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Ip3: Industrial Transformers Palm Oil

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Abstract: This Transformer oils are used to insulate and cool electrical transformers, but their petroleum-based composition is a major environmental issue because they are non-renewable and have adverse effects on ecosystems. With the increasing awareness of environmental issues worldwide, there is a growing demand for sustainable alternatives in the field of electrical engineering. Palm oil, a vegetable oil commonly used due to its desirable insulating characteristics, is a possible environmentally friendly option. Palm oil can be transformed into transformer oil with proper refining and treatment, providing a renewable and environmentally friendly substitute for conventional petroleum-based transformer oils. This project is concerned with the process of recycling used palm oil into quality transformer oil, thus minimizing the use of non-renewable petroleum products. By examining the viability of this method, the research will contribute to a more environmentally friendly solution for the electrical sector by emphasizing the benefits to the environment and waste reduction from palm oil production. The results of the research can lead to the development of palm oil as a better alternative to traditional transformer oils as a means of transitioning toward an eco-friendly and more renewable method for transformer insulation and cooling.

Index Terms - Transformer oils, Palm oil, Electrical Engineering, Insulation, Cooling, and Petroleum based oils, Environmental Sustainability, Renewable alternatives, Eco-friendly solutions, Waste reduction, Transformer oil production, Thermal conductivity, Insulating properties.

I. INTRODUCTION

- Transformer cooling is crucial for maintaining optimal performance, dependability, and lifespan of electric transformers. Good cooling improves the efficiency of operations and avoids overheating, which might result in equipment breakdown, possible risks and expensive downtime. Efficient ability to handle heat is important to keep the integrity of the transformers and provide continued power supply. Since several decades, mineral oils have also been extensively applied as insulating and cooling fluids because of their superior thermal conducting and dielectric characteristics, due to which they are extremely useful in transformer units.
- Yet, despite their advantages, mineral oils also have major drawbacks. These range from environmental drawbacks in the form of poor biodegradability, toxicity and dependence on non-renewable resources to their long-term sustainability issues. As the planet is increasingly aware of environmental factors and sustainability, the shortcomings of mineral oils are now more widely acknowledged. This has resulted in a great need for alternative cooling and insulating fluids that can solve such issues while satisfying the technical requirements of contemporary transformers.
- In the last few years, vegetable oils have been quite popular as a sustainable and alternative option to mineral oils. Produced from renewable feed stocks such as soybean, sunflower, and rapeseed, vegetable oils possess many benefits over conventional oils. They are biodegradable, non-toxic and have a lower environmental impact, making them ideal for green applications. Additionally, vegetable oils tend to possess higher flash and fire points, which improve safety in hot operating

conditions, thus making them particularly well-suited for application in critical transformer applications.

- The growing international emphasis on sustainability and environmental stewardship has further reinforced the argument for using vegetable oils in transformer cooling systems. These oils not only comply with environmental objectives but also fulfil the technical requirements of contemporary transformers. Their enhanced insulating properties and safety aspects make them a compelling choice for utilities and industries looking to reduce their ecological footprint without sacrificing performance.
- This research delves into the viability of filtered vegetable oils, especially palm oil, as a sustainable and environmentally friendly cooling medium for transformers. Through the examination of their thermal, dielectric and chemical characteristics, this study contrasts them to conventional mineral oils. The objective is to establish that vegetable oils, refined in an appropriate manner can offer a greener and renewable option for transformer systems. The findings would facilitate less dependency on petroleum oils, providing a more sustainable and more efficient method for transformer cooling within the electrical industry.

II. LITERATURE REVIEW

In our literature review, we delve into several articles to inform the development of our project, particularly focusing on purification and conversion of waste palm oil into transformer oil.

- One standout study in this realm is the research paper titled “IP3: INDUSTRIAL TRANSFORMERS PALM OIL”.
- The study suggests new ways to create transformer oil by using vegetable oil which are less expensive and bio degradable in nature.
- The aim of our project is to promote the less expensive transformer oil, bio degradable and non-poisonous oil while minimizing complexity and wastage of palm oil.

III. OBJECTIVES

- **Environmental Benefits:** High biodegradability minimizes long-term environmental impact in case of leaks or spills; Non-toxic nature ensures safety for ecosystems and reduces pollution risks and Supports sustainability goals by using renewable resources instead of fossil fuels.
- **Technical Benefits:** Higher flash and fire points reduce fire risks, making transformers safer in critical applications. Excellent dielectric properties ensure superior insulation for electrical components, while high thermal conductivity enhances cooling efficiency. Additionally, better moisture tolerance compared to mineral oils reduces insulation degradation risks.
- **Global Adoption Trends:** Increasing use in environmentally sensitive areas, such as near water bodies and forests. And Preferred in industries and regions prioritizing sustainability and safety.

IV. BLOCK DIAGRAM

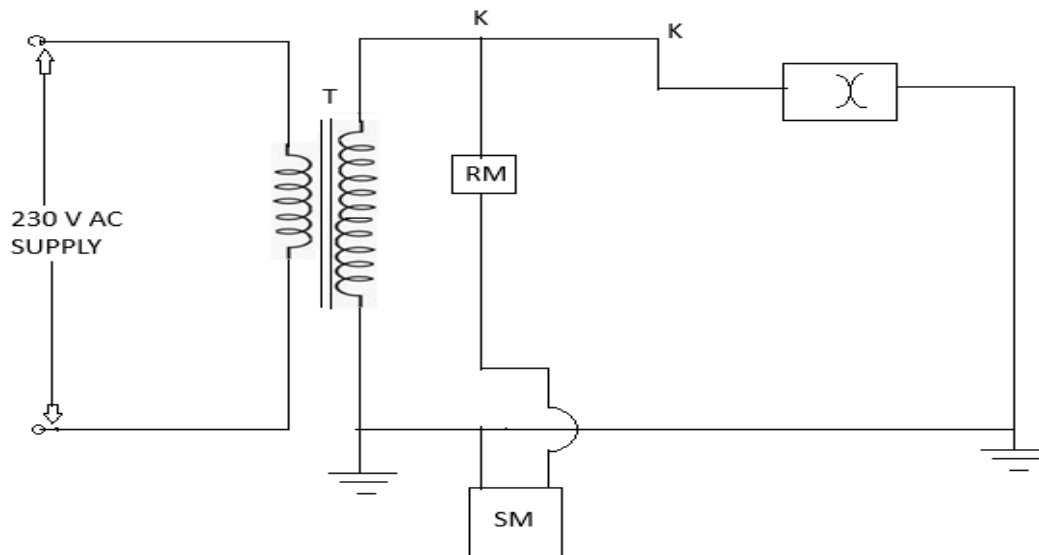


Figure 4.1: Block diagram of Breakdown Voltage Tester

- To check oil in a breakdown voltage tester, first clean the oil and remove any contaminants like moisture or dirt. Put the sample of oil in a clean container and set the temperature to the specified level, usually around 25°C (77°F).
- Then, prepare the breakdown voltage tester, consisting of two electrodes immersed in the oil. The electrodes must be properly aligned with the proper gap. Connect the tester to a high-voltage power supply and start the test. The tester increases the voltage slowly, normally at a rate of 2 kV per second.
- As the voltage increases, the oil will break down and pass electricity, signified by a flash over. The voltage at which this takes place is the dielectric strength of the oil. Take note of the breakdown voltage, wash the equipment afterward, and take all safety measures when using high-voltage test equipment.

V. METHODOLOGY

5.1 Pre-Treatment (Filtration & Heating)

5.1.1 Objective: To remove moisture and solid impurities from the used palm oil.

5.1.2 Process: Heat 500ml of used palm oil to 110°C for 15-20 minutes to evaporate any moisture present, Filter the heated oil using 150-micron filter paper to remove solid particles.

5.2 Degumming (Removal of Phospholipids and Impurities)

5.2.1 Objective: To remove phospholipids and other impurities from the oil.

5.2.2 Process: Add 20g of phosphoric acid (H_3PO_4) to the heated oil. Stir the mixture at 80°C for 30 minutes to allow the acid to interact with the oil and remove the impurities and allow the oil to settle for about 1 hour, then filter out the precipitate using 50-micron filter paper.

5.3 Neutralization (Reduction of Free Fatty Acids - FFA)

5.3.1 Objective: To neutralize the free fatty acids in the oil, this can affect the oil's stability and dielectric properties.

5.3.2 Process: Dissolve 10g of Sodium Hydroxide (NaOH) or 10g of Potassium Hydroxide (KOH) in 200ml of distilled water to create an alkaline solution. Slowly add this solution to the degummed oil while stirring at 70-80°C for 30 minutes. After the reaction, let the mixture settle for 30 minutes. Remove the soap-like precipitate formed by filtering the oil.

5.4 Bleaching (Removal of Colour and Odour)

5.4.1 Objective: To improve the colour and remove odours from the oil.

5.4.2 Process: Add 10g of bleaching earth and 20g of activated carbon to the neutralized oil. Stir the mixture at 90°C under vacuum for 30 minutes to allow the bleaching agents to absorb pigments and odours. Filter the oil using 50-micron filter paper to remove the bleaching agents.

5.5 Hydrogenation (Stabilization and Removal of Unsaturated)

5.5.1 Objective: To improve the oil's stability by hydrogenating the unsaturated compounds.

5.5.2 Process: Bubble of hydrogen gas (H_2) through the bleached oil at 120-150°C for 1 hour to remove unsaturated compounds and stabilize the oil. Use 10g of Nickel Oxide (NIO) as a catalyst to speed up the hydrogenation process.

5.6 Additive Enhancement (Improving Dielectric Properties)

5.6.1 Objective: To enhance the dielectric strength and antioxidant properties of the oil.

5.6.2 Process: Add 10g of Butylated Hydroxytoluene (BHT) as an antioxidant to prevent oxidation of the oil. Mix in 10g of Zinc Oxide (ZnO) and 10g of Boric Acid (H_3BO_3) to improve the dielectric properties and insulation strength of the oil. Stir the mixture at 90°C for 30 minutes to ensure proper dispersion of the additives.

5.7 Final Filtration

5.7.1 Objective: To remove any remaining impurities and moisture from the oil.

5.7.2 Process: Filter the oil again using 50-micron filter paper to remove any remaining particles and heat the oil until the moisture is evaporated.

5.8 Testing and Quality Assurance

5.8.1 Objective: To ensure the refined oil meets the required standards for transformer oil.

5.8.2 Process: Dielectric Strength Test: using BDV tester to assess the oil's ability to withstand high voltage without breakdown

VI. ADVANTAGES

- **Sustainability:** Utilization of waste palm oil as a source of raw material for transformer oil provides an environment-friendly solution. The waste oils are reduced by this method, reducing the level of environmental pollution. This process supports the principles of circular economy and sustainability through reuse of waste oils.
- **Cost-Effectiveness:** The used palm oil can be much cheaper than petroleum-based oils, making transformer oil less expensive to make. This becomes particularly useful in areas in which palm oil is abundant and accessible thus reducing dependency on imported or expensive synthetic oils.
- **Enhanced Thermal and Dielectric Properties:** The conversion process significantly enhances the thermal stability and dielectric strength of the oil, making it appropriate for use in electrical transformers. The refined oil is able to withstand high temperatures and provides reliable electrical insulation for the safe operation of transformers.
- **Reduction of Waste:** The project reduces the amount of waste oil that would otherwise be discarded by utilizing used palm oil. This contributes to waste management and promotes resource efficiency by turning waste into a valuable product.
- **Environmental Benefits:** It reduces the environmental impact associated with the disposal of used oils. It also reduces the carbon footprint compared to producing transformer oils from virgin petrochemical sources and therefore it is an eco-friendly alternative.

VII. APPLICATIONS

- **Electrical Transformer Insulation:** Transformer oil, which is produced from waste palm oil, insulates and cools electrical transformers to ensure efficient and safe operation.
- **Waste Oil Recycling:** The recycling of used oils is facilitated by the transformation of waste palm oil into transformer oil, promoting waste management and minimizing environmental pollution.
- **Renewable Energy Solutions:** Palm oil as a transformer oil provides a renewable solution compared to conventional petroleum-based oils, promoting sustainable energy infrastructure.
- **Cost-Effective Alternative to Remote Areas:** In countries where palm oil is in abundance, this method also helps decrease dependence on costly imported oils, thus it is a less expensive solution for transformer maintenance.
- **Environmental Conservation:** Palm oil-based transformer oil minimizes the environmental effects of disposing of oil and reduces the carbon footprint of the electrical sector.

VIII. RESULT AND CONCLUSION

8.1 Comparison: - Comparing Filtered palm oil with Pure Palm oil

TABLE: 8.1 : Comparing Filtered palm oil with Pure Palm oil

SL.NO	PROPERTIES	FILTERED PALM OIL	PURE PALM OIL
01	BREAKDOWN VOLTAGE Per MM	23kva/mm	40-70 Kva/mm
02	VISCOCITY	30-40 centipoise	40 -60 centipoise
03	THERMAL CAPACITY Per 500 ml	700 - 800 J/°C	874 J/°C
04	OXIDIATION	0.2 to 2.0 meq/kg	0.5 - 2.0 meq/kg
05	DIELECTRIC STRENGTH	55Kv	39Kv
06	BIODEGRADABLE	YES	YES
07	COST / 500 ml	30 Rs	75 Rs

Filtered palm oil to convert it into transformer oil, comparing it with pure palm oil for its suitability. Pure palm oil offers a higher breakdown voltage (BDV) of 40-70 kV, making it an excellent electrical insulator for high-voltage applications. On the other hand, filtered palm oil has a lower BDV of 28 kV, signifying its inability to withstand electrical stress but is still strong enough for most applications in transformers. Filtered palm oil, having been purified from debris, is less viscous than pure palm oil, allowing it to flow freely and improve the cooling efficiency of transformers. It also has enhanced oxidation stability because the filtration process removes contaminants that may encourage degradation, thus ensuring a longer lifespan and less build-up of harmful by-products. On the other hand, both oils have similar thermal capacities, though filtered palm oil has slightly better heat dissipation due to its

lower viscosity. In summary, even though filtered palm oil cannot compare with pure palm oil in BDV, it is better for conversion into transformer oil because of its increased oxidation stability and flow properties.

8.2 Final Result: - Calculation of final outcome of IP3 and Selection of transformer for IP3.

TABLE: 8.2 : Calculation of final outcome of IP3 and Selection of transformer for IP3

TEST NO	BREAKDOWN VOLTAGE (KV) RMS	BREAKDOWN VOLTAGE (KV) PEAK	BREAKDOWN STRENGTH KV/CM	AVERAGE BREAKDOWN STRENGTH KV/CM
01		47	188	
02		47	188	
03		46	184	184 kv/cm
04		45	180	
05		45	180	

8.3 CALCULATION: -

$$V_{avg} = 47+47+46+45+45/5 = 230/5 = 46 \text{ kV/mm}$$

$$\text{Gap between electrodes} = 2.5\text{mm} = 0.25 \text{ cm}$$

Now converting breakdown voltage value from mm to cm

$$1. 47/0.25 = 188 \text{ kv/cm}$$

$$2. 47/0.25 = 188 \text{ kv/cm}$$

$$3. 46/0.25 = 184 \text{ kv/cm}$$

$$4. 45/0.25 = 180 \text{ kv/cm}$$

$$5. 45/0.25 = 180 \text{ kv/cm}$$

$$\text{Average rate breakdown strength (kv/cm)} = 188+188+184+180+180 / 5 = 184 \text{ kv/cm}$$

The average breakdown voltage of IP3 is 184 kv/Cm and it can be used at 66Kv transformer where 66kv transformer needs oil of 160-180 kv break down voltage.

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