VACUUM COMMISSIONING FOR THE SWLS ABSORBER INSIDE A KICKER-CHAMBER AT TLS STORAGE RING

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Abstract

A 6T super-conducting wiggler, so called wavelength shifter, (SWLS) has been installed in the injection section of the 1.5 GeV Taiwan Light Source (TLS) electron storage ring. The intensive synchrotron radiation emitted from SWLS causes severe problems in the downstream kicker-chamber, such as radiation hitting on the ceramic parts, interfered non-uniform field and induced arcing from the absorber during kicker firing, etc.. A new absorber, designed to solve those problems, has been developed and installed in the kicker-chamber downstream the SWLS. The earlier stage of vacuum commissioning shows a high pressure-rise, stimulated by the photons, localized near the head of absorber that seriously constrains the beam lifetime. However, the pressure reduces by continuous beam cleaning. The injection efficiency of the electron beam is not degraded much. The temperature rise on the downstream chambers, behaves not so according to the beam current, is kept within allowable values.

INTRODUCTIONS

A 6T SWLS is installed in the 1.5 GeV TLS to obtain a higher flux and a critical energy of hard X-ray extend from 2.14 keV to 8.98 keV[1,2]. The irradiation from SWLS, 130 mrad photon span and 8.9 mm off-axis, hits the downstream taper, flange, kicker ceramic chamber, and drift chamber, etc.. An absorber is installed inside the 4th kicker ceramic chamber to prevent the non-cooled ceramic parts from irradiating the synchrotron light. The severe problem for the absorber inside the kicker chamber includes: (1) reducing the horizontal physical aperture that challenges the beam injection, (2) degrading the uniformity or kick-field, (3) causing the arcing and inducing serious problems of dramatic pressure rise and the micro-dust from the damaged film coated inside the ceramic chamber. Features of the absorber should be water-cooled, thin enough, higher thermal conductivity, electrical insulated from the chamber. The design and the commissioning result will be described in this paper.

DESIGN OF THE ABSORBER

Figure 1 illustrates the engineering drawing for the R1 straight section of TLS that contains SWLS and the 4 sets of kicker. There is not enough space between the SWLS and the 4th kicker for inserting an independent absorber. The parameters of SWLS at strength of 6 T and 5.3 T are shown in Table 1.

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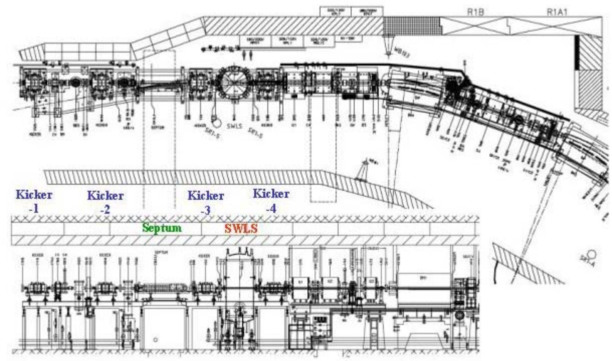


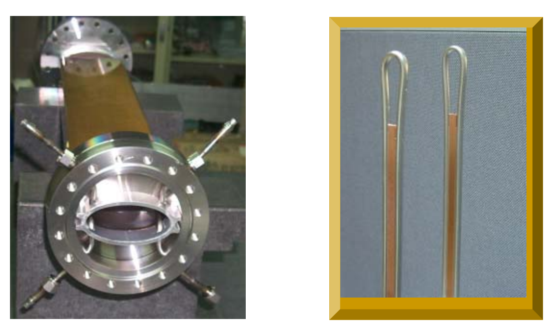
Figure 1: Engineering drawing for the R1 straight section of TLS, top view and side view.

Table 1: Comparison of the parameters of SWLS source at field strength of 6 T and 5.3 T

Field strength	**6 T (260 A)**	**5.3 T (230 A)**
Critical energy	8.98 keV	7.93 keV
Photon span	130 mrad	115 mrad
Total Power	2.56 kW	1.98 kW

Design

The absorber is made of OFHC copper sheet, 3 mm in width, 6 mm in height, and 460 mm in length, surrounded brazing with 1/4" stainless steel tube for cooling water. The flow rate is higher than 3 L/s. An extended Cu covers the tip of the SUS cooling tube to avoid the irradiation. The assembly is inserted from the downstream port of ceramic chamber, as shown in Fig. 2, where the RF bridge is installed to keep the same cross section.

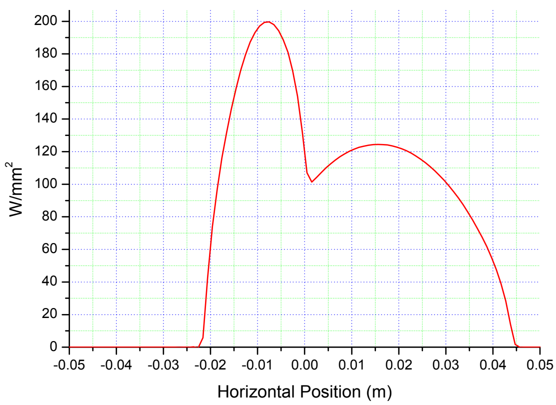


(a) (b)

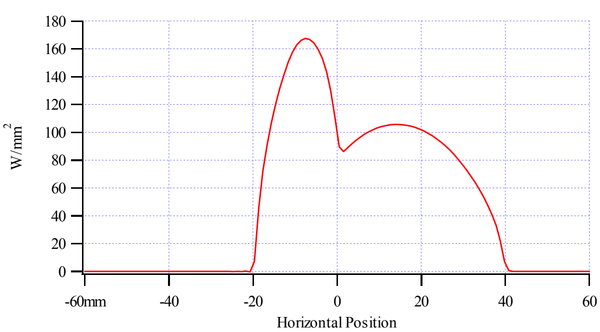
Figure 2: Photos of (a) the kicker chamber with the absorber, and (b) the cold head of the absorber.

Thermal analysis by ANSYS simulation

The curves of power distribution for SWLS at strength of 6 T and 5.3 T, located at 0.52 m from source, are shown in Fig. 3(a) and 3(b), respectively. Fig. 3(a) shows a maximum power density of 50 W/mm^2 at 0.04 m of horizontal position, the half width of ceramic chamber, in case of 6 T, and lower than 5 W/mm^2 in case of 5.3 T.



(a)



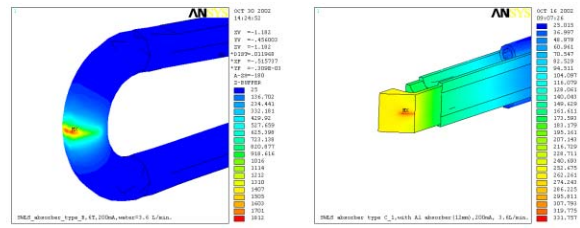
(b)

Figure 3: Power distribution for the SWLS at field strength of (a) 6 T, and (b) 5.3 T.

The thermal analysis by ANSYS for the absorber near the cold head without Cu cover, and with Cu cover and upstream absorber, are illustrated in Fig. 4(a), 4(b), respectively. The simulated results emphasize not only the necessity of covering the cold head with conductively cooled copper but also another upstream absorber to share the heat loads with the cold head. The upstream absorber is made by welding an Al absorber, 12 mm in height, on the inside wall of Al taper flange downstream the SWLS.

COMMISSIONING OF TLS

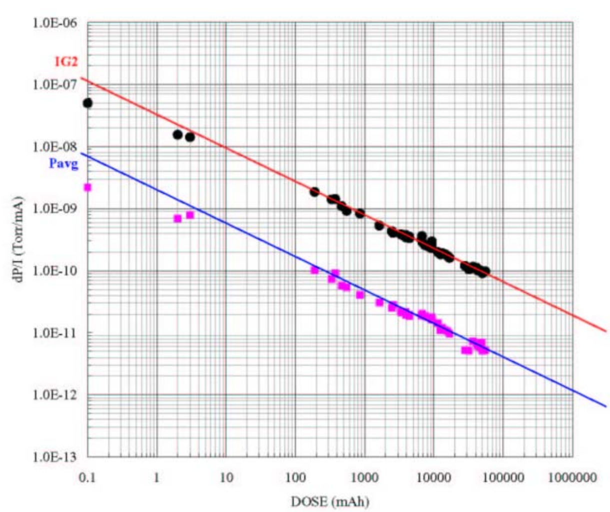
The absorber cannot protect the leading edge of kicker ceramic chamber from SWLS irradiated power density of 50 W/mm^2 in case of 6 T that causes the non-cooled ceramic spacer broken. The later commissioning of TLS is operated for SWLS at 5.3 T. Thus the photon span of SWLS light reduces from 130 mrad to 115 mrad. It is capable to shield the non-cooled ceramic chamber and components from irradiation. Since there is not enough space for additional pumps and poor conductance near SWLS, the pressure rise of R1IG2 due to photon stimulated desorption out of the absorbers and SWLS beam duct is the highest in the storage ring. The averaged pressure, Pavg, is determined by R1IG2. The pressure rise per beam current, and the product of life time with beam current, as function of the beam dose are shown in Fig. 5(a) and 5(b), respectively.



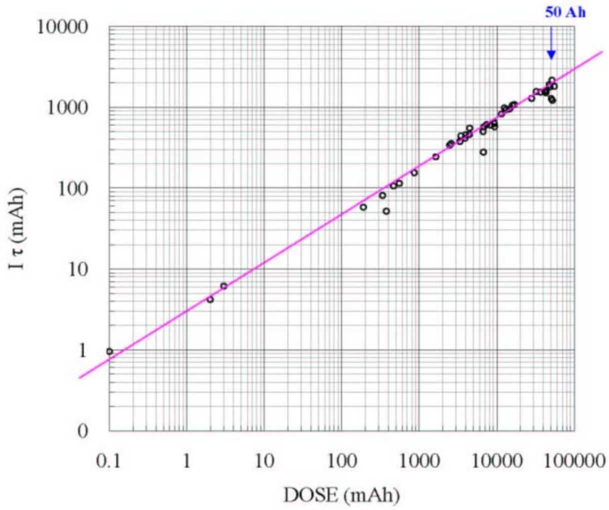
(a) (b)

Figure 4: Thermal analysis by ANSYS for the absorber (a) without Cu cover, and (b) with both Cu cover and upstream absorber.

A beam lifetime, limited by nuclear scattering from residual gas, of longer than 10 hours at a beam current of 200 mA has been achieved after the beam self-cleaning at an accumulated beam dose of 50 Ah. The averaged pressure rise due to photon stimulated desorption reduced to a level below 5×10^{-12} Torr/mA. The dominant pressure rise is determined by R1IG2, located near SWLS, comprised of H_2, CH_4, and CO. Fig. 6 shows the mass spectrum by a quadrupole mass spectrometer near the SWLS section where the desorbed gas species are measured. The product of pressure rise, IG2 or Ravg, with lifetime is nearly constant of 2×10^{-7} Torr·h or 1×10^{-8} Torr·h. It illustrate a result of gas scattering dominant lifetime compared with the Touschek lifetime before beam dose of 50 Ah.



(a)



(b)

Fig. 5: Pressure rise per beam current, (a), and product of beam current and lifetime, (b), as function of beam dose. IG2 and Pavg represent the pressure rise near SWLS and the average pressure of the storage ring respectively.

The temperature rise near downstream taper of SWLS and near the 4th kicker ceramic chamber is monitored by the PT100 thermal sensor. Fig. 7(a) shows the beam current and pressure rise near injection section and SWLS, and 7(b) shows curves of temperature rise near SWLS and downstream kicker chamber. T1 ~ T4 represent the temperature near both sides of taper and flange downstream the SWLS, while T5, T6 and T7, T8 near upstream and downstream of kicker chamber respectively. The temperature near the SWLS and kicker chambers are < 13 ºC, at 5.3 T of SWLS operation mode and 200 mA beam current.

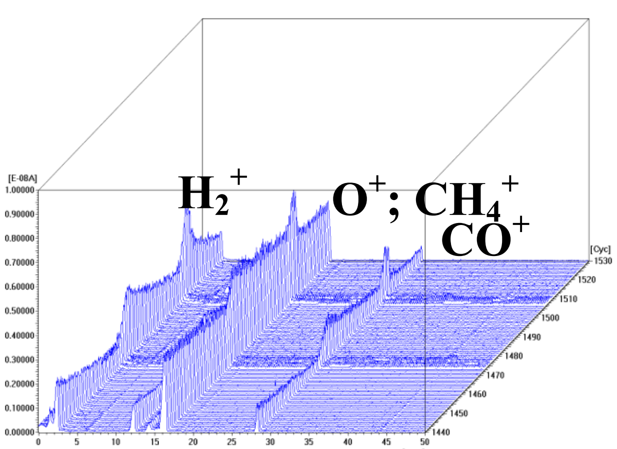
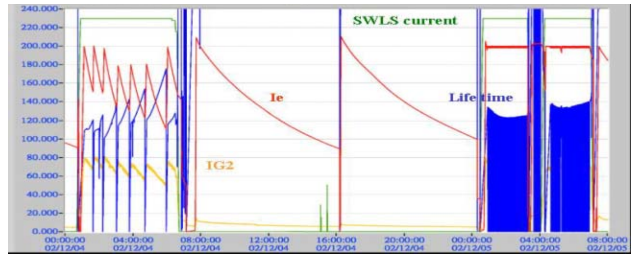
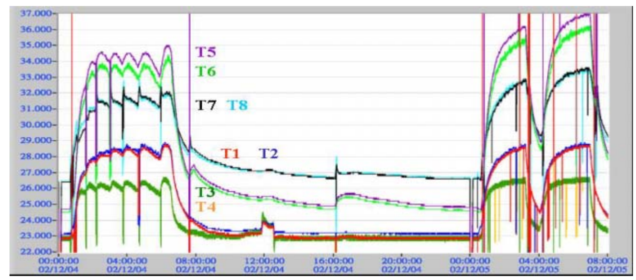


Fig. 6: RGA spectrum in mass range of 1 ~ 50 amu/e. The dominant residual gases include H_2, CO, and CH_4.



(a)



(b)

Fig. 7: (a)Beam current, pressure rise, lifetime; (b) Temperature near SWLS and 4th kicker chamber.

CONCLUSION

The commissioning result for the SWLS absorber inside the downstream kicker chamber is described. A lifetime of > 10 h at beam current of 200 mA was achieved after beam self-cleaning for accumulated beam dose of 50 Ah at SWLS field of 5.3 T. The dominant gas species are H_2, CH_4, and CO. The injection rate of > 200 mA / 3 min, after installing the SWLS, does not degrade. The cold head of the absorber is protected by an extended Cu cover and an Al upstream absorber. The temperature rise near the ceramic chamber is < 13 ºC.

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