THE STATUS OF THE UTILITY SYSTEM STABILITY IMPROVEMENT STUDY AT TLS

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Abstract

Previously, the Taiwan Light Source (TLS) at SRRC has proven that the good beam line quality mainly depend on the utility system stability. Subsequently, several studies on cooling water temperature control, tunnel environment temperature control, mini environment temperature control for the elliptic polarize undulator, and control system built up was in progress for improving the utility system stability. The paper presents the status of these works and the design concept of the improvement studies. The influences on the beam line quality are also investigated by the correlation between the air, water instability and the beam line fluctuation.

1. INTRODUCTION

The TLS has been conducting a series of beam quality studies on utility effects such as de-ionized cooling water, air conditioning and electric power [1][2][3]. The related thermal paths have mostly been verified and the main effects could be controlled to meet our requirements. The de-ionized cooling water, in particular, plays an important role in affecting beam behaviors and device performances. For examples, the temperature fluctuations with a 180-second period in the "copper" and "aluminum" de-ionized cooling water system induced the same period of photon position as shown in Fig. 1 and Fig. 2. A fluctuation of 0.6 °C contributed to a photon position fluctuation of 6μm. And the fluctuation of 1°C of the inlet water through RF devices with a 200-second period induced the same structure of the horizontal beam size and lifetime as shown in Fig. 3. In addition, devices such as I zero monitors always had structures like the variations of "Beam-Line" cooling water system as shown in Fig. 4. Currently, the temperature fluctuations of the three de-ionized cooling water systems could be controlled within ±0.15°C and lower.

With regard to air conditioning, the temperature fluctuations in the global tunnel area are controlled within ±0.2°C, with relative to time. In the mean time, the mini environment temperature control has been achieved, with relative to space experimentally.

While the major thermal effects have been suppressed, the electric power system is the main factor of the beam quality. Some beam behaviours from power defects have been verified sequentially. The related improved plans are also performed.

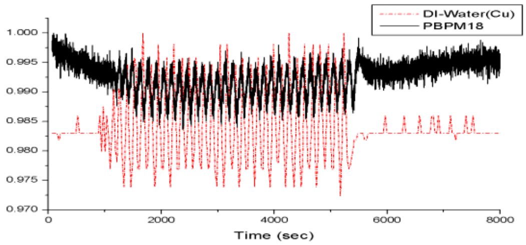


Fig. 1 Normalized fluctuations of the "Copper" de-ionized cooling water temperature vs. photon beam position.

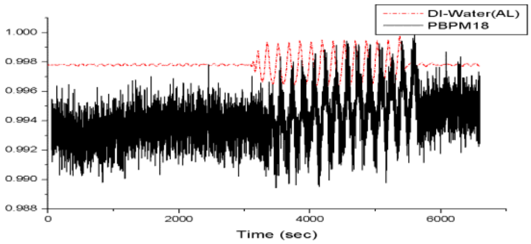


Fig. 2 Normalized fluctuations of the "Aluminum" de-ionized cooling water temperature vs. photon beam position.

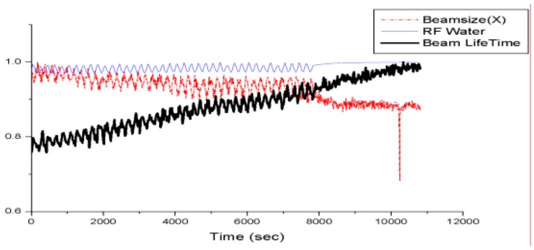


Fig. 3 Normalized fluctuations of the water temperature through RF devices vs. horizontal beam-size and beam-lifetime.

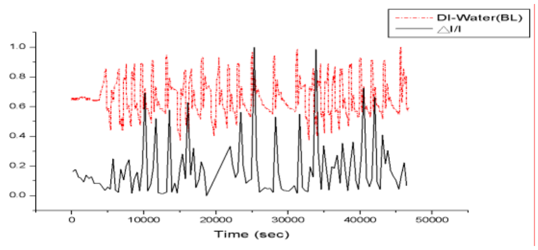
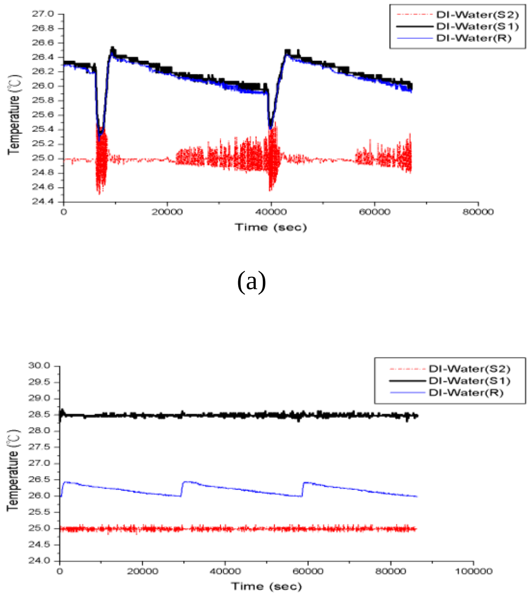


Fig. 4 Normalized fluctuations of the “beam line” de-ionized cooling water temperature vs. △I/I monitor.

2. DE-IONIZED COOLING WATER SYSTEM

Constant efforts have been made to reduce fluctuations of the de-ionized cooling water temperature from ±1°C to ±0.15°C. From the control point of view, the mechanism adopted in the “Top-Down” method indicates that the temperature controls of the cooling tower water, of the chilled water and of the de-ionized water are within ±0.5°C, ±0.3°C and ±0.15°C, respectively. It is helpful for simplifying control logics and enhancing control performance. Additionally, a series of control methods have been adopted, for instance, the variable frequency control of pump to regulate the flow rate under high pressure condition, cascade control for the effect of beam current decay on aluminum chamber cooling and the optimization of control parameters for season changes. However, the instability has still existed in mini- thermal-loading system such as the “aluminum” and “beam line” de-ionized cooling system. Therefore, the heating process was added into the de-ionized cooling system to avoid transient effect of the beam current decay and non-linearity of valves and the heat exchanger. The return water was heated up to 28.5°C, and was then cooled down to within 25 ±0.15°C as shown in Fig. 5. As for piping, the parallel piping for the aluminum chamber cooling has been adopted to reduce the temperature differences between the inlet and outlet water experimentally. This year, isolating the cooling piping through RF devices will be underway to avoid disturbance between different systems.

However, efforts made have not been sufficient to cope with the highly beam-sensitivity devices. The concept design of water cooling system at a fluctuation of ±0.01 °C has also been studied, using the “PCM” buffer application and beam-current-depended control. The “PCM” buffers use the latent heat of some materials to absorb and exhaust mini heat load. This could fine-tune the temperature fluctuations. The beam-current-depended control means that the control with feedback of the beam current decay could predict thermal loading to regulate water flow through each concerned device to maintain constant terminal temperature of the devices.



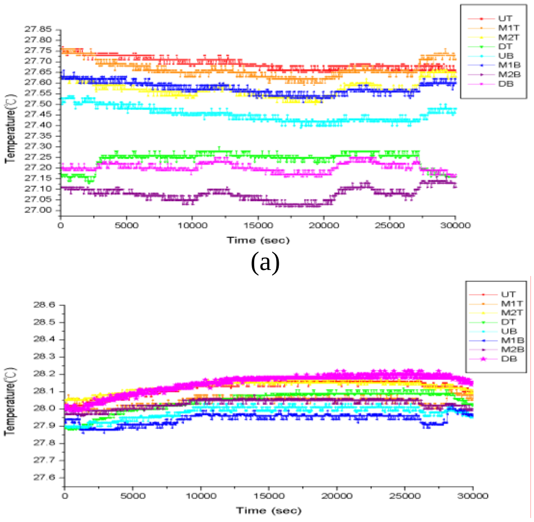
(a)

(b)

Fig. 5 Temperature fluctuations of the “Aluminum” de-ionized cooling water before (a) and after (b) improvements.

3. AIR CONDITIONING SYSTEM

A series of experiments and observations have been done to prove that the beam instability was also induced by air conditioning. The effect could result in beam orbit instability, girder structure deformation and non-uniform magnet arrases of insertion devices [4]. Efforts have been devoted to suppress effects induced by the air conditioning. First, the control and monitor system was upgraded to improve the level of control precision continuously. The booster injection energy was upgraded to 1.5GeV as storage ring energy to reduce temperature disturbance. And the air-conditioning piping and flow was re-arranged for some significant high-thermal devices. Relative to time, the temperature fluctuations of the global tunnel area are from ±1°C to ± 0.2°C . However, the fluctuations between temperature sensors remain different, and those of the non-water-cooling insertion devices are particularly the case. In order to suppress the temperature gradient relative to space, the air flows for elliptical polarization undulator (EPU) have been simulated and optimized [5]. And the mini environment control has been achieved for EPU area experimentally this year [6]. Currently, the temperature of this area could be controlled within ±0.2 °C relative to time. Temperature sensors distributed around EPU area have only a difference of ±0.2°C as shown in Fig. 6.



(a)

(b)

Fig. 6 Temperature fluctuations of the EPU area before (a) and after (b) improvements.

4. ELECTRIC POWER SYSTEM

The power noise from the harmonic distortion, sag, surge, electromagnet interference and poor grounding system could also change beam behaviors. Some beam behaviors have been found that a transformer with a voltage fluctuation of ±5 could induce a fluctuation of ±6 μm in the horizontal beam size as shown in Fig. 7. As a result, some improvement work for the electric power system has been performed. First, the supervisor control and data acquisition (SCADA) have been installed to improve system security step by step. In order to analyze μs-grade power defects, the power quality monitors have been setup. In addition, the grounding system and power source paths are being verified and re-arranged to isolate some equipments from power noise. The 0.2Ω grounding system will be built up to reduce the interference of the noise-sensitivity instruments next year.

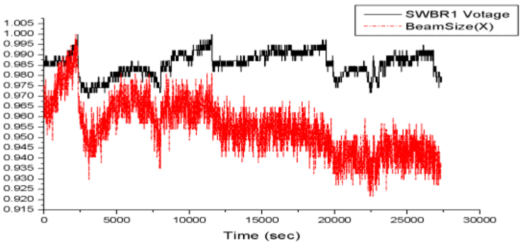


Fig. 7 Normalized fluctuations of the horizontal beam size vs. transformer.

5. CONCLUSION

This paper discussed some utility effects and improvements at TLS. The temperature fluctuations of the de-ionized cooling water and of the air conditioning have now been controlled within ±0.15 and within ±0.2 , respectively. Although methods mentioned previously could be used to reduce temperature fluctuations, the rigid temperature criterion for some thermal-sensitivity devices has been demanded at 0.01 . The concept and simulation must be studied continuously. Furthermore, the issue of the electric power is the one that TLS will have to address in the next two years. These propagation paths of the power noise are expected to be clarified and improved.

6. ACKNOLEDGEMENT

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