Ceramic chambers, bellows, windows, and SOR ports to improve the characteristics of TRISTAN Accumulation Ring (TAR)

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Abstract

Beam intensity in TAR is limited as 40 mA at 6.5 GeV. Instead, 50 mA at 8 GeV is expected in future physics. The corresponding power density is 5.3 KW/m. Longer beam lifetime is also required. Taking into account the two conditions and troubles in the past, redesign of ceramic chambers, bellows, windows and SOR ports are carried out. Wider horizontal aperture, kovar soldering, and absobers are equipped in ceramic chambers using SUS-Cu-Al clad material. Rf shield, SiO_2 coating, and absorbers are provided for bellows. Mask assembly is isolated from the window assembly. Pumping capacity and gap for SOR extraction are increased in SOR ports.

Introduction

As LEP and SLC were begun to operate,"future TRISTAN at KEK" has been discussed in various fields. In any cases, longer beam lifetime and higher beam current of TAR are required. TAR has been operated more than 6 years. Including the period of TAR design, about 10 years have passed as the TRISTAN era. Much experience on the TAR vacuum system has been stored during the 10 years. Therefore redesign of TAR considering the two requirements is the best opportunity. To realize higher beam current, the limiting condition on the ceramic chambers must be removed. Redesigned ceramic chambers, bellows, windows, and SOR ports are described taking into account the experience.

Requirements

8 GeV, 50mA beam is expected in future physics for TAR. Equivalent beam current is 6.5 GeV, 100 mA which are 2.5 times higher than the present limit, 6.5 GeV, 40 mA at SOR mode. Corresponding SOR power is 2.1 Kw/m. Therefore the power of 5.3 KW/m is taken into account for the redesign of ceramic chambers, bellows, windows, and SOR ports. An improvement for beam chambers is elliptical crossection, where their aperture is not changed(48 mm). Related change is to enlarge the gap in B chambers for SOR extraction. The main pump is DIP as before. As longer beam lifetime is requested from various fields, installation of more pumps is necessary.

Design

Ceramic chambers

Beam current is limited as 8 GeV, 20 mA, because ceramic chambers had troubles at the soldering part between short aluminum bellows and a ceramic rod. The soldering part is protected against radiation by making shadow (~320 mm) with an absorber. Originally, the absorbers are made of Al and their axial length is 5 mm. The length is not enough to shield radiation after the beam energy was increased higher than 6.5

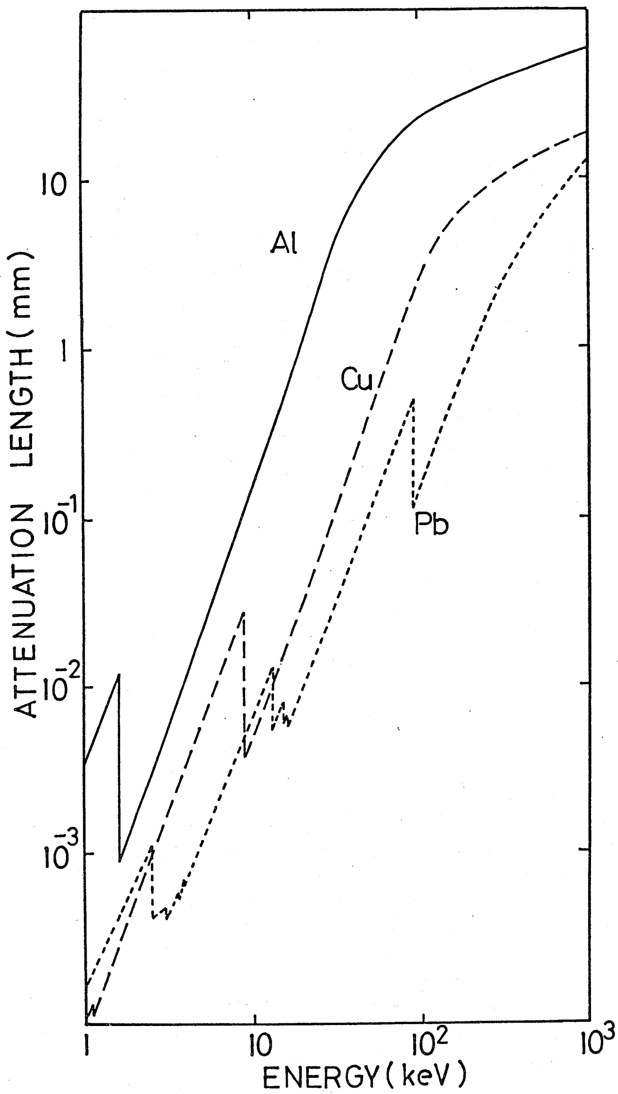

Fig. 1 Attenuation length of Al, Cu, and Pb as a function of photon energy.

GeV(Fig.1). Some of the absorbers are changed to new ones using clad material(Cu~ 4mm, Al~5.5mm). The height of the absorbers is 10 mm which can not make enough shadow on some of the ceramic chambers. In addition, transverse misalignment about 1mm results short shadow length about 30 mm which bring about radiation on the soldering part at the end of the ceramic chambers.

Improvement is applied as; the present crossection is 95 mm in horizontal length. From the beam axis, inner length is 45 mm and outer 50 mm. The outer length is made wide more 5 mm to obtain enough shadow on the end of ceramics. To improve the mechanical strength, Al soldering is changed to ceramic-kovar soldering. Therefore kovar is connected to Al chambers using SUS-Al transition material. Further, to obtain enough radiation length and shadow length, absorbers are set close to ceramic chambers by using SUS-Cu-Al transition material. At the end of ceramic rods, 28 thermometers are set to monitor temperature rise. Designed assembly around the cerammic rod and absorbers is shown in Fig.2. Attention is also paid to the alignment of these ceramic chambers. It must be mentioned that Al and Cu can easily make alloys. Heating accelerates the tendency and sometimes makes crack in Al-Cu boundary.[1] This can be overcome by changing combination of the clad material. More attention is paid on using SUS bellows in view of SOR radiation and gas desorbtion, and on instability due to steps in the transitioin material(absorbers). Temperature rise is estimated as 90 C. Simulation experiment using electron beam radiation can be used to evaluate the temperature rise precisely.

Bellows

In arc section of TAR, race track type bellows of 150 mm are used. No radiation damage protection and no rf shield is applied in present TAR. Therefore radiation damage will be supressed by applyng SiO_2(3 microns) coating on the outside surface. This is already done in TMR.[2] The instability due to wake field can be suppressed by inserting rf shield. The shield is applied on the new bellows with the same requirement as that of TMR. By adoptng the elliptical crossection, contacting pressure can be uniform in circumference distribution. In the present TAR, close to the bellows at the end of the Q or B chambers, Al absorbers(5 mm thick x 10 mm wide x 10 mm high) are welded as radiation shielding for bellows. However, 5 mm is not so effective at 8 GeV. Cu-Al clad material is going to be used in our design. Difference is to put the absorbers in the bellows itself. The absorbers are cooled down by water. The assembly is shown in Fig.3. The longest chamber unit for SOR port is 4200 mm long. Assuming temperature rise to be 130 C, expansion is 13 mm. Simplified calculation shows that temperature rise at Cu(absorber) is about 55 C in 5 mm high at 8 GeV, 50 mA . Experimental investigation using electron beam must be done.

Windows

Beam injection and extraction windows are made of vacuum tight beryllium(Be) plates(0.3 mm thick x10 mm high x 20 mm wide for injection, 1 mm thick x 10 mm high x 23 mm wide for extraction). Troubles in the past are vacuum leak due to corrosion of Be, mechanical blowing, and torque failure. The corrosion is estimated to be radiation damage accelerated by impurities(H_2O, O_2) in flowing helium gas. SOR is shielded by a molibdenum mask just in front of the Be window. The mask system (Mo) is about 1.3 kg and is

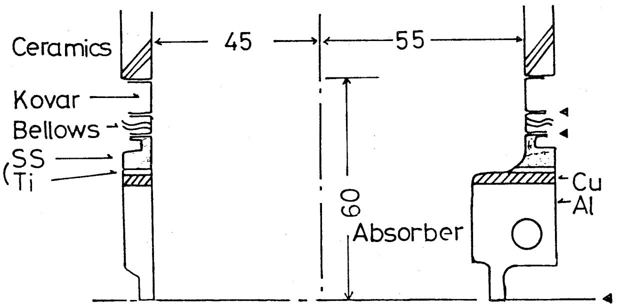

Fig. 2 Ceramic-kovar soldering and an absorber using SUS-Cu-Al clad material.

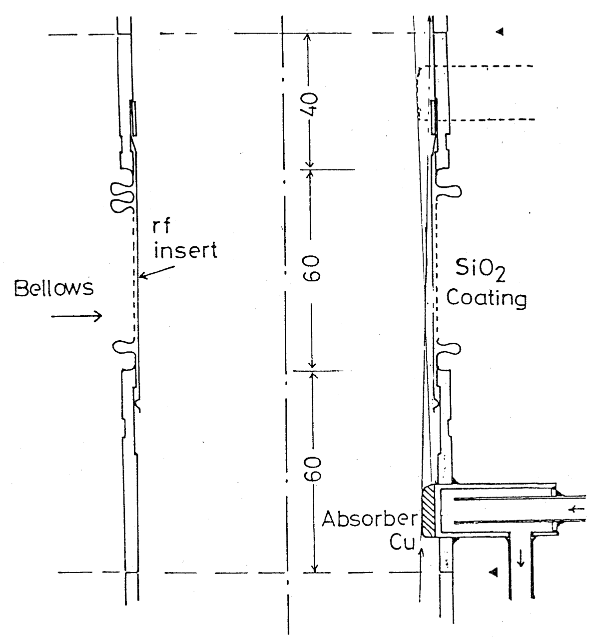

Fig. 3 Bellows with rf insert, SiO_2 coating, and absorbers.

attached to the window assembly. This makes access of the windows difficult. The window assembly and mask system should be isolated. The mask can be attached to the Q chamber just in front of the window. The fabrication technique of the window is electron beam welding as before. Welding shape can be circular instead of rectangular. The latter has technically hard and is high cost. Heat loading on the Be window is basically the same as in the present.

SOR ports

SOR ports are now used at NE1, NE5, NE7, and NE9. Monitoring ports are an x-ray window for electron beam and a mirror port for e+ and e- beams. As the increase of SOR studies will be expected, 24 SOR ports will be installed. Extracting angle is not changed, but pumping capacity at the downstream of the port will be increased to compensate the desorption due to radiation. One TSP and one IP are attached to the outside of a B magnet chamber. Extracting gap for the port is 20 mm at the downstream, however, at the sextupole magnet the gap including the chamber thickness is less than 20 mm (Fig.4).

Attention must be paid to the pure aluminum chamber, fixed point of the chamber, and assembling and alignment of the longest unit chamber.

Concluding remarks

Ceramic chambers limiting the beam intensity of TAR bellows, beam windows, and SOR ports are redesigned so as to be durable against radiation about 5.3 KW/m. The power density is more than 3 times of the present TAR operation. Rough calculation satisfies requirements, however, confirmation with measurements is indispensable. Without changing cooling capacity, reasonable temperature rise is estimated. Influence due to the temperature rise and radiation dose increase is not considered here. Further investigation is needed to complete this design.

Acknowledgement

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References

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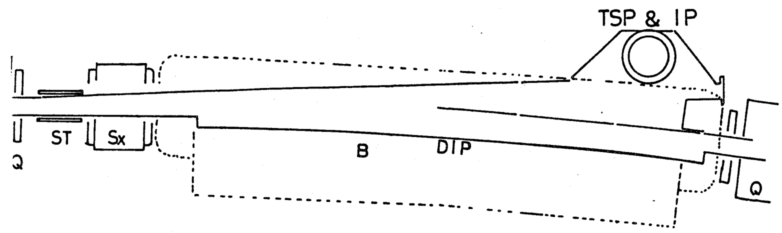

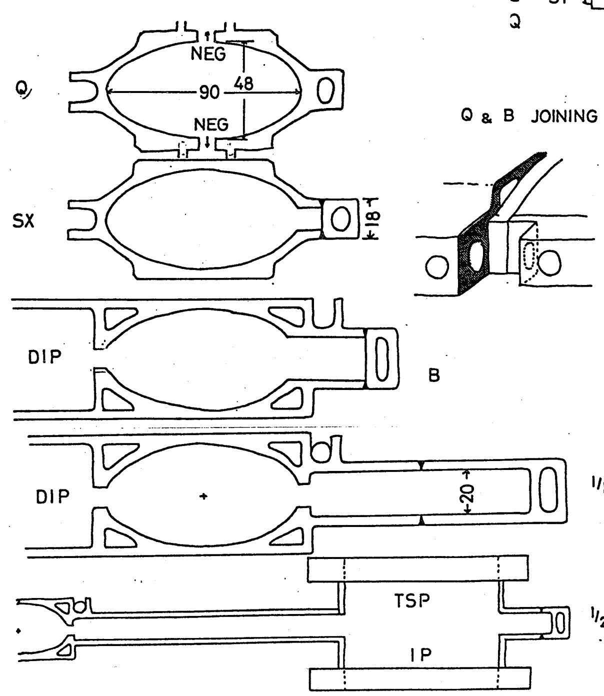

Fig. 4 Crossection of SOR extracting port and arrangement of pumps.