Impact of Magnetic Field on the Environment using Magnetic Induction and Transformer Proximity

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ABSTRACT: *Magnetic fields in the region where people live have direct and indirect effects leading to multiple issues. Magnetic field effects from conduits, high-voltage fixtures and transformation stations affect the environment considerably. Using the finite element method with FEM 4.2 at normal loads, we identify the effect of the magnetic field in the environment. The volume of the magnetic induction in the transformer proximity is calculated with the distribution level in this work.*

Keywords: Power Distributional Transformer ETN 630, Finite Elements Method, Magnetic Induction, Magnetic Field

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1. Introduction

In the past twenty years there has been growing concern among the scientific, but also with the general public, about the influence of magnetic fields on electrical devices that surround us, precisely from external and internal sources. The external sources are transmission lines, transformers, underground cables, substations and earthing systems.

The energy distribution transformers are the most widely used in the distribution network of power systems. Hence it is particularly important to make different types of analyzes that would improve the basic characteristics, and thus reduce their harmful impact on the immediate environment and on the people.

This paper will show the analysis of the power transformer type ETN 630. The distribution of the electromagnetic field in all domains of the transformer will be calculated, and the magnetic induction calculation will be performed.

As a tool that made magnetic analysis possible in this paper is the applicable software package FEM 4.2 which is specialized software for analysis of this type. The algorithm which is the basis of the software, performs calculations using the method of finite elements.

2. The Power Energy Transformer and Fem 4.2 Calculation

The power transformer ETN 630, which in the given paper is a subject to analysis, has initial sizes and nominal data given by the test protocol of an already produced transformer of this type, which is quite present in these areas and is produced by the EMO factory, Ohrid, R.N. Maceedonia. The nominal data of the analyzed transformer are : $S_n = 630$kVA , $U_{n1} = 10000$V , $U_{n2} = 400$V, $I_{n1} =$ 36.373A , $I_{n1} = 909.3$A .The analysis will be done with the software package FEM 4.2, which is a specialized program for design, modeling and analysis of electrical machines and appliances.

The basis on which the program is based is the finite element method (Finite Elements Method).

3. Transformer Model Display in Fem 4.2.

The complete look of the model of the energy transformer (its geometry on the magnetic circuit, the windings and the names of the materials constituting the unit blocks) are given in Figure 1. With the given boundary conditions for this model, an electromagnetic analysis with FEM 4.2 can be made.

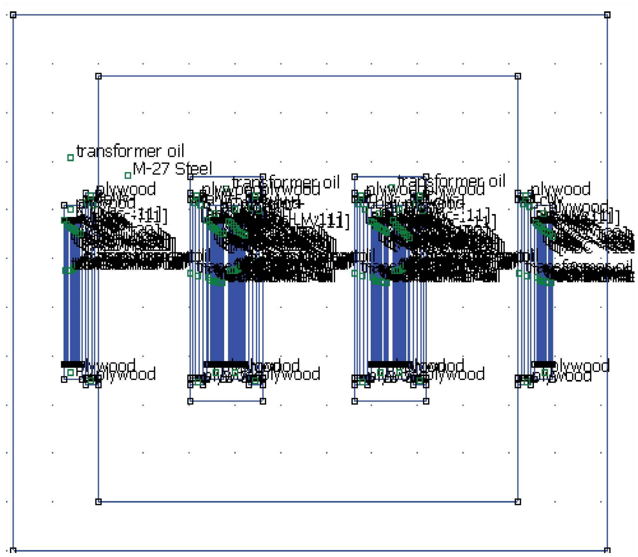

Figure 1. Full geometry of the transformer with the input characteristics of the materials

4. The Equations of a Transformer with a Finite Element Method

After defining the geometry of the transformer and the input of the materials with their characteristics, a solver mod with FEM 4.2 is starting. This option of the program performs automatic finishing of the finite elements network through the entered parameters.

Figure 2 shows the finite element mesh over the geometry of a three-phase power transformer. It contains 34590 nodes and 68828 triangular finite elements.

By activating the "solver" fkern.exe, calculations of the equations that describe the transformer are performed.

Calculations are repetitive iterative and more iterations are made of which each subsequent is faster than the previous one, since

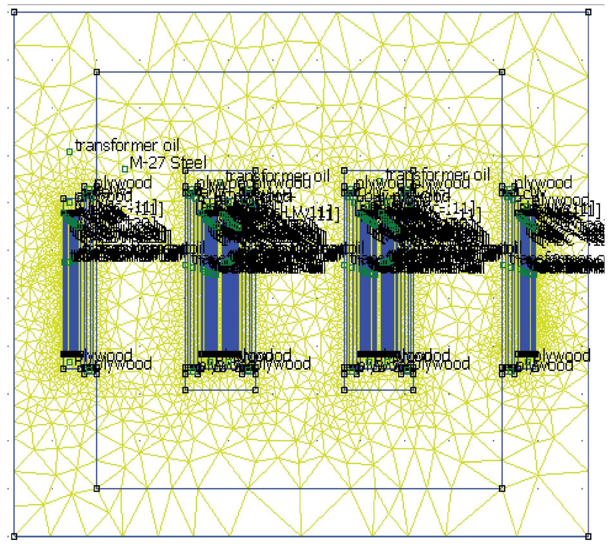

Figure 2. Finite element mesh of power transformer ETN 630

it can start with a previous solution that is close to the actual one. In the actual analysis, 12 Newton assays are carried out, for which approximately a time of about two minutes takes time with a computer with standard domestic conditions. The time for calculations depends on the number of nodes and triangular finite elements, that is, the dimension of triangular finite elements.

In the electromagnetic analysis of the transformer model, in order to obtain a good representation of the solution for the magnetic flux distribution according to the finite element method, it is best to draw magnetic lines. They are lines in which the magnetic flux is established in the transformer geometry.

When the magnetic lines are close to each other, then the flux density is high. In FEM 4.2, magnetic lines are drawings of the threaded contours of the magnetic vector potential A for planar problems such as in the concrete case, or threaded contours for 2 for axisymmetric problems. For this specific case, 20 magnetic bullets are shown, as in Figure 3, and their number can be larger and smaller.

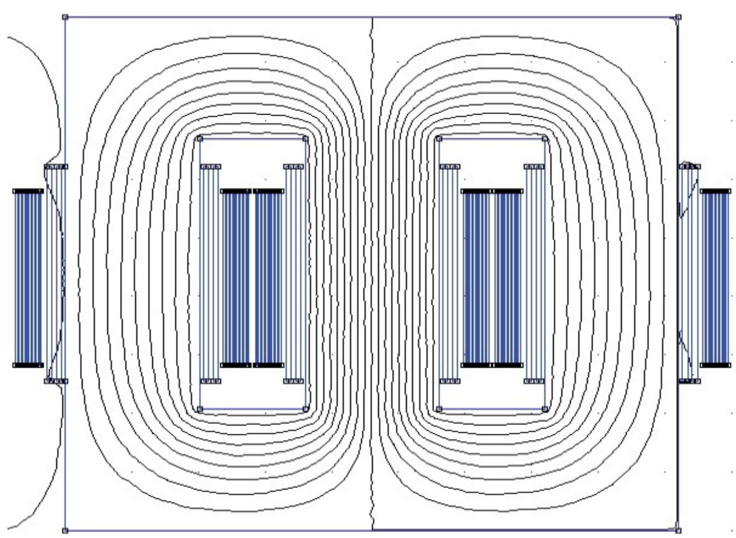

Figure 3. Distribution of the magnetic flux in the transformer

5. Calculation of the Characteristic Magnets of the Transformer with Fem 4.2

Calculations with FEM 4.2 allow us to obtain a visual overview, and in addition mathematically determine the values of the distribution of the magnetic induction and the magnetic field strength in certain regions of the analyzed distribution transformer. In Figures 4, the distribution of magnetic induction is shown. According to the colors and values themselves, it can be noticed that at a certain point in the middle has the highest values of the magnetic induction and the magnetic field strength. The more we move away from the middle of the transformer, the lower values are obtained in relation.

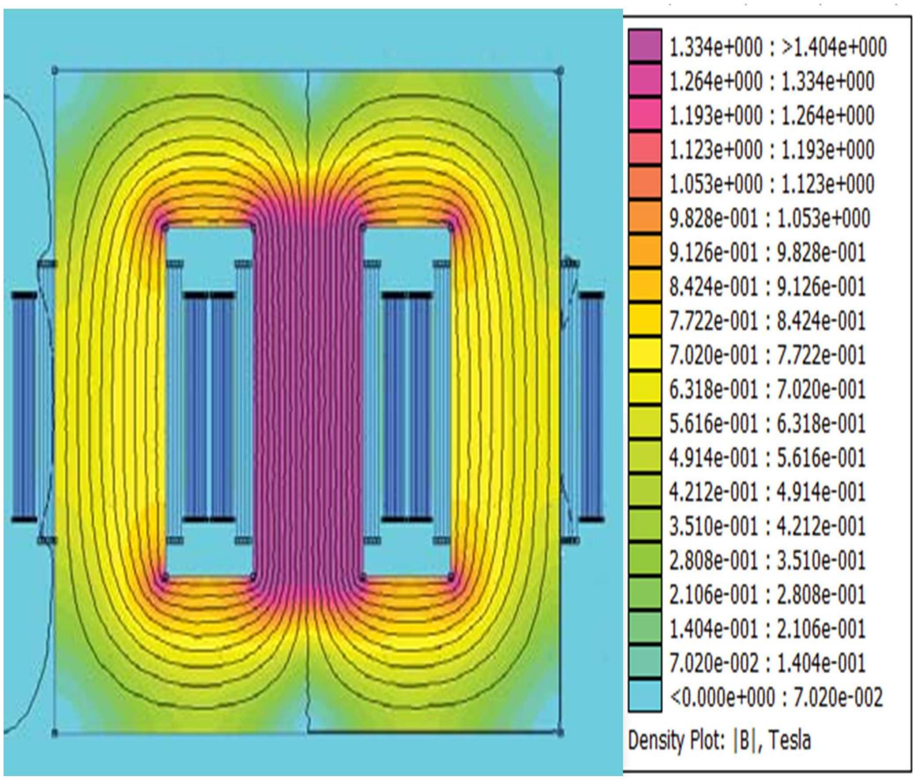

Figure 4. Distribution of magnetic induction in different regions of the transformer

According to this image and values, it can be noticed that at the point of the middle the value of the magnetic induction module is $|B| = 1.39935$ T, and the size of the magnetic field is $|H| = 440.33$ A / m.

In order to make a comparison with the measurements, we will take a few points in which the measurement will be made. In addition to the measuring point in the middle, the values of the magnetic induction and the strength of the magnetic field will be measured in 3 points: between the windings and two more in the outside of the windings.

In Figure 5 the values measured in point 1 are given, between the windings, in the middle with a yellow color, where the value of the magnetic induction module is $|B| = 0.712563$ T, and the size of the magnetic field is $|H| = 82.411$ A / m. The absolute values of both parameters fall.

Figure 6 will show the values of the parameters measured in point 2, which is closest to the windings, but still outside of them. The value of B is still decreasing and is $|B| = 0.00441$ T, and the absolute value of the strength of the magnetic field is $|H| = 3509.36$ A / m.

The measurement values in points 3 are located on the edge of the transformer. The value of the magnetic induction B decreases here and its value is $|B| = 0.00108225$ T, while the absolute value of the strength of the magnetic field is $|H| = 861{,}227$ A / m.

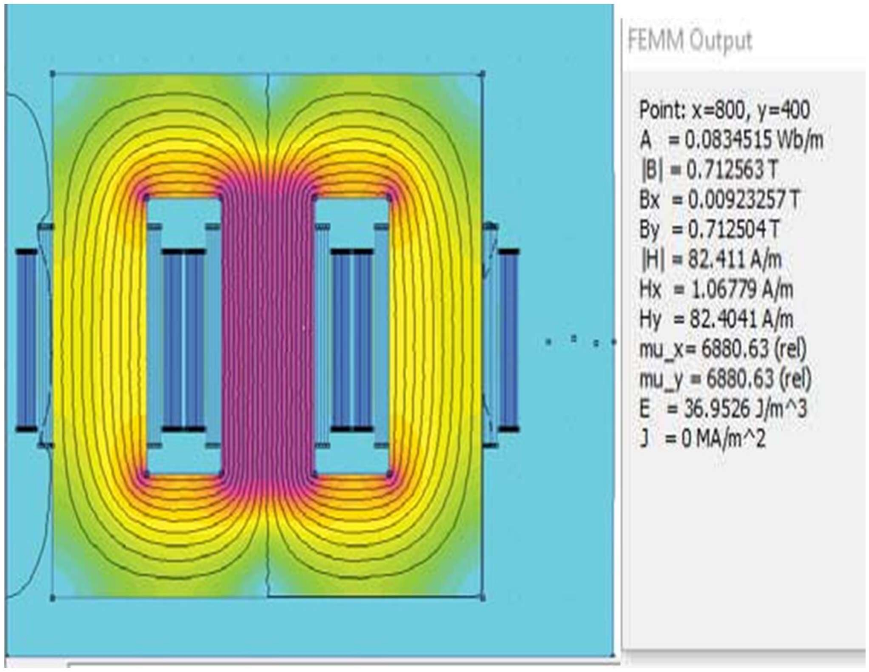

Figure 5. Measured values of |B| and |H| in point 1

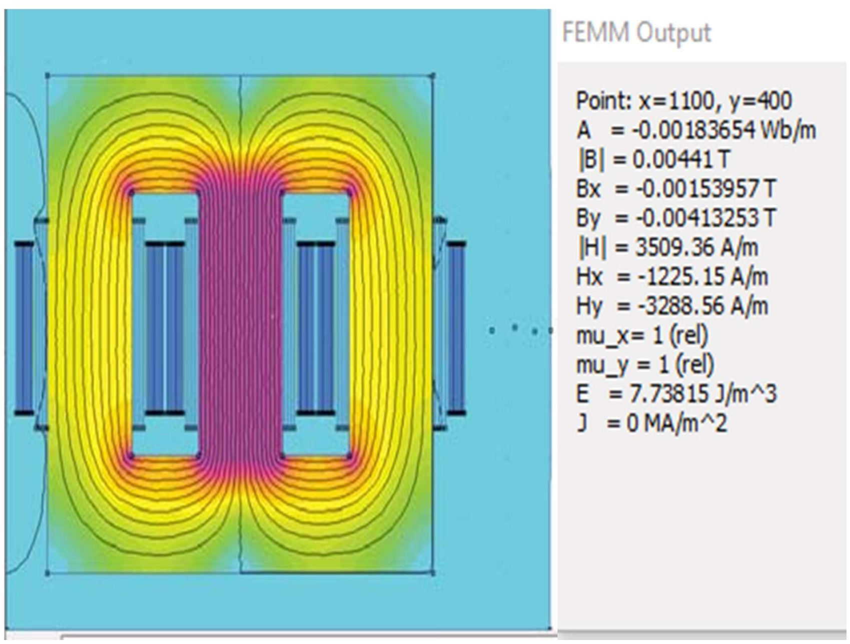

Figure 6. Measured values of |B| and |H| in point 2

6. Calculation of the Characteristic Magnets Outside of the Transformer with Fem 4.2

For measuring the value of the magnetic induction B and the value of the magnetic field strength H in the vicinity of the corresponding transformer, we used the 3D EMF TESTER measuring device, Model: EMF-828 shown in Figure 8.

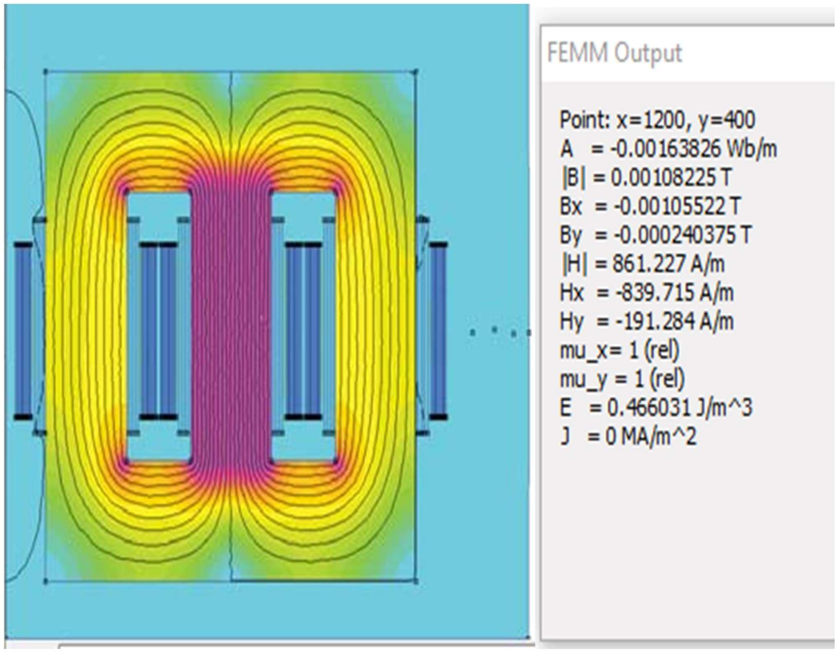

Figure 7. Measured values of |B| and |H| in point 3

Figure 8. 3D EMF Tester Model: EMF-828

The measurement was performed at several measuring points on two sides of the transformer, one of which is high voltage. The measurement results are given in Table 1.

However, it must be taken into account that the field measurements are carried out without knowing the thickness of the sheet metal and the internal parameters of the transformer.

The check was made with FEM 4.2 in order to determine whether the values of the magnetic induction at least roughly coincide. Comparing the values obtained with the measurements made by FEM 4.2, it can be concluded that the calculations obtained by

Measure points	Bx((μ*T*)	By (μ*T*)	Bz (μ*T*) |	B| (μ*T*)
Side 1 (highvoltage) On the door	0, 75	0.12	0, 28	0, 799
20 cm from the door	0, 31	0, 05	0, 24	0, 395
40 cm from the door	0, 80	0, 08	0, 10	0.810
Side 2	0.95	2, 8	0, 65	3, 023
10 cm from the door	0, 66	1, 70	0, 62	1, 926
20 cm from the door	0, 54	1, 23	0,4	1, 402
30 cm from the door	0, 31	1,01	0,27	1,09

Table 1. Results from external measurements

the program package do not deviate largely from the field analysis. It follows that the use of the FEM 4.2 software program greatly facilitates the analysis of the magnetic fields in and around the transformer.

7. Conclusion

From this research and completed magnetic analysis of the model of the energy transformer type ETN 630, the following conclusion may be adopted:

1.With this transformer model, the magnetic values typical of this transformer roughly match those obtained by computing time using the FEM 4.2 software. by finite element method. This manner of analysis offers a quick and easy way of displaying the magnetic field and magnetic induction in all sections of the transformer as well as outside it.

2.This type of transformer analysis with FEM 4.2 offers the ability to test the magnetic impact and radiation near a particular transformer. Measurements in the future can help improve the characteristics of power transformers in order to reduce the radiation near the transformer.

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