PULSE MAGNETIC FIELD MEASUREMENT FOR THE SIDE-PLATED CERAMIC CHAMBER

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Abstract

A superconducting wavelength shifter (SWLS) will be installed at the SRRC (Synchrotron Radiation Research Center) storage ring in May 2002 for x-ray diffraction experiments. Since this SWLS is located at the injection straight section, part of the emitted synchrotron light will shine on the inner surface of the kicker ceramic chamber and heat accumulation occurs. In order to solve this problem, a pair of water-cooled copper plate was designed to place inside of the ceramic chamber. This arrangement will reduce the physical aperture within the pulsed kicker magnet, from 78 mm to 50 mm horizontally. It is of great concern that this shall not degrade the quality of the pulsed magnetic field. A test bench was setup for the purpose of pulsed magnetic field measurement. This test bench includes a set of full-scale kicker magnet, ceramic chamber with cooling copper plates, pulsed power supply, and pulse magnetic probe. This report summarized the measurement results and electrical considerations of related engineering design.

1 CONSTRUCTIONS OF MEASURING SYSTEM

A testing platform was assembled in order to measure the magnetic field distribution of the modified ceramic chamber, as shown in Figure 1. This platform consists of electrical and electronic supporting components to the kicker pulser, a prototype kicker magnet, and the magnetic measurement system.

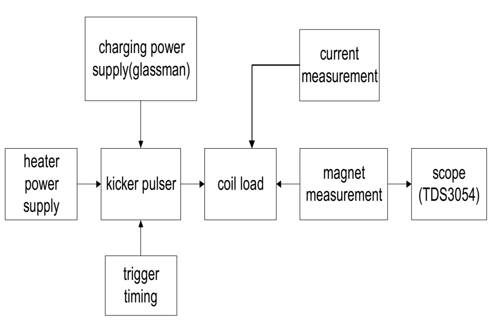

Figure 1 Functional block diagram of the testing platform.

1.1 Design and Manufacture of Magnetic Field Pick-up Coil

Since the kicker delivers a pulsed magnetic field of 1.2 μs half-sine base, a field probe was developed for measuring purpose. It is a precise 20 turns coil of 5 mm diameter assembled and fixed with epoxy. The calibration of this probe was done by using a commercial available pulsed current transformer (Pearson – 110). This field-pickup coil shall be adjusted properly such that the measurement will not disturbed the magnetic field to the precision requested. The appropriate probe dimension and integrated circuitry parameters adjustment is based on the following estimation.

(A) To calculate the magnetic field from the measuring pulsed current.

The measured peak current of the pulsed field is 5.9 kA and the magnet gap is 5.6 cm. Using the following relation in equation (1), a peak field of 0.132 T is obtained.

$$NI \equiv \frac{B_k g}{u_0}(MKS) \qquad (1)$$

$$\rightarrow B_k \equiv \frac{NI_p u_0}{g}$$

$$\because N \equiv 1, g \equiv 0.056m, u_0 \equiv 4\pi \times 10^{-7}\ H/m, I_p \equiv 5.9KA$$

$$\therefore B_k \equiv \frac{1\times 5.9\times 1.256\times 10^{-6}}{0.056}(T)$$

$$\rightarrow B_k \equiv 0.1323T$$

(B) To estimate the magnetic probe and signal integrator parameters to resemble the pulsed magnetic field.

The measured signal gives 2.95 V at nominal operating condition and the integrator parameters is estimated according to the relation shown in equation (2).(as seen in fig2).

$$v_{op} \equiv \frac{N\times A}{R\times C} B_p \qquad (2)$$

$$\rightarrow \because wire$$

$$d = 0.15mm^2$$

$$\therefore A = \frac{\pi D^2}{4} = \frac{\pi (5mm)^2}{4}$$

$$I_p = 5.9KA/0.1323T$$

$$\Rightarrow v_{op} = \frac{20\times 0.196}{20\times 10^{-6}}\times 10^{-8}\times 1323 = 2.59V$$

Figure 2   Probe & Integrator Model

1.2 *Calibration of the Magnetic Probe*

According the calculation and measurement results, the resemble magnetic field signal matches to the pulsed current signal with amplitude difference less that 2%. This is good enough for carrying out the bench measurement.(as seen in Fig3).

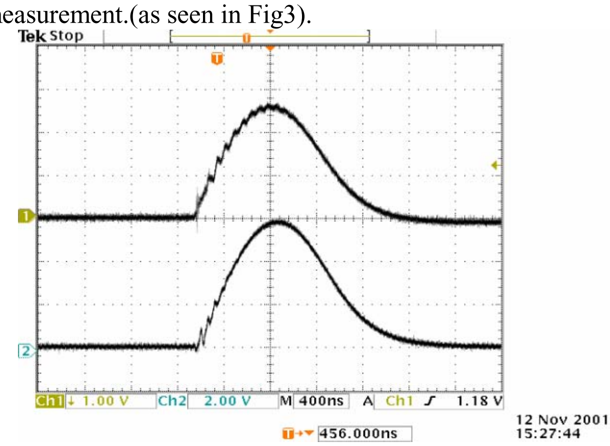

Figure 3   Testimonial Measurement Of the Probe

2   MAPPING OF MAGNETIC FIELD

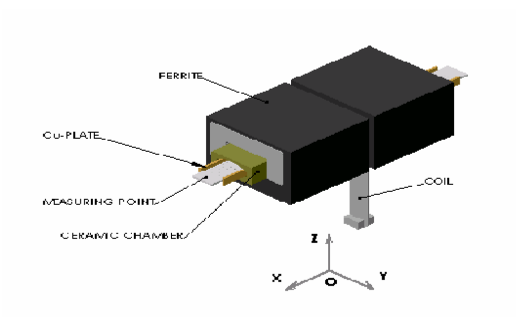

Figure 4   Assembly Diagram of Load End

Mapping of the magnetic field distribution over the entire plane of beam centerline has been done in the step of 10 mm, both horizontally and longitudinally. The horizontal physical dimension within the ceramic chamber is 78 mm. It will reduce to 50 mm after installing the copper plate. The schematic layout of the magnet, conducting coil and ceramic chamber is given in Figure 4.

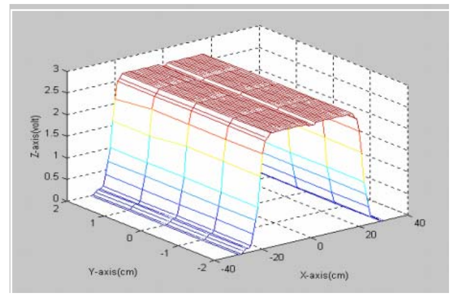

Figure 5   Allocation Diagram of Magnetic Field Without Ceramic Chamber

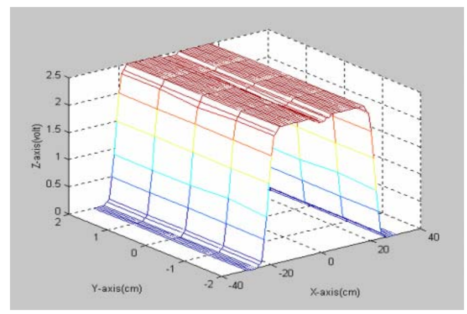

Figure 6   Allocation Diagram of Magnetic field With Ceramic Chamber

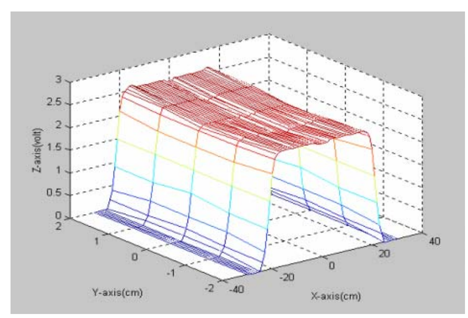

Figure 7   Allocation Diagram of Magnetic field With Ceramic Chamber and copper plate in place

The measurement of magnetic field distribution within the kicker magnet has been carried out for the cases of kicker magnet only, kicker magnet with ceramic chamber in place, and kicker magnet with copper plates installed inside of the ceramic chamber. The measured results are shown in Figure 5, 6, and 7, respectively. It indicates that the magnetic field strength reduces 1.8% due to the metallic coating on the inner surface of the ceramic chamber. Yet, the field distribution is as uniform as before installing the chamber. Probably adjusting the pulsed current knob can satisfy the compensation need. However, in the case of installing the copper plates, the field distribution is distorted nearby the conducting coil to some extent that it becomes 1.9% higher than that at beam centerline. This effect has been verified to be proportional to the copper plate area in the vertical magnetic field component. And this feature is caused by the eddy current, induced by the pulsed magnetic field, around copper plate and contributes to nearby field strength distribution. Consequently, the thickness of the copper plates has been modified several times in order to reduce the said effect. The data shown in Figure 7 is obtained with the final version of the complete unit before its installation.

3 CONCLUSION AND DISCUSSION

In order to examine the magnetic field distribution of modified ceramic kicker chamber, a test bench was built and magnetic field mapping has been carried out. The measurement results show that the installation of copper plates inside of the ceramic chamber gives disturbance to the field strength uniformity nearby copper plates of about 1.9%. This information is particular importance to aperture study of injection trajectory analysis. Some practical insulation problem while operating at high magnetic current will need to be further enhanced.

4 REFERENCES

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