NEW INSERTION DEVICE VACUUM CHAMBERS AT THE ADVANCED PHOTON SOURCE *

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Abstract

Six new types of insertion device vacuum chambers have been designed at the Advanced Photon Source (APS). One chamber has been designed for the APS canted undulator beamlines, two for the Canadian Light Source (CLS), and three for BESSY II. For the double canted undulators and CLS, a new extrusion shape with an oval aperture (not elliptical as usual) was developed and extruded. That required a thorough stress analysis and some compromise, which included a small increase of the vacuum chamber wall thickness. The details of the stress analyses and design of the chambers, along with lessons learned, are presented.

INTRODUCTION

The APS at Argonne National Laboratory developed a number of special vacuum chambers for the insertion devices (ID) [1]. Similar vacuum chambers designed and fabricated at Argonne National Laboratory are in use also at the Berlin Synchrotron Radiation Source (BESSY-II), Swiss Light Source (SLS), and European Synchrotron Radiation Facility (ESRF). This report is about a new type of ID VC designed and manufactured recently for the APS, Canadian Light Source (CLS) and BESSY-II.

NEW EXTRUSION SHAPE

All previous ID VC had an elliptical aperture. The deflection under atmospheric pressure for such a shape, even with 1 mm wall thickness, is below 100 µm per wall. Nevertheless, from the accelerator physics point of view, such a shape is not ideal. Each injected particle traces a rectangular area in x-y space because x and y motions are independent. The elliptical chamber reduces the aperture required for injection because some particles are lost at the corners of the ellipse. A rectangular aperture with small radiuses at the corners makes a better fit to the particle trajectories.

Of course, the deflection of the wall for a VC with a rectangular aperture is more than for an elliptical one. To keep the deflection reasonably small, we have found a compromise after a number of iterations: the horizontal aperture of the chamber was slightly decreased from ±20 mm to ±18 mm and the wall thickness was increased from the standard 1 mm to 1.25 mm while maintaining the same outside dimension of the ID VC as before: 10 mm. The new shape of the vacuum chamber is shown in Fig. 1.

* Work supported by the U.S. Department of Energy under contract # W-31-109-Eng-38

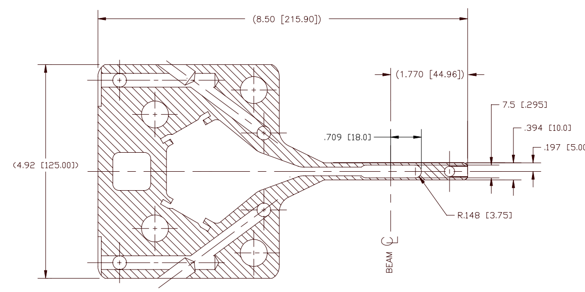

Fig 1: 7.5 mm vacuum chamber cross section.

Final results of the deflection calculation and stress analyses are shown in Fig. 2. The deflection at the location of the beam center is about 120 microns per side, and stresses are far away from the yield data.

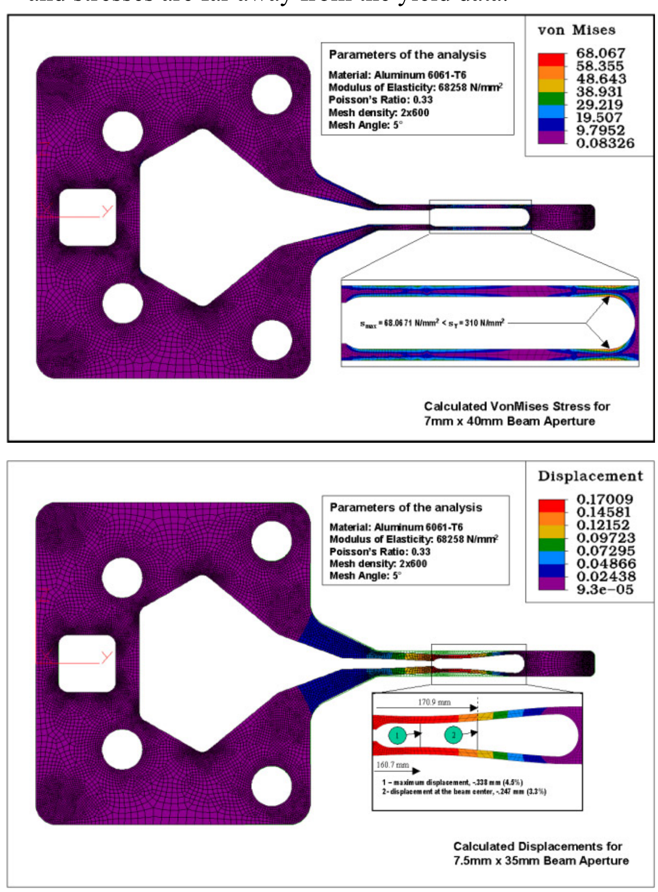

Figure 2: Stresses and deflection for 7.5 mm ID VC.

The extrusions of this new chamber were made, as usual, at Taber Metal, Russellville, Arkansas. Such a complicated extrusion shape, as always, is a puzzle, and this time it required 5 attempts. A uniform speed of the metal flow throughout the whole cross section must be achieved to yield a proper extrusion. Fig. 3 shows the extrusion cross sections after the second attempt and after the final attempt.

Figure 3: Extrusion cross section (left: second attempt, and right: final one).

DOUBLE-CANTED UNDULATOR VACUUM CHAMBERS

Three new sectors at the APS will be equipped with a new shape chamber, which will accommodate two undulators A and three dipole magnets [2]. From this straight section users can get two beams with a 1 mrad angular separation. The new VC will have the same length as usual (~5 m), but we added one additional set of beam position monitors (BPM) in the middle the of vacuum chamber to control the beam separation (Fig. 4).

Figure 4: Double-canted undulator vacuum chamber.

End boxes for the 7.5 mm VC have almost the same design as in the previous APS ID VC [3]. The design of the RF-transition cone and its cooling was simplified. Such changes were implemented for the first time in the design of the ID VC for the SLS and proved to be successful. During the design of this chamber, we have paid more attention to the smoothness of the RF-transition from the ID VC aperture to the standard accelerator vacuum chamber aperture (Fig. 5).

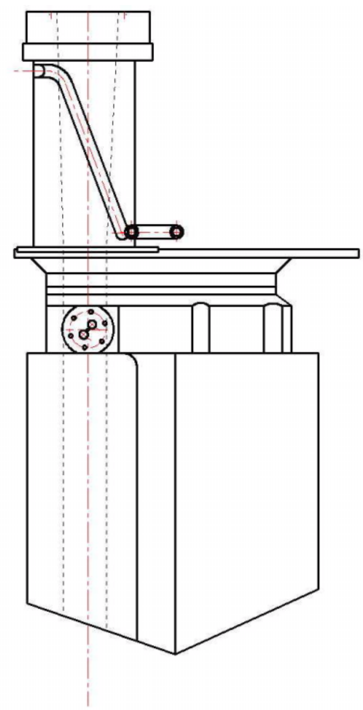

Figure 5: Smooth joint between vacuum chamber and end box.

Vacuum chambers for the same application will be used at the CLS with vertical apertures of 7.5 mm and 12 mm. The major difference in the design is that, for the CLS, two sets of BPMs were placed in the middle of the vacuum chamber. Also, the chamber length is shorter.

NEW VACUUM CHAMBERS FOR “BESSY-II”

Six new ID VCs are being manufactured now for BESSY-II: two standard ones, as APS has made previously and four short chambers with water cooling. The original 11 mm extrusion for BESSY-II had no provisions for the water cooling, so a gun-drilling procedure was used to place four cooling channels inside the body of the extrusion. One additional tube was welded to the flat plate and placed in a milled grove close to the VC aperture. Multiple screws and radiation-resistant thermal-conducting glue were used to enhance heat transfer. To avoid contamination of the chamber surface during the cleaning and certification, the glue applied only after final installation of the chamber in to the storage ring. One such chamber also has a laser channel welded to the downstream flange. The drawing of this chamber is shown in Fig.6.

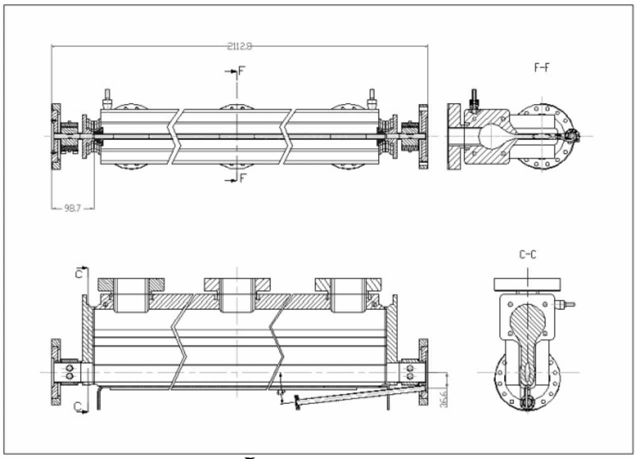

Figure 6: Vacuum chamber for BESSY-II with water cooling and laser channel.

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