

A STUDY ON MECHANICAL DESIGN ON BIODIESEL-DIESEL BLEND OF FUEL PROPERTIES

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Abstract— This analysis aimed to define the variations between petroleum-based diesel and biodiesel in the composition of combustion emissions and to determine whether the utilize of an emission meter would be a good adding to a possible laboratory setup. Via experimental monitoring of combustion emissions from all fuels and combinations with the help of a flue gas analyzer and a remaining biodiesel compliant combustion system, the team accomplished these objectives. In terms of biodiesel fuel proportions and nitrogen oxide, carbon dioxide and carbon monoxide exhaust concentrations and temperature dependence of emission compositions, the team has established good trends.

Index Terms— Biodiesel, Combustion of biodiesel, Emission control, Bio Diesel Blend with diesel.

I. INTRODUCTION

Biological Diesel

Society is growing and changing continuously into a better everyday existence. To achieve desired technical advancements, energy has been and will still be needed. As various means of harnessing resources are known, they would have the capability to modify humanity's climate. Petroleum plants have been utilized as one of the major energy sources, but with increasing populations over the next century, fossil supplies are expected to decline. The combustion of such fossil fuels may allow the publication of hazardous chemicals and pollutants. Awareness of the detrimental effects of carbon energy on wildlife and the atmosphere has changed in the past 30 years. As a result, plant-based resources, geothermal energy, renewable energy, and more were identified as potential alternatives. The optimal fuel for the future would be both energy-sensitive and more environmentally-friendly than current fuels.

The growing need has posed concerns around biodiesel for safer combustion fuel, which is also compliant with most modern diesel engines. Biodiesel is derived, as with conventional diesel fuel, from green organic fuels. Although the content of its stored energy is close to that of petroleum

fuel, its chemical, physical, and emission composition and characteristics vary greatly.

Worcester Institute of Polytechnics (W.P.I.) is capable of processing biodiesel gasoline. All this biodiesel and this petroleum diesel were contrasted with a gasoline heater from Espar. In the previous M.Q.P. project, this heater's design was designed to determine the changed oils' energy quality and efficiency.

The project aims to change the ventilation of the exhaust for use in the pollution and combustion efficiencies of diesel and biodiesel fuels by utilizing a modern emission meter. Such goals have been accomplished by:

Design a way to attach a research tool to the current combustion engine setup. Showing that the amount of exhaust emissions of both fuels varies. Analysis of increases in the composition of exhaust pollutants for pure oil, pure biodiesel, and mixtures. Determining and measuring acceptable ways of quantifying combustion efficiencies for pure ethanol, pure biodiesel, and mixtures in all instances.

II. LITERATURE REVIEW

A. BIO-DIESEL AND ITS CHEMISTRY

Biodiesel, including used oils, animal fats, and plant oil, is another to petroleum diesel derived from the renewable funds. The active compounds in biodiesels are called methyl esters of fatty acid (FAME) extracted from triglycerides in a trans-esterification reaction. The Cycle utilizes a methanol and potassium hydroxide catalytic converter to the active biodiesel compounds Methanol and triglycerides into glycerol and methyl esters. Potassium hydroxide (K.O.H.) is combined as a base with methanol. The general reaction equation for FAME formation with methanol is shown in Figure 1 below. This reaction mechanism makes it possible to distinguish glycerol from the esters of methyl quickly.

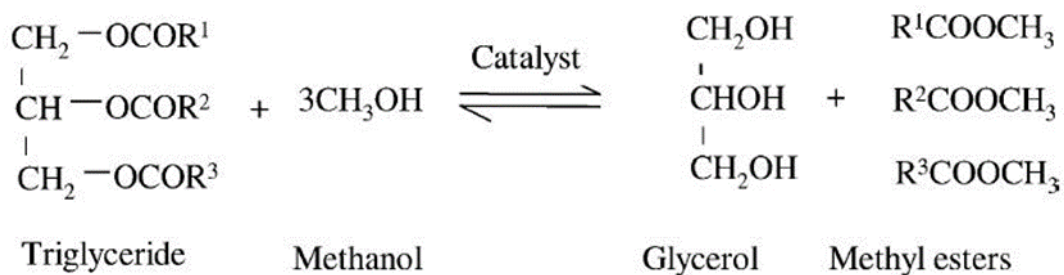


Figure 2.1: The General Method of Transesterification.

B. COMBUSTION CHEMISTRY

Combustion is known as an exothermic substance for this project response to the between oxygen & hydrocarbons to the production of CO₂, CO, and water. The full oxygen and hydrocarbon reaction is complete combustion to produce only carbon dioxide and vapor. Incomplete combustion takes place because the gasoline contains so little oxygen respond with carbon monoxide and thus shape something more than oil.

Dioxide, along with a vapor of water. Failure to burn the fuel with air can also result from improper mixing. Methane and oxygen reactions are the easiest methods of combustion. The energy generated by this reaction is heat and light.

Complete Combustion



Incomplete Combustion

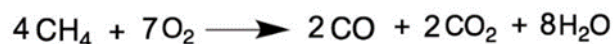


Figure 2.2: Methane Combustion

C. BIODIESEL DEVELOPMENT & PURIFICATION

Over 145 major biodiesel processing plants operate in the United States. As the reactant, plants utilize a mix of instinctive

fats, soy oils, or several dissimilar feed stocks. In Figure 2.4, the most widely used method is shown.

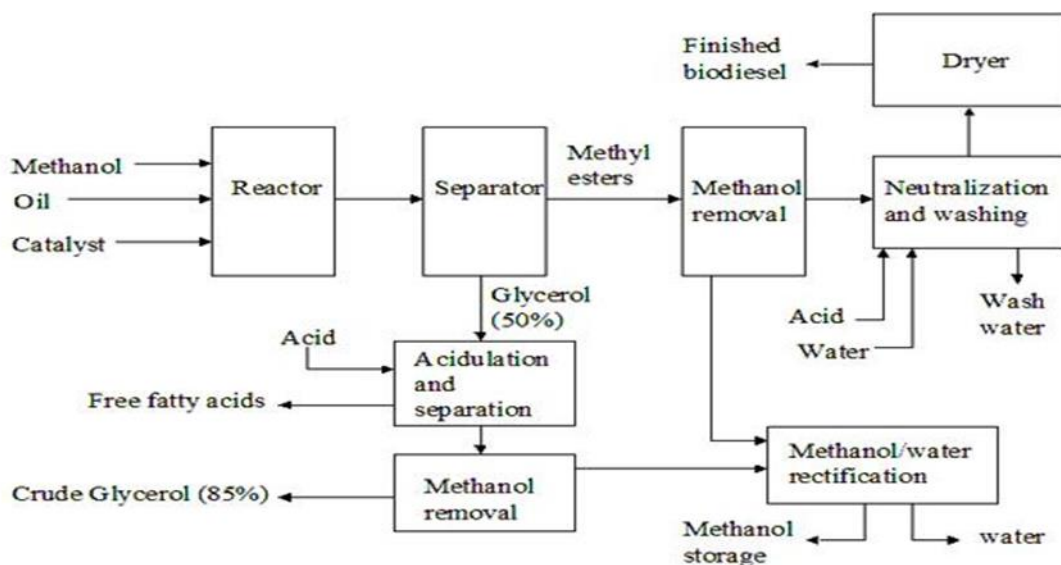


Figure 2.4: The Methanol Isolation Schematics (Van Gerpen, 2014).

III. METHODOLOGY

A. PYROLYSIS OR HEATING

High molecular weight compounds are heated or pyrolysis using electricity with or without a catalyst in smaller molecules. It is expected that the liquid components of spent vegetable oils will be converted into edible oils. Various studies also documented the pyrolysis of triglycerides for diesel-powered goods. Pyrolyzate oils are virtually equal in viscosity, in a flash, and in gasoline. The amount of cetane in the pyrolyzed oil was smaller. The pyrolyzed oils produce appropriate sulfa, water, and sediment content from vegetable oils and give a good copper corrosion yet low Carbon residue and ash. Owing to various structures and possible mixed triglyceride reactions, thermal decomposition pathways of triglycerides are expected to be complicated [59]. Billaud et al. [60] in a tube reactor among 500 & 5500 C and nitrogen dilution, the pyrolysis of a CH₃ (methyl) ester blend from the rapeseed oil was studied. The primary ingredient, which was chemically similar to fossil fuels, was unsaturated methyl ester.

B. BLENDING OR DILUTION

In a tube reactor among 500 & 5500 C and nitrogen dilution, the pyrolysis of a methyl ester blend from rapeseed oil was studied. The primary ingredient, which was chemically similar to fossil fuels, was unsaturated methyl ester. A resin, methanol, or ethanol may be used to dilute vegetable oils. Vegetable oils may be combined directly with gasoline and used by diesel engines. Several researchers have successfully attempted to mix vegetable oil with diesel. The quantity of 1:3 ratio dilution of sunflower oil with diesel fuels was investigated, and motor experiments were accepted out by Ziejewski et al. In which found that combination could not be used in direct-injection diesel engines for long term use.

The short and long-term efficiency experiments of blends of vegetable oil and diesel were conducted by Pryor et al. It was discovered that untreated degummed soybean oil and soybean ethyl in the short-term performance analysis ester were suitable alternatives to diesel fuel.

C. MICRO-EMULSIFYING

The development of micro mixtures is one plausible answer to the question of the viscosity of vegetable food oil. A micro-mixtures consists of a substance dispersed in an immiscible substance with or without an emulsifier. In droplets smaller than colloidal shapes. The Micro-emulsions are thermodynamically healthy dispersions by transparent or translucent thermodynamics of tar, water, surfactants, and even a tiny amphiphilic filament, named co-factions—the droplet diameters of the micro-emulsion range from 100 to 1000 Å. Vegetable oils with a co-solvent of vegetable oils that are boosted with or without a diesel fuel and a surfactant and cetane can produce micro-emulsion. Micro-emulsions give lower volumetric heating values than fossil fuels because of the alcohol content. Still, the alcohol is vaporized with high latent heat that helps cool the combustion chamber and minimizes

nozzles. Virtually the same engine performance with micro-emulsified sunflower fuel and a 25 percent mix of diesel sunflower fuel was shown by Ziejewski et al.

D. TRANS ESTERIFYING

The quickest process for converting oils as well as fats in biodiesel is transesterification. It is the maximum natural reaction to convert vegetable oils into biodiesel to decrease their viscosity. In some cases, this is the reaction of alcohol, methanol, triglycerides in gasoline, fats and recycled materials, biodiesel and glycerol growth. The response needs heat and a solid base substance i.e. hydroxide and sodium hydroxide. The stage of transesterification includes the response in the existence of a catalyst of vegetable oils with alcohols, including methanol or ethanol, to an ester and a by-product, glycerin at about 700 C, Methyl and ethyl esters in vegetable oil have been stated to be superior to pure vegetable oils.

E. TRANSESTERIFICATION BIODIESEL OUTPUT

Biodiesel fuels are produced by a transesterification cycle in which specific oils (triglycerides) are transformed by a chemical reaction with methanol, such as sodium or potassium hydroxide, into methyl esters in the presence of catalysts.

Glycerol and water are by-products of this chemical reaction that must be isolated from gasoline by methanol traces, unreacted catalyst triglycerides. Biodiesel fuels clearly contain oxygen that needs to be controlled to avoid issues with storage.

F. EMISSION or BEHAVIOUR COMBUSTION by BIODIESEL ENGINE

This thesis aimed to establish a manufacturing biodiesel method from low-cost feedstock's such as crude rubber seed oil.

1) Output from Diesel Engines by Vegetable Oils and Bio-Diesel

Many researchers and scientists have performed compression ignition engine output tests using different vegetable oils and biodiesel materials derived from various feed stocks. Performance parameters such as power supply, basic fuel usage, the temperature of exhaust gas, and thermal brake quality of different vegetable oils and biodiesel were discussed in detail in the following sections.

2) Vegetable and Biodiesel Combustion Pollution Characteristics

With the use of edible oils and biodiesel in a traditional diesel engine, hydrocarbons, carbon monoxide, and particulate matter are significantly reduced. Nonetheless, nitrogen dioxide levels are either decreased or marginally increased, depending on the service duration and monitoring procedures. Biodiesel reduces the carbon fraction of the solid particulate matter (because oxygen in biodiesel causes total combustion).

It removes the sulfur fraction (since there is no sulfur in the fuel). Higher unburnt hydrocarbons, carbon monoxide, smoke,

and particulates with an inevitable rise in N.O.X. are recorded in most studies on pollution from vegetable oils and biodiesel.

3) Biodiesel and Vegetable Oil Combustion Comportment

The thermal escape study is a way of implicitly demonstrating the combustion cycle in the turbine. A comprehensive scientific explanation of diesel engines' combustion innovations is highly complicated due to simultaneous air-fuel mixture forming and oxidation. This is applied under the first law of thermodynamics. Combustion, heat transfer, and mass loss influence the pressurized angle background of an engine. The release of heat

The pattern alone demonstrates the combustion influence. The heat release pattern affects the thermal output and peak cylinder strain tremendously. Until T.D.C. heat applied raises heat losses, lack of traction, and peak cylinder strain.

The burning takes place in three distinctive phases during the combustion cycle. The burning rate is very high during the first step and continues only for a few crank angles. This represents the duration of a significant rise in demand. The second step leads to a phased-down temperature average of around 400 CA. During these two steps, roughly 80 percent of heat energy is usually released. The third stage is a low but distinguishable heat release intensity that occurs through the expansion.

During this time, Heat energy is typically 20% of the overall fuel capacity. Dependent on the degree of accuracy with which the cylinder material is considered, the various methods for calculating the heat release rate from cylinder pressure data vary. Many techniques are easy to use, and some are difficult and require careful measurement to obtain precision.

Senatore et al. stated that heat is often emitted faster than mineral diesel with rapeseed oil ester because of its higher density and the higher peak cylinder temperature injected by biodiesel mixtures.

In an indirect diesel injection engine, from the simple pressure angle diagram of soybean oil ester as a fuel, McDonald et al. obtained the heat release. They observed that the total combustion properties were very similar to diesel activities, but for a shorter ignition time of soybean methyl ester.

G. PROCESS OF PRODUCING BIODIESEL AT WPI

1) Production

Using an ion exchange resin, the W.P.I. System Laboratory will build and purify biodiesel. In an experiment, senior students in chemical engineering are now producing Biodiesel for the Unit Operations Class. Two reactors powered by computers are used. Alcohol is referred to as methanol and K.O.H. as a solvent. Methanol and K.O.H. are combined collected into the first receptacle flask, and canola oil is fried in the second bowl. When the methanol-catalyst mixture exceeds a predefined temperature, it is injected into the second vessel in which the reaction happens. It is achieved in automatic hot water baths at a steady temperature of approximately 55 ° C and 60 ° C. When the reaction has been finished, it will cool for some days, after which two phases develop. The heavy layer of glycerol pure is then removed from the bottom of the bottle, and the lighter layer of biodiesel is regenerated. Usually, it takes about 2 hours, generating roughly 400 mL of unclean Biodiesel (Belliard, Carcone, Swalec, & Zehnder, 2014).

Students from the Chemical Engineering Operations Unit course at for this study, W.P.I.'s Unit Operations Research laboratory, and developed bio-diesel into the Goddard Hall.

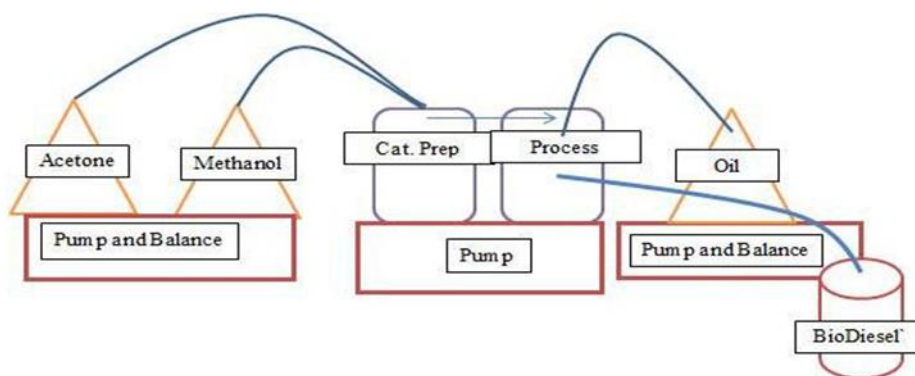


Figure 3.4: Biodiesel Production Schematic

Figures 3.4 and 3.5 demonstrate to the setup in the W.P.I. Unit Operations Lab to manufacture biodiesel. The following cycle description involves the two reactors and the two reaction source sources for an overall biodiesel receptor. The machine program manages the system's two reactors: the Catalyst Reactor and the Reactor in the Cycle. The contents of the

storage reactor for the catalyst are injected into the stage reactor. Machine reactor specimens can be collected and then tested for glycerol content. In procedures to disinfect reactors, acetone is used.

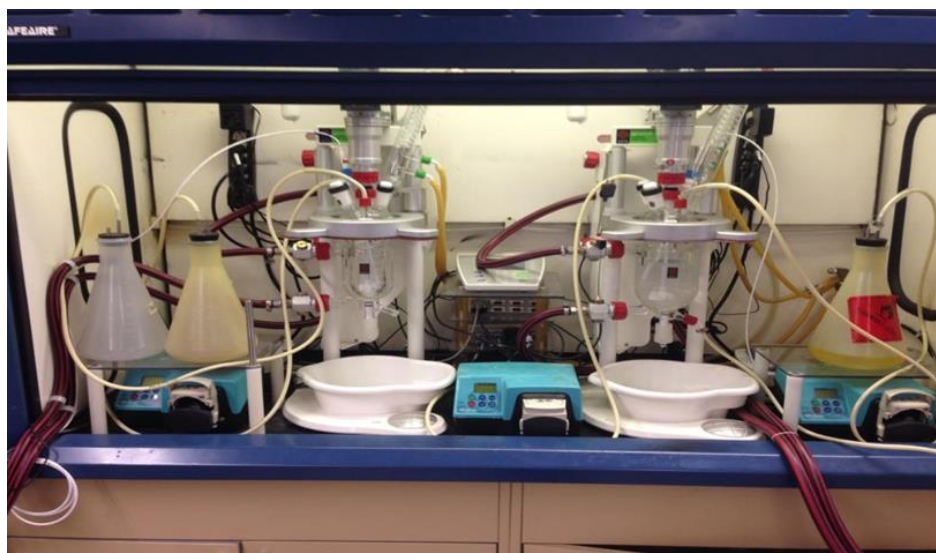


Figure 3.5: W.P.I. Biodiesel Production Setup

A mixture of methanol, glycerol, and biodiesel needs to be produced and then refined to extract both methanol and glycerol. Around 300-400 mL of accessible organic diesel is created by each run (about 40 minutes). The batches produced in the laboratory class were all prepared using canola oil, although other types of oils can be used to generate biodiesel.

3.8 PURIFICATION

The residual methanol in the bio-diesel stage is dispersed due to low pressures and temperatures of around 65°C. Then an ion exchange resin treats the rich form of biodiesel. By

incorporating glycerol, methanol, and catalyst, the resin is used for washing biodiesel.

The system is constructed to keep water from being pumped into biodiesel, which is otherwise known as dry-washing. In this method, Dudalite DW-R10 Ion Exchange Resin is widely used, which has been assumed to have higher adsorption rates than other resins. Although comprehensive studies have not been carried out to validate this, we conclude that refined biodiesel will comply with ASTM bio-diesel requirements (Belliard et al., 2014).



Figure 3.6: Two-Phase Separation and Resin Column

The two-phase glycerol and refined biodiesel distinction is shown in Figure 3.6. The dark orange-brown phase, a mixture mainly of trace volumes of glycerol and bio-diesel, is added, and the nearly clean bio-diesel above is omitted. The compound is shown at the bottom for the exchange of ions.

H. EXPERIMENTAL PROCEDURE

The community sought to measure the disparities between biodiesel and oil-based diesel in exhaust compositions. Correlations between different petroleum and biodiesel mixtures and the determined exhaust fuel concentrations were established.

The amounts of other pollution elements, Carbon monoxide and nitrogen oxides, including carbon dioxide, vary regardless of the quantity of gasoline used. A selection of materials tested with various mixtures has been performed by the Testo-340 meter for completeness.

At 25 percent, biodiesel and petroleum diesel blends, 50 percent biodiesel, and 75 percent pure fuels were made. The biodiesel provided by the Operations Research laboratory was selected to confirm that the feed typical and the biodiesel preparation system were handled. The fuel line was prepared with fuel with a preferred blend, and the burner could be kept steady. It happened when the air temperature was getting higher.

- Ensure that the device is loaded with coolants.
- Click and attach the heater device to its frame.
- Screw into the socket the electric source and turn on the water resource.
- Initiate the QuickDAQ 2013 data logging program. Make sure both thermocouples correctly transmit data.
- Fill the required fuel mixture of the gasoline tanks.
- Put the petrol container on the scale to ensure that there is adequate gasoline to be provided.

- Opening the yellow ball controller to supply the machine with tap water.
- To permit the machine to pump water, open the treated blue valve. By using the rotameter, switch the water flow rate to the desired degree.

Click the controller's red power button twice to toggle the heater on or to display "120." Start collecting temperature statistics in the data logging app. The coolant is going to begin to circulate at this point through the system.

- When the fuel does not drain after 1 minute, the machine is restarted.
- License thermocouple readings to the plateau, which will take approximately ten minutes before taking exhaust steps.

IV. RESULTS ANALYSIS AND DISCUSSIONS

A. EMISSIONS WITH DIESEL-BIODIESEL MIXTURES

The team performed several experiments utilizing the ESPAR heater varying with mixtures of diesel as well as biodiesel to assess the fuel formulation's influence on harmful pollution concentrations. Pure ultra-low sulfur fuel, canola oil biodiesel, and mixes of two comprising. They used biodiesel for 25 percent, 50 percent, and 75 percent. We contrasted our data with Figure 5, which was provided by a heavy-duty engine when our data was collected from the cabin heater. Both appliances work at very diverse temperatures as well as pressures that may impact performance. Also, while durable engines usually have set quantities of fuel consumed per sequence, the cab heater changes the quantity of fuel consumed to improve performance. On average, the data points are 3 to 4 measurements per fuel blend, providing concentrations of by-products in the fuel gas.

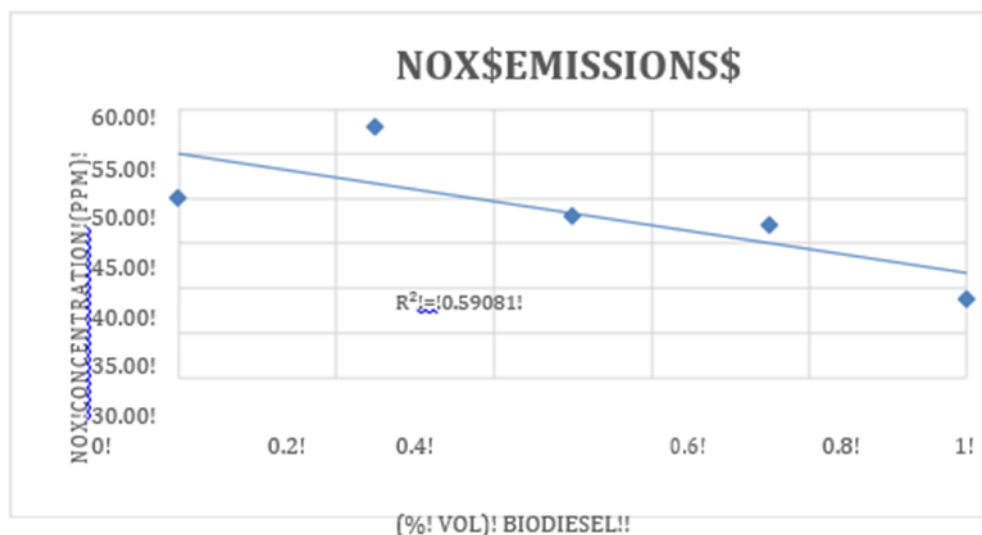


Figure 4.1: NOx Concentration (ppm) Vs. Diesel-Biodiesel Composition

To show a linear relation, the amounts of nitrogen oxides (NOx) compounds varied enough. Nonetheless, the levels of NOx decreased as the volume of biodiesel increased. The groundwater temperature changed greatly each day that may have impacted the fuel-flow with rate of burn. A persistent cooling water-flow rate was established during tests and temperature variability was not detected.

While almost half of the literature suggests a rise in NOx with biodiesel growth, our findings did not. The heat content of

the fuel will explain these effects. Biodiesel has a generally weaker heating capacity than fossil fuel, so stack temperature decreases overall as biodiesel volume rises. Therefore, because NOx production historically increased with a rise in combustion temperature, the extremely volatile stack temperature undoubtedly affected NOx rates. This association is illustrated by the following plot using data from both tests:

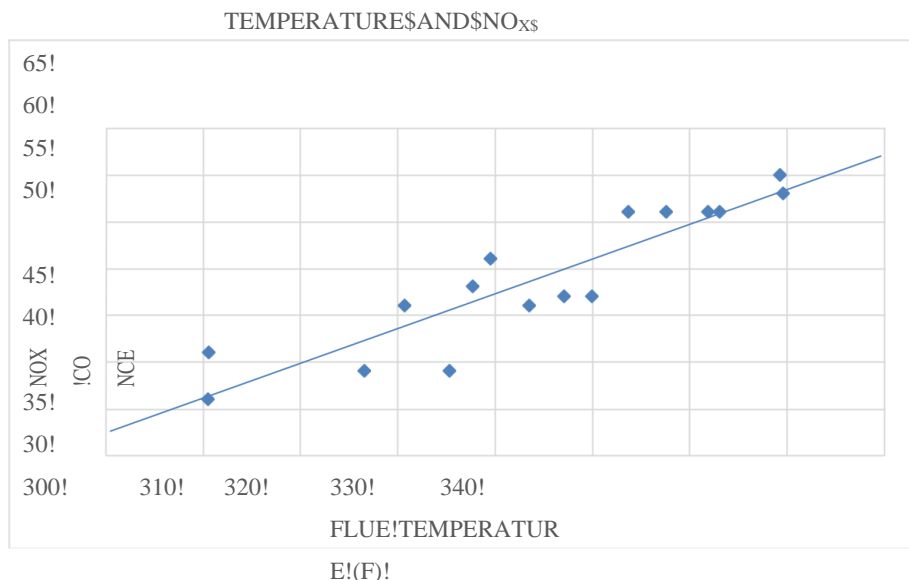


Figure 4.2: NOx Concentration vs. Flue Temperature

The measurements, the position of the metered sample, and the measurement duration can be due to the large variations in the stack's temperature. As the temperature reading on the probe rose, the measurement was recorded and seemed to be kept steady. Remain coherent. It is apparent from these data that at the temperature, the output of NOx tends to increase.

It is often used in combustion reactions through the mechanical, thermal production of NOx. For each diesel-biodiesel blend, carbon monoxide was also weighed. The CO measurements were, as with the NOx measurements, summed for each form of a diesel-biodiesel mixture.

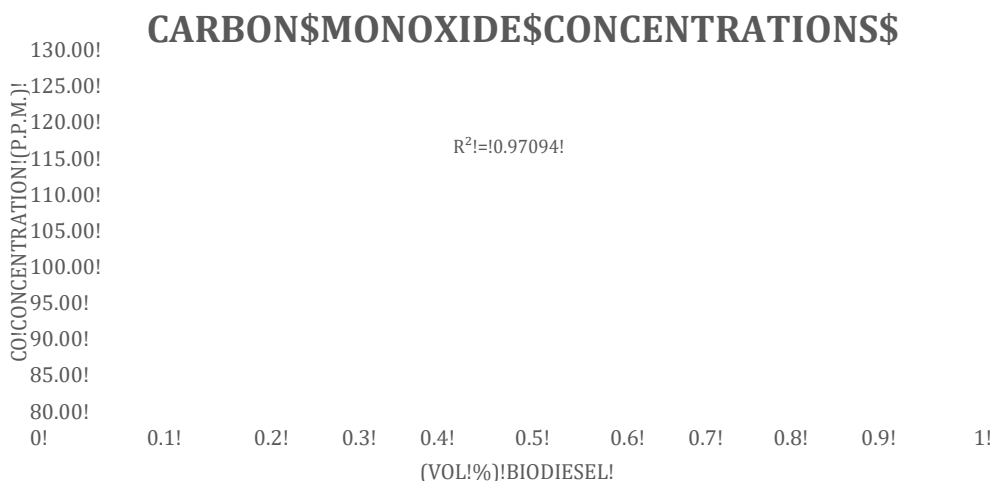


Figure 4.3: Carbon Monoxide Concentration versus Composition of Biodiesel.

A value of r^2 of 0.97 from the five plotted points indicates a strong linear negative relationship between exhaust CO and biodiesel structure concentration. The decline in CO emissions approves the conclusions of the literature. Virtually all biodiesels contain this decrease in CO emissions, which is one of the main reasons that it is important to use them. This is an extremely critical feature of science, as CO has a larger greenhouse effect than CO₂.

V. CONCLUSION

Biodiesel is a product similar to new coal or synthetic oil. Biodiesel can be made from pure palm oil, animal oil, seed, and left-over cooking oil. Transesterification is also process used to convert biodiesel from certain oils. This technique is also described below. The primary source of sufficient food is flower production, such as rapeseed, palm, or soya. Raping shows the highest biodiesel processing potential in the United Kingdom. The majority of the currently manufactured biodiesel is derived from restaurant vegetable oil waste, chip shops, industrial food producers such as birdseye, etc. Whereas economically, the possible source of petroleum directly from crops is not inherently because raw oil is too expensive. Once the costs of converting it to biodiesel have been added, this is simply too expensive to deal with conventional petrol. Vegetable waste oil can also be bought free of charge or already refined for a limited price. (The waste oil must be refined before being turned into biodiesel to eliminate impurities). This potential results of biodiesel from left-over vegetable oil to compete with conventional fuels. Further information on biodiesel rates and how items like customs play an important role can be found here.

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