BEAM ORBIT STABILITY AT TAIWAN LIGHT SOURCE

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Abstract

Beam orbit stability has been one of the major accelerator improvement programs at the SRRC since the storage ring started to be operational in 1993. In the past several years, several tasks have been carried out to tackle the orbit stability problems, e.g., the air and cooling water temperature regulation, the electrical and electronic noise reduction, the orbit feed-forward and feedback systems, etc. This paper presents the current status of the beam orbit stability at the SRRC storage ring TLS.

1 INTRODUCTION

The Taiwan Light Source (TLS) of the SRRC has been operated successfully for more than 5 years. In the meantime, a number of accelerator developments have been instrumented and commissioned in order to upgrade the performance of the light source operation so that it can provide a stable, high quality synchrotron radiation light source to the user. These include the installation of the insertion devices and orbit feedback systems, the increase of the beam energy to 1.5 GeV, suppression of the mechanical vibration sources and electrical noises, stabilization of the air conditioning and water cooling temperature, cure of the coupled-bunch instabilities. The orbit stability is of primary importance for the light source users. In this report, we describe the recent status of the beam orbit stability at TLS.

2 IMPROVEMENT OF THE WATER AND AIR TEMPERATURE CONTROL

An intensive study and upgrade activity of the TLS water temperature control units as well as air temperature handling units in the past two years results in a quite remarkable improvement for the daily usage of the systems.[1,2] The typical variation in the normal operation days could be kept within ±1°C for the air temperature in the storage ring tunnel. The outlet temperature for the cooling water temperature systems could also be held within ±2°C. However, it was found that after a long shut-down the air temperature in the tunnel would take several hours or even a few days to get in an equilibrium state. It was also observed that after such a long shut down, the ring circumference decreased 1 mm or so. To keep the orbit constant, we also performed the tuning of the radio frequency in the daily operation of the storage ring. The aluminum beam pipe of the storage ring is water cooled in the synchrotron radiation side. It was noticed that the temperature variation of the beam pipe demonstrated a strong correlation with the beam orbit changes. The inlet temperature changes as well as the operation beam current caused the temperature fluctuations of the beam pipe. Figure 1 shows the inlet and outlet temperature of the aluminum water system, and beam pipe temperature in a test run. Notice that the initial stored current after refill was 200 mA. The beam orbit changes from beam position monitors in a test run are given in Figure 2. To reduce the water-temperature-dependent orbit change, we optimized the water control settings and as a consequence beam orbit oscillation was suppressed.

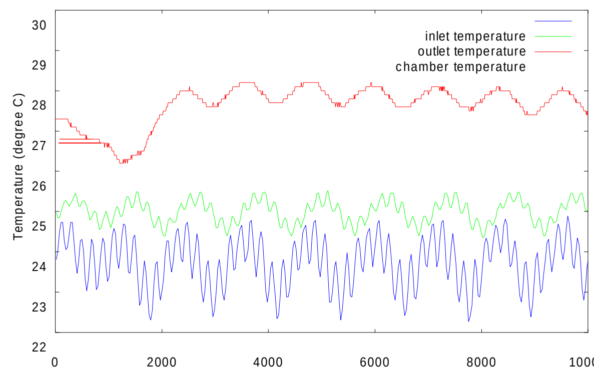

Figure 1: Water temperature (lower) and beam pipe temperature (top) in a test run.

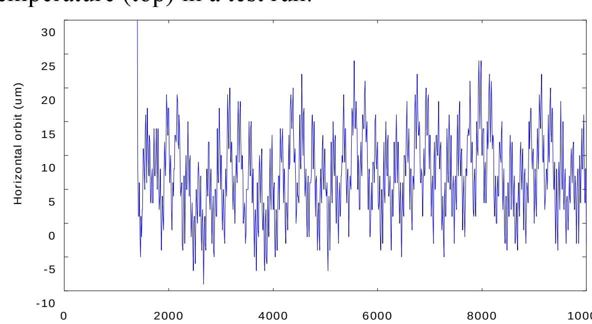

Figure 2(a): Horizontal orbit at one BPM with the condition given in Figure 1.

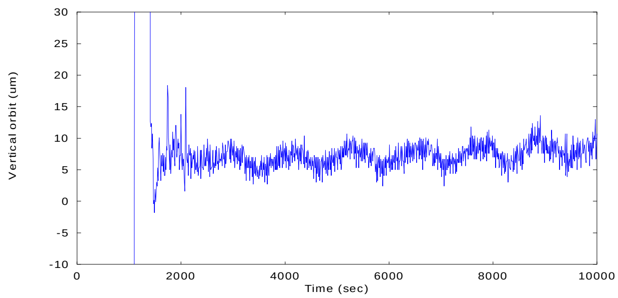

Figure 2(b): Vertical orbit at one BPM with the condition given in Figure 1.

3 MECHANICAL AND ELECTRICAL NOISE

Mechanical vibration such as air cooling fan at 18 Hz was observed couple years ago which induced beam oscillations in a few microns. This noise source has been eliminated and the fast beam orbit oscillation thus was within an acceptable level. Notice that during the users operation mode, the crane around the experimental hall is not allowed to move because its motion induces beam orbit change as shown in Figure 3(a) and 3(b). Although the fast feedback system can correct the beam orbit, the photon beam line components are still susceptible to this mechanical motion.

Electrical noise from the magnet power supply was well under control and it seemed to be not a major contribution to the orbit variation.

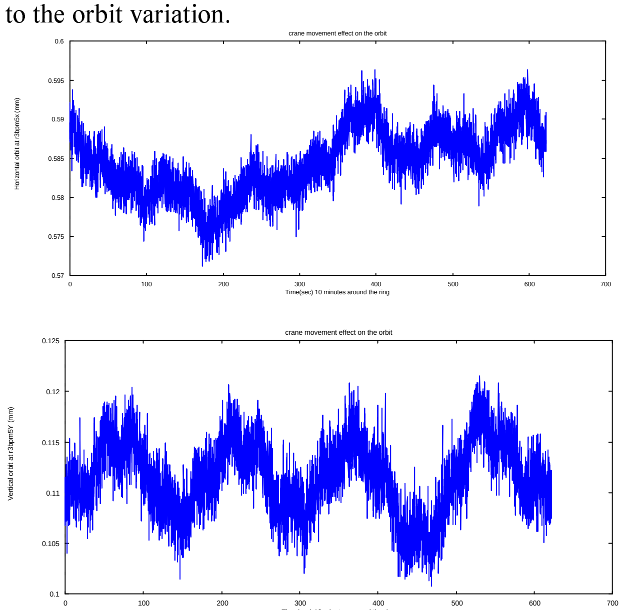

Figure 3(a), 3(b): Crane motion induced beam orbit change. The crane moves around the experimental hall for one turn.

4 INSERTION DEVICE EFFECTS

In the operation of the insertion devices, we need to change the magnetic gaps and the residual orbit thus is perturbed. To compensate such an orbit perturbation, the end-corrector strengths of the insertion devices are pre-set in the look-up tables. With such settings, the rms orbit perturbation could be reduced to a few microns as illustrated in Figure 4(a) and 4(b). Since the current dependent BPM offset may contribute to the residual orbit readings. We have measured the current-dependent orbit readings using a scraper to reduce the beam current from 200 mA to 100 mA in 5 minutes and it showed that it could be varied by 10 μm or so. In the slow orbit feedback operation, these offsets were taken into account in the orbit data.

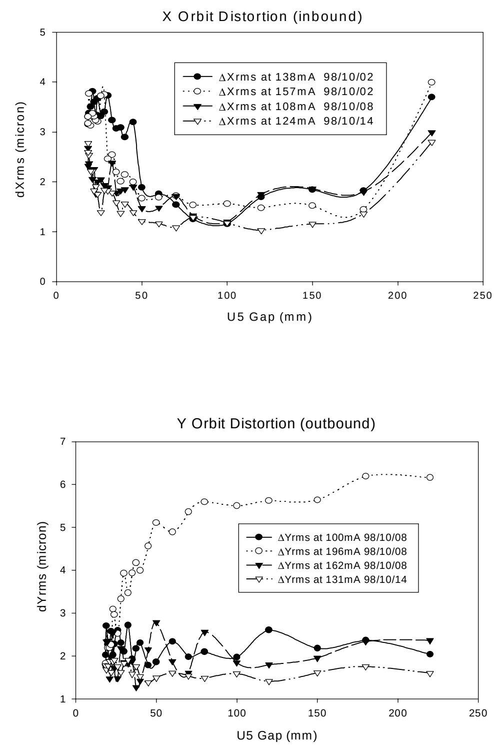

Figure 4(a), 4(b): Residual orbit of the ring as a function of the magnetic gap of one insertion device U5.

5 SLOW ORBIT CORRECTION

We have built a workstation-based slow orbit correction system. The bandwidth is about 0.1 Hz in both planes. We used almost all valid BPMs and correctors in the calculation of the correction matrix. Micado method was employed and only 5 most useful correctors were selected in the correction in both planes. Figure 5(a) and 5(b) depict the orbit with and without turning on the slow orbit correction system. Note that in this measurement, the fast orbit feedback system was off. It showed that the residual orbit drift could be down to less than 2 micron (the BPM readings were averaged 100 times).

6 FAST ORBIT CORRECTIONS

Digital global orbit feedback system has been implemented in the routine operation in the TLS. [3] The overall bandwidth of the system is about 10 Hz. Due to the lack of enough DSP processors, we can now only use a limited number of BPMs and correctors for both horizontal and vertical orbit planes. Presently, we

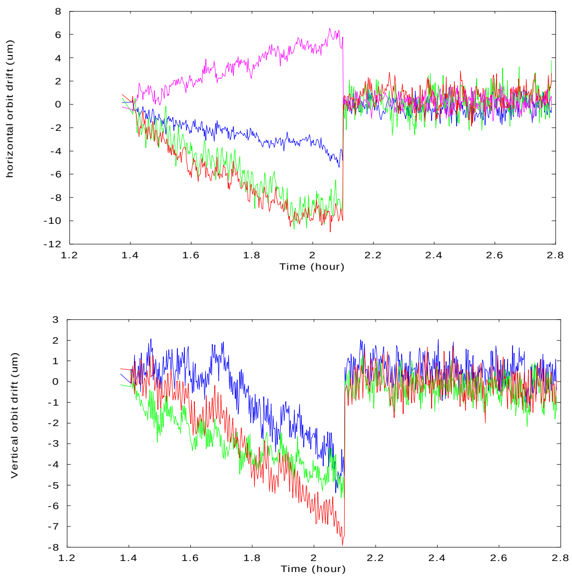

Figure 5(a), 5(b): Several BPM reading drifts with (right-hand side) and without (left-hand side) turning on slow orbit corrections.

emphasize the orbit correction in the vertical plane. However, in some demanding photon beam lines, we need to steer orbit locally in both planes.

We used SVD method to calculate the eigen-values of the corresponding corrector strengths. The achievable suppression level of the orbit fluctuation was 10 µm. As a matter of fact, the orbit noise spectrum revealed that it was buried in the BPM resolution region in a very short period, say 1 Hz. Therefore, at present, we optimized the system bandwidth in the low frequency region in favor of the suppression of the temperature-induced orbit drift. However, for the operation of insertion gap change as well as the EPBM photon beam line, which was constantly generating angular bump, we do need to tune the system to a wider bandwidth, say a few Hz.

7 OPERATION ACHIVEMENT AND FUTURE UPGRADE

In the daily operation in the user shifts, we turned on the fast orbit feedback system in the vertical plane and sometimes the horizontal fast feedback system as well. The system bandwidth was usually tuned to the low frequency part and the workstation-based slow orbit correction system did not help too much. In figure 6(a) and 6(b), we randomly choose the recent typical orbit data in the user shift. These BPMs are located at both upstream and downstream of the wiggler photon beam line. The BPM data are obtained from the ILC local signal processor and these are not averaged. As shown in figure 6(a), the horizontal orbit drift is about 10 micron in the first one hour after injection and then stay within 5 micron for the rest of the run in an 8-hour shift. In figure 6(b), the vertical orbit can be held within 10 micron in an 8-hour shift, and the orbit changes between refill are also within 10 micron.

In the future operation, we will strengthen the horizontal plane and we will also incorporate the photon BPM data as well as many local feedback systems in a package. The slow orbit correction could also be integrated. The mechanical rigidity will be examined. The full energy injection will be implemented soon. We will replace the exiting RF cavity with HOM-free ones to reduce coupled-bunch instability as well as orbit stability. The last, but not the least, the water cooling and air temperature control will be further improved.

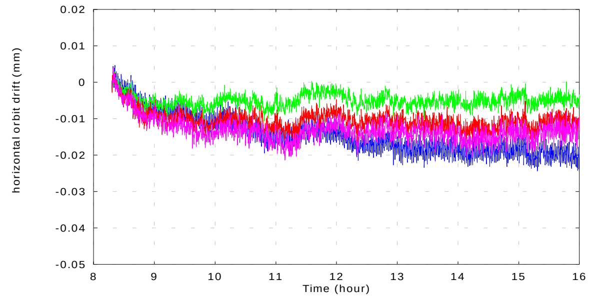

Figure 6(a): Typical horizontal orbit drift in one user shift for the BPM located at both upstream and downstream of a wiggler beam line.

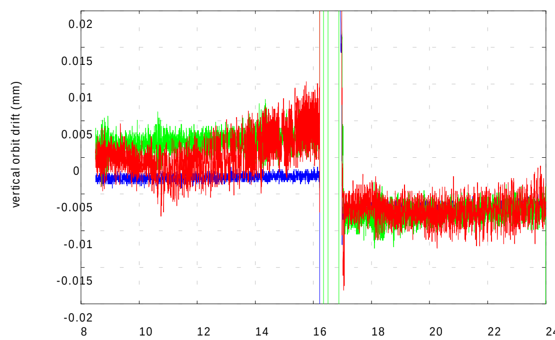

Figure 6(b): Typical vertical orbit drift from the BPM readings (without averaging) near a wiggler beamline. The orbit drift can be kept in 10 micron range and the refill causes a shift of orbit by 10 micron too.

8 ACKNOWLEDGEMENT

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9 REFERENCE

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