VACUUM SYSTEM DESIGN AND RESEARCH FOR THE SUPER SOR

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Abstract

The Super SOR is a third-generation VUV and soft X-ray light source that is being designed at the University of Tokyo. Eight insertion devices (ID) including a 27-m long undulator will be installed in the ring. Since the ring has a very narrow acceptance for beam loss by collision with residual gases, the vacuum system is required to achieve operation pressure of 10^{-9} Pa range in order to guarantee a long beam lifetime. According to the designed lattice, the pump location and pressure distribution was examined by a simple calculation. Beam chambers should be equipped with high pumping speed, especially in arc sections. The chambers for arc sections and insertion devices have been designed. Some vacuum components were manufactured for trial and examined.

1 PRESSURE AND BEAM LIFETIME

The beam lifetime of the ring is determined by the Touschek effect and pressure. Because ID chambers having a narrow aperture (16mm) will be installed in the section where the beta function is rather high (16m), the vacuum lifetime is very short. Figure 1 shows expected lifetimes in 1.0-GeV and 1.6-GeV operations as a function of the CO equivalent pressure. In order to guarantee a long beam lifetime, 1 Ah for example, the operating pressure of about 1×10^{-8} Pa is required in 1.0-GeV operation. A longer lifetime is expected in the 1.6-GeV operation because of the higher beam energy though the pressure increases approximately by 1.6 under same pumping condition. General description and machine parameters of the ring are given in this proceedings [1].

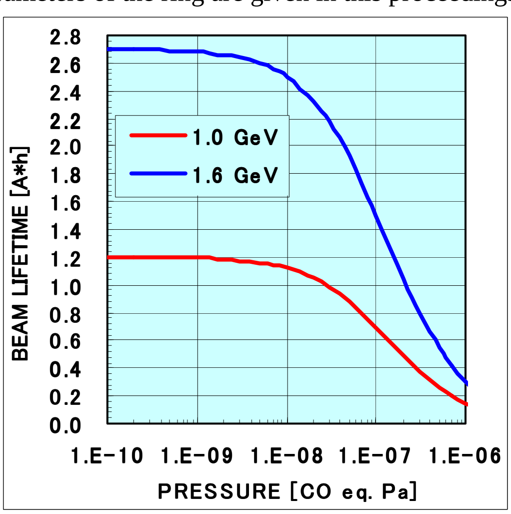

Figure 1: Expected beam lifetime in the Super SOR as a function of pressure.

2 PUMPING SPEED AND LOCATION

Dominant outgassing process in the ring is photon stimulated desorption (PSD). The pressure is principally determined by outgassing rate and pumping speed. To evacuate the gas efficiently and to achieve the required pressure, pumping speeds should be located according to the distribution of the incident photon flux on beam chamber wall. However, the pump space is restricted by magnet. The location of pumping speed and pressure distribution of the ring was examined and optimised by a simple calculation.

Figure 2 shows a typical example of a proposed distribution of the pumping speed with the designed lattice. In the calculation the beam chamber has uniform aperture of $\phi 60$ and the PSD yield is uniformly 1×10^{-6} molecules/photon. Additionally minimum outgassing rate is assumed as 1×10^{-9} Pa·m^3/s/m^2, which corresponds to the thermal outgas at the long straight sections suffer no serious photon-irradiation. The pumping speeds and their locations by which the required pressure can be obtained were searched against the magnet arrangement. As the result, every unit cell in the arc section should have the speed more than 1300 l/s. To obtain the high pumping speed we plan to make the pumping space in the quadrupole magnets. Also 250 l/s is located every 3 m in the long-straight sections and total pumping speed of 40000 l/s is needed in the proposal. Under above conditions the average pressure lower than 1×10^{-8} Pa is expected at 1.0 GeV-200 mA storage, from which the beam lifetime more than 5 h must be resulted.

3 DESIGN OF BEAM CHAMBERS

According to the magnet arrangement and required pumping speeds, beam chambers have been designed. Figure 3 shows a conceptual design of a beam chamber in a typical arc section. Aluminium alloy is used as main material and stainless steel is used for bellows. There is only one flange-connection a unit cell because beam position monitor, pumping port and bellows should be installed in the narrow space limited by many magnets. The length of the chamber is about 5.3 m. Main pumps are titanium sublimation pumps (TSP) and ion sputter pumps (SIP). Photon absorbers are installed just at the downstream of the bending magnet and first quadrupole magnet, and the pumping speed is concentrated in this region so that the outgas by PSD is efficiently pumped. The pumping space for TSP is made in the quadrupole magnet as well as in the bend chamber.

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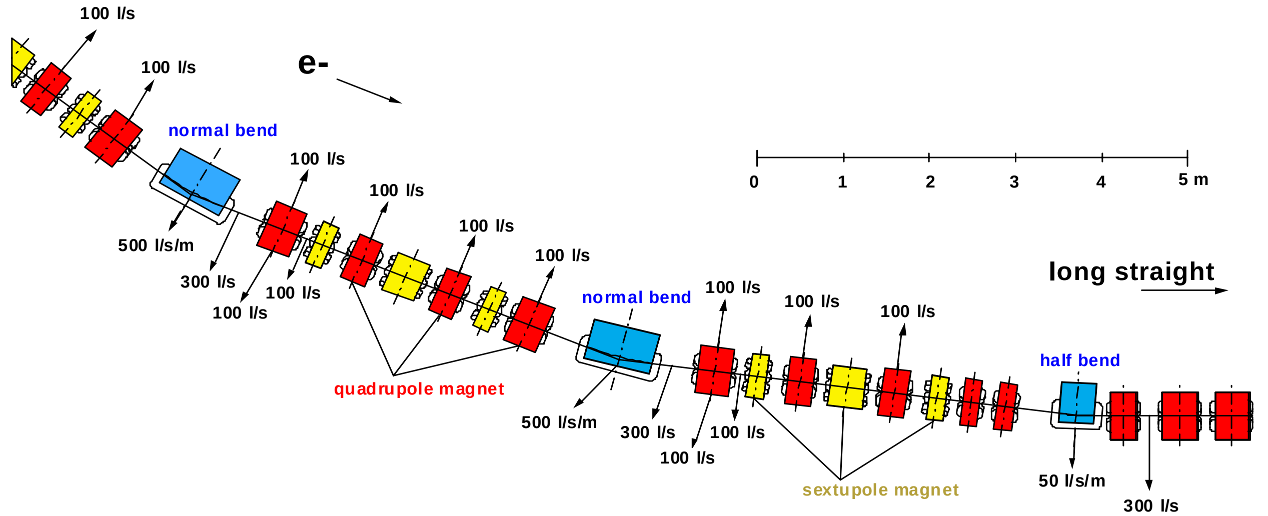

Figure 2: Magnet arrangement and a proposed pumping speed distribution. It is also planned to insert additional magnet between the bend magnet and its downstream quadrupole magnet (cf. Figure 3).

The bellows should have a slide-contact to maintain the uniformity of beam channel wall, which is usually used in the so-called RF shield. But the contact acts as a source of micro-dust more or less. The micro-dust generation depends upon not only surface roughness but also the combination of contact metals because some combinations have high surface energy that leads to the adhesive abrasion. The combination of stainless steel and CuBe(copper including 2% beryllium) was first used in a test shield. Then the generation of the dust increased, as the slide action is repeated, and the friction resistance also increased. In the second trial the silver plated CuBe was used to reduce the surface energy, and both the micro-dust generation and the friction resistance were successfully reduced. The surface energy of Fe-Cu combination is 3-4 times as large as that of Fe-Ag combination.

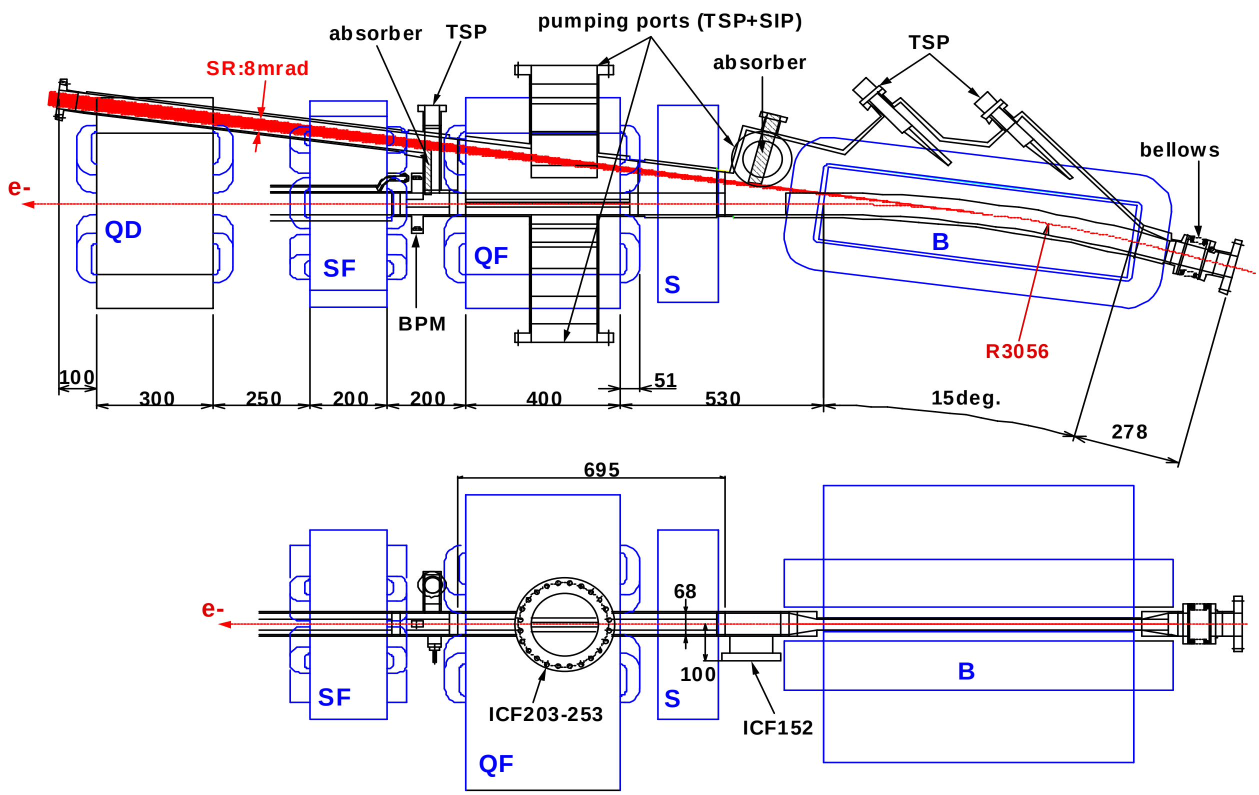

Figure 3: Conceptual design of a beam chamber in a normal cell.

Minimum gap of insertion devices is 20 mm except those of in-vacuum type ones, while the required vertical aperture of beam chamber is ± 8 mm in minimum. This means a long flat beam chamber with a thin wall is needed. Besides, the inner wall surface of such narrow beam channel must have a good conductivity to restraint the resistive wall instability [2]. We are planning to use copper-plated stainless steel as the chamber material. It is an urgent work for us to establish the fabrication method of such long beam chamber including Cu-plating and to examine the characteristics of the plated surface. Some research and designs for manufacturing of the chamber were undertaken. The characteristics and pumping behaviour of the plated surface has been examined by using test chambers and pieces.

4 PUMPING OF A TEST CHAMBER

Some test chambers were manufactured to examine the workability and the pumping characteristics. One of them is shown in Figure 4, which is a part of the normal-cell chamber installed in quadrupole and sextupole magnets (cf. Figure 3).

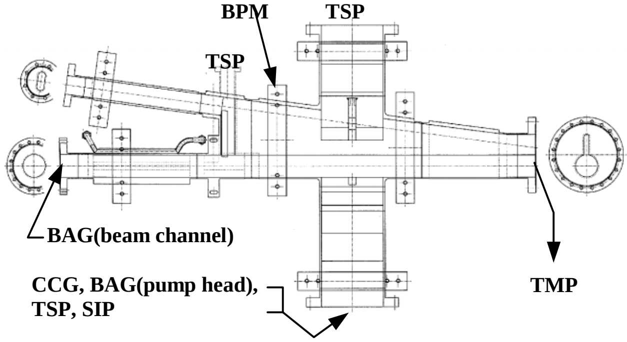

Figure 4: Pane of the test chamber.

A turbo-molecular pump (TMP) was used during rough-pumping, while three TSPs and an SIP were equipped as main pumps similarly as practice in the pumping test. The total pumping speed of the main pumps was estimated to be about 1000 l/s. After the 48h-baking at 120°C, the pressures at pump-head and far-side beam channel reached down to 8.6×10^{-9} and 4.5×10^{-8} Pa, respectively. The estimated outgassing rate was roughly 9×10^{-9} Pa·m^3/s/m^2. This value is acceptable as the preliminary result obtained in a short period, but it is considerably higher than the target value of 1×10^{-9} Pa·m^3/s/m^2.

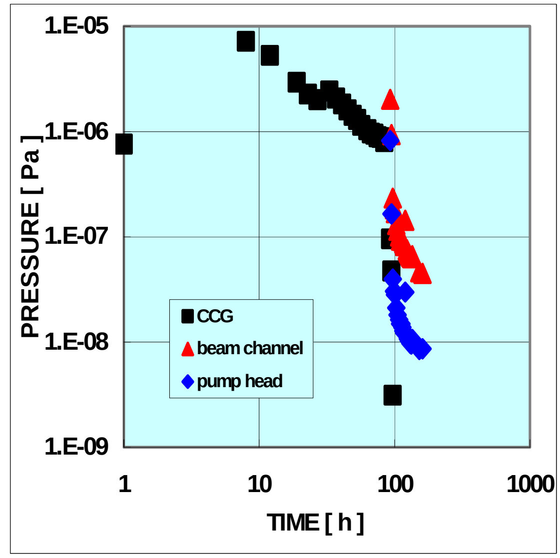

Figure 5: Pumping carve of the test chamber. Pressure was measured by a cold cathode gauge (CCG) during rough pumping and two ion gauges (BAG) after the baking.

5 SUMMARY

The vacuum system of the Super SOR has been designed. According to the designed lattice the pumping speed locations were optimised by a calculation of pressure distribution to achieve a required operating pressure of 1×10^{-8} Pa or low.

According to the proposed design some test chambers and bellows were manufactured to examine the workability and some vacuum characteristics. Sufficient results were obtained from preliminary tests.

6 REFERENCES

[1] K.Harada, M.Satoh, H.Takaki, T.Koseki, N.Nakamura and Y.Kamiya, “The Effects of the Insertion Devices at the Super SOR Light Source”, in this proceedings.

[2] M. Fujisawa, *et. al.* “Reduction in Resistive-Wall Impedance of Insertion Device Vacuum Chamber by Copper Coating”, EPAC’98, Stockholm, June 1998. (http://accelconf.web.cern.ch/AccelConf/)