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CONSTRUCTION OF CORE LOSS MEASURING SYSTEM FOR ARBITRARY WAVEFORM OF MAGNETIC INDUCTION

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ABSTRACT - For the core loss measurement under arbitrary waveform of magnetic induction, we have constructed a single sheet core loss measuring system which consists of yoke apparatus for single sheet of 10 cm x 10 cm, arbitrary waveform synthesizer, B-feedback system, and two channel transient recorder. Using the constructed measuring system, we can measure core loss including higher harmonics up to 2 kHz. Core loss of non-oreinted electrical steel was increased exponentially when higher harmonic frequency was increased or amplitude of harmonic induction was increased.

I. INTRODUCTION

Actual waveform of magnetic induction of cores in transformers and motors are not sinusoidal ie. higher harmonics are always included. thus core loss in actual electrical machines are different from the core loss which is measured by the standard method [1], because waveform of magnetic induction should be sinusoidal in standard method. For this reason, electrical machine designers are always use design factor which are not certain [2].

One of effective methods for the solution of this problem is to measure the core loss in a single sheet tester under the waveform of the magnetic induction which can be measured directly in electrical machine using potential probes or small search coil.

For this purpose, we need a special core loss measuring system under arbitrary waveform of magnetic induction, and we can measure core loss under actual waveform of magnetic induction in electrical machine.

II. CONSTRUCTION OF MEASURING SYSTEM

For the core loss measurement under given waveform of magnetic induction, arbitrary waveform synthesizer and B-feedback system are necessary. we can calculate secondary induced voltage waveform for the given waveform of magnetic induction, and the voltage waveform can be synthesized by arbitrary waveform synthesizer, after that this voltage is applied to primary winding via power amplifier and the secondary induced voltage could be controlled the same as the synthesized waveform using the B-feedback system.

For the loss measurement, two channel transient recorder whose memory size of 4 kbyte per channel was used for the higher harmonic frequency of magnetic induction. One channel for secondary induced voltage, the other for voltage across shunt resistor which is connected to primary winding serially to measure magnetic field strength.

Fig.1 shows block diagram of the

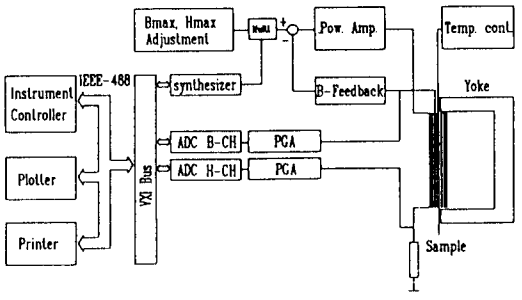

Fig. 1 Schematic diagram of the constructed core loss measuring system.

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constructed core loss measuring system. For the arbitrary waveform synthesizer(HP1445A) and for two channel transient recorder (HP 1429B) was used. This two instrument cards were controlled by VXI bus and the VXI system was controlled by computer via IEE-488 interface bus.

III. RESULTS AND DISCUSSION

Fig. 2 shows ac hysteresis loops of non-oriented electrical steel measured by the constructed core loss measuring system. Fig.2-a) is ac hysteresis loop at 60 Hz under maximum magnetic induction B_{max} of 1.5 T under sinusoidal induction. Harmonic amplitude of magnetic induction is 0.15 T but harmonic frequency was increased from $5f_o$ = 300 Hz to $13f_o$ = 780 Hz, ac hysteresis loop was changed as shown in Fig. 2-b), Fig. 2-c), and Fig. 2-d), and core loss value was increased form 4.32 w/kg to 6.72 k/kg.

Fig.3 shows the ac hysteresis loop under different amplitude of harmonic induction ΔB_{max} but fixed harmonic frequency of $25f_o$ = 1.5 kHz. Harmonic amplitude of magnetic induction ΔB_{max} was increased from 0.03 T to 0.15 T, ac minor hysteresis loops were increased and those were quite different from dc minor hysteresis loop shape. Due to

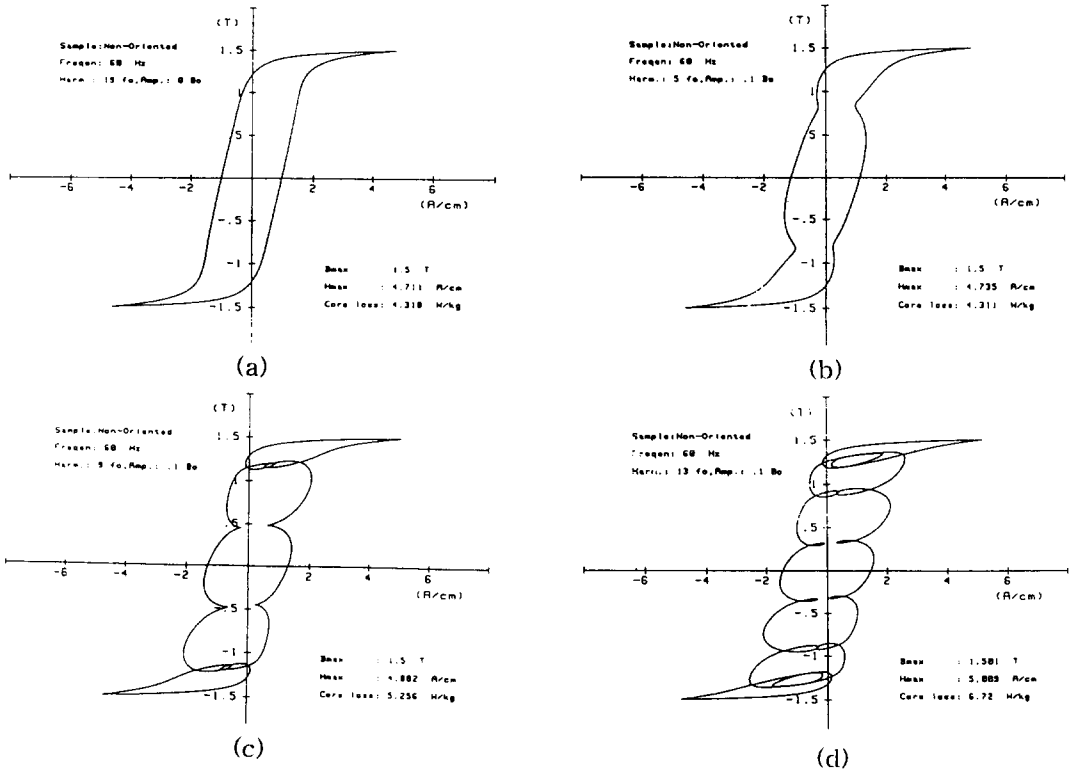

Fig. 2 Various ac hysteresis loops under different harmonic frequency at maximum magnetic induction B_{max} = 1.5 T and harmonic amplitude ΔB_{max} = 0.15 T.

this ac minor loop effect, width of ac hysteresis loop was increased and loss of minor loops are contributed to the core loss, so the core loss was increased about 3 times of fundamental harmonic condition.

Core loss depends on the harmonic frequency at harmonic amplitude of ΔB_{max} = 0.15 T shows in Fig.4. From Fig.4, we can see that the core loss was not increased up to 5th harmonics but above 5th harmonics, core loss was increased exponentially.

Core loss dependends on the harmonic amplitude of magnetic induction ΔB_{max} at harmonic frequency of $25 f_o$ shows in Fig. 5, and core loss was increased exponentially.

This situation can be explained in an induction motor as an example. Ac hysteresis loop in stator tooth, harmonic frequency depends on the rotating speed of rotor and amplitude of magnetic induction ΔB_{max} related to the torque of the motor.

If magnetic induction waveform in electrical machine is not sinusoidal ie. higher harmonic frequency component of magnetic induction is included, core loss is quite different from core loss measured by standard method. For the optimal design of electrical machine, harmonic analysis of core loss[3] not certain, and due to the non-linear effect of ferromagnetic material, core loss could not be easily predictable, but direct measurement of core loss under actual waveform of magnetic induction in electrical machine is an effective method.

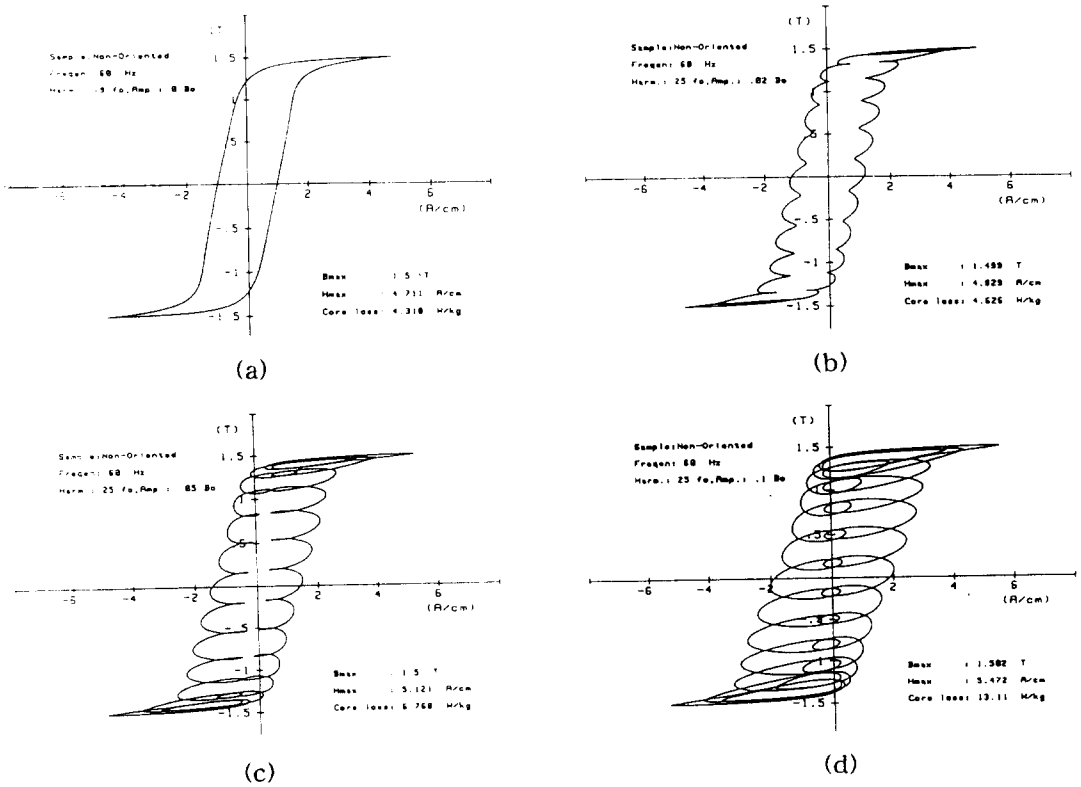

Fig. 3 Various ac hysteresis loops under different harmonic amplitude of magnetic induction at maximum magnetic induction B_{max} = 1.5 T and 25th harmonic frequency.

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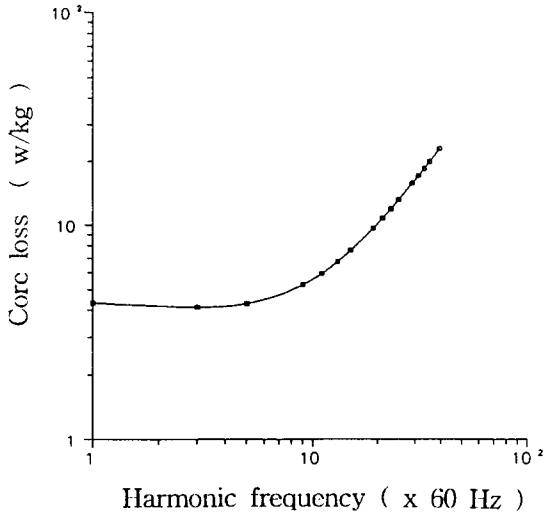

Fig. 4 Core loss changes due to the harmonic frequency under B_{max} = 1.5 T and ΔB_{max} = 0.15 T

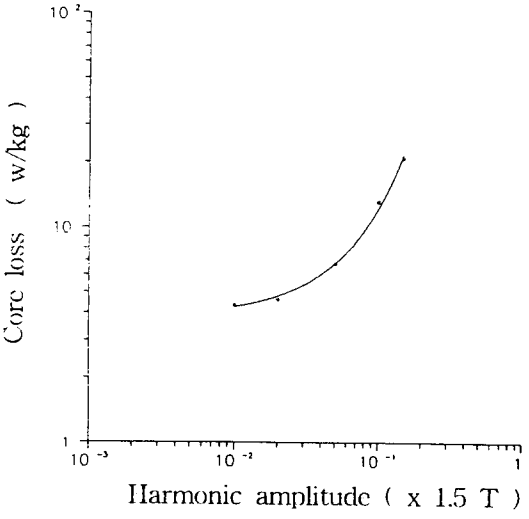

Fig. 5 Core loss changes due to the harmonic amplitude under B_{max} = 1.5 T and 25th harmonic frequency.

IV. CONCLUSION

For the core loss measurement under arbitrary waveform of magnetic induction, we have constructed a single sheet core loss measuring system which consists of yoke apparatus for single sheet of 10 cm x 10 cm, arbitrary waveform synthesizer, B-feedback system, and two channel transient recorder. Using the constructed measuring system, we can measure core loss including higher harmonics up to 2 kHz. The core losses of non-oriented electrical steel under different harmonic frequency and amplitude component of magnetic induction were measured. Core loss was increased exponentially when higher harmonic frequency or amplitude component of magnetic induction was increased.

From this experiment, the direct measurement of core loss under actual waveform of magnetic induction in electrical machine is an effective method for the optimal design of electrical machine.

REFERENCES

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