International Magnetics Conference
(INTERMAG '92)
St. Louis, Missouri, USA
April 13-16, 1992
FA-06 (発表予定)

RECIPROCITY IN COMPUTER SIMULATION OF MAGNETIC REPRODUCTION PROCESS

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Introduction

Conventionally the reciprocity[1] is widely used for calculation of reproduced output in the magnetic recording theory. On the other hand, we have performed the reproduction simulation taking the head-medium magnetic interaction into account by the magnetic recording simulation program based upon FEM and the curling magnetization reversal model[2]. In this paper, the reproduced voltage waveform and amplitude calculated by the reciprocity will be compared with those obtained by the simulation and validity of the reciprocity will be discussed.

Reciprocity Calculation

This study has been carried out for a SPT head and a Co-Cr/Ni-Fe double-layer medium combination. The recorded magnetization distribution within the medium has been computed previously by the FEM simulation in order to use in the reciprocity calculation. Conventionally the head field distribution in the absence of the medium is used as the reproduce-sensitivity function in the reciprocity calculation. But as a matter of fact, the magnetized medium surely exists in the reproduction process, and so the head-medium magnetic interaction is not negligible. Therefore we have nominated the following four distributions for the sensitivity function;

[a] *The head field distribution,* $H_h(x,y)$*, calculated by the FEM in the absence of the Co-Cr layer of the double-layer medium.*

[b] *The flux density distribution,* $B(x,y)$*, obtained by the recording simulation when the AC erased Co-Cr layer is magnetized by the recording head.*

[c] *The effective field distribution,* $H_e(x,y)$*, obtained after subtracting the magnetization distribution,* $M(x,y)$*, from the flux density distribution,* $B(x,y)$*, of [b].*

[d] *The field distribution calculated by the Karlqvist equations.*

The distribution of $B(x,y)$ is sharper than that of $H_h(x,y)$ because the magnetic interaction between the head and the medium becomes strong when the medium is magnetized. Since the effective field distributions is broadened by the influence of the demagnetizing field, the distribution of $H_e(x,y)$ is broader than that of $H_h(x,y)$.

Waveform Comparison

Figure 1 shows the reproduced waveforms (a) for an isolated transition and (b) for 102 kFRPI obtained by the reciprocity calculations and the FEM simulation. When the head field distribution, $H_h(x,y)$, was used in the reciprocity calculation, we have obtained a good agreement of the isolated pulseforms. This suggests that the head-medium magnetic interaction is not so strong in the reproduction process of an isolated transition. But a difference appears in the case of a high recording density as shown in Fig. 1(b). The following reasons have been supposed for this difference;

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2. Oral
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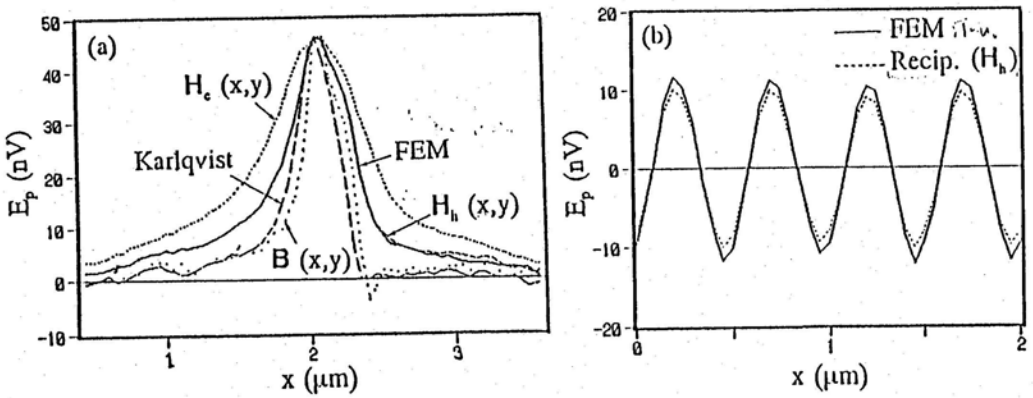

Fig.1 Reproduced waveforms (a) for an isolated transition and (b) for 102 kFRPI

[A] *The magnetization distribution will change in the reproduction process because the highly permeable reproduce-head decreases the demagnetizing field in the medium.*
[B] *The reproduce-sensitivity function will change when the head-medium magnetic interaction will change owing to the recorded magnetizations in the medium.*
[C] *The sensitivity function will change when the head will be saturated partially by the leakage flux from the recorded medium even in the reproduction.*

We have confirmed that the magnetization distribution has hardly changed in the reproduction process compared with that in the remanent state. Consequently the change of the sensitivity function owing to [B] and [C] might be the main reason.

Although we discussed here for a SPT head, we have also investigated for a ring head. When a perpendicularly anisotropic medium have been combined with a ring head, the reproduced voltage calculated by the reciprocity have become much smaller than the simulated output. This is because the perpendicular field distribution of a ring head is so broad that the reproduce-sensitivity function is also broad.

Conclusion

The reproduced voltage waveform and amplitude obtained by the reciprocity almost coincide with those for the FEM simulation. But at a high density the output for the reciprocity is a little smaller than that for the FEM. In the case of a perpendicularly anisotropic medium and a ring head combination, there is a big difference on the reproduced output. Consequently the difference should appear between the reciprocity and the FEM simulation when the magnetic interaction is strong between the head and the medium because the reproduce-sensitivity function should change as the magnetization distribution changes in the recorded medium.

References

[1] *C. D. Mee, E. D. Daniel: Magnetic Recording, Vol.1, McGraw-Hill Book Company*
[2] *Y. Nakamura, I. Tagawa : IEEE Trans. Magn., MAG-25, 4159 (1989)*