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APPLICATION OF CMM TECHNOLOGY IN ACCELERATOR MAGNET DETECTION

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Abstract

Accelerator magnet is one of the most difficult equipment in accelerator hardware system. With the improvement of physical requirements, more and more high technical requirements are put forward for magnets. This paper mainly introduces the new application of three coordinate measurement technology in the detection of accelerator magnet, and introduces the working process of CMM in the detection of accelerator magnet polar profile.

RESEARCH PURPOSE

Accelerator magnet is an important part of particle accelerator. The quality of its magnetic field will directly affect the beam debugging difficulty and beam quality. In view of the higher and higher requirements of magnetic field quality put forward by accelerator physics, magnet designers not only carry out further optimization design for the pole surface of magnet, but also put forward higher requirements for the process level of magnet processing and assembly.

In this paper, the application of CMM in the detection of accelerator magnet is studied. Taking the prototype magnet of a high-energy synchrotron radiation source verification device (heps-tf) as an example, the working process of CMM in the detection of accelerator magnet polar profile is introduced.

APPLICATION OF CMM

CMM

CMM (coordinate measuring machine) is an instrument that can calculate various geometric shapes, dimensions and other measurement capabilities through CMM software system according to the point data returned by the probe system in the three-dimensional measurable space.

CMM can be defined as a kind of detector which can move in three directions and can move on three mutually perpendicular rails. The detector transmits signals in contact or non-contact way. The displacement measurement system of three axes (such as optical ruler) calculates the coordinates X, Y, Z of each point of the workpiece and the measuring instrument of various functions by data processor or computer. The measurement functions of CMM include dimension precision measurement, positioning precision measurement, geometric precision measurement and contour precision measurement. Any shape is composed of three-dimensional space points, and all geometric measurement can be attributed to the measurement of three-dimensional space points. Therefore, accurate collection of space point coordinates is the basis of evaluating any geometry.

Application of Accelerator Magnet Detection

As a new type of high-precision detection method, coordinate measurement technology has been widely used in the fields of traditional processing, manufacturing and precision detection. With the increasing requirements of accelerator magnet technology, we try to apply the advanced technology of CMM in the field of accelerator magnet.

When the traditional accelerator quadrupole magnet is assembled and tested, the traditional measuring tools such as internal micrometer and vernier caliper are usually used, and the air gap size at the pole of the magnet is detected by manual detection, and the detection results at this point are used as the final assembly error detection standard. In the new magnet research project, we use the latest digital measurement technology, and use the high-precision three coordinate measurement system to detect the air gap at the pole of the magnet and the polar surface of the whole pole. Through the automatic detection means, we can more comprehensively grasp the magnet processing, assembly level. The comparison of accuracy, advantages and disadvantages of the two detection methods are shown in Table 1.

Table 1: Comparison of Detection Methods

	Traditional Detection	Coordinate Measurement
Equipment	Inside micrometer	CMM
Location	Air gap	Air gap + polar surface
Accuracy	± 0.01 mm	± 0.005 mm
Advantage	Fast and convenient	Comprehensive detection, high precision
Disadvantage	Local detection, low accuracy	The equipment is expensive

PROFILE MEASUREMENT

Testing Equipment

We use the coordinate measuring system of hexcon group to test the magnet, and use PC-DMIS software system with a resolution of 5° Hh-a-m5, probe_Tp20, exten 100 mm and 3 mm-30 mm Ruby probe were used to complete the test, see Fig. 1.

Definition of Magnet End Face and Coordinate System

The end face definition and spatial coordinate system of accelerator quadrupole magnet are shown in Fig. 2 magnet coordinate system schematic diagram. The two end faces of magnet definition are A and B end faces respectively.

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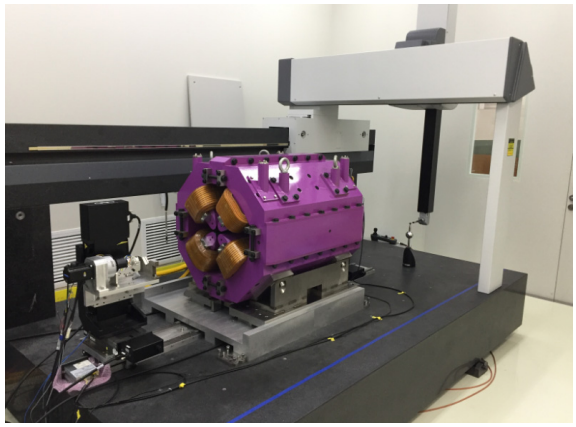

Figure 1: Testing Equipment and Magnet.

Along the axial direction of magnet, A-B is Z axis, along the horizontal upward direction of magnet is Y axis, the positive direction of vertical plane is X axis, and the coordinate origin is located at the center point of magnet.

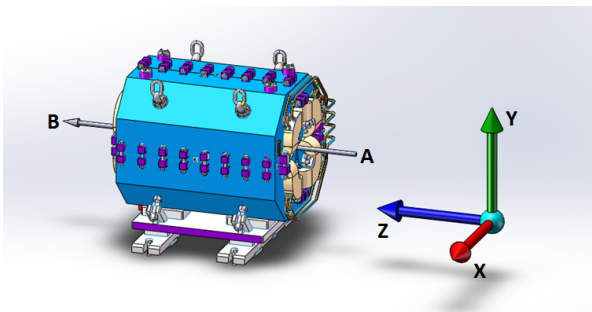

Figure 2: Schematic Diagram of Magnet Coordinate System.

Coordinate System Creation

We use the point line plane method to establish the workpiece coordinate system, and take the horizontal plane Y0 and the vertical plane X0 of the magnet as the first reference plane to construct the magnet coordinate system to detect the magnet, see Fig. 3.

By measuring the positioning points A1-A8, B1-B8 at the positioning plane of the pole head of the magnet, and using the plane construction function of PC-DMIS software [1, 2], the reference planes Y+, Y-, X+ and X- of the magnet are obtained by the best fitting method, and the split planes X0 and Y0 of the magnet are constructed according to the fitted plane.

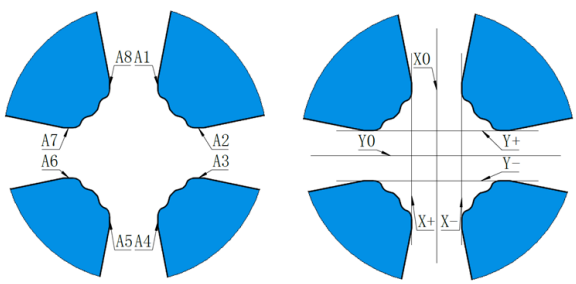

Figure 3: Survey Mark Point and Construction Plane.

According to the midplane of the magnet and other positioning points, the workpiece coordinate system of the magnet can be created by using the point line plane method with PC-DMIS software.

Measurement Result

The CMM is used to measure the profile and gap size of the magnet for many times. The measurement accuracy and repeatability are higher than the traditional measurement methods, see Figs. 4 and 5.

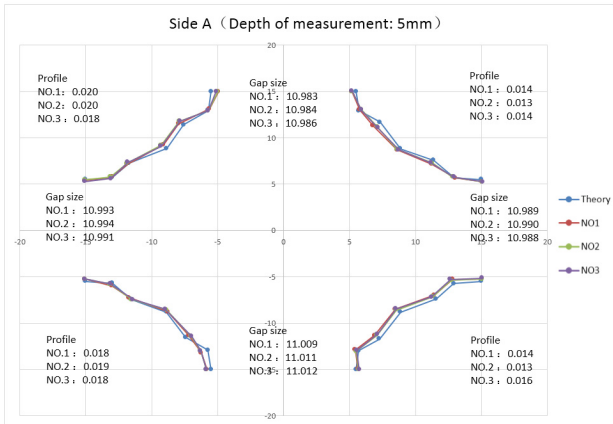

Figure 4: Measurement Result of Side A.

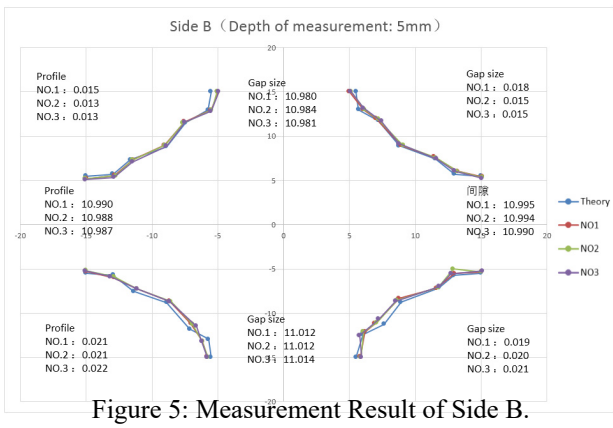

Figure 5: Measurement Result of Side B.

CONCLUSION

As a new, high precision and high efficiency measuring method, CMM can be widely used in accelerator magnet field. In the specific application practice, its measurement accuracy and repeatability are better than the traditional measurement method.

REFERENCES

[1] Liu Zhaoping, Wu Yinhua, and Wang Xiaowei, “The lrregular Arrangement of Feature Measurement Based on PC-DMIS”, *Metrology and Measurement Technique*, vol. 43, no. 03, 2016.

[2] CHEN Xiaowei, CHEN Ligui, LIU Kun, XIA Liping, “The Uncertainty Evaluation of Measuring Distance with Coordinate Measuring Machine Based on PC-DMIS”, *China Metal-forming Equipment & Manufacturing Technology*, vol. 52, no. 04, 2017.