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A Review of Image Processing Applications in Fault Detection of Transformer Oil

C M MAHESHAN
Assistant Professor
Department of Electrical Engineering
University Visvesvaraya College of Engineering
K.R. Circle, Bangalore -560 001. INDIA
maheshan.cm@gmail.com

PRASANNA KUMAR H
Assistant Professor
Department of Electrical Engineering
University Visvesvaraya College of Engineering
K.R. Circle, Bangalore -560 001. INDIA
uvcehpk@gmail.com

ABSTRACT

Power transformer plays an integral part in energy transfer between the electric power generation and transmission. Mineral oil is universally used dielectric liquid in all oil filled transformers, since it functions as an insulating as well as cooling liquid. The quality of the oil describe by its colour.Performance measure of the transformer invariably depends on health of the transformer oil. The change in the properties of the transformer oil (due to ageing as well as internal/external stresses) may causeincipient or severe faults in the transformer.There are many traditionaltime consuming methods are available to determine thequality of mineral oil. The digital image processing is an emerging tool for non-destructive diagnosis of faults occurred in power transferring components. This paper aims to present review ofimage processing applications in fault detection oftransformer oil.

Keywords—power transformer;transformer oil;image processing;faults;nondestructive test

I. INTRODUCTION

Power transformers has vital role in modern power system. The mineral oil performs the insulation and cooling of internal energized parts of the transformer in oil immersed transformers. The fault free operation of electric transformer is necessary for reliable operation and to avoid financial losses due to interruption of the power supply. Henceforth it is essential to detect the faults occurred within the transformer as early as possible to eliminate disastrous failures. In service power transformers are monitored by buchholz or differential relays to detect the faults occurred within the system. The limitation of these devices is that they operate only when there are severe failures. The program of monitoring and preventive maintenance is important to increase the life of the transformer as well as to avoid the outage of the system equipment. [1-2]

Most of the time, electrical equipment age depends on manufacturing quality, operating condition, environment, service and maintenance programs. With the occurrence of every type of probable electrical, mechanical and thermal stress results in decreasing lifetime of transformer. As a result, a superiorjudgment related to the existing condition of transformer leads to the following, (i) Increase in life of transformer (ii) Improvement in loading condition of the transformer (iii) Enhances the power system reliability (iv) Prevents the power loss or damage (v) Planned and condition based maintenance[3-4].

An image is a single picture representing a person, group of people or animals, or of an outdoor scene, or a microphotograph of an electronic component, or the result of medical imaging. Pictures are the most common and convenient means of conveying or transmitting information [5]. Pictures briefly convey information about positions, sizes and inter-relationships between objects. They portray spatial information for recognizing as objects. Human beings are good at deriving information from such images, because of innate visual and mental abilities [6].

Image processing refers to the manipulation of image to make the recognizable picture or to convey the correct information of random blur picture. Image processing applied to hard copies like printouts and photographs by the image analysts are termed as analog image processing and that of processing applied to the digital images through computer algorithms, vision and computer graphics are termed as digital image processing [7]. Currently image processing techniques are widely employed under non destructive testing of faults detection in mechanical and electrical equipments. The objective of this paper is to review the literatures of digital image processing applications in fault detection of transformer oil.

II. Faults

A fault to an electrical engineer implies a failure of insulation or accidental abnormal operation due to bypass, but primarily the former. Fault in power transformer are broadly classified as (1) Internal faults and (2) External faults.

(1)Internal faults: The abnormal condition arises inside the protected zone of the transformer are called internal faults. These faults are of two types. (a) Electrical faults: Faults arise from the failure of major insulation placed between the winding and core and between the primary and secondary windings and minor insulation like the insulation placed between adjacent turns and between coils of the same winding. Short circuit, overvoltage, overloading etc., are some examples of this type of faults. (b).Incipient or mechanical faults:Faults which do not immediately affect the line currents of the transformer, but would slowly develop into catastrophe requiring serious attention. Hotspots, coolant failures sludging etc., are some examples of this type of faults.

2) External faults: The fault which occurs outside the transformer zone but fed through the transformer. It may cause external short circuit or overload.[8]

Table 1: Typical Causes of Transformer Failures[9]

Typical Causes of Transformer Failures	
Internal	Design and Manufacturing defects
	Insulation deterioration
	Loss of winding clamping
	Overheating
	Oxygen
	Moisture
	Partial Discharge
	Sludge formation in transformer oil
	Winding Resonance
External	Lightning strikes
	System switching operations
	System overload
	System fault (Short Circuit)

The transformer oil used in oil immersed transformer (i) Provides effective and efficient cooling (ii) Maintains dielectric strength of insulation system (iii) Protects the transformer against chemical attack and (iv) Prevents the sludge buildup in the transformer. The faults in the transformer oil may be due to electrical faults (overvoltage, short-circuit, overload), Thermal faults (Manufacturing defects, overload, improper cooling etc.) and Chemical faults (humidity, moisture, decomposition of insulating paper/oil).

III. DIGITAL IMAGE PROCESSING

Digital image is a numerical double-dimensionalrepresentation of a three dimensional scene or an object and it comprises of limited set of digital values known as pixels or picture elements. Digital image processing lays emphasis on two main tasks: amelioration of pictorial information for the purposes of human interpretation and processing of data image for storage, representation, and transmission for independent machine perception. Digital image processing often engage many procedures such as formatting and correcting the data, digital enhancement to enhance an improved visual interpretation, or automated target classifications and features wholly by computer. Digital image processing involves image acquisition, image enhancement or image preprocessing which includes image filtering and image restoration, image segmentation, feature extraction and classification.

IV. LITERATURE SURVEY

1. ***Image Processing Methods for Evaluating Infrared Thermo graphic Image of Electrical Equipments [10]***

Infrared thermography is well known as one of the effective tools in monitoring the condition of electrical equipments. It has the capability to detect the thermal abnormality in electrical equipments. The recent research in this field has shown the interest on an automatic diagnosis system. This is due to fast analysis and robust compared to manual inspection. The common method that normally used in analyzing infrared thermogram can be divided into four steps: image preprocessing, segmentation, classification and decision making. This paper presents the review of image processing methods for both approaches in classifying the level of faults in electrical equipments. Some advantages and disadvantages of both approaches are also discussed.

2. ***Infrared Thermography and Distribution System Maintenance in Alexandria Electricity Distribution Company [11]***

This paper describes results of the power line inspections atAlexandria Electricity Distribution Company using athermal image camera and corrective actions taken fordiscrepancies found during the inspections. They can becategorized into two case studies as follows:1) The inspections for irregularities in overheadtransmission lines caused by inappropriate electricalconnections which heat up several equipment such as nontensionsleeve, jumper, tongue and disconnecting switch.2) The inspections for deficiencies and "hot spots" indistribution systems such as fuse connection heating, highvoltage insulator breakdown, ground current leakage,breaker connection heating and transformer connectionsoverheating.

3. ***Analysis of Transformer Oil by using MATLAB (Image Processing Tool) [12]***

Transformer Oil testing method is a part of any condition-based defensive preservation facilities. This is the most important in early protective system that can allow maintenance arrangement to identify repairing priorities, program schedules, arrange of outside service, and order necessary parts and materials. Transformer oil sample analysis is a useful, predictive, maintenance tool for determining transformer health. Along with the oil sample quality tests, performing a dissolved gas analysis (DGA) of the insulating oil is useful in evaluating transformer health. This paper focused on the transformer oil analysis by using MATLAB (Image Processing). Also study of classification of transformer cooling system as well as the ideal properties of transformer

4. ***A Novel Approach of Transformer Oil Quality Analysis Using Image Processing [13]***

There are numerous investigating methods to determine the transformer oil quality. Chemical method is most enlightening technique to examine the oil properties. Image processing is having significance in nondestructive quality testing of transformer oil. In this paper, experiments are conducted on images of tested transformer oil samples. During the experiment topping of oil to the transformer is neglected and working temperature is considered as 60 deg Celsius.An extensive experimental evaluation has been made using image processing technique to estimate the oil properties, which is inexpensive and effective technique. Texture Entropy is extended to compute the Neutralization Number (NN) or Acidity and tanδ (Dissipation factor).

5. ***Thermal Aging of Mineral Oil-Paper Composite Insulation for High Voltage Transformer [14]***

This paper reports the experimental results on the effects of thermal aging on the properties of paper-oil composite insulation. The samples used were thermally upgraded kraft paper and mineral oil. Samples were conditioned to the same initial conditions through the heating at a temperature of 100 °C for 24 hours. Mineral oil samples with volume of 800 ml and 6 gram insulating kraft paper were put in hermetical bottles. The paper-oil ratio reflects the typical ratio of oil and kraft paper inside a real transformer. Authors investigated the thermal aging on paper-mineral transformer oil composite insulation system at 120^0C and 150^0C with duration up to 672 hours. Dielectric properties of oil were investigated using IEEE and IEC standard. Gases generated during the aging were determined using DGA method. The morphological aging of the kraft paper was investigated using SEM (scanning electron microscopy) while chemical element change was investigated using EDS (energy dispersive spectroscopy) with accelerated voltage of 0.3-30 kV.

V. METHODOLOGY

An image processing technique plays wide application in the diagnostic tests and analysis of electrical equipment. Fig. 1 shows each stage of image processing analysis in fault detection of transformer oil. The different stages are transformer oil image acquisition or capturing through digital camera, preprocessing such as image filtering (noise removal) and restoration of the captured image, segmentation of region of interest of the image, feature extraction, classification and decision making.

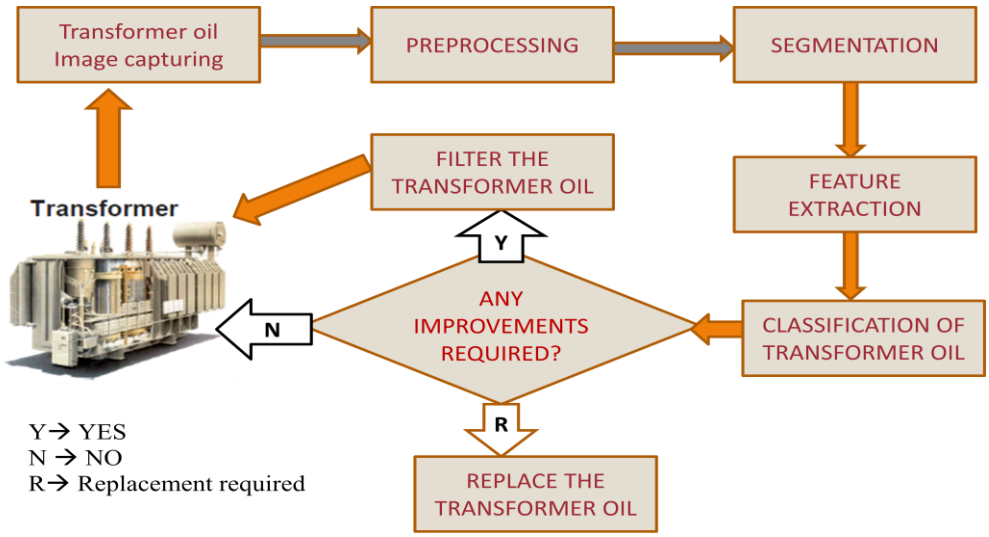

Figure 1: Methodology of image processing applications in transformer oil diagnostic test

VI. CONCLUSION

Transformer is a integral part of the power system. The performance of the transformer depends on the quality of insulation system. The proper insulation safeguarding depends on quality and quantity of the transformer oil in oil immersed transformers. Image processing is a tool in nondestructive qualitative analysis of transformer oil health. This paper reviews the literature survey of image processing applications in transformer oil diagnostic tests and different types of fault detection in electrical equipment. Also pictorially represented the methodology of digital image processing applications in transformer oil diagnostic test.

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