ABOUT THE APPLICATION OF HEAT TREATMENT FOR THE HOMOGENIZATION OF THE STRUCTURE OF THE FOREST AXE'S BLADE.

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RESEARCH ARTICLE

Abstract

This study presents an analysis of the induction hardening method applied to forest axe's blade. 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, Forest axe's blade.
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INTRODUCTION

Forest axe's blade are crucial tools for the forestry industries. Forest axe's blade is a robust, indispensable tool in the forestry industry, used for:

- Handling and moving logs during logging.
- Adjusting the position of the wood before cutting or loading.
- Pushing, pulling or turning large logs safely.

It is essential for Forest axe's blade to have a homogeneous structure that meets the necessary specifications (T. Leuca, 2002).

The induction hardening simulation method is highly versatile and can be adapted to a wide range of metal geometries. This approach takes into account the variations in electromagnetic and thermal properties caused by changes in temperature. A key focus is the temperature-dependent B-H relationship, which shifts from an iron-magnetic state to an air-like state. In this process, the interaction between eddy currents and thermal diffusion becomes especially significant near the Curie point.

The B-H relationship is modeled as linear, with magnetic permeability dynamically adjusted based on the maximum effective value of magnetic induction. Our method applies a linear framework to incorporate these variations into the simulation. (G.R. Cheregi, 2006).

MATERIAL AND METHOD

For our simulation, we utilized the FLUX 2D software package. The analysis involved solving the electromagnetic problem within a parallel-plane structure. This was simplified by focusing on a single-component vector potential, which adheres to an equation analogous to that of the scalar potential. A primary challenge in this hardening method is the coupling between thermal diffusion and eddy current phenomena.

To conduct a thorough analysis, it was essential to compute results for both eddy currents (power density) and temperature, incorporating thermal capacity and thermal conductivity into the evaluation.

Process stages:

Rapid heating (0-5 seconds): The temperature rises quickly, simulating exponential heating.

Thermal holding (5-15 seconds): The temperature remains constant at approximately 800°C to allow internal thermal processes.

Controlled cooling (15-25 seconds): The temperature decreases linearly, simulating cooling in a controlled environment (fig. 4).

RESULTS AND DISCUSSIONS

The application of the proposed heat treatment improves the mechanical properties of the blade, such as:

Edge hardening: Increasing the hardness of the cutting edge for greater wear resistance. The process of localized induction heating followed by rapid cooling (quenching) is ideal for this purpose.

Blade body strength: The steel in the axe's body can be treated to maintain a combination of strength and flexibility, preventing cracking or breaking during use.

Treatment focus: The advantage of induction heating is that it can treat only the cutting edge without affecting the entire tool body, which is important for complex tools like the forest axe.

The numerical simulation performed with the FLUX 2D software enables precise determination of the relationship between selected frequencies, the target treatment depth, and the power density. Accurately defining the desired treatment depth is crucial for effectively mapping and controlling the entire hardening process.

Figure 1. **Forest axe's blade**

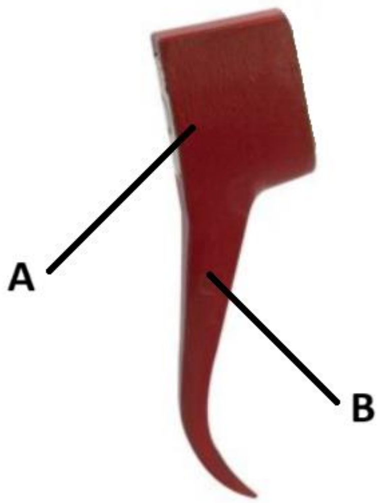

Figure 2. **Positioning of points A and B where the temperature field is analyzed**

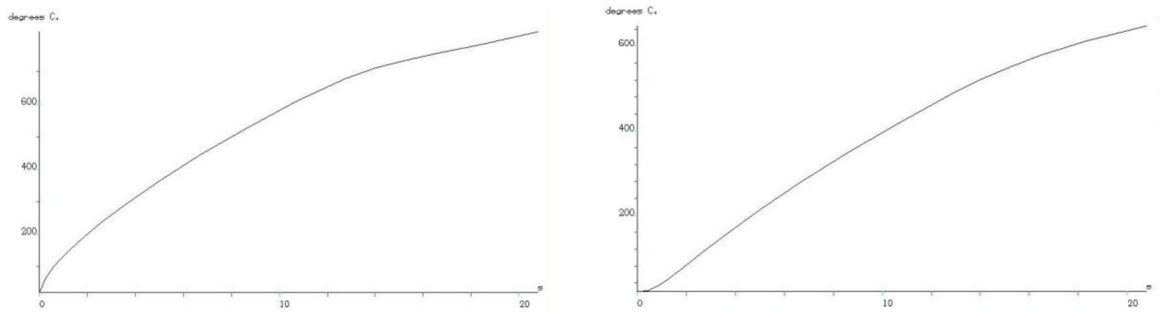

Figure 3. **The temperature in point A, B**

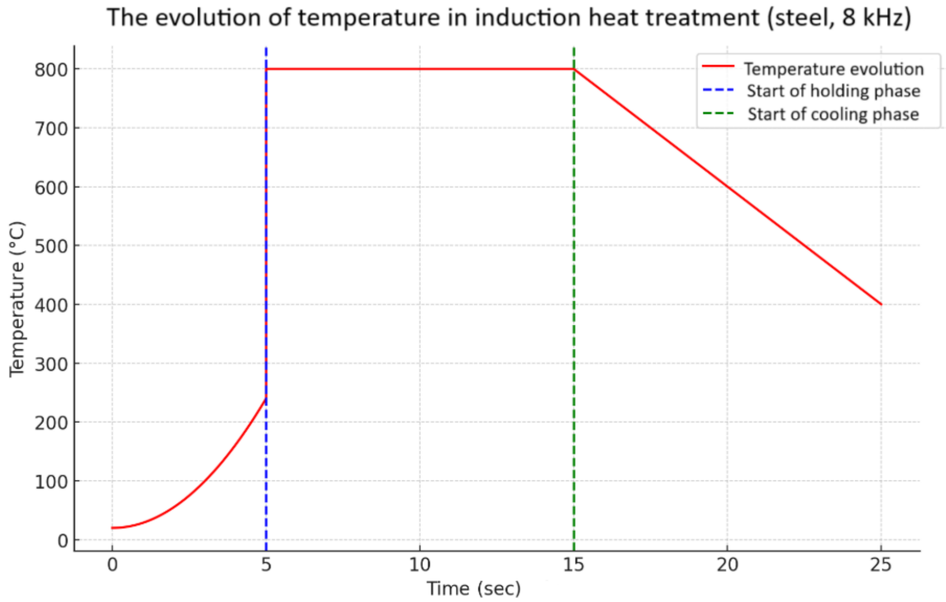

Figure 4. **The evolution of temperature**

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 Forest axe's blade (T. Leuca, 2007, 2009, M. Arion, 2008, M. Marincaru, P Minciunescu, 2011, F.I. Hanțilă 2012, A. Burcă 2012, 2013, 2014).

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FLUX 2D – tutorial.