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Construction and Performance Test of UHV Mirror Chamber for SLRI

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Abstract - This paper reports the design, construction and vacuum test of the ultra high vacuum (UHV) chamber which is planed to be installed as a collimating mirror chamber for hard x-ray beamline at Synchrotron Light Research Institute (SLRI). The chamber has been box-shaped designed and can be opened both on top and bottom. The compatible material for a UHV chamber need to have the characteristic of a low out gassing rate. As material a stainless steel has been selected for the chamber while an aluminium wire and OFHC copper gasket was chosen for the sealing of the UHV system. The helium leak rate is less than 0.1 × 10-9 Torr.-Liter/sec. After baking at 150° C for a week the chamber can provide an UHV level at 1.4×10 -10 Torr. The design, fabrication, inspection and testing will be presented. In addition, the total costs which consist of the sum of the following costs: engineering design, raw materials, fabrication, inspection check and testing will be shown.

***Keywords*:** Ultra High Vacuum, Vacuum Chamber, Beamline Component

1. Introduction

The collimating mirror chamber was developed due to our requirements. A standard chamber from OEM was not suitable for our application. An OEM customized order chamber would be too expensive compared to an in-house fabrication of the chamber. The collimating mirror chamber requirements are the following:

- The chamber can support three branches of x-ray beams which are separated by front-end slits from the hard x-ray source (a high-field 2.4 T multipole wiggler) for the different beamline application [1]. Two branches of the entry beam are reflected and collimated by collimating mirrors (top and bottom mirror) and another branch can pass through the chamber.
- A vacuum which is better than 5x10-10 Torr is required for this purpose

The collimating mirror chamber is based on a basic vacuum design [2, 3]. The chamber is designed as rigid structure, enough to withstand the external atmospheric pressure to keep deflection within its limits for sealing and demountable joints.

2. Design, fabrication, inspection and testing

The vacuum chamber design is box-shaped with rectangular and circular demountable ports for entry and exit of the x-ray beam, cooling system, vacuum pumping ports and ports to access optics mounted inside the chamber. Design scopes are considered about the vacuum seal method, the external atmospheric pressure effect, an UHV compatible material and the strength of the material. The chamber was fabricated from stainless steel because it is a standard material for most vacuum components which provides a good UHV compatibility, mechanical strength and low costs [4]. The dimension of the chamber is (LxWxH) 1553 mm x 728 mm x 761 mm. A 3D chamber model and the dimension of the chamber are shown in figure 1.

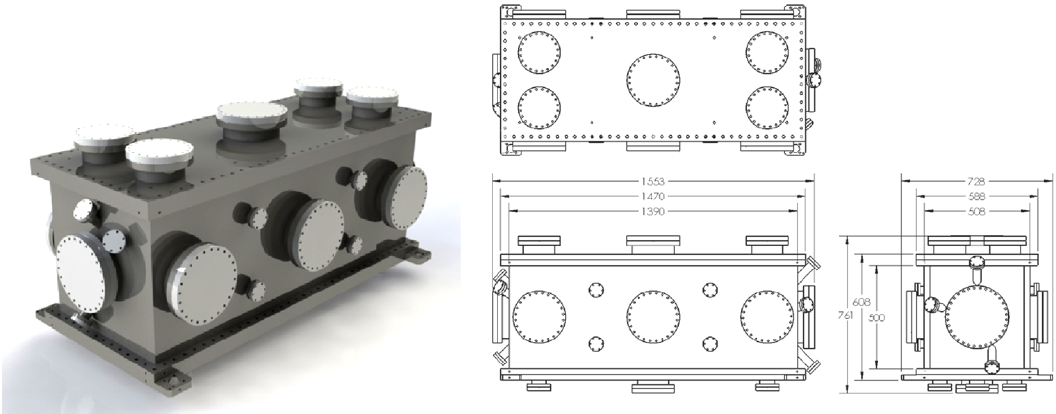

Fig. 1. 3D chamber model and dimension

Before the fabrication process started, the effect of external atmosphere pressure on the chamber was simulated by using the FEM software "ANSYS". The simulation results of deformation, stress and safety factor are shown in figure 2a, 2b and 2c respectively.

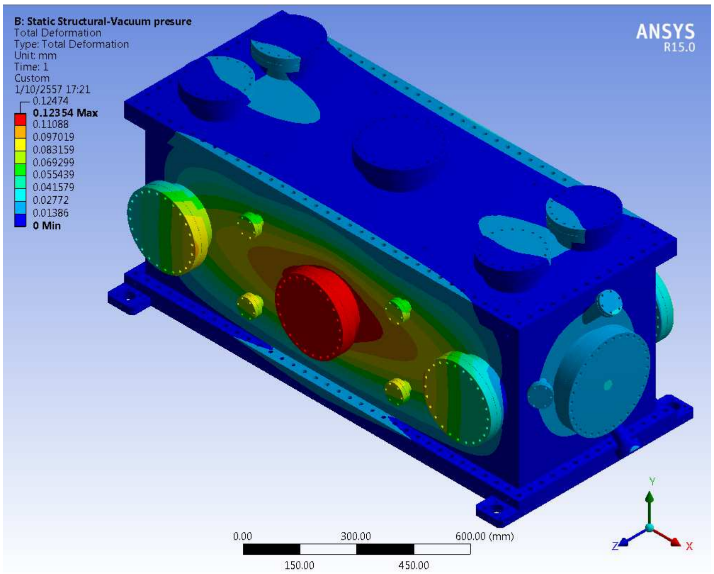

Fig. 2a. Chamber deformation from the external atmosphere pressure

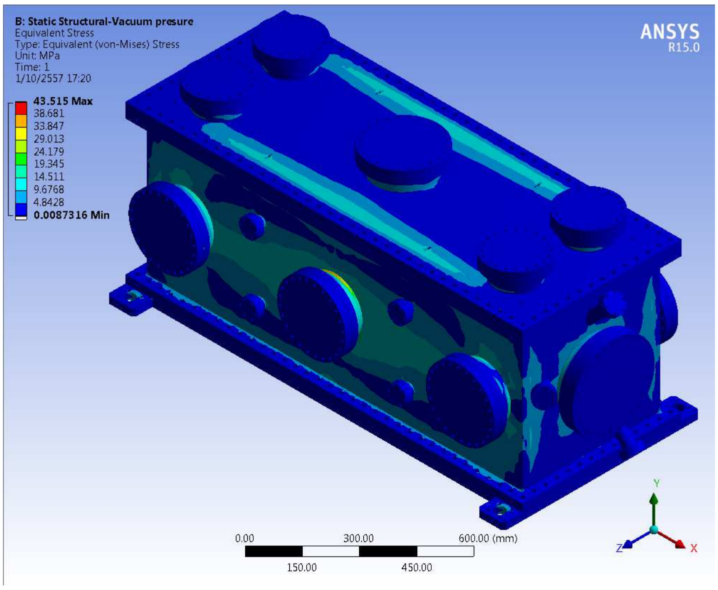

Fig. 2b. Stress on chamber from the external atmosphere pressure

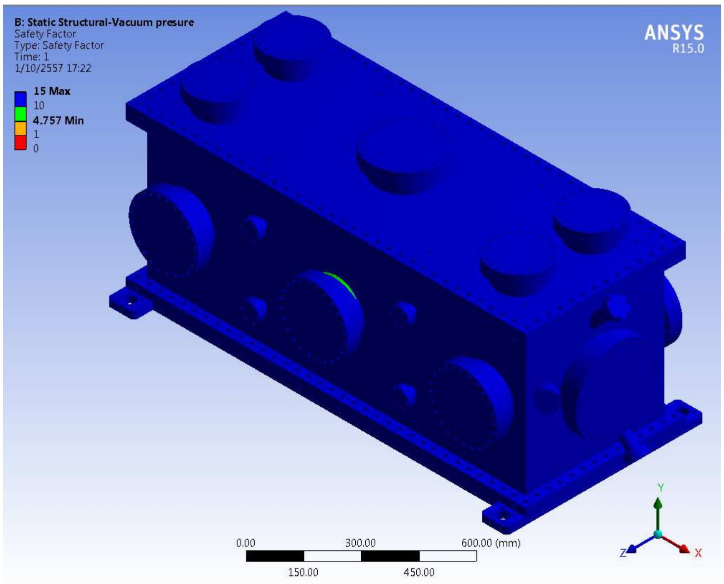

Fig. 2c. Safety factor on chamber from the external atmosphere pressure

The maximum deformation occurred on the left and right plates which have the largest areas so that the external atmospheric pressure will have more effect than on other sides.The stress analysis showed that the maximum occurring stress is lower than the yield stress of the material SUS 304 (215 Mpa). The safety factor (SF) in all areas of the chamber is larger than SF = 4, so the chamber design is strong enough to withstand the external atmospheric pressure at UHV level.

The chamber has two big cover plates on top and bottom which are vacuum sealed by a 99.99% pure aluminum wire. The Al wire vacuum seals on the sealing surfaces are shown in figure 3a and 3b.

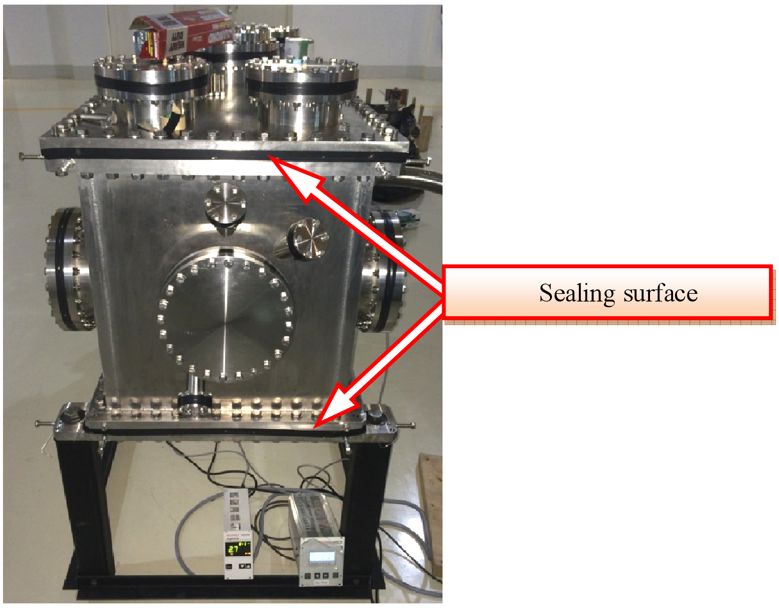

Fig. 3a. Sealing surface area on top and bottom cover plates

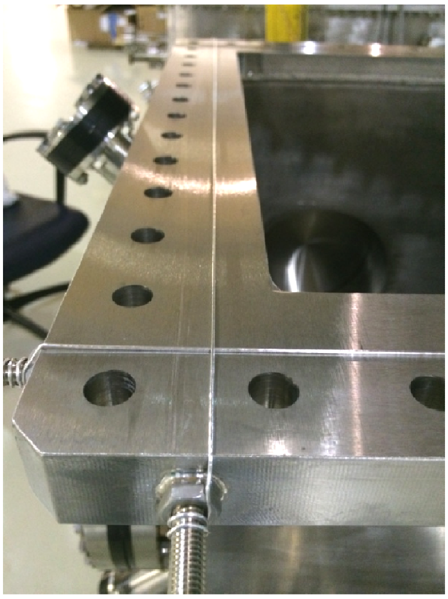

Fig. 3b. Sealing surface with 99.99% Purely aluminum wire

The sealing surface of the top and bottom cover plates had to be machined precisely considering the surface finish and the polishing direction. The surface finish is better than 1.6 µm with no scratches and dents on the sealing surfaces [5]. All other ports were designed as conflate flanges (CF-F) that use OFHC copper gaskets to seal UHV vacuum.

The parts of the chamber were machined on a CNC machine to achieve the desired tolerances. TIG welding was used to assemble the chamber and also used for a proper fixture to avoid distortion during welding. The chamber and other stainless steel parts were chemically and ultrasonically cleaned in order to reduce out-gassing [6].

After fabrication of the chamber was completed a portable CMM (coordinate measuring machine) with an accuracy of 20 µm was used to inspect the critical dimensions according to their tolerances.

For the vacuum pumping system setup, an ion pump (500 l/s), a turbo molecular pump (700 l/s) and a rough pump (250 l/s) were installed. A helium leak detector was used to check the leak rate to confirm the chamber was not leaking. The helium leak rate was less than 0.1 × 10-9 Torr.-Liter/sec. After baking at a temperature of 150 ˚C for one week to get rid of the water vapor, the chamber could provide an UHV level of 1.4×10-10 Torr (Fig. 4a and 4b).

Fig. 4a. Pumping system, helium leak test setup and baking system

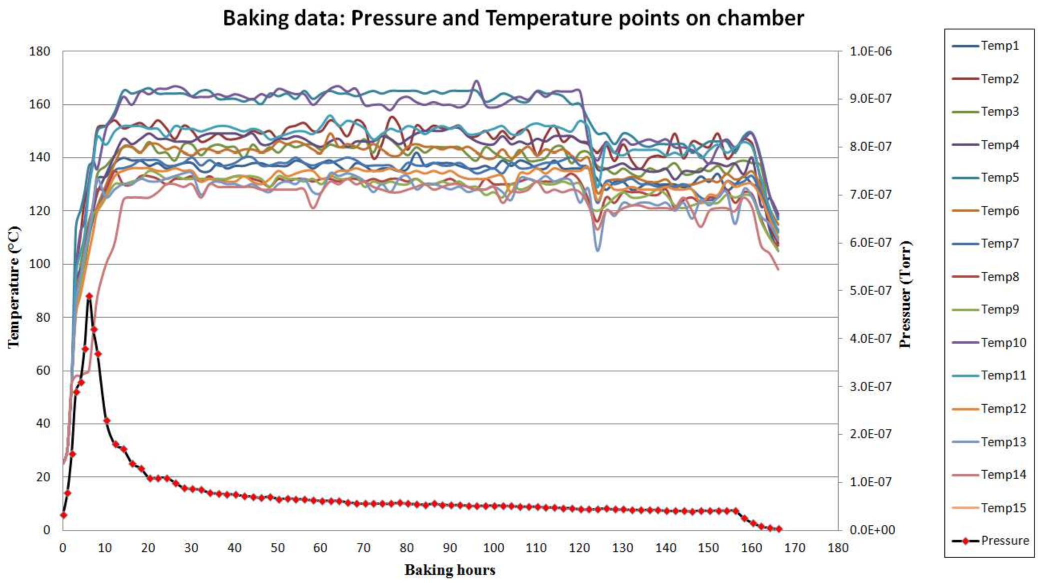

Fig. 4b. Baking data

3- Total costs

The total costs are considered from several terms which consist of the sum of the following cost; engineering design, raw materials, fabrication, inspection check, assembly and testing (Table 1).

Table. 1. Total estimated cost.

Item No.	Detailed cost	Estimated Cost (USD)
1	Engineering design and drawing	3,000
2	The raw materials	15,200
3	Fabrication	15,200
4	Inspection check	1,500
5	Assembly and Testing	3,000
	Total	37,900

4. Conclusion

The collimating mirror chamber is prepared for a mirror holder installation and the completed system will be installed at the front-end of a x-ray beam line. An ion pump (500 l/s) will be installed at the bottom side to keep the UHV vacuum. The collimating mirror chamber is a part of several vacuum chambers that were fabricated by SLRI in-house production and local companies in Thailand in order to save costs for ordering and importing of customized vacuum chambers. The production process of these chambers has been improved and developed continuously to increase quality, vacuum performance and support for any application.

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