EUROPEAN COOPERATION IN THE FIELD OF SCIENTIFIC AND TECHNICAL RESEARCH - COST

COST 526

Automatic Process Optimization in Materials Technology

(APOMAT)

Title:

Optimization of Heat Treatment of magnetic Materials applying the thermomagnetic Curves Data

Keywords: Optimization, Heat Treatment, Magnetic Materials, Thermomagnetic Curve

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1. Duration / run time of the project

January 1, 2002 to March 28, 2004

2. Overall cost

120 kEURO

3. Funding situation

Thinking about funding by Czech Ministry of Education, 30 kEURO

4. Project partners indicated to participate

We want to collaborate with the Faculty of Natural Sciences and Engineering, University of Ljubljana, as this partner is not only experienced in the field of optimization, but is also about to solve problems similar to those, presented in our proposal. We have concluded it after common discussion.

5. Project partners to be found

As we are concentrated in our scientific work on thermomagnetic and other structural measurements yielding approximate phase composition of the material together with critical temperatures of individual phases on one side, and studying of connection between material treatment and final magnetic characteristics on the other side, there are still at least two fields left, where the collaboration will be feasible for us. The first is the primary material preparation as we are equipped for preparing of small amounts of material only. The second is connected with the problem of algorithmization, because of the lack of experience in that particular problem. In both cases the collaboration will complete our capabilities and allow solving the problem on more generalized platform.

6. Short description of the material process to be optimized

The process of a heat treatment (annealing in vacuum furnace or in a furnace with a protective atmosphere of e.g. argon; in some cases also an atmosphere of hydrogen can be applied) and of a thermomagnetic treatments (the same as above, but with an external magnetic field applied on the material) will be optimized. Such a treatment of materials for magnetic circuits must be optimized due to the both quality and energy saving purposes. It is supposed to be the pilot process rather then an industrial one. During the material treatment there it is essential the shape of the temperature/time curve with special emphasis on temperature limits and delays. The influence of magnetic field during the heat treatment will be taken into account as well (thermomagnetic treatment). We can see the economic impact in lowering the number of negatively resulting trials and better quality of final material.

7. Material(s) involved:

Electrical steels and iron containing magnetic materials produced using a non-conventional technology, such as powders resulting from the electrical sparkling (erosion) process or mechanical alloying, melt

spun materials.

8. Optimization potential of the process or process step

Optimization of treatment will lower the processing time and improve the quality o material without basic changes in technology. As it will depend on frequency of new materials appearance and consecutive market demand, just a rough estimate can be done. The total economies of 25% of original costs are supposed. For one manufacturer it could bring annual savings of the order of 100 000 €.

9. Specified material properties to be achieved

The aim of the optimization is to achieve best magnetic properties according to the type of magnetic material. E.g. for soft magnetic materials (the most frequent case) the low coercivity and high permeability will be appreciated. It should be avoided the degradation of mechanical properties.

10.Process parameters to be optimized

Annealing temperature and time delays, chemical composition of the protective atmosphere, surface treatment, influencing the macroscopic magnetic parameters such as coercivity, permeability, saturation, energy product.

11.Material laws including material dependent coefficients

As a basis relation between coercivity (the important magnetic material characteristic) and material structure (grain size) will be taken. This law is usually published in the form of $H_c = 2K_1/M_s\ (D/d_B)^6$, where K_1 is the anisotropy constant, M_s the magnetization (magnetic moment), d_B the Bloch wall thickness, and D the grain size. Change of atomic magnetic moment (connected with the saturation, that also influences the material quality) according to the configuration of neighbours is ruled by a simple theory of an additive influence of neighbouring magnetic moments. Some of the data are available in publications. These two basic parameters (coercivity and magnetic moment) are driven by heat treatment through the grain size. Thus for their optimum values suitable heat treatment will be found.

12.Simulator

In case that simulation of annealing process will be necessary, the ANSYS package will be used.

13.Optimizer

At the beginning of this particular optimization task we want to start using Newton-Marquardt optimisation method that was already proved in the past on some other problems. We suppose to take it from the universal Optimization toolbox of the MATLAB software. As the optimization procedure will become more specific, more sophisticated packages either from the freeware or shareware domain (e.g. the GAMS library) or from commercial domain will be used.

14.Competence / activities of proposer:

The proposer works as a scientific co-worker in an institute specialized in material research. He is experienced in the field of Mössbauer spectroscopy, magnetic measurements, magnetic properties of soft magnetic materials, hyperfine interactions, computer controlled experiments, application software development.

15.International state of the art and references

The results of thermomagnetic curves are used to illustrate the connection between structural and magnetic properties of (soft) magnetic materials and define critical temperatures. However, up to the knowledge of the proposer, neither parametrization of such curves was published nor their utilization for common optimization of material processing.

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