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Transformer Oil Quality Analysis using Digital Image Processing

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ABSTRACT

Electrical energy is the paramount need in a nation's development. To cater for large demand for electricity there is a need for reliable and proficient power system. For a power system to work reliably, the role of Transformers is critical. Health of the transformer mainly depends on its insulation. Among the different insulating material used in transformers, mineral oil is the most widely used as insulating medium in oil filled transformers. The performance of the transformer depends on the quality of the insulating oil. Hence, the oil quality analysis becomes essential. Traditionally chemical diagnostic criteria are used for oil quality evaluation. However, this conventional method is expensive and time consuming. Extensive experimental evaluation has been fruitful to establish the acidity and tanδ of the transformer oil. Here, we are proposing Image processing technique to estimate the oil properties, which is inexpensive and effective technique. Namely Texture Entropy is extended to compute the Neutralization Number (NN) or Acidity and tanδ (Dissipation factor).

Keywords: **Entropy, Neutralization Number, Acidity, Power factor, Dissipation factor**

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I. INTRODUCTION

Transformers play an important role in providing a reliable and efficient electricity supply and are one of the most critical equipment's in electric power transmission and distribution systems. Transformer owner need to assess the status of the cellulose insulation for planning maintenance or renewal. However, taking paper samples from a transformer is both impractical and destructive. Thus, oil analysis is regularly used for assessment of both oil and paper. As the partition equilibrium coefficients of the various by products are both probably interdependent and for most of them not well known, oil analysis gives limited information about the status of the cellulose insulation. As a consequence, finding alternative non-invasive methods have become considerable interest for electricity utilities to examine the condition of the cellulose insulation in a transformer.

Electrical energy plays an important role in a nation's development. A reliable and proficient power system is needed to meet large demand for electricity. Transformer is an integral part of power system whose role is critical for a reliable power system. Periodically the health of transformer has to be checked which primarily depends on the type of insulation used. Out of different insulators used in transformer, mineral oil so as to say transformer oil is used as an insulation material in almost all transformers. Transformer oil not is only used for insulation purpose, but also for cooling purpose. Its dielectric strength, different chemical properties determine the type of insulator it is which in turn determines the health state of a transformer. Thus its performance mainly depends on characteristics of mineral oil used. Thus it is very important to perform oil analysis periodically to check transformer health. There are a number of traditional methods available. But these methods are very time consuming and expensive. This paper provides a quick simple method to analyze transformer oil and thus to check transformer health from the image of a transformer oil sample. The image processing technique involves pre-processing of the taken image of transformer oil in which first the noises are removed using median and weiner2 filter and histogram enhancement technique is used

for better visibility. Now entropy which is the statistical measure of randomness is calculated which depends mainly on the deterioration of the taken oil sample. Thus using regression method from the knowledge of entropy and learned data the state properties of oil can be predicted. Similarly the concentration of gases present in transformer oil can be calculated. This project also provides a tool to predict for the different faults in the transformer using key gas analysis method and IEC basic ration method.

Objective:

- We are proposing Image processing technique to estimate the oil properties(Normalization Number, Power Factor, Acidity constant, Dissipation Factor)
- This technique is easy and inexpensive.
- In this technique we find out the Age of oil which then is used to determine the quality of the oil.

II. LITERATURE SURVEY

Electrical energy is the paramount need in a nation's development. To cater for large demand for electricity there is a need for reliable and proficient power system. For a power system to work reliably, the role of Transformers is critical. Health of the transformer mainly depends on its insulation. Among the different insulating material used in transformers, mineral oil is the most widely used as insulating medium in oil filled transformers.
This work has made an effort to reveals the change in acidity, Interfacial Tension, power factor and tanδ properties of the transformer oil. Further, it emphasizes the inference as the outcome of experimentation. It enhances the acidity with respect to increase of tanδ. Image processing technique texture entropy yielded better results of transformer oil properties evaluation. In the sequence, it notices as quick and viable criteria as compared with conventional practices. Here, the proposed strategy works through statistical parameter such as entropy features of oil image. Subsequently, image processing complete procedure is employed to analysis of transformer oil quality. [1]

Frequency domain spectroscopy (FDS) has been used to assess the ageing condition of oil-paper insulation used in transformers. To further understand the ageing process, the reduction in degree of polymerization (DP) of cellulosic paper in itself on the dielectric response was investigated first.
This paper describes the usefulness of FDS technique as a modern non-destructive tool for the ageing condition assessment of transformer insulation. The findings of the laboratory investigations could be used as guidelines to evaluate the extent of deterioration of oil-paper insulation in transformers. The following conclusions may be drawn from the research. Compared with new mineral oil, water and acetone, the acetone is very effective in extracting the aged oil or aged products in the aged pressboard. [2]

A substantial quantity of testing has been performed on the degradation of paper insulation over the decades. The aim being to better educate the electrical industry on how to best operate expensive assets, such as transformers. The longevity of paper insulation is frequently tested using accelerated ageing experiments, where the effects of temperature and the chemical environment on paper lifespan can be studied. Such research has resulted in paper life expectancy curves being published by the IEEE and the IEC. The investigations tend to use sealed vessels. However, the disadvantage of using this method is that the water content of the paper changes during the ageing process which then changes the ageing rate. In these ageing experiments the water and oxygen content was controlled using a special test rig to compare the ageing rate to previous work and to determine the ageing effect of paper by combining temperature, water content of paper and oxygen content of the oil. We found that the rate of paper ageing can be more accurately determined by controlling the water and oxygen during the experiment which then produced noticeable changes in predicting life expectancy. [3]

Transformer Oil Testing is a technique, which should be a part of any condition-based protective maintenance facilities. This is the most important early protective system can allow maintenance arrangement to identify repairing priorities, program schedules, arrange of outside service, and order necessary parts and materials. The transformer's fluid not only used as a heat transfer medium but also it is used for the transformer's insulation system. In this paper we discussing about the transformer oil, their reclamation with help of image processing. Also study the all types of properties of transformer oil.
In this paper, we discussed about analysis of transformer oil with the help of image processing. We know that there are many techniques used for oil reclamation or oil filtration but those techniques are very vast and time consuming as compared to this method. In addition, if giving other some input data as a reference then accuracy of results is also increases and as compared to other methods, this method is more reliable and more suitable than the other methods. [4]

Transformer oil is a mixture of hydrocarbons which can tolerate high temperature and is an excellent insulator. This not only serves as insulator but also as a coolant. Besides this suppresses sparking, arching and corona. Oil degrades because of gases dissolved in it due to the occurrence of various faults and deterioration with respect to age. Increase in dissolved fault gases concentration in oil, results in oil losing its effectiveness; this will influence the transformer performance.
Thus in this project the presence of oil in ppm level is detected using linear regression method. Also by using the quantity of these gases the kind of fault in transformer is found out using two methods: key gas method and iec method and GUI models are built for easy graphical interface. Image processing technique for transformer oil analysis is software based analytic technique which is fast, reliable and user friendly. Median and weinner2 filters were used to filter out the white Gaussian and salt and pepper noise (if any). Using histogram modification techniques the image quality was enhanced for better visibility and analysis. Entropy technique was used to find out different oil properties like NN, dissipation factor, power factor etc. to determine the performance of transformer. [5]

III. PROPOSED WORK

The Block Diagram of the proposed system consists of Transformer Model, a camera, personal computer installed with Matlab, Serial to USB Converter, Microcontroller, GSM module, LCD, Buzzer.

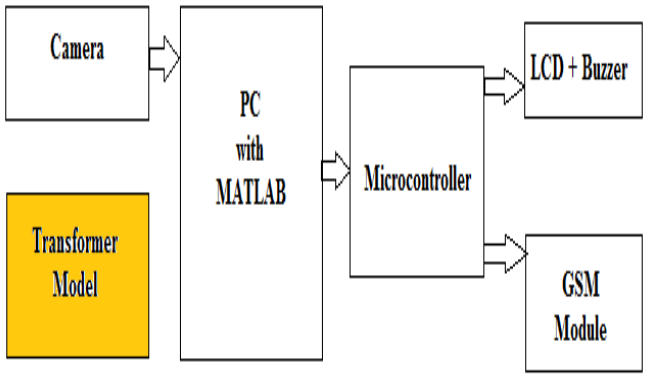

Fig 1. System Block Diagram

Camera

A camera is an optical instrument for recording images, which may be stored locally, transmitted to another location, or both. The images may be individual still photographs or sequences of images constituting videos or movies. The word camera comes from camera obscure, which means "dark chamber" and is the Latin name of the original device for projecting an image of external reality onto a flat surface. The modern photographic camera evolved from the camera obscure. The functioning of the camera is very similar to the functioning of the human eye.

Fig. 2 Camera

Key Features:

- The camera used here is I-Ball Robo K20.
- It is a high quality CMOS sensor.
- 8 M pixels still image resolution, 4 M pixels video resolution.
- High quality 5G wide angle lens.
- It has USB 2.0 Interface.
- Video Format is of RGB 24 bit.Video Resolutions are of 640x480, 1600x760, 1280x960, 1280x1024, 1600x1200 and 2304x1728.
- Frame Rate: 30frames per second

Computer

In the system a computer is required for the analysis of image which is performed using Matlab. MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis and numeric computation. Using the MATLAB product, we can solve technical computing problems faster than with traditional programming languages, such as C, C++ and FORTRAN. MATLAB is an integrated technical computing environment that combines numeric computation, advanced graphics and visualization and a high-level programming language.

Microcontroller

Microcontroller is defined as a system on computer chip which includes number of peripherals like RAM, EEPROM, etc. required to perform some predefined task. There are number of popular families of microcontrollers which are used in different applications as per their capability and feasibility to perform various task, mostly used of these are 8051, AVR and PIC microcontrollers. In this subject we will introduce you with AVR family of microcontrollers. AVR is an 8-bit microcontroller belonging to the family of Reduced Instruction Set Computer (RISC). In RISC architecture the instruction set of the computer are not only fewer in number but also simpler and faster in operation. The other type is CISC. We will explore more on this when we will learn about the architecture of AVR microcontrollers in following section.

The microcontroller transmits and receives 8-bit data. The input/output registers available are also of 8-bits. The AVR families controllers have register based architecture which means that both the operands for an operation are stored in a register and the result of the operation is also stored in a register. Discussing about AVR we will be talking on Atmega16 microcontroller, which is 40-pin IC and it belong to mega AVR category of AVR family.

ALGORITHM

- Evaluation of NN and tanδ of Transformer oil by Entropy method.
- Load the image, convert into gray scale and resize.
- To obtain the noise free image, Median filter is used.
- Find the Entropy (E).
- Declare k1 and determine the y value Ensure the y value ($y \geqslant 14$) if y is less than 14 years, Ac is declared as 0.013 for NN and k2is stated as 0.0021 for tan δ calculation.
- If y value is in between 15 to 25 years, Acandk2 are affirmed as 0.0159 and 0.00716 for acidity and tanδ computation.
- If y value is more than 25, result will be displayed as ERROR.

IV. FLOW CHART

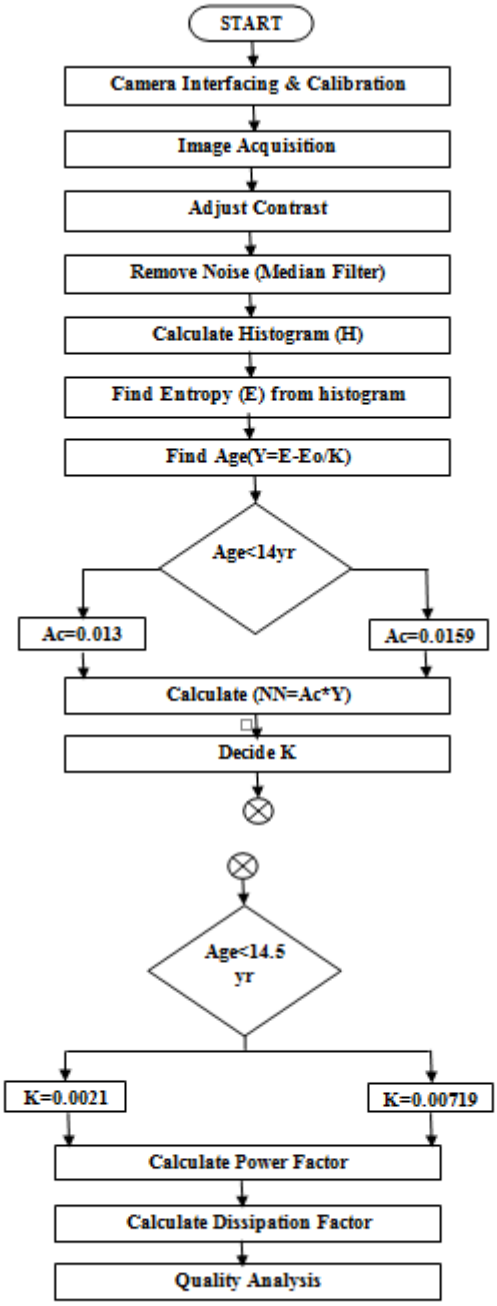

Fig 3. Flow chart

V. RESULT

Sample Oil Images

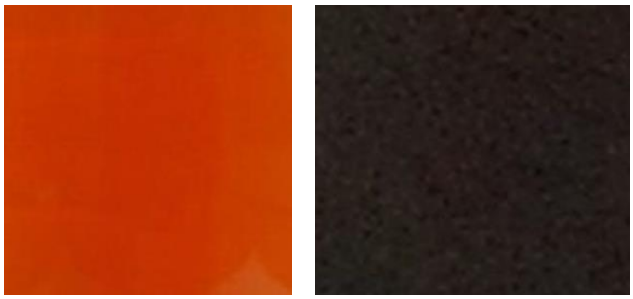

Fig 4. Sample Oil Images

Simulation Result

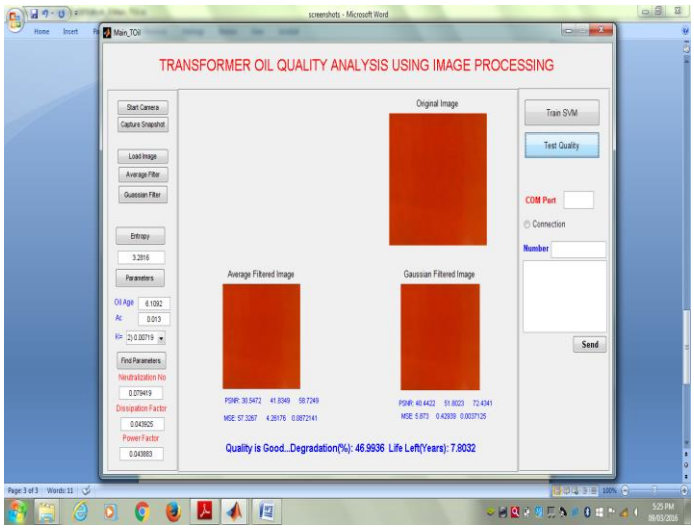

Fig 5.Test Quality analysis

VI. CONCLUSION

In this paper, we discussed about analysis of transformer oil with the help of image processing. We know that there are many techniques used for oil reclamation or oil filtration but those techniques are very vast and time consuming as compared to this method. In addition, if giving other some input data as a reference then accuracy of results is also increases and as compared to other methods.

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