NUMERICAL SIMULATION OF INDUCTION HEAT TREATMENT FOR MATTOCK WITH TEETH FOR ROOTS

Gabriel Remus CHEREGI[1#], Mihaela Codruța LUCACI[1], Laura Melinda DERECICHEI[1], Teodora Anca CODĂU[2]

[1] University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru Str, 410059, Forestry Department
[2] "Dimitrie Cantemir" Secondary School, 2A, Sextil Puşcariu St., Oradea, Romania

RESEARCH ARTICLE

Abstract

This study presents an analysis of the induction hardening method applied to Mattock with teeth for roots. The analysis involves solving thermal diffusion problems coupled with eddy currents to ensure that the required parameters align with practical applications.

Keywords: Numerical simulation, Electromagnetic field, Electromagnetic field coupled with thermal, Mattock with teeth for roots.
#Corresponding author: grcheregi@yahoo.com

INTRODUCTION

Mattock with teeth for roots are crucial tools for the scarification process, with their cutting area requiring optimal linear and angular parameters tailored to the specific terrain conditions. It is essential for Mattock with teeth for roots to have a homogeneous structure that meets the necessary specifications (T. Leuca, 2002).

The induction hardening simulation method is versatile and adaptable to various metal piece geometries. This method accounts for changes in both electromagnetic and thermal parameters in response to temperature variations. Of particular interest is the temperature-dependent B-H relation, transitioning from an iron-magnetic environment to air. In this context, the interplay between eddy current problems and thermal diffusion becomes prominent around the Curie point.

The B-H relation is linear, and magnetic permeability adjusts based on the highest effective value of magnetic induction. We employ a linear pattern and the B-H relation in our approach (G.R. Cheregi, 2006).

MATERIAL AND METHOD

We employed the FLUX 2D software package for our simulation. The analysis necessitates solving the electromagnetic problem within a parallel-plane structure. The magnetic field problem is simplified to determining a potential vector with a single component, which satisfies an analogous equation of the scalar potential. The core challenge of this hardening method lies in the coupling of thermal diffusion problems with eddy currents.

To ensure a comprehensive analysis, we must derive the results for eddy currents (power density) and temperature (thermal capacity and thermal conductivity).

RESULTS AND DISCUSSIONS

The numerical simulation conducted using FLUX 2D software provides an accurate determination of the relationship between the chosen frequencies, the desired treatment depth, and the power density. Understanding the desired treatment depth is vital for mapping the entire hardening process.

Figure 1. **The Mattock with teeth for roots**

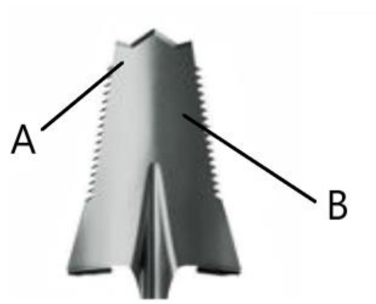

Figure 2. **Positioning of points A and B where the temperature field is analyzed**

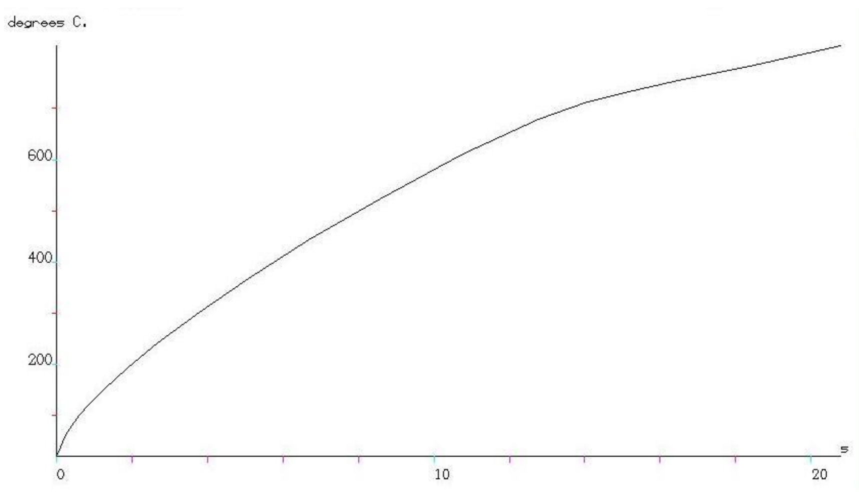

Figure 3. **The temperature in point A**

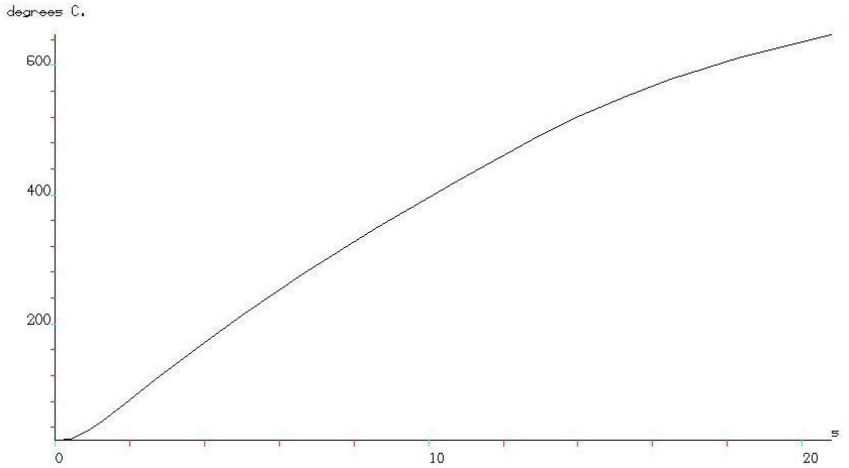

Figure 4. **The temperature in point B**

CONCLUSIONS

The thermal transfer to the workpiece's surface is characterized by a convection coefficient (α) of 20 $W/m^2/°C$ and a radiation coefficient (ε) of 0.75, which influences the temperature-dependent thermal transfer coefficient (αe).

The numerical simulation of the hardening process is inherently complex due to the nonlinear nature of eddy current problems arising from the nonlinear B-H relation. The thermal problem's nonlinearity stems from the dependence of thermal parameters on temperature.

Our simulation demonstrates that the coupling of these two problems results from the strong temperature-dependent relationship of the B-H relation. Through the proposed heat treatment, we achieve a homogeneous structure for the Mattock with teeth for roots (T. Leuca, 2007, 2009, M. Arion, 2008, M. Marincaru, P Minciunescu, 2011, F.I. Hanțilă 2012, A. Burcă 2012, 2013, 2014).

REFERENCES

V.Cingoski, "Analysis of magneto-thermal coupled problems involving moving eddy-current conductors", IEEE Transactions on Magnetics, May 1996 (vol.32, p.1042-1046)

K.Doppel, "Finite element method for calculating power frequency 2D electromagnetic field distributions in ferromagnetic materials", IEEE Transactions on Magnetics, May 1996 (vol.32, p.792-796)

T. Leuca, B. Cranganu-Cretu, M. Arion, G. Tarcau, "Numerical modelling of industrial processing by electromagnetic induction of ferromagnetic parts", 10th International IGTE Symposium on Numerical Field Calculation in Electrical Engineering, Graz, Austria 2002

T. Leuca, "Numerical modelling energy optimization of the electromagnetic and thermal coupled fields in the induction heating process of the cylindrical half-finished products", International symposium on non-linear electromagnetic systems, Braunschweig, May 1997

F. Hantila et all, "The numeric computation of eddy currents", Ed. ICPE, Bucharest, 2001 (in Romanian).

T. Leuca, M. Arion, G. Cheregi," Dual Frequency Simulation of the Electromagnetic Induction Process in Gear Wheels" Analele Univ din Oradea pp.36-39, Oradea 2005

G. R. Cheregi, "Contributions on the numerical analysis of the heating process through induction in the thermal treatments issues," doctoral thesis, 2006.

T. Leuca, M. Arion, G. Cheregi, I. Horge "About numerical computation of electromagnetic field in ferromagnetic bodies" Analele Universităţii din Oradea, 2007.

G. Cheregi, M. Arion "About the analisys of simultaneous induction hardening method of pinions with circular coil" Journal of electrical and electronics engineering, University of Oradea, 2008.

G. Cheregi, T. Leuca, M. Arion "About numerical analisys of electromagnetic field induce in gear wheels during hardening process" Journal of electrical and electronics engineering, University of Oradea, 2008,

M. Arion, G. Cheregi "About the analisys of simultaneous induction hardening method of pinions with rectangular coil" Journal of electrical and electronics engineering, University of Oradea, 2008.

T. Leuca, G. Cheregi „A simultaneous induction hardening method of pinions", Rev. Roum. Sci. Techn. – Électrotechn. et Énerg., 54, 2, Bucarest 2009

G. Cheregi, M. Arion „About the analisys of simultaneous induction hardening method of disk used at suspense harrow in agriculture with rectangular coil" Journal of electrical and electronics engineering, Vol. 3 nr. 2, University of Oradea, 2010,

M. Maricaru, P. Minciunescu, I. R. Ciric, G-M. Vasilescu, “A new vector boundary elements procedure for inductance computation” Rev. Roum. Sci. Techn. – Électrotechn. et Énerg., 56, 2, Bucarest 2011
Florea Ioan Hănţilă, Mihai Maricaru, Radu Mircea Ciuceanu, Lilica Corlan, “Harmonic analysis of circuits with nonlinear resistive elements” Rev. Roum. Sci. Techn. – Électrotechn. et Énerg., 57, 4, Bucarest, 2012
M. Arion, T. Leuca, F.I. hathazi, V.D. soproni, C. Molnar, G. Cheregi “Aspects Regarding the Numerical Computation of the Eddy Current Problem within the Electromagnetic Induction Processes of Thin Planes” Journal of electrical and electronics engineering, Vol. 5 nr. 2.University of Oradea, 2012.
Burca Adrian, Stanciu Bogdan, Mich-Vancea Claudiu., “Aided Design Elements of Induction Heating Process for Hardening”, Journal of Electrical and Electronics Engineering Oradea 2012
Burca Adrian, Leuca Teodor, Cheregi Gabriel,” Study on Using Concentrators in the Induction-Hardening Process of a Cylindrical Part”, Journal of Electrical and Electronics Engineering Oradea 2013
Burca Adrian, “Contributions to analyze electro-inductive systems equipped with high frequency inverters” doctoral thesis, 2014.
Cheregi Gabriel, Burca Adrian, Lucaci Mihaela Codruța, Derecichei Laura Melinda, Codău Anca Teodora – About Using Elta Software in Simulation of the Induction Hardening Method – Annals of Oradea University, Environmental Protection Fascicula, Vol. XXVII, pp. 365-370, 2016
FLUX 2D – tutorial.