Vacuum System

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1. Introduction

In 1995, the installation of the vacuum system of the Spring-8 storage ring in the storage ring tunnel has begun. And the final designs of injection section chamber and vacuum control system was completed. The mass production of the vacuum system has been proceeded with the program as arranged. The progress of the vacuum system is reviewed. The vacuum system of one unit cell [1] consists of three straight section chambers (SSC's), two bending magnet chambers (BMC's), two crotch chambers, one dummy chamber for future installation of an insertion device, and other components.

The supporting system of the straight section chamber can ensure the chamber displacement and deformation within the accuracy of 50μm and 30μm, respectively, or less at the positions of a beam position monitors (BPM's), even after repeated bake cycles.

The pumping system is based on non-evaporable getter (NEG) strips which are used in both SSC and BMC, lumped NEG pumps (LNP) which are concentrative pumps for SR-induced gas load, and sputter ion pumps (SIP). The BMC includes a rectangular pump channel in which a distributed ion pump (DIP) is installed.

Chamber components such as bellows, flanges and valves were designed so as to minimize their impedance. The bellows are shielded by RF slide fingers, and changes in the cross-section of the chambers are provided by means of tapered chamber having the angle less than five degree with the exception of special cases. The flanges and gate valves with RF contact are used.

2. Injection Section Chamber

The final design of the injection section chambers of the storage ring was completed. The injection section chamber consists of two parts, stainless steel chamber and aluminum alloy chamber. The aluminum alloy chamber are extrusions made of A6063-T5 and consists of a beam chamber and a slot-isolated antechamber in which a pair of NEG strips are installed. The stainless steel chamber is equipped with beryllium window for the injection of the electron beam pulse from the synchrotron. These two chambers are joined together by welding. The manufacturing of injection section chambers is in progress. Their installation of the will begin in October 1996.

3. Vacuum Control System

The vacuum control system consists of the VME system with remote-input-output devices (RIO) and the programmable logic controller (PLC). The VME-RIO system controls and monitors the vacuum apparatus such as vacuum pumps, vacuum gauges, vacuum valves and so on. The PLC system operates as an interlock system to protect the vacuum system of the storage ring against the vacuum trouble such as leak and deterioration of vacuum pressure.

The vacuum control system was designed and now is under construction. The system will be operated in November 1996.

4. Installation of the Vacuum System

4.1. BPM Calibration and Installation of DNP

Each of the 48 unit cells has 6 BPM's, giving a total of 288 BPM's. The BPM electrodes are welded directly to the straight section chambers, which are located at the quadrupole and sextupole magnet section. Prior to installation in the storage ring, BPM's were measured to find the difference between their mechanical and electrical centers, as well as their horizontal and vertical sensitivity in an area of 10 mm square by 1 mm step. This measurement was made in a clean room (class

100,00). A distributed NEG pump (DNP) were inserted into the pumping channel of the chamber after the BPM calibration in an adjoining clean room (class 10,000).

4.2. Pre-baking

Installation of the vacuum system into the SPring-8 storage ring began in July 1995. To remove chamber wraps --- caused by the construction process and welding --- the chambers were pre-baked at the temperature of 150°C in advance of the chamber installation in the storage ring tunnel. The pre-baking was done for the SSC's, BMC's and dummy chambers. Vacuum chambers are baked for about 20 hours at the maximum temperature of 150°C. The NEG pumps were activated during the pre-baking. Residual pressure after the pre-baking is in the order of 10^{-8} Pa or less. At present, the pre-baking rate is one cell per week.

4.3. *Installation in the Storage Ring Tunnel*

To avoid the interception of SR from the insertion device, the installation errors of photon absorber of the crotch and of the slot of the BMC must be less than 0.3 mm and 2 mm, respectively. The offsets of bellows in horizontal and vertical directions must be less than 1 mm since bellows assembly contains the RF slide fingers. Most of the crotches and the BMC's were installed with a required accuracy. For the longest SSC (5.7 m long), maximum installation error was about 2mm near the center of the chamber. The offsets of bellows in horizontal and vertical directions were less than 0.65 mm and 0.75 mm, respectively.

5. Vacuum performance

5.1. Baking Procedure at the Storage Ring Tunnel

After the installation of the vacuum system, the chambers were baked out in order to realize an ultra high vacuum condition. Super heated water which are pumped through the water channels of the vacuum chamber was used for baking. The baking temperature was kept at the maximum temperature of 145°C for 20 hours. The NEG strips and LNP were activated simultaneously for approximately 60 minutes at the last stage of baking procedure. Activation temperature was about 450°C. During the chamber baking and NEG activation, a movable type rough pumping system which consists of a turbo molecular pump and a rotary pump, was used.

Figure 1 shows the typical example of the baking temperature and pumping down curve of the vacuum system. The ultimate pressure was in the order of 10^{-8} to 10^{-9} Pa at most of the sections of the vacuum system.

5.2. Measurement of Displacement and Deformation of the Vacuum System

Since the button pickup electrodes of the BPM's are directly welded to extruded aluminum alloy chambers, the chamber deformation is one of the factors which limit the accuracy of the position measurement of the stored beam. Therefore after the installation of vacuum system in the storage ring tunnel, the displacement and the deformation due to the evacuation and baking were measured using dial indicators and depth gauges. Dial indicators were attached with magnetic base to magnet yoke of quadrupole and/or sextupole magnets as fixed reference points. After recording measured values at reference points,

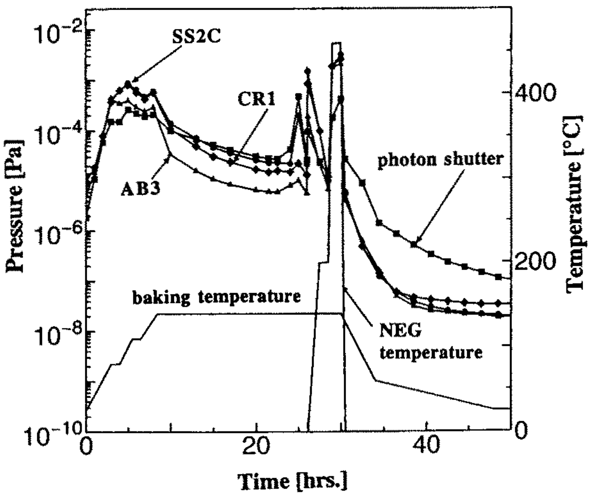

Fig. 1. Temperature and pump down curves of the vacuum system during baking at the Storage Ring tunnel.

vacuum chambers were evacuated from an atmospheric pressure using rough pumping systems. To suppress the effects of the chamber deformation at the BPM section, two reinforced blocks were mounted just beside the BPM in the SSC. A reinforced block of the SSC in the upper stream was fixed to a magnet girder. The chamber deformation at the BPM section due to evacuation of the SSC was less than 30μm, which was required for BPM. The position reproducibility at the BPM section due to baking was 15μm for horizontal direction and 55μm for vertical direction at the rigid support section.

The performance result were improved remarkably comparing with the the results of the assembly test for one unit cell performed in the test room last year [2], which was caused by good effects of the improvement for the chamber support system.

References

[1] H. Ohkuma, H. Saeki, H. Sakaue, K. Watanabe, Y. Wang, C.I. Xu and S.H. Be; Proc. of the 9th Meeting on Ultra High Vacuum Techniques for Accelerators and Storage Rings, KEK, Japan, 1994, p.29.

[2] H. Saeki, K. Watanabe, H.A. Sakaue, H. Ohkuma, M. Iizuka, S. Sato and S.H. Be; Spring-8 Annual Report, 1994, p.120.