THE MAGNETIC MEASUREMENT OF CONVENTIONAL MAGNETS FOR FREE-ELECTRON LASER PROJECT OF CHINESE ACADEMY OF ENGINEERING PHYSICS*

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Abstract

The project of free electron laser is worked together completed by CAEP (Chinese Academy of Engineering Physics) and IHEP (Institute of High Energy Physics, China). Conventional magnet of the project includes a total of three deflecting dipole magnet, an analysis of dipole magnet, and two quadrupole magnets. All of magnets to complete the measurement by IHEP Hall measuring equipment.The measurement trajectory of integral magnetic field for deflection dipole magnet is arc and arc tangent direction, using Labview software written a new measurement procedures,the Hall probe directly read absolute value of the three-axis(X, Y, Z) coordinate point (relative to the Hall probe in terms of absolute zero) measurement functions, Not only achieve the purpose of measuring the trajectory can be freely combined, but also effectively eliminate the accumulated error of Hall mobile devices.All measurement results of conventional magnets have reached the physical design requirements, and each magnet were carried out more than twice the measurement, the reproducibility of the measurement results are better than one-thousandth, fully meet the design claim of CAEP.

INTRODUCTION

To meet the requirements of material and biomedicine study a terahertz Free Electron Laser (FEL) user facility project was proposed by China Academy of Engineering Physics (CAEP).The facility operates in the quasi CW mode and the average power is about 10 W. The wavelength of the light can be adjusted between 100 μm/(3 THz) to 300 μm/(1 THz) according to the needs of users by changing the electron energy and the magnetic field of the wiggler. The facility mainly consists of the electron source, the main accelerating structure, the hybrid wiggler, the optical oscillator cavity, the terahertz-ray transmission system and the detector. In order to achieve the high brightness beam, the photocathode DC gun is used as the electron source. The electron will obtain energy by passing through a superconducting accelerator, and the electron energy after the accelerator is about 8 MeV, which is suitable to obtain the terahertz light[1]. The parameters of THz facility have been shown in Table 1. The facility of THz-FEL is shown in Fig 1

Table 1: Parameters of the THz Facility

(a)electron beam			
Energy/MeV	7.5	**peak cureent/A**	10
micro bunch/ps	10	**repetition rate/MHz**	54.17
emittance/πmm·mrad	10	**energy spread/%**	0.75(FWHM)
wave-guide cross-section	30mm×14mm		
(b)wiggler			
period/cm	3.8	**peak field strength/T**	0.33
(c)optical			
wavelength/μm	160.3	**cavity length/m**	2.769
mirror curvature/m	1.85		

Figure 1: Layout of the high average power THz-FEL facitility.

Conventional magnet of the project includes a total of three deflecting dipole magnets, an analysis of dipole magnet, and two quadrupole magnets. The measurement trajectory of integral magnetic field for deflection dipole magnet is arc and arc tangent direction.

According to the physical requirements of this experiment, first, a new program of measurement has been written by Labview software. The Hall probe directly read absolute value of the three-axis(X, Y, Z) coordinate point (relative to the Hall probe in terms of absolute zero) measurement functions, Not only achieve the purpose of measuring the trajectory can be freely combined, but also effectively eliminate the accumulated error of Hall mobile devices.Second, the preparation for hardware, the device of measurement and collimation. The device about measurement includes the Hall-probe measurement facility, the power supply and the magnets; the device of collimation includes theodolite, level and collimation target.

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THE DESCRIPTION OF PROGRAM

The measurement trajectory of integral magnetic field for deflection dipole magnet is arc and arc tangent direction. First, the program for the command of move the motor was compiled to "read the absolute coordinate values." Then, we can calculate the trajectory of measuring absolute coordinates of each step by the polar coordinates, and finally, the data is read into the program, we can start measuring.

The Tesla meter is via RS-232 serial port to communicate with the computer. The main program consists of several parts, the serial port is defined, write, read, close, data acquisition (temperature and magnetic field values).The main structure of the program is the while loop and conditional structures.The program flow diagram and the front panel of the program is shown in Fig. 2.

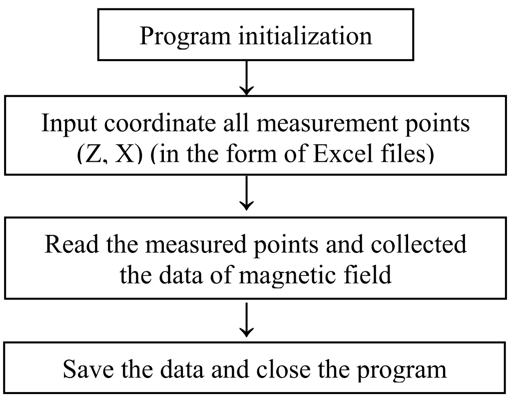

Figure 2-a: The program flow diagram.

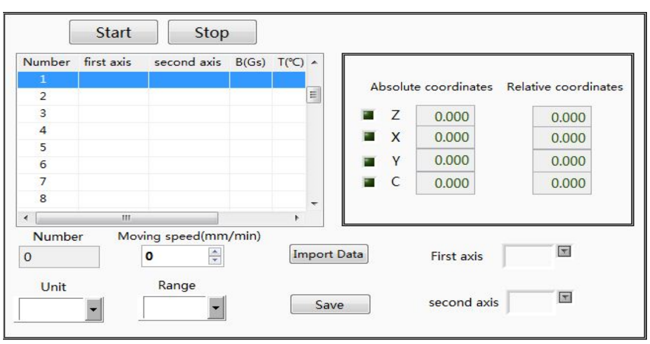

Figure 2-b: The front panel of the program.

THE DESCRIPTION OF HALL-PROBE MEASUREMENT FACILITY

The Hall-Probe measurement facility is a 3-axises motion bench. The movement of 3-axises(x, y and z) can be operated by computer. The positioning accuracy of x, y and z axis is ±0.001mm and the positioning repeatability accuracy is ±0.01mm. In addition, this machine can be also used to adjust the rotation and pitch adjustment probe ensure that the probe can measure the magnetic field perpendicular to enter the area of the magnet, so that the total is a five-dimentional adjustment system. The Teslameter and Hall probe are produced by Group3 Led. The sensitive of the MPT-141 Hall Probe is 1×0.5(mm).

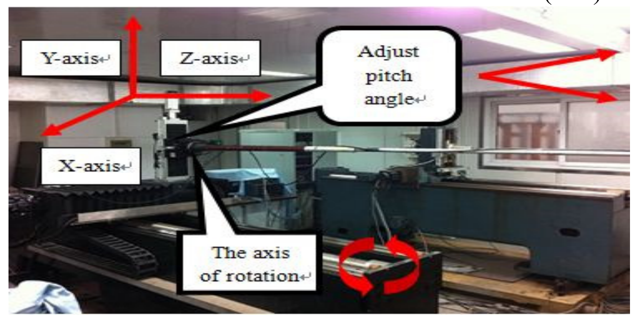

Figure 3: Hall-Probe Measurement Facility.

The DTM-151 Digital Teslameters offer accurate, high resolution measurement of magnetic flux densities, with direct readout in tesla or gauss, and serial communications by fiber optics or RS-232C for system applications.The instruments are light and compact, and the probes are easy to use. The DTM-151 has been engineered to withstand the severe electrical interference produced by high voltage discharge [2].

Group3 Hall probes are built to be as robust as possible for a small, precision device.However, it is most important that certain precautions be taken when handling and installing probes so that they are not damaged or destroyed [3].

Table 2: The Performance Overview of DTM-151 and MPT-141

Hall Probe	MPT-141	**The measurement of maximum magnetic field**	3T
Sensitive area(mm)	1×0.5	**Zero drift(μT/ºC)**	±1
Accuracy/ 25 ºC	±0.01%		

THE PROCESS OF MEASUREMENT

The Content of Measurement

The angle of deflecting dipole magnet is 45°. The requirement of measurement is distribution for integral field. The horizontal measuring range is the range of the magnet center from (-18mm) to 18mm, the size of measured step is 3mm. The measuring current is 5.6A. The requirement of integral measurement is the arc of 45° and the tangent of this arc, the arc portion measuring the angle of each step is 1°, arc tangent section with a length of 200mm straight line, each step is 4mm, each line a total of 146 points measuring points (the measuring trace is shown in Fig 4).

The angle of analysis magnet is 90°. The requirement of measurement is distribution for integral field. The

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horizontal measuring range is the range of the magnet center from (-17.5mm) to 17.5mm, the size of measured step is 3.5mm. The measuring current is 5.42A. The requirement of integral measurement is the arc of 90° and the tangent of this arc, the arc portion measuring the angle of each step is 1°, arc tangent section with a length of 200mm straight line, each step is 5mm, each line a total of 171 points measuring points(the measuring trace is similar to Fig 4);

The objective measurement of above two dipole magnets is to get the maximum value of the magnetic center, error distribution for integral field and the effective length of the magnet.

Because of the measurement of quadrupole magnet is calibrated to the rotation coil for rotating msasurement, the content of measuring is small, it does not introduced here.

Some pictures for the measurement are shown in Fig 5.

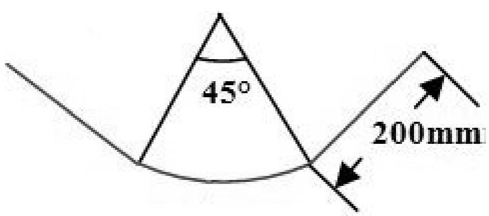


Figure 4: the trace of integral measurement.

Figure 5: The pictures of measurement.

The Process of Collimation

The collimation of magnet is by Theodolite and Level. These devices are shown in Fig. 6.

(1) The theodolite has been levelled, and then the probe has been moved back and forth along the Z axis for alignment of the theodolite.

(2) Adjusted the level of the magnet by the Level and the engraved lines of the magnet.

(3) Adjusted the rotation of the magnet by the theodolite and the engraved lines of the magnet.

The collimation of the magnet has been completed by the above steps.

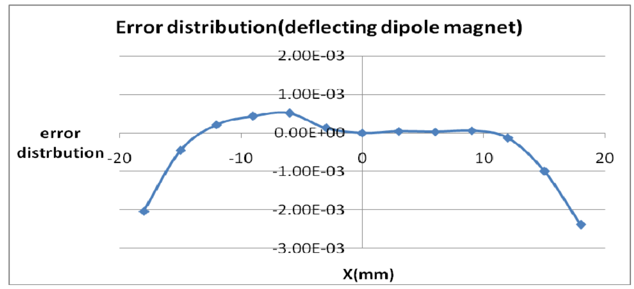
Figure 6: The Theodolite and Level.

THE RESULTS OF MEASUREMENT

The measurement result is shown in Table.3. The error distribution for integral field is shown in Fig.7.

Table 3: The Result of the Measurement

Magnet	effective length/mm		Center field value/Gs	
	Theoretical	Measured	Theoretical	Measured
deflection	≥158	160.6	1604	1605.3
analysis	≥478	482.7	1303	1304.6



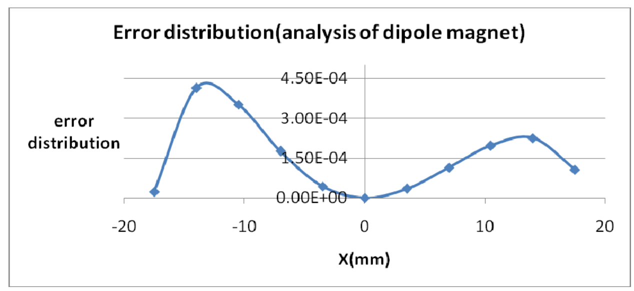


Figure 7: The error distribution for integral field.

CONCLUSION

According to the measurement results, the effective length and center field value for two types of magnets are meets the requirements of the theoretical value; the error distribution of integral for two types of magnets is less than 5.00E-03(the error distribution of theoretical requirement).

ACKNOWLEDGEMENT

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