SIMULATION OF FAILURE IN TRANSFORMERS USING MATLAB

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Abstract: *Simulation of failures in transformers based on MATLAB environment is presented in this paper. Sensors positions are initially defined. Random number generator for time delay between the measurement impedances and possible failures are used in the simulation. The results so obtained can be used for real practical analysis and diagnostic purposes.*

Key words: *MATLAB simulation, transformers, failure position.*

1. INTRODUCTION

One of the main equipment in transmission and distribution of electrical power in electrical substations are transformers. Their reliable operation requires an optimum preventive diagnostic and maintenance schedule to be applied. It is important to know the condition of the transformers and their components to make the expected performance quantifiable, and to make risks and costs predictable and controllable [1]. One of the most important criteria for the transformer's state is the presence of failure.

Because of the diversity of transformers in now days, the failure modes of transformers have been well studied. Failures in transformers can usually be connect with the failure of a constituent element. It can be occur in the bushings, windings, core, tap changer or the tank shield (screen) and dielectric transformer oil [2].

The main idea of this work is to create an algorithm for predicting the probability of failure in transformer using MATLAB.

2. METHOD FOR DISCOVERING OF FAILURE

The methods for discovering and evaluating the failure are based on the power exchange. This exchange can be electromagnetic wave, chemical reaction, impulse current, dielectric losses, sound, gas overpressure and etc. Random number generator for time delay between the measurement impedances and possible failures are used in the simulation. The oldest and most accessible method is found on measuring the sound level during the discharge, but there are difficulties persistent in isolating the discharge typical sound from the aside noises, especially when the measurement are taken in operation conditions.

For achieving localization of the failure source six measurement impedances are used. The bushing insulators of transformers have measurement outputs (PIN), which are suitable for connecting measurement impedances. Suitable places for mounting additional measuring impedances are the metal parts of the tank of the transformer, which are connected with bolt junctions (revision outlets, flanges of the coolers and others). It is reasonable one or two flanges of the cooling system in the bottom part of the tank of the transformer to be chosen.

2.1. Theoretical description

If $\boldsymbol{(x_i, y_i, z_i)}$, $\boldsymbol{i=1,\dots,n}$ are coordinate of measure impedance $\boldsymbol{i}$ with delay of electromagnetic wave $\boldsymbol{\Delta t_i}$, $\boldsymbol{i=1,\dots,n}$ which are due to failure then distance from failure to measure impedance with coordinate $\boldsymbol{(x_i, y_i, z_i)}$ will be:

$$r_i = \sqrt{(x-x_i)^2 + (y-y_i)^2 + (z-z_i)^2}\,. \tag{1}$$

Otherwise it can be established with delay of electromagnetic wave $\boldsymbol{\Delta t_i}$, $\boldsymbol{r_i(t)=V(\Delta t_i+t)}$, where $\boldsymbol{V}$ is the speed of electromagnetic wave and t is equal for all points of the measurement.

Location of failure could be found if in the every measurement point $\boldsymbol{i}$, $\boldsymbol{i=1, 2, \dots, n}$, where are registered delay $\boldsymbol{\Delta t_i}$, a sphere with radius $\boldsymbol{r(0)=V.\Delta t}$ are made. With consequent step of $\boldsymbol{t}$ are made different spheres till they crossed.

This procedure could be present with solving of this minimization expression:

$$\min_{(x,y,z,t)} \sum_{i=1}^{n} \left[(x-x_i)^2 + (y-y_i)^2 + (z-z_i)^2 - (V\Delta t_i + Vt)^2 \right] \tag{2}$$

Where unknown are the coordination of failure and the value of consequent step.

2.2. Practical implementation and MATLAB description

This method is applied for an example for determining the damage with testing a power transformer 400/220 кV. Electromagnetic waves are registered from six measurement impedances.

Measurement impedances are posed on the 400кV side bushing insulator, two of them are on the bushing insulators on the side 220 кV, on the bushing insulator of the neutral point, on the screen and on a flange of the cooling system.

After establishing the presence of failure, the time delay of the electromagnetic waves to each one of the measurement impedances is registered. If the transformer is presented like rectangular parallelepiped and the theoretical method in MATLAB is applied. Optimization problem is solved by the algorihm which is shown in Fig. 1.

After applying the method in MATLAB and discovering the minimum volume of spheres intersection, the place of the failure on Fig. 3 and Fig. 4 is shown.

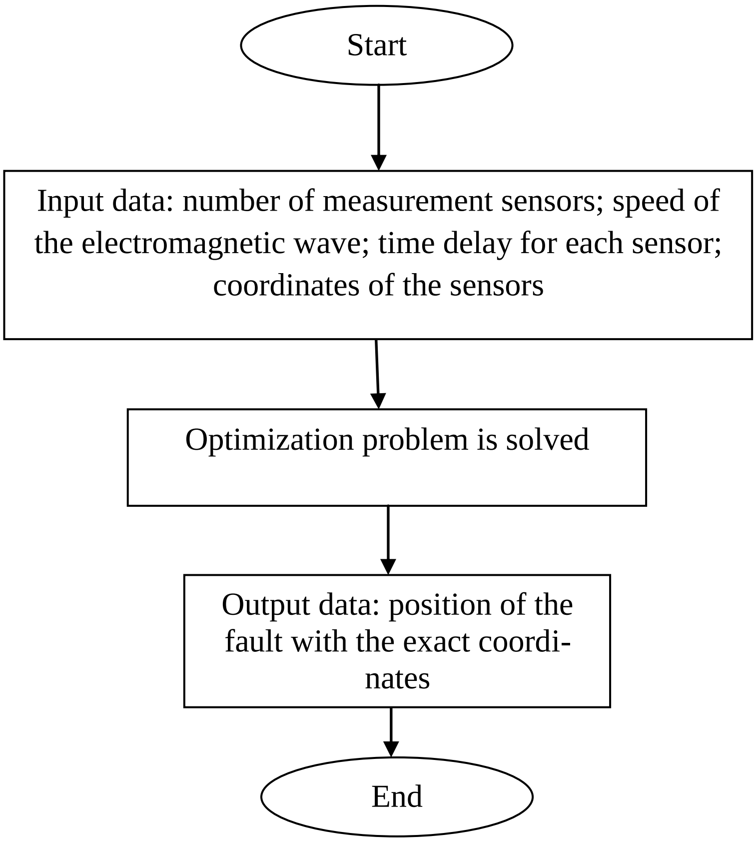

Fig. 1. Applied algorithm

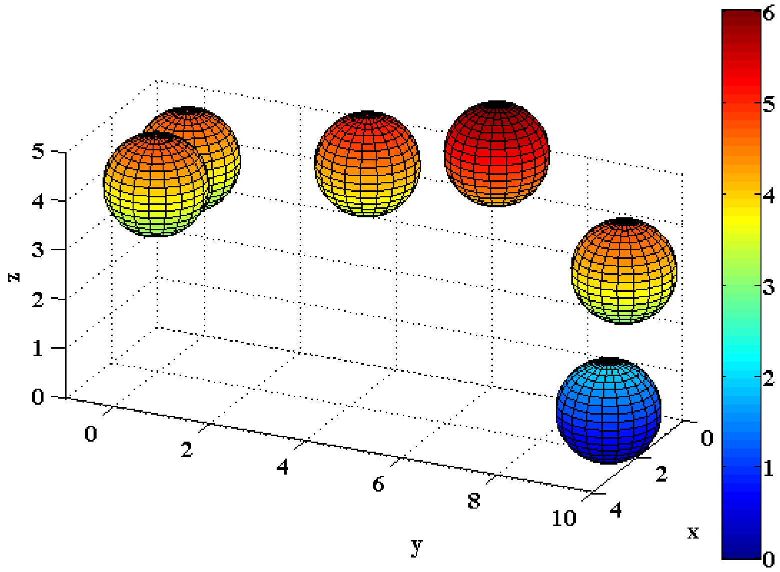

Fig. 2. Transformer model with measurement impedances

The significant role of the power transformers for the power system leads to the necessity of being aware of the causes and locations of their break-up. It is ascertained, that the most often damages are 40% in the tap-changers, 35% in the magnetic core, 14% in the bushing insulator, 6% in the tank and 5% in other parts of the transformer [3].

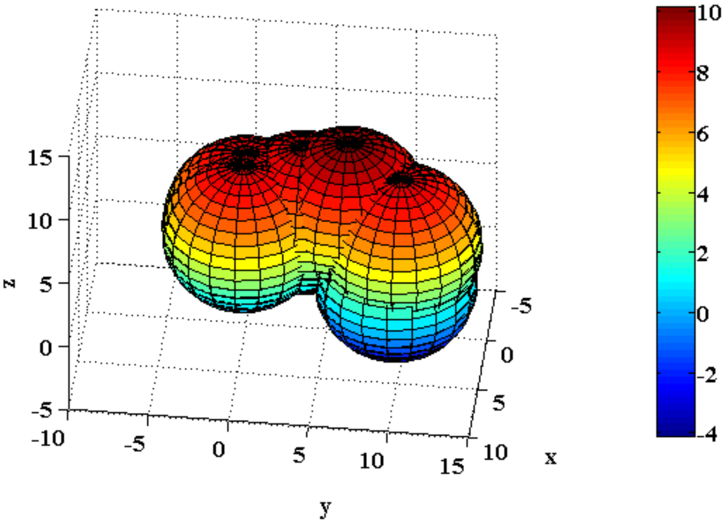

Fig. 3. Localization of failure

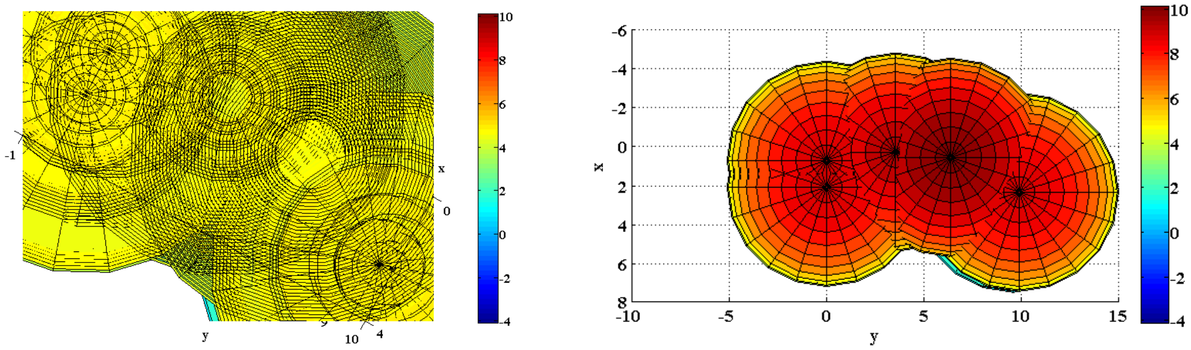

Fig. 4. Crossed area of all spheres

3. CONCLUSION

As a result of the applied method for determining the place of failure and making use of the construction draft, the seriousness of the damage is analyzed and the necessary measures for its elimination are taken.

References

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