Upgrade Design for Vacuum System of TRISTAN Accumulation Ring

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I. Introduction

Design, and research and development of TRISTAN accumulation ring (TAR) was begun around 1979. Construction was done during 1981 and 1982 FY. In November 1983, beam acceleration test was suceeded. This is the shortest record in the accelerator history. After TRISTAN colliding ring was completed, TAR has been functioned as an injector for the main colliding ring. In addition, TAR also has been serving for internal target experiment, synchrotron radiation (SR) studies, and B-physics experiment. From now on, improvement on beam lifetime and current is required as SR studies and colliding experiment increase. To improve beam lilfetime drastically, the effective pumping speed must be increased with a level of order. Straight section between the B- and Q-magnets in TAR is the shortest in the existing electron storage ring. Main pump of TAR is a distributed ion pump (DIP) in a bending magnet (B-) chamber, however, the DIP is not in a quadrupole (Q-) magnet chamber. The latter fact limits lifetime. More information on gas elements and pressure distribution is neccesary to investigate beam lifetime. On the other hand, a factor to limit beam current is ceramic chambers.

II. Basic design

Installation will be done on scheduled shutdown in summer, 1991. After installation, required beam lifetime and current shuold be obtained as soon as possible. Much experience during the 10 years helps us to obtain the highest performance. Failures in the past are mainly due to the results of compromise, therefore, specification down is not in our design. Performance requirements must be added in ordering to the traditional structural and material requirements. UHV characteristics must be confirmed with preassembling, prebaking, and preaging before installation. The highest performance is persued utilizing extremely high vacuum (XHV) techniques[1]. Without troubles of vacuum components, beam life can be increased. Therefore, reliability of the components is investigated hard. To improve lifetime, the most effective distribution of pumps as well as gauges is our object. The synchrotron (SR) ports are equipped as many as possible in B-chambers. Chamber material is determined with the past research and development. On the fabriaction techniques, surface treatment techniques established during the developments XHV are applied. Welding in a chamber with argon atmosphere, automatic welding for elliptical cross section, and electron-beam welding are positively adopted. All assembly is done in a clean room.

III. Detail Design

Beam chambers

Elliptical crossection is adopted instead of racetrack type without changing aperture. The elliptical crossection improve the characteristics of rf contacts equipped in bellows, that is, stress against chamber deformation is decreased. Gap between two water cooling pipe in a B-chamber is enlarged as possible to extract SR effectively in SR ports (Fig1). Pumping holes are changed from long holes to circular holes to decrease leakage of rf power due to bunched beam. Many SR ports are equipped in a B-chamber as possible. SR shield for undulators is installed in one of the SR ports. Power density of the shield is extremely high, dispersion using Be-Al-Cu is considered. Precise alignment must be available for contraction and expansion during baking. Q-chambers have housings for the NEG strip ST-707 both top and bottom of the chamber. Beam position monitor (BPM) are electron-beam welded at the platoes on and below the Q-chambers (Fig.2). Fixed frames are adopted to fix the BPM. Chamber material is changed to high purity 99.99%Al[2] from A6063 alloy. Eectron beam welding is agressively adopted to minmize the welding stress. Installation in the tunnel is done using automatic welding machines. The rf shields and SR absorbers are equipped in elliptic bellows with outside SiO_2 coating against radiation damages.

Pumps

For the DIP in B-chambers, pumping characteristics in UHV range is much interested. Abnormal discharge, short, and insulation damage in the present DIP electrodes need reliability with simple electodes, no bolts, and thermal expansion free parts. Ceramic insulation is protected. For Q-chambers, non-evapolable-getter (NEG) is adopted as a main pump. NEG strips and sputter ion pump (SIP) are used in the straight sections. In the SR ports in the B-chambers titanium sublimation pump (TSP) are used. SIP are installed close to beam as possible (Fig.3). Main pumps are served to evacuate CO effectively. High voltage aging is applied to DIP and SIP. Roughing pump system has a 300 l/s turbomolecular pump (TMP) with magnetic bearings, and a port surrounding the beam chamber to improve conductance (Fig.4). Pumping speed for CO in 10^{-10} Torr range must be measured precisely. Partial pressure (especially for CO) is measured precisely during operation to give precise correspondent betrween beam life and pressure. Pumping speed of DIP and SIP is measured at 10^{-10} Torr range with background pressure of order 10^{-12} Torr. The measurement is done to obtain the effect of preaging, and baking as well as the effect of magnetic and

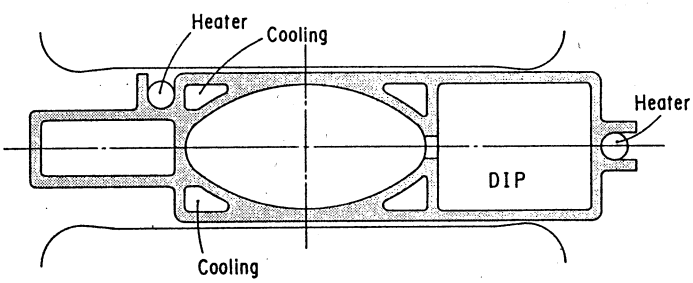

Fig.1 A cross section of bending magnet chamber.

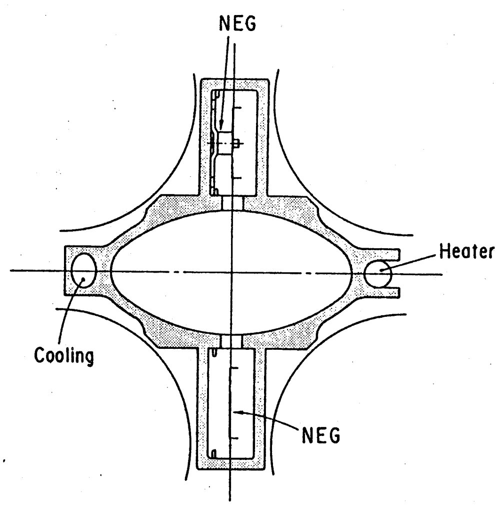

Fig.2 A cross section of quadrupole magnet chamber.

electric fields. Exchange desorbtion of the DIP and SIP is considered. The pump and pressure distribution are shown in Fig.5. This is obtained by considering the gas loads due to SR and adopting much DIP, SIP, NEG as possible. Obtained effective pumping speed is 3 times higher than the present TAR.

Vacuum monitoring

Many gauges are installed as possible to get information for beam life and small leak. Cold cathode gauge and BA gauges used to measure 10^{-11} Torr. Many quadrupole mass filter are used. The gauges are set close to beam to be able to precise monitoring.

Other componments

Trouble makers in the past; light angle valves, high voltage feedthroughs for DIP, and ceramic chambers must be changed to highly reliable ones. Ceramic chamber has an enlarged horizontal length to escape SR and effective absorbers. Gate valve should have life and reliability more than 10^4 times, where no small dust prevent the sealing characteristics. So far, several operation tests after transmittance were carried out, however, initial trouble was inevitable. From now, repeated test amount to 1 % of life shold be applied and the test can avoid initial trouble? The high voltage feedthroughs must be durable to the preaging voltage higher than the operation voltage. The feedthroughs have to have mineral insulated cables to supress radiation damages. Scrapers, gauges, and gaskets are prebaked and preaged in vacuum furnace. Super dry nytrogen (100 ppb in H_2O) is introduced to improve re-evacuation characteristics. Elastomer O-rings in roughing pump system are changed to metal sealing to supress radiation damage.

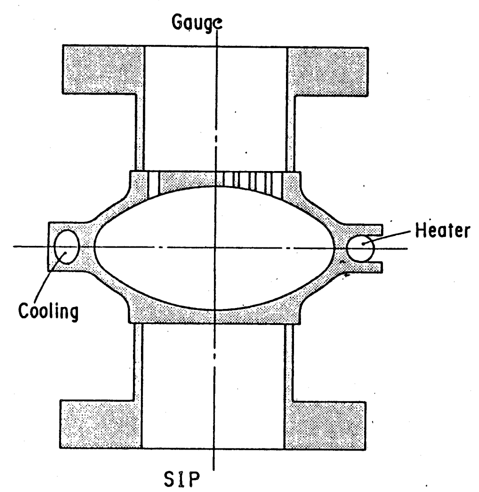

Fig.3 A cross section of manifolds for a sputter ion pump and gauges.

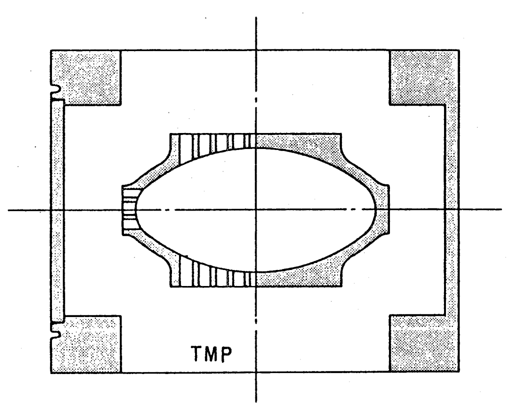

Fig.4 A cross section of manifolds for roughing pump.

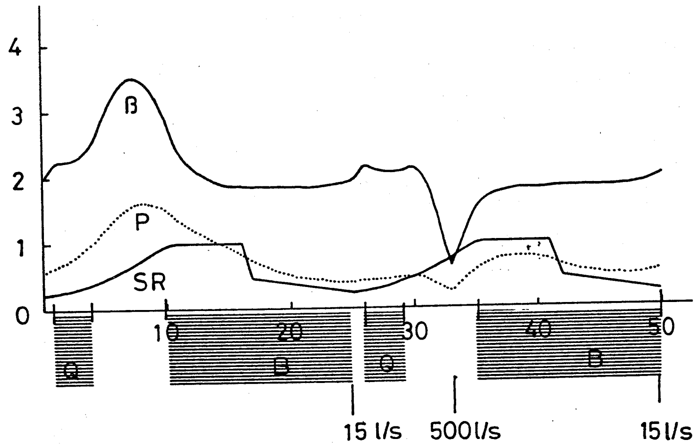

Fig.5 A calculation of power distribution of synchrotron light for electron beam and pressure distribution. β is inverse of pumping speed. P is pressure. SR is power of synchrotron radiation.

IV. Installation

Installation is made effectively during short scheduled shutdown in summer. A B-chamber and a Q-chamber are welded and made a connected unit in the assemble factory. Using flanges at both ends of the unit, UHV performance is confirmed by applying pretreatments. On DIP, preaging is applied using B-magnets. In a mini clean room in the tunnel, by removing the flanges the unit is automatic welded. New Q-chambers have housing for NEG, therefore, Q-magnets are set below during the insrtallation. After welding, more strict leak test is applied. The chambers are evacuated to the order of 10^{-8} Torr. Then DIP and SIP are activated. To maintain effective CO pumping speed, NEG strip is activated at enough low pressure. Because of electric current of Q-magnet, NEG can not be activated. At the initial operation, much activation is neccessary. TSP is also preaged using other chambers. Enough preaging and baking must be applied on DIP and SIP to prevent the exchange desorbtion. At the initial operation with beam, pararell operation with roughing pump system must be used. Baking is made using hot water cycling system.

V. Schedule

Fine design will be made until end of 1989 FY. Design and arrangement of magnets and chmbers are done and controlled using CAD. In parrarel; with the design, fabrication test of B- and Q-chambers, bellows, DIP and NEG will be done. UHV characteistics pf DIP and NEG will be evaluated by the winter in 1989. By the end of 1989 FY three combined unit B- and Q-chmbers will be comleted. The unit will be totally evaluated and beam loading test on the two units will be done in TAR after installatiion in summer 1990. The remained one will be tested following long period. After confirming the characteristics and reliability of the units, whole chambers will be produced. During schedule shutdown in summer 1991, whole chambers will be renewed.

VI. Summary

Beam lifetime and current are mainly limited by vacuum characteristics of TAR. In future, the role a SR ring or electron-positron colliding ring will increase rather than the present role as the accumulation ring of main colliding ring. To correspond this status, redesign of TAR is investigated. Draft of the TAR design is described to dissolve the problems in the past. The best performance and reliability will be realized considering research and development and operational experience in the past 10 years.

Acknowledgments

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References

1. H.Ishimaru: J. Vac. Sci. Technol., A7 (3), May/Jun 2439 (1989)
2. H.Ishimaru, K.Narushima, and K.Kanazawa: Proceedings of Vacuum design of advacnced and compact synchrotron light sources, BNL Upton, NY 219 (1988)