Topping Up Experiments at SRRC

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ABSTRACT

In the operation of a synchrotron radiation facility, it is very desirable to be able to provide beam with almost constant intensity. This has considerable advantage in terms of calibration and normalization of detectors, heat load of optical components, and the duration of data taking time. To achieve that goal, the topping up mode injection has been tested at SRRC. The experiment was performed to fill automatically the stored beam current up to 200 mA whenever it was decreased to a preset low limit value. Following items were examined: reproducibility of the bunch train structure of the injected beam, stability of the storage ring pulsed injection magnets, injection startup and bucket address system. Effects on the stored beam stability will be studied and methods to minimize disruption to research program during injection time will be investigated.

1 INTRODUCTION

In the operation of a synchrotron radiation source, an electron beam with almost constant current can give the experimental devices a stable heat load which will lead to a constant experimental condition[1,2]. When the insertion devices were installed into the storage ring, it was also noticed that the beam life time was reduced due to the reduction of dynamic aperture and vacuum chamber aperture. This phenomena causes the mentioned concern even worse. It was suggested that the topping up mode injection can provide a cure to these problem. Therefore, the topping up mode injection was studied at SRRC. The experiment was performed to fill automatically the stored beam current up to 200 mA whenever it decreased to a preset low limit value. In the following sections, test results of the hardware reliability and control interfaces related to this mode of operation are described.

2 INJECTION SEQUENCE

The electron beam was first injected into the storage ring to a preset high current limit. Since all of the booster subsystems were in operation mode, triggering the gun-enable gate would actually trigger the injection process. When the stored beam current was sensed by a digitized DCCT in the storage ring to be lower than a computer adjustable preset value, the topping up mode program will send a trigger signal to trigger the gun-enable gate. Also, a parallel signal was sent to the storage ring pulsed injection magnets, i.e. septum and kickers, incorporated with the beam acceleration in the booster. Then, the injection process would start automatically. As long as the beam current reached the high preset limit, the injection process would be switched off automatically also. During the topping up injection process beam accumulation in the ring would repeatedly start from the low preset limit value and stop at the high preset limit value. The injection sequence is described in the following.

Steps :
1. adjust bucket addressing and set beam current to be stored.
2. start injection process.
3. stop injection automatically when preset beam current is reached.
4. selecting topping up mode bucket addressing, low and high current limit.
5. start topping up injection mode.
6. injection start automatically as beam current decreases to lower than a preset low current limit.
7. injection stop automatically as beam current reaches to higher than the preset high current limit.
8. go to step 6, as long as the topping up mode is operating continuously.

Preserving the stored beam filling pattern was one of the factors concerned in the topping up mode injection. As shown in figure 1, refilling related parameters can be adjusted together with the topping up mode limits. Operator was able to choose the appropriate refilling steps so that bunch distribution can be done in a controllable manner.

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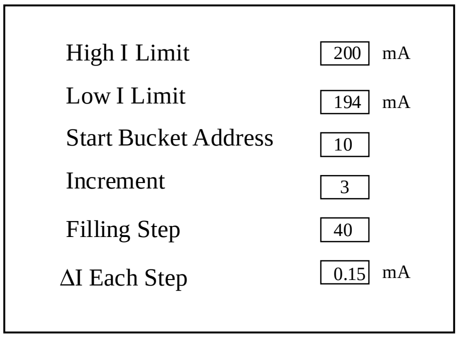

Fig. 1 Control panel of topping up mode injection

3 TEST RESULTS

3.1 System capability

At present, for the topping up mode operation at SRRC, the injector has to run all the time as long as the storage ring is operated. The reliability of the injector, transport line, and storage ring injection magnets were examined together in this experiment. System test runs have been taken place during some of the machine shifts in the period of 3 to 5 hours in order to verify its reliability in terms of bucket addressing and timing control of the pulsed components of the injection system. Typical result is shown in figure 2. System components were shown to be capable of performing the topping up injection to an extended period of time.

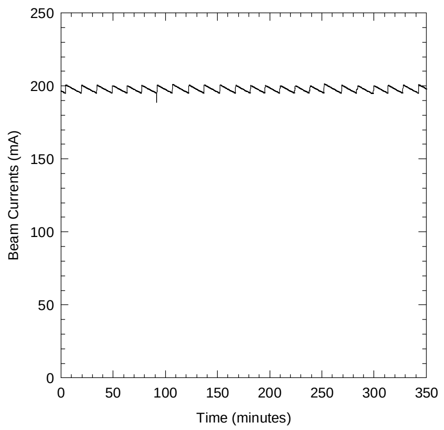

Fig. 2 Typical result of SRRC topping up mode operation.

3.2 Reliability Consideration

As shown in figure 2, a glitch was seen at the 7th injection cycle. This might disrupt the continuing topping up injection process. It was noticed that one of the booster extraction bumper magnet tripped due to the noise interruption of the corresponding control unit. In order to minimize the number of elements been put into operation all the time, but only trigger them in time when needed during the top up mode process, the injection sequence of timing control has to be modified for pulsed power subsystems, such as pulsed magnets, microwave system of the linac and gun related electronics.

3.3 Radiation

The safety issue from the radiation during the topping up mode injection process has been a major concern. The radiation level during the topping up injection at SRRC was also monitored. It was found that with the existed shielding installation, the radiation level was much lower than the accepted value in the case of 1.3 GeV operation. It showed obviously no safety problem.

3.4 Improvement Consideration

During our current study, we found that even applying the transverse damping system [3], the orbit of stored electron beam was still jittering during the injection process due to the disturbance caused by the unbalanced bump from the injection kickers. Thus, the stable synchrotron light was not available during the injection. In order to have a stable beam during the injection, some of the hardware may need to be modified. Or, some modified interface scheme should be considered in order to let the users use only the stable synchrotron light from the stored beam, not from the beam during injection.

Tests have also been made with the existed insertion devices (1 wiggler and 1 undulator) gap closed. As the gaps of insertion devices were almost fully closed, the injection efficiency became very poor and the beam accumulation, in some cases, became not possible. Although the topping up injection was still possible with the wider undulator gap, but it was still impossible while the wiggler gap was closed. This should be the result of the change of electron beam orbit when the gaps of these two insertion devices were closed. To obtain a better orbit for the topping up mode injection, the beam dynamics should be studied and the orbit should be optimized when the insertion devices are closed.

We have also found that a vacuum chamber installed recently at one of the future 14 mm gap undulator site has inner aperature only about 8 mm. The small aperature resulted in the loss of a large amount of electron beam in this section. This problem should be able to be corrected with an optimized orbit or a hardware modification in order to improve the injection efficiency.

From our present study, we know that if the topping up mode injection will be used effectively at SRRC, an appropriate modification on the present control interface and a better electron beam orbit during topping mode injection should be investigated. This should lead to a better beam injection efficiency and stable orbit. Thus, it will lead to a better synchrotron light. Then, the beam line users will certainly benefit from it.

ACKNOWLEDGMENT

The authors would like to thank the whole Injection Group member for their assistance during the experiment and the Radiation and Safety Group for providing the data about the monitored radiation level.

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