Parametric Evolution of B20 Mahua Biodiesel with Nanomaterial Additives

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By

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CERTIFICATE

I hereby certify that the work being presented in the dissertation entitled "Parametric Evolution of B20 Blend Mahua Biodiesel With Nano Additives" in partial fulfillment of the requirement of the award of the Degree of master of technology and submitted to the Department of Mechanical Engineering of Lovely Professional University, Phagwara, is an authentic record of my own work carried out under the supervision of Ketan Jowney, Designation Department of Mechanical Engineering, Lovely Professional University. The matter embodied in this dissertation has not been submitted in part or full to any other University or Institute for the award of any degree.

Date:

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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Signature of Examiner

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Abstract

Growth in demand for fuels in day to day life and its depletion has been becoming a serious problem for everyone all around the world. Increase in fuel cost, increase in greenhouse gases through emissions and decrease in fuel supply are the main reasons for promoting development of the Alternative fuels now a days. Diesel is one of the main fuel used for transportation sector, agricultural sector and power sectors in India and also all around the world. Biodiesel is a most commonly used alternative fuel because it is renewable and it can either be used as a fuel with different blends directly in common diesel engines without any modifications to it. Biodiesel can be easily produced from the oil of different seeds which are abundantly available in nature. The properties like higher density, high fuel consumption, lesser heating value, and emissions etc. can be reduced with the addition of fuel additives to the biodiesel without effecting its initial properties and performance. Metal based additives or metal oxide based additives, antioxidant additives, cetane number additives and oxygenated additives are the most widely used additives which helps in improving the combustion, fuel economy and reducing the emissions. This review is based on biodiesel with metal oxide additives and its performance characteristics.

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CHAPTER 1

INTRODUCTION

German scientist named Rudolf diesel is the inventor of Diesel engine. His engine was designed for use of coal dust, peanut oil and other vegetable based oils as a fuel, but later after conducting various experiments diesel is being used as fuel for compression ignition (CI) engines. Diesel can be extracted from crude petroleum oil by fractional distillation process at about 270°c. After extraction of diesel from crude oil, the diesel will be refined for removing the impurities present in it. The refined diesel can be used in various purposes like for transportation sector, agricultural sector, construction sector and for power sector etc. As the population all around the world is increasing rapidly day by day, fuel consumption is also increasing which leads to depletion in fossil fuel resources, increase in the cost of the fuel and increase in greenhouse gases like Hydrocarbons, carbon monoxide, carbon dioxide, oxides of the nitrogen and the particulate matter. The increase in amount of greenhouse gases causes global warming which includes rise in temperature, improper and irregular rain fall, melts the glaciers hence rise in sea-level etc. In the process to overcome or reducing these problems the development for alternative fuels has been promoted. Many researches were done on these alternative fuels and still going on.

Table [1] Demand of fuel consumption from commercial energy

Source	Units	1994-1995	2001-2002	2006-2007	2011-2012
Electricity	Billion units	289.36	480.08	712.67	1067.88
Coal	Million tonnes	76.67	109.01	134.99	173.47
Lignite	Million tonnes	4.85	11.69	16.02	19.70
Natural gas	Million cubic meters	9880	15,730	18,291	20,853
Oil products	Million tonnes	63.55	99.89	139.95	196.47

There are many types of alternative fuels such as Ethanol, Methanol, Natural gas, Electricity, Hydrogen and biodiesel etc. The alternative fuels are not produced through the

finite fossil fuels and they can be helpful in many ways like reducing emissions, contribution to smog is less, reducing the global warming and becoming fuel independent. Most commonly used alternative fuel is biodiesel.

Table [2] Various Sources of Biodiesel

Primary biodiesel	Natural bio-fuel	Fire wood, animal waste, land fill gas, crop residues etc.
Secondary biodiesel	1st generation bio-fuel	Sugarcane, wheat, corn, potato, peanut oil, soybean oil, rapeseed oil, mustard oil, palm oil, sunflower oil etc.
Secondary biodiesel	2nd generation bio-fuel	Non-edible vegetable oil (mahua, jatropha, karanja, cotton seed, annona squamosa seed etc.), grass, waste recycled oil, animal fats (beef tallow, yellow grease, pork, fish oil etc.).
Secondary biodiesel	3rd generation bio-fuel	Microbes, micro algae etc.

Biodiesel is a biodegradable and renewable alternative fuel. This refers to the fuel generated from vegetable oil based, recycled cooking oil based or animal fat based oil instead of fossil fuels. Based on the nature of soil and climatic conditions biodiesel can be prepared with different types of vegetable oils or non-edible oils in different countries. Some of the oils used for preparation of biodiesel are Annona squamosa (Custard apple), Pine, Hazelnut kernel, Coconut, Mustard, Jojoba, Croton, Clove stem, Soybean, Sesame, Rape seed, Palm, Calophyllum inophyllum (honne), Ceiba pentandra, Castor seed, Orange, Rubber seed, Mahua, Karanja, Jatropha, Cotton seed, Turpentine, Waste cooking, Microalgae, Cashew nut shell liquid, Fish, Beef tallow, mixture of oils with ethanol, methanol, and natural gas etc. using of biodiesels from the edible vegetable oils reduces food resources, to eliminate this problem non-edible oils were used in most of the

biodiesels. Biodiesel is non-toxic in nature and also biodegradable and less inflammable than typical petro-diesel. Biodiesel refineries are simple and eco-friendly in terms of design when compared with normal petrochemical refineries. The major disadvantage from using biodiesel is that it sets a direct competition between feeding people and feeding vehicles and machines, and it won't absorb the fuel emissions generated while growing the crops and preparing biodiesel. To reduce these drawbacks various types of additives can be added to biodiesel. Metal based additives, antioxidant additives, oxygenated additives, cold flow behaviour improving additives and cetane number improver additives are most widely used additives in biodiesel blending. Transesterification is the most widely used process to produce biodiesel. In this process oil is reacted with alcohols such as ethanol and methanol with a catalyst of acid or base catalyst. After the reactions that occur it forms glycerol and biodiesel and glycerol will be separated from it.

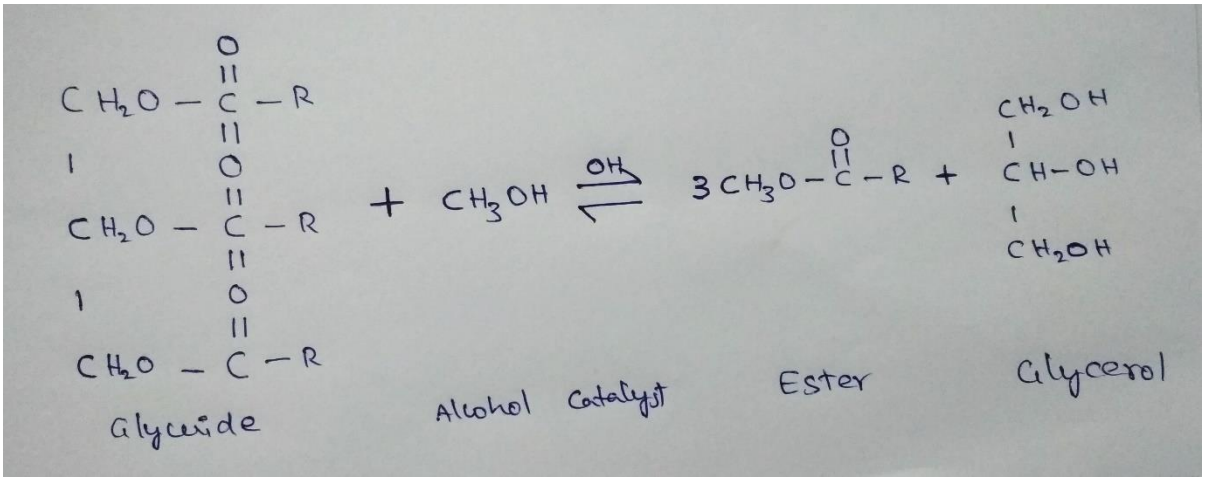


Figure-1 Esterification reaction

Cetane improver additives improves performance of engine, reduces emissions and cost effective. These additives helps the diesel during ignition in the combustion chamber by decreasing the auto ignition temperature which is around 220^{o}c for petro-diesel. This also helps the engine for quick start-up and the faster combustion which leads to less smoke, reduces engine knocking and noise, the fuel will ignites easily in cold conditions also, and minimum deposits in the engine and lowers engine wear by better combustion.

Oxygenated additives contain oxygen in their chemical structure, are generally used for petroleum products for reducing carbon monoxide, hydrocarbon and soot emissions which are generated when the fuel burns. The commonly used oxygenated additives are Ethers and Alcohols. Some of the ethers which are used as additives are Di-isopropyl ether

(DIPE), Ethyl tetra-butyl ether (ETBE), Tetra-hexyl methyl ether (THeME), Methyl tetra-butyl ether (MTBE), Tetra-amyl ethyl ether (TAEE) and Tetra-amyl methyl ether (TAME). Alcohols which are used as additives are Methanol (CH_3OH), Ethanol (C_2H_5OH), n-butanol (C_4H_9OH), Isopropyl alcohol (C_3H_7OH) and t-butanol (C_4H_9OH).

Table-3 Projected demand for petrol, diesel and biodiesel

Year	**Petrol**	**Diesel**	**Biodiesel**		
			5%	**10%**	**20%**
2006-2007	10.07	52.32	2.62	5.23	10.46
2011-2012	12.85	66.91	3.35	6.69	13.38
2016-2017	16.40	83.58	4.81	8.36	16.72

Fuel antioxidants like Pyrogallol, Propyl gallate, Butylated hydroxyl anisole, Tetra-butyl hydroquinone, and butylated hydroxyltoulene helps in stabilizing the fuel and manages the free-radical reactions occurs in fossil fuels and biofuels to attain the quality specifications. Fuels having free-radical propagation are prone for the formation of gum, degradation of colour and reduction in induction periods and fuels when oxidized causes formation of sediment, these problems can be reduced by using antioxidant additives.

Additives like Ethylene vinyl acetate copolymer, Glycerol acetates, Phthalimide, Glycerol ketals, and Succinimide copolymers will improves the fuel's cloud point property. This helps to avoid freezing and formation of crystal like structures of wax contents in the biodiesel which may affect the cold filter plug point (CFPP) during cold conditions, these additives are also known as Cold flow improving additives.

Metal additives are mostly used as micro sized and nano sized particles of different sizes in ppm or percentage. Metals like Aluminium (Al), Iron (Fe), Manganese (Mn), Magnesium (Mg), Silver (Ag), Graphene, Copper (Cu), Gold (Au) and oxides of metals like Cerium oxide ($Ce0_2$), Copper oxide (CuO), Zinc oxide (ZnO), Titanium oxide (TiO_2), Cobalt oxide (Co_3O_4), and Aluminium oxide (Al_2O_3). They helps in reducing pollutants in emissions, proper combustion of fuel, short ignition delay periods and flash point. As the particles are in nano size they provide more surface area which results in quick oxidation of additives and fuel burning. Adding more amount or less amount of additives will fail in

providing good results and the optimum range of metal additives provides better results based on the fuel and fuel blend used.

The amount of heat energy generated when one kilogram of fuel was burnt completely is fuel power or output of the engine. The amount of energy which is available at the crankshaft is brake power and this includes all the frictional losses at piston and cylinder walls, bearings of connecting rod and crank shaft. The ratio between fuel power and brake power is known as Brake thermal efficiency or in a simple manner we can say that the efficiency of the engine when the frictional losses are considered is Brake thermal efficiency. The ratio of rate of the fuel consumed by the engine to power produced by the engine is known as brake specific fuel consumption (BSFC). The Brake thermal efficiency decreases with increase in loads and due to improper combustion, Brake specific fuel consumption increases with increase in load and improper combustion depending on type of fuel. Using proper fuel and air-fuel mixture can help in improving BTE and BSFC characteristics.

Brake Power (BP) = $2\pi NT / 60000$

N = RPM of engine shaft

T = Net load * Radius of Brake drum

BTE = Brake power / Mass of fuel supplied * Calorific value of fuel

BSFC = Mass of fuel * 3600 / Brake power kg/Kw.hr

The energy utilisation in an engine indicated by the temperature of exhaust gas, if the exhaust gas temperature is more, then the energy utilised by the engine is less and vice versa. As the load applied on the engine increases the exhaust gas temperature (EGT) increases because the engine demands more fuel as the load increases and this leads to improper combustion of the fuel (depends on fuel). EGT is less in diesel when compared with biofuels.

The parameters of engine operation such as type of fuel, air-fuel ratio, design of the combustion chamber and ratio of atomization causes the emissions in exhaust gas by the engine. The emissions such as gases (oxides of nitrogen and carbon and hydro carbons), liquids (poly nuclear aromatic hydro carbons, sulphuric acid and oil derived or fuel derived soluble organic fractions) and solids (agglomerated particles, sulphates, ash, engine wear

particles and inorganic air and fuel contaminants). Emissions such as unburnt hydro carbons, oxides of carbon, oxides of nitrogen and smoke and particulate matter are having a major role in emissions and also they are having negative effects on the health of living beings and environment. These emissions can cause many diseases, formation of smog, improper rainfall, global warming and ozone layer depletion. Unburnt hydro carbons, carbon monoxide and carbon dioxide mainly produced due to the improper combustion of fuel, improper air fuel mixture, insufficient oxygen, dilution of engine oil in combustion chamber, fuel detonation in combustion chamber, impurities present in the fuel, and oxides of the nitrogen were produced due to high temperature in combustion chamber. They can reduced by providing sufficient time for combustion, proper air fuel mixture ratio, and design of the combustion chamber, using additives and providing oxygen with the help of turbocharger or super charger, exhaust gas recirculation.

Combustion of the fuel is a major process that occurs in an engine, in combustion the fuel burns and produces the required energy for the engine to run. The parameters required for combustion of fuel in the combustion chamber are Pressure exerted by piston in combustion chamber, Proper ratio of air fuel mixture, and ignition time and temperature. Combustion of the fuel also decreases with the increase in load on the engine. Deficiency of these parameters will cause improper combustion and further leads to reduce in mileage or output power of the engine, detonation of the fuel in combustion chamber, generation of emissions and reduce the life span of engine. With the help of providing sufficient ignition time, air-fuel mixture and the pressure in the combustion chamber and proper additives to the fuel.

CHAPTER 2

SCOPE OF STUDY

This report is a comprehensive review on performance, emission and combustion characteristics of a diesel engine fueled with diesel, biodiesel and its blends with the nano-metal additives. Many researches were done on various biodiesels and additives used for blending of biodiesels and still going on. The main aim of these researches is to reducing the cost of fuel, more efficient fuel, increase the life span of engine and to reduce the emissions coming out from engines or due to the usage of the fossil fuels. As the population all over the world is increasing usage of fossil fuels is also increasing and this causes depletion of fossil fuel resources and emissions. The emissions evolved from fossil fuels causes many health hazards and effects the environment. To minimize these problems a renewable, biodegradable and eco-friendly fuel is required and to obtain a fuel with those required qualities researches were going on different edible and non-edible oils, waste cooking oils, animal fats and other alternatives for the fuel and additives, and this study mainly focuses on biodiesels with nano metal additives to reduce the fuel consumption, cost of the fuel and reducing emissions evolving from the engines.

CHAPTER 3

OBJECTIVE OF STUDY

- To obtain the required information for preparing an alternative fuel with Mahua (Madhuca indica) oil along with nano metal additives and comparing the values of the different additives for performance, emission and combustion for a better and efficient alternative fuel.
- To improve the performance characteristics of the engine and to obtain the possible and solutions for improving the performance characteristics of the CI engine.
- To reduce the emissions such as unburnt hydrocarbons, oxides of carbon, oxides of nitrogen and particulate matter by using additives.

CHAPTER 4

LITERATURE REVIEW

P.Tamilselvan et al. [1] were analysed and reviewed about biodiesels of different types which are available abundantly. Description about nature of oil, properties, availability, blending properties with diesel, past researches and future scope of various seed oils and animal fat oil like karanja oil, jatropha oil, cottonseed oil methyl esters, mahua oil, turpentine oil, waste cooking oil, fish oil, orange oil, rubber seed oil, microalgae, palm oil, hone oil, ceiba pentandra (kapok), castor seed oil, cashew nut shell liquid, soybean oil, sesame oil, rape seed oil, beef tallow, coconut oil, mustard oil, clove stem oil, jojaba oil, croton oil, pine oil, hazzlenut kernel oil, annona squamosa methyl ester, mixture of oils like eucalyptus and paradise oil, kapok and pine oil, jatropha and palm oil, dual fuel mode of the eucalyptus oil and natural gas was given in this present review.

G.Bhaskar et al. [2] were conducted experiments on Manganese doped Zinc oxide nano catalyst as a heterogeneous catalyst for producing biodiesel with less activation energy. They investigated the crystalline nature of manganese doped zinc oxide nanocatalyst by X-Ray diffraction (XRD), morphology of catalyst using SEM analysis, raw mahua oil was analysed by using FT-IR analysis and observed the effects of the oil to the methanol ratio, and manganese doped zinc oxide nanocatalyst concentration, reaction time and temperature, reusability of manganese doped zinc oxide nanocatalyst on yield of biodiesel. They concluded the manganese doped zinc oxide nanoparticles which are calcined at 600^{o}c represented the maximum catalytic activity and both the mahua oil and manganese doped zinc oxide nano catalyst are suitable for the production of biodiesel in a large scale.

C.Syed Aalam et al. [3] were conducted various experiments on four stroke single cylinder common rail direct injection (CRDI) diesel engine with B20 blend of mahua biodiesel by adding two variants of aluminium-oxide nanoparticles as additive. They used ultrasonicator and homogenizer with cetyl the trimethyl ammonium bromide as cationic surfactant for blending of the biodiesel and aluminium oxide nanoparticles. Substantial enhancement in the brake thermal efficiency and a slight reduction in pollutants like CO, HC, and smoke were observed from their experiments and the operation of common rail direct injection diesel engine was normal and smooth by using mahua oil biodiesel blend

of B20 when it is added with different proportions of aluminium nanoparticles as an additive to the biodiesel.

S.Debbarma et al. [4] were experimented on a single cylinder diesel engine with palm oil biodiesel and iron nanoparticles of 50ppm and 75ppm as an additive for performance and emission characteristics. By their experiments they concluded that advanced heat release, shorter ignition delay, increase in BTE by 3% and BSFC by 3.3%, slight reduction in CO and NO_x emissions in comparison to diesel, and increase in density, calorific value and viscosity of fuel blend with increase in concentration of iron nanoparticles.

A.Syed et al. [5] were conducted various experiments on a single cylinder four stroke direct injection diesel engine having a rated power 3.5kW at a rated speed of 1500rpm with four different injection operation pressures of 200, 225, 250, and 275 bar which is compared using the operation of diesel at 200 bar pressure as the baseline. The engine is operated on dual fuel mode with hydrogen and mahua oil methyl ester. Observations of these experiments are minimum brake specific fuel consumption, maximum brake thermal efficiency, and less CO, HC and smoke emissions with increase in NO_x concentration were obtained at injection operation pressure of 250 bar for dual fuel mode of B20 hydrogen. Decrease in BTE, increase in CO, HC and smoke emissions were observe with increase in injection operation pressure to 275 bar. They concluded the injection operation pressure of 250bar for B20 hydrogen dual fuel mode is optimum.

Swarup kumar nayak et al. [6] investigated on production of biodiesel using neat mahua oil through base catalysed transesterification process and blending of biodiesel with dimethyl carbonate additive in different proportions to generate different test fuels for applying on water cooled single cylinder diesel engine. The results obtained with their experiments are increase in additives in mahua oil leads to increase in brake thermal efficiency, decrease in brake specific fuel consumption due to better combustion, decrease in exhaust gas temperature, less CO, NO_x, smoke and HC emissions when compared to mineral diesel.

Devarajan et al. [7] conducted experiments on twin cylinder four stroke direct injection diesel engine of 21kW with mahua biodiesel by adding ferrofluid nanoparticles of 14nm and compared with conventional diesel fuel. They found that the emissions of CO, HC, and smoke are less, and less in-cylinder pressure in biodiesel blend with ferrofluid than

biodiesel and conventional diesel when compared with each other. Kinematic viscosity of biodiesel without ferrofluid is high so it created more ignition lag and higher Heat release rate. The brake thermal efficiency of biodiesel with ferrofluid at full load is higher than normal biodiesel of same blend and adding of nano ferrofluid improved the properties of the fuel.

F.Sundus et al. [8] have analysed the different tribology aspects like properties of biodiesel, metal contamination, storage time, temperature, and moisture absorption. They discussed the various factors affecting the usage and stability of the biodiesel and the refining techniques for improving stability of biodiesel and the possible remedies for improving biodiesel's stability were summarized.

M.Vijay kumar et al. [9] has explained about the effects of additives on combustion, performance and emissions for biodiesel. Their review concludes that the additives plays an important role in increasing the engine's performance, combustion and emission characteristics, and using additives on second generation biodiesel are better than petro-diesel and biodiesel.

Chiranjeeva rao seela et al. [10] has conducted various experiments with zinc oxide nanoparticles on diesel and mahua biodiesel fuel on a single cylinder diesel engine for performance characteristics. They have implemented Generalised regression neural network (GRNN) on the engine for performance characteristics at different operating conditions. They concluded that with B20 biodiesel and zinc oxide nano metal additives Brake thermal efficiency is increased by 2-3% and NO_x emissions are also less when added with 50ppm and 100ppm of zinc oxide nanoparticles, GRNN predictions and experimental values are very close and this can be used for predicting unknown findings of experiments and it requires less labour, cost and time.

Hariram venkatesan et al. [11] gave a brief review on fuel's physical and chemical properties, performance and emission characteristics of the engine when using the nano metallic additives with diesel and biodiesel. They compared the properties of fuel i.e. flash point, fire point, kinematic viscosity, density, calorific value and cetane number of various blends and composition of additives of diesel and biodiesel. They also compared the performance characteristics (BTE and BSFC) and emission characteristics of unburnt hydro carbons, carbon monoxide and oxides of nitrogen of different fuel blends with different metal additives of various compositions at different testing conditions and concluded that

nano metal additives is having a prominent role for improving the properties of fuel and its performance and emission characteristics. Aluminium oxide, aluminium, carbon nano tube and cerium oxide gave good results when compared with zinc oxide and the addition of zinc oxide nanoparticles should be more than other nanoparticles to obtain equivalent results. Based on the fuel and fuel blend used, the amount of additives must be optimum for obtaining better results.

Sanghoon lee et al. [12] were conducted various experiments with different blends of Karanja biodiesel (KB40,KB60 & KB100) on spray characteristics for injection pressures of 50MPa, 100MPa and 150MPa and performance and emission characteristics were analysed at various operating conditions of the engine. To investigate the effects of karanja biodiesel blending ratio on injection rate, spray evolution and spray behaviour they did spray investigation. They observed that the maximum injection rate and transient motion of needle were influenced by fuel properties such as density and viscosity, the biodiesel's higher viscosity slows down the needle's movement at FIP (fuel injection pressure) of 50MPa but with increase in FIP the fuel flow rate is increased and higher density of biodiesel blends increased the maximum rate of fuel. When biodiesel blends compared with diesel the maximum torque, brake thermal efficiency and exhaust gas temperature were less and brake specific fuel consumption is high. Smoke is less with KB40 biodiesel blend but particulates below 50nm were more because of its lower volatility and higher viscosity. Combustion duration is longer with KB40 blend at a speed of 2500rpm than baseline diesel.

K.Krishna et al. [15] were investigated on single cylinder four stroke water cooled DI diesel engine and at a constant speed of 1500rpm with palmstearin methyl ester as fuel of B100 blend and aluminium oxide nano particles as additives to study the effects of the metal additive in biodiesel. Their results shows Due to the high oxygen in aluminium oxide nano particles for blends of 150ppm and 200ppm BTE is reduced and for pure biodiesel and 50ppm blend have better BTE and it is relatively same for diesel and biodiesel with 50ppm aluminium oxide nano particles, slight increment in BSFC with biodiesel and its blends respectively, slight decrement in CO_2 and NO_x emissions in biodiesel blends, increment in NO_x emissions for pure biodiesel because of its reactive nature at high temperature, unburnt hydrocarbons were relatively same for all blends, less CO emissions for biodiesel blends with additives because of the oxygen molecules present in the additives and they converted the carbon monoxide to carbon dioxide.

Sivakumar Muthusamy et al. [16] were conducted various experiments on single cylinder DI diesel engine for combustion, performance and emission characteristics with pongamia methyl ester blended with aluminiumoxide nano particles at different engine operating conditions and constant speed. The results of their experiments indicates that the BTE has a slight increment and BSFC has decrement with additives. Emissions such as CO, HC and smoke were decreased when compared with Mineral diesel and NO_x emissions were increased. Rate of heat release and gas pressure in cylinder increased with increasing fraction of nano particles of aluminium oxide due to the increase in surface area of nano particles to their volume ratio.

Chandravati et al. [19] were evaluated the thermo analytical characteristics of the biodiesels which are produced from Flaxseed and Mustard oil, and Karanja and Mahua oil methyl esters. They have employed transesterification for mustard oil and flax seed oil, and due to high free fatty acid content in non-edible oil they employed two stage transesterification process for production of biodiesel. These resulted in more oxidative stability of non-edible esters than edible esters due to the more saturated components in non-edible esters and this led to cold flow property of fuel and the methyl ester's viscosity is less than viscosity of oils of raw vegetables.

Senthil Ramalingam et al. [20] reviewed about the effects of antioxidant additives and operating parameters with bio diesels and with the study they concluded loss of brake thermal efficiency with biodiesels because of their high viscosity which led to the poor atomization, increase in brake specific fuel consumption, and reduction in unburnt hydrocarbons, oxides of carbon and smoke emissions because of the high oxygen content present in biodiesel, increase in NOx emissions and the antioxidants are having a prominent role in different parameters when added with biodiesel.

ShikhaGangil et al. [21] were prepared the biodiesel with three step method which consists Saponification, acidification and esterification with colloidal silicate (Ludox) and fumed silica for purifying the biodiesel. The used absorbents were re-used as adsorbents to remove the glycerine from the biodiesel and to evaluate effectiveness of purity of biodiesel. They observed the higher yield when ludox was used at 100^0c with an acid catalyst H_3PO_4 and base catalyst NaOH. It enhances the glycerol movement in liquid stage and the adsorption affinity and capability of adsorption of silica were minimized.

M. Senthil Kumar et al. [23] conducted various experiments to study the influence of various high octane-fuels like eucalyptus oil, methanol and ethanol on combustion behaviour of a single cylinder diesel engine with mahua-oil based dual fuel. The energy released by eucalyptus oil is more than methanol and ethanol, Methanol showed more reduction in the cycle temperature because of its higher latent heat of the vaporization, ignition delay is higher after 40% load, increase in duration of combustion of fuel, increase in Brake thermal Efficiency, higher smoke and lower NO_x emissions are observed.

K. Prasada Rao et al. [27] investigated on IDI engine with Diesel, Methanol additive and mahua methyl ester blends. The experiments were carried on load and fuel parameters to study BTE, BSFC, Exhaust gas temperature, unburnt hydrocarbons, CO, CO_2, O_2, NO_x, and smoke. Taguchi method and Grey relational analysis were used to reduce cost and time and validation is given by response surface methodology. The conclusions from these experiments are mahua methyl ester will be used as an alternative fuel, using of taguchi method and grey relational analysis helps to reduce the cost and time and identified the parameters influencing the characteristics, reduction in HC and CO emissions, Grey relational analysis is simple and efficient technique, the error of validation results with experimental results is 0.097, it is relatively same for both the procedures.

H. Raheman et al. [31] have conducted various experiments to investigate about fuel properties and performance of a four stroke, single cylinder, and Ricardo E6 engine of compression ratio 18:1 with Madhuca indica biodiesel of different blends (B20, B40, B60 & B80). They found reduction of density when the Mahua oil is converted to Biodiesel, increase in viscosity and decrease in calorific value of biodiesel with increase in concentration, higher flash point than high speed diesel, pour point depends on blending of biodiesel, less ash content, increased BSFC and decreased BTE, less smoke, lower CO emissions and NO_x emissions. They concluded that B20 blend has more similar properties as mineral diesel than other blends and also it is more efficient for performance and emission characteristics.-

CHAPTER 5

RESEARCH GAP

Based on the literature study I found that using additives with biodiesel in compression ignition engine helps the engine in improving its performance characteristics and in reducing the emissions emitted by the engine.

- Using additives as nano particles gives more surface area for bonding with the fuel molecules and helps in better combustion
- Using metal oxides gives more oxygen molecules to the fuel and helps in reduction of emissions from the engine.
- Biodiesel blend B20 contains 20% of biodiesel and 80% of mineral diesel, from the literature study I found that this is the most optimum blend of biodiesel for improving performance and reducing emissions.
- Previous researches were conducted on various types of biodiesels and on different nano metal additives, but study on mahua biodiesel with different nano metal additives are very few and comparison of mahua biodiesel with different types of nano metal oxide additives has been selected for present work for an efficient alternative fuel.

CHAPTER 6

MATERIALS AND EXPERIMENTAL SETUP

The required materials and equipment of experimental setup for further proceedings are

- Mahua oil (purchased from local store in Delhi).
- Diesel (purchased from petrol pump).
- Nano metal additives (aluminium oxide, zinc oxide, ferrous oxide, copper oxide and cerium oxide), (purchased from nano research lab, Jamshedpur).
- Methanol (purchased from scientific emporium, Ludhiana).
- Potassium hydroxide (purchased from Jalandhar).
- Setup for transesterification (Conical flask, Stirrer, Beaker, Funnel) (available in R&D lab, sardar swaran singh national institute of renewable energy, kapurthala).
- Ultrasonicator setup for blending of biodiesel with nano metal additives (available in R&D lab sardar swaran singh national institute of renewable energy, kapurthala).
- Diesel engine setup (available in R&D lab, sardar swaran singh national institute of renewable energy).

CHAPTER 7

RESEARCH METHODOLOGY

Initially a broad topic has been selected for this study. The area of research selected is biodiesel. Many researches were done on alternative fuels for a better and efficient fuel to reduce cost and emissions without affecting the performance of the engine. The previous studies shows that biodiesels are better alternatives for mineral diesel but it has some drawbacks depending on the oil used, blend of biodiesel used to overcome these drawbacks additives were introduced into biodiesels which gave better results. Biodiesel can be prepared in many ways and esterification is the most suitable and easy process for preparation of biodiesel. After biodiesel preparation additives can be added to it based of the type of oil used for biodiesel. Literature review has been done on this to know more about this topic from previous journals and articles.

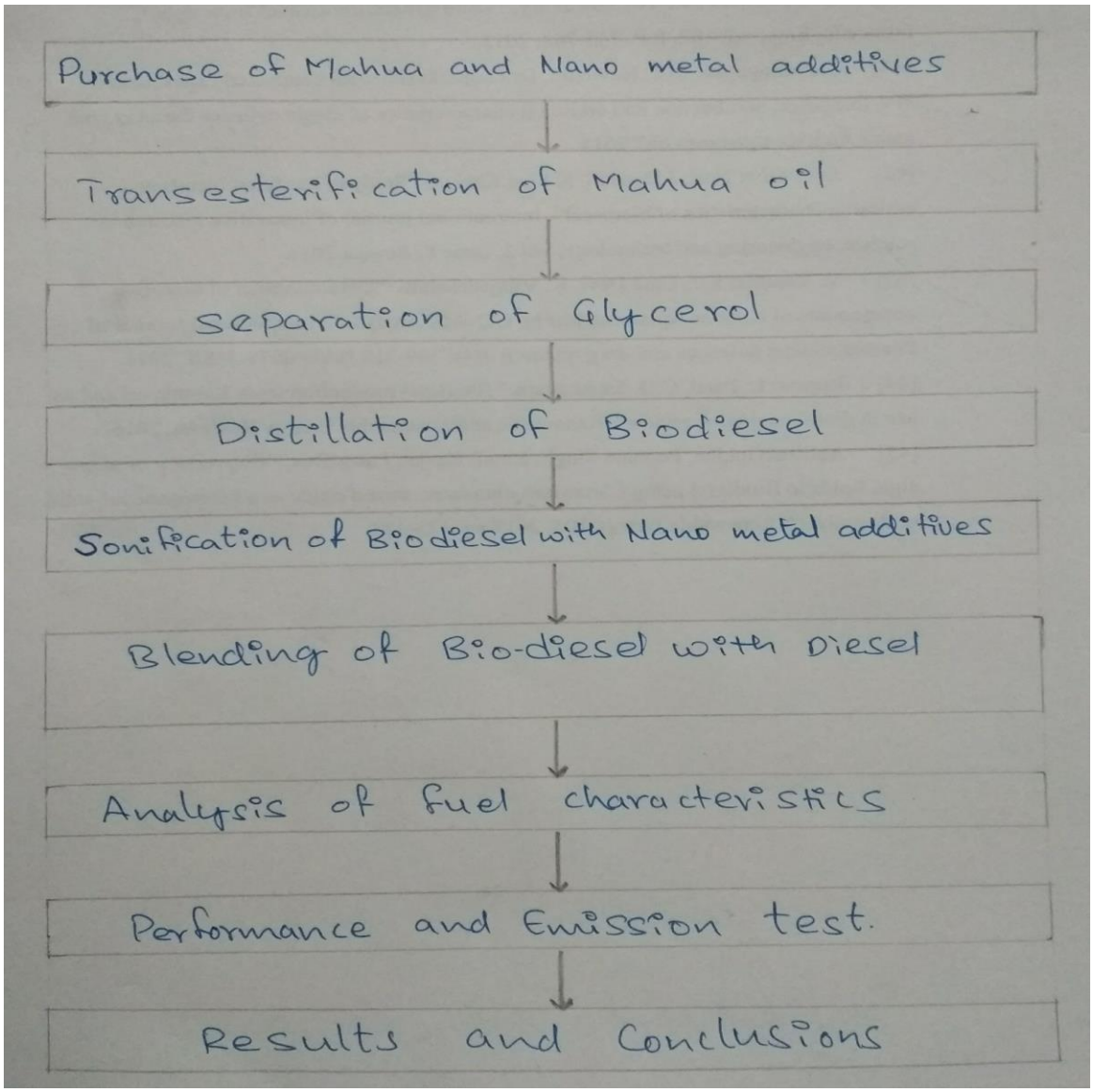


Figure-2 Flowchart of research process

The literature study was done to select the type of oil to be used, to know about suitable process for preparation of biodiesel and its blending and to know about additives that should be added to this. Mahua oil has been selected for preparation of biodiesel through transesterification process with nano metal additives aluminium oxide, zinc oxide, copper oxide, ferrous oxide and cerium oxide. The nano metal particles will be added with B20 blend of mahua biodiesel by sonification process and will be tested on Compression ignition engine.

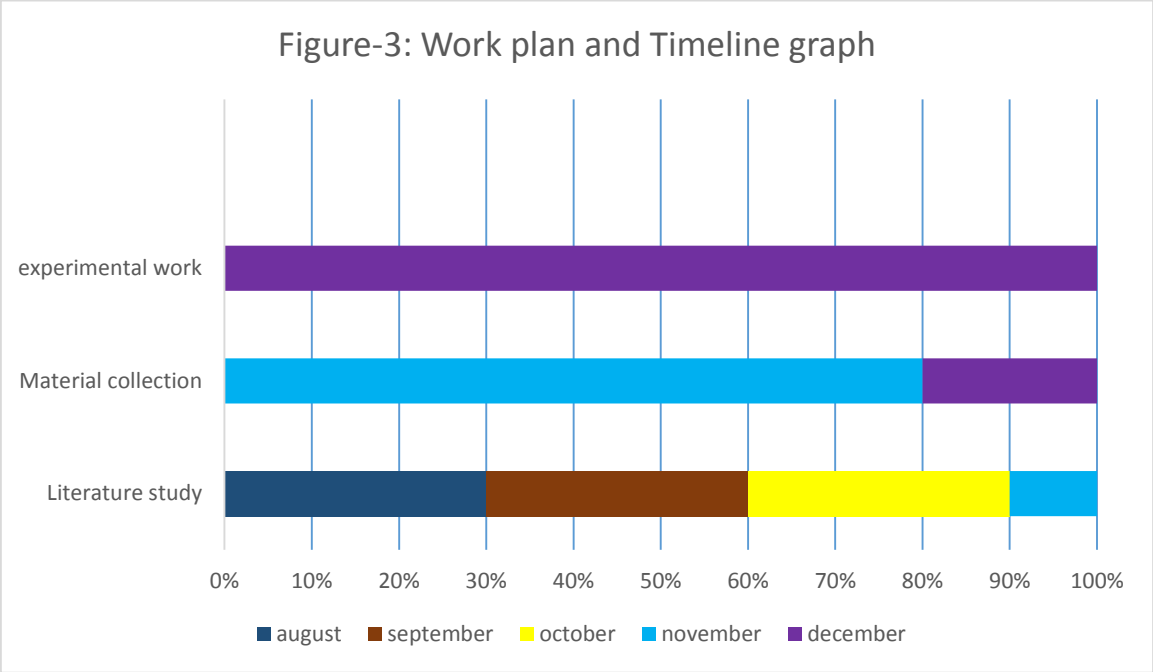
Biodiesel can be prepared from transesterification process and it is blended with mineral diesel. After this nano-metal additives will be added to the biodiesel by using ultrasonicator for efficient and accurate addition. Experiments will be carried out for performance, emission and combustion characteristics. Everything will be done at Sardar swaran singh national institute of renewable energy located near kapurthala, Punjab. After the experiments the procedure and experimental values will be verified and if any errors found in that the experiments will be done again for accurate results until the obtained results were satisfied and conclusions will be made according to the results.

CHAPTER 8

PROPOSED WORKPLAN WITH TIMELINE

Month/date	Work done/to be done	Description
August	Topic selection	Selected the topic biodiesel and started studying about biodiesel
September	Literature	Started studying various types of biodiesels and their additives
October	Continuation of literature survey	Continued studying about biodiesels and their additives
November 1st week	Report and materials	Started writing report and searched for materials availability
November 2nd week	Report and equipment	Continued writing report and searched for availability of equipment required for preparation of biodiesel, blending with additives and testing.
November 3rd week	Materials and equipment	Requested for quotation of prices of materials and visited Sardar swaran singh national institute of renewable energy for equipment verification and charge for testing.
November 4th week	Report	Completed writing the report
December 1st week	Collection of material	Mahua oil, nano particles, and other required materials
December 2nd week	Permissions	Getting permissions to proceed further for experiments
December 3rd week	Preparation and experimentation	Biodiesel will be prepared and blending with nano particles, and experiments will be done
December 4th week	Analysing	Results obtained will be analysed for errors

December 4th week	Feedback	Comparison of values will be done
December 4th week	Analysing	Experiments will be done again if any errors were found in the procedure for accurate results
December end	Report	A brief report about the experimentation will be submitted
January	Paper writing	Paper writing for publishing in journal will be started



CHAPTER 9

EXPECTED OUTCOMES AND CONCLUSIONS

- Obtaining output values of performance and emissions through experiments with mahua biodiesel and nano metal additives.
- Comparing the output values of B20 mahua biodiesel with different nano metal additives such as Aluminium oxide, Zinc oxide, Ferrous oxide, Copper oxide and Cerium oxide.
- Observing the better blend of biodiesel among them and its advantages and drawbacks.
- Concluding the further improvements (if any) to overcome the drawbacks and for better and efficient alternative fuel.

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