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Replacing Mineral Oil with Vegetable Oil to Improve the Transformer's Performance

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ABSTRACT

In this paper, the replacement of mineral oil by vegetable oil for better performance of transformer was studied. This paper reveals benefits of vegetable oil over mineral oil based on their electrical characteristic, expectation, requirement , suitability, aging, environmental impact, safety, evaluation and dielectric properties of vegetable oil. Mineral oil was traditionally used to provide isolation, but vegetable oil has become increasingly popular in the last few years, and it is presently used in the range of small- to medium-size transformers. The application of transformer is expressly accreted. The competent electric transformer division in recent years has normally been immersed in mineral oil that acts as a medium insulating the energy supply of electric equipment. This paper provides information on the key environmental and fire resistance properties and associated values for natural vegetable oil transformers. Transformers filled with such fluids are generated in general. This work motivates the transformer performance to be determined by using natural dielectric vegetable fluid in comparison with ideal mineral oil. In also to estimate the degradation of both the oils the dissolved gas analysis is carried out. However, the dielectric dissipation factor of the mineral oil was about 77 times lower than that of natural oil [1]. The application of these liquids in transformers guarantees better life span. In transformer applications, vegetable isolating oils are now commercially available as replacements for mineral-based oils. In future, the vegetable oil will be the best replacement for mineral oil.

Keywords: Vegetable oil, mineral oil, Natural Easter, Transformer performance, isolating oils

1 Introduction

The transformer is an electromagnetic transmitter, which transfers electrical energy without the change in frequency from circuit to circuit. In a power system, it is a vital and expensive tool. Transformers are produced in various sizes, shapes and classifications. The isolation system plays eventual roles in the life and performance of the transformer for all transformers, because most transformer failures have been caused by insulation difficulties. Liquid transformer duty insulation is used to feed the dielectric medium, which acts as isolation of different energy conducers. By entering and filling spaces between wound insulation flakes, oil makes a decent contribution to transformer insulation. One of our secondary functions is the absorption of heat from areas and the equally large mass of oil and tank in the devices dispersing thermal energy. It is transferred to the surrounding environment through conduction, convection and radiation.

In 1882Elihu Thomson patented the first concept of oil being used as the dielectric fluid in the transformer. To date, oils extracted from crude oil have been used for isolation purposes, and they have also served as a cooling media for power transformers, condensers, and so on. As mineral oil is non- biodegradable, it is serious environmental demolition [3]. Vegetable oils have advantages, like high biodegradability, fire safety; low coefficient of thermal expansion; low humidity content and are easily available.

Mineral oils extracted from crude oil. It is widely used for the cooling and insulation motive in transformers as the most generally liquid isolation. High flash- point characteristics and broad production around the world were the major reasons why mineral oil is used. There are two grades of mineral oil, crude mineral oil, and mineral oil refinement. The refining process is used to reduce the number of waxes, sulfur, nitrogen, and oxygen and aromatic hydrocarbon for refining mineral oils. The mineral oil has good isolation properties after the refining process. Vegetable- oil fluid meets every demand for the addition of renewable raw materials to a high-temperature isolated fluid. It is the organic acid and alcohol synthesized compound. Two main classifications of esters are generally synthetic and natural. The synthetic ester comes from alcohol and organic acid. Since the early 1990s, there has been curiosity about replacing vegetable isolated oil as a substitute for mineral oil as transformer insulation. Several types of research have been initiated to obtain completely biodegradable isolated oil. Vegetable oil is produced and readily available from natural resources. Vegetable oil is made up of fatty atomic acid esters of triglycerides [2].

The following paper examines vegetable oil; it includes transformer properties, properties of this oil, and its impact on the transformer operations also making corresponding comparisons to mineral oil in which this fluid is analyzed as a possible option for transformer mineral oil.

2 Methodology

2.1 Environmental Impact

The industry now recognizes vegetable oil as the environmentally friendly dielectric insulating liquid of its choice. This eco-friendliness of vegetable oil can bring significant advantages to the user. These liquids are by their very nature non- venomous and biodegradable. The negative carbon footprint of vegetable growth means that vegetable oils have an ear neutral carbon footprint. This reduces their overall environmental impact further. The German Federal Environmental Agency also categorizes vegetable oil as non- toxic to water [2].

2.2 Performance of vegetable oil

When it moves through the inner parts of the transformer, the vegetable oil is more impressive as the heat dissipates. For the selection of a dielectric fluid, a fire point is one of the most important aspects. Every oil type has a different behavior, with the transformer's useful life, the fireplace for mineral oil remains comparatively constant. At the beginning of useful life, the vegetable oil fell to the point of fire. Relatively stabilized at a lower value than its specified limit, making it more fire resistant. During all periods of vegetable oil, the required force to break the insulating paper was higher. In other words, vegetable oil maintains the insulting paper more than the immersed mineral oil paper, which gives isolation a longer useful life. An FR3 vegetable oil transformer is capable of meeting demands for increased loads without increasing its temperature excessively [9]. Avoid overload defects and therefore service defects. Lower failure rates due to overloading and finally improved

conditions of service. The study shows that a vegetable oil transformer has a greater benefit than a mineral oil transformer. Excellent fire security characteristics are High Flash Point, which guarantees better safety in the operation, handling, storage and transport of the oils mineral, with only 30 percent biodegradability and a much lower biodegradability of high-temperature oils [7]. In order to ensure its suitability in an isolation system, the normal operating temperature of the oil is around 60 ° C of oil. Synthetic antioxidants such as Butylated Hydroxy Anisole (BHA), Butyrate Hydroxyl Toluene (BHT), Tert Butyl Hydroxyl Quinine (TBHQ) and Propyl Gallate (PG) are the most common food-grade additives to use. Inherently, natural esters are more likely to be oxidized. During this decade, the research effort began to develop completely biodegradable dielectric isolation liquids based on vegetable oils for transformers caused by major utilities spending millions annually to clean up spills and leaks from transformers [4]. After combustion, the by-products of natural esters are also much less toxic than those of mineral oils, reducing their overall environmental impact further. This survey reveals that transformers that are filled with natural ester liquids are allowed to achieve higher temperature and temperature increases compared to similar mineral oil- filled transformers. Dielectric insulation and cooling capacity are the major functions of an insulating liquid [13]. The amplitude of the applied voltage is the main factor governing the streamer propagation speed in the ester liquids and mineral oil. The dielectric performance of a natural ester liquid-filled transformer is as good as that of a conventional mineral oil-filled transformer, and no additional protection is necessary. The transformer winding core and cooling equipment have slow flows of natural ester liquids in comparison to mineral oil. At the same time, natural ester liquids are more thermally conductive and have a smaller thermal capacity than mineral oil. The higher viscosity of natural ester liquids can only slightly offset these improved thermal proprieties. Ester is better off than mineral oil than its breakdown strength. Naturally, it can be seen that dielectric dissipation is around 77 times higher than mineral oil [1].

2.3 Aging

The aging process is another factor that contributes both to the deterioration in mineral as well as vegetable oils of the oil characteristics of methane (CH4). The degradation of cellulose paper in transformers is mainly caused by thermal aging [12]. In addition, oil aging can contribute mainly to the growth of the two gases. Different aging properties are measured during aging, such as 2-FAL, acidity, and dissolved gases [2]. In synthetic and vegetable oil, the high moisture solubility is an advantage compared with conventional mineral oils because they attract more moisture in the transformer from cellulose insulation and decrease the aging rate of cellulose [3]. The break- down voltage of the new oil should be high as soon as possible as it is aged. Dielectric material properties may be affected by temperature and an increase of dissipation factor indicates aging of oil or oil contamination.

2.4 Property

The increase in transformer oil temperature due to overload may affect dielectric behavior of that dielectric oil. One of the most important electrical properties of good transformer oil (for a healthy insulation system) includes high breakdown voltage (bdv) and low dissipation factor (df) [7]. Generally there are two possible parameters that influence the oil performance that are frequency and temperature. Highly loaded transformers needs better quality of oils for high voltage and high frequency applications. The vegetable oil has always a significantly higher breakdown voltage than mineral oil [10]. Whenever satisfactory result is not received from use of liquid dielectric the oil was subjected to various treatments such as neutralization, filtration, and addition of anti-oxidants to improve the characteristics of dielectric oil.

Nowadays peoples are like to use natural vegetable oil instead of mineral oil to overcome the disadvantages. It has noted that ester oil is less viscous compared to mineral oil [10]. For better dielectric performance of vegetable oil some Food grade additives were also going added. The natural ester liquids have always greater viscosity than that of mineral oil [4]. Over the ageing it is observed that the acidity level of both types of oils increases. Some standard values of parameter related to transformer oil are listed in table 1).

Table1: Standard values related to transformer oil

	Mineral oil	Vegetable Oil	Test Method
Dielectric breakdown(kv)	30/85	82/99	IEC 60/56
Visocity at 100 C	2/2.5	4/8	ISO 3104
Pour point (C)	-30/-60	-19/-33	ISO3016
Flash point (C)	100/110	315/328	ISO2592
Fire point (C)	110/185	350/360	ISO2592
Density at 20 C kg.dm3	0.83/0.89	0.87/0.92	ISO03675

2.5 Safety

The transformer designers and users are continuously working to improve fire and explosion safety of conventional transformers. Gas and gas/vapor type insulation are nearer to meet some of the expectations, but not all there are some limitations, especially in the case of high voltages and large MVA ratings [8]. Vegetable based oil reduces the risk of fire as well as explosion with some other interesting aspects. The value of the resistivity of the oil must be high for obtaining good insulation [11].

The large power transformers require careful assessment of the insulating oil for better performance, high reliability and safety [6]. The transformer filled with mineral oil has heavy collateral damage when they faced explosions or fires and also raised major safety concerns.

There are also major environmental concerns related to the toxic effects of uncontained mineral oil spills. Finally, it has been observed that vegetable oil reduces environmental impact and improved safety and performance. Consequently, for indoor applications and outdoor areas of heightened safety sensitivity applications the vegetable oil meets fire safety requirements without any safety equipment.

2.6 Cost and Availability

Vegetable oils are abundantly available in nature and don't requires any complex apparatus for their extraction. Vegetable oil is biocompatible and renewable and it also recognized by industries as the eco-friendly dielectric insulating liquid. The vegetable oil filled transformers would be more than 20% smaller than other equivalent mineral-oil filled transformer [4]. And for continuous operation at higher temperatures it gives more flexibility for a transformer designed. Vegetable oil is also extracted from seeds that grow in farms in a large quantity. So that's why the cost of vegetable oil compared to mineral oil is very less and it is easily available anywhere.

3 Conclusion

The data collected shows that the vegetable oil used in this study has completely different properties than mineral oil. In the fluid- immersed transformer, vegetable oil has demonstrated an environmentally friendly alternative to mineral oil. Nearly all flammable fluids in transformers are halogenated hydrocarbons [9]. The conclusion can be drawn from the mixing with mineral oil that the decompression voltages of synthetic ester and natural ester decrease. The temperature of natural ester oil was found to be directly proportional to the dissipating factor and to be inversely proportional to the dielectric strength [5]. In the final analysis, it was shown that the effects of natural dielectric isolation fluids reduced and safety and efficiency improved.

4 Competing Interests

All authors declared that no conflict of interest exist in the publication of this article.

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