A Project Synopsis on

"A COMPREHENSIVE STUDY ON THE INFLUENCE OF INJECTION PRESSURE ON PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE WITH THE BLENDS OF DIESEL, BOILED COOKING OIL BIODIESEL AND OXYGENATED ADDITIVE AS AN ALTERNATIVE FUEL."

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CERTIFICATE

This is to certify that the project work **"A COMPREHENSIVE STUDY ON THE INFLUENCE OF INJECTION PRESSURE ON PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE WITH THE BLENDS OF DIESEL, BOILED COOKING OIL BIODIESEL AND OXYGENATED ADDITIVE AS AN ALTERNATIVE FUEL."** carried out by **HemanthM K, V N Subrahmanian, Swati R Hegde, Sufiyan Ahmed H N**, bearing USN- **4NI19IP018, 4NI19IP052, 4NI19IP051, 4NI19IP048**, bonafide students of **The National Institute of Engineering, Mysuru**, an autonomous institute under Visvesvaraya Technological University, Belagavi, submitted in partial fulfillment for the award of Bachelor of Engineering in the **Department of Industrial and Production Engineering** during the year 2022-23.It is certified that all suggestions/corrections suggested during Internal Assessment have been incorporated in the Report deposited in the departmental library.

The report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the award of the said Degree.

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(Sandeshgouda K V)

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The rapid depletion of fossil fuels, coupled with rising demand, faster price increases, and toxic exhaust emissions, has sparked a serious quest for alternate fuels. Only the next 40 years will be covered by the present petroleum reserves, claims a survey. India imports crude oil on average for Rs. 80,000 crore per year; even a 5% substitution of petroleum fuel with biofuel might save our nation about Rs. 4000 crore annually in foreign cash.

The best source of fossil fuel going forward may be biodiesel, which some people refer to as natural fuel. A variety of biofuels are available, including Jatropha, Curius, Pongamia, Pinnata, Madhuca Indica, Simarouba, Cotton Seed Oil, Calophyllum, Neem Oil, and animal fats such used fish and chicken fat. For this experimental effort, Boiled Cooking Oil (BCO) was chosen as the biodiesel. Boiling cooking oil is transesterified into biodiesel using the RSM Technique and a nanocatalyst made of MgO/MgAl2O4.

The production of biodiesel from a Boiled Cooking Oil (BCO) blend with diesel in various ratios was done, and the results were compared to pure diesel. In order to test the properties, performance, and emission characteristics of various blends, including [D100, B12.5DEE2.5, B25, B25DEE5, B37.5, B37.5DEE7.5, B50, B50DEE10], prepared bio-diesel was put through a single-cylinder, 4-stroke diesel engine with a variety of standard injection pressures [300 and 325 bars]. A 4-stroke, single-cylinder, naturally aspirated, water-cooled, computerised diesel engine is used for the experimental work.

On a single-cylinder, four-stroke diesel engine with standard injection pressures, performance and emission characteristic tests were conducted to evaluate the BP, BSFC, Air-Fuel ratio, mechanical, volumetric, and braking thermal efficiency as well as emission characteristics including CO, CO2, NOx, O2, and HC. The comparison was done to show which prepared blend was the best. The obtained results will be plotted on the performance graphs.

Keywords: *Diesel engine, Boiled Cooking Oil, Biodiesel, Nanocatalyst, Response surface methodology (RSM), Performance.*

INTRODUCTION

According to the International Energy Agency report, the energy demand in Asia will increase by 76% by 2030. Along with other energy resources such as solar, wind, hydroelectric, and nuclear energy, biodiesel can help reduce fossil fuel dependence [1].

LITERATURE REVIEW

Shashi Kant Bhatia et al. [1].in this research paper discussed biodiesel is a non-toxic renewable energy source that is gaining attention globally owing to its direct applicability in pre-existing engines without any modification. Various feedstocks have been explored for oil production and can be categorized as vegetable oil (edible and non-edible oil), animal fat, and WCO (Waste cooking oil)

Almost 95% of biodiesel production processes are based on edible oils, Animal fats are attractive feedstocks for biodiesel production owing to their low production cost, chemical inertness, zero corrosivity, and high calorific value.

Biological method of extraction - In biological methods, enzymes are used to treat biomass and recover lipids. Enzymes hydrolyze the structural components (polysaccharides and proteins) of the cell membrane and help release molecules entrapped inside the cells. enzyme-assisted aqueous extraction coupled with sonication in combination with different enzymes for lipid recovery from algal biomass.

Biomass derived catalyst- Biodiesel can also be produced by the transesterification of oil performed by catalysts (homogenous or heterogeneous). The selection of the catalyst depends on the amount of FFAs in the oil.

The main advantage of enzyme-based transesterification is it is environmentally friendly and can be performed under mild conditions. Reactions are not affected by FFA acid content in oil. Immobilized enzymes can be used several times. Downstream processing of biodiesel is easy.

Conventional reactors used in transesterification have limited mass-transfer ratio and prolonged reaction time and need high temperature and pressure. To overcome these limitations, different types of reactors have been designed and used in the last few decades; these reactors afford higher product yield in a shorter duration of time than conventional reactors.

The conclusion of this literature paper is the use of non-edible and waste oils (animal fat and WCO) for biodiesel production appears a promising approach for biodiesel production. The efficient recovery of

oils using single methods does not seem sufficient and the use of various combined methods showed high recovery of oil.

Behgam Rahmani Vahid et al. [2]. In this research paper a series of MgO/MgAl2O4 nanocatalyst were synthesized to study the role of different fuels by the solution combustion synthesis. XRD, FESEM, BET-BJH, EDX, FTIR and TG analyses were applied to investigate their physicochemical properties. The prepared nanocatalysts were evaluated through the transesterification reaction for the biodiesel production at 110 °C, 12 M ratio of alcohol/oil and 3 wt.% of catalyst/feed for 3 h reaction time. It was found out the sample which fabricated by urea as fuel had the highest yield of biodiesel with a conversion of 95.7%.

The paper suggests that through this study it can be said that the MgO/MgAl2O4 catalyst provides good potentials for industrialization due to its suitable performance in biodiesel production as well as its simple and inexpensive preparation method.

Manash Jyoti Borah et al. [3] In this paper experiments are conducted to test the effectiveness of the Nano catalyst in trans esterifying waste cooking oil into biodiesel. The results showed that the Zn substituted waste egg shell derived CaO Nano catalyst was highly effective in promoting the transesterification reaction, with a biodiesel yield of up to 97%.

The paper concludes that the Zn substituted waste egg shell derived CaO nano catalyst is a promising catalyst for the transesterification of waste cooking oil into biodiesel. However, further research is needed to optimize the reaction conditions and minimize the drawbacks associated with the use of the nanocatalyst.

Some drawbacks from this paper is of using the Nano catalyst, including the need for high reaction temperatures and long reaction times. This occurs due to the need for the Nano catalyst to overcome the activation energy barrier of the transesterification reaction.

S. Madhankumar et al. [4]. This paper provides a brief introduction to the importance of using alternative fuels for diesel engines to reduce their emissions (CO2) and dependence on fossil fuels. The paper also consists of methodology, including the fuel properties and engine specifications used. The authors conducted experiments with different oxygen enrichment levels (0%, 10%, 20%, and 30%) and different engine loads to measure the engine's performance and emissions.

The results by deep technical analysis, showed that oxygen enrichment led to a significant improvement in the engine's performance, including an increase in brake thermal efficiency, brake specific fuel consumption, and exhaust gas temperature.

The drawbacks are of oxygen enrichment, including an increase in NOx emissions, which is a major contributor to air pollution. The authors attribute the increase in NOx to the higher flame temperature caused by the oxygen enrichment, which promotes the formation of NOx.

Sukumar Puhan et al. [5]. In this paper we study that the effect of fatty acid composition, chemical formula and molecular weight of crude linseed oil on performance, emissions and combustion characteristics of the engine with varied fuel injection pressures at 200, 220 and 240 bar with different size parameter of sprayers. Thermal efficiency at 200 and 220 bar injection pressure was comparatively lower than that of diesel. On the whole it can be concluded that 240 bar injection pressure could improve the performance and emissions with linseed methyl ester in a diesel engine and at 240 bar injection pressure thermal efficiency, performance, emissions and combustion is comparatively same as diesel. It can be seen that at 240 bar injection pressure the efficiency is marginally higher than diesel. This may be due to the better combustion of LOME. It is to be noted that the oxygen (12%) contained in the LOME take part in combustion which in turn enhance the combustion process. the higher injection pressure, which improves atomization and mixing leading to better combustion.
In this paper there are various problems associated with vegetable oils, used cooking oil, fish fat oil being used as fuel in diesel engines. These problems are due to high viscosity, density, iodine value and poor volatility of the vegetable oil, and delayed in ignition. This paper clearly show that transesterification is the best way to use vegetable oil as a fuel in existing diesel engines.
The above said problem can be resolved by blending diesel with biodiesel which will reduce the viscosity. The other way to improve atomization is injecting biodiesel at higher pressures which in turn increase the atomization process by increasing dispersion of biodiesel spray.

M.S. Gad et al. [6]. In this research work conducted experiments with different nano-additives (iron oxide, zinc oxide, and titanium oxide) and different engine loads to measure the engine's performance and emissions. The results showed an increase in the engine's performance and braking technology. The increase in NOx to the higher combustion temperature caused by the nano-additives, which promotes the formation of NOx is the drawback which is found in this paper.

Obed M. Ali et al. [7]. In this article we review of the effect of different additives on biodiesel properties, performance, emission characteristics, and to identify the various additives used to improve the cold

flow properties of biodiesels and improve the performance of a diesel engine and its emissions while using additive blended biodiesels.

Here, fuel additives become indispensable tools not only to decrease these drawbacks but also to produce specified products that meet the international and regional standards of petroleum products.

From these researches, the effect of biodiesel additives on fuel cold flow properties, engine power, fuel economy and emissions including regulated and non-regulated emissions, and the corresponding effect factors were surveyed and analysed in detail.

Various results of improvement in cold flow properties have been obtained by using different additives with different blending ratio of additives and chemicals to biodiesel.

However, there is a major drawback in the use of biodiesel as low heating value and NOX tends to be higher. On the other hand, its relatively poor low-temperature flow properties are a characteristic of biodiesel which limits its application.

The main disadvantages of biodiesel are injector coking, engine compatibility, and high price. The effects of oxidative degradation caused by contact with ambient air (auto oxidation) during long-term storage present a legitimate concern in terms of maintaining the fuel quality of biodiesel.

Other disadvantages of biodiesel is lower thermal efficiency which cause in performance of engine, viscosity, cold temperature, etc

A key property of biodiesel currently limiting its application to blends of 20% or less is its relatively poor low-temperature properties.

Karthickeyan Viswanathan et al. [8]. In this paper is focusing on study of the engine characteristics, namely, emission and performance of a Jojoba oil biodiesel (JB100) fuelled diesel engine with Butylated hydroxyl anisole (BHA) as an antioxidant at distinct mass fractions (50, 75, and 1000 ppm). JB100 was observed as a noticeable substitute for conventional fuel and BHA presence helps to improve the performance and emission parameters. JB100+ BHA1000 sample was deliberated advantageous compared to JB100+ BHA750 and JB100 + BHA500 based on its engine characteristics. Efficiency of antioxidant compositions were presented as JB100+ BHA1000 > JB100+ BHA750 > JB100+ BHA500. Conversely, high CO, and HC emissions from JB100+ BHA1000 fueled diesel engine was considered as the crucial issue. Progressively, the custom of using a catalytic converter (CC) in JB100+ BHA1000 operated engine might need to achieve the strict emission criteria and for widespread commercial application in energy generating areas.

K. Nanthagopal B et al. [9]. In this paper the diesel fuel is considered as a major contributor for its effective utilization in internal combustion engines, in particular, in the compression ignition engine. The key qualities of petroleum diesel such as high combustion efficiency, reliability and handling facilities make it one of the chief contributors of energy in the industrial and agricultural sectors.

In this paper we have studied that biodiesel is an alternative sustainable energy source and can be utilized in the compression ignition engine without any changes in the engine design. This research work focuses on the preparation of Calophyllum Inophyllum methyl ester through two steps of transesterification process (transesterification is a chemical reaction used for the conversion of triglycerides contained in oil into usable biodiesel) Two biodiesel blends of 10 volume % and 20 volumes % with remaining quantity as diesel have been used as fuel in a diesel engine at a fuel injection pressure of 600 bar at 5%, 10% and 15% pilot injection variations. The experimental results revealed that an increase in the blend ratio of biodiesel enhances the combustion, performance characteristics and proliferation of pilot injection from 5 to 15% facilitates spontaneous and complete combustion.

From the literature cited above, it is perceived that the Calophyllum Inophyllum biodiesel seems to be one of the best biodiesels which could substitute the petroleum diesel in the case of partial or incomplete form, very few studies were available in the diesel engines of common rail direct injection (CRDI) type, particularly at very high injection pressures. In addition, most of these works were carried out using 10% and 20% biodiesel–diesel blends only.

B. Ashok et al. [10]. In this paper, we have studied that the research work aims at investigating the effect of newly developed multifunctional additive with diesel and Calophyllum Inophyllum biodiesel on compression ignition engine characteristics. A newly developed hydrocarbon based multifunctional fuel additive named as "Thermol-D" which comprises of various ingredients at suitable composition like surfactant, demulsifier, lubricity enhancer, dispersant, cetane improver, anti-oxidant and combustion catalyst.

Vegetable oil extracted from Calophyllum Inophyllum seed is synthesized into biodiesel via transesterification process. Further, Thermol-D additive at various proportions is mixed with the produced biodiesel.

A three-stage transesterification process is used to make Calophyllum Inophyllum Methyl Ester (CIME) from Calophyllum Inophyllum vegetable oil with support of alkali catalyst.

Thermol-D is mixed with both diesel and pure biodiesel at three different concentrations such as 0.5 ml, 1 ml and 2 ml by volume with 1 L fuel sample. After preparing all the fuel samples, the solubility of these fuel samples has been tested using simple gravimetric analyses.

Overall, it can be concluded that Thermol-D is an effective multifunctional fuel additive for improving the performance and reducing the emissions in diesel and biodiesel fuels for CI engine applications. Also, the addition of 0.5 ml of Thermol-D results in the better performance, emission and combustion characteristic for diesel and biodiesel.

Ayyasamy Tamilvana et al. [11]. This paper presented an experimental investigation conducted to examine the working characteristics of compression ignition (CI) engine using oxygenated additives such as diethyl ether and ethanol to the blends of Calophyllum Inophyllum biodiesel. Experiments were conducted on a water-cooled single-cylinder constant speed DI (direct injection) diesel engine under same operating circumstances. The results indicate that an enhancement of brake thermal efficiency is up to 3.7% and 6.2% with an addition of ethanol and DEE additive in biodiesel blended fuels respectively at maximum load condition. This is attributable to the existence of higher oxygen value and volatile nature of the additives.

The study showed that The addition of high volatility and highly oxygenated fuels, such as ethanol and diethyl ether up to 5% (by volume) could be a hopeful technique to use along with Calophyllum inophyllum biodiesel/diesel blends in CI engines with no modifications in the existing engine.

Karthickeyan Viswanathan et al. [12]. The study produced renewable alternative fuel from curry leaf (Murraya koenigii) oil using transesterification technique in the presence of catalyst along with alcohol. The important properties of produced biodiesel were explored in accordance with ASTM and further chemical compositions were explored by means of FTIR and GC–MS analyses.

The aim of the present work was to produce novel curry leaf oil biodiesel and examine its engine characteristics in both normal and YSZ ceramic layered engine. The study found that the ceramic layered engine had better performance than the normal engine.

The investigations were essential to measure the impact of curry leaf oil biodiesel on the formation of NOx emission by altering the engine operating parameters like injection pressure, injection timing and compression ratio. Also, the examination on advanced combustion technologies like low temperature combustion and reactivity-controlled combustion were required to inhibit NOx formation. For commercial application of curry leaf oil biodiesel, this work might include post combustion treatment for NOx reduction.

RESEARCH GAP IN THE INVSTIGATION AND OBJECTIVES OF THE PROJECT

RESEARCH GAP IN THE INVSTIGATION:

From the literature survey observed, very few researchers did work on both optimization and biodiesel production using $MgO/MgAl_2O_4$ nanocatalyst and also did engine performance and emission test experimentation on standard injection pressure and its effect. In the current research project work, both Response surface methodology (RSM) technique for biodiesel production from Boiled Cooking Oil(BCO) and the influence of standard injection pressure(300 and 325 bars) on performance and emission characteristics are considered.

OBJECTIVES OF THE PROJECT:

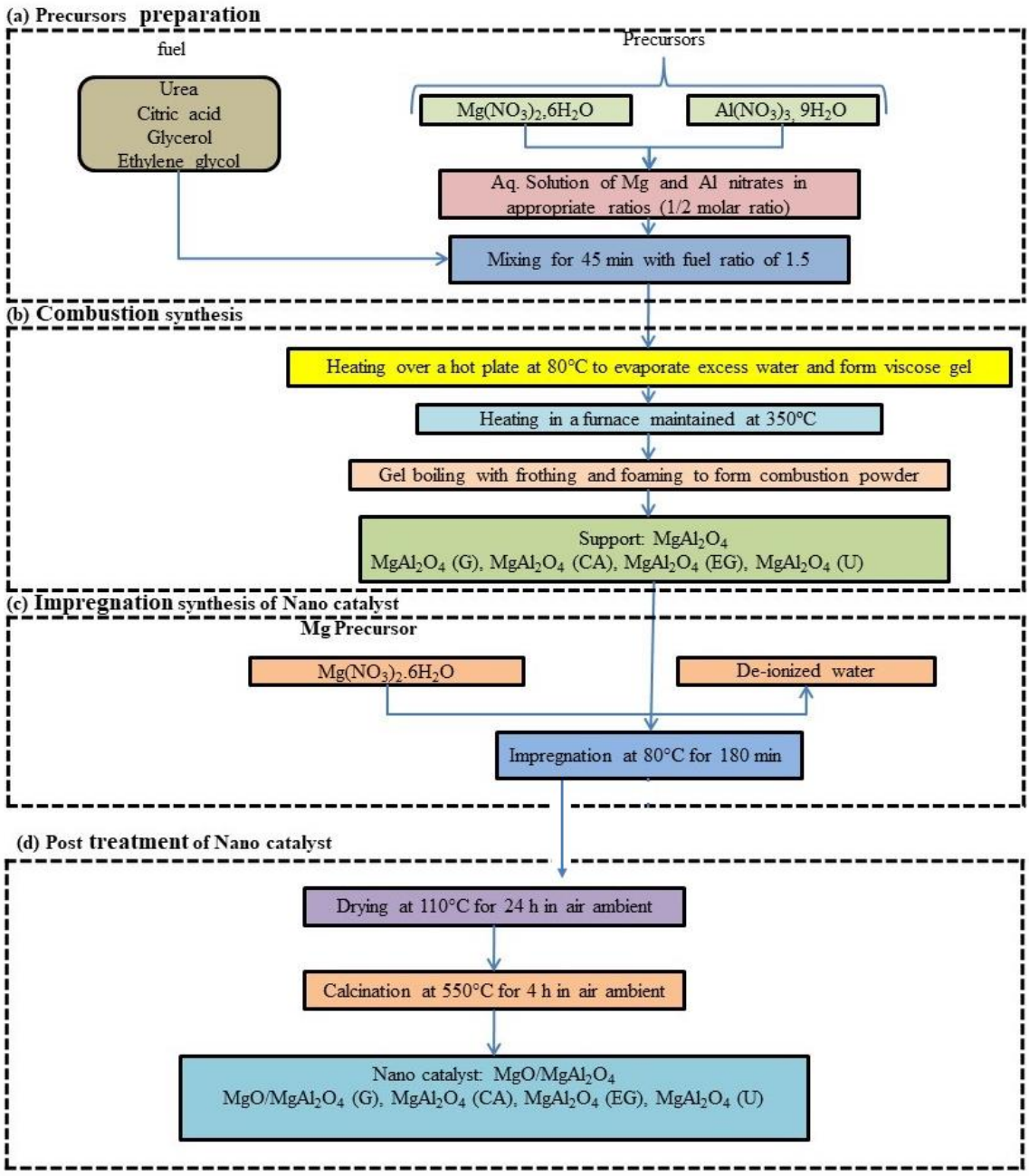
- To Collect Boiled Cooking oil from Hotels and Restaurant in and around Mysuru city.
- To synthesis $MgO/MgAl_2O_4$ nano catalyst by the combustion method.
- To characterize the synthesized nano catalysts using FESEM analysis.
- To Optimize the transesterification process parameters using Response Surface Methodology (RSM) technique.
- To determine Physico-chemical properties of Boiled Cooking oil and its biodiesel.
- To Study the Performance, Combustion and Emission characteristics of diesel engine fueled with Boiled cooking oil biodiesel, Diethyl ether and its blend with conventional diesel engine.
- To study the influence of different standard injection pressure and addition of Oxygenated additive (Diethyl ether) on Biodiesel and its blends fueled with Diesel engine.

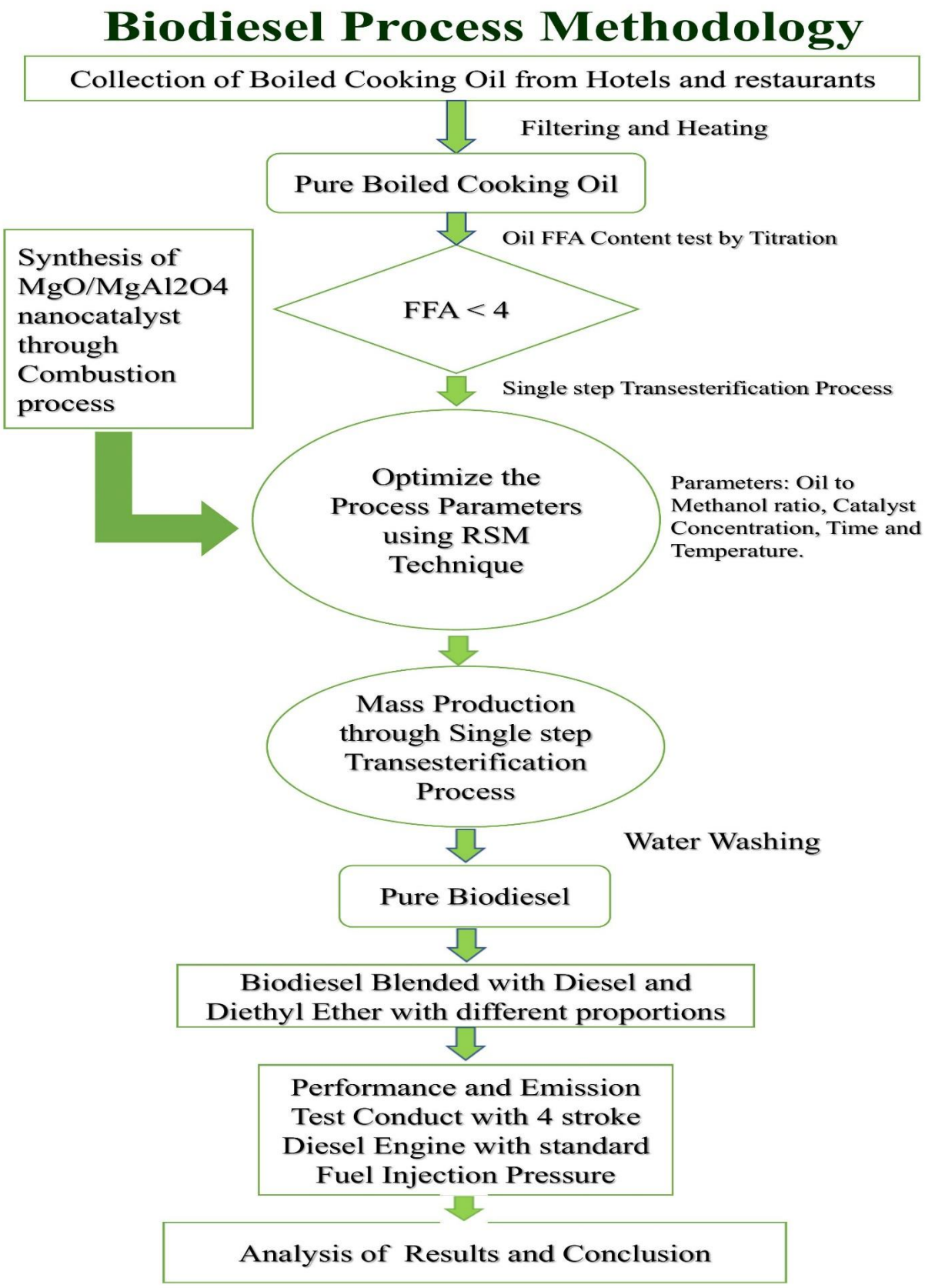
METHODOLOGY

- Collection of Boiled Cooking oil (BCO) in and around the Mysuru.
- Filtration techniques used to remove the foreign particles and by Thermal Heating method remove the water vapor present in the BCO.
- Synthesis of $MgO/MgAl_2O_4$ nano catalyst by the combustion method.
- Determination of chemical characterization of Boiled Cooking oil (BCO) using GC-MS analysis.
- Characterize the synthesized nano catalysts using FESEM analysis.

- Optimization of transesterification process parameters like: Methanol to oil molar ratio, reaction time, concentration of catalyst and reaction temperature to maximize the methyl ester yield by using Response Surface Methodology (RSM) with central composite design (CCD).
- Characterization of Boiled cooking oil biodiesel using GC – MS Analysis.
- Preparation and Characterization of Boiled cooking oil biodiesel/Diethyl ether and its blends with Conventional Diesel Oil.
- Using Computerized Single cylinder four stroke diesel engine for computation of performance combustion and emission characteristics for the prepared test fuel samples with different standard injection pressure.

Flow diagram of Combustion synthesis of $MgO/MgAl_2O_4$ nanocatalyst using various fuels as depicted below:




Biodiesel Process Methodology
Collection of Boiled Cooking Oil from Hotels and restaurants
Filtering and Heating
Pure Boiled Cooking Oil
Oil FFA Content test by Titration
FFA < 4
Single step Transesterification Process
Synthesis of MgO/MgAl2O4 nanocatalyst through Combustion process
Optimize the Process Parameters using RSM Technique
Parameters: Oil to Methanol ratio, Catalyst Concentration, Time and Temperature.
Mass Production through Single step Transesterification Process
Water Washing
Pure Biodiesel
Biodiesel Blended with Diesel and Diethyl Ether with different proportions
Performance and Emission Test Conduct with 4 stroke Diesel Engine with standard Fuel Injection Pressure
Analysis of Results and Conclusion

EXPECTED OUTCOME AND SCOPE OF THE PROJECT

Boiling cooking oil is used to produce biodiesel that complies with ASTM and IS requirements. In developing nations like India, the conversion of waste sources to energy plays a significant role. Large amounts of boiled cooking oil are readily available in and around Mysore, where they can be used to produce biodiesel in order to meet the need for diesel fuel energy. After being combined with diesel and diethyl ether as an oxygenated additive, the biodiesel produced from boiled cooking oil is tested for performance and emissions using a 4-stroke diesel engine that is operated at various standard injection pressures.

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