Modelling of the Electromagnetic Field in Bimetallic Components

Claudia Olimpia STAŞAC* and Dorel Anton HOBLE**

* Departnment of EMUEE
University of Oradea, Faculty of Electrical Engineering and Information Technology
410087 Oradea, Romania, e-mail: claudiastasac@yahoo.com

** Departnment of EMUEE
University of Oradea, Faculty of Electrical Engineering and Information Technology
410087 Oradea, Romania, e-mail: dhoble@uoradea.ro

Abstract *- The theme of this paper is focused on a study that refers to the distribution of the electromagnetic field in structures realized of two materials subjected to the heating process by inductive methods. The study , presented in the paper is a first phase of a complex study regarding inductive heating of the structures realized through various materials.*

Keywords: *electromagnetic field, inductive heating, heating process bimetallic components*

Introduction

Essentially, the electromagnetic field can be considered , conceptually as being a physical form of material, constituted by two components, namely : electric field and magnetic field, and is characterized by intensity figures of the electric field , E and electric induction D. The magnetic field appears in magnetized corps, this being characterized by the intensity length of magnetic field, H and magnetic induction, B.

The knowledge of the electric and magnetic field, spatial repartition constitute the premise of a calculation of the global performances in any functioning regime.

By numerical modellation of the processes one can precisely estimate the values of the field figures resulted after imposing certain conditions regarding the geometric shape of the studied device , the materials used , or may determine the answer of the equipment at the variation of certain parameters: feeding, material a.s.o.

All these data are extremely useful in projection, on condition that the errors between the values calculated on model and measured on a real system to be small enough , and the model to be experimentally validated.

Presentation of the study case

For the study developed in this paper an assembly made up of two pieces of cylindrical shape, empty inside and coaxially assemblied, the structure of the piece being presented below-Figure 1. The inside element is made up of brass and the exterior one of iron. Two materials were chosen , exterior and interior to allow the the study to develop a subsequent development towards the combination of the hybrid structures, using the electromagnetic processing.

The technology of combination of the two materials is basecon the structure heating towards the exterior structure up to a certain temperature, after hat the the inductor energy supply is stopped, the transfer of the heating towards the assembly interior producing the thermic conduction phenomenon.

Due to the different expanding index a pressure force of the interior structure to the exterior structure appear which in the case of the well controlled process leads to the structural combination of the two materials.

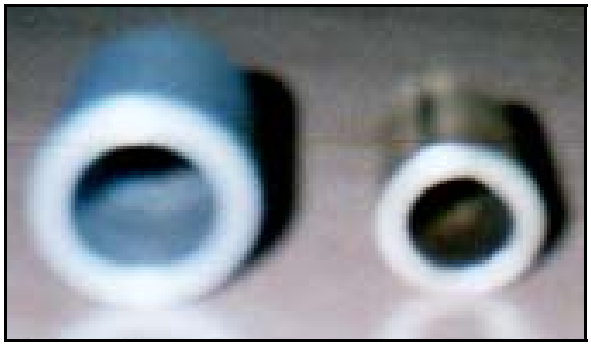


FIGURE 1. *The pieces to be processed*

The local form of the general laws of the electromagnetic field in structures characterized by continuous and uniform environments from the physical features point of view have the form :

- *electromagnetic induction law:*

$$\mathrm{rotE} = -\frac{\partial \mathrm{B}}{\partial \mathrm{t}}$$

- *magnetic circuit law :*

$$rotH = J + \frac{\partial D}{\partial t}$$

- *electric allot conservatio law:*

$$divJ = -\frac{\partial \rho_v}{\partial t}$$

- electric flux law:

$$divD = \rho_v$$

- magneticflux conservation law:

$$divB = 0$$

The geometry of the study field

Etapele principale în construirea geometriei domeniului de calcul sunt prezentate în figura 2, procedura clasică presupunând construcția punctelor, apoi a liniilor şi a regiunilor de tip suprafețe.

The main phases in building space geometry in calculation area are presented in figure2, the classical procedure implying the points construction , then the lines and regions of surface type.

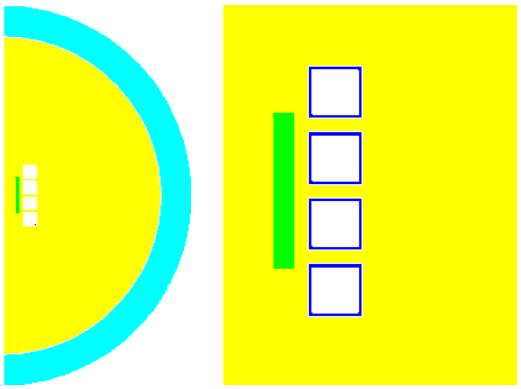


FIGURE 2. *Geometry of the calculatioon field*

The discreditation network in finite elements of the calculation field is constituted exclusively of triangles, the maximal fineness corresponding to the areas of major interest in the study.

In figure 3 is presented the network of discreditation in the studied structure and in figure 4 the discreditation network of the whole study field.

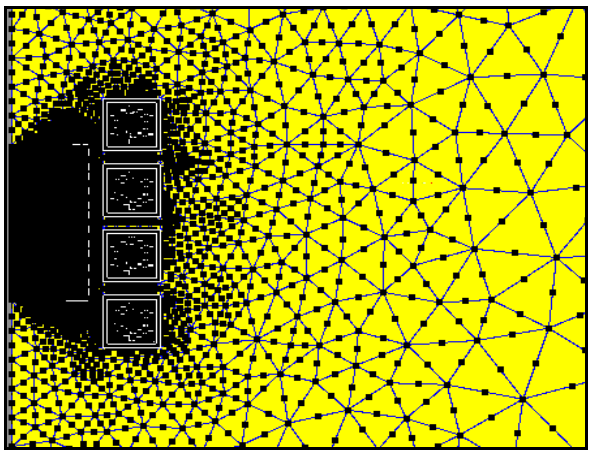


FIGURE 3. *The discreditation network correspondant to the calculation field*

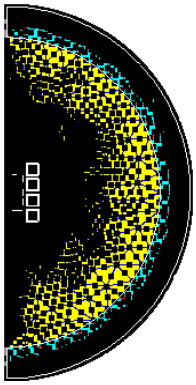
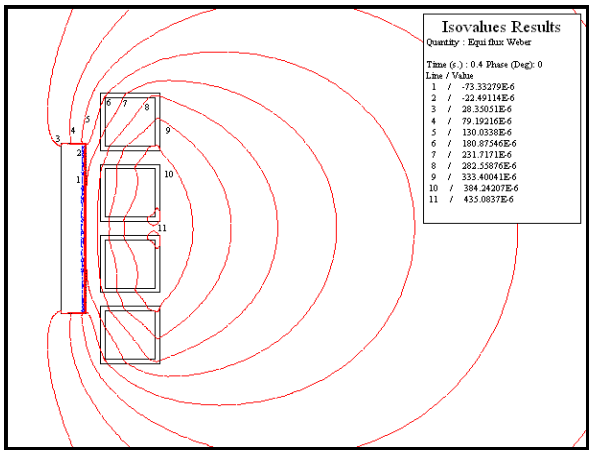


FIGURE 4. *The discreditation network of the whole study field*

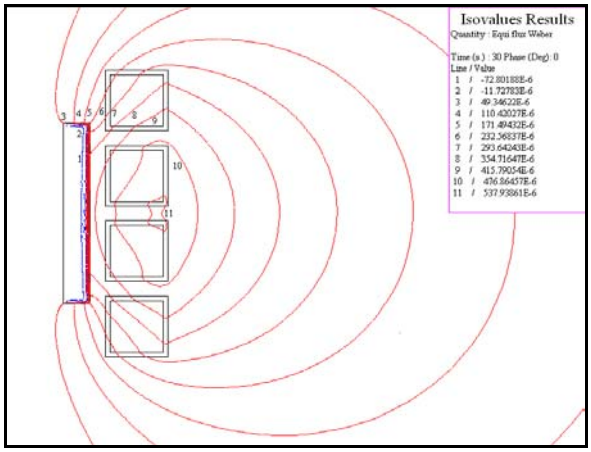
The numerical modellation

For the achievement of the numerical modellation, the modellation and simulation progeamme FLUX 2D, and entry dataand electricity density on inductor of 16 A, and work frequency of 2500Hz.

After numerical simulation , the repartition of the magnetic field density in formed shape was studied , the simulation result being presented in figure a and b.



a



b

FIGURE 5. *Magnetic field lines at 0,4 s and frequency 2500 Hz (a) and at 30 s and frequency 2500 Hz (b)*

Next we present the results of the steel cooling process with brass inside, at the following time steps :1s, 5s, 17s, and 30s.(Fig. 6)

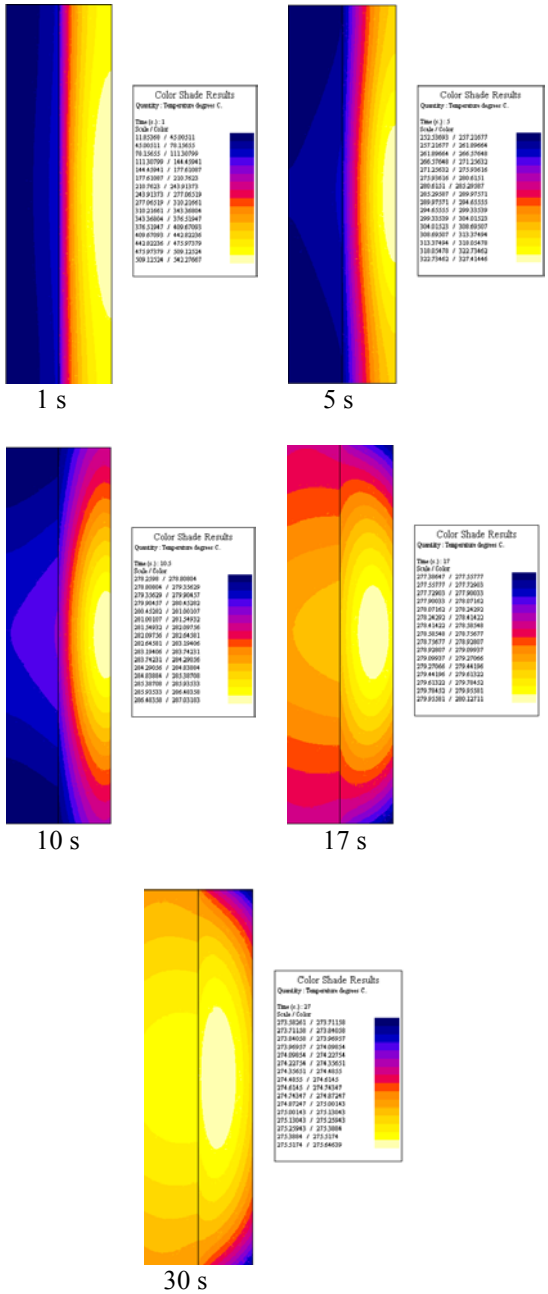


FIGURE 6. *Steel cooling with interior brass*

Conclusions

The above mentioned paper is a first step in studying the bahaviour of the structures realized of materials with different properties , during their inductive processing.

On the results obtained the study can be continued , in the sense of optimizing the phenomena of electro energetic conversion, in processes of inductive heating of such structures , by changing diffferent constructive parameters , or functional of the studied structures.

REFERENCES

1. J.C. Bourhis : "Chauffage de billettes par inducteur multicouche : Du prototype a la premiere reference industrielle"- *Les cahiers de l ingeniere , No 62 , 1996*
2. D. Hoble , C.Staşac : "Study about the inductive heating of a cylindrical workpiece , used torsioned inductor" – *Proceeding of HIS-01 , Padua , Italy 2001*
3. D. Hoble : "Numerical modeling and experimental validation of a inductive heating process with a doublelayer inductor." – *The 10th International IGTE Symposyum on Numerical Field Calculation in Electrical Engineering, - Graz, Austria 2002*
4. D.Hoble, C.Stasac : " Study about the increasing of the heating efficiency of the coaxial bimetallic workpieces" -" *Proc. of International Conference of Central European Energy , Efficiency and Renewable Energy Sources – Prague 2003*
5. *** CEDRAT "Flux 3D, versiunea 3.3 "CAD Package for Electromagnetic and Thermal Analysis using Finite Elements".