ISSN 0543-5846
METABK 63(2) 209-211 (2024)
UDC – UDK 669.15.782:621.771-539.373:620-18.002.3:620.18=111

Y. Y. SHAO, Z. W. JIA, Q. GUO

EFFECT OF FINISHING ROLLING REDUCTION ON MICROSTRUCTURES AND TEXTURES OF GRAIN ORIENTED SILICON STEEL

Received – Primljeno: 2023-08-22
Accepted – Prihvaćeno: 2023-11-20
Original Scientific Paper – Izvorni znanstveni rad

The effect of finishing rolling reduction on microstructures and textures of grain oriented silicon steel was researched by optical microscopy, zeiss ultra 55 Scanning Electron Microscope (SEM) and Electron Backscatter Diffraction (EBSD) technique severally. The results show that the grain size of hot rolled sheets and decarburized strips decreases, while the center grain size of the normalized sheet increases with the increase of the finishing rolling reduction. The pearlite content increases with the increase of the finishing rolling reduction after normalization. Compare with the previous research, the effect of finishing rolling reduction on the grain size of primary recrystallization is greater than that of roughing rolling reduction, and large rolling reduction is beneficial to the formation of {110}<001> texture.

Key words: grain oriented silicon steel; finishing rolling reduction; SEM; EBSD; microstructure

INTRODUCTION

Grain oriented silicon steel which is known as cold rolled transformer steel is an important ferrosilicon alloy used in transformer manufacturing industry. The purpose of preparing oriented silicon steel is to obtain sharp {110}<001> texture during secondary recrystallization. Some research shows that the {110}<001> texture is a typical shear texture formed during the hot rolling process, and it has obvious heritability[1-4]. It can be indicated that hot rolling texture has significant influence on the secondary recrystallization texture. Consequently, it is very important to improve the magnetic performance of the grain oriented silicon steel that clarify the effect of hot rolling process on the microstructures and the textures of it. As in the previous studies, the effect of hot rolling temperature and roughing rolling reduction on microstructures and textures of the grain oriented silicon steel was studied respectively[5, 6]. In this paper, the effect of finishing rolling reduction on microstructures and textures of the grain oriented silicon steel will be researched.

EXPERIMENTAL MATERIALS AND METHODS

Grain oriented silicon steel was selected as the experimental material with main components of 0,053 % C, 3,18 % Si, 0,115 % Mn, 0,028 %. Continuous cast slab was rolled to 2,3 mm and 2,0 mm thickness during the hot rolling process respectively. Then the hot rolled sheets were designated as 2,3-sample and 2,0-sample separately. Subsequently, the microstructure was observed by using optical microscopy technique. The crystallographic orientation measurement was carried out on the lateral section of the samples using an HKL (Hough Kikuchi Laue) -EBSD system, and the image field was the region of 1/2 thickness beneath the surface of hot rolled and normalized sheets.

Y. Y. Shao: College of Applied Technology, University of Science and Technology Liaoning, Anshan, Liaoning, China
Z. W. Jia: Iron and Steel Research Institutes , Ansteel Co. Ltd., Anshan, Liaoning, China
Q. Guo: Cold Rolling Silicon Plant, Ansteel Co. Ltd., Anshan, Liaoning, China
Corresponding author: Y. Y. Shao (Email address: shaoyy1980@163.com)

MICROSTRUCTURE ANALYSIS

Figure 1 shows the microstructures of the hot rolled sheets with different final rolling thickness. It can be

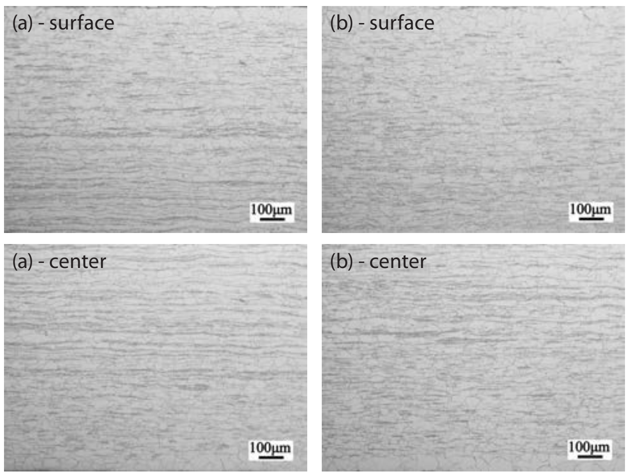

Figure 1 Microstructures of hot rolled sheets
(a) 2,0-sample; (b) 2,3-sample

seen that the grain size of the hot rolled sheets decreases with the final rolling thickness thinning. The reason is that the deformation energy storage of the strip steel is large with the increase of finishing rolling reduction, which leads to the increase of recovery and recrystallization driving force, and thus the number of dynamic recrystallized grains increases. According to the results of statistics, the recrystallized grain size ratio of 2,3-sample is 15 – 60 %, while that of 2, 0-sample is 14 – 63 %.

Figure 2 illustrates the microstructures of the normalized sheets with different final rolling thickness. According to the statistical results, the surface grain size of the normalized sheet decreases, while the center grain size of the normalized sheet increases with the final rolling thickness thinning. However, the change of the center grain size is not obvious. The main reason for this result is that the pearlite content in the center layer of 2,0-sample with high reduction is more than that of 2,3-sample with low reduction after hot rolling. In addition, the pearlite content increases with the increasing of finishing rolling reduction after normalization, which is related to the acceleration of the cooling rate caused by the thinning of the sheet thickness.

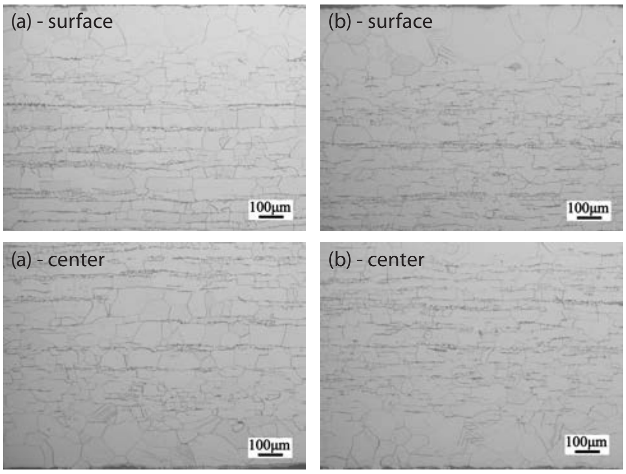

Figure 2 Microstructures of normalized sheets
(a) 2,0-sample; (b) 2,3-sample

Figure 3 shows the microstructures of decarburized strips with different final rolling thickness. It can be found that the average size of primary recrystallized grain decreases with the increase of the final rolling reduction. According to the result of statistics analysis, the grain size difference between the two samples is about 0,8~1,5 μm, while the standard deviation difference is about 1,2 μm. It can be recognized that the finishing reduction has a more obvious effect on the grain size of primary recrystallized grain than roughing reduction[6].

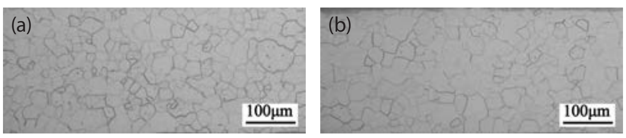

Figure 3 Microstructures of decarburized strips
(a) 2,0-sample; (b) 2,3-sample

TEXTURE ANALYSIS

Figure 4 shows the EBSD orientation maps of the hot rolled sheets. It can be seen that the surface layer of the hot rolled sheet is dominated by shear textures, such as sharp {111}<112> and {110}<001> texture. Moreover, the center layer of the samples is dominated by deformation textures, such as α fibre texture <110>. By comparison, the surface shear region of the 2,0-sample is thicker, and more {110}<001> oriented grains can be found. Furthermore, the strong {111}<112 > texture is formed in the center deformation region of the 2,0-sample. The reason is that the friction and shear effects on the surface layer of the sample are larger, and the plane compression effect on the center layer is larger during the high reduction hot rolling.

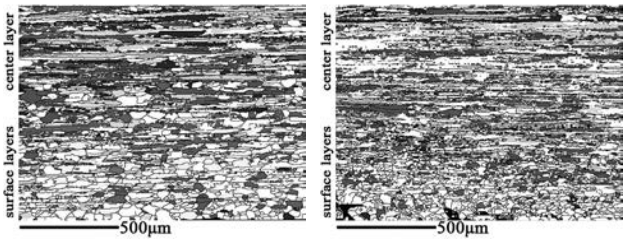

Figure 4 EBSD orientation maps of hot rolled sheets
(a) 2,0-sample; (b) 2,3-sample
{110}<001>; {114}<481>; {111}<112>;
{111}<110>; {110}<112>

Figure 5 indicates the EBSD orientation maps of the normalized sheets. As can be seen from the figure, the surface layer grain size of the normalized sheets decreases, while the number of recovered and recrystallized grains of the center layer increases with the increasing of the finishing reduction. Compared with the hot rolled sheet, the texture components of the samples are basically similar, but the sharpness of the textures is decrease after normalizing. It can be seen by comparison that the {110}<001> texture intensity of the 2,0-sample is higher than that of the 2,3-sample, while the {114}<481> texture intensity of the 2,0-sample is weaker than that of the 2,3-sample. Therefore, high reduction rolling is beneficial to the formation of the

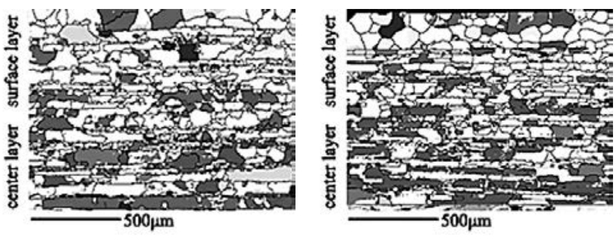

Figure 5 EBSD orientation maps of normalized sheets
(a) 2,0-sample; (b) 2,3-sample
{110}<001>; {114}<481>; {111}<112>;
{111}<110>; {110}<112>

{110}<001> texture. The sharp {110}<001> texture obtained in the surface layer of the 2,0-sample indicates the heritability of the texture, while the sharp {110}<001> texture formed in the center layer shows the rotation of {111}<112> to {110}<001> texture.

CONCLUSIONS

The grain oriented silicon steel is hot rolled under different finishing rolling reduction, and the conclusions are as follows:

The grain size of hot rolled sheets and decarburized strips decreases, while the center grain size of the normalized sheet increases with the increase of the finishing rolling reduction.

The pearlite content increases with the increase of the finishing rolling reduction after normalization, which is related to the acceleration of the cooling rate.

The effect of finishing rolling reduction on the grain size of primary recrystallization is greater than that of roughing rolling reduction.

Large rolling reduction is beneficial to the formation of {110}<001> texture. The {110}<001> texture of the surface layer indicates the heritability of the texture, while that of the center layer shows the rotation of {111}<112> to {110}<001> texture after normalization.

Acknowledgements

This work is financially supported by Liaoning province Department of Education fund item, No. LJKZ0305.

REFERENCES

[1] M. Munetsugu, S. Tomohiko, Y. Suga. Origin and development of through the thickness variations of texture in the processing of grain-oriented silicon steel [J]. Metallurgical Transactions A, 17(1986)8, 1313-1322.

[2] I. Yukio, M. Chizuko, I. Yo, et al. Transmission Kossel study of origin of Goss texture in grain oriented silicon steel [J]. Transactions of the Iron and Steel Institute (1983)23, 440-446.

[3] Y. Y. Shao, P. Yang, Y. J. Fu, et al. Texture evolution of columnar grains in electrical steel during hot rolling [J]. Journal of Iron and Steel Research, International 20(2013)10, 99-106.

[4] M. Q. Yan, H. Qian, P. Yang, et al. Behaviors of brass texture and its influence on Goss texture in grain oriented electrical steels [J]. Acta Metallurgica Sinica 48(2012)1, 16-22.

[5] C. J. Wang, Q. Guo, Y. Y. Shao. Effect of hot rolling temperature on microstructures and textures of grain oriented silicon steel [J]. Metalurgija 60(2021)3-4, 216-218.

[6] Y. Y. Shao Z. W. Jia, Q. Guo. Effect of hot rolling reduction on microstructures and textures of grain oriented silicon steel [J]. Metalurgija 61(2022)3-4, 697-699.

Note: The responsible translator for English is Yuan Yuan Shao, University of Science and Technology Liaoning, Anshan, China