Effect of Dynamic Heat Treatment on Microstructure Evolution and Magnetic Properties of FeSi Steels.

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Non-oriented FeSi electrical steels are an important class of soft magnetic materials commonly used as core components in various types of rotating electrical equipment. Their soft magnetic properties strongly depend on the ability to control grain size, crystallographic texture, and the chemical composition of the final steel sheets. The most favorable texture for non-oriented silicon steels is the "rotating cube" texture, which ensures isotropic magnetic properties in all in-plane directions of the sheet metal. This study examines the microstructure and texture evolution of temper-rolled, non-oriented FeSi electrical steels subjected to heat treatment at different heating rates.

Keywords: FeSi steels, texture, microstructure, coercivity

1. Introduction

Electrical steels play a crucial role in the generation, transmission, distribution, and utilization of electrical power and are among the most important magnetic materials produced today. Typical applications of electrical steel sheets include motors, generators, and transformers [1]. This study focuses on the use of the strain-induced grain boundary migration effect in combination with the heat transport effect for the evolution of the microstructure of non-oriented (NO) silicon steels during dynamic continuous annealing. The objective is to develop a coarse-grained microstructure with an increased intensity of the “Cube” {100}<0vw> and/or “Goss” texture components.

2. Results and discussion

In this study, low-silicon steel was used as the experimental material. The final-state samples were subjected to varying degrees of mild cold rolling deformation, ranging from 2% to 10%, and subsequently annealed under dynamic conditions at three different temperatures.

The results obtained from EBSD measurements, which illustrate the intensities of specific crystallographic texture components in both the as-received and laboratory-treated states, are presented in Fig. 1. The initial microstructure of the

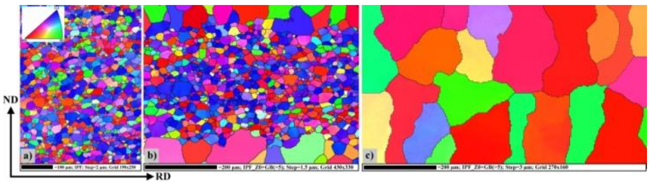

Figure 1: IPF maps represent the crystallographic orientation of individual grains of samples taken after annealing in a) industrial conditions, dynamic conditions b) 850°C and c) 950°C

steel samples received from the industrial production line is shown in Fig. 1a. The onset of columnar grain growth in the investigated samples after annealing at 850°C and the fully developed columnar microstructure obtained after annealing at 950°C for 10 minutes are depicted in Fig. 1b and Fig. 1c, respectively. The heat treatment of the experimental samples was performed under both dynamic and long-term annealing conditions.

The dependence of the measured coercivity (Hc) on the applied deformation and annealing temperature is presented in Fig. 2. The lowest coercivity value recorded for the sample was 17 A/m in the DC magnetic field and 67 A/m at 1.5 T in the AC magnetic field. These coercivity values were obtained for laboratory samples subjected to temper rolling with a 4% reduction, followed by final annealing at 950°C for 10

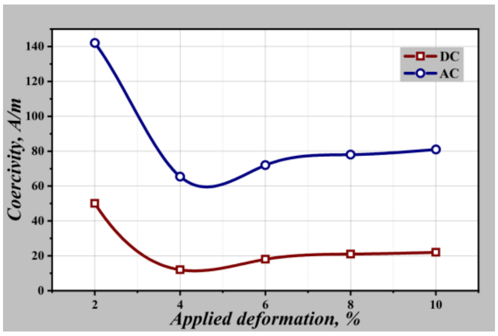

Figure 2: The values of coercivity measured in DC and AC (50 Hz) magnetic field as a function of applied deformation

minutes. In comparison, the coercivity values for the samples taken from the industrial production line were 75 A/m in the DC magnetic field and 185 A/m in the AC magnetic field.

Using a strain-induced boundary migration mechanism, we have demonstrated that a columnar microstructure can be achieved in isotropic electrotechnical steels. As shown, the laboratory thermo-mechanical treatment resulted in increased intensities of the favorable cube {100}<0vw> and Goss ({111}<001>) texture components, along with a reduction in the unwanted {111}<uvw> deformation texture.

References

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