THE VACUUM SYSTEM FOR THE SSRF STORAGE RING

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Abstract

SSRF is the first third generation light source in China. The storage ring vacuum system adopts SS316LN chambers with antechamber structure and discrete absorbers. Several chamber models using SS316L material were developed to confirm the fabrication technology. There are three types of absorber in the ring. TSP and SIP+NEG combined pumps are used for the system. The vacuum chambers with accessory components will be pre-baked before installation. RF shielded bellows with single finger structure have been designed and tested.

INTRODUCTION

The Shanghai Synchrotron Radiation Facility (SSRF) is the first third generation light source in China. The main part of the facility is a 3.5GeV, 300mA storage ring with a circumference of 432m. There are about 60 beam lines can be set to the ring and 7 beam lines are constructed at the first stage [1].

SYSTEM DESIGN

The main performance requirements for the storage ring vacuum system are as follows: (1) To keep the average pressure $<1\times10^{-7}$Pa for more than 10Hrs beam lifetime. (2) To design a reliable chamber with low impedance. (3) To extract the required SR beams and to absorb the rest part of the SR safely. (4) To enhance the mechanical stability for the chambers. The general design for the vacuum system was done under the detail consideration for all the above items. All the SR is stopped on discrete photon absorbers except to the beam lines. The photons will not irradiate the chamber inside wall directly. Large pumping speed pumps are located near the absorbers. There are 6 short section chambers in one cell. They are connected to 3 longer sections through 3 pairs of rectangular flanges with knife edge sealing structure. The 3 long chamber sections are connected by 2 DN150 RF shielded bellows. The location and structure of the absorbers are optimized to make the chamber narrow. The centre of the flange is designed offset to the centre of the beam channel in order to reduce the whole size of the bellows and valves. A standard cell vacuum chamber arrangement is shown in Fig.1.

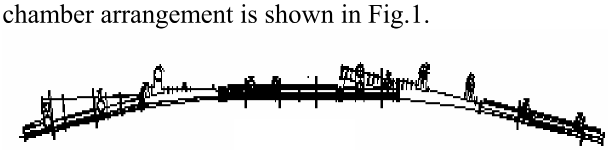

Figure 1: Layout of a standard cell

CHAMBER

The vacuum system for the storage ring adopts stainless steel chambers with antechamber structure. Stainless steel, aluminum and copper are all suitable materials for the medium energy storage ring. Stainless steel chambers are cheaper compared with the one made of aluminum alloys or copper. Stainless steel 316LN is used for the cell chambers in SSRF due to its higher yield strength and very low magnetic permeability after forming and welding. The beam position monitor blocks are used to connect short chamber sections by welding. The chamber pieces are formed by a deep-drawing die and cut by laser or wire cutting methods along the contour. TIG welding is used for the chamber. A section chamber is shown in Fig.2. There is no cooling channel design for the straight section of the chamber in quadruple and sextupole magnets region because of the space limited. The OFHC shielding bar inside of the chamber in dipole region, the absorbers, and the RF shielded bellows are designed with cooling water channel. All the chambers must withstand the power of synchrotron radiation emitted from dipole magnets up to 5mA without interlock operation.

To keep the BPM position stable is a key point for the support design. A stiff support is set to the BPM block as a fixed point for each chamber while other parts are supported on flexible SS plates. In order to avoid the chamber vibration generated by cooling water, smooth water channel and suitable valves are adopted and the flow velocity is limited below 2m/s in design.

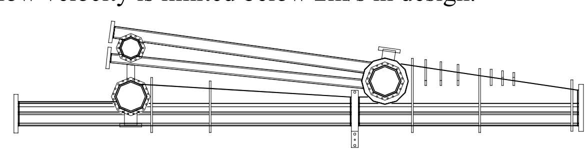

Figure 2: The section chamber structure

PUMPING SYSTEM

The required pressure in the storage ring is 1×10^{-7}Pa or less to get a beam lifetime of 10hrs or more. Assuming that the photon stimulated desorption coefficient $\eta=2\sim3\times10^{-6}$mol./ph. after 100Ah operation, the estimated total gas load is $Q=1.3\times10^{-2}$Pa.l/s. The required nominal pumping speed is about $2\sim3\times10^{5}$l/s in the ring. A sputter ion pump combined with NEG can increase the pumping speed at low pressure and the ratio of pumping speed to pump volume. Titanium sublimation pumps are used near absorbers for large gas load. The model for the combined pump has been tested and shown in Fig.3.Larger pumping speed is also necessary for the place where β_y is larger.

Movable units of TMP and piston dry pump will be used for start of the system.

The three chamber sections with its accessory components in one cell will be pre-baked before installation. They will be kept in vacuum condition while be carried to the tunnel and installed in their final location. The chambers will be vented to atmosphere pressure, connected by bellows and re-pumped as soon as possible because the in-situ bake out will not be performed for the chambers after installation. The vacuum chambers and absorbers will be scratched by photons during the beam cleaning period. As the beam cleaning effect can be memorized for the chamber surface, the pressure will be recovered quickly even if the system is exposed to atmosphere again during maintenance later.

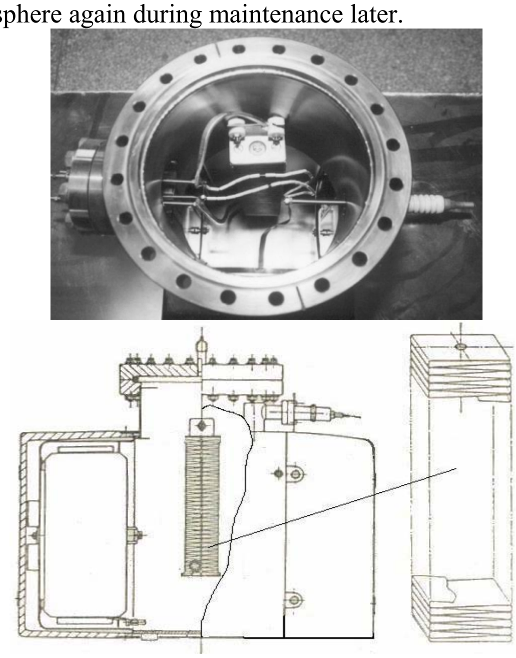

Figure 3: Model of a combined pump (SIP 200l/s+NEG WP1250)

ABSORBER

Absorbers are used to collimate the synchrotron radiation extracted to the beam lines and absorb the rest part of the photons to avoid direct impact of photons on the chamber. Two kinds of absorbers are designed due to the limited space in the ring, which are shown in Fig.4 and Fig.5.

Figure 4: Vertical absorber

Figure 5: Horizontal absorber

To decide the dimension of absorbers and array the absorbers in the ring, many issues should be considered in detail including the radiation fan in a cell, the electron beam orbit shift, the chamber fabrication tolerance and deformation, as well as the chamber installation error. The shadow overlap between two neighbouring absorbers is around 10mm for safety. The absorbers are arranged with margin of 8mm between the chamber wall and the edge of the SR fan to avoid the damage of chamber. Some absorbers are inserted into the slot between beam channel and pumping channel because of the limitation in space. The beam current 400mA is used in the design analysis for the absorber in order to keep margin for safe operation. OFHC copper material is selected for all the absorbers in the ring.

RF SHIELDED BELLOWS

Many efforts should be made to make the total impedance of the beam chambers along the ring less than 1ohm. It is essential to design every component carefully. The inside wall of the beam channel should be as smooth as possible. The tapered transition in the channel should be <1/5. All the step height such as the connecting flange, the welding bead and so on should be less than 0.5mm. Most of the pumps and the vacuum gauges are set on pumping channel. Shielded structure must be designed for the opening on beam channel at the place where the direct connection can not be avoided.

Bellows and gate valves with RF shielding are used in the ring. A single finger structure is applied to the bellows because of its larger offset capacity up to 5mm. Three kinds of inner shape are designed to fit the channel size of neighbouring components. Fig. 6 shows the first group of products for each type of the bellows just after fabrication and test. The contact force between the finger and the inner tube is 60g/finger. Bellows are designed in each side of the high precision BPM block to isolate the movement of the long chambers. The BPMs are fixed on Invar material supports to decrease the thermal influence to the BPM.

Figure 6: RF shield bellows

INSTALLATION TEST

The first products for chambers, absorbers and bellows have been tested after fabrication. All the design specifications are achieved. The vacuum components are installed with other system hardware together. The components engineering design have been confirmed in the installation. Fig.8 to Fig.10 show the chambers in installation.

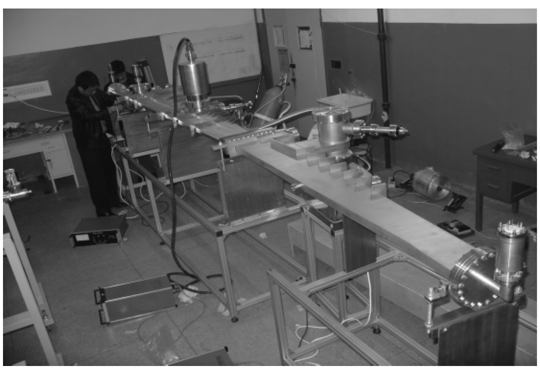

Figure 7: Vacuum test for the model of chambers

Figure 8: Suspend and install the chambers

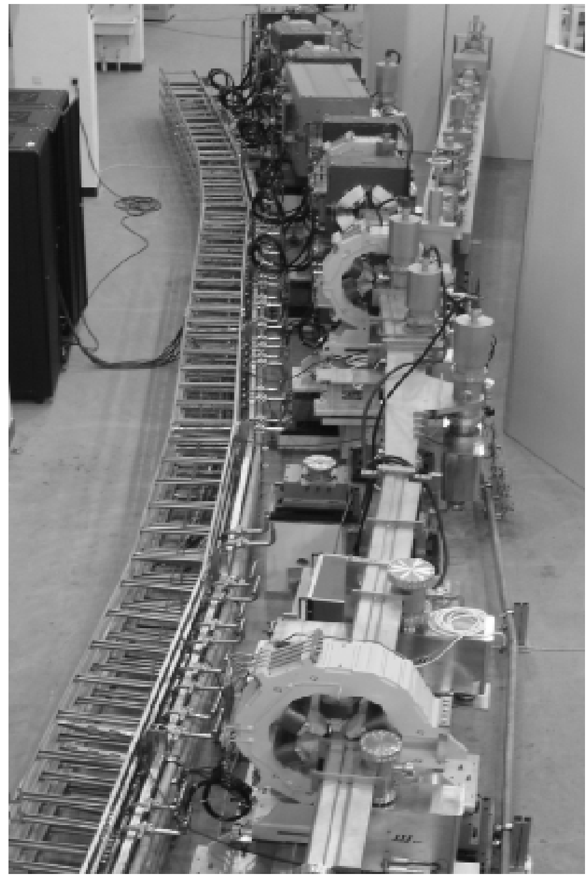

Figure 9: Chambers installed into magnets

SUMMARY

The engineering design for the SSRF vacuum system has been completed. The first products for each of the key components were fabricated and tested. All the specifications were achieved. The mass production for the hardware has been started and will be finished in this August.

REFERENCES

[1] Z.T.Zhao and H.J.Xu, et al, “Status of the Shanghai Synchrotron Radiation Facility”, PAC’05, p. 249