ASPECTS REGARDING THE NUMERICAL SIMULATION OF INDUCTION HEATING PROCESS IN PIECES OF CYLINDRICAL SHAPES

Mihaela NOVAC, Ovidiu NOVAC, Radu SEBESAN

Department of Electrotechnics, Measurements and using of Electrical Energy
University of Oradea, Faculty of Electrical Engineering and Information Technology,
3700, 5, Armatei Române Str., Oradea, Romania, mnovac@uoradea.ro,rsebesan@uoradea.ro
DeDpartment of Computers
University of Oradea, Faculty of Electrical Engineering and Information Technology
3700, 5, Armatei Române Str., Oradea, Romania, ovnovac@uoradea.ro

***Abstract* - In this work we present results of numerical simulations of induction heating process in pieces of cylindrical shapes, in a inductor with variable step between the coils. The modeling of the inducting heating process was made with the Flux2D software, for study we present the temperature charts of the billet at different time steps.**

Keywords: *induction heating, Electromagnetic Field, Thermal Field, inductor. numerical simulation, inductor efficiency*

1. INTRODUCTION

Induction heating is based on electromagnetic induction phenomenon. Faraday discovered this phenomenon in 1831, and he showed that currents could be induced in a closed or secondary circuit by varying currents. The secondary circuit is heated by the induced currents. Induction heating has an important role in industrial applications. Using this induction heating method we can heat very accurately surface areas and depths, in clean environment (operating conditions) with short heat times and with high power density. The induction heating device is formed by an inductor feed with alternating supply and the work pieces. The inductor comprises coils. These coils have to be optimized (number of turns, position on turns, relative position of inductor coils from pieces that are heated etc). Inductor coils are the most critical components of an induction heating installation. One of the most effective methods for their improvement is the use of magnetic flux controllers (core). Controllers influence the efficiency, the power factor and the impedance as well as the power distribution along the surface of the work piece. This paper dealt with the axisymmetrical induction heating system with pieces of cylindrical shapes. In figure 1 is presented the geometry of the inductor-pieces device.

2. NUMERICAL MODELING

This paper analyses induction heating system with axial symmetry. The length of inductor is L_i=420 mm, and one particular property of the inductor is the variable step between the turns of coils. Also the shape of inductor turns is rectangular.

We have obtained the following results from calculus:

- current density J_i= 23 A/mm^2;
- frequency f = 2500Hz;
- inductor length L_i = 420 mm;
- piece length a_2 = 100 mm;
- piece diameter d_2= 80 mm;
- turns number N_{sp}= 20.

The inductor process pieces of cylindrical shapes and the distance between two consecutive turns is variable, In middle of inductor the distance between two consecutive turns is 5 mm, at the end of inductor the distance between two consecutive turns is 1 mm.

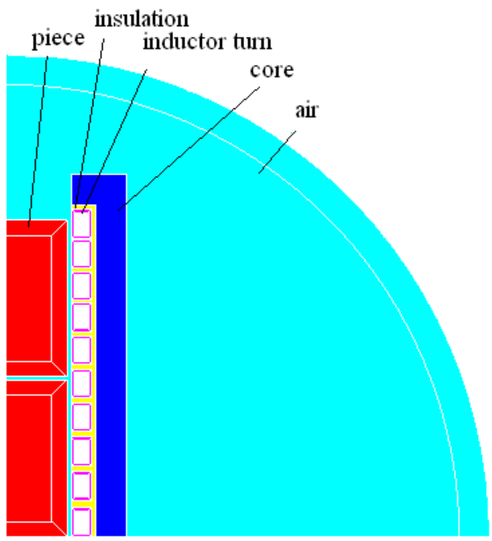


Figure 1: Geometry of inductor-piece device

This paper deals with the use of finite element method (FEM) software. Flux2D is a 2D finite element method software devoted to compute electromagnetic and electrothermal fields. In figure 2 we have presented the Magnetic field lines, at the start of heating process.

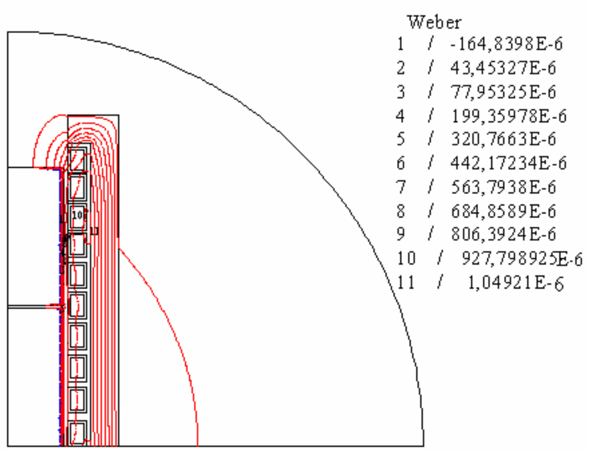


Figure 2: Magnetic field lines, start of heating process.

In figure 3 we have presented the Magnetic field lines, at the end of heating process.

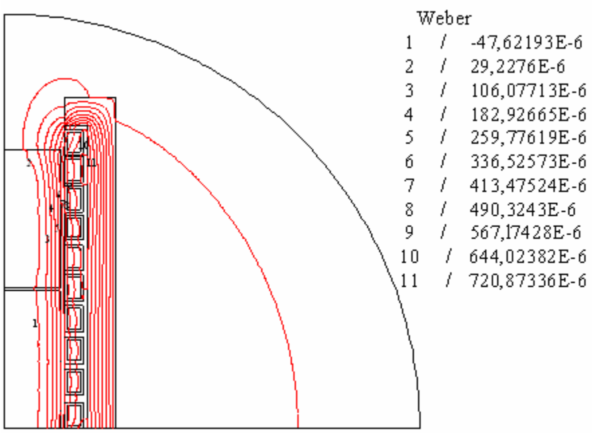


Figure 3: Magnetic field lines, end of heating process.

The structure of Magnetic field lines demonstrate the poor penetration of electromagnetic lines at the start of heating when all the piece is magnetic; at the end of heating when we reach the maximum temperature (1300°C), the surface of piece is characterized with temperature above the Curie point, the piece is non-magnetic, and the electromagnetic field has a better penetration in the piece.

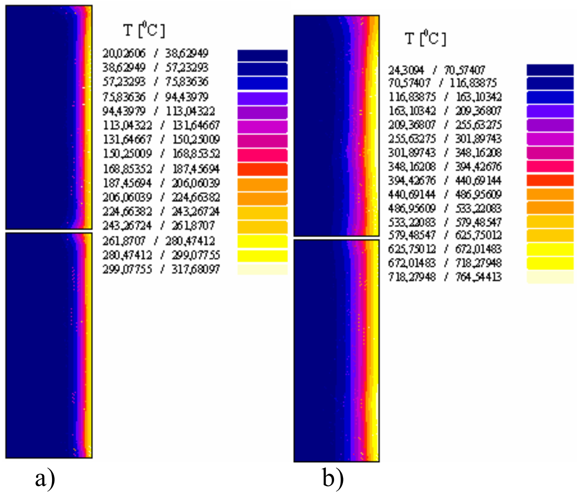


Figure 4: a) temperature map in piece, t=1 sec; b) temperature map in piece, t=5.088 sec.

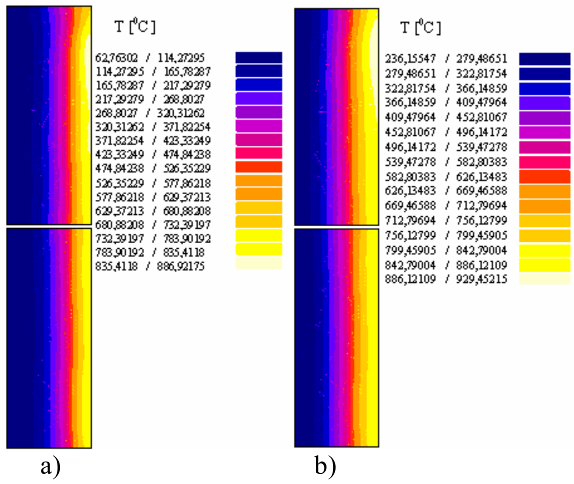


Figure 5: a) temperature map in piece, t=10.318 sec, b) temperature map in piece, t=20.318 sec.

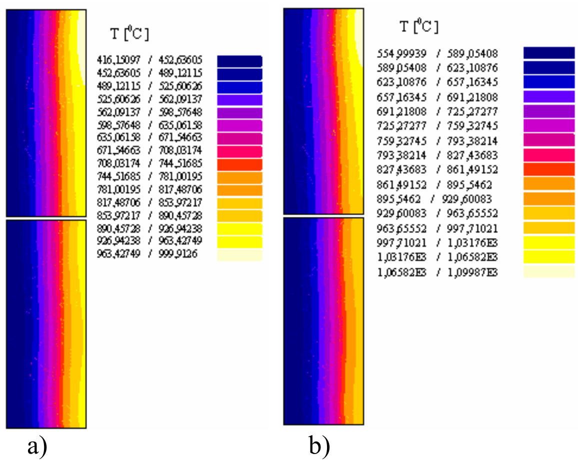
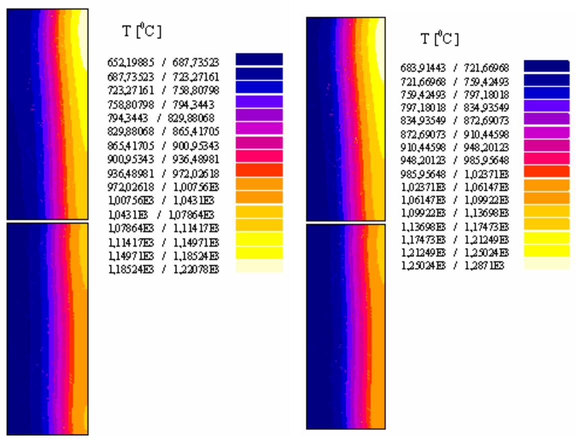


Figure 6: a) temperature map in piece, t=30.318 sec, b) temperature map in piece, t=40.318 sec.



a) b)

Figure 7: a) temperature map in piece, t=50.318 sec, b) temperature map in piece, t=55 sec.

The distance between two consecutive turns of inductor is variable at the end of inductor and is equal to 1 mm, and the distance increase towards the middle of inductor until 5 mm between two consecutive turns. From this reason we observe that at the end of heating process (figure 7 a) and b)), the pieces towards the ending of inductor has higher temperatures.
In figure 8 we present the location of points 1, 2, 3, 4 in pieces, where we will make the analysis of temperature field.

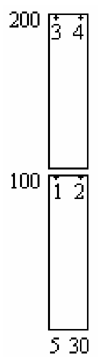


Figure 8: Position of points 1, 2, 3, 4 in pieces.

In figure 9 we present the temperatures evolution in the following points:

1 - (5 100),
2 - (30 100),
3 - (5 200),
4 - (30 200).

The point 1 is situated in the middle on the piece and the point 2 is situated at the surface of the piece. The point 3 is situated in the middle on the piece and the point 4 is situated at the surface of the piece.

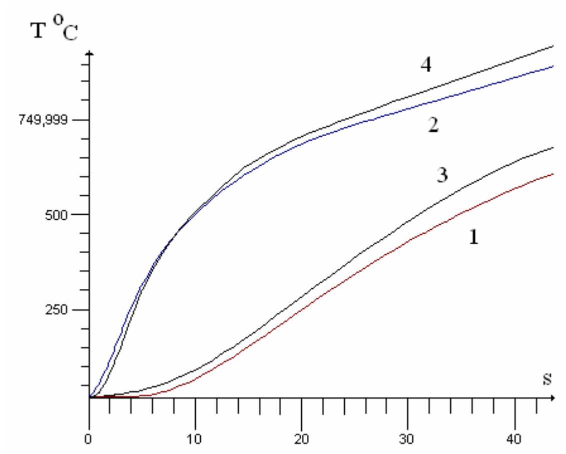


Figure 9: Temperature evolution of in points 1, 2, 3, 4.

3. CONCLUSIONS

The paper presents the examination results of induction heating process of cylindrical shapes pieces with distance between two consecutive turns variable. Simulation was carried out on the basis of two-dimensional, axisymmetrical model. Flux2D was used to solve coupled electromagnetic and temperature problems. On the basis of the obtained results we can com to following conclusions:

- At the end of heating process when we reach the maximum temperature (1300°C), the surface of piece is characterized with temperature above the Curie point, the piece is non-magnetic, and the electromagnetic field has a better penetration in the piece.
- At the end of heating process, the pieces towards the ending of inductor has higher temperatures, were the distance between two consecutive turns of inductor is lower (turns are more dense)
- Application of magnetic core can improve parameters of the heating device. Additional advantage is considerable limitation of electromagnetic radiation round the inductor.

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