New Products & Technologies

Low Iron Loss Non-oriented Electrical Steel for High Efficiency Motors "RMA Series"*

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1 Introduction

The development of high efficiency electric appliances is one of the most important technological issues from the viewpoint of energy saving. Since compressor motors used in air-conditioning systems and refrigerators are responsible for the major part of consumer electric power consumption, great efforts are being made to increase the efficiency of these kinds of motor cores.

Non-oriented electrical steel sheets are generally used as core materials for small- and medium-sized motors. These sheets used in compressor motor cores are repeatedly stamped into the motor core shape, stacked to form their core and then annealed to relieve stress at about 750°C. Electrical steel sheets used in high efficiency motor cores therefore need excellent magnetic properties after stress relief annealing.

Kawasaki Steel has developed a non-oriented electrical steel, the "RMA Series", with low iron loss and high magnetic flux density after stress relief annealing, for use in high efficiency motor cores. The features and properties of these electrical steels are described below.

2 Key Technologies

Iron losses are composed of eddy current loss and hysteresis loss. Eddy current loss depends almost entirely on alloy content such as Si. On the contrary, hysteresis loss decreases with fewer grain boundaries which prevent domain wall displacement[1]. So, it is important to control the grain growth during stress relief annealing in order to develop lower iron loss materials.

Inhibition strength against grain growth is proportional to the volume fraction of inclusions and is also inversely proportional to average radius[2]. Kawasaki Steel developed a new method of controlling the amount and size distribution of inclusions. **Figure 1** shows the inclusion size distribution and iron loss of conventional (A) and newly developed (B) electrical steel sheet.

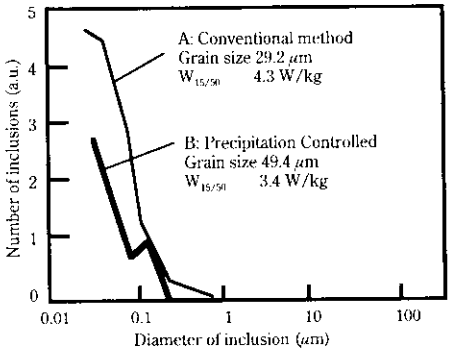

Fig. 1 Effect of precipitation controlling on size distribution of inclusions

The RMA Series features improved grain growth during stress relief annealing by controlling the amount and distribution of inclusions and purifying the material, which leads to lower iron loss.

3 Product Features

Typical magnetic and mechanical properties of the RMA Series are shown in **Table 1**, and the relationship between magnetic flux density B_{50} after stress relief annealing and iron loss $W_{15/50}$ are shown in **Fig. 2**. The RMA Series has higher magnetic flux density and lower iron loss compared with JIS grade materials. A newly developed material, 50RMA350, possesses the best specification among the RMA Series[3].

Figure 3 shows the influence of materials and excitation frequency on A.C. inverter drive motor efficiency. The efficiency of 50RMA350 is greater than that of 50RM700 in the whole frequency region, because it has higher flux density and lower iron loss than 50RM700.

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Table 1 Typical magnetic and mechanical properties of RMA series

	Grade	Thickness (mm)	Density (g/cm³)	Magnetic properties		Hardness (Hv)
				$W_{15/50}$ (W/kg)	B_{50} (T)	
RMA series	50RMA350	0.50	7.80	3.08	1.75	126
	50RMA500	0.50	7.80	4.61	1.73	115
	50RMA600	0.50	7.85	5.15	1.75	108
Conventional JIS grade	50RM700	0.50	7.80	4.24	1.73	135
	50RM1000	0.50	7.85	6.20	1.75	115

Notes (1) The values were measured according to the method JIS C 2550 the Epstein specimens, with a half the total number of which sheared parallel, and the other half sheared transverse, to the rolling direction.
(2) The specimens for magnetic properties were tested after annealing. Annealing condition: 750°C × 2h under N_2 atmosphere.

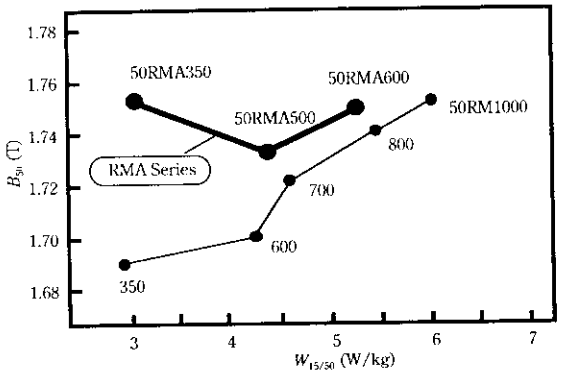

Fig. 2 Magnetic properties of RMA series (The values of RMA series were measured after stress relief annealing)

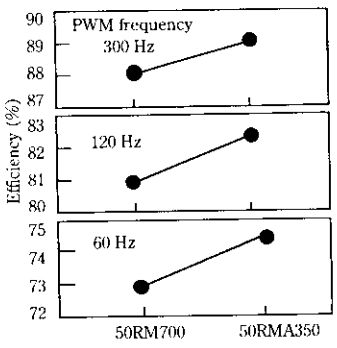

Fig. 3 A.C. inverter motor efficiency of 50RMA350

Table 2 Motor efficiency of RMA350

	Type of motor	Steel	Increase of efficiency (%)
Company A	D.C. inverter motor	50RMA600 → 50RMA350	+0.6% at 50 Hz +0.9% at 60 Hz
Company B	A.C. inverter motor	50RMA500 → 50RMA350	+1.4% at 50 Hz +1.3% at 60 Hz

4 Applications

50RMA500 and 50RMA600 have been used for the core materials of many compressor motors.

A newly developed 50RMA350, which has been produced since 1996, also has been used for the core materials of several compressor motors. **Table 2** shows the efficiency of motors actually produced using 50RMA350, 50RMA500 and 50RMA600. 50RMA350 improves the motor efficiency by 0.6-1.4% more than 50RMA500 and 50RMA600.

The application of the RMA Series, having excellent magnetic properties after stress relief annealing, greatly improves the efficiency and compactness of small- and medium-sized electric appliances.

References

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