Low Loss of Mg-Mn-Zn Ferrite for Deflection Yoke
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Abstract. We examined the reduction of the core loss of Mg-Mn-Zn ferrite for deflection yoke cores. We tried to decrease hysteresis loss by selection of composition and additive, because hysteresis loss is much larger than eddy current loss in Mg-Mn-Zn ferrite having high resistance. We succeeded in decreasing hysteresis loss and improved the core loss approximately 30% compared with conventional materials. And as the result of a simulation, we can expect that the rising temperature of it is smaller than that of our conventional materials for deflection yoke at high frequencies and high magnetic flux density.

1. INTRODUCTION

A deflection yoke for highly detailed and wide display is used at higher frequencies more than 100 kHz. Therefore, low loss Mg-Mn-Zn ferrite at a high frequency for deflection yoke is required. In order to reduce the core loss of Mg-Mn-Zn ferrite, we examined its composition and additives.

2. EXPERIMENTAL PROCEDURE

In this examination, we obtained samples in the following method. Raw materials were mixed to obtain various ferrite compositions. These mixtures were calcined in the air and pulverized in a ball mill. Then, each powder sample was granulated and pressed into triform samples and was sintered in the air. We measured the core loss, curie point and surface resistance of these samples.

3. RESULTS AND DISCUSSION

![Figure 1: Relationships between quantity of Fe₂O₃, MnO, ZnO and core loss.](image)

Figure 1 shows a core loss and table 1 shows characteristics of each sample. Figure 1 indicates that the core loss is reduced with increment of ZnO quantity and MnO/(Fe₂O₃+MnO). But table 1 shows that surface resistance is increased with rising MnO/(Fe₂O₃+MnO), because Fe⁺ lowered resistance of ferrites. And Fe⁺ is increased with increment of Mn³⁺ in order to hold electric charge balance. And the curie point is also declined greatly, because the rate of the quantity of Fe₂O₃ to ZnO is decreasing.

<table>
<thead>
<tr>
<th>MnO/(Fe₂O₃+MnO) (%)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Resistence</td>
<td>100</td>
<td>7000</td>
<td>4000</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Curie Point</td>
<td>1050</td>
<td>100</td>
<td>200</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Characteristics of samples (ZnO: 18mol%)
Figure 2 shows that the core loss is separated into a hysteresis loss and eddy current loss in the sample of ZnO 18 mol%. In this figure, hysteresis and eddy current losses were calculated by core loss/f - f plots. As MnO/(Fe$_3$O$_4$+MnO) is increased, hysteresis loss is greatly reduced, but eddy current loss is hardly influenced. Therefore, a reduction of core loss by increasing MnO/(Fe$_3$O$_4$+MnO) is due to decreasing of hysteresis loss.

Figure 3 shows sintered density and core loss of samples in relation to addition of Bi$_2$O$_3$. The composition of samples is MnO/(Fe$_3$O$_4$+MnO): 19.2 % and ZnO: 18 mol %. As an addition of Bi$_2$O$_3$ increases, sintered density becomes higher and the core loss is reducing. It is well known that addition of Bi$_2$O$_3$ is effective for rising sintered density[1]. Increment of sintered density by addition of Bi$_2$O$_3$ is caused by that impurities and vacant lattice are removed to the boundary layer. As a result, a magnetic domain wall can be easily transported and the core loss reduces. But in case an addition of Bi$_2$O$_3$ is more than 0.6wt%, crystal sizes become non-uniformity, because of large particles caused by abnormal grain growth. Therefore, a core loss is not reduced.

Figure 4 shows the temperature characteristic of the core loss and table 2 shows a result of simulation of heat generation of each material used as deflection yoke of display. X106 is controlled composition of Fe$_3$O$_4$, MnO and ZnO, and contents of Bi$_2$O$_3$. H44 and H44F are our conventional materials. The heat generation is calculated for the distribution of magnetic flux density of a core computed by the magnetic moment method and core loss database.[2] Core loss database is measured to some conditions of magnetic flux density, frequency and temperature. According that result, we expect X106 to be suitable for the deflection yoke for the display used under the condition of high frequency and high magnetic flux density.

Table 2. Result of simulation of heat generation

<table>
<thead>
<tr>
<th>Item</th>
<th>Frequency</th>
<th>Temp</th>
<th>Heat Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(MHz)</td>
<td>(°C)</td>
<td></td>
</tr>
<tr>
<td>H44</td>
<td>96kHz</td>
<td>100</td>
<td>3.78</td>
</tr>
<tr>
<td>H44F</td>
<td>96kHz</td>
<td>100</td>
<td>4.15</td>
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<tr>
<td>X106</td>
<td>10kHz</td>
<td>100</td>
<td>3.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.79</td>
</tr>
</tbody>
</table>

4. CONCLUSION

1) As a method of reducing the core loss of Mg-Mn-Zn ferrite, it is effective to reduce a hysteresis loss by controlling ratio of MnO/(Fe$_3$O$_4$+MnO) and contents of ZnO.
2) The core loss can be reduced by addition of Bi$_2$O$_3$. Reduction of core loss is caused by increment of sintered density.

5. REFERENCES