"MB4" — A Low Power Loss MnZn Ferrite for Power Applications*

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1 Introduction

Kawasaki Steel succeeded in manufacturing soft ferrite, which is a soft magnetic material designed for high-frequency use, and started making products in October 1990 at Kawatetsu Magnex Corp. (now Kawatetsu Ferrite Corp.). The Kawasaki Steel Group is the only soft ferrite maker that manufactures this product in an integrated manner from raw iron oxide to cores.

In recent years the demand for smaller and thinner electronic devices such as notebook-sized personal computers and portable telephones has been growing stronger. Switching power supplies are used to power these electronic devices. Great technological innovations have increased switching frequencies and reduced losses, allowing smaller but higher-performance power supplies to be developed. Therefore, demands are rising that the soft ferrite cores, which are the principal components of transformers, have high-performance properties.

Kawatetsu Ferrite Corp. is already producing MB3[1] that provides low core losses of the industry's top class in a mass production environment. Kawasaki Steel has energetically continued the development of materials to respond to further demands of users for low losses, and succeeded in establishing manufacture recipie for MB4, which has 30% lower core losses as compared with MB3. Kawatetsu Ferrite Corp is now mass-producing MB4.

2 Points of Development of MB4

Low core losses of mass-production products are achieved by controlling raw material preparation and sintering conditions in terms of original adjusting metbods of raw material properties and microstructure that determines the magnetic properties.

Analyses of the main causes of core losses at high frequencies indicated that 35% of losses are hysteresis losses, less than 2% are eddy current losses, and the remainder is residual losses[2]. Majority of residual losses comes from grain size-dependent causes. Because both hysteresis and residual losses depend on grain size, the development of MB4 was carried out by focussing on the following four points, resulting in substantially reduced core losses:

(1) Principal components and additives were selected to reduce hysteresis losses.
(2) Grain size and sintering conditions were optimized to minimize hysteresis and residual losses.
(3) The high-purity iron oxide KH-CP[3] developed by the Chemical Division of Kawasaki steel was used as a starting material.
(4) MB4 was sintered in a stable manner in a mass production environment by the practical application of a roller hearth type kiln whose atmosphere is precisely controlled.

3 Magnetic Properties of Product

The magnetic properties of the newly-developed material MB4 and conventional material MB3 are shown in **Table 1**[5,6]. The dependence of core losses in the frequency range of 25 to 500 kHz on magnetic flux density is shown in **Fig. 1**. Some DC hysteresis curves are shown in **Fig. 2**. **Figure 3** shows a comparison in the temperature dependence of core losses at 100 kHz and 200 mT between MB4 and MB3. It is apparent that a nearly 30% reduction in core losses is achieved in MB4 compared with MB3.

4 Concluding Remarks

Kawatetsu Ferrite Corp. produces the MnZn ferrite MB4 with extremely-low core losses at high frequencies on a mass production scale and supplies the products to

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Table 1 Magnetic characteristics of MB4 and MB3

			Temp. (°C)	MB4	MB3
Initial permeability	μ_{iac}		23	2500 ± 25%	
Saturation flux density at 1 200 A/m	B_{ms}	(mT)	23	520	510
			60	470	450
			100	400	390
Remanence	B_{rms}	(mT)	23	130	130
			60	88	90
			100	54	55
Coercivity	H_{cms}	(A/m)	23	12.7	14.3
			60	8.0	10.3
			100	6.4	8.8
Core loss at 100 kHz, 200 mT	P_{cv}	(kW/m^3)	23	630	700
			60	430	500
			100	300	410
			120	400	500
Curie temp.	T_c	(°C)		≧ 215	
Resistivity	ρ	($\Omega \cdot$ m)		≧ 4.5	≧ 6
Density	d	(kg/m^3)		4.9 × 10^3	

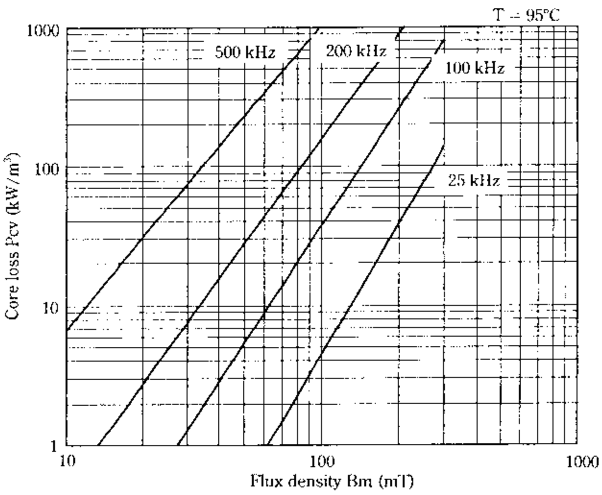

Fig. 1 Dependence of core loss at high frequencies on flux density

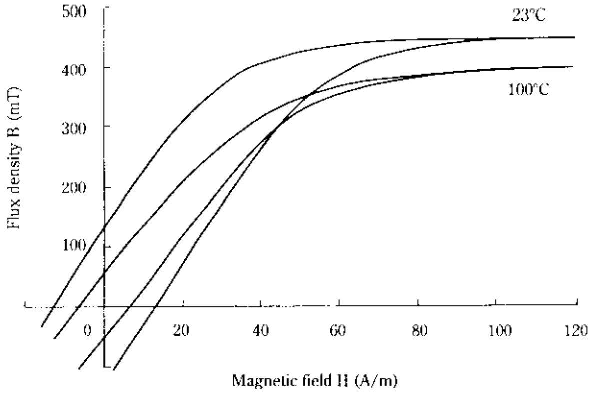

Fig. 2 Static magnetization curves

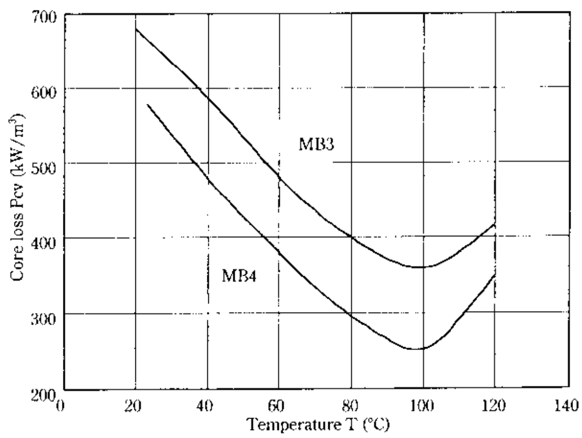

Fig. 3 Temperature dependence of core loss at 100 kHz and 200 mT

users requiring higher performance. Kawasaki Steel and Kawatetsu Ferrite Corp. intend to further reduce core losses and carry out the development of materials that can meet practical demands.

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