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Simulation of the Operation Regimes of a Welding Transformer

The object of the paper is constituted by the simulation of the operation regimes of an electric transformer, using specialised simulation software, in order to determine the electromagnetic strains to which welding transformers are subjected to in the case of the faulty operation. The monitoring processes of the modern welding equipment impose the reduction of the risk of their breakdown, grace to the collection and processing of detailed information about the condition of the transformers with the help of specialised modelling software with finite element.

Keywords: *transformer, welding, simulation*

1. Pre-processing Stage

In general, the geometric model of the domain, in which the studied processes take place, should comprise all the regions having a certain influence upon the studied phenomena.

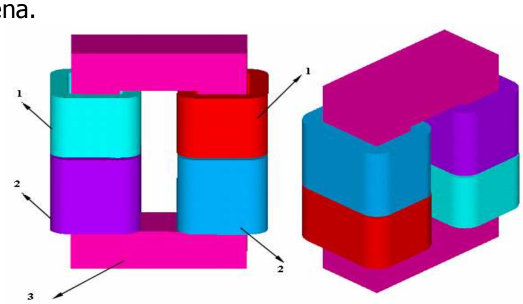

Figure 1. Geometric model of the two-winding welding transformer

In the case of the simulation constituting the object of the present paper, the main regions are:

– The two halves of the primary coil, marked with 1;

– The two halves of the secondary coil, marked with 2;
– The core, made of two columns and two yokes, marked with 3**.**

In order to reduce time necessary to the simulation and the file dimensions, obtained as a result of the running of the simulation software, we took into consideration the fact that there is a symmetry of the electromagnetic field both to the median plane of the core and to a plane perpendicular on the yoke and which passes through its middle.[2]

The mentioned regions are represented in fig.1.

On this basis we will use a ¼-reduced geometric model obtained through the sectioning of the complete model by the two planes and represented in fig.2.[3].

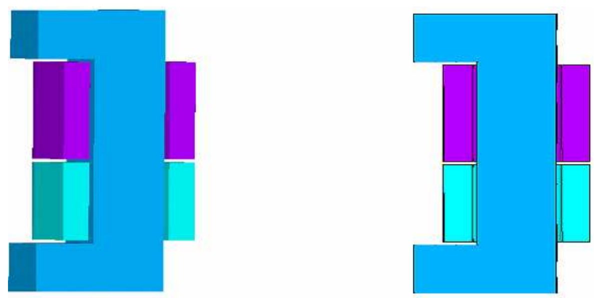

Figure 2. Reduced geometrical model

In order to solve any differential mathematical model, we must impose Dirichlet- or Neumann-type frontier conditions, in the points on the surface bordering the domain where the studied processes take place, plotted in fig.3.

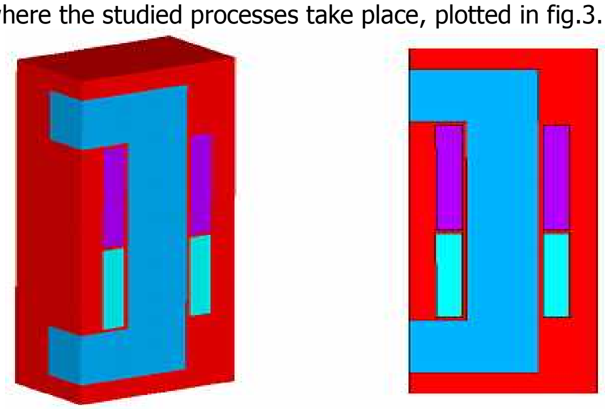

Figure 3. Imposing the frontier conditions

In principle, these conditions consist in imposing that one of the components of the magnetic induction be null in the points of this surface.

The condition that the normal component be null is known under the denomination of "parallel flux", while the condition that the tangent component be null is also called "normal flux".

The solution chosen consists in considering a portion of the surrounding air of a parallelepipedic shape, as shown in fig.3.

One defines the material properties.

The geometric model considered contains three distinct regions: core, coils and air.

The core is made of sheet metal made of electrotechnical steel 0.5 mm thick, for which, experimentally, one obtained the values of the magnetic induction B, corresponding to diverse values of the intensity of the magnetic field H, presented in table 1.

Table 1

H	300	340	400	480	570	720	930	1280
B	0,6	0,7	0,8	0,9	1	1,1	1,2	1,3
H	1820	2900	4700	8300	4200	2400	35000	51500
B	1,4	1,5	1,6	1,7	1,8	1,9	2	2,1

The model with finite elements is obtained through the division of the domain considered into disjoint sub-domains, defined as finite elements, fig.4.
As the geometric model is 3D, one uses solid-type finite elements .

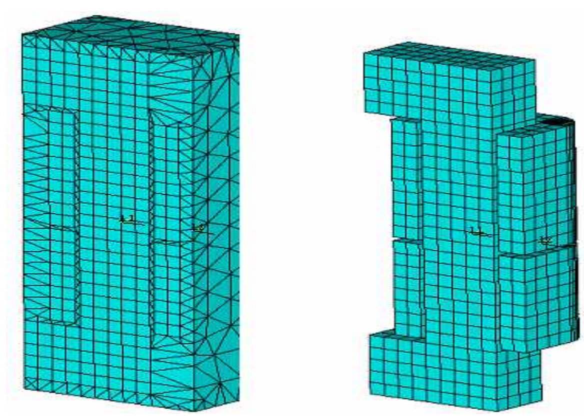

Figure 4. Model with finite elements

In order to simulate the operation regimes of the transformers, first one has to supply the primary winding. One can proceed in two ways:

- One introduces the voltage drop on the primary winding;
- One introduces the electric current through the primary winding;

2. The Post-Processing Stage

For the density and current vectors, from the knots of the two coils, there resulted a distribution presented in fig.5.

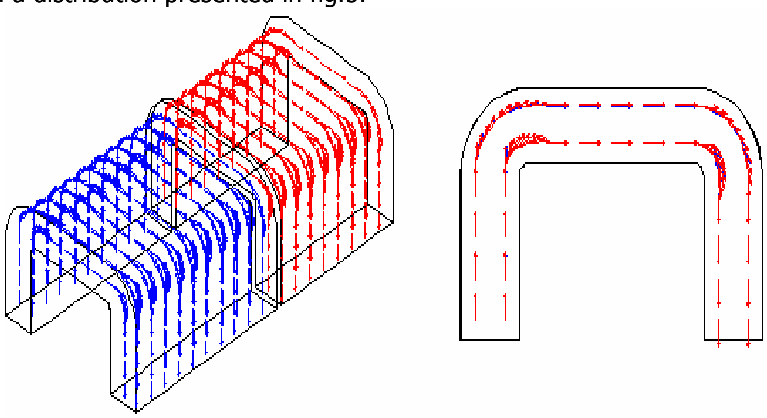

Figure 5. Distribution of the density and current vectors

Based on all the above, one drew the conclusion that all the results to be obtained correspond to the real ones but with a certain error specific to the software used.

One continues by performing a transitory analysis, for the case when the supply voltage has a step-type variation in time. The duration of the analysis was chosen to be 0.6 s with a time step equal to 1 ms.

The resulted primary current had a time variation in the shape plotted in fig.7. as expected, due to the own inductance of the primary winding, the primary current has an exponential variation and tends towards the value of 200 A.

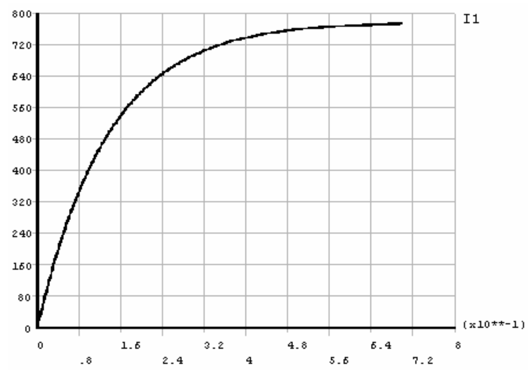

Figure 6. The variation of the primary current form the welding transformer

As such a value is obtained for the case of the supply at direct voltage with a value equal to U_m, based on these data one can determine the electric resistance of the primary winding.

Moreover, the time variation in fig.6 allows the determination of the time constant of the primary winding, which has the value of 60 ms.

The following analysis was performed for the case in which the supply voltage has a sinusoidal variation in time, resulting a variation in time s-of the primary current with the shape shown in fig.7.

This variation highlights the transitory regime taking place at the connection of the primary winding to the power supply network.

The primary current has a peak value of 37 A and then it is damped at an amplitude of 12 A, close to that admitted in the technical design.

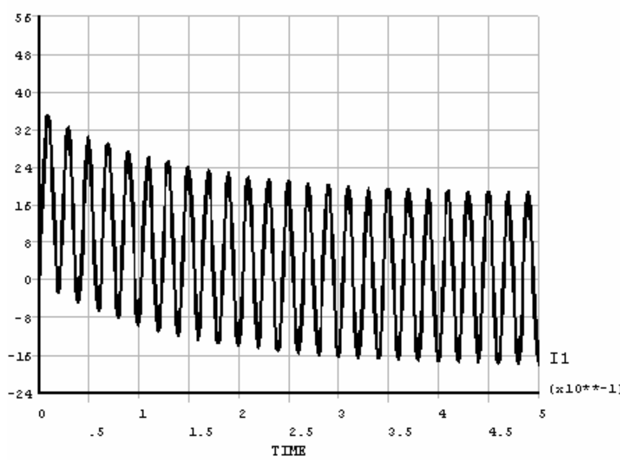

Figure 7. Sinusoidal variation of the primary current

3. Conclusion

The use of the finite-elements modelling of the industrial processes of this type allows the recording of the events taking place in the electrical equipment of the machine-building companies, in view of certain analyses focused on the quality of the welding joinings.[1]

Moreover, the analysis of certain unwanted post-breakdown events allows the deduction of the causes of certain events or abnormalities in the interior of electric transformers, as well as their location.

The economic effects of the use of the equipment proposed for realisation will be, among others, the reduction of the own technological losses in the welding installations, the observance of the quality standards of the electrical energy, the minimisation of the breakdown rate, the reduction of the electric power consumption.

The results of the simulation compared to the results obtained experimentally offer precious indications to the designing engineers and to technologists.

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