Realignment magnets of Siam Photon Source storage ring

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1. Introduction

The accelerator complex of Siam Photon Source is based on the SORTEC accelerator complex which had been transferred to the National Synchrotron Research Center. It consists of (a) a 40 MeV injector linac and a low energy beam transport line (LBT), (b) a 1.0 GeV booster synchrotron (SYN) and a high energy beam transport line (HBT) and (c) a 1.0 GeV electron storage ring (STR). The magnet lattice structure of STR and the magnet layout of HBT of the SORTEC accelerator system are reformed in the Siam Photon Sources [1], [2]. The magnet lattice of STR has been changed from FODO to DBA [2]. Aiming at upgrading the machine characteristics, we have added some magnets to the ring and expanded the circumference from 45.7 m to 81.3 m to make four long straight sections for insertion devices. A new building to accommodate the accelerator complex and the experimental hall has been built. The linac and SYN are installed underground at the level 4.5 m lower than that of STR. This enables the beam injection from the inside of STR and all space 360^{o} around STR can be used for experiments.

The floor structure to support SYN such as the number and the layout of piles and the shapes of concrete beams on them is different from that of STR. In general, the floor settlement occurs in a short a period after the building construction is finished. If an intolerable amount of floor subsidence occurs after the installation of the machine, the resulting machine misalignment must be corrected. This was the case and we had to realign SYN and STR. The installation of SYN and STR was completed in July 2000 and in December of 2000, respectively. The SYN was realigned in June 2001. Owing time constraint, we decided to start the commissioning of the machine in October 2001 without realigning STR. We succeeded in storing the 1.0 GeV electron beam in STR in December 2001, one year after the installation. However, the attempt to increase the stored current has been impeded by several problems and the stored current was limited to be below 28 mA. As one of the pieces of investigation of the causes and pertinent actions, STR level was surveyed. The maximum difference of dipole magnet levels was found to be 4.2 mm. This is considerably large for a ring with 81.3 m circumference. Therefore, we decided to realign STR. In this report, we describe the procedures taken for the STR realignment work and the consequent result of machine commissioning after the realignment.

2. Survey of STR

2.1 Magnet levels

For the machine alignment, PASCO [3] established the survey network and installed reference marks and carried out the alignment work. As mentioned already, we ignored the anticipated magnet misalignment due to the uneven floor subsidence and started the machine commissioning. The irregular floor settlement had occurred while preparation work such as the vacuum chamber baking, the repair of the RF tuner bellows tube, the installation of the machine control system, its commissioning and the repair work of various other broken components had been underway. We surveyed the STR magnet positions again, using the existing reference marks. Figure 1 shows the variation of the vertical levels of the magnets before and after the realignment. The irregular movement of magnet positions before the realignment is clearly recognized in the figure. The variation of the magnet location is so large that COD caused by it cannot be corrected only steering magnets. Therefore the magnet levels must be realigned. The magnet levels after the realignment are also shown in Fig.1. All magnets were brought to the same level within ± 0.2 mm from the central line.

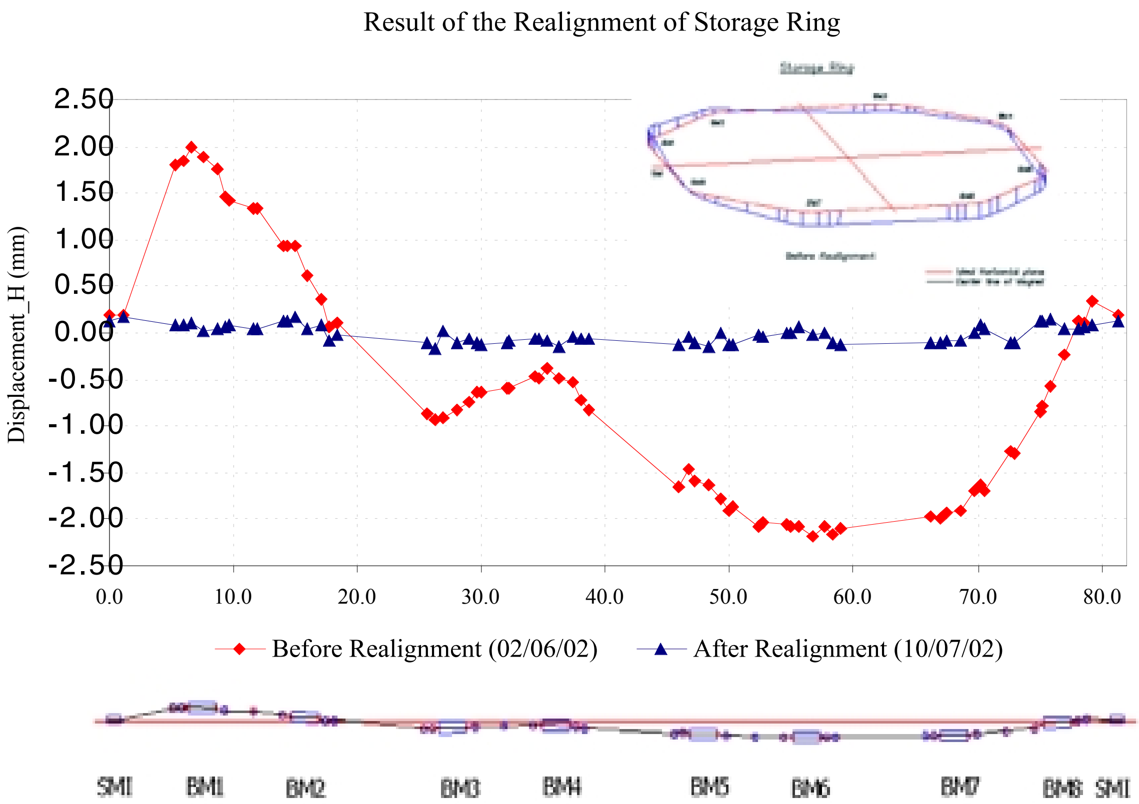

Figure 1. The displacement of magnets in STR before and after the realignment

2.2 Horizontal plane

To realize a high precision for the magnet position setting, the existing reference marks [3], [4] were surveyed. A laser tracker SMART 310 and accessory tools were borrowed from the Spring8 magnet group and used for the precision measurements. From the survey, the positions of some reference marks were found to be shifted from the installed positions. Moreover, some of the power supplies had been installed inside STR after the first alignment and these power supplies obstructed many lines of sight and limited the utilization of the existing network. Therefore, we decided to use two selected reference marks as the starting positions for the calculation of the correct positions. The correct positions of all magnets were calculated using a computer program for the least square method calculation. The calculated result was used for the magnet realignment as described in the next section.

3. Realignment of the magnets

Owing to the limitation in available time and manpower, we decided to realign all magnet positions without breaking the vacuum of the STR chambers. We had to take special care in order to keep the STR vacuum in the range of 10^{-10} Torr during the whole period of the realignment work. We had to adjust the vertical locations of each magnet gradually and stepwise, since the vacuum chambers existed already between the magnet poles. We chose the level of a magnet at the end of HBT to be the reference level. Since we decided to keep the vacuum and not to open the upper halves of the magnet yokes, all magnet levels were measured at the tops of the magnets. New adapters were specially prepared for the level measurements. The offset positions were added to the calculated positions and used for the realignment.

3.1 Dipole magnet realignment

In the alignment work, all of the dipole magnets were first moved to the calculated correct positions. The laser tracker was used to monitor the horizontal positions and the vertical positions were monitored by a precision level. The positions of the laser tracker were chosen carefully so that the surveying could cover the whole area. As shown in Fig.1, the dipole magnets were brought to the positions within $\pm$ 0.2 mm from the ideal positions. The tilt of each magnet was adjusted to be within $\pm$0.2 mm/m.

3.2 Multipole magnets realignment

Since the vacuum chambers were not removed, a problem was found in the alignment of old quadrupole and sextupole magnets from SORTEC. The center position of each magnet was not known precisely. This was the case in both horizontal and vertical directions. By using the data from the first alignment [4] however, it was possible to decide the center positions of the magnets from the top target holes. The dipole magnets were used to project the straight line needed for the realignment of multipole magnets in each section. After the realignment, all multipole magnets were brought to the required locations with a precision of $\pm$0.2 mm from the central line. The tilts were measured to be smaller $\pm$0.2 mm/m.

3.3 Readjustments of septum magnet and the RF cavity

Since the vacuum chambers were not removed, it was impossible to use the same alignment method as that applied in the first alignment. In the case of the septum magnet, we used the target holes put on the top corners to project the position of the central orbit through the magnet. The laser tracker was found to be very useful in finding the center of the round flanges. For the RF cavity, new reference marks were projected from the existing ones by using the laser tracker and the precision level. The cavity was lifted up step by step to let the deformation of the bellows tubes on both sides be within the tolerable amount. In this way all components could be brought to the vicinities of correct positions.

4. The commissioning of STR after the realignment

Evidently, we found that the realignment of STR has improved the machine performance greatly. Since the magnets were moved to the new positions, new parameters must be obtained. The storage of 1.0 GeV electron beam has been accomplished within one month after the realignment. The stored beam current and the beam lifetime were gradually increased. At present, we have achieved the beam current up to 86 mA. The beam lifetime at 30 mA is 65 min. The maximum injection rate is 10 mA/min. Progressive improvement has been observed on a daily basis. This indicates the success of the realignment work.

5. Conclusion

The realignment of a 1.0 GeV electron storage ring of the Siam Photon Source has been accomplished. The alignment is based on the existing network and newly calculated positions. Special care was taken to adjust the magnet locations while keeping the ultrahigh vacuum in the ring. The success of the work is indicated by conspicuous improvement of the performance of the ring.

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