test carried out on biodiesel samples submitted to it for analysis whether in tort or in contract, due to any act, omission or error of whatever nature, whether or not negligence and howsoever caused. Furthermore all expenses and implied warranties are specifically disclaimed.

ከሠላምታ ጋር

ስዩም አራጋው
የነዳጅ ጥራት ማረጋገጫ
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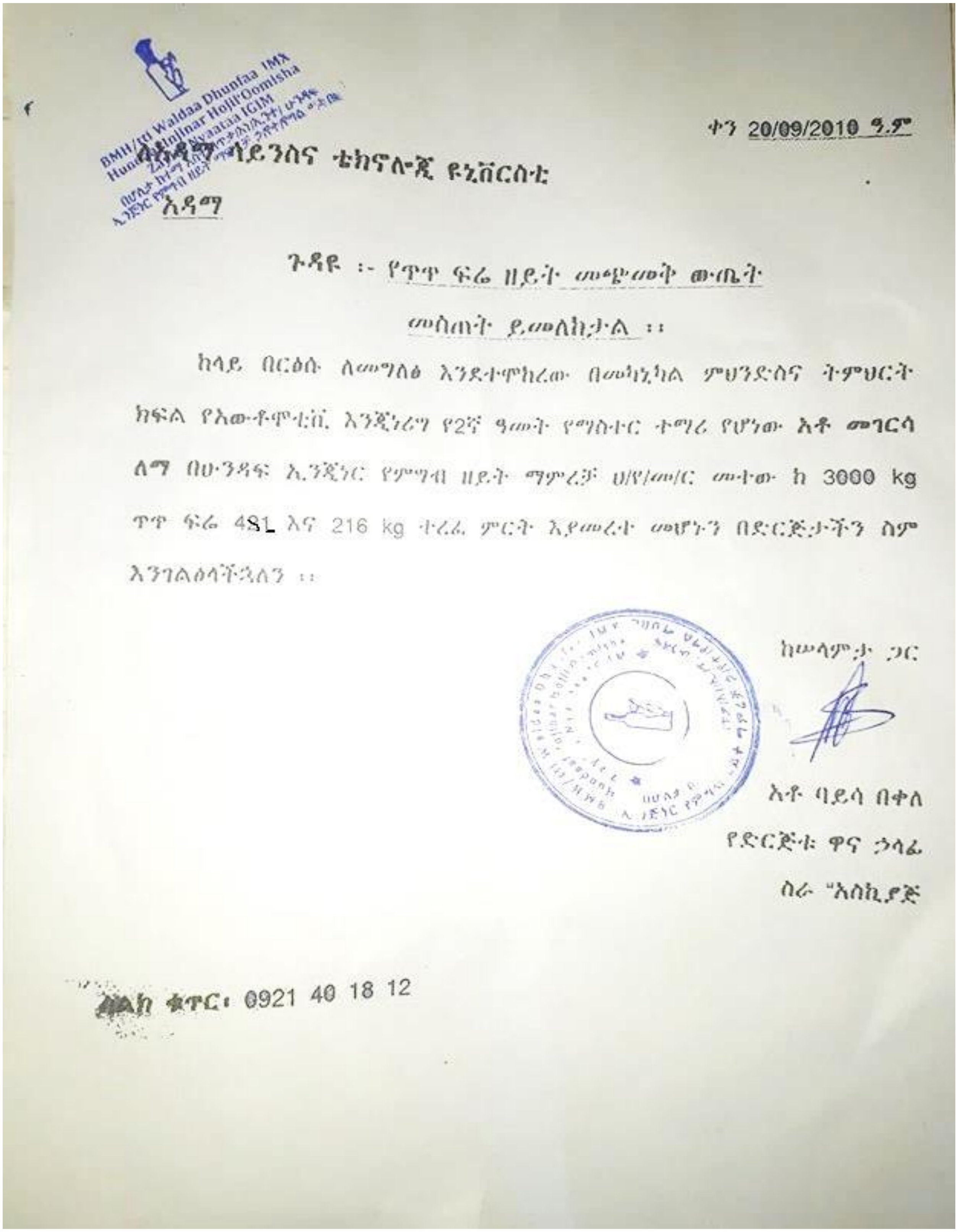
የኢትዮጵያ ነዳጅ አቅራቢ ድርጅት 1959 1966 ...pian Petroleum Supp...

ጥራቱን የጠበቀ የነዳጅ ምርት በማቅረብ የአገራችንን ልማት ለማፋጠን በሚደረገው ርብርብ ውስጥ የድርሻችንን እንወጣለን!

APPENDIX-E



ቀን 20/09/2010 ዓ.ም

አዳማ ሳይንስና ቴክኖሎጂ ዩኒቨርስቲ

አዳማ

ጉዳዩ :- የጥጥ ፍሬ ዘይት መጭመቅ ውጤት መስጠት ይመለከታል ::

ከላይ በርዕሱ ለመግለፅ እንደተሞከረው በመካኒካል ምህንድስና ትምህርት ክፍል የአውቶሞቲቭ እንጂነሪንግ የ2ኛ ዓመት የማስተር ተማሪ የሆነው **አቶ መገርሳ ለማ** በሁንዳፍ ኢንጂነር የምግብ ዘይት ማምረቻ ሀ/የ/መ/ር መተው ከ 3000 kg ጥጥ ፍሬ 481 እና 216 kg ተረፈ ምርት እያመረተ መሆኑን በድርጅታችን ስም እንገልፅላችኋለን ::

ከሠላምታ ጋር

አቶ ባይሳ በቀለ

የድርጅቱ ዋና ኃላፊ

ስራ አስኪያጅ

ስልክ ቁጥር፡ 0921 40 18 12

APPENDIX-F

ዲላ ዩኒቨርሲቲ
አካ/ጉ/ም/ፕ/ጽ/ቤት

DILLA UNIVERSITY
Office of the Vice-President for Academic Affairs

ቁጥር ዲዮ/ዘ/ወተ 103/16 4/88
ቀን 28/12/2010

ለአ.ሳ.ቴ/ዮ

<u>ጉዳዩ፡- የባዮ ዲዝል ላብ ቴስት መስራቱን ይመለከታል</u>

ከላይ በዕርሱ ለመጥቀስ እንደተሞከረው በተፃፈልን የትብብር ደብዳቤ መሰርት በMechanical Systems & Vehicle Engineering ት/ቤት የAutomotive Engineering የሁለተኛ ድግሪ (Masters) የሁለተኛ ዓመት ተማሪ የሆነው ተ/ሪ ሙገርሳ ለማ የBiodiesel Test በMechanical ባnd Automotive ላብራቶሪ በCT.110 Test Stand በ CT 100.22 Diesel Engine ላይ መስራቱን እናሳውቃለን ::

ከሠላምታ ጋር!

Dilla University

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