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A multi-criteria computer package for power transformer fault detection and diagnosis

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ABSTRACT

A package in Maple that helps users in power transformers fault detection and diagnosis has been developed. Transformers are required throughout modern interconnected power systems. Their range comprises from a few kVA to over a few hundred MVA, both in low voltage and in high voltage electrical network. As they are considered the key element in such systems, several maintenance methods have been reported in the literature: dissolved gas analysis (DGA) technique, short-circuit impedance (SCI) measurement, frequency response analysis (FRA) and power factor testing among others. All of them have as main goal to increase its useful life; normally reduced from aging process, stress conditions or electrical faults. Besides, they require special measurement devices and the experience of engineers, in order to make a proper diagnosis. This paper firstly determines the requirements of these tests to be applied and coordinate their input data and their output (diagnoses and recommendations). Afterwards, the package developed, that guides the users throughout the diagnosis processes, automatizes data processing and returns of the different tests (underlining if any contradiction between them arises) is summarized. The method is extensible/scalable by means of adding new techniques on this field of application.

1. Introduction

A package in Maple that helps users in power transformers fault detection and diagnosis has been developed.

Maintenance activities are critical for assuring the reliability and extending the useful life of any industrial equipment as well as reducing the associated further costs. It is well known that traditional maintenance operation strategies can be basically listed into three classes:

- Corrective maintenance: actions and repairs are carried out just after a breakdown of equipment [1].
- Preventive maintenance, time-scheduled maintenance or routine time-based: maintenance operations are performed for a preset period. It conducts routine inspections and tests so that impending troubles can be detected and reduced or eliminated [2].

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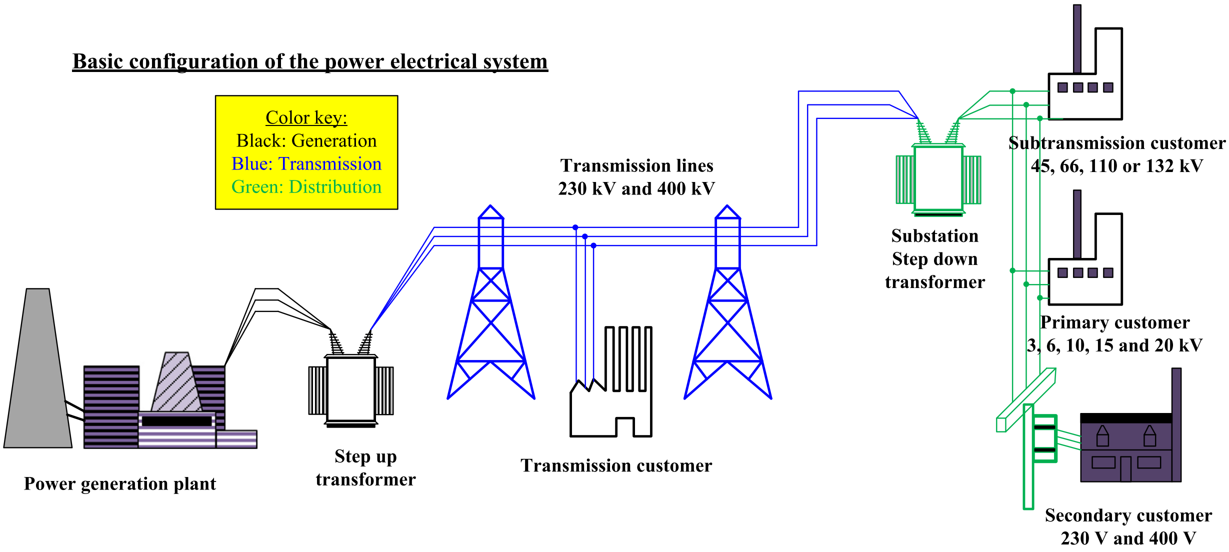

Fig. 1. Electrical system scheme with three power transformers.

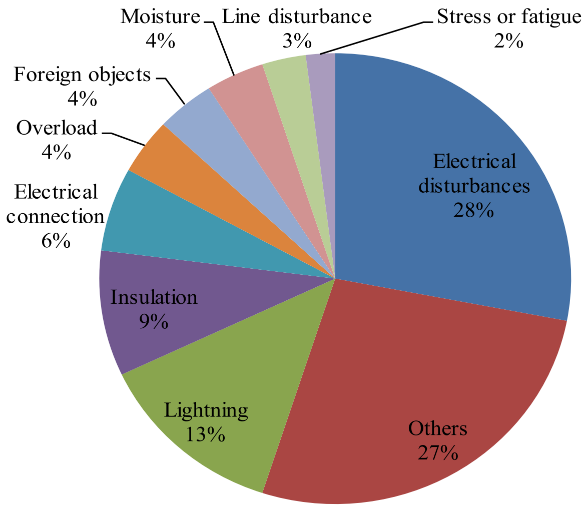

Fig. 2. Causes of transformers failures between 1991 and 2010 (the data are obtained from [6]).

• Predictive maintenance or condition-based maintenance: actions and repairs depending on the health condition of the equipment.

In the electrical power system scenario, transformers play a key role in energy transmission and distribution [3], being considered as the heart of such systems (Fig. 1). They act as interface between the different AC voltage levels with a constant or variable (in a tight range) winding ratio. This last configuration allows maintaining the terminal voltage values between the normalized boundaries. In addition, by changing the voltage value (amplitude or phase), transformers are able to regulate the reactive and active power flows through the transmission line.

An important datum to take into account is the high percentage of transformers, which were built some decades ago remaining still in use [4]. Theoretically, power transformers have an almost eternal useful life, but some studies and experiences demonstrate that the average useful life is around 25–30 years [5] because of the natural aging process, some usual stress conditions or electrical faults. Due to the aforementioned reasons, the change from routine time-based to predictive maintenance is becoming popular in this kind of infrastructure to extend their life within acceptable reliability thresholds.

Damages in power transformers derive from overloads, short-circuit currents, switching transients, earthquakes, careless transportation between factory and installations, explosion of combustible gases produced into the transformer oil tank, among others [6,7] (Fig. 2). All of them can lead to the thermal degradation of the oil and paper insulation, which could cause different effects and faults such as arcing, partial discharges, overheating or hot spots, and to mechanical defects

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