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Flux 3D application package for the analysis of electromagnetic field in an induction heater for cylindrical charges

Streszczenie. *W pracy przedstawiono wyniki obliczeń składowych pola elektromagnetycznego w procesie nagrzewania indukcyjnego wsadów cylindrycznych od wewnątrz. Wykonano obliczenia w programie FLUX 3D metodą elementów skończonych. Obliczenia pola magnetycznego wykonano dla trzech różnych czasów nagrzewania. Rozkład pola magnetycznego wyznaczony został dla prądu o wartości skutecznej 2kA i częstotliwości 9835Hz.* ***(Zastosowanie programu FLUX 3D do analizy pola magnetycznego nagrzewnicy indukcyjnej wsadów cylindrycznych)***

Abstract. *The paper encloses the results of the numerical analysis of electromagnetic field in the induction heating device for cylindrical charges. Numerical simulation was made for three different value of the times. The magnetic field in the charge was calculated for current I=2000 A and frequency f=10 kHz. Its distribution was simulated and analyzed in the FLUX 3D program by using of finite element method.*

Słowa kluczowe: Pole elektromagnetyczne, nagrzewanie indukcyjne, hartowanie indukcyjne, pola sprzężone.
Keywords: Electromagnetic field, induction heating, induction hardening, coupled fields.

Introduction

Induction heating is often used in many production processes such as the automotive industry. An example may be hardening, which means hardened from the center of various types of bushings Therefore, heat treatment often occur at the individual contract businesses. For the individual needs of the chosen process parameters of inductors and power sources to achieve the proper temperature on the surface of the load. Figure 1 shows a cross section of the pipe-hardened from the inside. Inside the pipe is five spiral inductor.

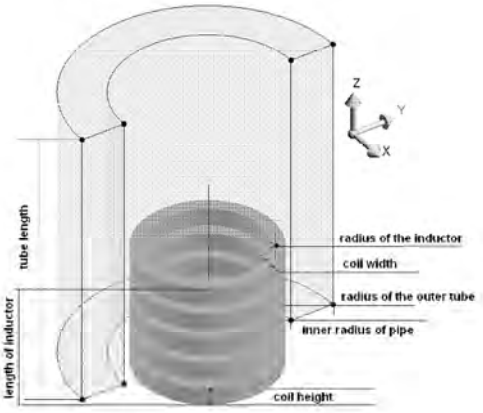

Fig.1. cross-section of the charge of internal inductors.

Construction of mathematical model

The electromagnetic field in an induction heater is described in Maxwell equations. Composite magnetic field for potential sub-divisional heater takes the following form [2-3]:

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

- for the inductor

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

The current density is determined by the relationship:

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

Power density in the charge is calculated using the formula [1]:

(4) $$p = \gamma\omega^2 \underline{A} \cdot \underline{A}^*$$

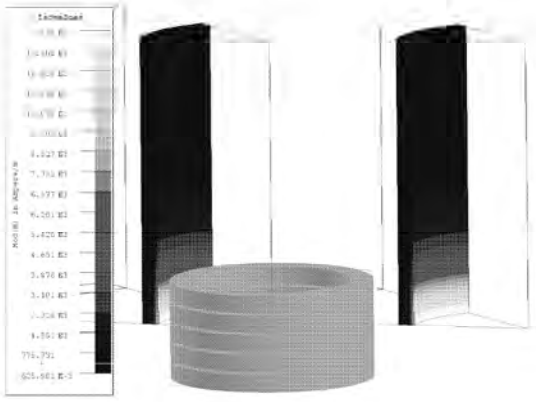

Fig.2 distribution of magnetic field strength.

Conclusions

Using multi-variant calculations performed FLUX of magnetic field intensity. In this paper we present only the results obtained for the frequency of the power source of 9835 Hz. The highest value of magnetic field strength in the inner layer of the charge is 13 kA/m. The presented research shows advantages using computer program like FLUX 3D for calculating of distribution of magnetic field in the induction heating device for cylindrical charges.

This work was partly financed by the Polish Ministry of Science and Higher Education from means of budget on science in years 2010-2012 as research project N N510 256338.

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