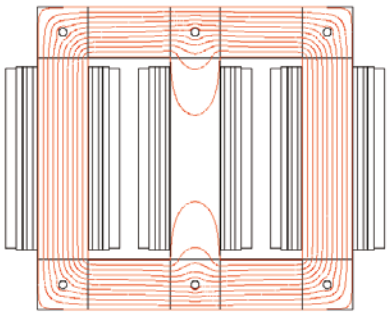
Non-oriented fully processed electrical steels

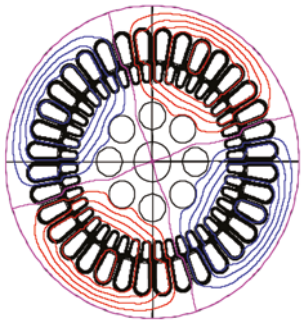
A real alternative for transformers into the 150 kVA range

Properties

There are two major types of fully processed electrical steels: grain-oriented (GO) and non-oriented (NO). The fundamental difference between these two types is the direction of magnetisation: GO grades show optimal magnetic behaviour in one direction only, whereas NO grades have magnetic properties that are as isotropic as possible. This corresponds to the requirements of the standard applications of these products: GO for transformers and NO for motors/generators. The typical field lines in these machines explain why rotating machines need multidirectional magnetisation, whereas for transformers, unidirectional magnetisation within the limbs requires only one preferred direction of magnetisation.

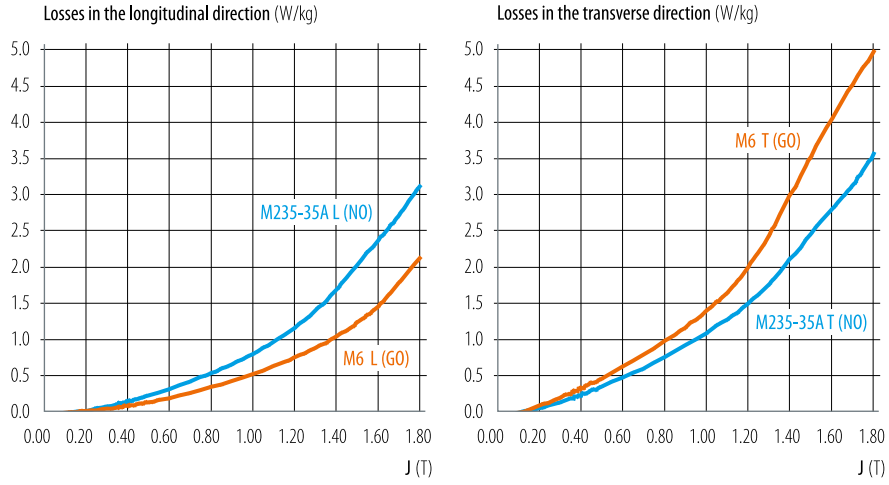


3-phase transformer field lines (No Load, Phase 30°)



4 pole induction motor field lines

GO and NO electrical steels therefore have different thermo-mechanical production processes, leading to different magnetisation characteristics, resulting essentially from different crystallo-graphic textures. This gives GO steels better magnetic properties in the rolling direction, while NO steels may have better properties in the transverse direction (loss curve comparison for GO grade M6 compared to NO grade M235-35A). The production process for GO steel, with its specific Goss texture, is more complex than for NO grades, which have a cubic fibre texture, and this is reflected in the higher price of GO grades.



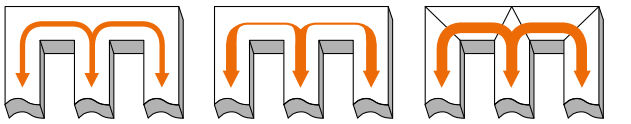
GO (orange) has lower losses than NO (blue) in the longitudinal (L) sense, but higher in the transverse direction (T).

Advantages

Despite its excellent magnetic behaviour in the direction of rolling, grain-oriented (GO) material is not necessarily the best choice for all transformer applications. The following criteria need to be considered:

Specific construction mechanism of the transformer

- With an E-I design, certain flux paths follow the transverse steel direction, so the non-oriented (NO) grade has an advantage in those zones: the back of the E-shape.
  This cutting mode is normally limited to smaller transformers (and ballast and contactors), but the use of NO can be considered for larger transformers as well.



non-oriented material E-I design

grain-oriented material E-I design

grain-oriented material design using longitudinal strips

- The way in which the ends of the steel strip meet at corners affects rotational losses, and NO grades may offer an advantage here. The induction path can hit the end of the cut lamination at 90° (rectangular strips) or 45° (trapezium shaped strips), which will influence the continuation of this path and the associated losses. This assembly method, using cut strips, is more common for larger transformers.

Volume and weight requirements

If minimum dimensions or maximum weight requirements are less important, the use of GO is also not mandatory. A NO grade can be used instead, provided the transformer is redesigned, as described under "Applications".

Non-oriented versus grain-oriented

In the above cases, the use of GO material may be unnecessary, since a NO grade will do the job very well, and without the typical drawbacks of GO steel, such as

- Price. GO is considerably more expensive than NO.
- Reduction of cutting tool life as a result of abrasive GO coatings. NO grades are available with specific coatings allowing extended tool life.

Applications

Finite element and analytical calculations on specific transformer/winding geometries were performed in our research centre to examine the impact of using NO instead of GO steel.
Both GO and NO materials were 0.35 mm gauge, so that the cost of manufacturing the transformer was comparable, including cutting and assembly. These calculations took into account the difference in iron loss and polarisation/permeability levels of each material, and adapted the transformer geometry in order to maintain the same machine performance at different load levels. Modifications to the geometry were required, involving both the transformer iron core stack and consequently the copper or aluminium windings.
The proposed transformer redesign was adopted by different customers, after fine-tuning the final geometry according to the polarization working point they selected and other proprietary customer data (thermal and magnetic).

Recommendations

It has been shown that the replacement of M6 GO by M235 35A NO for transformers of up to 150 kVA can represent distinct savings on the cost of materials for the transformer constructor. The same machine output can be maintained, but larger stacks and modification of the windings are required. Transformer construction will become cheaper as a result of the extended life of cutting tools. All this adds up to the conclusion that redesigning the construction in this way will yield an economic advantage for the machine constructor, on the basis of the present price gap between GO and NO grades.
The use of GO is unavoidable for large transformers, but certainly not the best alternative for smaller transformers. Switching to a NO grade is definitely a better solution for your company's smaller transformer applications.

We're here to help you

For further information, detailed catalogues or technical data, please visit:
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