

RECYCLING OF WASTE ENGINE OIL USING CHEMICAL FILTRATIONS METHOD

Submitted in partial fulfillment of the requirements of the award of
Bachelor of Engineering degree in Mechanical Engineering

By

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INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **R.MANOJ KUMAR** (Reg No. **37150115**) and **B.S.MELVIN FREDDY** (Reg.No.**37150119**) who carried out the project entitled "**RECYCLING OF WASTE ENGINE OIL USING CHEMICAL FILTRATIONS METHOD**" under my supervision from September 2020 to April 2021.

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We, R.ManojKumar (37150115) and B.S.Melvin Freddy (37150119) hereby declare that the Project Report entitled “**RECYCLING OF WASTE ENGINE OIL USING CHEMICAL FILTRATIONS METHOD**” done by us under the guidance of **Mr. M. PURUSOTHAMAN, M.E, (Ph.D)**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

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ABSTRACT

The treatment of waste engine oils that have been treated with acetic acid is the focus of this report. A recycling process was invented, and the findings eventually became similar to some of the more conventional approaches. The recycled oil can be re-used in vehicle engine safter being treated with the required additives. The use of acetic acid has the advantage of causing little or very minor reactions with base oils. The recycling process takes place at room temperature. Acetic acid has a slight impact on base oils and oil additives, according to research. When the used oil was treated with 0.8 percent acetic acid, it separated into two layers: a transparent dark red oil and a black dark sludge. At the very back of the container bottom. The findings of this paper were compared to base oils provided by other recycling methods. The comparison revealed that the recycled oil obtained by acetic acid treatment is equal to that obtained through other traditional approaches.

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LIST OF SYMBOLS AND ABBREVIATIONS

MEK	-	Methyl Ethyl Ketone
NaOH	-	Sodium Hydroxide
BTHE	-	Break Thermal heat efficiency
SFC	-	Specific Fuel Consumption
O ₂	-	Oxygen
CO ₂	-	Carbon Dioxide
CO	-	Carbon Monoxide
Hc	-	Hydro Carbon
No	-	Nitric Oxide
OA	-	Oil Analysis
OPD	-	Outsourced Product Development

CHAPTER-1

INTRODUCTION

1.1 HISTORY AND BACKGROUND

Waste fuel oil is a high-polluting substance that demands careful handling. When waste fuel oil is poured into the fields or into water streams, like sewers, it may damage the atmosphere. Which could lead to pollution of ground water and soil. The recycling of such polluted items would help to save money on engine oil. Furthermore, it would have a substantial positive environmental effect. Common waste engine oil processing strategies either require a high-cost technology like vacuum distillation or the use of hazardous materials like sulfuric acid. These methods often contain contaminating by-products of high sulphur levels, which are particularly harmful to the environment. in Iraq's Kurdistan province. Lubricant oils have mainly been used to reduce friction between moving parts of different machines or appliances, reduce material wear, increase equipment/machinery performance, and save fuel and electricity. Lubricants are important in any industrial society because they minimise friction and wear by creating a thin liquid layer between moving surfaces, as well as removing heat, keeping equipment clean, and avoiding corrosion. Two of the most popular applications are gasoline and diesel engine oils. Waste lubricating oil includes items like car grease, transmission oil, hydraulic, and grinding oils. It also applies to plastics, ash, carbon residue, water, varnish, gums, and other contaminating ingredients contaminating new lubricating components, as well as the formation of asphaltic compounds on the engine's bearing surface. These oils must be repaired and removed from the car after a few thousand kilometres of driving due to the stress generated by severe corrosion in service. The annual production of lubricating oils in Europe and the United States is immense, ranging from 1.7 to 3.5 million tonnes. This vast quantity of used engine oil has a substantial economic and environmental

influence. They cost millions of dollars to produce and, when discarded, are a high pollutant material. Since they emit toxic metals and other toxins into the air when dumped into the soil, water, or even burned as a low-grade gasoline, they can cause significant pollution issues. A series of experiments were carried out for this thesis on two separate types of collected oils. After 3000 to 3500 kilometers of use, the oils were obtained from car oil change shops and personal vehicles. Ravenol (VSi SAE 5W-40), a base oil produced in Werther, Germany, was used in this analysis. Many random tests were carried out to validate the capacity of glacial acetic acid to isolate the base oil from the polluted compounds. The first experiment was conducted with oils obtained from local stores. For the purpose of evaporating the water and poisonous compounds in the used oil, the oil was heated to a temperature of over 250°C for one hour. This is to mimic the acid-clay method's technique. The oil was then cooled to room temperature (16°C in the winter) before being divided into equivalent volumes (10 mL) and placed in a series of beakers. The used oils in the beakers were then mixed with various amounts of glacial acetic acid. To each 10 mL sample, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, and 2 mL of acid were applied. These samples were then mixed at 600 rpm for half an hour and heated to 25 °C on a hot plate stirrer (LabTech, ES35A-Pro). The beakers were exposed to the environment. The oil arising from the stirring and heating were then centrifuged for a quarter hour at 3000 rpm (Sigma, 2-6E, Sigma Laborzentrifugen GmbH, Osterode am Harz, Germany). Apart from the absence of a change in the colour of the treated used oil, no distinction was found after this operation. This may be due to acetic acid evaporation caused by the heating. This may also be attributed to the short time the acid spends interacting with the oil. In the second series of tests, the mixing time was increased to half an hour and then one hour, followed by centrifugation. No division happened the second and third years, and the absence of and color changes in the treated used oil was noted.

The third experiment was carried out in covered beakers, with the mixing phase lasting an hour at room temperature. After that, the mixture was allowed to sit at room temperature for 24 hours before being centrifuged. A transparent reddish lubricant oil coating and sludge at the bottom of the test tube is separated. Since the sludge was concentrated at the end, the lube oil dispersed quickly from the sludge of the test tubes. The lube oil and sludge were also measured. The test tube was heated to determine the weight of the sludge, and the sludge was then separated from the tube using cotton bits. The cotton was weighed a head of time, and the cotton with the sludge was dried for 24 hours at 50 °C in an oven (Memmert, UF110, Schwabach, Germany). The sludge's weight was reported to be 0.2 to 0.4 gm/10 gm sample of the used oil after drying. Denver Instrument (Denver, S/SI-603, Denver, CO, USA) provided the weighing balance.[1]

The findings showed that as the amount of acid applied to the samples increased, the amount of sludge increased as well, up to a point. The sludge obtained was black in colour, rigid, and compacted in a narrow region in the bottom of the test tube during the centrifugation process up to the 1.0 mL acid added/10 mL used liquid. After increasing the acid content above 1.0 mL/10 mL used liquid, the sludge modified dramatically. The sludge took on the appearance of an emulsion and turned pink, taking up a fifth of the test tube. The experiments with the first kind of lubricant oil (oil obtained from shops) were replicated with the second kind, Ravenol person alcar lubricant oils brand (VSiSAE5W-40) collected after being in use for 3000 to 3500 km. The treatment process used was similar to that used on oil obtained from super markets. As compared to the treated used oil obtained from oil-change stores, the tests carried out using used oil from personal cars yielded better results in terms of clarification. It's worth remembering that Koya city's oil-change shops collect used oil from both CI and SI engine crankcases.

Automobiles that have been seen After being in service for 3000 to 3500 kilometres, lubricant oils were obtained from car oil-change shops in Koya city/Erbil, Iraq, and from personal vehicles. These oils were collected in 20-liter tanks, which were then separated into smaller containers of 5 litres after being mixed thoroughly by hand shaking for 15 minutes. The residue from the used engine oil was removed as the first step in the recycling process. The used engine oil was combined with glacial acetic acid at a ratio of 0.8mL acetic acid per 10mL used engine oil. The mixture was then stirred in a closed container at room temperature and pressure for an hour. To extract the base oil from the toxins, the mixture was left at room temperature for 24 hours before being centrifuged for an hour. The separated base oil was mixed with kaolinite at a ratio of 1 mL oil to 4 g kaolinite. The kaolinite was added to eliminate the dark colour and odour that had formed due to the oxidation of some of the oil's components. This was achieved by heating to just above 250 °C, then centrifuging for 30 minutes. This process yielded a yellow clear base oil with a sludge content that was very close to the initial weight of the kaolinite plus 5%. By performing oil analysis, the second step in the recycling process was to determine the chemical and physical properties of the resulting materials (OA). The following materials were tested: base engine oil produced by the acetic acid - clay method, base oil produced by local companies in the Kurdistan region using the sulfuric acid-clay method, base oil produced by vacuum distillation-clay treatment, base oils (Ravenol, VSi SAE 5W-40), used engine oil, and by-product (sludge). Oil analyses (OA) is a laboratory examination of the physical and chemical properties of engine oils, as well as suspended contaminants and wear debris. Oil analysis is carried out as part of routine preventative maintenance. to provide meaningful and accurate lubricant and machine condition information Trends can be established by tracking oil analysis sample results over the life of a machine. [2]

1.2 ENGINE OIL'S METALLIC CONTENT

Metals are heteroatoms that occur in engine oil mixtures. Metal concentrations range from a few hundred to thousands of parts per million, and their concentrations increase as the boiling point or API gravity of the engine oil decreases. Metallic constituents in engine oils are linked to heavy compounds which are often found in residues. Metal content of base and base engine oils is very low, indicating their purity. Some metals found in high amounts in virgin oils are used as additives to increase the efficiency of the engine oil. Owing to depletion of different additives, engine bearings or bushings, and dilution of the engine oil with fuel containing metal additives, several more are added into the oils after use. Metals can be used in two types in spent fuel oil: Contamination of metal particulates. Metallic particulates penetrate the engine oil as a result of ineffective lubrication, mechanical working, abrasion degradation, and/or deterioration of oil-wetted surfaces. Metallic particles from decaying component surfaces are usually strong, and as their accumulation in the oil grows, so does the rate of wear. Elementalism (Metals) Metallic elements have been applied to several oil constituents to improve the oil's quality. Metals in engine oils are generally treated as pollutants that must be tirelessly withdrawn in order to create a sufficient base oil for the production of fresh virgin oil. After bearings, fatigue, and valve guides, copper (Cu) is applied to engine oils. Engine oil coolers, as well as some oil additives, can contribute to copper content. The copper concentration in recycled oil with acetic acid combined with vacuum distillation is 0.4 ppm, opposed to zero ppm in oil recycled with sulfuric acid, as shown in This is due to the fact that sulfuric acid is more potent. Copper is more reactive with acetic acid and forms a precipitate. Magnesium is usually added to fuel oil as part of an additive kit. Magnesium is one of the most popular wear metals in used engine oil, and it can be found in virgin oil as magnesium phenates and magnesiums alicylates, which act as antioxidants at high temperatures indicates that

when sulfuric acid was applied to the base oil, the concentration of magnesium(Mg) in the oil was impaired rather than when acetic acid was added. This is attributable to sulfuric acid's reactivity with Mg, which may result in precipitated compounds.

The appearance of chromium in engine oil is usually linked to piston ring wear. Dirt in the air intake or split rings may also contribute to high amounts. Excessive wear of chromed components, such as rings and liners, can be shown by chromium . As seen in Table 4, the volume of chromium in the used oil is very limited, as this element is only found in a few parts of the engine. The volume of this metal seems to be reduced from 1.5 ppm to 0.2 ppm after recycling with acetic acid and vacuum distillation. It shows the same finding in terms of tin. After piston wear, some shaft sizes, bearings or bushings, and valve guides, tin is added into the liquid. Tin must be totally separated from base oils because it is considered a contaminant. Bearing wear, fuel supply (leaded gasoline), and corrosion due to the use of galvanised containers are both related to lead (Pb). Since lead is considered a base oil contaminant, it has little concentration of virgin oils. It shows the used engine oil has a lead content of 14.6 ppm. This is due to engine oil dilution caused by leaded fuel treated with tetraethyl lead for anti-knocking and engine component wear. The mixture of acetic acid recycling and vacuum distillation is very effective in extracting this metal. It assisted in lowering the metal content of used oil from 14.6 to 0.4 ppm. Iron is the most common wear metal that is added into the fuel oil during a cycle of use in a car's engine. Liners, camshafts, and crank shafts, pistons, gears, chains, and the oil pump are also sources of iron in the engine. The amount of iron in engine oil is determined by the engine's bearing conditions. As a bearing breaks, the amount of iron in the used fuel oil rises. During the start-up of the motor, the wear increases at a higher pace. There must be no toxins in the

base oils iron entirely because it is involved in the production of oxidation products as a result of various chemical reactions.[3]

It's also apparent that recycling with acetic acid and vacuum distillation is very effective at separating the metal entirely. Zinc is added to base oil as an anti-oxidant, corrosion agent, anti-wear, detergent, and severe pressure resistance additive kit. Zinc is added to base oil as an additive, such as : Zinc diethyldithio phosphate (ZDDP), which acts as an oxidation agent and boosts the oil's oxidation resistance. Zinc dithio phosphates are a form of anti-oxidant that also serves as a wear inhibitor. This improves the oil's oxidation resistance. Zinc dithio phosphates, which not only serves as an anti-oxidant but also as a wear deterrent and corrosion protection for engine metals. This compound, zinc dialkyldithio carbamates, is mostly used as an antioxidant, but it also has high pressure activity. Table 4 shows that the zinc content in the base oil is 1,200 ppm. This is a multi-functional additive that is applied to base oils to improve their consistency. Zinc concentration of used fuel oil is 1280 ppm. Wear of the galvanised piping causes an increase of zinc content in spent fuel oil. As sulfuric acid is added to the base oil, it produces Zinc content was reduced by 28 percent, compared to 11 percent for acetic acid. Zinc reacts with sulfuric acid to form precipitated compounds. Wear of cylinder liners, tubes, and shafts introduces manganese (Mn) into the system. Just a small amount of manganese is found in the used engine oil, as seen in .The combination of acetic acid recycling and vacuum distillation is very useful in removing this metal completely. Cadmium (Cd) is a contaminant that is released into engine oil during operation. Cadmium is not present in base oils. shows the cadmium in the used oil is just 1 ppm, and that it can be fully replaced with acetic acid therapy.

1.3 ENGINE OIL OXIDATION

Analyze the Products The supply of oxygen, as well as in-cylinder pressure and temperature, influence the oxidation of fuel oil within the engine [52]. There are two forms of oxidation: low-temperature oxidation and high-temperature oxidation. Alkylhydroperoxides ROOH , dialkyl peroxides ROOR , alcohols ROH , aldehydes RCHO , and ketones $\text{RR}'\text{C}=\text{O}$ are formed when engine oil is oxidised at low temperatures. Diketones $\text{RCO}(\text{CH}_2)_x\text{COR}'$, ketoaldehydes $\text{RCO}(\text{CH}_2)_x\text{CHO}$, and hydroxy ketones $\text{RCH}(\text{OH})-(\text{CH}_2)_x\text{COR}'$ are also formed when a dihydroperoxide is cleaved. The engine oil oxidation process can be separated into a primary and secondary oxidations path at high temperatures ($>120^\circ\text{C}$). The initiation and completion of primary oxidation occur during this process.

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At higher temperatures, the secondary oxidation process occurs, and the viscosity of the bulk medium increases due to the polycondensation of the difunctional oxygenated materials produced in the primary oxidation phase. Sludge is formed by further polycondensation and polymerization reactions of these high molecular weight intermediates.

The IR spectra of reaction oxidation compounds in oil samples were calculated qualitatively using a Fourier Transform Infrared Spectrometer (Thermo Scientific, Thermo Matts on Nicolet 300-FTIR). Since the (C=O) bond strongly absorbs at this frequency, a spectral band at 1700–1750 cm⁻¹ showed the existence of oxidation compounds. The IR findings of the base oil, as seen in Figure 3 and Table 8, revealed no oxidised substance peaks, confirming its virginity. The presence of oxidation products in the used engine oil sample is shown by a medium peak at 1704.61 cm⁻¹ in the IR spectra.[4]

1.4 OBJECTIVE OF THE STUDY

The goals of this study are to:

- 1) Highlight the sources and selection of spent fuel oil; and highlight the sources and collection of spent engine oil.
- 2) Digata more reliable and safe way of processing used fuel oil.
- 3) Assess the cleanliness of the handled oil before reusing it.

CHAPTER-2

LITERATURE REVIEW

2.1 INTRODUCTION

Refining of used Engine oil using M.E.K Mr. Merai Yash P. worked on refining of used engine oil and having carried out the following process:

Dehydration is a common ailment. To boil off emulsified water and some of the fuel diluents, the oil is heated to 130°C in a closed vessel. The saturation limit is the point at which an oil contains the highest volume of dissolved water. The saturation point rises with temperature, implying that more water is held in solution, in the dissolved form. Similarly, the greater the amount of water that can be dissolved, the older the oil. Dehydration is used to dissolve water since it causes some contaminants in the oil to form, such as waxes, suspensions, carbon and oxide in solubles, and also microorganisms. Distillation in a vacuum

The internals of a vacuum distillation column must have strong vapour liquid interaction while still retaining a very low pressure erise from the top to the bottom of the column. As a result, the vacuum column only uses distillation trays when removing materials from the column's edge (referred to as sided raws). Since packaging material has a smaller pressured rop than distillation trays, the rest of the column's vapor- liquid touching is achieved with packing material. Structured sheet metal or uniformly discarded packings may be used as this packaging material. The dehydrated oil is then continuously fed into a vacuum distillation plant for fractional distillation in precisely the same manner it was before.[5]

THE FOLLOWING ARE THE FRACTIONS OBTAINED:

1. Light fuel and gasoline: It will generate enough diesel from used oil feed stock to power all of the burners and boilers, ensuring maximum fuel independence.
2. Lubricating oil: The plant can distil the remainder of the feedstock and create a lubricating oil fraction.
3. Residue: The portion of the feeds tock that isn't distill able. All of the carbon, wear metals, degraded additives, and the majority of the lead and oxidation products are found here. This residue has been successfully used as a reading bitumen extender.

Final air distillation and solvent extraction In the solvent extraction process, Methyl Ethyl Ketone (MEK) is a selective aromatic solvent. By agitation, the lubricating oil obtained by vacuum disillusion is mixed in a 2:1 ratio with MEK. In the separator tank, the lubricating oil and solvent mixture is allowed to settle. The aromatic material and degraded additives in the lubricating oil fraction will fall to the bottom, while the lubricating oil fraction and solvent mixture layer will form on top. The solvent mixture is exposed to another round of atmospheric distillation. At a temperature of about 80°C, which is the boiling point of MEK, atmospheric distillation is carried out. The MEK vapour is diluted and re-used as a solvent by combining it with new solvent. At this point, the lubricating oil produced is similar to the base lubricating oil. To boost the prop- retires even further and make them suitable for use in car engines, additives must be applied. The most popular additive used in lubricating oil is zinc dialkyldithio sulphate.[6]

Refining waste lubricants may be beneficial to both the atmosphere and the economy. Refining waste oil to make base oil uses less energy than reprocessing waste oil to make petrol. The energy needed to process refined oil from used oil is just one-third of the energy required to produce virgin oil to produce virgin base oil. Therefore, re-refining is considered by many as a preferred option in terms of conserving resource as well as minimizing waste and reducing damage to the environment.

2.2 REFINING OF USED ENGINE OIL USING BLEACHING AGENTS

Mr. Abdulkadidiscussestheresultsofusing syntheticbleaching agenthand activated carbon as bleaching agents to regenerate spent fuel oil. To extract the aromatic content and boost the colour and consistency of the oil, it goes through acidification and bleaching steps. The process produced regenerated oil of higher quality, with a viscosity of 53.16cP at 40 degrees Celsius. The below are the procedures Treatment with acid: In a 500 mL beaker, 300 mL of used engine oil was weighed. In a single 50 mL beaker, 30 mL of sulphuric acid was also weighed. The hot plate of the regulator was turned on, and the measured base oil was poured onto top . The base oil (used fuel oil) was kept at a constant temperature of 40-45 degrees Celsius. Sulphuric acid was added to the used engine oil at this temperature, and the mixture was stirred for ten minutes. Decantation/Sedimentation is a term used to describe the process of separating solids from liquids The acidic oil was allowed to settle for four hours after the acid treatment process, forming sediment at the bottom of the beaker. During this time, the acidic oil was fully sedimented and decanted into a new 500mL beaker, while the waste, or acidic sludge, was removed.[7]

Following that, the acidic oil in the beaker was bleached. The oil was mounted on a regulator hot plate and held at a temperature of 110 degrees Celsius. In the oil, 6 wt% bleaching earth (industrially produced) was added, and the mixture was stirred continuously for 10 minutes. The bleached oil was neutralised at the end of the bleaching process.

The bleached oil was neutralised to get the pH level back to normal. By taking into account the pH of the bleached oil at a given point in time, 4 wt percent of the oil of hydrated lime was added into the bleached oil at this step. After 10 minutes of constant manual stirring, the bleached oil was neutralised. After the bleaching and neutralisation steps, the oil was allowed to settle for 4 hours in the beaker before being decanted into it, with the excess at the bottom of the beaker being discarded.

If the acidic oil is to be bleached with activated carbon (char- coal) at the end of the acid treatment stage, the same process as for bleaching with industrial bleaching earth is used. Except that the temperature was elevated to 130°C– 140°C and remained there. The same amount of activated carbon and hydrated lime is used as in the industrial bleaching plant. Decantation / Sedimentation: The oil was allowed to settle in the beaker for 4 hours before being decanted into another beaker, with the residue at the bottom of the beaker being discarded.[8]

Finally, these sedimented oil was filtered with a filter cloth, and the filtrate was gathered in a filtration flask and found to be pure, while the residue (filter cake) was discarded. Using fuel oil can be regenerated on a bench scale under stable conditions, according to the results of the experiment. It disclosed a higher content of regenerated oil made with industrial bleaching earth, with a viscosity at 400°C, specific gravity, and total acid number that were all similar to the normal grade.

2.3 REFINING OF USED ENGINE OIL USING A NEW WASHING AGENT

Ihsan Hamawand, Talal Yusaf, and SardashtRafat worked on the refinement of used engine oil, performing the following procedure: The aim of this paper is to explore the recycling of waste engine oils that have been processed with acetic acid. The use of acetic acid has the advantage of not reacting with base oils. At room temperature, the recycling process takes place. The residue from the used engine oil was removed as the first step in the recycling process. The used engine oil was combined with glacial acetic acid at a ratio of 0.8 mL acetic acid per 10 mL used engine oil. After that, for one hour, the mixture was stirred in a closed container at room temperature and pressure. The mixture was left at room temperature for 24 hours before being centrifuged for an hour to remove the base oil from the pollutants. A ratio of 1 mL oil to 4 g kaolinite was used to blend the extracted base oil with kaolinite. The kaolinite was added to eliminate the dark colour and odour caused by oxidation of some of the oil's components. This was done by heating to a temperature just above 250°C, then centrifuging for 30 minutes. This method yielded a yellow transparent base oil and a sludge that was very similar to the original weight of the kaolinite used plus 5%. Conclusion: Used fuel oil can be processed using glacial acetic acid, according to this report. This process yields base oil that is comparable to that obtained by traditional methods[9]

CHAPTER-3

AIM AND SCOPE OF THE PROJECT

3.1 AIM OF THEPROJECT

- Strength should be greater than stress induced
- Simplicity of Design
- Safety & Convenience of control
- Low Cost
- Good Appearance

3.2 SCOPE OF THE PROJECT

- Highlight the sources and selection of spent fuel oil; and highlight the sources and collection of spent engine oil.
- Digatamore reliable and safe way of processing used fuel oil.
- Assess the cleanliness of the handled oil before reusing it.

CHAPTER-4

MATERIALS AND METHODS

4.1 METHODOLOGY OF RESEARCH

Since the base oil never spoils, it just becomes dusty, we use a glacial acetic acid - clay treatment to separate it from toxins and additives[10]. as shown in the fig (4.1)

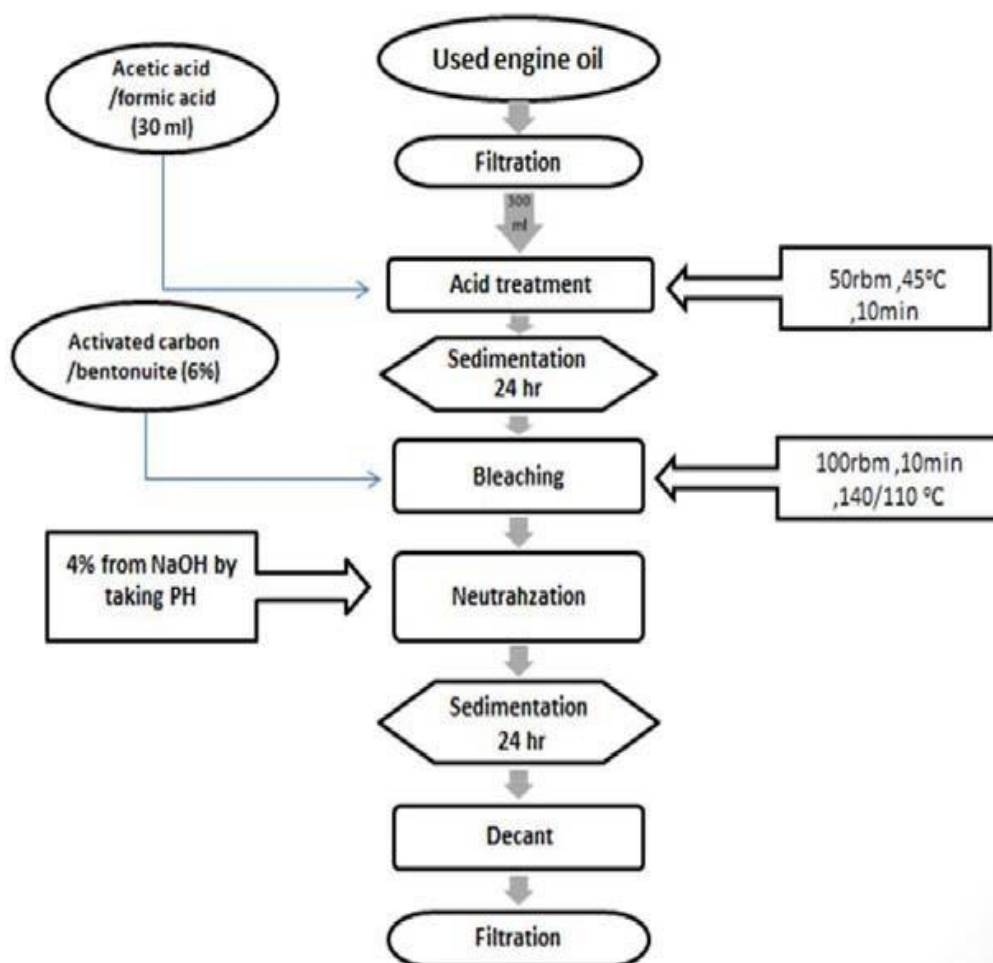


Fig 4.1: Flow Chart of Experimental Methodology

4.2 MATERIALS REQUIRED

The materials required for our research work are waste engine oil, acetic acid, activated carbon, sodium hydroxide (NaOH).

4.3 RECYCLING USING CHEMICAL FILTRATION METHOD

4.3.1 *Supplementation of acetic acid:*

Acetic acid is proportionally mixed with used engine oil (with 2 litres of used engine oil, 16 ml of acetic acid is used), so the Refining of Used Engine Oil mixture is stirred in a closed container at 100°C temperatures for 10 minutes[11]. After that, the mixture is set aside for 24 hours to sediment. as shown in the fig (4.2)



Fig 4.2: Treatment with Acetic Acid

4.3.2 Bleaching using activated Carbon:

The oil is heated to 40°C and then moved to the mixing chamber, where activated charcoal is added and it is mixed for about 10 minutes before being able to settle for 24 hours. The residue settles at the bottom and is then discarded, leaving a dark red clear base oil that is then deposited in the base oil bottle[12]. as shown in the fig (4.3)



Fig 4.3: Bleaching with Activated carbon

4.3.3 Neutralization using NaOH:

The oil is then moved to the mixing chamber, where sodium hydroxide (Na OH) is added and mixed for about 10 minutes before being left to settle for 24 hours, with the residue settling at the bottom. After that, it's put in the base oil bottle. as shown in the fig (4.4)

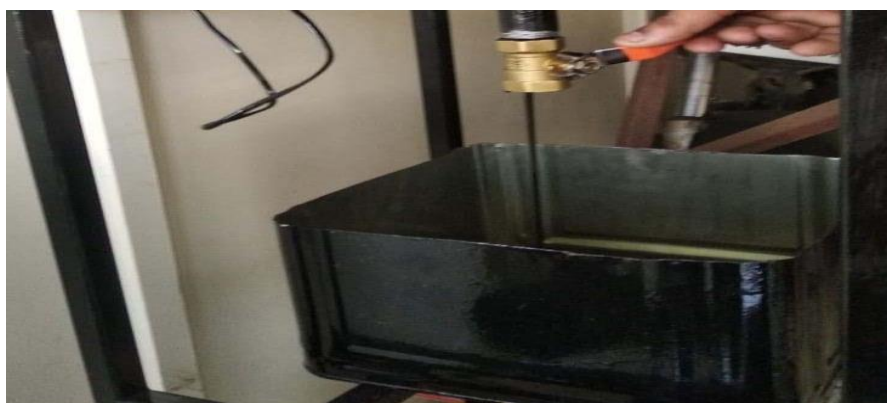


Fig 4.4: Neutralization with Sodium Hydroxide

4.3.4 Sedimentation Process:

Using fuel oil can be regenerated on a bench scale under stable conditions, according to the results of the experiment. It was discovered that using regenerated oil increased the consistency of the oil[13]. as shown in the fig (4.5)



Fig 4.5: Sedimentation Process

4.3.5 Transesterification Process:

Transesterification is the process of converting one substance into another. The process is carried out, and further work is carried out. The mechanism of transesterification is where a factor oil reacts with an alcohol to produce esters and glycerol. To increase the reaction rate and yield, a catalyst is used. Excess alcohol is used to move the equilibrium to the product sides of the reaction is reversible[14]. as shown in the fig (4.6)



Fig 4.6: Transesterification process

4.4 DESIGN AND FABRICATION

4.4.1 Design process:

The oil refining unit was designed and built in an attempt to find an environmentally sustainable method of waste oil refining. It's a viable alternative to the massive imports of engine oil. It is a prototype / laboratory scale model that will be used as a starting point for the creation of commercial oil refineries. The frame, used oil storage container, glacial acetic acid container, mixing chamber, kaolinite / Bleaching chamber, heating chamber, and base oil storage container are the main components[15]

4.4.2 Conceptual Design of oil Refining Unit:

The images below display the CAD model of the oil refining plant, which was created using Solid works software 2017, as well as the operating model. The concept was created with expense, simplicity, and avoiding fabrication complexity in mind.

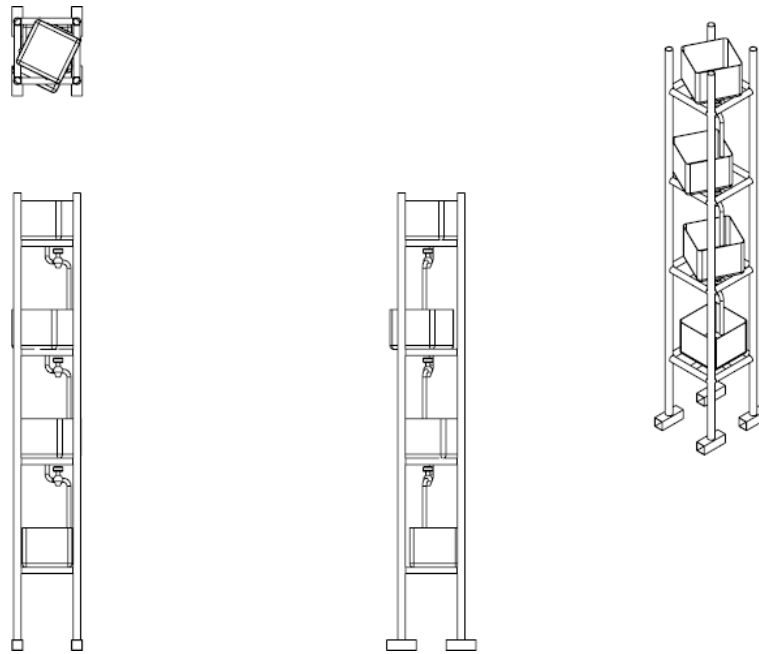


Fig 4.7: 2D Design of Frame And Boxes

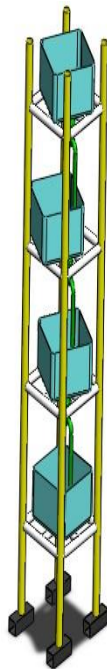


Fig 4.8: 3D Design of Frame And Boxes

4.4.3 Conceptual Design of Frame:

The measurements of the frame are seen below; the frame bears the whole weight of the oil refining complex, so the factor of strength should be greater than the stress is taken into account[16].

4.4.4 Conceptual Design of Containers:

The containers were created using Solidworks software 2017. The dimensions of the containers are as follows: used oil storage container, kaolinite/Bleachingmixingchamber,mixingchamber,heatingchamber,andbase oil storage container. The containers have a 5 litre size. As seen below, there are a total of 5 containers of the same dimensions and capacities.

4.4.5 Conceptual Design of Acetic Acid Container:

The Acetic Acid container was created using the Solid works software in 2017. The dimensions of the acetic acid container are seen below, and the container's size is 1 litre. There is only one container with the dimensions mentioned below[17].

4.4.6 Fabrication process and machining operations:

Cutting the pipes to necessary lengths, welding the pipes to the tube, drilling holes for the container, cutting of panels, threading of pipes, and grinding and finishing are some of the manufacturing and machining operations that were carried out.

Fabrication of oil Refining unit parts The following Parts were fabricated at the Workshop

1. Frame
2. Containers
3. Piping

4.4.7 Cutting the Pipes to Required Dimensions:

Pipe of inch diameter was cut for different lengths of 3 inches (4 Nos.), 4 inches (4 Nos.) and MS pipe of inch diameter was cut for different lengths of 55inches and 4 inches (2 Nos.) and 2 inches (2 Nos.) and level pipe of 12 inches was cut to bind the glacial acetic acid jar and mixing container using a hacksaw blade.

4.4.8 Welding Pipes to Container:

To weld the MS pipes to the kaolinite/bleaching container and the heating container, electric arc welding was used. To make the jar leak-proof, solder the cover plates at the rim. Welding the 10x12inches sheet metal plate to the Base frame.[18]

4.4.9 Cutting of Sheets:

A grinder was used to cut MS sheet metal into circular forms of diameter 200mm and 10mm for the bottom and top of the containers, as well as a10x12inches rectangular shaped sheet metal for the electronic screen.

4.4.10 Grinding and Finishing:

The tension accumulation induces splitting, which can be avoided when using the grinding technique. The grinding machine has an abrasive compound grinding wheel disc that can quickly strip rough and brittle materials that are difficult to remove with cutting tools while still providing the necessary surface finish. as shown in the fig (4.9)[19]



Fig 4.9: Schematic diagram of oil purification unit

4.5 COMPONENTS OF THE PROJECT

The main components designed and fabricated for the refining process are as follows:

1. Base Frame.
2. Mixing container,
3. Heating container,
4. Oil Immersion Heater,
5. Thermometer

4.5.1 Base Frame:

The machine's frame is its basis. The structure is made of steel and is sturdy enough to support all of the pipes, piping, and valves. Apart from supporting the weight, the frame could be light and cost as little as possible. Taking all of these considerations into account, mild steel was selected. The mild steel has excellent formability or workability, and the frame was designed using SOLID WORKS 2017[20]. as shown in the fig (4.10)



Fig 4.10: Base frame

4.5.2 Mixing Container:

This is the bottle in which the used engine oil and acetic acid will be combined in the correct proportions (for 2 litres of used engine oil, 16ml of glacial acetic acid will be used) and the mixing process will be begun for a duration of 24 hours. as shown in the fig (4.11)



Fig 4.11: Mixing container

4.5.3 Heating Container:

This bottle has an industrial oil immersion heater that heats the oil evenly and rapidly, freeing it from long chain carbon atoms and removing humidity and moisture content in the used fuel oil[21].as shown in the fig (4.12)



Fig 4.12: Heating container

4.5.4 Oil Immersion Heater:

This is based on the joule heating theorem. A temperature sensor activates a thermostat to monitor the temperature of the oil, and an electrical resistance heating unit encased in a tube converts electrical energy into heat energy[22]. as shown in the fig (4.13)



Fig 4.13: Oil Immersion heater

4.5.5 Thermometer:

While a single thermometer will determine degrees of hotness, readings from two thermometers cannot be matched because they are on the same scale. There is now a thermodynamic temperature scale that is absolute. Centered on fixed points and interpolating thermometers, international temperature scales are built to come close to this. as shown in the fig (4.14)



Fig 4.14: Thermometer

4.6 PROPERTY TESTING

4.6.1 Measurement of Flashpoint

It is a tool for assessing whether or not a sampled combination of vapour and air is flammable. It may also be used to calculate the temperature at which a sample becomes flammable. The flash point of a substance is the lowest temperature at which its vapours combust from an ignition source.[23]

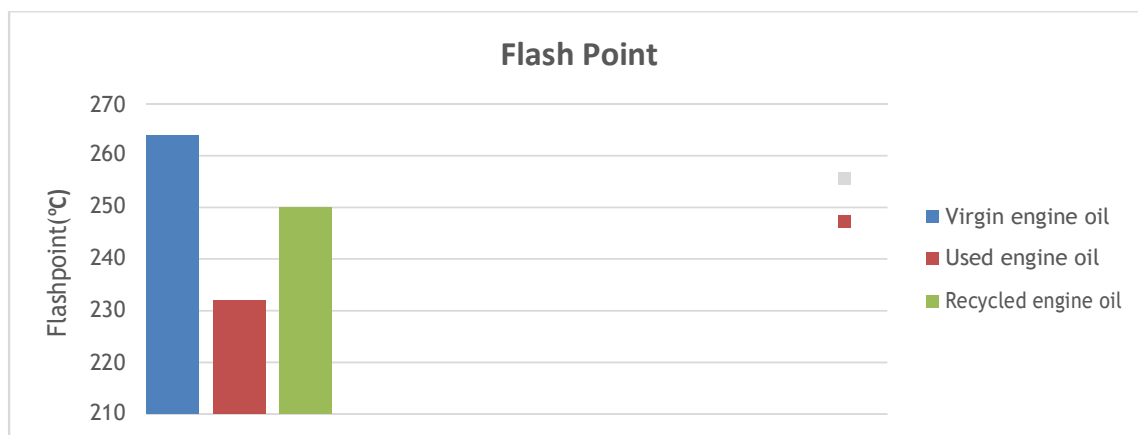


Fig 4.15: Flash point

4.6.2 Measurement of Pour point

The lowest temperature at which the test fluid can be poured under the defined test conditions is known as the pour stage. It's one of the properties that determines a lubricating oil's low-temperature fluidity[24].



Fig 4.16: Pour point

4.6.3 Measurement of Viscosity index

The viscosity index (VI) is an arbitrary, unit less calculation of a fluid's viscosity transition as a function of temperature. The lower the VI, the more temperature fluctuations influence the viscosity. The larger the VI, the more temperature variations do not affect the viscosity[25].



Fig 4.17: Viscosity index

4.6.4 Measurement of Specificgravity

The ratio of the mass of a given volume of product to the mass of an equivalent volume of water at the same temperature is known as relative density for petroleum products. ASTM D1298 is used to measure specific gravity; the higher the specific gravity, the heavier the substance.

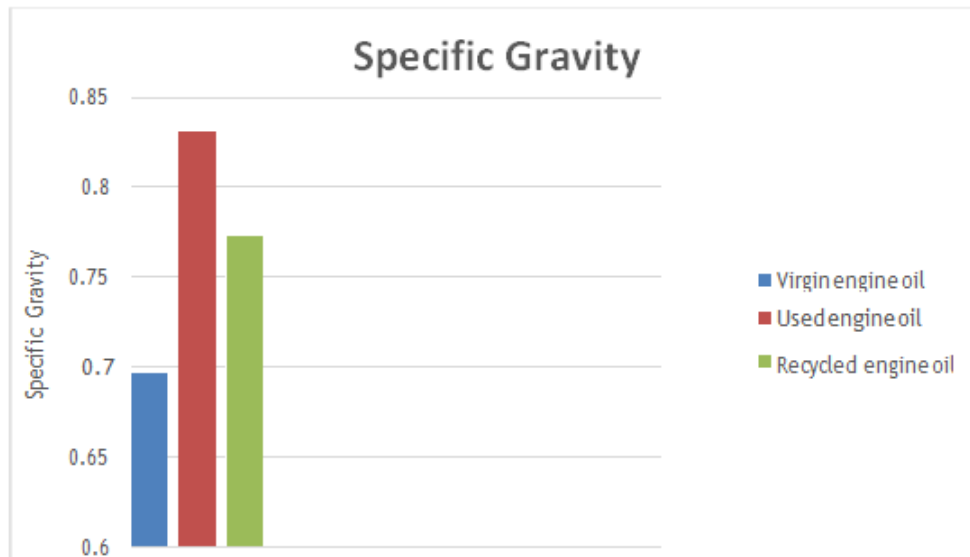


Fig 4.18: Specific gravity

4.7 ENGINE TESTING AND ANALYSIS

The experimental research is done in a single cylinder, four stroke diesel engine and it is connected to an eddy current type dynamometer for loading. For the Combustion pressure and crank angle measurements it is provided with necessary instruments.[26]

4.7.1 Engine Details

The engine specifications that was used to carry out the various test are mentioned in the table 4.1.

Table 4.1: Engine specifications

Cooling	Water-cooled engine
Model	Kirloskar TV1
No.of. Cylinders	1
Cubic Capacity (liter)	0.661

Rated Speed (rpm)	1500
Governing	Class“A2/B1”
Power	5.20KW
Power Rating	7 hp
Cylinder bore	87.50mm
Stroke length	110.00mm
Connecting rod length	234mm
Compression ratio	17.50
Swept volume	661.45cc
Overall dimensions	Width2000*length2500*height 15 00mm.

4.7.2 Combustion parameters

The combustion parameters of the engine are mentioned in Table 4.2 [27]

Table 4.2: Combustion Parameters

Specific Gas Const (kJ/kgK)	1.00
Airdensity (kg/m3)	1.17
Adiabatic Index	1.41
Polytrophic Index	1.06
No.of. Cycles	10
Cylinder pressure reference	6
Smoothing	2
TDC reference	2

4.7.3 Performance Parameters.

The performance parameters of the engine are mentioned in Table 4.4 [28]

Table 4.3: Performance Parameters

Orifice Diameter (mm)	20.00
Orifice Co eff. Of Discharge,	0.60
Dynamo meter arm length	185
Fuel Pipe dia (mm)	12.40
Ambient Temp. (DegC)	27
Pulses Per revolution	360
Fuel Type	Diesel
Fuel Density (Kg/m ³)	835
Calorific Value Of Fuel (kj/kg)	40150

4.7.4 Schematic Diagram of the engine

The schematic diagram of engine is shown in Fig 4.19.



Fig 4.19: Testing Engine.

4.8 PROPERTIES OF FUEL SAMPLES

Physical properties of engine oil samples with their various treatment methods:

N o	Sample	Flash Point (°C)	Pour Point (°C)	Kinematic Viscosity @ 40°C	Kinematic Viscosity @ 100°C	Viscosity Index	Refractive index	Specific Gravity
1	Virgin engine oil	264	-19	149. 91	16.30	115	1.493	0.69 7
2	Used engine oil	232	-18	169. 00	15.80	94	1.591	0.83 1
3	Recycled engine oil	250	-15	129. 20	15.23	112	1.413	0.77 3

**Chemical properties of engine oil samples with their various treatment
Methods:**

No	Sample	Total Acid No MgKOH /g	Metalliccontent (ppm)	Sulphur content (%)	Carbon residue (%)
1	Virgin engine oil	5.186	Fe ²⁺ :0.0057	-	0.57
			Zn ²⁺ :0.0527		
			Cu ²⁺ :0.0013		
			Cr ²⁺ :0.0047		
2	Usedengineoil	10.214	Fe ²⁺ :0.064	0.9	1.82
			Zn ²⁺ :0.056		
			Cu ²⁺ :0.0021		
			Cr ²⁺ :0.0050		
3	Recycledengineoil	4.205	Fe ²⁺ :0.0082	<0.01	0.73
			Zn ²⁺ :0.0228		
			Cu ²⁺ :0.0013		
			Cr ²⁺ :0.0067		

CHAPTER 5

RESULT AND DISCUSSION

5.1 INTRODUCTION

In comparison to sulfuric acid, which reacted strongly with the used oil, glacial acetic acid and formic acid had almost no reaction with base oils. This obviously shows that acetic and formic acids have no effect on the oil's original composition. Furthermore, the use of acetic acid and formic acids in the recycling of used oil is rather beneficial. This new method of recycling used fuel oil did not release harmful gases into the atmosphere, such as sulphur dioxide. Furthermore, as opposed to sulfuric acid, glacial acetic and formic acids have a lower harmful effect on manufacturing machinery. The foundation can only require a small amount of additive recycled by acetic acid- clay method due its low reactivity with the used oil. Further research is required in order to take this process to the commercial stage. However, while many variables have been studied in this research, there are many others that need investigation such as temperature, pressure, settling time, mixing, centrifugation speed and type of adsorbent.[29]

5.1 PERFORMANCE CHARACTERISTICS

This section explains brake thermal strength, real fuel consumption, and exhaust gas temperature, which are all performance characteristics of blended fuel.

5.1.1 Brake Thermal Efficiency

Brake thermal efficiency is defined as the ratio of output power to input power, which is proportional to the energy used to generate that power. The split thermal efficiency is heavily influenced by fuel properties such as heating value and density. This includes details about the engine's efficiency in converting heat energy to mechanical energy. In all cases of mixed oils, brake thermal performance improves as the load increases. The amount of heat lost will decrease as the load increases. If we continue to increase the ester content in the mix, the engine's thermal performance will improve.[30]

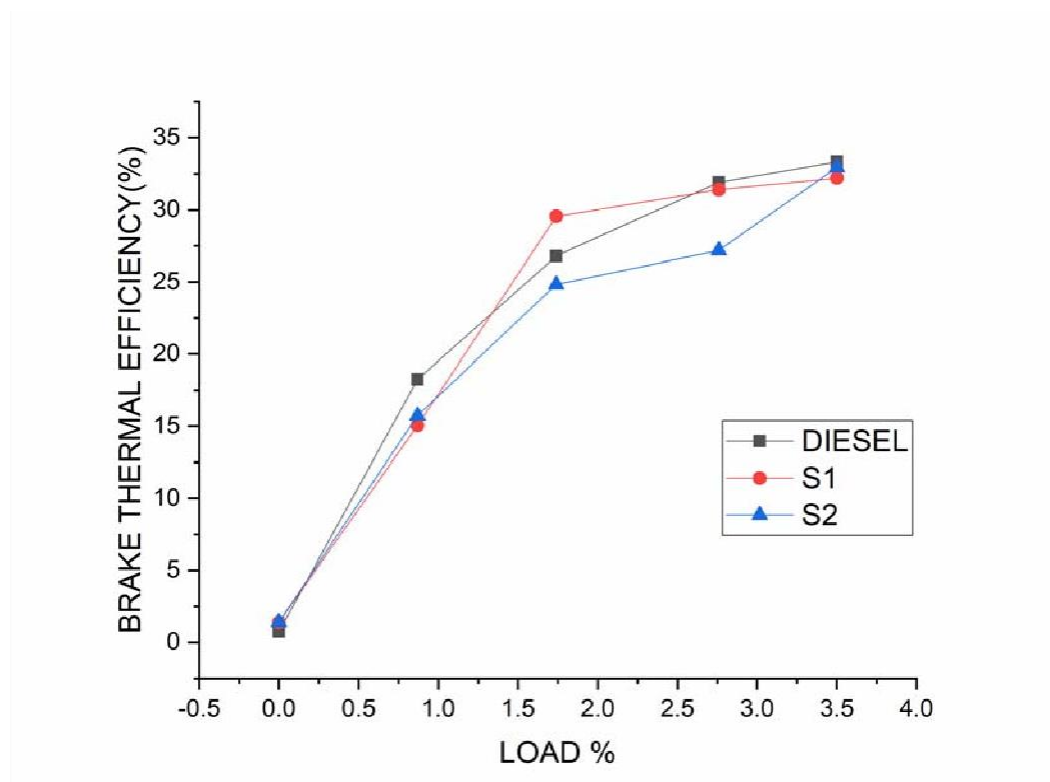


Fig 5.1: Brake thermal efficiency

5.1.2 Specific Fuel Consumption

The specific fuel consumption is defined as the amount of fuel consumed to generate a unit of power in a given amount of time. It calculates the fuel efficiency of any engine or prime mover that uses shaft power to drive by burning fuel. It is the amount of fuel used by any engine during the generation of power. The value of the density of the fuel used for engine combustion will be used to measure specific fuel consumption. Fuel properties such as heating value would undoubtedly influence the volume of brake-specific fuel consumption. An engine has its own unique fuel consumption figure.[31]

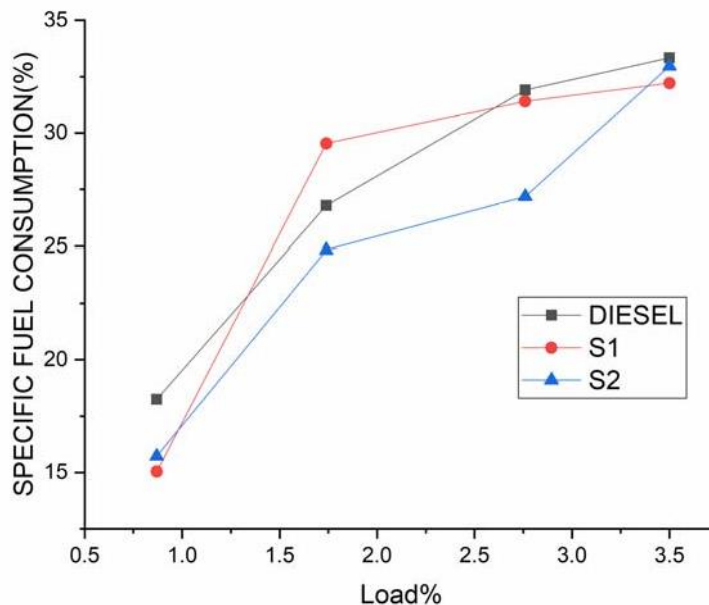


Fig 5.2: Specific fuel consumption

5.2 EMISSION CHARACTERISTICS

This section examines and discusses pollution characteristics such as CO emissions, CO₂ emissions, NO_x emissions, HC emissions, and smoke emissions findings by drawing diagrams for all emission levels at various loads.

5.3.1 CO Emissions

Colorless, odourless and tasteless carbon monoxide (CO) is a poisonous air pollutant that pollutes the atmosphere. As carbon-containing fuels such as diesel, natural gas, coal, and wood are burned inefficiently, carbon monoxide and other greenhouse gases are emitted by the exhaust gases.[32]

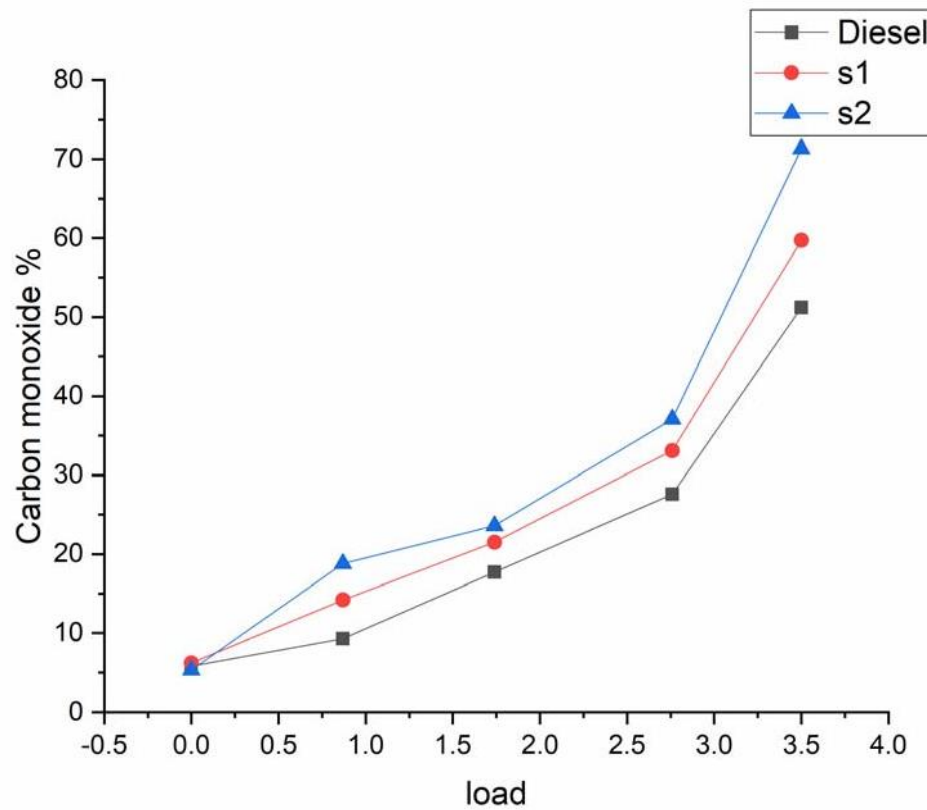


Fig 5.3: CO Emissions

5.3.1 CO₂ Emissions

Carbon dioxide is a gas generated by the burning of fossil fuels such as coal, gasoline, and natural gas in engines. By replacing oxygen in the atmosphere, carbon dioxide would have an effect on human wellbeing. When carbon dioxide emissions rise day by day, the world becomes hotter and temperature changes occur, resulting in global warming.[33]

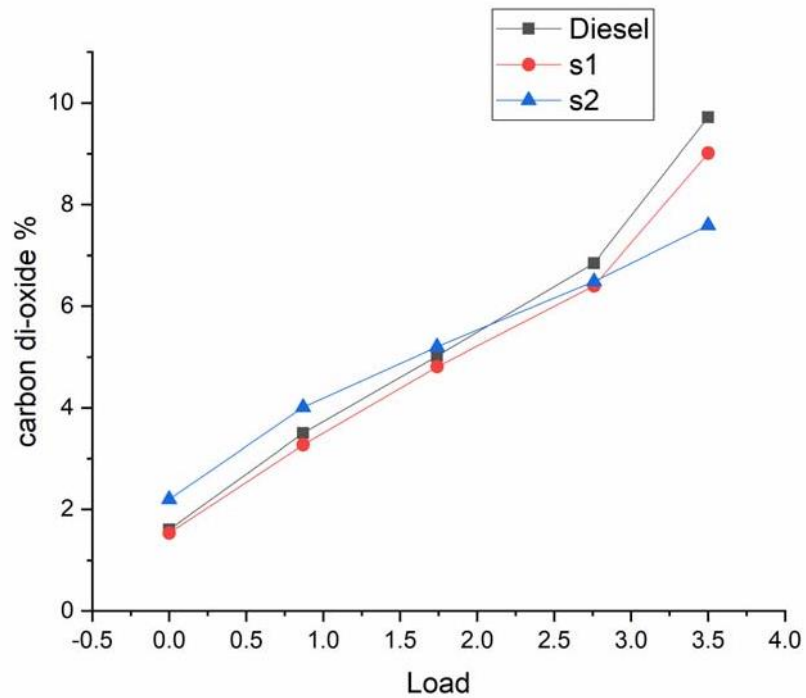


Fig 5.4: CO₂ Emissions

5.2.1 HC Emissions

Hydrocarbons, also known as gasoline, are a form of raw petroleum. Because of the inadequate ignition of the gasoline, a large number of hydrocarbons would be released into the atmosphere. The production of hydrocarbons is caused by the burning of very rich and lean mixtures. Excessive mixing of the air-fuel mixture above the lean flammability limits would result in the release of hydrocarbon gas into the atmosphere, resulting in emissions.[34]

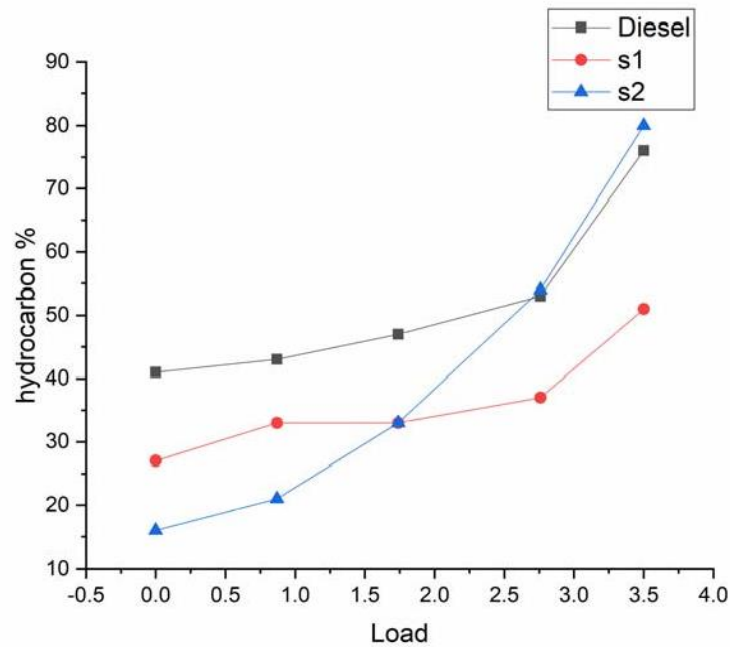


Fig 5.5: HC Emissions

5.2.2 NO_x Emissions

The nitrogen oxides, such as nitrogen dioxide and nitrogen oxide, are collectively referred to as NO_x pollutants. When the engine's air-fuel mixture is very lean, high NO_x emissions will result. The leakage of nitrogen oxides into the atmosphere may be caused by a leak in the fuel tank or a fault with the vehicle's oxygen sensor. The nitrogen oxides (NO_x) react with water to create acid rain, which is a nightmare for the environment and has a major impact on human health[35]

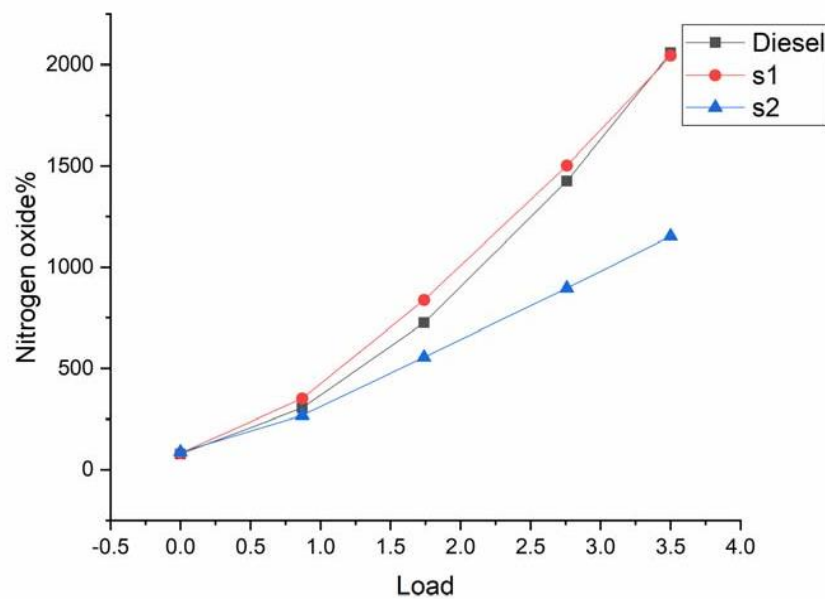


Fig 5.6: NO_x Emissions

CHAPTER- 6

SUMMARY AND CONCLUSION

In comparison to sulfuric acid, which reacted strongly with the used oil, glacial acetic acid and formic acid had almost no reaction with base oils. This obviously shows that acetic and formic acids have no effect on the oil's original composition. Furthermore, the use of acetic acid and formic acids in the recycling of used oil is rather beneficial. This new method of recycling used fuel oil did not release harmful gases into the atmosphere, such as sulphur dioxide. Further more, as opposed to sulfuric acid, glacial acetic and formic acids have a lower harmful effect on manufacturing machinery[36]. The foundation can only require a small amount of additive recycled by acetic acid-clay method due its low reactivity with the used oil. Further research is required in order to take this process to the commercial stage. However, while many variables have been studied in this research, there are many others that need investigation such as temperature, pressure, settling time, mixing, centrifugation speed and type of adsorbent[37].

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