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Application of subtractive clustering for power transformer fault diagnostics

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Abstract

The issue of developing methods and implementation of hardware and software for power transformer state control is relevant due to the need for enhancing stability and durability of essential expensive equipment. A promising diagnostic condition control technique for the high-voltage oil-filled electrical facilities is the method of positioning partial discharges (PDs) and their intense measuring. The paper provides outcome of experiments enabling acoustic PD positioning at the transformers of the power plant units. It considers the methods and algorithm of processing results of the periodical acoustic PD positioning based on the subtractive clustering technique. These methods provides a fault tracing and identification as well as assessment of their trend.

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Keywords: power plant; power transformer; technical state; fault; diagnostics; tracing; methods; subtractive clustering method; algorithm; use.

1. Introduction

Implementation of means for fault diagnostics of oil-filled power transformers is challenging and highly urgent. This is due to a number of intrinsic reasons one of which is a physical equipment wear being as high as 50–70% in the Russian power sector. Furthermore, development of means and systems of technical diagnostics is the most essential condition of the Smart Grid technology introduction into the industrial electric networks [1-3].

One of the advanced and intensively developing methods of condition monitoring without deenergization (in on-line mode) is the partial discharge positioning. PDs have been recorded at the high-voltage facilities for diagnostics

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over the last 20 years. However, this method is used today mainly for monitoring power systems, large power plants and heavy-duty arc steel-making furnaces [4–6]. This fact may be explained by technical, research and methodical problems. One of substantial reasons is a lack of methods of transformer condition diagnostics based on processing and analyzing results of the periodic PD intense measurements.

2. Main part

We propose the engineering practice for identification of power transformer faults by analyzing complex partial discharge parameters. Fig. 1 shows the functional structure explaining the essence of the procedure developed.

It includes the following methods of mathematical analysis of PD parameters:

- analysis of PD intensity dependency upon the limit values;
- PD cluster analysis based on generation of uniform characteristics of the power equipment condition;
- amplitude and phase analysis of the time-dependent behavior of PD signals;
- spectrum analysis of harmonic content of PD signals.

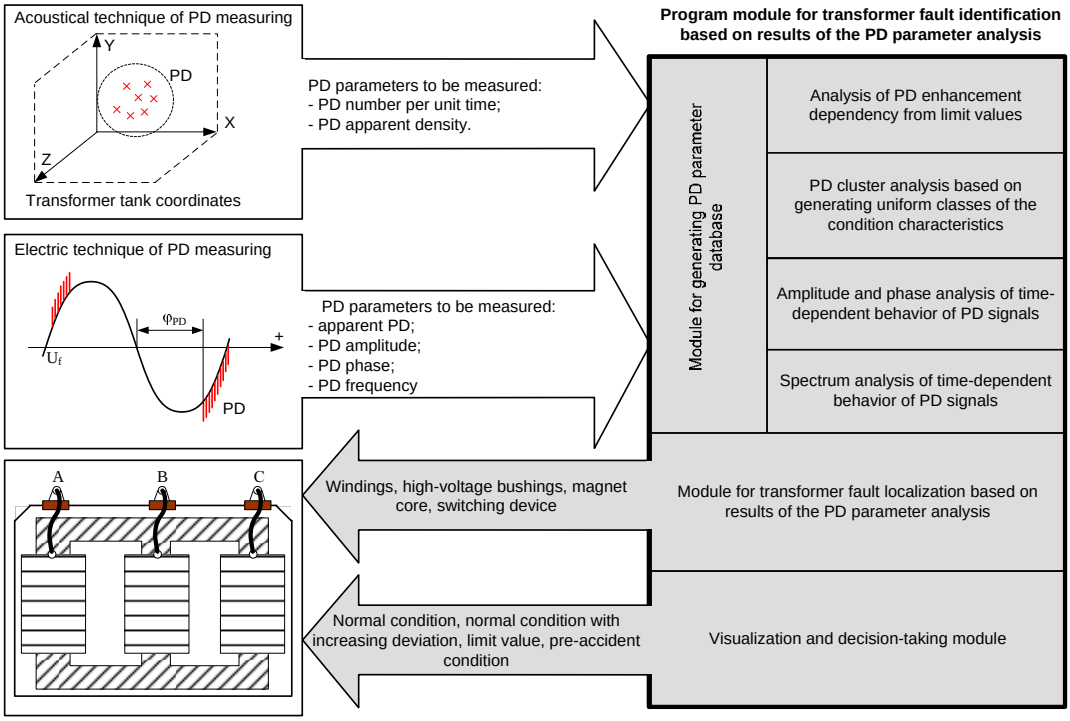

Fig. 1. Functional structure explaining the developed technique of transformer fault identification.

2.1. Experimental research of discharge activity

Within the framework of engineering implementation of the developed technique, acoustic tracing and processing data of partial discharges in the transformer tanks of the power sub-stations of industrial power plants were performed. Measuring was carried out with portable device for PD analysis and tracing defect zones in the insulation of the AR-700 high-voltage facilities [8]. For this, acoustic sensors were installed on the outer sides of the tank. Their location was chosen with methods specified by GOST 20074-83.

Fig. 2 shows intrinsic flow charts obtained at the transformer. Acoustic spikes recorded in pickup signals provided by sensors characterize the PD amplitude, frequency and duration [9].