VACUUM CHAMBER FOR AN UNDULATOR STRAIGHT SECTION*

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Abstract: A prototype aluminum extruded vacuum chamber for an undulator straight section of the Advanced Photon Source is described. The 5.2-m long vacuum system is designed so that the undulator gap variation does not interfere with it. The chamber is gripped in a stiff close toleranced mounting structure to insure dimensional tolerance of the chamber height.

Introduction

In the Advanced Photon Source (APS) proposed at Argonne, the first harmonic radiations from two interchangeable undulators in one straight section should provide a wide range of tunability in the hard x-ray regime of photon energy.[1] Since the undulator parameters are based on the permanent magnet blocks of $SmCo_5$ and Nd-Fe-B with permendur poles, the low limit of the tunable range depends significantly on the minimum gap of the undulator. The minimum gap of the APS undulator is to be 10 mm starting with a gap of 15 mm at the initial phase of the operation. The loss of tunable range due to the increase of the minimum gap of 1 mm starting from 10 mm, for example, is equivalent to approximately 0.3 GeV increase of the 7-GeV storage ring energy for the compensation of the loss of the tunable range.

The undulator is located outside of the vacuum chamber for the present design study of the APS. Therefore, the height of the chamber, which determines the minimum gap of the undulator, becomes a critical parameter to achieve the desired tunability of the photon energy.

To investigate the feasibility of the required minimum gap of 10 mm, a prototype aluminum vacuum chamber of this height has been developed. A comparatively large stiff stainless steel mount structure is designed to contain and constrain the chamber within close tolerances. The main concept of the design is such that the undulator gap variation be decoupled from the vacuum chamber during the operation of the storage ring. The goal of the chamber height tolerance is (10 ± 0.025) mm throughout the whole undulator straight section 5.2-m length.

Vacuum Chamber

The cross-sectional view of the vacuum chamber and its photo picture are shown in Figs. 1 and 2. The 5.2-m long chamber has an overall cross-sectional dimension of 84 m x 10 mm. The elliptical aperture of 50 mm x 8 mm for the positron beam of the storage ring allows the chamber wall thickness of 1 mm at the top and bottom of the aperture.

The geometry of the elliptical aperture is chosen to minimize the deflection of the top and bottom of the aperture. A finite element stress analysis shows that with a Young's Modulus of 70 GN/m^2 the deflection due to one atmospheric pressure at the 1-mm thick wall at the top and bottom of the aluminum chamber will be less than 0.035 mm. Anealing the

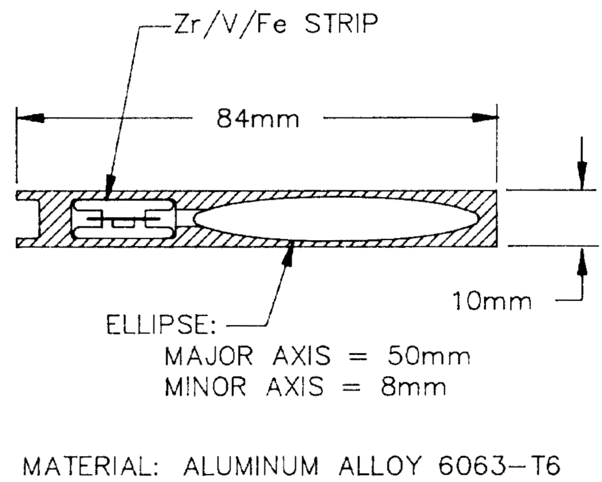

Fig. 1. Cross section of the vacuum chamber. The wall thickness at the top and bottom of the elliptical aperture is 1 mm.

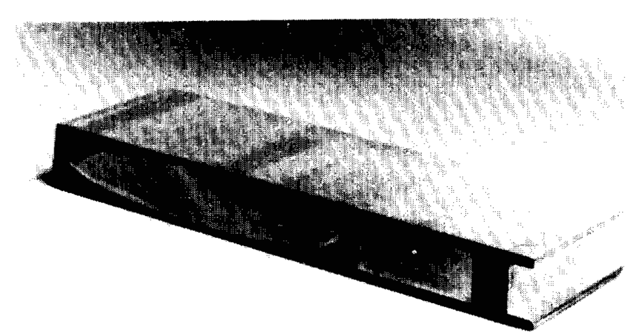

Fig. 2. Photograph of the aluminum-extruded vacuum chamber.

chamber to 150°C for outgassing will reduce the modulus only 5%. This will not increase the deflection more than 0.001 mm. The actual deflection measured for the delivered chamber shown in Fig. 1 at the 1-mm thickness was less than 0.003 mm at room temperature.

The antechamber has a dimension of 18 mm x 7 mm. To achieve the required vacuum pressure of 1 nTorr or better, a non-evaporable getter (NeG), which is a nonmagnetic strip coated with an alloy of Zr/V/Fe, is mounted inside the antechamber as shown in

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Fig. 1. Considering a possible photon desorption rate of 2.5×10^{-8} Torr•ℓ/s in the chamber, the 15-mm wide strips with ion pump assistance will reduce the chamber pressure to approximately 0.3 nTorr.

Vacuum Chamber Support Mount

The cross-section of the 5.2-m long chamber mount structure is shown in Fig. 3. The mount

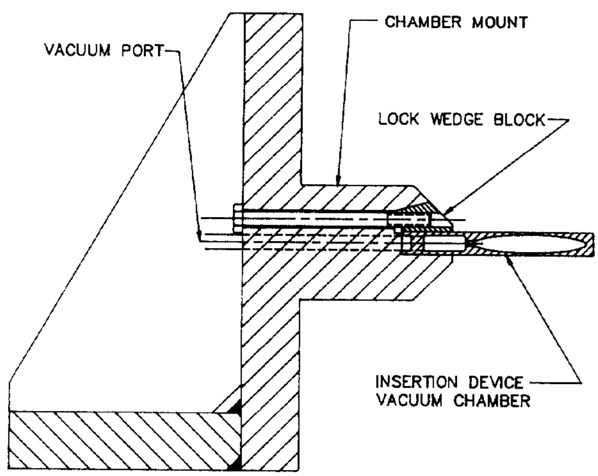

Fig. 3. Cross-sectional view of the vacuum chamber mounted in the chamber mount structure. The vacuum port slots and tightening screw rods are located at different places along the longitudinal direction of the chamber.

structure grips one end of the vacuum chamber rigidly by tightening the screw of the lock wedge block. The massive mount structure is designed to constrain the chamber straight to the dimensional tolerance of the mount structure itself.

Considering low conductance of the pumping in the longitudinal direction of the chamber, vacuum slots are located in every 0.3 m along the chamber for rough sorption pumping and the later stage ion pumping. The tightening screw rods for the lock wedge block are located between the vacuum slot paths in the mount structure.

The distance from the aperture center to the tip of the mount structure in Fig. 3 limits the half width of the undulator magnet blocks. The undulator support structure will be located from the opposite side of the vacuum chamber mount structure.

Conclusion

The support step for locating the vacuum chamber in place within the chamber mount structure of Fig. 3 will be fabricated to ±0.025-mm tolerance by a machine tool manufacturer. Inspection of the delivered 5.2-m long vacuum chamber clearly indicates that it will readily adhere to the tolerances of the chamber mount structure once it is securely clamped in place.

Reference

[1] J.P. Viccaro and G.K. Shenoy, "Undulator Tunability and Synchrotron Ring Energy," in these proceedings.