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# Domain-Refined Grain-Oriented Electrical Steel Sheet: JGSE™ Series†

## 1. Introduction

With worldwide promotion of energy conservation efforts in recent years, including sharp increases in the prices of power generating resources, use of natural energy, etc., efficiency regulations for power transformers are also being strongly promoted because transformers are a critical component element of power transmission systems. Part of this trend can be seen in the 2nd judgment standards for transformers (Enforced in April 2014) in Japan's Top Runner Program, the Ecodesign Regulation (Enforced in July 2015) in Europe, the DOE Standard for Distribution Transformers (Enforced in January 2016) in the United States, and others. For this reason, further reductions in iron loss in the grain-oriented electrical steels which are used as core materials in transformers are required, and demand for ultra-low iron loss magnetic domain-refined materials is increasing.

Although the main application until now was materials for wound cores, which are subjected to annealing treatment, JFE Steel supplied the JGSD™ series[1–3] of heat resistant magnetic domain-refined materials which can also be used as-is in stacked cores, which do not require annealing. However, to meet the above-mentioned needs for ultra-low iron loss magnetic domain-refined materials, on this occasion, JFE Steel began supplying the JGSE™ series of non-heat resistant magnetic domain-refined materials which show low iron loss characteristics for use in stacked core type transformers, which are not annealed.

## 2. Methods of Achieving Low Iron Loss

Iron loss in electrical steel sheets comprises hysteresis loss and eddy current loss. Low iron loss in grain-oriented electrical steel had centered on reduction of hysteresis loss by improvement of the orientation integration degree of the (110) [001] orientation, and iron loss was dramatically improved by the development of high magnetic flux density grain-oriented electrical steel. Following this reduction in hysteresis loss, eddy current loss accounted for approximately 70% of iron loss. Therefore, various techniques were used to reduce eddy current loss, including increasing the resistivity of the steel by increasing its Si content, reducing the grain size, reducing the sheet thickness, and performing magnetic domain-refining treatment.

In the conventional material, JGSD™, domain refining is performed by introducing physical linear grooves by etching. In contrast, in the new product, JGSE™ series, domain refining is achieved by introducing local strain in high magnetic flux density grain-oriented electrical steel sheets, which results in a large decrease in

Table 1 Specification and typical magnetic properties of JGSE™ Series

| Thickness | Grade | Specification | | | Typical value | | |
|---|---|---|---|---|---|---|---|
| | | Iron loss | | Induction | Iron loss | | Induction |
| | | Max. | Max. | Min. | Ave. | Ave. | Ave. |
| | | 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) |
| 0.23 mm | 23JGSE075 | 0.75 | 0.98 | 1.90 | 0.73 | 0.96 | 1.92 |
| | 23JGSD080 | 0.80 | 1.04 | 1.87 | 0.75 | 0.97 | 1.88 |
| | 23JGSD085 | 0.85 | 1.12 | 1.87 | 0.78 | 1.02 | 1.88 |
| 0.27 mm | 27JGSE085 | 0.85 | 1.13 | 1.90 | 0.81 | 1.08 | 1.93 |
| | 27JGSD090 | 0.90 | 1.18 | 1.87 | 0.84 | 1.11 | 1.88 |
| | 27JGSD095 | 0.95 | 1.25 | 1.87 | 0.88 | 1.16 | 1.88 |

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iron loss.

## 3. Magnetic Properties

**Table 1** shows a comparison of the magnetic properties of the conventional JGSD™ series and the new product, the JGSE™ series.

The new JGSE series made it possible to supply low iron loss 23JGSE075 and 27JGSE085, which exceed the highest grade of the conventional JGSD. The new products also show higher magnetic flux density. In particular, 27JGSE085 is advantageous for large-scale transformers from the viewpoints of extremely low iron loss and reduction of man-hours for stacking work.

## 4. Conclusion

A large energy saving effect can be expected by using the non-heat resistant magnetic domain-refined materials 23JGSE075 and 27JGSE085 in stacked core type transformers.

### References

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