Impact of Core Segmentation on Eddy Current Loss in Mn-Zn Ferrite Cores for High-Frequency Operation

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Introduction

The adoption of wide bandgap (WBG) semiconductors such as SiC and GaN enables high-frequency operation in power converters, increasing power density through downsizing of passive components. However, core losses in inductors rise at high frequencies, with eddy current losses becoming significant [1]. In low-resistivity materials, laminated structures are known to suppress such losses [2]. Mn-Zn ferrite, with a volume resistivity of several tens of Ω·m, is less affected at low frequencies, but eddy current losses can become non-negligible at high frequencies [3]. Although laminated structures are also expected to be effective for Mn-Zn ferrite, the influence of core segmentation has not been sufficiently discussed in the literature.

Experimental Procedures

This study experimentally evaluates the impact of segmentation on eddy current loss in Mn-Zn ferrite cores. Four types of toroidal core samples with identical material (MB20D, Proterial Co., Ltd.) and volume but different numbers of segments (1, 2, 3, and 6) were fabricated. The proposed segmented core structure is illustrated in Fig. 1. The core losses were measured using a B-H analyzer (Iwatsu SY-8219) under excitation conditions of 50–500 kHz and 30 mT.

Results and Discussion

Fig. 2 shows the frequency characteristics of iron loss for each segmentation number. From Fig. 2, it can be confirmed that increasing the number of core segments shows a tendency to reduce iron loss. This reduction effect becomes more pronounced with increasing frequency. However, it can be confirmed that the effect tends to saturate as the number of segments increases.

The enhanced loss reduction effectiveness at higher frequencies is considered to be attributed to the increased proportion of eddy current loss. The saturation tendency is presumed to occur because eddy current loss becomes sufficiently small compared to other loss factors, reducing the benefits of further segmentation.

Conclusion

This study measured iron loss in Mn-Zn ferrite cores with different segmentation (1, 2, 3, and 6 segments) at 50-500 kHz. Results showed that segmentation effectively reduces iron loss, particularly at higher frequencies, though the improvement saturates with excessive segmentation.

Acknowledgement

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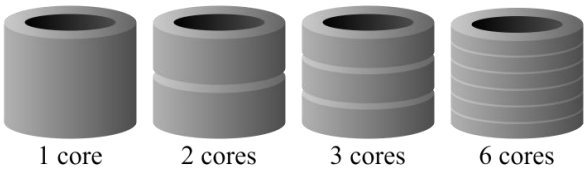
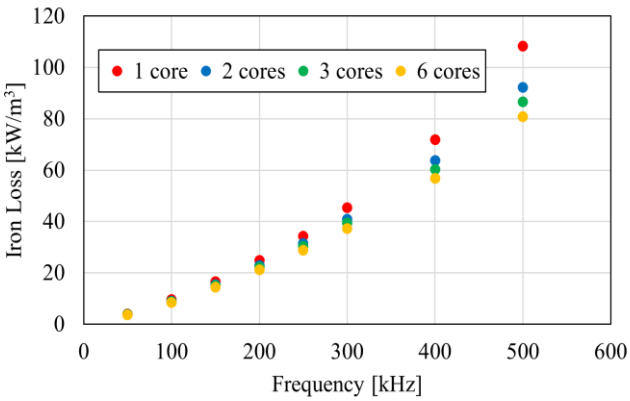


Fig. 1. Schematic of the segmented core structure



ig. 2. Frequency dependence of iron loss for various core segmentations

References

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