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## **Effects of Cr Content on Electromagnetic Properties of Medium and Low Grade Non-Oriented Electrical Steel**

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**Abstract:** This paper takes the medium and low grade non-oriented electrical steel as the research object. Through the data analysis in the production process, the corresponding relationship between the Cr content and the electromagnetic properties of the non-oriented electrical steel was studied. The results show that with the increase of Cr content, the core loss increases and the magnetic induction decreases, thus the magnetic properties are directly proportional to Cr content.

#### **1. Introduction**

Medium and low grade non-oriented electrical steel is widely used in electromechanical products such as small and medium-sized motors, and its output accounts for more than 70% of non-oriented electrical steel <sup>[1-3]</sup>. The functional level of electrical steel is mainly measured by the two indexes of electromagnetic performance, core loss P (W/kg), and magnetic induction B (T) <sup>[4-5]</sup>. Inclusions in steel are an important factor affecting the electromagnetic properties of non-oriented electrical steel. Lean ore is widely used in ironmaking in a steel plant. In the ore, the content of Cr is very high, which is difficult to remove in the steelmaking process and will affect the stability of electromagnetic properties of non-oriented electrical steel. Based on the corresponding analysis of Cr content in the molten iron and the electromagnetic properties, this paper finds out the corresponding relationship between the two, which provides a reference for the coal blending and ore blending in the production organization of medium and low grades of non-oriented electrical steel.

#### 2. Comparison between the Magnetic Properties and Corresponding Cr Content

The relationship between the average core loss and magnetic induction of different batches of the medium and low grade non-oriented electrical steel produced by a randomly selected steel plant with the average Cr content is shown in Figures 1-4 and Table 1.

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Figure 2 The relationship between magnetic induction and Cr content



Figure 3 The relationship between core loss and Cr content

Figure 4 The relationship between magnetic induction and Cr content

	Cr content, %		core loss, W/kg			Magnetic induction, T			
Producti on time	minimu m value	Maximu m value	Averag e value	minimu m value	Maximu m value	Averag e value	minimu m value	Maximu m value	Averag e value
July	0.022	0.038	0.028	4.784	5.21	5.014	1.726	1.735	1.731
August	0.02	0.032	0.026	4.824	5.181	4.975	1.728	1.734	1.731
Septemb									
er	0.047	0.059	0.054	4.743	5.64	5.141	1.726	1.736	1.73

Table 1 The relationship between magnetic properties and Cr content

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It can be seen that the core loss and the corresponding Cr content are low in August; In September, the core loss of the medium and low grade non-oriented electrical steel increases significantly, the Cr content also increases, and the magnetic induction decreases, thus the core loss is almost directly proportional to the Cr content.

The magnetic properties of the medium and low grade non-oriented electrical steel with different Cr content are shown in Figure 5, Figure 6, and Table 2. In Table 2, performance 1 is the magnetic performance with Cr content  $\leq 0.03\%$ , while performance 2 is the magnetic performance with Cr content> 0.03\%.

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Figure 5 The relationship between core loss and Cr content



Table 2 The influence of Cr content on the magnetic properties	fluence of Cr content on the	magnetic properties
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	Cr content, %			core loss, W/kg			Magnetic induction, T		
	minimu	Maximu	Averag	minimu	Maximu	Averag	minimu	Maximu	Averag
Project	m value	m value	e value	m value	m value	e value	m value	m value	e value
Performan									
ce 1	0.018	0.03	0.025	4.75	5.457	5.022	0.721	1.734	1.29
Performan									
ce 2	0.031	0.059	0.042	4.743	5.64	5.1	1.726	1.736	1.728

It can be seen that compared with Cr content  $\leq 0.03\%$ , the core loss of the medium and low grade non-oriented electrical steel with Cr content > 0.03% significantly increases and the magnetic induction decreases.

#### 3. Changes of Cr content in liquid iron

The change of Cr content in liquid iron from July to September in blast furnaces supplying the medium and low grade non-oriented electrical steel is shown in Figure 7 and Table 3.



(a) The Cr content in liquid iron in July



(b) The Cr content in liquid iron in August



(c) The Cr content in liquid iron in September Figure 7 The Cr content in liquid iron from July to September

Table 3	The average	Cr content from	July to September
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Month	July	August	September
Cr Content/%	0.037	0.040	0.085

From the scatter plot of the Cr content of the blast furnace hot metal from July to September, it can be seen that the Cr content of the blast furnace hot metal in July was below 0.05%, and it began to increase significantly in late August, mainly due to the addition of Indonesian powder to the sinter, which has a high Cr content of 1.8%.

#### 4. Analysis and Discussion of the Reason

Cr has a certain affinity with O, N, and other elements dissolved in the steel. Cr, O and N will remain in the steel in the form of CrN,  $Cr_2O_3$ , and other inclusions <sup>[6]</sup>, which increases the dislocation density in the surrounding area and causes an internal stress field many times larger than its own volume, making the magnetic wall difficult to move. Such inclusions are non-magnetic, hard, angular, insoluble or slightly soluble in liquid steel. Therefore, it is difficult to magnetize, which will inhibit the grain growth in the steel during annealing, increase the core loss and reduce the magnetic induction. Compared with other spherical inclusions, needle-shaped inclusions such as CrN and  $Cr_2O_3$  are more harmful <sup>[7]</sup>. Therefore, the Cr content in electrical steel should not be too high, and its target content is generally required to be less than 0.03%.

#### 5. Conclusion

Through statistical analysis of data and theoretical research, it can be seen that with the increase of Cr content, the core loss of electrical steel shows an upward trend, while the magnetic induction shows a downward trend. When the Cr content is less than 0.03%, the electromagnetic properties of the medium and low grade non-oriented electrical steel are better. Since Cr is not added in the smelting process of electrical steel, the liquid iron is the main source of Cr in steel. Therefore, the coal and ore blending in ironmaking process must be controlled to control the content of Cr in liquid iron.

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