

TPS VACUUM SYSTEM

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Abstract

The Taiwan Photon Source (TPS) vacuum system has been designed for a 3 GeV electron storage ring of 24DBA lattice, 518.4 m circumference, 24 unit cells and 24 long straight sections of 6 in 12 m and 18 in 7 m. The vacuum ducts for each cell made from thick aluminum plates and extruded aluminum beam pipes will be precisely machined and welded for obtaining a low impedance with small quantity of flanges and bellows. The beam ducts in long straight sections will be flat extruded aluminum pipes of 10 mm vertical height inside which will be ready for installation of the undulators without breaking the vacuum. The BPMs, 2 in each straight sections and 5 in each cells, will be fixed on the ground or on the girder rigidly through the strong supports maintaining a displacement of < 0.1 micron against the stress force of 10 kg from the beam ducts. The small aperture of 10 mm inside the aluminum bending chamber rejects the PSD outgas from the crotch absorbers backfilled to the beam channel, while the surface of bending chamber will be cleaned with ozonated water to reach lower thermal outgassing rate that maintains a much lower averaged pressure below 100 nPa inside the beam ducts.

INTRODUCTIONS

The design of the vacuum system for the electron storage ring of 3 GeV Taiwan Photon Source (TPS) adopts the concepts of oil-free machining and cleaning process for the aluminum chambers to achieve the lower surface outgassing rate after baking in the laboratory, precise dimensional control by machining and the least quantity of flanges to achieve the smooth structure of lowest impedance along the electron beam channels, pre-assembly and pre-baking for each cells in laboratory and installation of cells in-vacuum to the pre-aligned girders in the tunnel by carriers and overhead cranes [1, 2]. The prototypes of vacuum chambers and vacuum components for one cell, 1/24 arc-sections, are under manufacturing for the performance test. The status of the design and partial of the prototyping test for the TPS vacuum system will be described in the following sections.

LAYOUT OF DESIGN

The TPS vacuum system contains 24 unit cells and 24 long straight sections of 6 in 12 m and 18 in 7 m for matching the 24DBA lattice. Figure 1 depicts the layout drawings of typical vacuum system for two cells at downstream of 12 m long straight (LS) and 7m standard straight (SS) sections, respectively. Each cell contains 2

sector gate valves with RF contact shielding (SGV), 6 ionization gauges (IG), 10 non-evaporable getter (NEG) pumps, 8 sputtering ion pumps (IP), and 8 turbo-molecular pumps (TMP). The vacuum chambers inside the cell contain 2 short S-ducts of S3, S4, and 2 B-ducts of B1, B2. While the S1 and S2 S-ducts are on both ends of the cell isolated with the two SGVs.

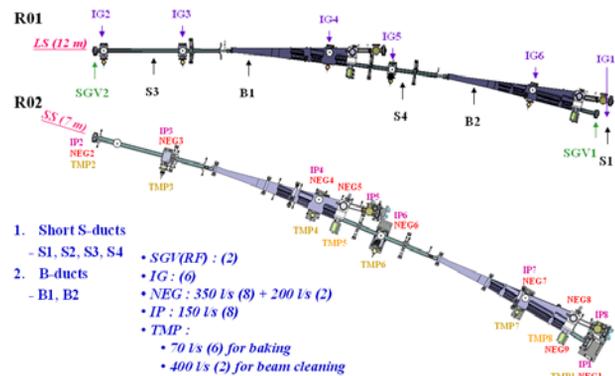


Figure 1: Layout of typical vacuum system for two cells at downstream of 12 m long straight (LS) and 7m standard straight (SS) sections, respectively.

The assembly drawing for B2-chamber, shown in fig. 2, depicts the locations of (a) crotch absorber, and (b) local pumps, fitting in limited space between the magnets that suits the feature of effective localized pumping near the dominant PSD-outgas regime.

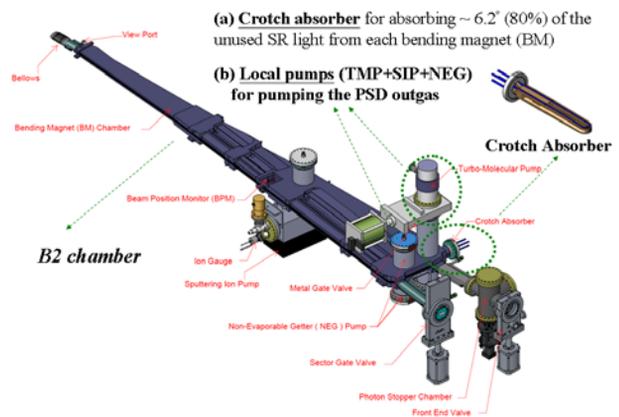


Figure 2: Assembly drawing of B2-chamber.

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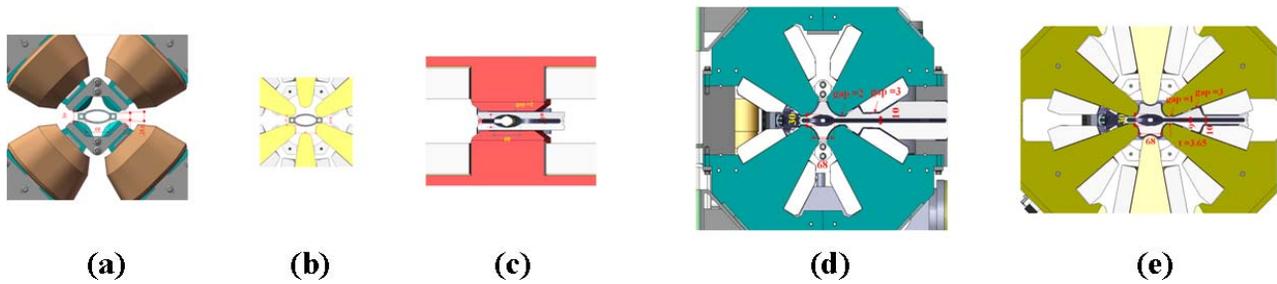


Figure 3: Cross section views of (a) S-duct in Q-magnet, (b) S-duct in S-magnet, (c) B-duct in D-magnet, (d) B-duct in Q-magnet, and (e) B-duct in S-magnet.

Fig. 3 illustrates the cross section views of S-duct and B-duct located in Dipole (D-) magnet, Q-magnet, as well as in S-magnet. The clearance between the ducts and the magnets is > 3 mm in general except some smaller clearances of 2 mm between B-duct and the poles of Q-magnet shown in fig. 3(d) and 1 mm for the S- and B-ducts closed to the poles of S-magnet shown in fig. 3(b) and 3(e). The parts of the aluminum beam ducts near the magnet poles should be machined precisely to allow the clearances enough for accommodating the tolerances from the assembly and the installation.

MANUFACTURING OF PROTOTYPE

Several prototypes of vacuum components for one cell especially the parts along the beam channel, contains the short S-ducts, B-ducts, Bellows, BPM, et al, have been manufactured for the functional test and pre-assembly. The status of the prototyping will be described in the following sections. In additions, the carrier for hanging the cell ~ 14 m in length has been designed and will be manufactured as well.

Short S-ducts

The short S-ducts, S3 and S4, for one cell are composed of the (a) flanges, (b) drift chambers, (c) BPM chambers, (d) pumping port chambers, and (e) Bellows, et al, as shown in fig. 4. The “black triangle” in fig. 4 represents the location of GTAW-welding for the components, made of aluminum alloys. The impedance of the components has been evaluated and acceptable during the design [3]. The aluminum flange on the duct is made of A2219T87 alloys with CrN coating on the knife edge and mounted with the aluminum RF bridge. The drift chambers, the pumping chambers, and the BPM chambers, are made of A6063T5 aluminum extrusion. The cooling water channels are extruded on both sides of the beam ducts. The pumping port chambers will be machined out the same cross section as the drift chamber on the body for inserting the drift chamber and then welding. The part of drift chamber inside the pumping chamber will be drilled many holes, 3 mm in diameter and 4 mm in depth, for pumping the gases out of the beam duct and shielding the HOM field.

B-ducts

The B-ducts, B1 and B2, are made of A6061T6 aluminum alloys. Each duct is composed of two half plates welded each other on peripheral. The two half plates, about 3.5 \sim 3.9 m in length and ~ 0.6 m in width, were machined by computer numerical control (CNC) sprayed with pure alcohol [1]. All the CNC machining works are proceeded in the dust controlled clean room with ambient temperature of $25 \pm 0.5^\circ\text{C}$ and relative humidity $< 50\%$. The overall flatness of half plate for B-ducts after machining is < 0.05 mm.

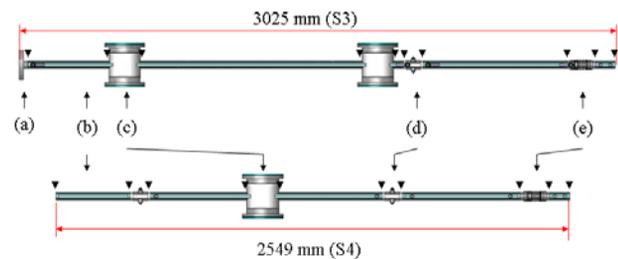


Figure 4: Assembly drawing of the S-ducts in one cell.

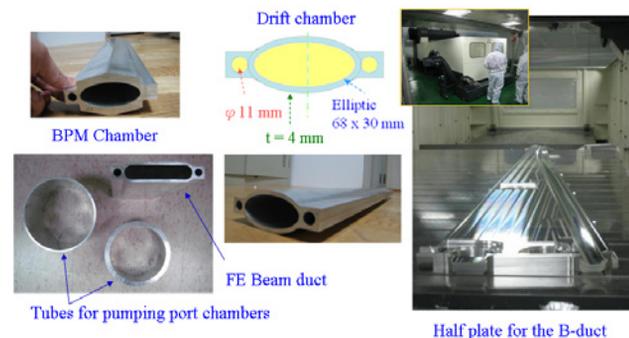


Figure 5: Prototype chambers for the S- and B-ducts.

BPM on B-ducts

Each B-duct is equipped with one BPM where the precise machining is performed to < 0.01 mm. A prototype stainless steel BPM flange block is precisely machined to accommodate two sets of the BPM feedthrough with button which is under welding test by

Nd-YAG laser beam. The button, 6.5 mm in diameter and 3 mm in depth, is welded to the SMA-R type feedthrough. And the two feedthrough with buttons are inserted into the BPM flange block, aligned with 6.7° perpendicular to the elliptical shape of B-duct and a distance of 17.5 mm between two buttons, and then welded to the block. The gap between the button and the flange block is 0.5 mm. The assembly of BPM flange block will be inserted to the B-duct sealed with helicoflex metal gasket after leakage test and the electrical measurement. Figure 6 depicts the (a) BPM assembly, (b) design drawing, (c) laser beam welding test, and (d) jig for fixing the button on the feedthrough before welding. The photograph of BPM assembly shown in fig. 6(a) presents the feedthroughs, one is under inserting and the other has been inserted on the position.

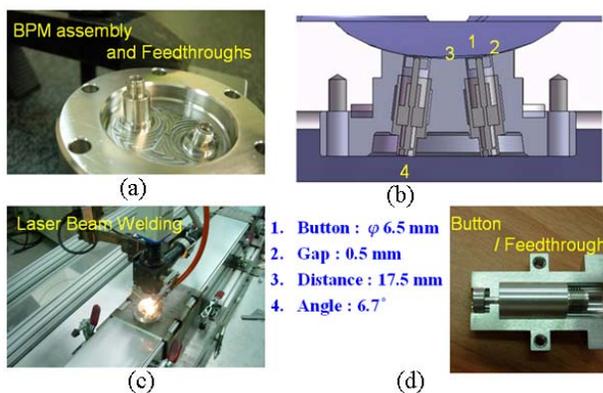


Figure 6: Prototype of BPM flange block for B-ducts.

CONCLUSIONS

The TPS vacuum system request the base pressure of $P < 1 \times 10^{-7}$ Pa which needs thermal outgassing rate $q < 1.3 \times 10^{-10}$ Pa·m/s, and the yield of PSD $\eta < 1 \times 10^{-6}$ molecules/photon. The prototypes of vacuum components for one cell are under manufacturing and testing. The aluminum chambers for the S-ducts have been extruded. The pumping chambers for the S-ducts have been extruded. The pumping chambers will be machined and welded to the drift chambers as well as the aluminum flange. Completely oil-free manufacturing process for the aluminum B-ducts includes the CNC machining in clean room reveals a good result of flatness control of the aluminum half plates, ~ 3.5 to 3.9 m in length, within 0.05

mm overall after machining. The following Ozonate water cleaning and the automatic GTAW welding in clean room will be proceeded soon. The preliminary test of machining and welding for the BPM assembly for the B-ducts has been done. The dimensional control of the BPM block accommodates the feedthrough and button is precise. The electrical capacitance for the BPM will be measured afterwards. Each cell in the arc-sections will be pre-aligned in the laboratory and completely welded to one piece. The pre-baking for the cells in the laboratory confirms the achievement of UHV without any problem prior to the installation. Each cell, vacuum sealed with two sector gate valves on both ends, will be moved to the tunnel hanging with the carriers and the overhead crane and installed on the girders for reducing any risky work and save the working hours in the tunnel while the reliability of whole system will be high as well. The assembly of one cell will be completed before end of 2009.

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