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ANALYSIS OF THE BEAM LOSS MECHANISM DURING THE ENERGY RAMP-UP AT THE SAGA-LS

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Abstract

The accelerator of the SAGA Light Source consists of the 255 MeV injector linac and the 1.4 GeV storage ring. The accumulated electron beam current of the storage ring is about 300 mA. The energy of the electrons is raised up to 1.4 GeV in 4 minutes in the storage ring. At the moment of the beam acceleration, the electron beam is lost. The amount of beam loss is normally about 5 mA to 30 mA. All electrons are sometimes lost. We investigated the relationship between the beam loss and the betatron tune shifts. The tune shifts during the beam acceleration were analyzed from the measured data of the output currents of the magnets power supplies by using beam tracking code of TRACY2. It was found that the anomalous output of the power supply of bending magnets was one of the causes of the beam loss.

INTRODUCTION

The accelerator of the SAGA Light Source (SAGA-LS) consists of the 255 MeV injector linac and the 1.4 GeV storage ring [1, 2]. The accumulated electron beam current of the storage ring is about 300 mA. The energy of the electrons is raised up to 1.4 GeV in 4 minutes in the storage ring. At the moment of the beam acceleration (the beam energy is lower than 400 MeV), the electron beam is lost (see Figure 1). The amount of beam loss is normally about 5 mA to 30 mA. All electrons are sometimes lost. To understand the beam loss mechanism, which depends on the beam current, we developed high-speed logging system of 100 kHz for monitoring the beam current and the magnets power supplies using National Instruments PXI. We investigated the relationship between the beam loss and the betatron tune shifts. The tune shifts during the beam acceleration were analyzed from the measured data of the output currents of the magnets power supplies by using beam tracking code of TRACY2 [3]. To estimate the K-value of the quadrupole magnets, we used orbit response matrix analysis method [4]. By adopting the new high-speed logging system, the time structure of the beam loss process was clearly observed. In this paper, we describe the data acquisition and the data processing system, and the result of the analysis.

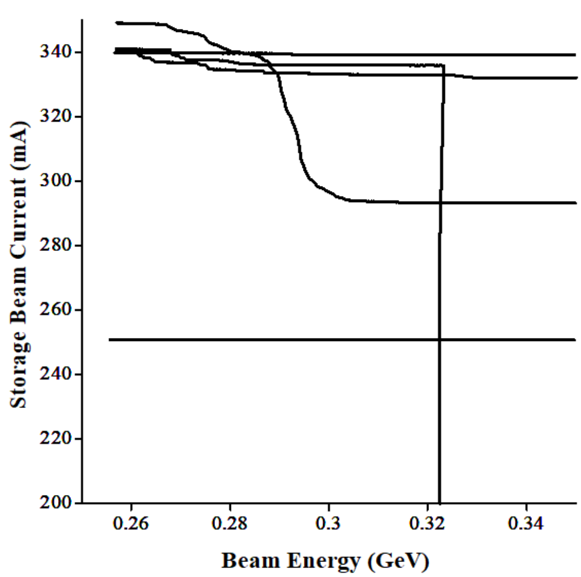

Figure 1: Beam loss at the energy ramp-up.

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METHODS

Commonly we use N.I. Fieldpoints, PLCs and PCs system for controlling and monitoring the SAGA-LS accelerator [5]. The beam loss occurs at the moment of the energy ramp-up and it observed like a step function by using slow (1 Hz) monitoring system. Therefore, we developed high-speed logging system of 100 kHz for monitoring the beam current and the magnets power supplies using National Instruments PXI. Figure 2 shows the data acquisition and analysis system for investigation of the beam loss. Since the signals of output currents of the power supplies are highly noisy, the low-pass filter (100 Hz) was performed to the measured data. The data sets were thinning out to 1/100 to calculate tunes and Twiss parameters step by step. Orbit response matrix analysis method [4] was adopted to estimate effective K-value of quadrupole magnets from the measured output currents of the power supplies of the quadrupole magnets.

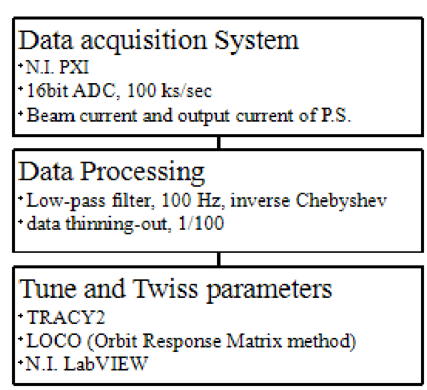

Figure 2: Data acquisition and analyses System.

The TRACY2 was used to calculate the tunes and Twiss parameters. The tracking code of TRACY2 was called from the National Instruments LabVIEW. The Data processing and the optics calculation were performed under the environment of LabVIEW for Microsoft Windows.

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RESULTS

Figure 3 shows the output current of the bending magnets at the case of the all electrons were lost. As can be seen in Figure 3, measured data of the output currents of the power supplies contained high frequency components. After the data processing of low-pass filter, the output current of the power supply of the bending magnets is obtained. Figure 4 shows the anomalous output of the power supply of bending magnets. Since the ramp-up pattern is monotonically increases and fixed, power down of the power supply during the ramp-up couldn't be expected. Figure 5 shows the large betatron tune shifts at the beam loss. The beam energy was estimated by using the magnetic field measurement data and the monitoring value of the power supply of the bending magnets. Figure 6 shows the beam current at the period.

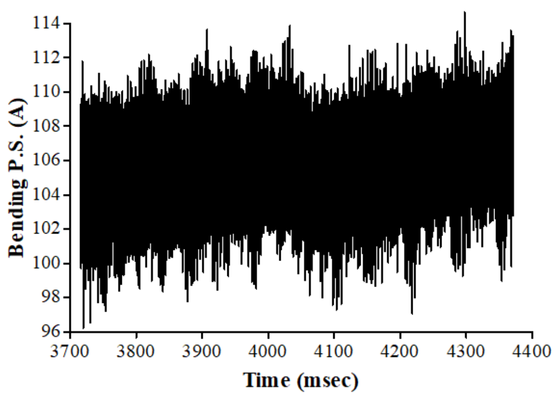

Figure 3: Output current of the power supply of the bending magnets measured by using PXI system at the all beam loss.

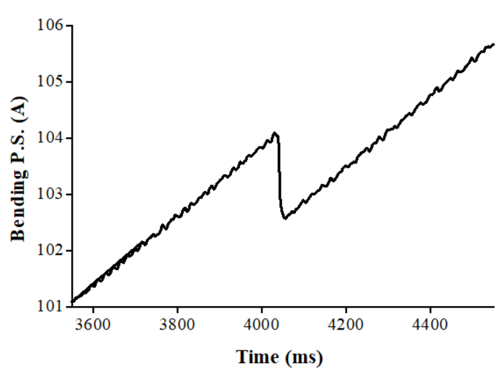

Figure 4: Output current of the power supply of the bending magnets after low-pass filtered.

We confirmed that the beam loss due to the anomalous power down during ramp-up has occurred several times. On the other hand, there were the cases that couldn't be explained by the power supply faults.

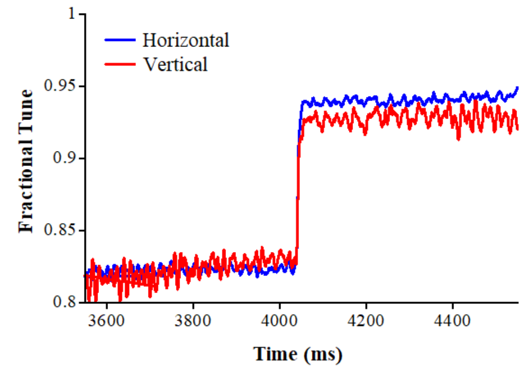

Figure 5: Calculated tune sifts at the all beam loss.

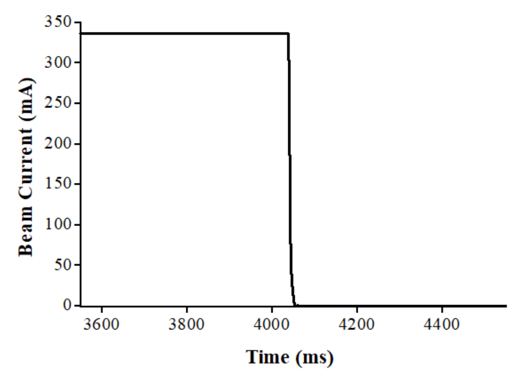

Figure 6: Beam current at the all beam loss.

CONCLUSION

The first data acquisition system of the PXI and the data processing of low-pass filter were useful to find the anomalous output of the power supply of the bending magnets. The anomalous output of the power supply of bending magnets was one of the causes of the beam loss. The longitudinal motion will be taken into account for the further investigation of the beam loss mechanism.

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