# Calculating the distribution of current density in the cylindrical workpiece in the process of induction heating by using of Flux 3D program

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***Abstract*** **The paper presents a model of an induction heating implemented in FLUX 3D. Taken multi-variant calculations of current density distributions. The paper presents the distribution of current density only for the power source frequency of 9835 Hz. Knowledge of current density distribution is the key to designate the input impedance of the heater, which is strongly influenced by the parameters of the power source.**

***Keywords*** **Induction heating, inductor-tubular workpiece, electromagnetic field, FLUX 3D program.**

## I. INTRODUCTION

The induction heating uses electromagnetic induction by M.Faraday Formulation. It is about inducing in any closed circuit alternating magnetic field at the time, the electromotive force is proportional to the speed of change and flux values, covering the circuit. in the centers of three-dimensional, there are many closed circuits, the electric field intensity vectors described Maxwell's II equation, under the influence of which, in the centers conducting, it creates a field induced eddy currents, with a specific distribution of vector current densities in each of his place. The mechanism and mathematical description of electro-transformation occurring in the elementary volumes of the medium described in [2-5, 6-9] The inductive method, the frequency of the electromagnetic field used for generating inductive conduction currents (eddy currents) varies from a few Hz to tens of MHz [10-11].

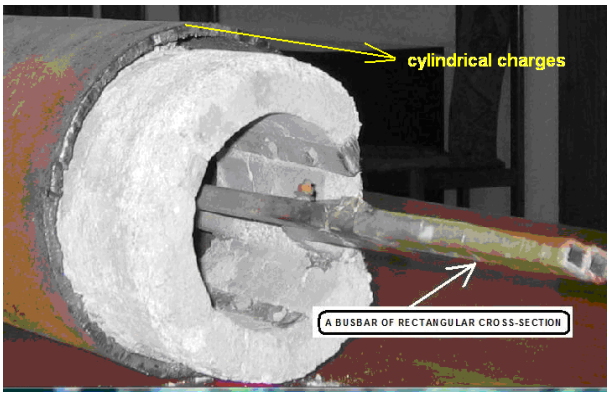


Fig. 1. Cylindrical charge with internal inductors Real system

The second important phenomenon accompanying induction heating is the skin effect, manifested by uneven density currents in a conductive medium and increasing their concentration, with the increasing frequency of the field in the surface layers of the resort.In induction machines (fig.1) [1], due to the geometrical proximity of the various guides, distributions of magnetic field strengths can be uneven. Therefore, in the method of induction, in addition to skin effect phenomenon should also take into account the approximation.

## II. CONSTRUCTION OF MATEMATICAL MODEL

Figure 1 shows a fragment of the real system. Visible is a cylindrical charge and busways leading driver.
Figure 2 shows the model of the real system, where 1/8 has been implemented in the program FLUX 3D.

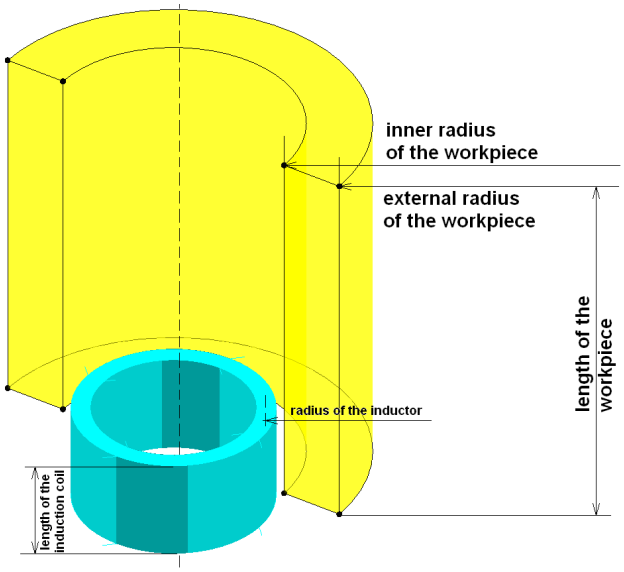


Fig. 2. model of a cylindrical workpiece with internal inductors

The electromagnetic filed in the induction heating element is described by the Maxwell equations. The compound potential of the electromagnetic field for

separated subregions of the heater are determined by the formulas [1]:
- for the worpiece

$$\nabla^2 \underline{A} - \mathrm{j}\omega\mu\gamma\underline{A} = 0 \qquad (1)$$

- for the internal inductor [4-5]

$$\nabla^2 \underline{A} - \mathrm{j}\omega\mu\gamma\underline{A} = -\mu\underline{J} \qquad (2)$$

The current density is described by the formula:

$$\underline{J} = -\mathrm{j}\omega\mu\gamma\underline{A} \qquad (3)$$

Figure 3 shows the mesh with the parameters listed in Table I.

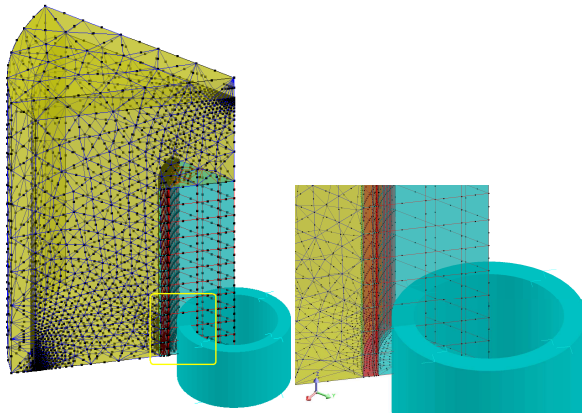

Fig. 3. The mesh on selected faces of the computation domain.

TABLE I
DATA OF THE USING GRID

| Number of nodes | Number of line elements | Number of face elements | Number of volum elements |
|---|---|---|---|
| 44181 | 512 | 5010 | 22683 |

Figure 3 shows the distribution of current density of a cylindrical workpiece. We also see a 5 coil coil is covered with a grid computing.

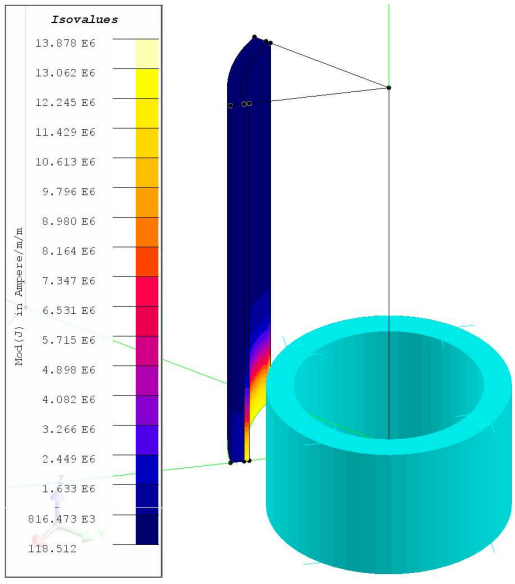


Fig. 4. current density distribution of a cylindrical workpiece.

## II. CONCLUSION

Performed simulations show that the FLUX is a useful tool for preliminary and approximate analysis of the distribution of current density. With this program was carried out multi-variant computer simulation which shows that for high-frequency inductor current over 5kHz clear skin effect and the effect of the approximation. The highest current density values ranging 13.3 MA/m2 inner layers were obtained for the charge for the power source frequency of 9835 kHz. Internal inductor is placed in the middle of the tube. Presented preliminary results of the analysis of this model will be the heater starting point for further analysis. Further analysis will provide the bulk densities and distributions of surface heating power. Performed simulations undoubtedly serve to shaping member and a power actuator system which is the inductor. Individuality uses induction heating equipment and the complexity of their mathematical description, and thus complicating the designation of electrical parameters and the calculation of temperature fields and flow fields, large and impossible to overestimate the importance of gaining the ability to simulate such systems work. The results obtained are useful in predicting the temperature distributions in cylindical workpiece and construction of heating systems.

## III. ACKNOWLEDGEMENTS

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