Straightness Measurement of Mechanical Centers of Magnetic Pole for Alignment Check of the Storage Ring

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1. Introduction

The storage ring has a circumference of 1436m with 48 cells. In each cell, there are 17 magnets as the sum of quadrupoles and sextupoles which are mounted on three girders (A, B, and C) and are two bending magnets. Alignment of multipoles is done through two-step process. The first step is the alignment of girders themselves. In the second step, the multipoles on a girder are aligned. Two target stages have been fixed after fine adjust at the 500.00mm above the magnetic axis at magnetic field measurement on both end magnets as shown in Fig.1.

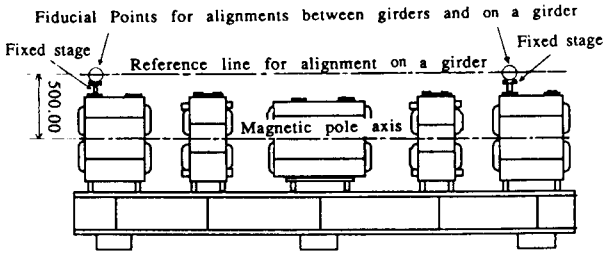

Fig.1. Alignment reference line and magnetic pole axis.

At first, the tracker target are put on the fixed stage and girders are surveyed on the horizontal plane with a laser tracker system by making network[1]. After the survey these girders are smoothed. The relative displacement between girders of ±0.04 mm has been achieved. The levels of fixed stages are surveyed after the girder positions are fixed. Finally, each magnet on the girder is aligned by using the Reference line in Fig.1. A system which consists of a laser and a CCD camera has been developed to align magnets on a 5 m-long girder within an accuracy of 10 μm[2,3]. The standard deviation of this alignment error in a girder were about 6 μm in horizontal and vertical directions.

However, these fiducial points and Reference line for the alignment are on a height of 0.5m from the median plane of the magnet pole. Thus in order to check the alignment, it is important to measure the symmetrical center of several magnetic poles.

2. Apparatus

In order to measure the pole center the apparatus shown in Fig.2. are made. The diameters are the same as bore ones (quadrupole : 85, sextupole: 92mm). Thick glass plate (made by Taylor Hobson) on which the parallel lines are coated is inserted and adjusted so that the pattern center coincides with that of the outer circle.

Before setting this apparatus the coating for a rust preventive on the pole surface is removed by acetone or paint remover. The apparatus touches the only two pole faces. Spring plungers are used for support when this touches the upper or side poles.(Fig.3) By rotating it measurements are repeated 4 times for quadrupole and 6 times for sextupole. Averaged value is used.

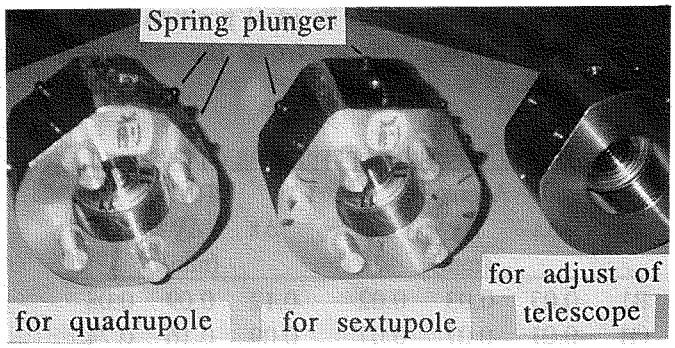

Fig.2. Apparatus for measuring the pole center.

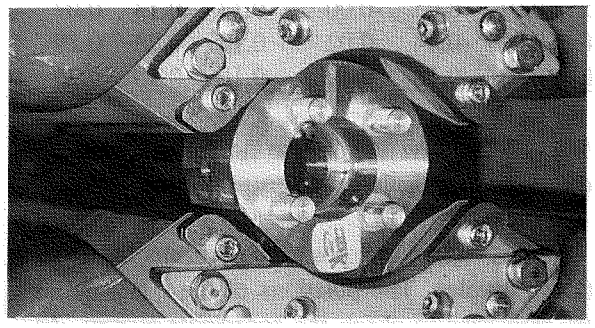

Fig.3. Apparatus in the quadrupole magnet.

A target shown in Fig.4 was made to measure the center of the fixed stage. The center of glass target coincides with that of the spherical surface (ø75) and the target seal is stuck on the extension pipe. This target is also used when the fixed stage cannot be seen because of the interruption of view by gate valve etc.

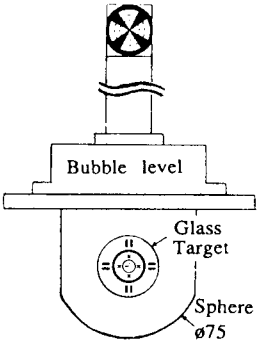

Fig.4. Extended target.

3. Method and Results

3-1 Alignment Check Between Girders

The pole center is measured with a theodolite or an alignment telescope and the apparatus(Fig.5). The glass target is illuminated by light.

The center of the fixed target stage must be in a precise position perpendicular to the magnetic axis. The magnetic axis is defined by pole centers of both end magnets with the apparatus. The theodolite is set on the extended line of the magnetic axis. After above procedure the line of site is raised up vertically and the target on the fixed stage can be seen. The distance between the raised line of the pole center and the target center was measured for 22 quadrupole magnets. These

values were less than 10~20 μm and are comparable with the measurement error.

The two girders on both sides of a insertion device are aligned straight. The deviations of magnetic pole centers from the straight line are less than 0.1mm.(Fig.6)

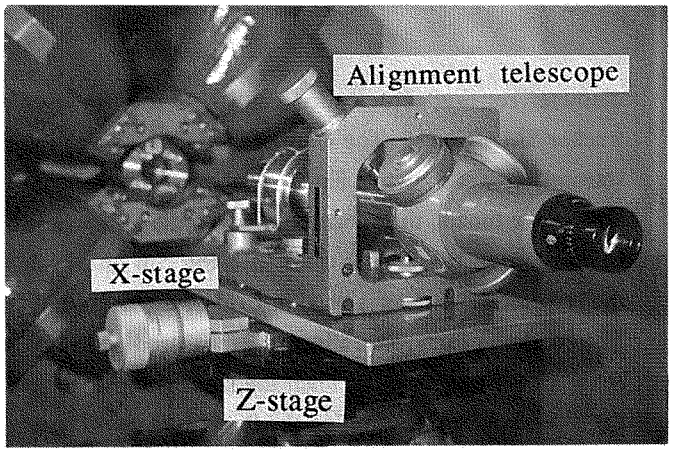

Fig.5. Setup for the straightness measurement.

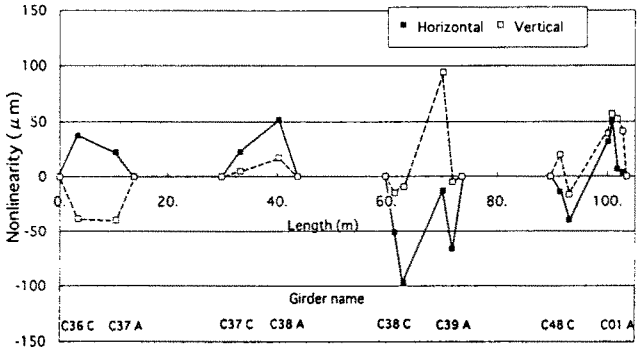

Fig.6. Straightness between two neighbor girders.

3-2 Alignment Check In a Girder

The magnet usually has small rotation errors. Thus we measured the pole centers at three positions, that is upper stream, middle, and down stream. Figure 7 shows the histogram of these rotations of quadrupole magnets. The symbols θx and θy denote the rotation errors around horizontal and vertical axes, respectively. These tolerances are 1 mrad. Average θy is not 0 but about 80 μrad in the right-handed screw direction from top view.

The deviations of pole center from the straight line are shown in Fig.8. This straight line is decided by the pole centers of quadrupole magnets on both sides of one girder. These deviations are connected by lines in one girder. The standard deviations are less than the tolerances (50 μm in one girder).

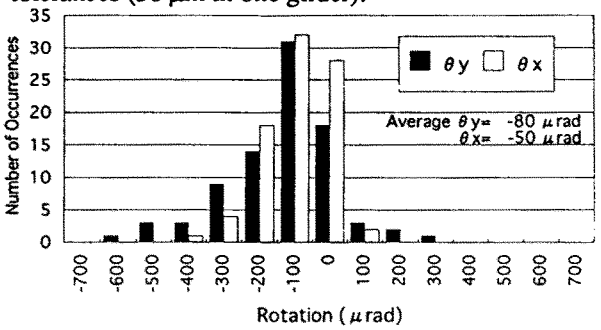

Fig.7. Histogram of rotation errors of quadrupole.

The multipole magnets are of two-pieses construction. The upper half is split and reassembled due to the installation of vacuum chamber. These results are obtained before magnet split. Multipole magnets are split after precise alignment by the crane. We measured also after split and reassembly only one cell (No37 cell 17 magnets). In this case there were no large changes.

4. Conclusion

The rotation and the averaged center of each magnetic poles are seemed to be aligned within the tolerances. We think that the measurement of magnetic center, the girder survey using laser tracker, and the alignment system of laser and CCD camera have no serious problems.

References

[1] C. Zhang et al., Proc. 4th International Workshop on Accelerator Alignment, Tsukuba, 1995, p185(1996)

[2] S. Matsui et al., ibid., p174(1996)

[3] Y.Chida et al.,ibid., p194(1996)

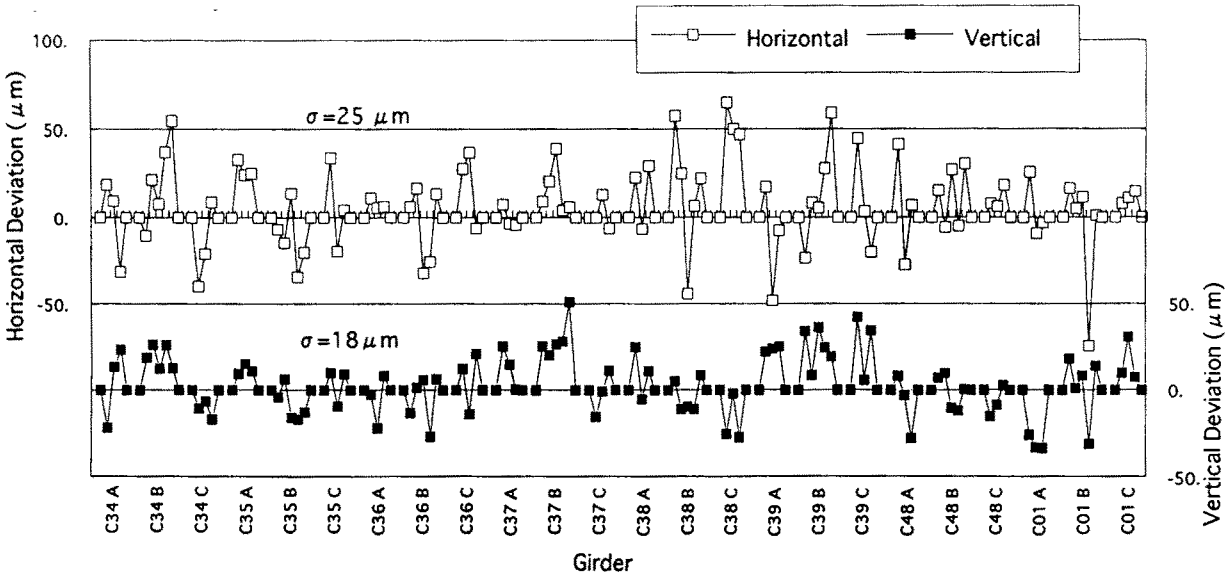

Fig.8. Deviation of magnetic pole centers from straight lines in a girder.