The Vacuum System for Shanghai Synchrotron Radiation Facility (SSRF)*

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SSRF is the first third generation light source in China. The storage ring vacuum system will adopt SS 316LN chambers with antechambers and discrete absorbers. Several chamber models using SS 316L were developed. There are three types of absorbers. TSP and (SIP + NEG) combined pumps will be used. A model of (SIP 2001/s + NEG WP1250) was developed. The vacuum system in total cell will be pre-baked before installing, then in-site baking will not be adopted. RF shielded bellows containing a single finger shielding structure and the high precision BPM section have been designed.

1. Outline

Shanghai SYnchrotron Radiation Facility (SSRF) is the first third generation light source in China. Its energy is 3.5 GeV, current 300 mA, and circumference 432 m. About 62 beam lines (26 for synchrotron radiation from insertion devices and 36 for synchrotron radiation from bending magnets) will be connected to the ring, and 7 beam lines will be constructed at the first stage.

The main performance goal of the storage ring vacuum system is as follows: (1) to construct reasonable design and low impedance chambers, (2) to keep average pressure $< 1 \times 10^{-7}$ Pa for longer life time, (3) to draw out required SR beams and to absorb the rest SR to keep the safety of chambers and (4) to enhance the mechanical and heat stability of chambers. The general design was done and the collective layout of cell A is shown in Fig. 1.

2. Chamber

The SSRF storage ring will adopt stainless steel chambers with antechamber and discrete photon absorbers, photons will not irradiate chambers directly. Six short sections of the chambers in a cell are connected to the three longer sections where flanges and two DN150 RF bellows connect them. The array and structure of the absorbers are optimized to make the chamber structure narrower. We make the flange center eccentric to the center of the beam chambers to reduce the whole sizes of RF bellows and valves.

Stainless steel, aluminum and copper are suitable materials for medium energy machines. Stainless steel chambers are cheaper than that made of aluminum alloys and copper. Stainless steel 316LN is used for the cell chambers due to its higher yield strength and very low magnetic permeability after welding and forming. Beam position monitor blocks are connected to several short sections. The chamber profiles are manufactured by a deep-drawing die and laser or wire cutting of the outlines. TIG welding is used. Straight chambers in quadruple and hexa-pole magnets do not need to be cooled. The Cu shield in the BM chambers, absorbers, and RF bel-
lows can be cooled. Chambers must withstand for the synchrotron radiation BMSR emitted from the electron beam of 5 mA without interlock.

Stronger supports are fixed to the BPM blocks and flanges. Simple supports made of SS plates are fixed to the ribs welded on the chambers. These supports are suitable for lighter weight SS chambers. To keep the BPM position stable mechanically is a key. In order to avoid chamber vibration due to cooling water, its flow velocity is limited below 2 m/s, and smooth channel and suitable valves are adopted. The temperature of air in the ring tunnel and cooling water is kept at 20 ± 0.5°C.

3. Pumping

The required pressure in the duct is \(1.3 \times 10^{-9}\) mbar or less to get the beam lifetime of 10 hr or more. When we adopt top-up injection, the beam lifetime will be longer enough in practical meaning. Assuming \(\eta = 1 \times 10^{-6}\) mol./ph after 200 Ah operation, we estimate the total outgas \(Q_g\) of \(1.3 \times 10^{-4}\) mbar.l/s, thus the required total nominal pumping speed \(S_n\) is of \(3 \times 10^5\) l/s. A Sputter ion pump (SIP) combined with NEG can increase the ratio of pumping speed to pump volume and the pumping speed at low pressure. Titanium sublimation pumps are used near absorbers. Larger pumping speed is necessary when \(\beta y\) is larger and the geometrical gap of the chamber is narrow where the Coulomb scattering restricts the beam lifetime \(\tau_{cs}\) as \(\tau_{cs} \sim g_i^2/(P_i \beta y)\) and the suffix \(i\) corresponds to residual gas components. Movable units of a TMP and piston dry pump will be used.

The three longer chamber sections in a cell will be pre-baked, then they will be carried to the tunnel and installed in the final position keeping in vacuum. Finally they will be exposed to air and connected by bellows with RF shields. In-situ baking will not be adopted for the chambers in the cells, but the SIP will be baked. The vacuum duct can be irradiated by photons during the ring operation. As the photon dose is accumulated, the photon cleaning process proceeds. The photon dose effect is memorized on the duct. Pressure in such beam ducts can be recovered quickly, even if the chamber exposed to atmosphere.

4. Absorber

Absorbers can collimate photons to the SR beam lines. They can absorb most photons and avoid direct impact of photons on the chamber. Two kinds of absorbers are designed due to limited space, which are shown in Figs. 3 and 4.

The array and dimension of absorbers should be designed for the beam shift, chamber deformation and installation error, so the shadow overlap between the two neighboring absorbers is 10 mm. The absorbers are designed with the size of 10 mm in three direction. This design concept can give us margin of 8 mm between the duct wall and the edge of the SR beam. Some absorbers are inserted into the slit. Small angle of incidence SR can make it possible to use OFHC copper not Grid Cop. Design, which is suitable for 400 mA.
5. RF Shield Bellows with Single Fingers

The effort should be made to make the total impedance of the beam chambers less than 1 ohm. It is essential to control the impedance of every part. The inside wall of the beam chambers along the total ring should be smooth. The angle of the tapered transition pipes is <1/5. All step heights should be less than 0.5 mm to minimize HOM loss at not only the connecting flange but also the welding bead for duct components. The open aperture for the pumps and vacuum gauges on the beam chambers should be shielded. Generally pumps and gauges are not located on the beam chambers.

Bellows and gate valves with RF shields are used. A single finger type is applied to the RF shield, because it is helpful to reduce an accident caused by installation due to the larger geometrical offset of bellows. The contact force between a finger and the beam tube is (60±10) g/finger. High precision BPM section consists of RF bellows, BPM and Invar supports. It is necessary to measure the impedance of RF bellows before installation.

6. Progress

The main milestone of SSRF construction process is as follows:
- SSRF commissioning and test operation 08/1~90/4
- Vacuum system installation and test 07/7~07/12
- Manufacture of all vacuum chambers and pumps 06/6~07/6
- Manufacture of vacuum chamber in one cell 06/1~06/4
- Design review and making contracts 05/12

Now we have made several models of main vacuum parts as shown in Figs. 5–9.