PROGRESS ON THE COMMISIONING OF THE SIAM PHOTON SOURCE

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Abstract

Various problems encountered in the commissioning and performance improving work for the accelerator complex of the Siam Photon Source are reported along with their cures. As representative examples, the irregular floor settlement, the effect of residual gas on the beam lifetime and undesirable noise are described. Since the original components were built about 15 year ago, we have found various problems inherent in an old and used machine and also in the infrastructure of the area during the course of component storage and machine commissioning. Experiences made here provide us with useful examples of trouble shooting covering various fields of accelerator technology.

1. Introduction

The Siam Photon Source (SPS) is a light source accelerator complex, major of which has been transferred from the SORTEC Laboratory. The high energy beam transport line and storage ring have been rebuilt and modified to have a more advanced structure for the utilization of synchrotron radiation. The main parameters of SPS storage ring are summarized in Table 1. After the construction and installation period, the beam commissioning of SPS started in October 2001. The 1.0 GeV beam was stored successfully in December 2001.

At the beginning, the progress of increasing stored current proceeded slowly. This was ascribed mainly to uneven floor settlement and instabilities of the electricity and water supplies[1]. The vertical level difference was measured to be as large as 4.0 mm, that is considered to be very high for a ring of 81.3 m circumference. In July 2002, the realignment of storage ring was conducted without breaking UHV[2]. With help from Spring8's magnet group, the magnet vertical positions were brought back to the level with the required precision. Immediately after the realignment, the commissioning was resumed. The 1.0 GeV beam was re-stored within 1 month and the beam current increased gradually. In February 2003, a stored beam current of 155 mA was recorded. With sufficient beam currents, the measurement of several beam parameters such as betatron tunes and COD shifts could be implemented. The beam lifetime increased also gradually, the accumulated beam dose became higher.

In this paper, the current status of the SPS's machine commissioning especially the performance of the 1.0 GeV electron storage ring (STR) after the realignment, and some result from machine study will be described.

Table 1
Main parameters of storage ring

Electron energy, E	1.0 GeV
Circumference, C	81.3 m
Magnet lattice	DBA
Superperiodicity	4
Long straight sections	7 m x4
Betatron wave numbers; ν_x , ν_y	4.76, 2.83
RF frequency, f_{RF}	118 MHz
Critical energy of synchrotron radiation, ε_c	798 eV
Beam sizes; σ_x , σ_y	0.94,0.15mm

2. Result from the realignment of the storage ring

The realignment work of SPS's STR has been reported elsewhere[2]. Although the vertical levels were moved back to the vicinity of the decided level, the horizontal positions of some multipole magnets from SORTEC could be moved owing to the displacement of the top target holes. This magnet displacement cannot be determined precisely since we moved magnets with caution against breaking the vacuum of the STR vacuum chambers during the period of realignment. Similarly, the locations of beam position monitors (BPM) cannot be aligned perfectly. In order to re-store the beam, several steering magnets had to be excited with large current. In addition to the maximum beam current of 155 mA, the beam lifetime was recorded to be about 50 min at 100 mA. The injection efficiency was also improved by the adjustment of the magnetic field parameters of synchrotron (SYN) and high energy beam transport line (HBT). The inaccurate positions of multipole magnets could cause the electron trajectory to have large deviation from the ideal orbit. As a result, we observed very large COD ($(\Delta x(s))_{rms} \approx 3.6$ mm, $(\Delta y(s))_{rms} \approx 1.8$ mm) for the electron trajectory in STR. One possibility is the misaligned horizontal positions of some quadrupole magnets. The analysis of current–lifetime data also suggested the occurrence of the scraping process. The possible inaccuracy of the alignment of BPMs could also lead to the observed large COD. In the case where large

COD exists, it is impossible to use sextupole magnets for making finer beam correction. This prevents STR to operate at its best performance. Figure 1. shows the change of the STR beam current during one day in December 2002. At this stage the beam lifetime was not long and the beam dump occurred from time to time. Thus, the major effort has been focused on the COD correction and the beam-based alignment. However, several problems impeding the progress of the commissioning such as power line instability, room and cooling water temperature fluctuations must be resolved at the same time. The goal of the next stage is to improve the beam stability and bring the beam lifetime up to the value that experiments can be carried out with high precision.

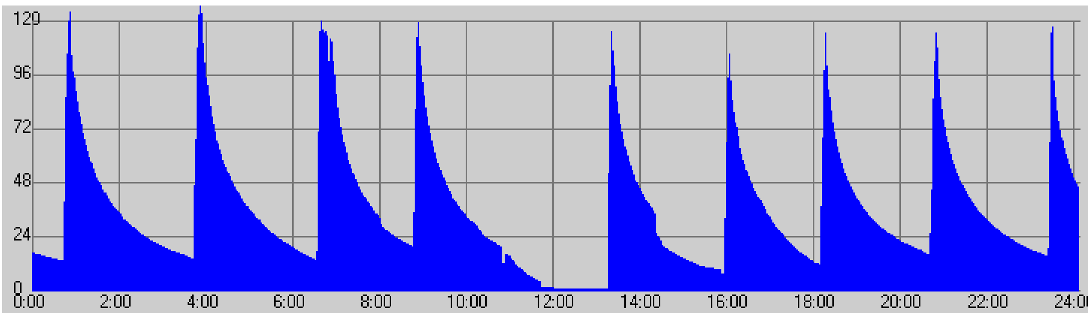

Figure 1. STR beam current within a day in December 2002.

3. Measurement of beam parameters

To improve the machine performance, measurements of some of the beam parameters must be carried out. STR machine studies have been performed during the last three months in 2002. This included the measurements of betatron tunes. To measure the tunes, an RF tracking signal was fed through a strip line RF-KO system and the beam signal picked up by strip lines were analyzed by a spectrum analyzer. To distinguish the vertical tune from the horizontal tune, a telescope with a filter was used to observe the beam shape directly. The observed beam shapes and the working diagram are shown in Fig 2. The betatron tunes were measured to be $\nu_x = 4.83$, $\nu_y = 2.77$ for the most stable condition. This values are not much different from the designed values of $\nu_x = 4.76$, $\nu_y = 2.83$. However, several sources of instabilities exist. They make the betatron tunes shift during the operation and the beam moves suddenly. This reduces the beam lifetime and the beam dumps eventually.

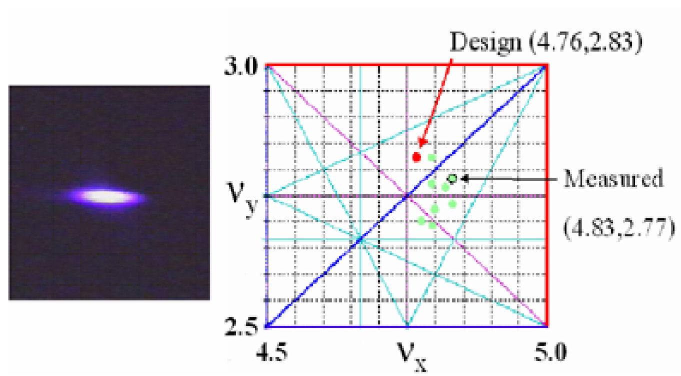

Figure 2. Left: 1.0GeV beam shape, Right: working diagram.

4. Beam lifetime and photon beam dose

Apart from the beam instability effect described in the proceeding sections, the lifetime of the electron beam is mostly determined by the scattering with residual gas molecular ions in vacuum chamber. They emerge out of the vacuum chamber wall when the wall is irradiated with synchrotron radiation. In the early period, when the beam was stored in the STR, the pressure was enhanced rapidly through the photodesorption process. This limited the initial stored beam current to a value below a few milliamperes. As the injection efficiency was improved and the beam dose increased, the stored current and lifetime increased gradually. Figure 3. shows the plot of the product of beam current and lifetime versus the integrated beam dose. From the data, the trend that the lifetime increases is roughly expressed as $y = 449.71x^{0.645}$ where y is a current-lifetime product and x is the integrated dose. This is similar to the published data of the other storage ring[3],[4]. The instabilities arising from defects in hardware and environment such as cooling water temperature fluctuations, and noise prevent the lifetime improvement.

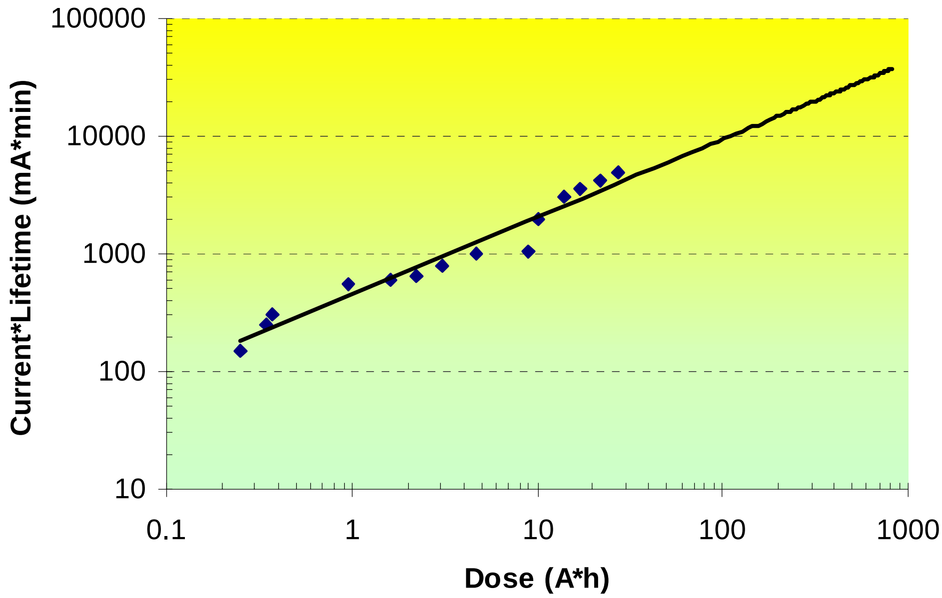

Figure 3. Plot of the beam current-lifetime product versus integrated beam dose

5. Trouble shooting

Various problems to cause the beam instability in STR have been found during the commissioning. Some of them have been removed. Some hardware defects have been found in several parts of the accelerator system including the pure water supply, the air conditioning system, and the internal and external noise affecting the magnet power supplies and the machine operation control system. As the measures for occasional power failures and voltage fluctuations in the primary line, several pieces of UPS with a large capacity were installed. A new independent power plant exclusively used by SPS will soon be constructed. The inappropriate design of the water cooling system gave rise to difficulties in controlling magnet temperature. The temperature fluctuates along with the outside ambient temperature and heat generated in the machine. This caused fluctuations in magnet current and has affected the beam position in STR. During the beam injection to STR, noise from the linac varied current in some quadrupole magnets and steering magnets. At present, the work for cures of the problems is underway.

6. Conclusion

The progress of work for the performance improvement of the Siam Photon Source is summarized. To remove troubles arising from uneven floor subsidence, the storage ring was realigned. The 1.0 GeV beam has been stored in STR up to 155 mA. The beam lifetime has improved gradually with increasing beam doses following a normal trend line. Works for noise removal and stabilizing temperature fluctuations in cooling water is underway.

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