VACUUM SYSTEM FOR SSRF STORAGE RING

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Abstract

A vacuum system for Shanghai Synchrotron Radiation Facility (SSRF) storage ring is operated at the end of 2007. Chambers are made of stainless steel (SS). Discrete photon absorbers locate on antechambers. RF shield bellows have a single finger structure. (SIP+NEG) combined pumps, SIP's and TSP's are used together. The pressure of 5×10^{-9}Pa in all chambers is reached after vacuum pretesting. The pressure of 2×10^{-8}Pa is reached in the ring after in situ baking the chambers in the straight sections and all pumps on the ring. The pressure of 1.3×10^{-7}Pa is corresponding to the current of 100mA, the energy of 2.5GeV and a lifetime of 16 hours after beam dose of 110Ah.

INTRODUCTION

The SSRF is a new third-generation light source with an energy of 3.5GeV, a current of 300mA and a circumference of 432m, being divided as 20 magnet cells.

The residual gas scattering beam lifetime must be 30 hours to ensure a beam lifetime of 10 hours for which an average pressure of 1nTorr in the beam channels of chambers is required. The chambers with antechambers are made of stainless steel (SS) 316LN. Discrete absorbers rank on antechambers to collimate the synchrotron radiation (SR) beams into front ends and to absorb all abandoned SR to ensure chamber safety. Lumped pumps are located near absorbers to be close to gas loads. The impedance of beam channels of chambers should be very small. The RF shield bellows with a single finger structure are adopted. 20 RF shield gate valves locate at both ends of 10 straight sections to form separate vacuum sections now, and more RF gate valves will be installed at both ends of all straight sections in future. In situ baking is not ready for the vacuum system due to high efficiency of photon cleaning effect for absorbers. A layout of the vacuum system in one cell is shown in Fig.1.

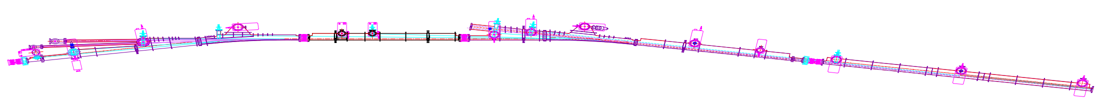

Figure 1: Layout of vacuum system in one cell.

VACUUM CHAMBERS

Vacuum chambers are made of sheet and boards of SS 316LN produced in Japan. The structure design and the thermal property of chambers are optimized using ANSYS. In order to satisfy design parameters of chambers, a manufacture process becomes very complex, many technical problems are solved with special tools and techniques after developing nine chamber prototypes. A big vacuum anneal furnace is built for chambers. More details about chambers are shown in a paper presented at EPAC'08[1].

PHOTON ABSORBERS

In order to ensure safety and thermal stability of chambers and to collimate SR beams into front ends, 172 discrete photon absorbers made of OFHC are located on antechambers. There are three kinds of absorbers, vertical, horizontal and special, as shown in Fig.2. There are 24 specifications of absorbers with different structures and dimensions. Total power radiated by 40 bend magnets is 435kW for a current of 300mA and an energy of 3.5GeV, the biggest power deposited on an absorber is 1128W. The absorber is split as two halves, a up piece and a down piece, which is like a comb [2]. Teeth of the up piece and the down piece do not contact each other, and can expand respectively when their temperature increases, so the stress inside this absorber is mitigated. Thermal analyses and mechanical analyses for 24 specifications of absorbers are done with ANSYS program, not only for a current of 300mA but for 400mA hoped in the future. The maximum temperature and stress at 400mA are 168°C and 70MPa for the horizontal absorbers, similar values are 295°C and 111MPa for the vertical absorbers respectively. The maximum temperature at boundary between cooling water and tube is 100°C. All absorbers will normally work at a current of 400mA.

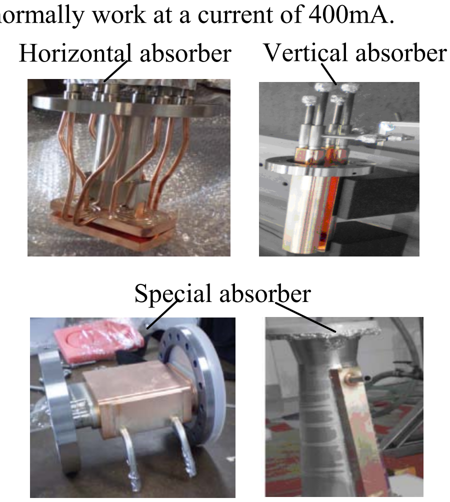

Figure 2: Three kinds of absorbers for SSRF.

RF SHIELD BELLOWS

There are two kinds of RF shield bellows, normal RF bellows and high precision BPM RF bellows (HP BPM bellows), as shown in Fig.3. Two sets of normal RF bellows connect long chamber segments in a magnet cell. Two sets of HP BPM bellows locate at both ends of a straight section. One set of HP BPM bellows consists of a BPM block and two short normal RF shied bellows, the BPM block hold a pair of BPM and sit down on a support made of invar material, two short RF shied bellows connect the BPM block and the adjacent chambers. A single finger shield structure avoids contact force and friction between double fingers, and allows larger offset more than 5mm.

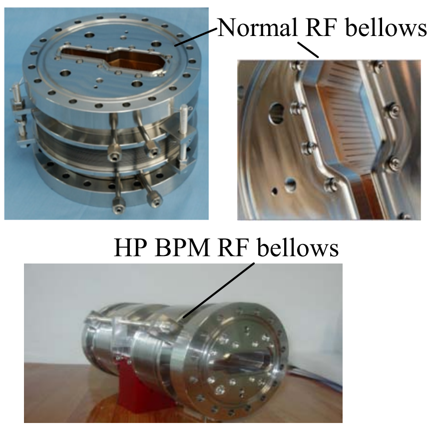

Figure 3:RF shield bellows for SSRF.

PUMPING

A gas load from photon induced desorption (PID) at a current of 300mA and an energy of 3.5GeV after a beam dose of 100Ah is about 1.3×10^{-2}Pa.l/s, a total effective pumping speed of 1×10^{5}l/s is necessary to get an average dynamic pressure of 1.3×10^{-7}Pa. (SIP+NEG) combined pumps, TSP's and triode SIP's are arranged, their total normal pumping speed is about 3×10^{5}l/s which will be able to cope with a current of 400mA in the future. Qualified and cheaper SIP's, TSP's and (SIP+NEG) are made in China.

One NEG module (WP1250) supplied by SAES is inserted into the cavity of SIP to form a (SIP+NEG) combined pump shown in Fig.4, it increases a ratio between pumping speed and volume, it is significant because spaces for SIP's are limited by magnets. (SIP+NEG) combined pumps integrate advantages of SIP and NEG and compensate their disadvantages each other, their ultimate pressure are 1.1×10^{-8}Pa and 7×10^{-10}Pa before and after activating NEG respectively, their pumping speed for CO after activating NEG is about 700l/s, being double of SIP[3]. Procedures about sublimating, activating, baking and rough pumping must be arranged reasonably and carefully to save the pumping capability of NEG's and TSP's.

One set of (SIP+NEG) combined pump and one set of TSP are together near an absorber, they both need a big AC current for activating NEG module or sublimating Ti wire, fortunately a current of 50A is together settle for them and can be used by turns. Then a new power supply for them is developed, it consists of two parts, a controller which is located outside the ring and a power supply which is near pumps, so staff can operate pumps easy and electric powers are saved by a thickset cable between the pump and the power supply.

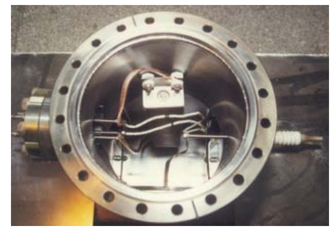

Figure 4: (SIP+NEG) combined pump.

VACUUM CONDITIONING AND MACHINE COMMISSIONING

A pressure of 5×10^{-9}Pa has been reached in all long chamber segments after vacuum pretesting. In order to speed up machine commissioning, vacuum chambers in straight sections and all pumps on the ring are baked in situ, and a pressure of 2×10^{-8}Pa in the ring is quickly reached. Residual gas components mainly are H2 (70%) and CO (13 %) and H2O (13%). We guess a pressure of 10-9Pa in the ring can be reached if all chambers in magnets are baked in situ also. It seems a degas effect during annealing in the vacuum furnace is obvious.

Fig.5 shows the relationship between beam lifetime, pressure and beam dose until 110A.h. A pressure of 5×10^{-8}Pa relatives to a current of 100mA and an energy of 2.5GeV and a lifetime of 16 hours after 110Ah. Fig.6 shows the relationship between PID coefficient η and beam dose until 110A.h, η is 2×10^{-4} mol/ph for beam does of 110A.h. Fig.7 shows a pressure distribution in a cell, the practical pressure is lower than calculated value.

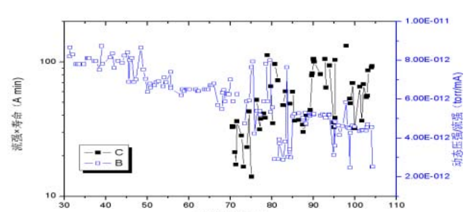

Figure 5: Relationship between I.t and Pav/I and A.h(0~110 A•h).

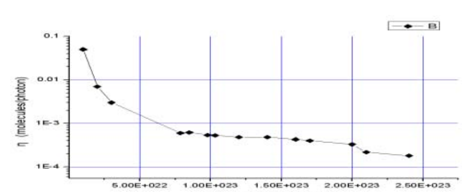

Figure 6: Relationship between η and dos.

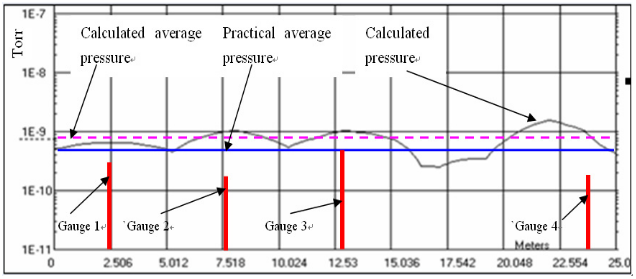

Figure 7: Pressure distribution at Cell.

The temperature rise of chambers is 1~2°C commonly, but it is about 8°C somewhere photons land, being reflected from some absorbers. The temperature rise of cooling water for all absorbers and Cu bars in BM chambers is less than 3°C that means chambers are safety.

ACKNOWLEDGMENT

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