THE COMMISSIONING OF THE SIAM PHOTON SOURCE

W. Pairsuwan. R. Apiwatwaja, *G. Isoyama, S. Rugmai, S. Rugirawat, N. Songuansak and T. Ishii
NSRI, P.O.Box 93, Nakhon Ratchasima 30000, Thailand
*Also at ISIR, Osaka University, Osaka 567-0047, Japan

Abstract

Various problems found and solved in the course of the commissioning of the Siam Photon Source, a 1.0 GeV light source accelerator complex obtained second hand and reformed to a more advanced structure, are described. Among various obstacles having been encountered, issues of some representative examples as hardware defects in the linac, setting up of the pattern memory for the synchrotron operation, the broken timing system, both internal and external noise affecting the machine control system and the irregular floor settlement causing large COD are presented.

1 INTRODUCTION

The Siam Photon Source [1] is the second-hand machine transferred from the SORTEC Laboratory, although some parts, particularly in the storage ring, have been appreciable reformed. Thus, the problems inherent in the second-hand machine exist and they must be overcome for successful commissioning.

During the commissioning of the Siam Photon Source, some defects of hardware have become distinct. They were found in many parts in the accelerator system including the pure water supply, the air-conditioning system, the injector linac, the booster synchrotron, the storage ring and the beam transport line. The serious defects have been cured.

The SORTEC accelerator complex was designed and built in the period from 1986 to 1990. It was shut down in 1995 and dismantled in 1996. All the machine components had been stored in the warehouse of the Siam Photon Laboratory over almost 3 years before the reassembling work started. New components were added for changing the magnet lattice structure of the storage ring. The machine control system, the vacuum system and the HBT (high energy beam transport) line were renewed. The details of the machine control system are described separately [2].

The storage ring was successfully filled with the electron beam on December 17, 2001. It was about 9 months after the start of the commissioning. The maximum stored current in the middle of September, 2002 is 81 mA. The lifetime at 30 mA is 60 min and that at 10 mA is 267 mA.

2 PROBLEMS HAVING AFFECTED THE ELECTRON STORAGE

2.1 Linac

Representative examples of the problems an procedures are as follows:

(a) Klystron tank

Short circuit in the high voltage line in the klystron tank was found. It was cured by changing fixing screws, which were too short.

(b) Water temperature controller

The temperature of cooling water for the power controller circuit was not regulated properly. The degraded temperature controller was replaced with a new one.

(c) Noise causing unstable operation.

The beam intensity was unstable because of noise coming into the power supplies through the lines between the control system in the control room and those between the control circuits on the site and those in the control room. The lines picking up noise are changed.

(d) Power amplifier tube

The gain of the power amplifier had decreased. The relation of the output voltage versus the input voltage should have a flat top in a range of the input voltage. He output voltage decreases sharply on both high and low input voltage sides of the flat top region. The curve has an approximately trapezoidal shape. In the flat top range the output voltage does not vary as the input voltage changes. The amplifier tube was degraded to give a gain about 80% of the maximum value. Thus the output voltage varied considerably as the input voltage varies even slightly. If noise was on the input line, it was amplified and the output signal involved a considerable magnitude of noise. This caused the fluctuation of the output intensity of the electron beam. The long-term fluctuation deformed or shifted the energy spectrum of the electron beam. As the cure, the amplifier tube was replaced with new one. This improved the situation great a lot.

2.2 Synchrotron

(a) Realignment

The synchrotron was reassembled first. At this time it was aligned accurately. However, the magnet alignment was deformed in half a year. The synchrotron was realigned shortly before the machine reassembling. The situation was similar to the case of the storage ring.

(b) Commissioning

The procedure was as follows:

(1) First, the magnetic fields were fixed at values corresponding to 40 MeV beam energy that electrons coming out of the linac possess. We confirmed the capture of the electron beam by the synchrotron with a DCCT current monitor.

(2) Then the magnetic field was increased according to the acceleration pattern memory. The field increased automatically following the memorized pattern.

(3) Third, the RF acceleration field was supplied to the cavity.
(4) The beam capturing and acceleration were confirmed with a DCCT current monitor and by observing visible synchrotron light through a view port. We found the qualitative confirmation with synchrotron light very useful. We also used a γ-ray monitor to observe the location where the electron beam was lost. This was quite useful to find whether or not electrons make one turn in the machine.

In the implementation of the procedure described above, we made a first mistake in the process to set up parameters to run both bending and quadrupole magnets following the pattern memory. We had to spend some time before we found the proper sets of parameters.

We first assumed that COD (closed orbit distortion) was negligible, and we did not use the steering magnets installed in the synchrotron. Later, we found that this was not the right procedure and we excited steering magnets.

(c) Troubles

(1) We found some of the component elements in a magnet power supply and the vacuum system control circuits. The components were replaced with new ones.

(2) The existence of indispensable amount of COD was found accidentally by γ-ray monitoring. COD occurring at the relevant site was corrected by the use of some steering magnets. The complete survey of COD and its correction will be made in the near future.

(d) Unstable output intensity

At present, the output beam intensity fluctuates in a certain interval. Since the intensity of the electron beam from the linac fluctuates, we cannot conclude that the operation of the synchrotron is unstable. The investigation is underway.

2.3 Storage Ring

(a) Bump magnets power supply

All packages of dismantled components of the SORTEC accelerators had been kept in the warehouse of NSRI. Some of the components were moistened. Serious damage occurred on the power supply of the bump magnet. We removed rust from corroded parts but a circuit board had to be renewed. Later, another component was also renewed.

(b) Hardware defects in the vacuum system

The vacuum chambers and the attached evacuation system as well as beam position monitors had been renewed completely. During the transportation, several vacuum chambers made of aluminum were broken. The cause was incomplete welding and bad packing. Later, the welded part of a vacuum chamber connected with a beam position monitor was also broken. In this case, the cause was bad workmanship in the chamber alignment work. All broken parts were welded again.

One of distribution pumps is out of order. The cause may be bad workmanship or it is caused by a mistake in the chamber design. Since the effect on the total pumping speed does not appear to be serious, the repair work is postponed.

(c) The RF acceleration system

The RF acceleration system of the SORTEC storage ring is used without any reformation. Prior to the accelerator reassembly, the characteristics of the cavity were measured. Although the Q value was reduced and the total impedance was higher than the value obtained by SORTEC engineers, we used the cavity making no reformation.

The bellows tube to connect the tuner had leak. We replaced the bellow tube. Another hardware trouble was found in the temperature controller of the cooling water. We replaced the broken components such as a valve and the flow controller.

When the injection of the beam started, we realized that we had no means to measure the RF field intensity in the cavity. We had been measuring the intensity of the reflected wave. We adjusted the wave intensity being aware of this fact.

Although the tuner worked well, it was always vibrating mechanically. By the investigation of the control circuits, we found a mistake in the circuit design. The positive feedback was given to a circuit in which the negative feedback should be supplied. This resulted in the undesirable vibration of the tuner. We changed the wire connection in the circuit so that the negative feedback was supplied.

(d) Magnets

Since the lattice structure of the SORTEC storage ring has been reformed to a new DBA lattice, a considerable number of magnets are added to the new storage ring. The support flames rusted during the transportation. They were polished again.

(e) COD

The storage ring has a considerable amount of COD. The work for the COD correction is underway. However, the majority part of COD correction has not yet been completed. Because of the machine realignment, however, the machine performance has been improved. We will complete the COD correction work soon.

We consider that the machine study to map the operating points on the resonance diagram must be carried out following the COD correction. Work along this direction is also underway.

After the storage ring had been realigned, the location of the beam was found to move horizontally by 9 mm at the source point of light to BL4. This affects the location of the first mirror in BL-4. Since the COD correction has not been completed, the location of the beam will be changed through the COD correction.

The most important observation made so far is that the beam location is shifted as the operating point is changed.

3 TIMING SYSTEM

Before the beam injection, we had to confirm that every part of the accelerator complex works as it should do. During this work, we found many small defects that were able to be repaired. One serious trouble we had to overcome was the timing system.

(a) Timing System

The troubles were found in the synchronous pulse generator. The source of the troubles of the synchronous pulse generator appear to be two fold. One was caused by the death of a battery supplying power to circuit boards. The memories input in them disappeared. The other is the breakdown of the software storage part of a computer installed in the synchronous pulse generator. The parts of the lost memories were repaired by replacing the batteries and inputting the memories. However, a part of the computer installed in the synchronous pulse generator could not be repaired. Thus, the SORTEC timer system was abandoned. Instead, a new timer system has been built. The work has been almost completed. The details will be presented in the separate report[2].

4 NOISE PROBLEM

Obvious noise sources are the linac and the synchrotron. Noise from the synchrotron was picked up in a magnet power supply for the HBT line located in the synchrotron power supply room and affected the RF acceleration controller of the storage ring. The noise has been transferred through the cooling water pipe. Noise came into the RF power control circuit and the injection timing system also through wiring. Various pieces of instability arising from such kinds of noise have been cured already.

There were two more items to be settled. Both caused the sudden cut-off of the stored beam. One appeared to be the charging-up of some elements in the vacuum chamber. The realignment work mentioned later involved the temporary removal of the wire connection and the rewiring work following the realignment gave rise to imperfect wire connection due to bad workmanship. We cured this by making line grounding complete. This improved the injection efficiency in that the beam was not cut-off in the course of beam storage.

Through the 24-hour operation of the machine, we found that the accelerator complex worked quite stably at night and during holidays. This suggests that the source of the instability is also from the outside the laboratory. We will build a power station, which connects directly with the major high voltage power line and supplies power only to Siam Photon Laboratory and the precision measurement laboratories of SUT independent of other facilities around them. The recent investigations show that the noise causing the overall instability is not contained in the primary line. The instability is rather caused by the improper operating points.

5 NOISE PROCED BY HARMONICS

We have had the problem of the 5th order harmonics generation in the primary power supply line. The power supplied to the synchrotron magnet changes regularly at 0.5 Hz following the pattern memory and producing the large reverse electromotive force in the primary line. Thus filters for removing the surge are installed. Among them, the 5th order harmonics filter did not work properly (the fundamental frequency is 55 Hz) because of the resonance of the surge with existing noise of 5th-order-harmonics frequency. The large current arising from this resonance destroyed the circuit of the high quality static condenser and led to the improper operation of the 5th harmonics filter. The filter system has recently been repaired. We found that the filter system works properly.

6 REALIGNMENT OF THE STORAGE RING

The most serious problem of the machine system was the short lifetime of the stored electron beam. From the measurements of the pressure distribution in the vacuum chambers of the storage ring and of the γ-ray generation along the ring as well as the survey of the magnet alignment, we concluded that the beam scraping caused by large COD and photodesorption by synchrotron light were the probable origins of the short lifetime. Thus, we realigned the storage ring.

The distortion of the magnet alignment had been caused by the irregular settlement of the building floor. We are now investigating the cause of the uneven floor subsidence. The irregular alignment of magnets was first found in the booster synchrotron about half a year after they had been accurately aligned. The synchrotron was realigned shortly before the machine commissioning started. Although irregular alignment was found also in the storage ring, we ignored this and the machine commissioning was started. Since COD was found so large, we realigned the storage ring recently. We repeated the survey of the machine alignment two months after the preceding survey. We confirmed that the alignment was the same as before.

Although the conclusion about the cause of the uneven floor subsidence leading to the deformation of the magnet alignment cannot be drawn out at present, we can find a few possible causes for this. One is the structure of the floor foundation at the magnet locations. The other is the nature of soil here. The investigation of the soil property will be carried out soon.

7 REFERENCES

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