About Realignment of New SUBARU Ring and Its Transport Line

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1. Introduction

New SUBARU is a 1.5GeV electron storage ring being constructed at the SPring-8 site in the stage of commissioning. The ring provides light beam in the region of VUV and soft X-ray. It has a circumference of about 119 meters, and possesses two very long straight sections for a 11-meter undulator and an optical klystron, four short straight sections for a 2.3-meter undulator, a superconducting wiggler, rf cavity and injection magnets respectively.

Magnets of the storage ring are composed of twelve bending magnets, six inverse bending magnets, fifty-six quadrupoles and forty-four sextupoles, *etc*. Multipoles (quadrupoles and sextupoles) are mounted on twenty-four girders. The beamline height is 1.21 meters.

New SUBARU ring uses 1GeV linear accelerator of the SPring-8 as an injector. Beam transport line from the linac to the ring is switched to L4-beam transport line or NS-beam transport line.

2. Alignment Results of the Ring and Problems

Method of the ring alignment was described in preceding reports [1,2]. First, We make first-order alignment references with the bending magnets and inverse bending magnets by network survey method. Then all other multipoles, injection magnets, as well as insertion devices etc. are aligned by referencing the first-order references with a 3-D laser tracker and a CCD laser system.

Main magnets completed installation in March 1998. After that, the multipoles were divided and combined to install vacuum chambers. Then vacuum chamber was evacuated and baked out. Any process above influence on aligned magnet positions. Unfortunately, we could not recover the precision achieved from the first alignment in the later readjustment for some mechanical reasons.

On the stage of completing magnet installation, the multipoles on one girder were adjusted within 0.015 mm for transverse deviation. Bending magnets, first order reference, were aligned within 0.03 mm with respect to the mean orbit in horizontal plane. Multipoles' deviation with respect to bending magnets was 0.06 mm (r.m.s.) in horizontal transverse. After magnet division and combination, this statistic value was 0.08 mm and it kept so after evacuation and baking of chambers. While in vertical plane, multipoles' deviation with respect to (w.p.t.) the bending magnets was 0.1 mm before the chamber installation. And, this value did not change even after the magnet dividing and the chamber baking. That is, the multipoles moved obviously at the time of magnet division. A probable reason is that in many places the vacuum chambers were in touch with magnet poles, which means that vacuum chambers were not well aligned within tolerance. The force produced from the touched chamber is easy to move magnet horizontally. It was found that the physical aperture of the ring was very small at the first stage of commissioning. Effort was made to find the problem. Although it was finally confirmed to be due to the deformation of the rf contact fingers at the insertion devices, misaligned chamber reduced the aperture obviously.

Figure 1 shows the vacuum chamber and the chamber block of beam profile monitor in a short section. Position of vacuum chamber was checked at two end flanges of each chamber.

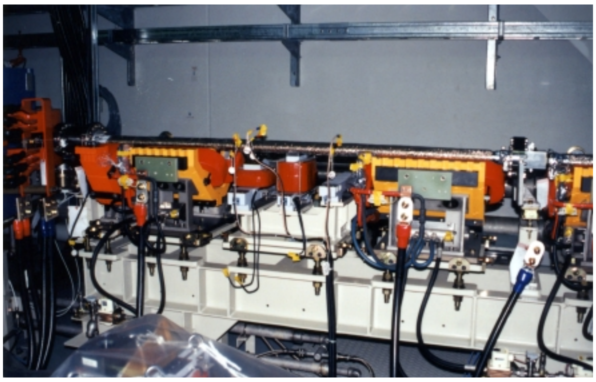

Fig.1. Multipoles are divided to install the vacuum chamber.

At first, the chamber was found to have maximum displacements of 6 mm in horizontal and 3 mm in vertical at long straight section. Chambers at the outlet of each inverse bending magnets were settled down by 2-3 mm, because the pump bellows were freed for the baking. Chambers at these sections were readjusted afterwards. Positions of the chamber blocks w.p.t. magnets for the beam position monitors need to be measured often because of the deformation of the vacuum chambers. For this purpose a tool stage, erected from the upper surface of BPM and hold a Laser tracker's target, is used. A coinciding-type leveler used to correct tilt error of the stage has a capability to measure 10 mrad inclination.

Figure 2 shows displacements of vacuum chambers and beam position monitors. Horizontal displacement is evidently larger than vertical's, because the chamber position is difficult to be measured and installed in this direction. Position of the BPM is no more precise than chamber's and has systematic installation error.

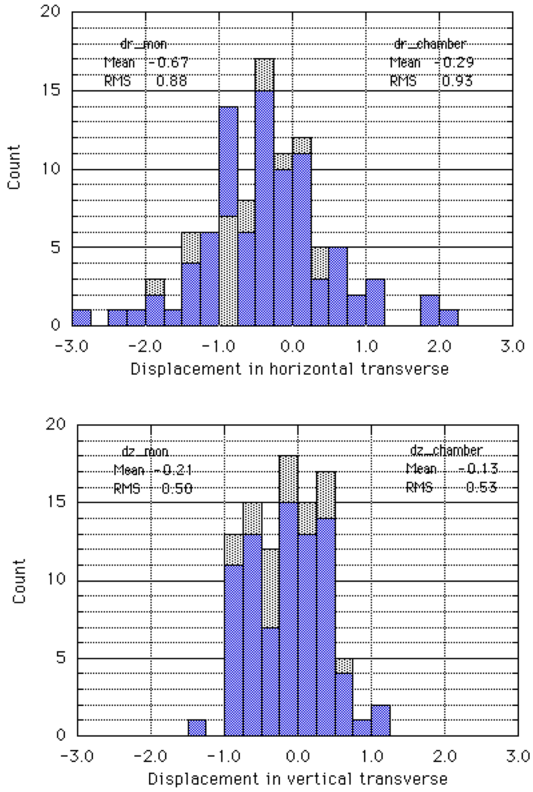

Fig. 2. Chamber and BPM positions w.p.t. the bending magnets.

Distortion of the chamber much influences the position of the multipoles. Moreover, it makes it difficult to adjust magnets which are in touch with chamber. Another problem made it feel difficult to realign the ring is that we have no rigid girders to keep multipoles not moving when the short sections are adjusted. As a result, the relative positional accuracy for adjacent magnets is hard to be restored.

3. Realignment for the NS Transport Line

For about 80 m NS beam transport line (NS-BT), there are thirteen quadrupole magnets, one bending magnet, and five beam profile monitors. It was confirmed that the positional displacements of these magnets exceeded the tolerances, and it made commissioning difficult. In order to smooth beam path, all of the magnets as well as the beam profile monitors were realigned.

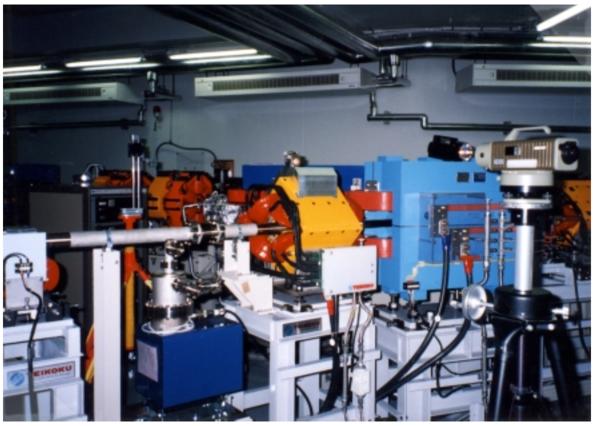

Fig. 3. Realignment for a quadrupole near injection point.

Height reference for NS-BT is taken from the magnets at injection section of the ring. They are 1483 mm for quadruple and 1,210 mm for BPM. Both are below the height reference of the bending magnet of the ring, which is 1,560 mm. We use a 400-mm digital height gauge stuck with a paper optic target to translate the height differences. Figure 3 shows the realignment for a quadrupole near injection point, and height of the quadrupole is being adjusted through the translation height gauge. This method ensures an accuracy of several micrometers for height translation. References in horizontal plane are the two end magnets in each beam transport line. Realignment of the transport line is relative adjustment both in horizontal and vertical planes.

To measure the center of a beam profile monitor, the level N3 need to be set just beside the monitor and to see through the window. So, beside each monitor a paper optic target is stuck onto the wall to give the height reference of 1,210 mm. A theodolite T3000, which is aligned beforehand to the horizontal reference line, is used to determine planar position of the monitor through its upper window (Fig. 4).

Quadrupoles in NS-BT transport line were manufactured without fiducial points. Center of magnet poles were used in primary alignment when installation. In the realignment we have to make an optic tool platform to represent the center of the quadrupole as shown in Fig. 5. The platform directly employs magnetic core surfaces of a quadrupole to locate its center with six contact points. It holds two optic targets and a Nivel20 tilt-meter. Measurement accuracy depends on manufacture of the core surface. Reversing the platform's touching surface with quadrupole's two upper planes can eliminate manufacture-caused measurement error.

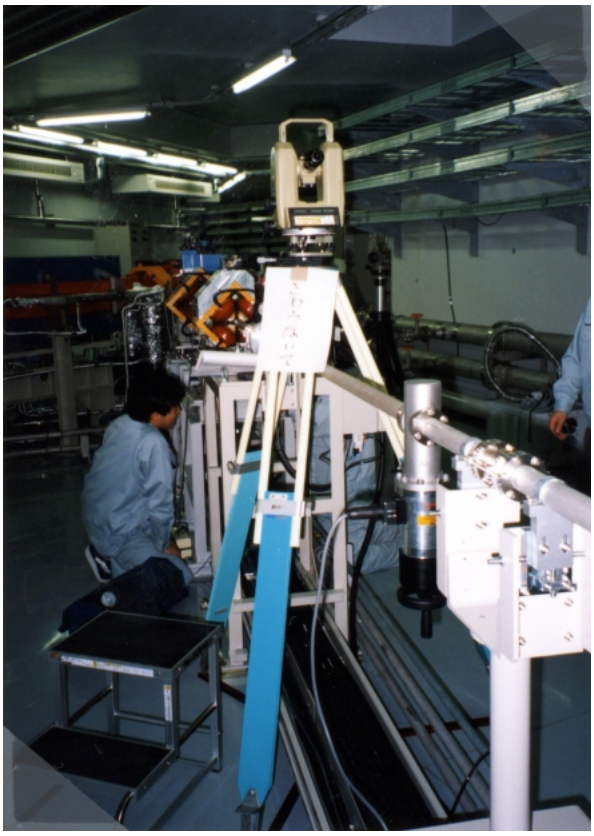

Fig. 4. Planar positions of quadrupole and beam profile monitor are measured with theodolite.

Fig. 5. Optic tool platform for quadrupole magnet alignment.

With these methods the magnets in the NS-BT transport line are realigned to accuracy about 0.1 mm for beam transverse direction and 0.1 mrad for inclination.

4. Conclusion

Purpose of alignment is not only to achieve best results in the first stage of magnet installation but also to keep or recover the component positions later. Position of chamber influences the position of magnet. Realignment will be easier if the chamber is well adjusted, and if relative magnet positions are kept when making adjustment.

References

[1] C. Zhang, *et al.*, SPring-8 Annual Report 1997, 180 (1997).
[2] S. Matsui, *et al.*, SPring-8 Annual Report 1997, 177 (1997).