IMPROVEMENT OF THE STORAGE RING UHV SYSTEM OF NSRL

Y. Wang, W. Wei, F. Y. Zhao, J. P. Wang, D. M. Jing, L. Fan, C. Y. Guan,
Guanyuan Wu, National Synchrotron Radiation Laboratory, University of Science and Technology of China, Hefei, Anhui 230029 P. R. CHINA

Abstract

NSRL storage-ring has been operated for fourteen years, The typical life time is 600 mins at 200mA and 800MeV. The new injection ceramic chamber, bend chamber, undulator and NEG pumps were installed, new vacuum measure and control system was debugged in 2002 summer, as part of NSRL phase II project to enhance the quality, stability and long-term reliability. The average pressure of storage ring is better than 2E-8 Pascal after 48 hour large current direct backout and 48 hour ion pumps operation, this better vacuum can benefit the phase II project's object, beam lifetime 600 mins at 300mA and 800MeV.

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. Its commissioning is to end in December 1991. The NSRL storage ring routinized to run for users in 1993. The typical beam lifetime of the NSRL stored beam was over 600 minutes at 200mA and 800 MeV. In the summer shutdown in1999, a 6 Tesla superconducting wiggler magnet has been setup, so that the radiation of shorter wavelengths near 1Å is already available for users, and a pure permanent magnets Transverse Optical Klystron (TOK) have been design and constructed for the Storage Ring FEL (free electron laser). It will be used for the coherent harmonic generation (CHG) experiment firstly. The experiments of spontaneous radiation have been carried out. The further more work will be continued. For these TOK chamber, wiggler vacuum system was install and some new chambers was modified to install the absorbers to protect the stainless steel beam ducts from wiggler magnet intense synchrotron radiation. Last summer the vacuum system of storage ring was shutdown to improve again in order to reach the Phase II project object of long-term reliability, stability and reliable operation [1].During this operation, the vacuum system had been exposed to air for 45 days, after the long exposure to air, the new equipments of ring vacuum system was assembled and the whole system was baked out by passing a large current through it. The average pressure without beam and RF power was 2·10-8 Pa, which is better than that before improvement. The operation and improvements for vacuum system of storage ring are presented here.

OPERATION

We started on the designing the UHV system of the NSRL in April 1983. The principal parameters for the storage ring vacuum system are shown in Table 1. The vacuum chambers of the ring were made of stainless steel pipes and plates (SUS304l, SUS316l). The whole system was baked out by passing a large current through it. The average pressure without beam and RF power was 5×10E-8 Pa. We welcomed the first synchrotron radiation light in April 1989.

NSRL Storage ring UHV system has been operating for fourteen years. The typical beam lifetime of the NSRL stored beam was over 600 minutes at 150mA and 800 MeV. The total accumulate beam dose is about 200A·hr every year.

Table 1: Main parameters of the NSRL ring

Beam Energy [MeV]	800
Beam Current [mA]	300
Circumference [m]	63.66
Bending radius [m]	2.222
Main ion pumps [l/sec]	11200
Auxiliary NEG pumps [l/sec]	2400
Power on chamber wall [Kw]	4.893
Average pressure [Pa]	2×10^{-8}
Dynamic pressure [Pa]	2×10^{-7}
Lifetime [hrs]	> 8
The total beam dose [A.hr]	> 400 (every year)

Based on operating results, we have determined the experimental relation of beam dose for NSRL to be [2]:

P/I=1.06×10-6·D-0.61 [Pa/mA]

The storage ring vacuum system had been exposed to atmosphere eight times due to unexpected leaks and five times due to controlled venting with dry nitrogen at the end of last year. After vacuum system baked out and 75 A·hr of beam cleaning, The dynamic average pressure of general storage ring exposed to atmosphere had reached the design goals, and we got beam lifetime over 600 minutes at 150mA and 800 MeV. If only SIP pumps baked out, the same result could be got after 100 A·hr of beam cleaning or more.

We decided to make further improving performance of the vacuum system, so that much higher beam currents can be stored to reach the Phase II project goals of long-term reliability, stability and reliable operation.

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VACUUM SYSTEM IMPROVEMENTS

In machine operation, we find the pressure rise high in the downstream of each bending chamber when the storage current over 150 mA. Based on the calculation, about 30% of the synchrotron radiation lights irradiate on the downstream of each bending chamber, which can cause PHD (photon stimulated disabsorb) gas disabsorb, and the pressure rising is due to the insufficient pumping speed of distribute ion pump. So the first improvement was to increase pumping speed in that area. Because of the space limits, the NEG pump with less volume and high pumping speed in high and ultra-high vacuum is the best choice. The GP100 MK4 NEG pumps made in SAES Getters Company of Italy were equipped in the downstream of every bending chamber. Each NEG pump has the pumping speed of is 240 l/s for H_2 and 85 l/s for CO, and was put in the downstream of every bending chamber to reduce dynamic pressure difference. The better vacuum can do help to store much higher beam currents and lengthen the beam's lifetime.

As a result of the operation of more than fourteen years, some welded bellows had been found to have gas leakage after the system had been baked for several times. So we use the oil pressured bellows instead of the welded bellows. The RF shields (Cu-Be) as the quadrate-round transition board between rectangle-cross chamber and circle-cross chamber have been used to reduce the impedance of bellows . The RF shield ought to keep good electrical contact and smooth mechanical movement. The vacuum impedance of new bellow chamber with RF shield is 3 times smaller than that of the old bellow chamber. [2] At the same time the new bellow chamber design makes it possible for us to setup NEG pumps in the downstream of bending chambers.

In order to research the relation between dynamic pressure of vacuum system and beam lifetime and stability, the vacuum measure, analyses and interlock system has been improved. The pressure distribution of storage ring differs very much and the vacuum system of our ring uses point pumping method, so it is difficult to find tiny leakage of the storage ring vacuum chamber. Now vacuum pressure monitor points by Bayard-Alpert type ionization gauge have been increased from 7 points to 21 points. Compared with the history note, small leakage is easily to find, because the distance from gauge to gauge is just 3 m length, and this method is much easier and more accurate than concluding leakage by the ion current of sputter ion pump. An Industrial PC is used as Input/Output Controller (IOC) and it connects the 7 Varian vacuum Multi-Gauge controllers with serial communication (RS485 mode). The pressure values are displayed in a PC with Linux, which is used as operator interface (OPI). The pressure values are archived in a database and some data analyses are also done, which is necessary to research the relation between dynamic pressure of vacuum system and beam lifetime and stability.

As a goal of our machine improvement we need lower emittance operation. So in injection equipment modification we use the thyratrons for pulse switch of kick power supply instead of the spark gap of the old one. The four ceramic chambers of kick in the same straight section for injection are set up instead of three kick chamber in the three straight section of the former injection scheme. Moreover, a new RF cavity and a new RF power supply are manufactured and installed, The cooling loop of the new cavity will be more reasonable and the frequency tuning capability will be larger than the old one. The RF power of the new transmitter will be larger than the old one. The RF cavity will provide higher RF voltage for a sufficient Touschek lifetime of electron beam, the new RF cavity is under test now. A 29-period gap-variable NdFeB permanent magnet undulator as an insertion device is being designed and installed in ring. Its wavelength range will be 100 to 2000 Å. The brilliance is about 2 or 3 orders higher than that of bending magnet generated radiation. The undulator chamber is a quadratic welded chamber, the beam channel cross section is 80×24mm and its length is 2750 mm. The straight degree and the plane degree of the undulator vacuum chamber is 1 mm. The photon beam ports of the two new bending chambers were changed to 0 degree to provide the radiation from the injected devices. The photon beam port of Infrared and Far Infrared Spectroscopy has to be rebuilt to provide a much larger vertical acceptance and much near to the light source point. The all metal valves with RF shields have been installed at each end of RF cavity, division point of phase II and phase III and that of phase IV and injection chamber, to make the future vacuum system maintains and components installation easier.

PRESSURE CHARACTERISTICS AT PRESENT

In the last summer shutdown, all the new vacuum equipment had been installed and the vacuum system improvement except the RF cavity had been finished. During the installation period the whole storage ring vacuum system had been exposed to air for 45 days. After the vacuum chamber were connect and evacuate and whole system was baked out in 200ºC for 48 hrs by passing a large current through it, the lower static average ring pressure of 2×10-8Pa without beam had been get. Figure1 shows the distributed pressure in the beam orbit of the ring after improvement of the vacuum system. According to this picture the pressure distribution in the beam orbit is very small, due to the NEG pumps in the downstream of the bending chambers. So the improved vacuum system can provide the necessary vacuum environment for the high beam current, and its pumping speed with the NEG pumps is sufficient for the PHD disabsorb in the downstream of the bending chambers. The dynamic pressure has very important effects on the beam lifetime and it concern with the vacuum material’s PHD character and cumulative irradiation dose. So the dynamic pressure of NSRL storage ring will be affected by the new equipment modulating and long-term stabile operation.

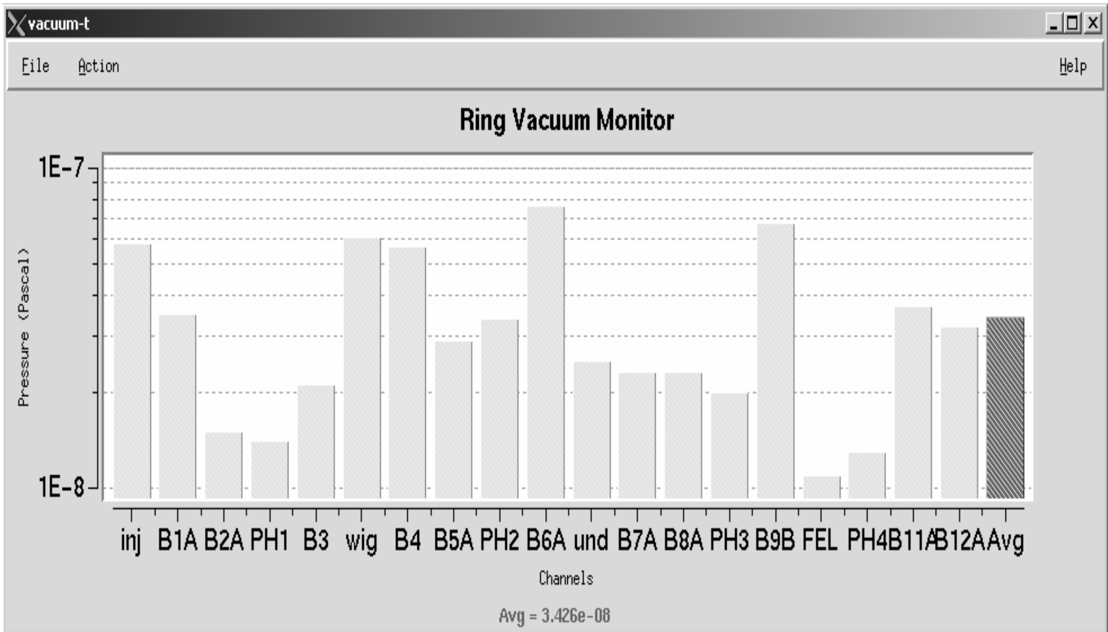

Fig.1: Display window of NSRL storage ring vacuum measure system

CONCLUSION

The improvement of NSRL storage ring vacuum system with RF shield oil pressured bellows chamber design has been proved to be successful by the low static vacuum pressure which is necessary to long-term reliability, stability and reliable operation. NEG pumps can pump the PHD gas effectively, and the four all metal gate valves with RF shields will benefit to the future maintain, new components installation and the system safety.

REFERENCES

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