TEST OF AMORPHOUS CORE FOR DC BEAM MONITOR

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ABSTRACT

A characteristics of the cobalt-based amorphous alloy having low coercivity (Hc < 2A/m) and high square hysteresis (Br/B1>0.95) in B-H curves at high frequency have been measured for the dc beam monitor in the synchrotron & cooler ring, TARN-II. A small core test and a large core test have been performed. The experimental results of the test cores well agree with the design characteristics.

INTRODUCTION

The nondestractive dc beam monitor for an intensity measurement will be equiped in the synchrotron & cooler ring, TARN-II. An expected beam current is between 0.1 and 100 micro-ampere. (!1)

The traditional way to measure the dc beam is performed with a magnetic modulator-demodulator system. Since the magnetic modulator generates a various even harmonic components proportional to the dc beam current, the second harmonic component is detected by the demodulator in that system.

To increase the second harmonic component, higher permeability at the high excitation frequency is required. A large second harmonic signal is necessary to obtain the high signal to noise ratio in the electronics system. To suppress the noise, stringent shielding should be performed to realize a low noise environment.

We made a preliminary test of amorphous cores with a small size to find the best material suited for dc beam monitor. Toshiba and VITROVAC are selected as a test core suppliers. They have the cores providing the permeability of order of 100,000 at the excitation frequency of 400 Hz. The maximum permeability and quantity of second harmonic signal have been measured. (!2)

On the basis of preliminary test, the dc beam monitor with a large size core have been designed. The measurement of property of the large size core is being carried out.

!1 The intensity measurement at the old TARN was performed by the permalloy core monitor with the time constant of 5second and sensitivity of 0.2 micro-ampere.

!2 The ordinaly dc beam current monitor employs the material composed of Ni-Fe alloy which have the high permeability order of 10,000.

SMALL CORE TEST

The schematic of test stand is shown in Fig.1. The small troidal core is driven by the triangle waveforme generator through the current limitting resistor and 35turns excitation coil. The second harmonic output voltage is given by

$$V2 = 8NS\mu fHo \sin(\pi Hsat/Hpeak)\sin(4\pi ft)$$

where

N	Turn number of detection coil,
S	Crosssectional area of the core,
μ	Maximum permeability,
f	Excitation frequency,
Ho	Induced magnetic field due to dc beam current,
Hsat	Core saturation field,
Hpeak	Magnetizing force produced by excitation current,
t	Transition time of magnetizing force.

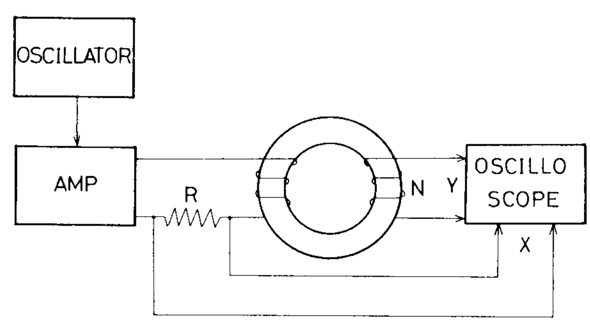

Fig.1 The schematic of test stand

The output signal level of the magnetic induction circuit is proportional to dB/dt of the core. The formula dB/dt can be written as dB/dH*dH/dt. The dB/dH means maximum permeability and the dH/dt means magnetizing speed in proportion to the coil excitation frequency.

For a given cores, the second harmonic output voltage per turn depends only on Ho (A/m), and is therefore output voltage is normalyzed by a crosssectional area (S) and a magnetic pass(Lfe). The Toshiba MA-26 shows the quantity V2 of 16.7 mV/(A/m)cm^2,which have S=0.169 cm^2 and Lfe=6.6 cm. The VITROVAC-6025Z(Vacuumschmerze) was also measured and quantity V2 of 14.9mV/(A/m)cm^2 was obtained. The measurement results show that the type of Toshiba MA-26 is useful to construct the beam monitor.

Table 1. Specification of Large Core

Saturation flux density(Bs)	0.65T
Courie temperature	270 °C
Crystallization temperature	540 °C
Density	8.0g/cm³
Max. strip thickness	20 µm
Max. permeability	DC 1000,000
	400Hz 100,000
	20KHz 20,000
Static coercivity(Hc)	DC 0.4 A/m
	400Hz 2.0
	20KHz 9.6
Remanence ratio(Br/Bs)	DC 0.90
	400Hz 0.93
	20KHz 0.96
Core loss(Bm=0.5T)	400Hz 0.3 W/Kg
	20KHz 60.0
Weight	1.6 Kg

LARGE CORE TEST

It is designed to construct the dc beam monitor with the sensitivity of 0.1 micro-ampere. This monitor consists of the 6 cores to increase the sensitivity to the dc beam current. The large size core have the dimmension of 186 mm in outer diameter, 143 mm in inner diameter and 20 mm in height. The core is housed in the plastic case and sealed by the silicon compound. The specification of the large size core are listed in Table 1. The core material is composed of (Co,Fe,Ni,Nb)75 (SiB)25 and is smelted from the ingot in the same condition.

The maximum permeability have been measured as the function of excitation frquency. The high power amplifier (50 watt) is used to increase the excitation power to the core. Turn number of the excitation coil and the detection coil are 10 turns, respectively. The current limitting resistor is 50 ohm with the maximum power rating of 50 watt. The measurement results are shown in Fig.2 and Fig.3. Fig.2 shows the dB/dt as a function of excitation current. The maximum permeability of 310,000 (CGS) is obtained at the excitation frequency of 400 Hz. Fig.3 shows the output signal at the opened detection coil. The peaking output due to transition field is observed which corresponds to the maximum permeability.

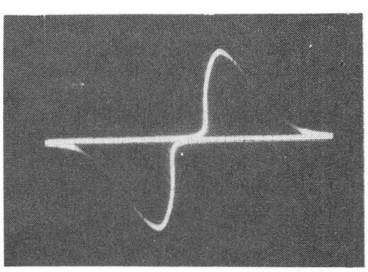

Fig.2 dB/dt as a function of excitation current. Excitation frequncy is 400 Hz.

X;0.4A/d
Y;10V/d

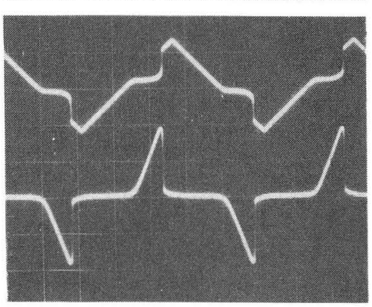

Fig.3 Output signal at the current limitting resistor(upper). Output signal of detection coil(lower).

V; 50V/d (upper)
10V/d (lower)
H; 0.5 ms/d

When the second harmonic is measured, the two cores are used and detection coil of each core are combined inversely so as to cancel the fundamental or odd frequency components of the higher harmonics (Fig.4). Fig.5 shows the frequency spectrum of the signal appeared at the detection coil. It is shown that the fundamental(400Hz) and odd(1200Hz) frequency components are suppressed comared with the signal summed in same phase.

The current sensitivity of 10 mV/mA is obtained by this cores. This value well agree with the calculation based on the formula described in the former section. Thus, the beam current sensitivity of 0.1 micro-ampere will be realized if the noise level at the input stage of the preamplifier is kept in 1 micro-volt.

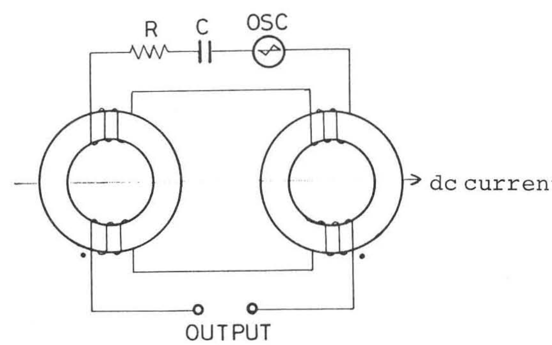

Fig.4 Measurement of Second Harmonic Signal

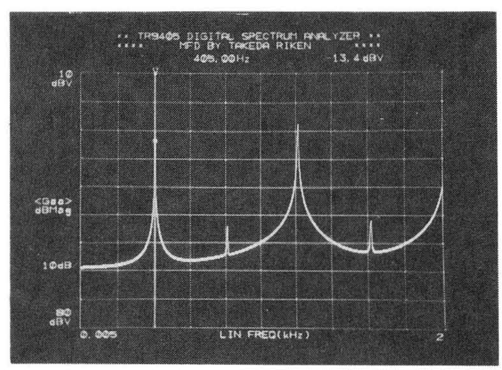

Fig.5 Frequency spectrum of output signal.

SUMMARY

The amorphous core with large size is utilized to detect the dc beam current circulated in the synchrotron & storage ring. The current sensitivity 16.7 mV/(A/m)cm² per turn is obtained at the excitation frequency of 400 Hz.

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