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NEW ALL ALUMINUM ALLOY VACUUM SYSTEM for the TRISTAN e^+e^- storage accelerator

Hajime Ishimaru, Gen'ichi Horikoshi and Yoshitaka Kimura

National Laboratory for High Energy Physics
Oho-machi, Tsukuba-gun, Ibaraki-ken, 305, JAPAN

Summary

A new all aluminum alloy vacuum system for TRISTAN e^+e^- storage accelerator[1] is described. The system[2] is designed to satify such conditions as high reliability, simplicity, low residual radioactivity, impedance matching, low space factor, light weight, standerdization of the components and low cost. Aluminum alloy is chosen to be as material of the vacuum system.[3,4] The construction of the accumulator ring starts from April 1981.

Introduction

Bakeout temperature of the aluminum alloy system is limited to approximately 150°C. If ordinary stainless steel components applied to almost aluminum system, effective bakeout for stainless steel is prevented by the previous temperature. Then ultimate pressure is limited by outgassing of the stainless steel. The ordinary stainless steel system and the stainless steel-aluminum transition are eliminated as much as possible.

Beam Channel

Aluminum alloy is preferred to stainless steel because of its good thermal conductivity, low residual radioactivity, low outgassing rate after bake out, easiness of manufacturing complicated profile by extrusion, low material cost, and so on. The aluminum alloy [6063-T6] vacuum chamber in the dipole magnet is designed to accomodate the beam clearence region required and to allow an automatic welding between the chamber and a racetrack type bellows as shown in Fig. 1. The vacuum chamber requires a complicated profile with a distributed pump, cooling and heating structures. The vacuum chambers straight sections are shown in Fig. 2.

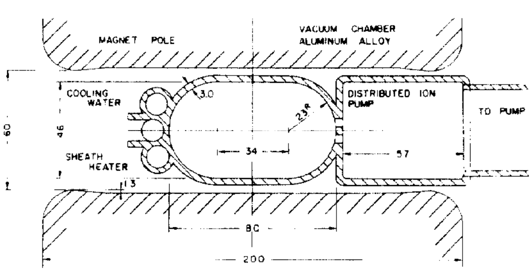

Fig. 1 Aluminum alloy vacuum chamber of the dipole magnets. [D-chamber].

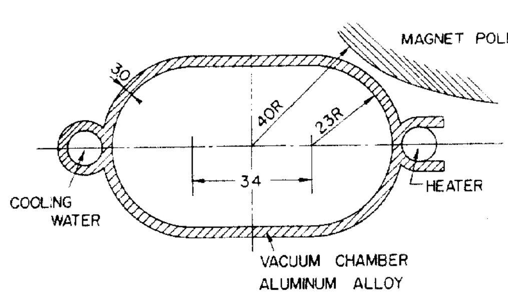

FIg. 2 Vacuum chamber of the quadrupole magnet.

The thickness of both chamber is 3 mm. The dipole chamber has two cooling channels. The fabrication of the extraction channel for the synchrotron light is easy with holding two cooling channels. Uniform cooling along the beam is obtained by opposit two streams. Thermal load of the dipoel chamber due to the synchrotron light is less than that of the quadrupole chamber. At the RF sections and the experimental regions, the aluminum alloy [6063-T6] normal pipes are used. Tapered vacuum chambers are inserted between the racetrack chamber [D and Q] and circular pipes for smooth wall current flowing. All aluminum alloy cooling is adopted. It is resistant to the corrosion of the beam channel.

Septum Chamber

The vacuum chamber for the septum magnet is fabricated from the dipole chamber and the quadrupole chamber as shown in Fig. 3. Thickness of the wall of the septum side is 1 mm. The window of the injection is the beryllium foil whose thickness is 0.1 mm.

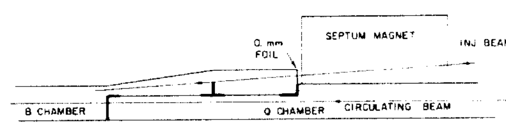

Fig. 3 Vacuum chamber of the septum magnet.

Bellows

To absorb mechanical telerances, misalignments of the components and the thermal expansion due to the bakeout procedure, a bellows between these aluminum vacuum chambers is required. Aluminum alloy [5052-0] seamless bellows of racetrack shape is inserted btween the aluminum alloy vacuum chambers. The bellows element is produced by the hydraulic forming of a 0.3 mm thickness seamless tube. The cross section of the bellows is shown in Fig. 4. The hollow spaces in vacuum side are minimized as much as possible to reject the RF resonance effects between the beam and the hollow spaces. It has a life time of more than 500 cycles of ± 20 % expansion and contraction.

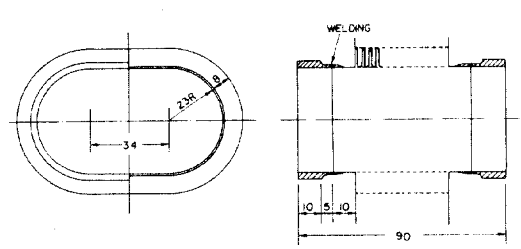

Fig. 4 Aluminum alloy seamless bellows of racetrack shape.

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Gate Valve

Installation of many gate valves is preferrable to isolate the large ultrahigh vacuum system from venting to air. By relaying on the differential pumping for seal, the dual flat seals are used without the gasket or the knife edge. The sealing surfaces of the valve body are superfinished to smooth mirror by diamond tool and coated with CrN to harden. The valve seats, which are 0.1 mm thick stainless steel, are pressed by compressed air to the sealing surfaces of the valve body. The closely contacted metal surface sealing[5] is obtained. The maximum conductance is 10^{-4} ℓ/sec for each flat seal. Total leak rate with differential pumping speed of 20 ℓ/sec is less than 4×10^{-7} torr ℓ/sec. The aperture of the gate valve is the same as the beam channel [D and Q]. When the valve opens, a bellows assembly is inserted in the aperture of the gate valve for impedance matching as shown in Fig. 5.

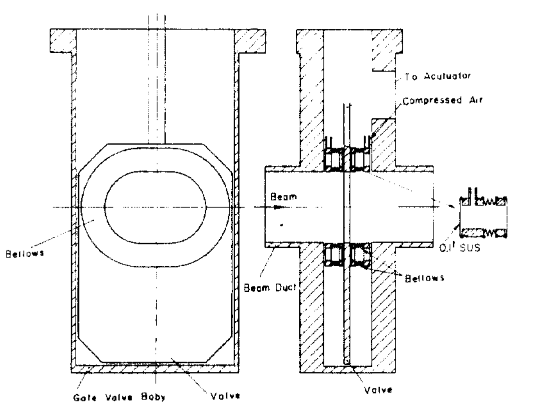

Fig. 5 All metal gate valve with dual flat seals by the differential pumping.

Ceramic Chamber

The ceramic vacuum chambers for the kicker magnet and the slow beam intensity monitor are inserted in the aluminum alloy chamber as shown in Fig. 6. The ceramic chamber is bonded to the aluminum alloy piece with the aluminum alloy solder [Aℓ-Si 11 %] by the vacuum brazing. The inner surface of the ceramic chamber is coated with CrN for smooth wall current flowing.

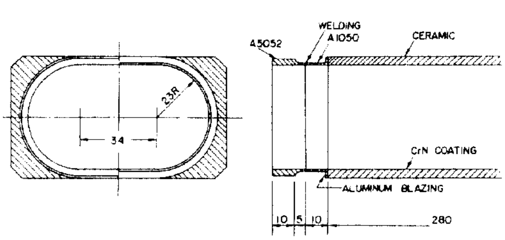

Fig. 6 Ceramic chamber.

Beam Position Monitor

Four button type pickup electrodes to detect the beam position are installed in the vacuum chamber of the short straight sections as shown in Fig. 7. SMA type vacuum feedthroughs[6] are used. The feedthrough consists of ceramic-aluminum alloy seal same as the ceramic chamber.

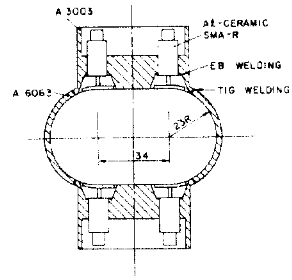

Fig. 7 Cross sectional view of the pickup electrodes. SMA type feedthrough is made of aluminum alloy and ceramic.

Jointing

The beam channels, gate valves, ceramic chambers and the bellows are jointed by a fully automatic AC-TIG welder as shown in Fig. 8. Most of the joints are non-demountable. The automatic welder consists of a guide rail with gear and a moving stage. The welding torch, filler wire feeder and arc voltage regulator are mounted on the moving stage. An example of the welding bead is shown in Fig. 9. To replace a defective beam channel by new one, the racetrack type pipe is cutout with an automatic cutter easily.

For demountable joints new Conflat type seal[7] has been developed in which CrN coated aluminum alloy flanges and the aluminum gasket are used. Aluminum alloy [2219-T87] flange and the gasket [1050] are structually same as traditional Conflat types. The CrN treatment [$\sim$ 5 μm] on the knife edge and other surfaces of the flange is performed for hardening [100 gr, Hv: $\sim$ 1800]. The CrN treatment on the flange gave nearly perfect protection against sticking between the knife edge of the flange and the gasket, and surface scratching. The aluminum alloy chamber [6063-T6] and the flange [2219-T87] were welded by AC-TIG process using an aluminum alloy [4043] filler wire. Helicoflex O-ring[4] is preferrable for the combination system of the aluminum Conflat and the ordinary stainless steel Conflat flange with thermal cycles. For the Helicoflex system, tight vacuum can held for spring back of the flanges by about 0.05 mm. Anodized aluminum bolts [2024-T4], non-anodized nuts [2024T4] and anodized washer [2024-T4] are used to tighten the flanges.

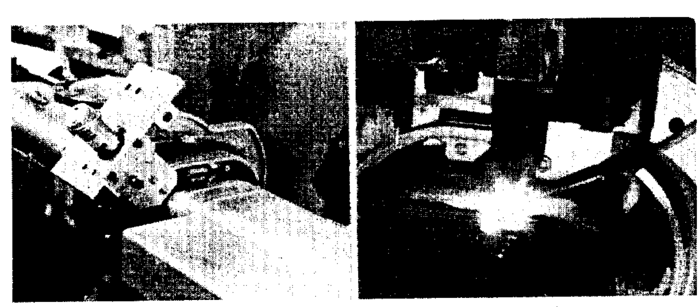

Fig. 8 Fully automatic welder for the racetrack shape pipe.

Distributed Ion Pump

The distributed sputter ion pumps in the dipole magnets hold the ultrahigh vacuum with beam. New pump element [8] consists of the five layers perforated stacked aluminum anode cells and the isolated titanium filaments. Because of the isolated cathode, discharge current does not contain the leakage current between

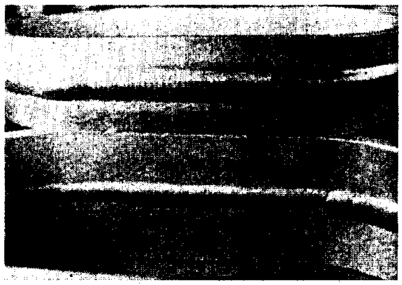

Fig. 9 Welding bead of the aluminum alloy pipe by automatic welder: outside and inside of the pipe.

the high voltage insulators. The pressure can be observed down to 10^{-9} torr by measuring the discharge current.

Ion Pump

Lumped sputter ion pumps which have pumping speed of 30 ℓ/sec are installed in the dipole chamber and maintain the system at high vacuum without operating the dipole magnets. The pump shell, flanges and the pump element except for the titanium chathode are made of aluminum alloy.

Roughing Pump

Pump down is accomplished by a combination of a 50 ℓ/sec turbomolecular pump and a mechanical pump. To make up the ion pump and the roughing pump in the pressure range from 10^{-4} to ultrahigh vacuum, we use bulk getter pump. The automatic isolation angle valve [Aℓ-ICF-114] between the dipole chamber and the roughing pump are made of aluminum alloy. The actuator of the valve is a pneumatic ratchet type. The roughing pumping system is shown is Fig. 10. Typical vacuum system of the short straight sections is shown in Fig. 11.

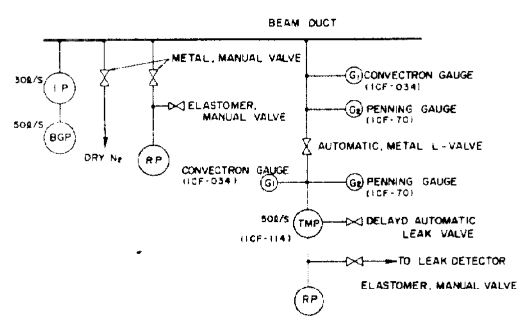

Fig. 10 Roughing vacuum system.

Heater and Insulation

A straight sheath heater, which is made of aluminum alloy [6063-T6] sheath, Ni-Cr coil heater and zirconia insulation, is pressed into the chambers. The vacuum chambers are thermally insulated by laminated Kapton films which are aluminized and embossed.

Conclusion

The present system satisfies such conditions as high reliability, simplicity, low residual radioactivity, impedance matching, low space factor and low cost, which are essential to the vacuum system for the large scale electron storage accelerator.

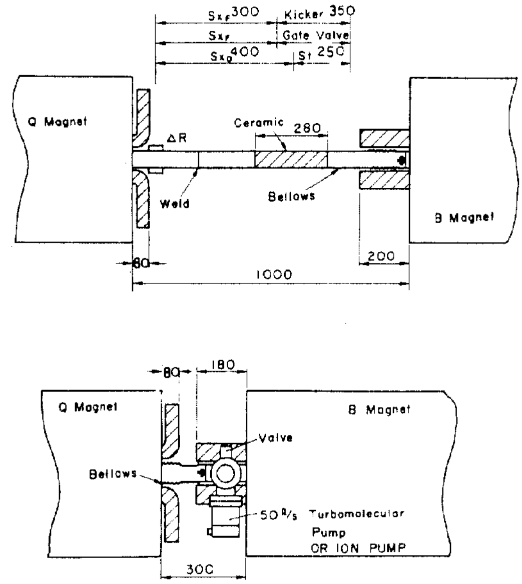

Fig. 11 Typical vacuum system of the short straight sections.

Acknowledgement

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