MAGNETIC PROPERTIES AND TEXTURE OF ORIENTED Fe-Si-Sb MATERIALS[1])

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In the paper presented the results obtained in the investigation into the influence of antimony of the final recrystallization textures and magnetic characteristics of Fe-3% Si steel are presented. The experiments proved a substantial influence of antimony alloying on the quantitative representation of (110) [001] and (100) [001] textures. The confrontation of texture analyses with magnetic measurements proved a substantial correlation between them.

МАГНИТНЫЕ СВОЙСТВА И ТЕКСТУРА ОРИЕНТИРОВАННЫХ МАТЕРИАЛОВ Fe-Si-Sb

В работе приведены результаты исследований влияния примеси сурьмы на финальные рекристаллизационные текстуры и магнитные характеристики стали Fe-3% Si. Эксперименты указывают на существенное влияние легирующей сурьмы на количество текстур типа (110) [001] и (100) [001]. Сравнение анализа текстуры с магнитными измерениями показывает их значительную корреляцию.

I. INTRODUCTION

The development and production of oriented transformer steel sheets with low specific losses and a high magnetic induction represent a highly topical set of research problems. Technical literature has enabled us to improve the physical properties of oriented Fe-Si sheets by means of the modification of their chemical composition by surface active elements, such as B, Sb, and Se [1—3]. The aim of the present paper is to study the influence of antimony micro-alloying upon the development of texture and the magnetic characteristic of sheets of 3% Si steel.

[1]) Contribution presented at the 7th Conference on Magnetism, KOŠICE, June 5—8, 1984.

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II. EXPERIMENTAL METHODS AND RESULTS

For our experiments we used specimens of sheet made by means of the technology of hot rolling and cold rolling, rolled to the thickness of 0.35 mm after complete thermal treatment. The chemical composition of transformer steel produced in an oxygen converter, as well as the analysis of the experimental material after antimony alloying are shown in Table 1. Antimony was added to steel in moulds, applying ferroantimony Fe_xSb_y. For the study of texture in the examined specimens, we used {110} pole figures obtained by means of Schulz's method. The values of the intensity of reflections marked in the pole figures are related to the standard measure of powder Fe. Specific losses and induction were measured with the help of Epstein's apparatus.

Table 1

Chemical composition (wt %) of experimental materials 3 % silicon transformed steel

	Sample	C	Mn	Si	P	S	Sb	Al	Ni	N_2
Analysis of steel		0.020	0.070	3.150	0.014	0.014	—	0.003	0.010	0.008
Analysis of sheet	A	0.002	0.050	3.200	0.009	0.016	—	0.017	0.020	0.008
	B	0.002	0.060	3.210	0.009	0.014	0.048	0.015	0.020	0.009

A — samples without antimony
B — samples with antimony

Table 2

Results of magnetic measurements
Standard values of quality E_o10 and E_o11

Sample	Cole losses [W/kg]			Magnetic induction [T]		
	$P_{1.0}$	$P_{1.5}$	$P_{1.7}$	B_{30}	B_{2500}	B_{10000}
E_o10	0.49	1.02	1.65	1.20	1.88	1.98
E_o11	0.52	1.12	1.75	1.12	1.84	1.96
E_oA	0.49	1.15	1.75	1.00	1.84	1.98
$E_{sb}B$	0.40	0.94	1.39	1.25	1.90	2.02

The texture analysis of specimens (labelled A) prepared of silicon steel of standard composition proved a substantial representation of texture (110) [001].

The pole figure is documented in Fig. 1. The analysis of specimens (labelled B) with the content of 480 ppm Sb showed, apart from a substantial representation of the Goss component, also the presence of cubic (100) [001] texture with the intensity of reflections $p_i = 3.5$. The pole figure is shown in Fig. 2.

The results of magnetic measurements are processed in Tab. 2. They can be compared with the best qualities $E_0 10$ and $E_0 11$ according to ČSN 42 0231.

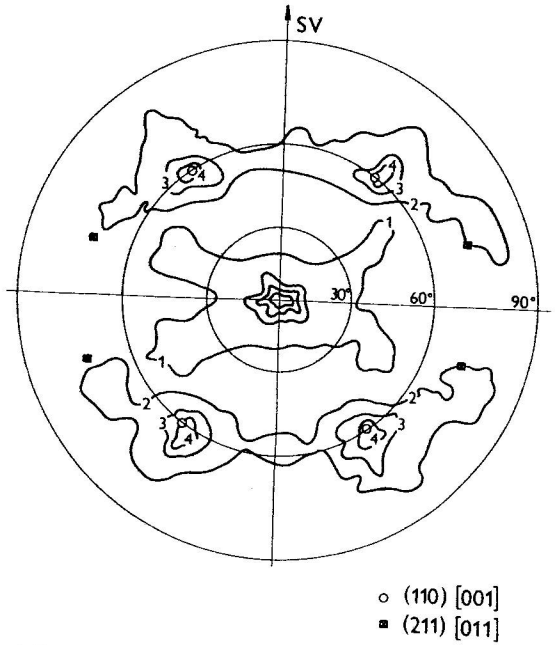

Fig. 1. Pole figures of Fe-3% Si steel without Sb after final treatment.

III. DISCUSSION

It is well-known that the magnetic properties of sheets made of 3% Si steel are directly dependent on the volume representation, type and perfectness of texture. With regard to the high magnetocrystalline anisotropy of Fe-3% Si alloys it is important for transformer sheets to have grains oriented in the direction of light magnetization; therefore only textures of types {110} ⟨001⟩ and {100} ⟨001⟩ are of practical importance. The accomplished confrontation of the results of magnetic measurements (Table 2) with texture analyses (Figs 1, 2) proved the coexistence of Goss and cubic textures only in Sb-alloyed specimens. This also explains their more advantageous magnetic properties when compared with specimens made of classic steel. Our results are in agreement with data published in technical literature concerning the positive influence of some surface-active elements upon texture—forming processes and magnetic properties of Fe-Si alloys [1—5].

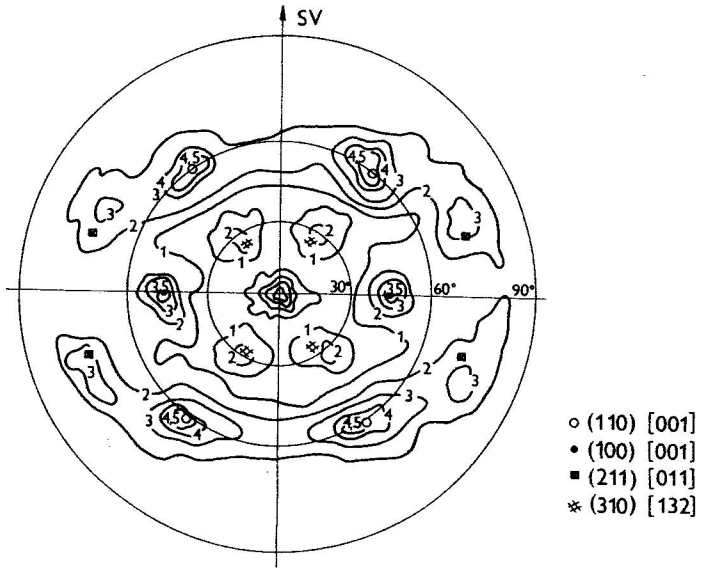

Fig. 2. Pole figures of Fe-3% Si steel with Sb after final treatment.

IV. CONCLUSIONS

1. Our experiments confirmed the influence of antimony upon the process of optimizing the resulting crystallographic and magnetic texture of oriented transformer sheets.

2. Antimony was added to silicon steel in a suitalbe concentration as an alloying addition with a positive influence of the resulting magnetic properties of anisotropic Fe-3% Si sheets.

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Received December 14th, 1984