Effects of Cold Rolling Annealing Process on Corrosion Resistance of Semi-process Electrical Steel of Middle and Low Grades

Feng Zhou1,3,a, Shunqiang Yao 2b, Qing Zhou 1c

1Foshan Polytechnic, Foshan 528137, Guangdong
2Zhongshan Zhongsheng Metal Strip Technology Co., Ltd., Zhongshan 528441, Guangdong
3Guangdong Gent Material Surface Technology Co., Ltd., Zhongshan 528437, Guangdong

aemail: whzf1234@fspt.edu.cn, bemail: yaoshunqiang@126.com
Qing Zhou: email: zhouqing@fspt.edu.cn

Abstract: Semi-process non-oriented electrical steel with poor corrosion resistance is easily rusted during the process of production, transportation, and application by end customers. In response to this problem, the paper studies the effect of different tapping temperatures in the cold rolling annealing process and cleaning process after tapping on its corrosion resistance. The results show that the higher the tapping temperature is, the worse the corrosion resistance will be. Cleaning with formic acid can increase its corrosion resistance.

1. Introduction
Semi-process non-oriented electrical steel is prone to rust during the process of production, transportation, and application, resulting in significant quality and economic losses to manufacturers and customers, and severely hindering the domestic promotion and application of this product. Every year, steel corrosion inflicts huge losses to the country [1]. Liang Caifeng et al. studied the influence of alloying elements on the corrosion performance of steel in the atmosphere [2], and Wang Bin et al. studied the effect of hot-rolled controlled rolling on the corrosion performance of low alloys [3-4], while Shen Kai et al. studied the effect of rolling temperature on the corrosion performance of low alloys [5-6]. So far, there is no research conducted on the effects of cold-rolled annealing temperature and cleaning process of semi-process non-oriented electrical steel on the corrosion performance. Through laboratory simulation of the cold-rolled annealing temperature and cleaning process of semi-process non-oriented electrical steel, this paper studied the effects of different annealing temperatures on corrosion performance as well as the effects of cleaning processes on corrosion resistance, which provides theoretical guidance for the design of cold-rolled annealing process parameters and the formulation of cleaning processes for semi-process non-oriented electrical steel.

2. Experimental materials and methods
The semi-process non-oriented electrical steel 50WB800 cold rolled steel plate from Hunan Valin Lianyuan Iron & Steel Co., Ltd was selected as the experimental material, with its chemical
composition shown in Table 1.

Table 1 The chemical composition of 50WB800 (mass fraction, %)

| Steel    | C   | Si | Mn  | P     | S     | Al  |
|----------|-----|----|-----|-------|-------|-----|
| 50WB800  | 0.0032 | 0.75 | 0.24 | 0.0100 | 0.0010 | 0.024 |

The cold rolled annealed strip of 50WB800 was processed into a 0.5mm×100mm×100mm sample, and then put into the SYX-6-17 box-type resistance furnace, and next heated to 50°C, 75°C, 100°C, 125°C, 150°C at a heating rate of 0.5°C/min, for 5-minute warm-keeping and finally was cooled to room temperature in the furnace. The cold-rolled samples of semi-process non-oriented electrical steel 50WB800 were cleaned with formic acid aqueous solution with a concentration of 8% and a temperature of 30°C. After acid cleaning for 30s, the samples were rinsed with tap water for 8-10 s, and rinsed with distilled water for 3 times, and dried immediately with cold air. Then, the VersaSTATMC electrochemical workstation is used to perform electrochemical tests on these samples, with the following conditions: the temperature was about 25°C, with 3.5% NaCl as the working medium and no stirring, and the reference electrode was a saturated calomel electrode, with carbon rods used as auxiliary electrode, and the test area of the research electrode was 1cm².

3. Experimental results
The electrochemical measurement results are shown in Figures 1 and 2.

![Figure 1](image1.png)

Figure 1 The effects of annealing temperature on the polarization curve of steel plate

![Figure 2](image2.png)

Figure 2 The effects of cleaning after annealing on the polarization curve
It can be seen from Figure 1 that as the tapping temperature rises, the corrosion potential is constantly moving up, which can be concluded that the higher the tapping temperature is, the worse the corrosion resistance of the steel plate will be.

It can be seen from Figure 2 that samples cleaned with formic acid has significantly higher corrosion potential in polarization curve than those without formic acid cleaning, indicating that its corrosion potential is greater, and the corrosion resistance of the steel plate is significantly increased after formic acid cleaning.

The AC impedance spectrum within different tapping temperatures is shown in Figure 3. It can be seen from Figure 3 that the higher the tapping temperature is, the worse the corrosion resistance of the steel plate will be.

The easily oxidizable elements like Mn, Al, Cr, Si, etc. in the steel present different degrees of segregation under different temperature conditions. The higher the temperature is, the easier the segregation will be. In particular, under high content of Mn, segregation on the steel plate surface is easier. the metal matrix and the precipitated oxidation will easily form corrosion micro-battery, which improves the activity of Fe⁺ on the steel plate surface and accelerates the corrosion process of the steel plate: Fe→Fe²⁺+2e⁻, 1/2O₂+H₂O+2e⁻→2OH⁻.

In the annealing process of semi-process non-oriented electrical steel, many factors may affect the accumulation of various easily oxidizable elements on the steel plate surface, such as preheating (heating temperature rate, furnace atmosphere, etc.), annealing (holding temperature, holding time, etc.), cooling rate and aging, etc.; the deformation amount and total reduction rate in different passes during cold rolling of semi-process non-oriented electrical steel will also affect the accumulation, diffusion and distribution of easily oxidizable elements during the annealing process. However, in general, as the annealing temperature rises, more oxides are precipitated, which accelerates the steel plate corrosion process.

4. Conclusions
(1) The higher the temperature of 50WB800 cold-rolled annealing is, the worse the corrosion resistance of the steel plate will be. Therefore, during the production process, the steel plate needs to be cooled to below 50 °C in the bell furnace before discharge.

(2) If the 50WB800 annealed steel plate is cleaned by formic acid, the corrosion resistance can be greatly increased.

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