Vacuum System

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1. Introduction

The vacuum system of the SPring-8 Storage Ring was described in previous Annual Reports of SPring-8 [1]-[3].

Beam commissioning of the Storage Ring was started in March 1997 and user operations were started in October 1997 [4][5]. The operation of the vacuum system shows a good feature, i.e., quick beam self-cleaning. The performance of the overall vacuum system is described elsewhere [6].

2. Photon Absorber and Vacuum Pump

The vacuum chamber materials of the Storage Ring are mainly aluminum alloys due to their low outgassing rates, high thermal conductivity, low radio activity, and so on. To achieve a long beam lifetime, the vacuum chamber with its pumping system should be designed so as to maintain the beam-on pressure on the order of 10^{-7} Pa or less with a circulating electron beam of 100 mA. As the main vacuum chambers are slot-isolated ante-chambers, most of the synchrotron radiation (SR) is intercepted by the photon absorbers of crotch and other absorbers placed just downstream and upstream of the bending magnets.

The total photon beam power from a bending magnet is 10.5 kW. About 6.6 kW (34 kW/cm^2) of the photon beam power is irradiated at the photon absorber of the crotch and the remaining beam power deposits at the other absorbers placed downstream of the crotch. The absorbers have structures that effectively trap particles such as reflected photons, photo-electrons, and SR-induced outgases.

The main pumping system is based on non-evaporable getter (NEG) strips which are used in the straight section chambers and bending magnet chambers. Concentrated pumping systems consisting of a lumped NEG pump (LNP) and a sputter ion pump are installed at the crotch and absorber location. SR-induced outgases are evacuated locally by the high-capacity pumping system before the outgases have a chance to bounce into the beam chamber.

3. Operation of Vacuum system

The averaged pressure readings of the Storage Ring are $\leq 1\times10^{-8}$ Pa without the stored beam, and 2×10^{-7} Pa at a beam current of approximately 20 mA. After continuous self-cleaning by the SR, the pressure rise due to the effect of photon induced desorption is significantly reduced. Figure 1 shows curves of the pressure per Ampere of the beam current (P/I) at various positions of the unit cell versus the accumulated beam dose. The value of P/I decreases by about two orders of magnitude after an accumulated beam dose of 29 Ah. This shows the beam self-cleaning effect on the absorbers and vacuum chambers.

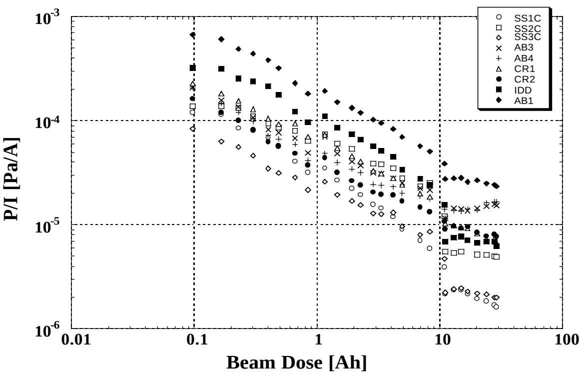


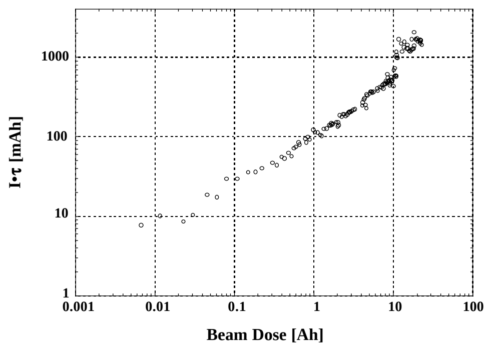
Fig. 1. Pressure per Ampere of the beam current versus the accumulated beam dose at various positions of the unit cell.

An accumulated beam dose of 29 Ah and a beam lifetime of approximately 100 hours at a current of ~20 mA were achieved by the end of 1997. Figure 2 shows the product of the beam current (I) and the beam lifetime (τ) versus the accumulated beam dose. The trend of the Iτ curve is determined by the scattering of the electron beam by the photo-desorbed gas resident in the ring vacuum system.

4. NEG Activation

Because of gas loading, the pressure in

Fig. 2. Product of beam current (I) and



beam lifetime (τ) versus the accumulated beam dose.

the vacuum chamber of the Storage Ring without the stored beam increased gradually to the order of 10^{-8} Pa by the summer shut-down period for maintenance. In this period, all of the NEG strips and LNP were re-activated at the temperature of 450℃ for approximately 60 minutes without chamber baking. During the NEG activation, mobile-type rough pumping systems which consists of a turbo molecular pump and a rotary pump were used. As a result, the ultimate pressure recovered was on the order of 10^{-8} to 10^{-9} Pa at most of vacuum chamber. The beam-on pressure was reduced by about one second, and then the beam lifetime rose. A beam lifetime of about 65 hours was achieved at the current of 19 mA after the summer shut-down period.

5. Miscellaneous

4.1. Vacuum Chamber with an Extraction Mirror of Visible SR

A vacuum chamber equipped with a mask absorber and a mirror to extract the visible component of SR for diagnosing the electron beam of the Storage Ring was designed and constructed. The vacuum chamber was installed in the photon extraction line of the No. 38 cell during the winter shut-down period.

X-ray components of SR from the bending magnet, which has high heat loads are absorbed into a water-cooled mask made of copper (OFHC-class 1). The mask has two openings located at the upper and lower parts of it. Visible SR passes through the two openings.

A water-cooled mirror made of OFHC is installed downstream of the mask and reflects visible SR to be extracted to the atmosphere through an optical window made of sapphire. The surface coating of the mirror is Al which has a thickness of 1 µm. The pumping system of the chamber consists of two sputter ion pumps and a titanium sublimation pump.

4.2. Temperature Monitoring of rf fingers on the inside of bellows

A special bellows chamber was constructed to monitor the temperatures of the rf fingers. It was installed in the straight section of the No. 4 cell of the Storage Ring during the winter shut-down period.

In the vacuum system of the Storage Ring, in order to reduce the rf impedance of the bellows, an rf bridge with CuBe sliding fingers is equipped inside of the bellows. The contact force of each sliding finger is >50g. In the case of a high beam current per bunch, such as single bunch or a few bunches operation, the generation of heat at the contact point on an rf sliding finger is concerned due to image currents of the inner wall of the vacuum chamber. Four thermocouples are attached on the rf fingers at the upper and side parts of an rf bridge. In a single bunch operation, the temperature rise of rf finger is measured.

References

[1] S. H. Be; Annual Report of SPring-8, 1994, p. 25.
[2] H. Ohkuma et. al; Annual Report of SPring-8, 1995, p. 20.
[3] H. Ohkuma et. al; Annual Report of SPring-8, 1996, p. 18.
[4] N. Kumagai; Journal of the Japanese Society for Synchrotron Radiation Research, pp. 74-76 (1997) in Japanese.
[5] H. Ohkuma et al.; Proceedings of the 11th Symposium on Accelerator Science and Technology, pp. 62-64 (1997).
[6] H. Ohkuma, et al.; Proceedings of the 11th Symposium on Accelerator Science and Technology, pp. 359-361 (1997).