DEVELOPMENT OF LOCAL TECHNIQUES FOR RECYCLE AND REUSE OF TRANSFORMER'S OIL

by

Eng. Ali Gomaa Ali Abd El-Aziz
B.Sc. in Electric Power Engineering
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A thesis Submitted in Partial Fulfillment of the Requirement for the Master Degree

In

Environmental Engineering

ENGINEERING DEPARTMENT
INSTITUTE OF ENVIRONMENTAL STUDIES AND RESEARCH
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2005

Dedication

To whom I owe her my existence
The one who shaped my past, present
And future

TO MY MOTHER

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ABSTRACT

The objective of this is to propose an approach for recycling the transformer oil used in high voltage transformers.

The recycling technique provides environmental friendly usage and safe disposal.

The study is based on acid/cement kiln dust for treating the used transformer oil. The different oil samples were taken from two different Substations: Egyptian Petroleum Research Institute (EPRI) 11/04 kV Quaha 66/11 kV.

The physiochemical properties together with the electrical properties were tested for the oil samples both before and after Treatment. The physiochemical properties testing and reclamation process were carried out in the chemical labs of Egyptian Petroleum Research Institute (EPRI).

However, the electrical properties were tested in the high voltage labs of faculty of engineering, Ain Shams University.

The optimum treated conditions were achieved by using sulphuric acid 5 wt%. Time mixing 90 minutes, temperature 40°C and by pass kiln dust 7 wt%.

Results showed that the recycled transformer oil have lower density, viscosity, pour point and total acid number. Further more, remarkable improvements in the electrical properties have been achieved, e.g., breakdown voltage and power dissipation factor.

The acid sludge which produced from the recovery of the used transformer oil was treated by different formulation from inorganic salts. The formulation efficiency which gives the better Separation of hydrocarbons was determined. The proposed technique was proven to reduce environmental problems of the used transformer oil.

SUMMARY

In this study, an approach for the regeneration of waste transformer oils by using acid /by-pass kiln dust cement was achieved.

The physicochemical properties of the used oils under study, show that the kinematic viscosities of UTO1 and UTO2 are 19 and 21 cSt; density 810.2 and 0.8159 g/ml: total acidity number 0.41 and 0.58; pour point -10and -9^{o}C: breakdown voltage 30 and 25 kV; dissipation factors 0.03 and 0.05, respectively. These data reveal that the used transformer oils are out of IEC296 specification limits and do not meet with the standard specifications.

Structural group analysis for the used transformer oils UTO1 and UTO2 were characterized by high aromatic content 20 and 23 wt% and conradson carbon residue 0.71 and 0.82 wt%, respectively. These undesirable constituents are the main factors for the poor quality and bad electrical properties of the transformer oil. In addition, the carbon distribution and structural group analysis reveal that the used transformer oils are containing considerable portions of paraffinic compounds.

The average molecular weight of the used transformer oils (UTO1 and UTO2) are 432 and 445, respectively. Correlation of the average molecular weights and the n-d-M data reveals the complex nature of the hydrocarbon molecules of the used transformer oils.

Correlation of the type of aromatics classes and n-d-M data reveals the complex nature of the used transformer oils (UTO1 and UTO2) under study.

High performance liquid chromatography show the polyaromatic hydrocarbons compounds is one of the most common causes of deterioration in the insulating oils quality.These compounds (PAHs) are hazardous organic compounds and particular importance as environmental contaminants. Most of them are toxic and those with four or more rings are organic compounds often carcinogenic.

IR spectra, GC, HPLC for used transformer oils reveal that the oil UTO2 is

more deteriorated than oil UTO1 this reveal that the potential power of the station.

The breakdown voltage increases with increasing the mixing time for sulphuric acid dosages of 3 wt% and 5 wt% but decreases at 7 wt% sulphuric acid.

The average molecular weight of the used transformer oils (UTO1 and UTO2) are 432 and 445, respectively. Correlation of the average molecular weights and the n-d-M data reveals the complex nature of the hydrocarbon molecules of the used transformer oils.

Infrared spectra of the UTO1 and UTO2 samples show a group of weak absorption bands in the region 1850-1650 cm^{-1}, particularly four bands at about 1780, 1745, 1710 and 1655 cm^{-1}. These bands result from stretching vibrations of C=O of ester (1780 and 1745 cm^{-1}); ketones, aldhyeds and carboxylic acids (1710 cm^{-1}) and highly conjugated carbonyls such as quinone-type structures and amides (1650 cm^{-1}). It is evident, therefore, that the oxidation reaction is favored in electrical station.

According to the degree of deterioration of used transformer oils under investigation there are many processes that occur in the electrical station such as thermal cracking, polymerization, cyclization and isomerization reactions. Thus, paraffins, polycyclic hydrocarbons (naphthenes & aromatics) and some heavy components can be created. This finding is deduced from the chromatogram of gas chromatogrphy as a hump of unresolved complex mixture.

The chemical analysis of the by-pass kiln dust (Table 6) reveals that contains low amount from both oxides Al_2O_3 (3.14 wt%) and Fe_2O_3 (2.84 wt%). Kiln dust is also enriched in CaO and Na_2O (53.1 and 2.5 wt% respectively), which causes the high alkalinity. This alkalinity of the by-pass kiln dust plays an important role in the eliminating the acidic compounds which cause the formation of emulsions with moisture in the transformer oil

and also it has efficient as adsorbent and bleaching agent.

The effect of stirring time with different weight percentages of sulphuric acid is examined to select the optimum addition time. The reaction was carried out at different times of 30, 60, 90 and 120 minutes. The yield of the recovered oil, total acidity, total aromatics and flash point decreases by increasing mixing time at all dosages from sulphuric acid. The breakdown voltage increases with increasing the mixing time for sulphuric acid dosages of 3 wt% and 5 wt% but decreases at 7 wt% sulphuric acid when increasing mixing time. This could be attributed to the removal of sulpher, sludge oxidative and undesirable components by sulphuric acid.

The efficiency of sulphuric acid activity increases by increasing the mixing time and dose percentage leading to increasing the attacks on various compounds.

Concerning the total acid number, the acidic components are removed effectively when the used transformer oil has been treated with either percentage of 5 wt% or 7 wt% sulphuric acid. However, the yields of the treated oil decrease with such increase in the sulphuric acid percentage. The correlation between wt% sulphuric acid and the acceptable limits of total acid number, taking into consideration the yields, reveal that 5wt % of sulphuric acid is the optimum ratio with respect to both the quality and yield of the treated (processed) oil.

The optimum treated conditions were achieved by using sulphuric acid 5wt%. Time mixing 90 minute, by-pass kiln dust 7wt%, and temperature 40^{o}C data show that the recycled transformer oils have lower density, viscosity, pour point and total acid number. Further, remarkable improvements in the electrical properties have been achieved. In addition, the above reclamation conditions gives oils have good physical and electrical characteristics within the standard specifications required.

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INTRODUCTION

One of the major concerns has been the disposal of by-products generated during the regeneration of the used transformer oil by turning problematic waste products into saleable. Egypt is now faced with enormous problems of environmental protection, a continuous decrease in petroleum reserves and the ever increasing demand for energy.

Transformer oil represents today, one of the most important of a long series of petroleum specialty oils. This oil serves as a dielectric and coolant medium in transformer units. In performing these functions, the oil gradually deteriorates by oxidation and picks up moisture. If the free moisture content rises above a certain level, its insulating efficiency deteriorates and arcing therefore may occur deteriorate. As the result, asphaltenic materials precipitate and deposit on the core and in the transformer cooling coils, thus giving bad insulating and cooling.

Reclamation of the used transformer oil eliminates insoluble and dissolved contaminants to attain oil with characteristics similar to those of new oil. Clay is used in the refining step of the used oils to improve their color and to remove asphaltic and resinous materials. The refining action of the clay depends on its nature, method of application and treating.

The cement industry produces a large amount of waste dust. This dust arises from two sources. Firstly, cement dust from the rotary kiln, known as kiln dust , that settles from the electrostatic precipitation used to purify the flue gases evolving from the kiln ;and secondly, by-pass dust, which constitutes a "purge" from the kiln in order to minimize the amount of alkalis in the effluent flue gases from the kiln. The first type can usually be recycled to the kiln since its alkali content is usually low. By-pass dust, on the other hand can not be recycled to the kiln, its alkali content usually exceeding 10%. The rate of by-pass dust production usually ranges from 3 - 8% of the kiln production rate. A capacity of 4000 ton/day clinker will produce about 200