DEVELOPMENT OF VACUUM COMPONENTS FOR XFEL/SPRING-8

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Abstract

Several new vacuum components have been developed for the XFEL/SPring-8 project. Vacuum waveguide flanges for C-band and S-band were successfully developed. These flanges provide both RF seal and vacuum seal. This seal mechanism can make vacuum seal even with a scratched gasket. New vacuum flange for accelerator beam line can use three types of gasket. A solid-lubricated clean bolt and nut were developed for C-band and S-band flanges to avoid organic dust pollution that induces RF discharge. A small RF contact for 28 mm inside diameter bellows was developed. This unfixed RF contact can move freely in all directions and displace large.

VACUUM SYSTEM

The target pressure of the XFEL is $1x10^{-6}$ Pa on beam operation. This pressure is required from the protection of RF discharge in the accelerator. The vacuum chamber of the accelerator of C-band and S-band are made of oxygen free copper and other chambers are made of stainless steel. The vacuum pumps in the accelerator section are sputter ion pump, and pumps in the undulator section are excel pump (ion pump) and NEG cartridge pump. This vacuum system does not need bake out. Main vacuum gauge is the cold cathode gauge (CCG). The CCGs are used for interlock system for its fast response (< 50 msec) to the pressure rise. This interlock is used to prevent the RF discharge in the accelerator.

VACUUM FLANGE

Vacuum waveguide flanges for C-band and S-band (named ADESY flange) were developed based on the flanges used in the DESY. These flanges provide both RF seal and vacuum seal. The vacuum seal edge and the gasket of the ADESY flange have a round corner (Fig 1). The material and properties of the gasket is the same as the gasket for conflat flange. The vacuum seal design of the ADESY flange is shown in figure 2. The step edges compress the gasket to make plastic flow at the outside corner of the edge (vacuum seal point in Fig.2). This compression also makes an expansion of the gasket to the outside. The reaction force from the outside rim to the seal edge stabilizes the vacuum seal. The plastic flow at the edge corner introduced by large compression force plugs scratches on the gasket and make complete vacuum seal.

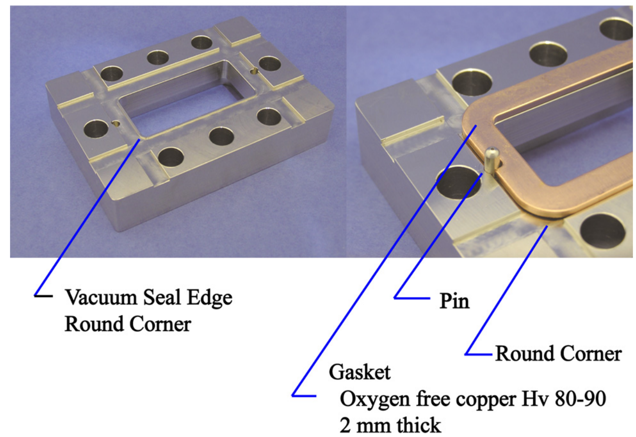

Figure 1: ADESY flange.

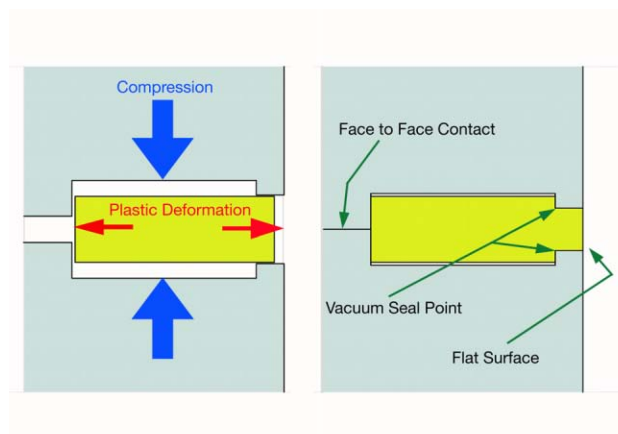

Figure 2: Vacuum seal design of the ADESY flange.

Figure 3 shows the experiment of vacuum seal mechanism. A 160 micro m depth of the V-shaped cut was machined on the gasket. After fastened the flange, the V-shaped cut was shrinked and plugged at the corner of the seal edge by the copper plastic flow.

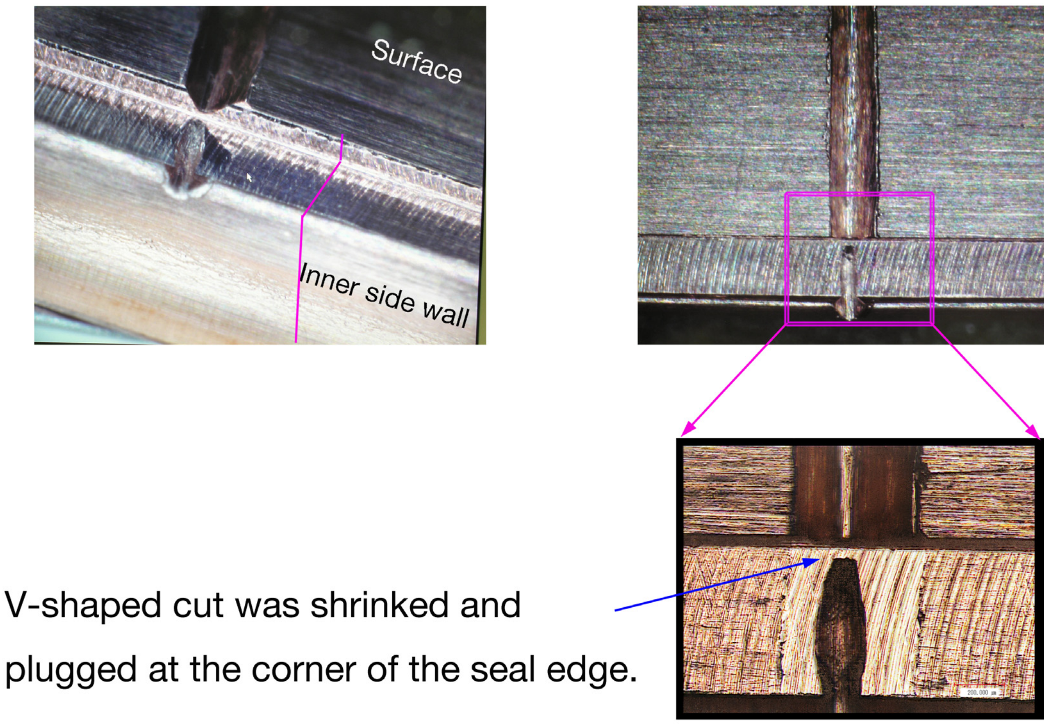

Figure 3: After the ADESY flanges were fasten, a 160 micro m depth of V-shaped cut machined on the gasket was shrinked and plugged by the plastic flow of the copper.

Another type of a ADESY flange for accelerator beam line, named Hybrid flange, was also developed (Fig 4). The hybrid flange has two vacuum seal edges, the ADESY flange type and the conflat flange type for backup. The hybrid flange can use three types of gasket, the ADESY, the conflat and the IPD.

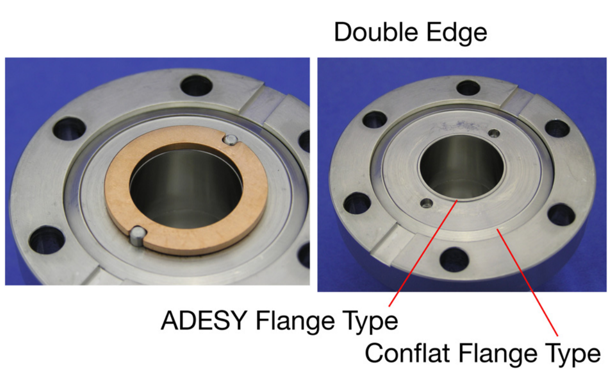

Figure 4: Hybrid flange.

SOLID LUBRICATED BOLTS AND NUTS

The bolts and nuts for the ADESY flanges required lubricity and cleanness. The organic lubricant paste like a MoS_2 often pollute the vacuum duct and become the source of outgases to make RF discharge.

Several solid lubricant coatings on the bolts and nuts were tested. Figure 5 shows the relations between torque and axial force of the coated bolts and nuts. The DLC (Diamond-Like Carbon) coated bolts and coated nuts showed same ability as MoS_2 pastes. Other coatings showed low axial forces that made fastening the flange difficult.

Typical characteristics of the DLC are (1) high hardness; Hv=1000-3000, (2) low friction; 0.15, (3) gas barrier.

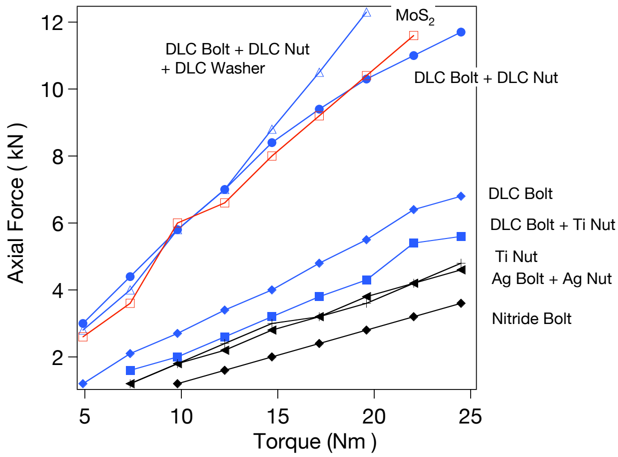

Figure 5: Torque and axial force of the bolt sand nuts.

CONPACT RF-SHIELDED BELLOWS

To realize the compact XFEL, the length of vacuum components should be short. The design of bellows structure requires small thin flange, short bellows, small diameter of the bellows to be able to insert the bolts from the bellows side. These structures regulate the RF contact size and we gave up the one side fixed contact finger type that often adopted accelerator bellows. Fortunately, the wall current of our XFEL is small and heat problem is not serious. For this reason, new type of RF contact was developed (Fig.6.). This RF contact has no fixed side and move freely to all direction and angle to realize big displacement (Fig.7.).

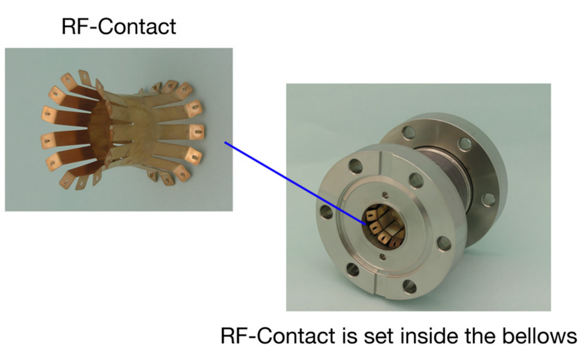

Figure 6: RF contact and bellows.

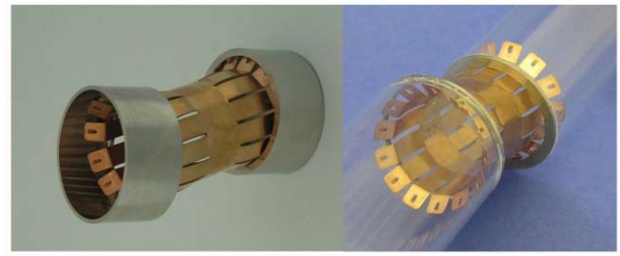

Figure 7: Displacement of RF contact.

IN-VACUUM UNDULATOR

The in-vacuum undulator developed in SPring-8 was adopted to reach shorter wavelength with a shorter magnetic period. This undulator enables to reduce the electron energy and leads to contain the total cost of construction. The biggest problem to realize the in-vacuum undulator was the outgas from the permanent magnets. A 3300 magnets are in a undulator. To reduce the outgas, a 5 micron m TiN coating was made on the surface of the magnets (Fig.8).

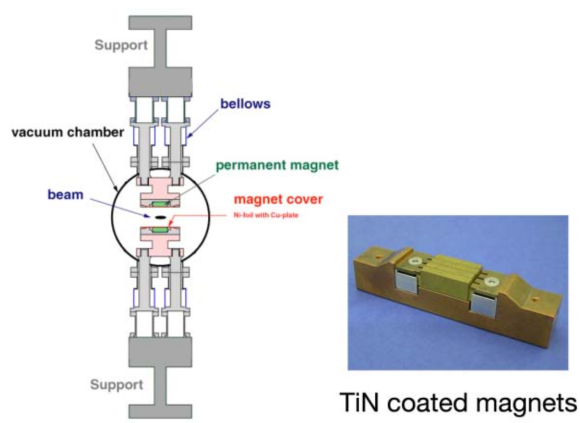

Figure 8: In-vacuum undulator and TiN coated magnets.