

Highest Grade Non-Heat Resistant Domain-Refined Grain-Oriented Electrical Steel: 23JGSE070

1. Introduction

In recent years, measures to achieve carbon neutrality at the global scale have accelerated in response to a heightened sense of crisis about global warming, and energy conservation efforts such as the use of natural energy, as represented by offshore wind power generation, are strongly demanded. Each nation also regulates the efficiency of transformers, which are an important component element of electric power transportation systems. Strict transformer efficiency regulations are now imposed in the form of the Top Runner Program (Second Evaluation Standard, 2014) in Japan, the Department of Energy (DOE) regulations (2016) in the United States and the Ecodesign Directive (Tier 2, 2021) in Europe, and further strengthening of regulations is also expected in the future. For this reason, even lower iron loss is required in the grain-oriented electrical steel used for the core materials of transformers, resulting in greatly increased demand for magnetic domain-refined materials with ultra-low iron loss.

JFE Steel supplies the JGSD™ Series^{1, 2)} of heat resistant domain-refined materials that are applied mainly for wound core type transformers, which are subjected to annealing treatment, and that can be used without annealing treatment for stacked core type transformers, and the JGSE™ Series of non-heat resistant domain-refined materials that meet the need for ultra-low iron loss and show even better iron loss properties for stacked core type transformers, which do not require annealing.

2. Properties of the Developed Material (23JGSE070)

The iron loss of electrical steels is classified into eddy current loss and hysteresis loss. Eddy current loss is loss that occurs due to an inductive current that flows in a transformer core under AC excitation. The effective measures for reducing eddy current loss are decreasing the sheet thickness, increasing electrical resistivity by increasing the Si content of the steel, reducing the grain size, and refining magnetic domain. The effective measures for reducing hysteresis loss are higher cleanliness in the steel sheets by removing impurities, and increasing the magnetic flux density by heightening the degree of integration to the rolling direction of {110}<001> grains, which is called the Goss direction and is easily magnetized. JFE Steel adopted magnetic domain refinement by efficiently introducing local strain in the steel sheet surface, and began sales of the JGSE Series with greatly reduced iron loss in 2014³⁾. Subsequently, through further improvement, JFE Steel also succeeded in developing the 070 grade with guaranteed iron loss $W_{17/50} = 0.70$ W/kg, which could not be achieved with the conventional material with a sheet thickness of 0.23 mm. The developed steel was commercialized as 23JGSE070.

In comparison with the 0.20 mm and 0.18 mm thickness materials of the same grade, 23JGSE070 is also an excellent product in terms of stacking man-hour reduction and the better BF (building factor) which means the iron loss increase ratio after the assembly of a transformer, and has earned an out-

Table 1 Specification and typical magnetic properties of 23JGSE070

Grade	Thickness	Specification			Typical value		
		Iron loss		Induction	Iron loss		Induction
		Max.	Max.	Min.			
		1.7 T/50 Hz (W/kg)	1.7 T/60 Hz (W/kg)	800 A/m (T)	1.7 T/50 Hz (W/kg)	1.7 T/60 Hz (W/kg)	800 A/m (T)
23JGSE070	0.23 mm	0.70	0.91	1.90	0.68	0.89	1.93

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standing reputation.

Table 1 shows the typical magnetic properties of 23JGSE070. 23JGSE070 has the lowest iron loss among grain-oriented electrical steels with a sheet thickness of 0.23 mm, and is used mainly in stacked core type transformers for regions that impose strict efficiency regulations on transformers. The JGSE Series also has the distinctive feature of a high degree of integration of the Goss direction, as mentioned above, and therefore is also highly evaluated as a material for transformer applications with low noise specifications.

3. Conclusion

By applying JFE Steel's highest grade non-heat resistant domain-refined grain-oriented electrical steel

23JGSE070 to stacked core type transformers, it is not only possible to obtain a large energy-saving effect due to the reduction of iron loss, but also to produce low noise specification transformers.

References

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- 2) Sato, K.; Fukuda, B.; Kan, T.; Hina, E. Development of Heat-Proof Domain-Refined Grain-Oriented Electrical Steel (RGHPD). *MATERIA.* 1995, vol. 34, no. 6, p. 777–779.
- 3) [Domain-Refined Grain-Oriented Electrical Steel: JGSE™ Series. JFE GIHO. 2015, no. 36, p. 37–38.](#)

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