COMMISSIONING OF 360 mA TOP-UP OPERATION AT TLS

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Abstract

Taiwan light source (TLS) started the 200 mA top-up operation in October [1], 2005, and subsequently, the stored top-up beam current was raised gradually to 300 mA in November, 2005. Several machine issues were encountered and have been solved in the past three years. Presently, the TLS is performing routinely as user mode operation. However, due to the increasing need of higher photon intensity from the users, it is proposed to explore the possibility of raising the top-up operation to 360mA. This beam-test study has been performed recently. The experimental results show that the TLS is capable of carrying out 360mA top-up operation.

INTRODUCTION

The performance of top-up operation at TLS is well described by applying the indication of "user availability". The merit of "user availability" incorporating with three categories of parameters is defined as: top-up beam current stability; mean time between failure (MTBF); and beam stability. Different types of operation difficulty have been encountered and giving poor user availability. Whenever anyone of the problems was solved, the merit of user availability improved. The problem-solving process is briefly summarized in the following paragraph.

First, the steady top-up beam current was quite often interrupted by radiation over-dosage interlock in early stage of top-up operation due to poor injection efficiency. Also, various malfunctions of booster devices [2] caused similar effects in deteriorating the steady amount of top-up beam current.

Second, MTBF indicates the reliability of TLS in operating top-up. Usually, the top-up was terminated due to various causes of beam loss events such as non-synchronized firing of kicker pulsers during beam filling; arcing in association with the super-conducting rf (SRF) system; quenching of the super-conducting insertion devices. In the worst case, there was more than five beam loss events occurred within one week of user shifts.

Third, the beam stability was often degraded by two types of disturbances in user operation. One type of the disturbance comes from the side coil and the associated correctors of the Superconducting Wavelength Shifter (SWLS). They followed a faulty reading of the SWLS main power supply. The other disturbance was due to abnormal working condition of transverse feedback systems.

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The above mentioned machine problems were allocated and solved step by step over the past three years. Consequently, we are able to evaluate the feasibility of operating 360 mA top-up in fulfilling user demand at TLS.

DESCRIPTION OF EXPERIMENTS

Due to the limited machine shifts available for the 360mA top-up beam test, the experiments were taken places at three separated shifts with the same machine conditions and equal 8 hours shifts.

The criteria to evaluate the machine performance in operating 360 mA top-up were based on the following observations. They were injection efficiency, booster refilling capability, machine performance, and beam stability.

INJECTION EFFICIENCY REQUIREMENT

The capability to maintain stable and standard injection efficiency is the basic requirement of top-up operation. We have established a standard operation procedure to maintain the injection efficiency. The parameter fine tune procedure [3] must be reliable and followed. An empirical tuning procedure have been developed to search for and to determine the optimum conditions for injection. The procedure for this particular example is described as follow:

a. recognize the proper setting of the injection septum after reaching of its thermal equilibrium;

b. fine tune the working tune of the storage ring;

c. fine tune the launching conditions of booster.

Figure 1 shows the improving trend chart of injection efficiency over the past three years.

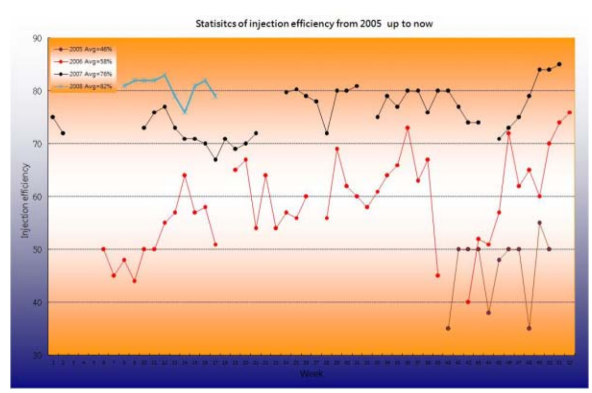

Figure 1: The improving trend chart of injection efficiency.

The injection efficiency of 360 mA top-up operation experiments is shown in figure 2.

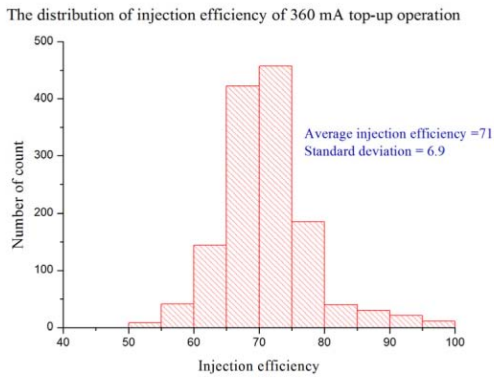

Figure 2: The distribution of injection efficiency of 360 mA top-up operation.

The injection efficiency of 360 mA top-up operation experiments was about 70%, a little bit less than that was achieved in routine 300 mA top-up operation. The main reason of this discrepancy was due to the limited machine study shifts available. It will be further improved as the tuning procedure is optimized.

EVALUATION OF BOOSTER CAPABILITY

The booster filling capability becomes more important when the beam current of top-up operation increase to 360mA. It is because that the refilled current is proportion to the operating current. The booster tuning is difficult during the top-up operation whenever there is a need for that purpose. Presently, the refilling period is once every minute with 2 seconds duration, at most. Before every refilling, the available booster tuning time is 20 seconds, set by the injection control algorithm.

Figure 3 shows that the booster capability can refill in the 360 mA top-up operation. The single interruption in the figure was purposely setup to examine and to demonstrate the refilling capability of the booster in this particular experiment.

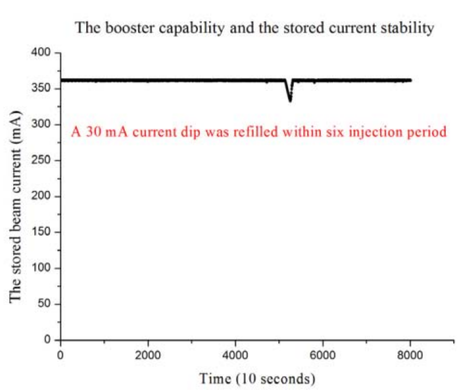

Figure 3: The 30 mA dip of the figure was proposed to test the re-filling capability of booster current. It shows that the operating current was returned to 360 mA within six injection cycles.

In order to preserve the filling pattern in the storage ring, the refilling bucket adjustment receipt has been developed. The present applying receipt requires a short bunch train which make gun pulse adjustment becoming critical. A real time monitor of gun pulses has been implemented for this purpose, as shown in figure 4.

The operator can adjust the gun-pulse tuning knobs in response to the practical need by observing the information shown in the monitor.

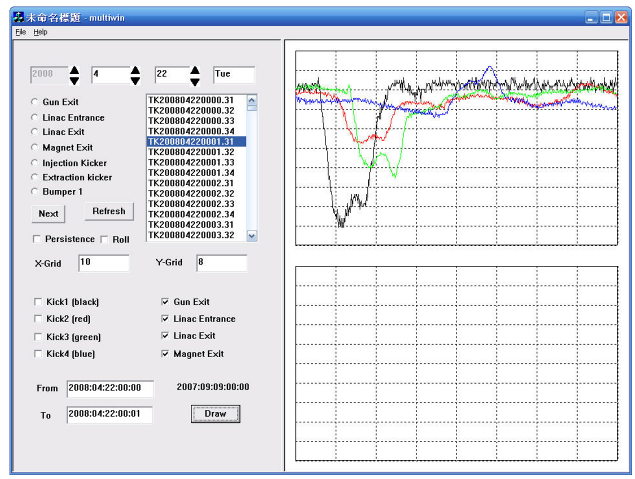

Figure 4: The gun and linac pulses archive provide real time information for operation tuning.

MACHINE RELIABILITIES

The trip rate of top-up operation raised to twice of the trip rate in decay mode operation in 2006. It was not acceptable to the user and it must be solved. Among all trip events, more than 50% beam loss was caused by electromagnetic interference (EMI). The EMI could induce kicker misfired event, arc event to trigger the interlock of SRF system, and temperature interlock to trigger the interlock of superconducting magnet. A massive amount of effort had been made in order to overcome the EMI. For example, the grounding and shielding engineering had been done and the diagnostics of trip event had been built. The annual number of beam loss of 2007 dropped to 45% of 2006 [4]. Yet, the allocation of the EMI sources is still not successful.

Figure 5 is the kicker waveform archive that can be applied to monitor a waveform shifting event.

The machine reliability becomes more important when the operating current of top-up operation is raised to 360 mA. Moreover, there are three more insertion devices to be installed in TLS next year. There will be an increasing need of the rf power from SRF system. Experience shows that as the rf power increased, the possibility of running into SRF system trip becomes higher. It is expected that the system will be prepared by that time.

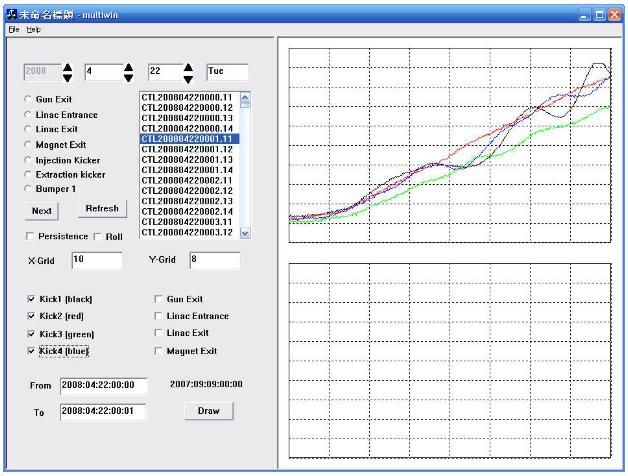

Figure 5: The kicker waveform archive that was designed to observe a waveform shift event.

For carefully observing and testing the actual response of the machine status of 360mA top-up operation. The 360mA top-up operation experiment was divided in three equal periods to indicate the reproducibility. The figure 3 shows there was no any occurrence of beam trip event.

BEAM STABILITY

As far as the routine operation is concerned, beam stability is usually relied on the performance of orbit feedback, transverse feedback, and longitudinal feedback systems.

The slow orbit feedback system was implemented to maintain the electron orbit while changing the gap of insertion devices. The gap changing speed of insertion devices was limited to the response of the orbit feedback system. Observation shows that the photo flux has non-negligible fluctuations in some of the particular gap changing configuration among all insertion devices. Implementing a fast orbit feedback system in the coming months is proposed to overcome this problem.

The vertical beam size blow-up phenomena appeared after installing the 5 m long ceramic chamber for injection kicker in January 2005. It was then temporally suppressed by an analogous transverse feedback system at that time and had been fully cured by a newly installed digital transverse feedback system [5] in Nov. 2005.

The horizontal beam size instability was fully suppressed after implementing the digital longitudinal feedback system in February 2006 [6]. Proper adjustment of the tuning knob in association with the feedback systems is important in relaxing the tolerance of working tunes and orbit feedback system.

Fig. 6 shows the quality of beam stability during 360 mA top-up operation. A few spikes appeared in the figure deteriorate the overall stability evaluation. Further examination indicates that these spikes were originating from poor tuning of the feedback systems and had existed in the 300 mA top-up operation. After optimizing the overall performance of the feedback systems, these spikes are no longer exist in routine 300 mA top-up operation.

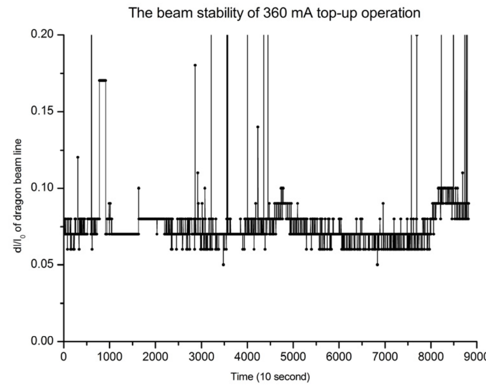

Figure 6: the beam stability of 360 mA top-up operation was indicated by beam quality index of a diagnostic beam line.

CONCUSIONS

The feasibility of operating 360mA top-up at TLS has been examined in terms of injection efficiency, beam current refilling capability, and beam stability. The results of overall performance of the accelerator system indicate a promising possibility for routine user operation. There are more insertion devices to be installed in the coming year, the overall performance of the machine including SRF and feedback systems will be further examined.

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