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New Products & Technologies

Low Iron Loss Non-Oriented Electrical Steels Applicable to Large Motors and Generators, "50RM230" and "35RM210"*

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1 Introduction

In recent years it has become increasing necessary to improve the energy efficiency of large rotary machines, such as turbine generators (**Photo 1**), water-wheel generators, etc. Electrical steels, the materials used to make up the cores of these machines, have also become more necessary than ever before to provide lower iron losses.

To meet the above requirements, Kawasaki Steel has developed excellent non-oriented electrical steels, the "50RM230" and "35RM210," which achieve the highest standard for low iron loss. These are suitable for large rotary machines, such as generators, and large motors. The features and properties of these electrical steels are described below.

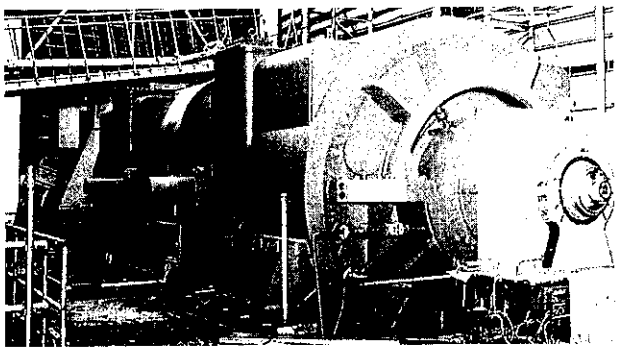

Photo 1 Appearance of turbine generator

* Originally published in *Kawasaki Steel Giho*, 29(1997)3, 180–182

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2 Key Points of Development

The cores of large rotary machines require this steel type to keep iron loss to a minimum. It is generally known that the metallographic factors which govern iron losses are inclusions, grain size and texture. In the newly-developed electrical steels, iron losses are reduced, to an extent never before achieved in conventional electrical steels, by applying high-accuracy metallurgical control technologies based on a quantitative examination of these factors. The principal technologies used in the development are:

(1) Technology for reducing inclusions which prevent magnetic domain wall displacements and technology for controlling the distribution of inclusions

(2) Technology for optimizing the grain size and composition of steels

(3) Technology for optimizing the texture by controlling the grain size before cold rolling

3 Properties of 50RM230 and 35RM210

(1) Magnetic Properties and Mechanical Properties

Tables 1 and **2** respectively compare the magnetic properties and mechanical properties of the new electrical steels 50RM230 and 35RM210 and the conventional one 50RM250. The new steels meet the highest standards for low iron loss in non-oriented electrical steels. The 50RM230 guarantees iron losses $W_{15/50}$ of 2.3 W/kg or less at a sheet thickness of 0.5 mm and the 35RM210 guarantees 2.1 W/kg or less at a sheet thickness of 0.35 mm. In the new electrical steels, an improvement in iron loss of 0.10 W/kg or more is expected at a sheet thickness of 0.5 mm. The mechanical properties of the new electrical steels and the conventional one do not differ greatly. **Figures 1** and **2** respectively compare the relationship of magnetic flux density to iron loss and the B-H and μ-H curves for the newly-developed steels and conventional steel

Table 1 Comparison of typical magnetic properties between new materials and conventional one

Grade	Thickness (mm)	Density (g/cm^3)	Resistivity ($\mu\Omega$-cm)	Iron loss (W/kg)				Flux density (T)			
				$W_{10/50}$	$W_{15/50}$	$W_{10/60}$	$W_{15/60}$	B_{10}	B_{25}	B_{50}	B_{100}
35RM210	0.35	7.60	58	0.84	2.03	1.08	2.52	1.48	1.57	1.66	1.78
50RM230	0.50	7.60	58	0.99	2.25	1.25	2.80	1.48	1.57	1.66	1.78
Conventional (50RM250)	0.50	7.60	57	1.02	2.40	1.32	3.04	1.50	1.59	1.67	1.79

Table 2 Comparison of typical mechnical properties between new materials and conventional one

Grade	Thickness (mm)	Yield point (N/mm^2)		Tensile strength (N/mm^2)		Elongation (%)		Hardness Hv (1)	Space factor (%)
		L	C	L	C	L	C		
35RM210	0.35	448	465	539	568	18	19	234	97.5
50RM230	0.50	448	465	574	594	18	20	234	98.0
Conventional (50RM250)	0.50	431	441	539	549	19	20	220	98.0

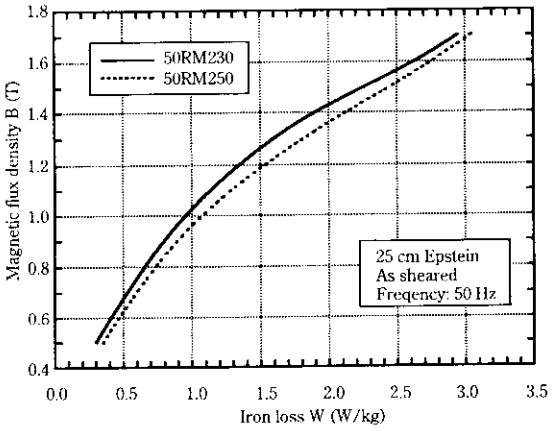

Fig. 1 Iron loss curves of 50RM230 and 50RM250 at 50 Hz

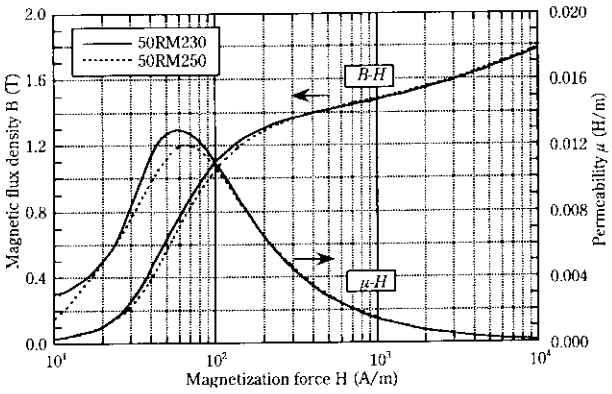

Fig. 2 DC magnetization and permeability curves of 50RM230 and 50RM250

50RM250. The new steels keep iron losses low in the low to high magnetic flux density area and have high permeability in low magnetic fields.

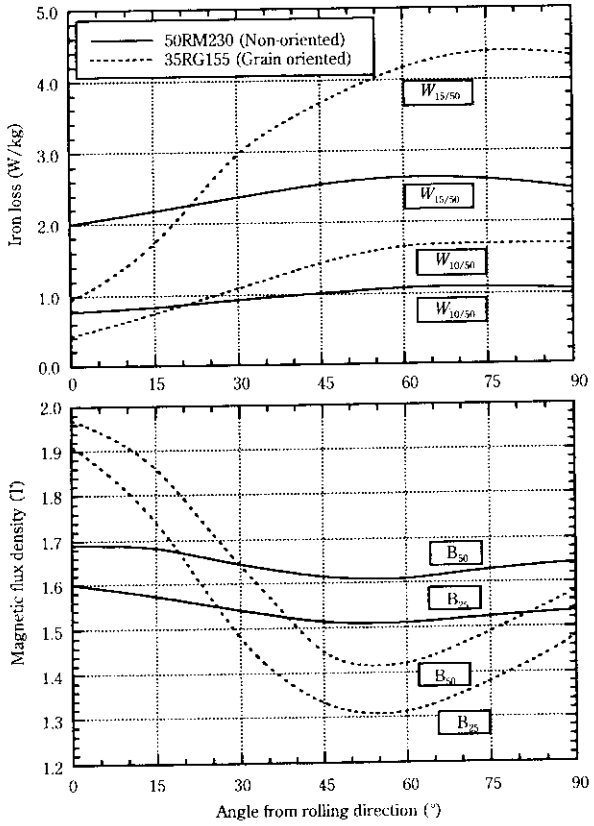

Fig. 3 Dependence of rotation angle from rolling direction on magnetic properties of 50RM230 and 35RG155

(2) Magnetic Anisotropy

Figure 3 compares changes in the magnetic properties at each angle from the rolling direction for the 50RM230 with those for the grain-oriented electrical steel 35RG155, which has been used up to now in large turbine generators, etc. The newly-developed

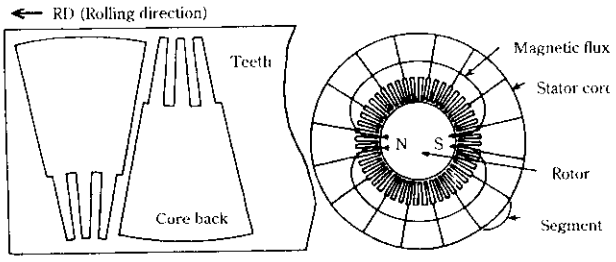

Fig. 4 Punching configuration of stator segment and magnetic flux flow in a two-pole turbo-generator

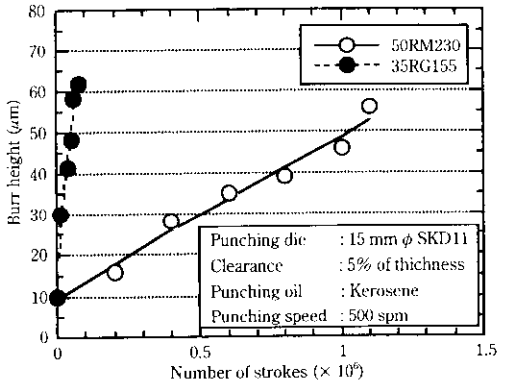

Fig. 5 Dependence of burr height on number of strokes

non-oriented electrical steel 50RM230 is superior in both iron loss (W) and magnetic flux density at rotation angles of 20–30° or more from the rolling direction and has uniform and excellent magnetic properties in all directions. It is, however, inferior to the grain-oriented electrical steels in its magnetic properties at an angle to the rolling direction.

(3) Size, Shape and Coating

The electrical steel sheets are rolled on a highly-advanced rolling mill with a shape control system, excellent gauge accuracy, and capablities of providing steel sheets with a maximum width of up to 1 200 mm. This increase in width may cause the size of the fan-shaped generator segments to widen and decrease the number of lamination layers of each segment.

The surface is finished with a semiorganic Al coat, which is excellent in its insulation quality and punching properties. This coat can extend the punching die life.

4 Application to Large Rotary Machines

There are many examples in which the magnetic properties at an angle to the rolling direction are applied for use in turbine generators, one of the places in which the newly-developed electrical steels are used. For example, a steel sheet is punched in fan-shaped segments, as shown in **Fig. 4**, and arranged in a circle to form a core. In this case, because the magnetic flux flows in the rolling direction of the sheet at the core back, grain-oriented electrical steel sheets are frequently used. In the teeth portion, however, magnetic fluxes flow at transverse to the rolling direction of the sheet, exerting a great influence on total iron loss. The proportion of iron loss at right angles to the rolling direction increases in water-wheel generators with low rotation rates, because these generators have many poles. For this reason, the conventional grain-oriented electrical steel with excellent properties in the rolling direction is not necessarily advantageous in terms of its magnetic properties. It might be considered that the newly-developed non-oriented electrical steel 50RM230, which provides uniform and excellent magnetic properties in all directions, can be advantageously used in this application.

Furthermore, when 50RM230 is used as a substitute for a grain-oriented electrical steel, it can provide excellent punchability because of a lack of forsterite film. Results of a punching test of the 50RM230 and the grain-oriented electrical steel 35RG155 are shown in **Fig. 5** as an example. In the case of 35RG155, the number of strokes which the burr height reachs to 50 μm, whereas the corresponding rate for the 50RM230 is 1 000 000. Thus the newly-developed electrical steel is by far superior in its punching properties. Owing to the above decrease in the number of lamination layers for each segment, which results from an increase in the width of a sheet and improvements in the punching property as mentioned above, the newly-developed electrical steels can also contribute greatly to reducing manufacturing costs.

5 Summary

It is considered that the application of "50RM230" and "35RM210," the non-oriented electrical steels with low iron loss at the highest specification, can contribute greatly to making of large rotary machines more energy efficient and reducing the costs of manufacturing these machines.