FIFTEEN YEARS OPERATION EXPERIENCES OF TLS VACUUM SYSTEM

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Abstract

The Taiwan Light Source (TLS), a third generation accelerator, has been operated successfully since 1993. It has been upgraded to increase the beam energy from 1.3 GeV to 1.5 GeV and the consequent capability of full energy injection afterwards. While the beam current has been increased from 200 mA to 300 mA after replacement of RF cavities with superconducting one. The vacuum pressure tends to decrease continuously after installations of 3 undulators and 4 wigglers as well as the new front ends. The accumulated beam dose increased faster up to > 14500 Ah after the routine operational top-up mode since 2006 with average pressure has been maintained below 0.13 nPa/mA. The beam life time of 6 hours at 300 mA has been kept with a limitation of Touschek life time at a stable beam with variation of photon flux < 0.05%. However, the photon absorbers of front ends have been replaced with new ones for subjecting the higher irradiation power after upgrading. The good dynamic pressure reflects the effective pumping performance. The experiences of components failures will be summarized in this paper.

INTRODUCTIONS

The TLS vacuum system has been completed the construction and confirmed the first turn of circulated beam on Feb. 23 1993 as well as the following beam test, and then started the commissioning since July 1993 after an in-situ bake out for all the vacuum systems. The operation of TLS in the past 15 years is roughly divided into 4 stages, as listed in Table 1, including (i) 1993/07 ~ 1994/07 for commissioning, (ii) 1994/07~1999/07 for users with new insertion devices and front ends, (iii) 1999/07~2005/12 for users with new superconducting wigglers, and (iv) 2006/01~2008/12 for users with SRF and IASW6. The operation experiences in the four stages will be described in the following sections.

Table 1: Four stages of operation of TLS in 1993 ~ 2008.

Range of Years	E(GeV)/ I(mA)	Accumulate Dose (Ah)	Insertion Devices
(i) 1993~1994	1.3 / 200	167	(NA)
(ii) 1994~1999	1.3 / 200	3004	W20, U5, EPU5.6, U9
(iii) 1999~2005	1.5 / 200	8840	SWLS, SW6
(iv) 2006~2008	1.5 / 300	14765	IASW6

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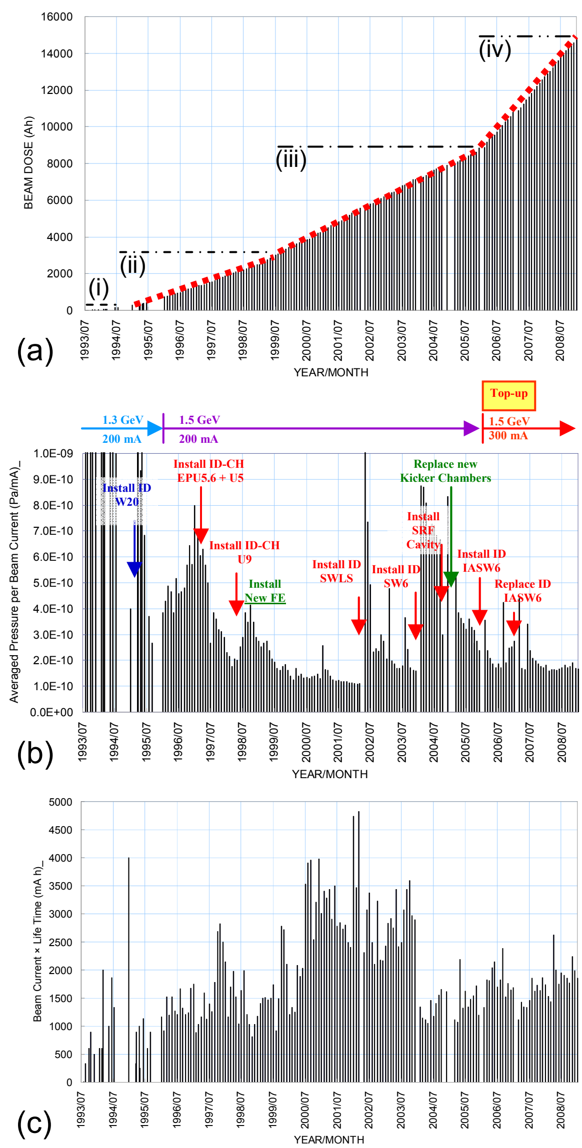

Figure 1: Operation status of TLS vacuum system in the past 15 years through 1993 ~ 2008. (a) Beam dose vs. Year/Month, (b) Average pressure per beam current (dP/I) vs. Year/Month, (c) Beam Current × Life time (I·τ) vs. Year/Month.

OPERATION EXPERIENCES

There have been different strategies made for manipulating the vacuum systems from the point of view of the operational efficiency evolved from the reduction of outgas of photon stimulated desorption (PSD). Figure 1 depicts the operation status of TLS vacuum system showing the (a) accumulated beam dose, (b) average pressure per beam current, and (c) product of beam current and life time, versus the operation calendar year and month. The dashed curves in fig. 1(a) for 4 stages shows the linear and smooth growing of the monthly accumulated beam dose with different slopes. No significant problem was happened which causes the long period interrupt to the routine operation. However, the continuous installation of 3 undulators, U5, EPU5.6, U9, and 4 wigglers, W20, SWLS, SW6, and IASW6, and the new front ends causes the pressure rise from the downstream new absorbers that affects the beam life time drastically, as shown in fig. 1(b) and 1(c), respectively.

Operation Stage (i) in 1993/07 ~ 1994/07

During the first year of commissioning, the magnetic suspended turbo-molecular pumps (TMP) were used for evacuating the large amount of desorbed gas molecules out of the vacuum chambers [1]. Since it was not planned to switch the sputtering ionization pumps (IP) on before the pressure be reduced to lower than 1.3×10^{-6} Pa for eliminating the potential problem of particular production from the IP. The non-evaporable getter (NEG) pumps were activated during the vacuum baking of the chambers. However, the pumping efficiency of the NEG is not high enough due to the fact of the lower diffusion rate in comparison of the getter rate at the pressure as high as 1.3×10^{-5} Pa. After one year's commissioning with beam dose up to 167 Ah, the average pressure rise due to PSD reduced from 2.2×10^{-7} Pa/mA to 1.0×10^{-9} Pa/mA. The coefficient of PSD was 3×10^{-6} molecules/photon near straight chambers, and 6×10^{-7} molecules/photon near bending chambers. The major contribution of beam cleaning for the new chambers has been achieved at this stage. The dominant outgas species, monitored with the RGA, contained the H_2 (93%), CO (4.4%), CO_2 (1.2%), CH_4 (0.5%), and H_2O (0.5%).

Operation Stage (ii) in 1994/07 ~ 1999/07

The increase of beam dose smoothly illustrates the feature of routine operation in stage (ii). The insertion devices including the W20, EPU5.6, U5, and U9, as well as the front ends have been installed in this stage. The vacuum chambers downstream the W20 were replaced by the ones with new absorbers and double side cooling channels. In additions, the new ID chambers of small inner apertures and long length were installed where the outgas inside the beam ducts was difficult to pump out. Thus it took longer time to pump down the PSD outgas while the TMP pumps near the absorbers were kept on running. Besides, the in-situ baking process has been applied every time when breaking the vacuum for installation of new chambers which resulted in many problems including the accidental over heating of the O-ring sealed gate valves, break of electric feedthrough of IP during switch on at high temperature [2], moving the original positions of BPM due to thermal expansion, back filled outgas from the mechanical pumps, TMP or fore line dry pumps, to the chambers due to accidental power failure, and so on. The pressure rise was reduced to 1.9×10^{-10} Pa/mA and the beam life time increased to ~ 9 hours at 200 mA eventually. Since the combination of IP and NEG pumps performed well in the ultrahigh vacuum, the TMP pumps were replaced by additional NEG pump for removing the vibration sources from mechanical pumps and the risk of backfilled outgas due to power failures.

Operation Stage (iii) in 1999/07 ~ 2005/12

The routine operation in stage (iii) is getting aggressive after upgrading the TLS from 1.3 GeV to 1.5 GeV of full energy injection and the replacement of RF cavities with superconducting one (SRF) later. Two superconducting wigglers, SWLS and SW6, have been installed in the straight sections for the injection kickers and for the SRF, respectively. The severe problems of insufficient pumping near SWLS and the absorbers for the downstream kicker ceramic chambers results in the higher local pressure, complicated structure, and the broken ceramic insulators inside the kickers [3]. The noise from pulsed magnets interfered with the nearby vacuum gauges causes the hanging of output signals and the consequent malfunction of interlock system. The lowest pressure of 1.1×10^{-10} Pa/mA has been achieved before installation of SWLS. The sensors and cables of the gauges near the pulsed magnets are wrapped with the electrical shielding clothes for isolating the impact of the noise. A program for archiving the historical data of all the subsystems has been established for tracing the correlation of signals which helps the finding of malfunctioned parts and the sources of instabilities. The variation of the photon flux of < 0.05% has been achieved after the major improvement of stabilization of temperature for cooling water, ambient temperature, the electricity power, the positioning of BPM, and so on [4].

Operation Stage (iv) in 2006/01 ~ 2008/12

The routine operation in stage (iv) not only increases the beam current from 200 mA to 300 mA for the sake of SRF, but also realize the top-up injection. Besides, additional SW, IASW6, has been installed in the acromatic arc-section due to not available space in straight section. However, the leakage of the injection Be window occurred due to the frequent injections. The new ceramic chambers and the injection chamber built with new Be window have been replaced for accommodating the routine operation with top-up injection. All the photon absorbers and apertures in the front ends have been replaced with the new ones with directly built-in cooling water channel for accommodating the heat load higher than before. The reliability of the TLS vacuum system becomes high after those improvements.

CONCLUSIONS

The TLS vacuum system has been operated for 15 years. The utilization of TMP pumps for removing large amount of PSD outgas major in the first year of beam cleaning is efficient. The gas load to the IP and NEG after beam cleaning with TMP are significantly reduced which keep the getter materials fresh and increase the duration of reactivation as well as the life time of the getter materials. The valves with O-ring sealing should be replaced with the metal ones for highly reliable ultrahigh vacuum system. In-situ baking not only causes the problems of damage the vacuum components or positional shift due to thermal expansion, but also leave the heavy work loads and long time for the maintenance inside the tunnel. It is better to complete the baking for the vacuum components outside the tunnel and assure the good ultrahigh vacuum qualities being achieved, then using the super-dry N_2 purging and super-dry ambient air shower exposing system and procedure for the installation of UHV components to avoid the in-situ baking inside the tunnel.

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