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VACUUM SYSTEM OF HLS-II STORAGE RING*

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Abstract

Hefei Light Source (HLS) has been operated for more than twenty-five years. From 2010 to 2014, the upgrading project of HLS has been carried out and the new machine is called HLS-II. The main improvement include: the emittance is reduced to 40 nm·rad, 3 new insertion devices (2 IVU and 1 EPU undulators) are added and the injection energy increases to 800 MeV. The typical life time is 300 mins at 300mA, 800 MeV. The average pressure of static and dynamic vacuum are below 2×10^{-8} Pa and 1.2×10^{-7} Pa respectively. The design, installing and commissioning of the vacuum system of the storage ring are detailed stated in in this paper.

INTRODUCTION

The 800MeV electron storage ring of the National Synchrotron Radiation Laboratory (NSRL) is a dedicated VUV and soft X-ray synchrotron radiation light source. The construction of NSRL facility began on November, 1983 and was completed in 1989. HLS comprises of 200 MeV injector, 800 MeV storage ring, 12 beamlines and 15 experimental stations by 2010. In order to supply synchrotron light with higher brightness and stability to the users, the upgrading project of HLS has been carried out during 2010-2014[1]. The main changes of the new HLS (HLS-II) include: The energy of the injector increases to 800 MeV, so the electrons can be injected to the storage ring with full energy. The lattice of the storage ring was changed from TBA to DBA. The beam emittance decreased to 40 nm·rad. A group of multifunctional sextuple magnets are employed and thus the long and short straight section are both lengthened. Five insertion device were installed in the storage ring.

LAYOUT OF THE STORAGE RING

The circumstance of the storage ring is 66.13 m, as shown in Fig. 1. It consists of four DBA cells and each cell has 2 dipoles, 4 quadrupole and 4 sextupole magnets. The synchrotron light is emitted along the direction of 0°and 15° with the beam orbit. There are 8 long straight sections and their length account for 38% of the ring. Insertion devices are located in 6 LSS. Injector and RF cavity are located in the other 2 LSS.

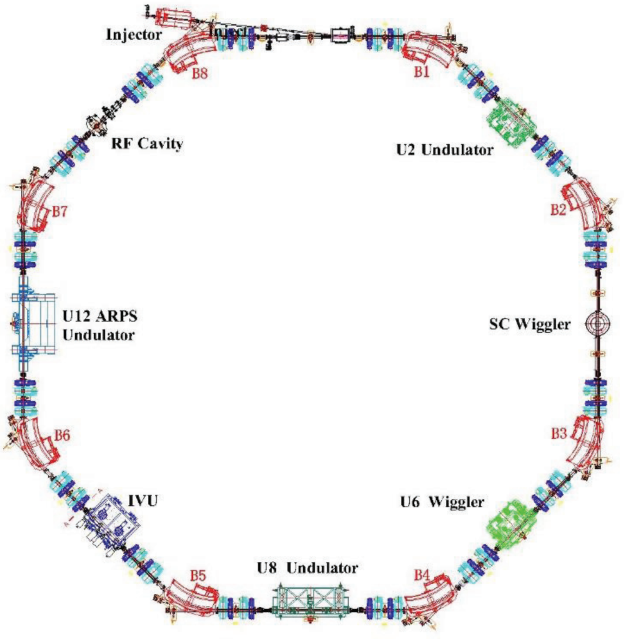

Figure 1: Layout of HLS-II storage ring.

VACUUM SYSTEM DESIGN

The storage ring's circumference is 63.66 meters. The main vacuum pipes are made of 316LN stainless steel by welding. The section is octagonal as shown in Fig.2. To reduce the surface degassing and the magnetic permeability induced by welding, the chambers are baked at 900 °C in the vacuum furnace. After this treatment, vacuum chambers of the total leak rate, outgassing rate and magnetic permeability are below 2×10^{-8} Pa L/s , 2×10^{-11} Pa L/s cm^2 and 1.02 respectively, which meet the design requirements. Considering the convenience of installing, commissioning and maintenance, 3 RF-shielded all-metal gate valves are used to separate the storage ring into three cells. 20 UHV gauges are distributed in the storage ring to monitor the vacuum and for the interlock protection system.

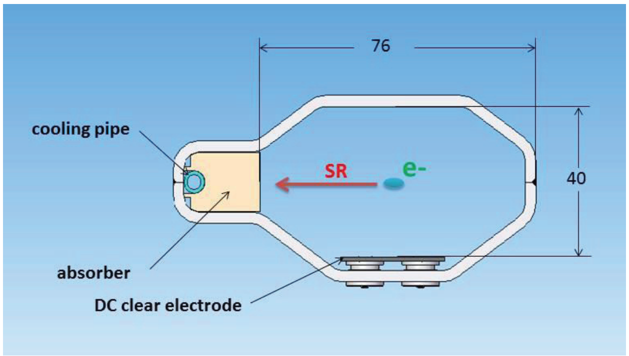

Figure 2: The section of the main vacuum pipe.

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Facility Design and Updates

Because of the low electron energy, the deflection angle of the dipole magnet is relatively large, so the synchrotron light can hardly be absorbed by a lumped photon absorber. To ensure the thermal stability of the vacuum pipes and reduce the photon stimulated desorption, water-cooled absorbers made of oxygen-free copper, which can protect the inner surface of the dipole magnet pipe from being hit by the synchrotron light, are arranged in the pipes along the beam direction and near the light outlet, as shown in Fig.3. The absorbers in the pipes also act as supports and simplify the design of the vacuum pipe.

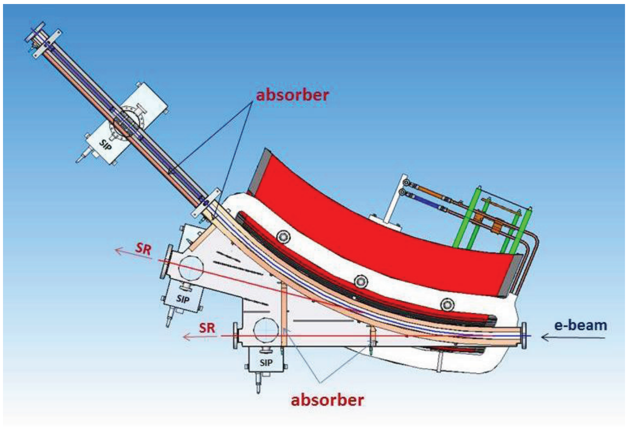

Figure 3: A standard segment of the storage ring.

18 RF-shielded bellows, as shown in Fig. 4, are adopted to eliminate the machining and installing errors, deformation induced by temperature difference, and for smooth transition of chambers with different sections. The bellows are machined by welding with high stability. Considering the smooth transition of the chambers and the high frequency contact resistance, the RF shield is achieved by using shield fingers. Shield fingers (Cu-Be) which bridge the gap between the neighbouring flanges inside the welding bellows. The permissible longitudinal and transverse error are ±10 and 1.5 mm respectively. The design value of the contact stress of shield finger is larger than 25 Kg/cm2.

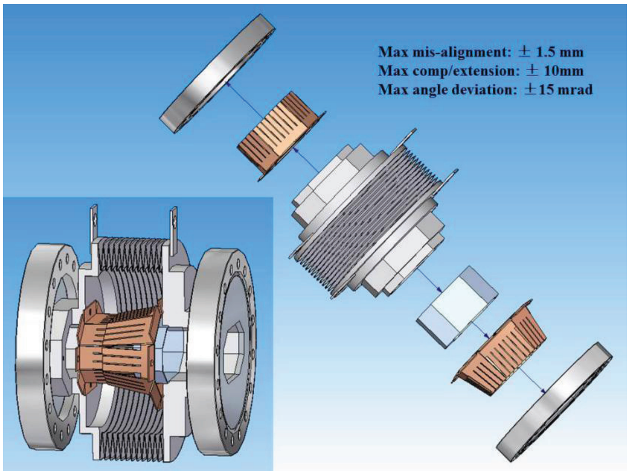

Figure 4: A standard segment of the storage ring.

The pumping system comprises 38 SIPs with the pumping speed of 200 L/s and 3 SIPs with the pumping speed of 400 L/s. NEG strips WP1250 supplied by SAES are added into the SIPs and the pumping speeds are increased by 2-3 times[2]. According to the calculation, the overall degassing of the storage ring after beam scrubbing with 100 Ah dose is approximate 2×10^{-3} Pa·L/s. The pumping system can evacuate this amount of gas load and even higher gas load while the storage is operated at 500 mA.

INSTALLING AND COMMISSIONING

The storage ring of vacuum pipes can't be in situ baked due to the limitation of small aperture of the magnets. Therefore, before the installing of the pipes, the entire ring was divided into 17 subsystem for assembling and vacuum pre-commissioning and each subsystem was baked so that the ultimate vacuum could be better than 5×10^{-8} Pa. After the subsystem was hoisted in place, installed and aligned accurately on the support, high purity nitrogen was introduced and then all the subsystems are connected together. The installing of a subsystem is shown is Fig.5. Only the pipes outside of the magnets and SIPs were baked on 200°C for 48 hours. Two days after the activation of NEG and start of the SIPs, the average pressure is 5×10^{-8} Pa and one week later this value is 2×10^{-8} Pa.

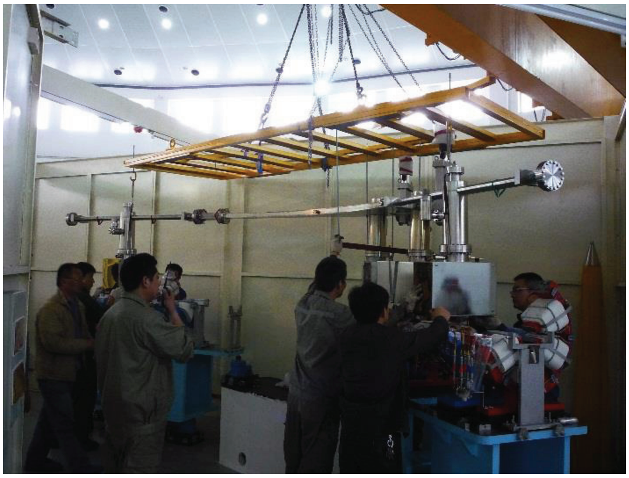

Figure 5: Installing of a subsystem.

Now the HLS-II has been commissioned and operated for more than one year and the total accumulated beam dose is over 1200A·hr. The process of beam scrubbing is shown in Fig.6.

The lifetime with the beam of 300 mA and 800 MeV is more than 300 minutes just after 80 A·hr. In November 2014, the storage ring was exposed to air for replacing of ceramic chambers. After the replacement and baking, the vacuum and beam lifetime restored quickly to the values before exposure to the air, as shown in Fig.6

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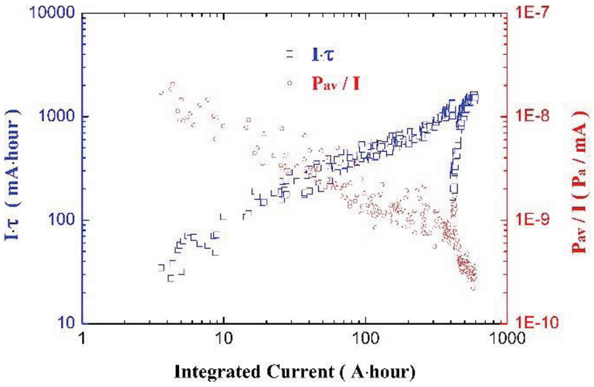

Figure 6: Progress of beam cleaning and growth of beam lifetime.

CONCLUSION

The HLS-II storage ring vacuum system after one year commissioning and operation, the average pressure of static and dynamic vacuum are below 2×10^{-8} Pa and 1.2×10^{-7} Pa respectively and the beam life is more than the design value of 5 hours. All this indicates that the design, installing and commissioning are successful.

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