PRESENT STATUS OF TARN-II VACUUM SYSTEM

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Abstract

The vacuum system for new cooler/synchrotron,TARN-II, was constructed in the fall of 1988. All vacuum system is designed in the condition of the organic free and is bakable up to 350°C. Now, the pressure of 4×10^{-10}Torr is achived at good region.

Introduction

The heavy ion cooler/synchrotron,TARN-II, was constructed in 1988. This ring has the performance which accelerates ions up to the energy of 1.1 GeV for protons and 370 MeV/u for heavier ions with the charge to mass ratio of 1/2, respectively[1-5]. The ring has mean radius of 12.4 m and circumference of 78 m and has 24 dipole magnets and 18 quadrupole magnets, and 6 long straight sections in which beam injection, extruction, electron cooling device and rf cavity are located.

The vacuum pressure better than 10^{-10} Torr is required to obtain long life time of heavy ions for beam storage and cooling experiments at TARN-II. In order to keep the pressure lower than 10^{-10}Torr, the out gassing rate from the chamber wall must be reduced to minimum. Then the vacuum system is fabricated with the organic free materials. This constitution is efficient for the high temperature baking. Low out gassing rate lower than 1×10^{-12}Torr·l/s·cm² was already obtained by baking experiment of the chamber[6], so the required pressure will be obtained after high temperature baking.

Design and construction of the vacuum system

Basic design of the vacuum system

TARN-II is operated as heavy ion storage ring, so the vacuum pressure of better than 10^{-10} Torr is required to keep long beam life time. the vacuum system was designed on the basis of following points.

1. Organic free materials as stainless steel and pure alumina ceramics are chosen for vacuum chambers.
2. All vacuum chambers are bakable at 350°C.
3. All metal gaskets are used and elastmer is not used.
4. Ion pumps, Titanium sublimation pumps and Turbo-molecular pumps are employed.

Table 1

Parameters of the TARN-II vacuum system

Circumference	78 m
Total surface area	5×10^5 cm²
Required vacuum pressure	$< 1 \times 10^{-10}$Torr
Total pump speed	1.7×10^4 l/s
Titanium sublimation pump	1500 x 7 "
Sputter ion pump	800 x 5 "
"	400 x 3 "
Turbo-molecular pump	500 x 3 "
Out gassing load (Required)	$< 2 \times 10^{-6}$ Torr·l/s
Out gassing rate (Required)	$< 4 \times 10^{-12}$ Torr·l/s·cm²

Vacuum chamber

Operation mode of TARN-II is planed rather slow acceleration period as 0.1 Hz, so the vacuum chambers as dipole and quadrupole magnets are used 316L stainless steel plates of 4mm in thickness. The vacuum chamber which correspond to two stage of the dipole magnets has 3 m in length and has cross sectional area of 240 mm (horizontal) x 53mm (vertical). The vacuum pump port and auxiliary port are located in the middle of the chamber. The flange of the both side of the chamber are 325mm in diameter and the stainless steel O-ring gaskets coated with silver are used. Layout of the chambers are shown in Fig. 1.
The vacuum chambers of the quadrupole magnets have diamond shape of cross section of 190 mm (horizontal) x 90 mm (vertical) and 460 mm in length. The bump magnet chambers are made from pure alumina ceramics and its cross sectional area is 190 mm (horizontal) x 33.5 mm (vertical) and 520 mm in length. The chambers of the ring are connected by mainly conflat flanges with oxygen free copper gaskets and partly metal O-ring seal and helicoflex seal are used.

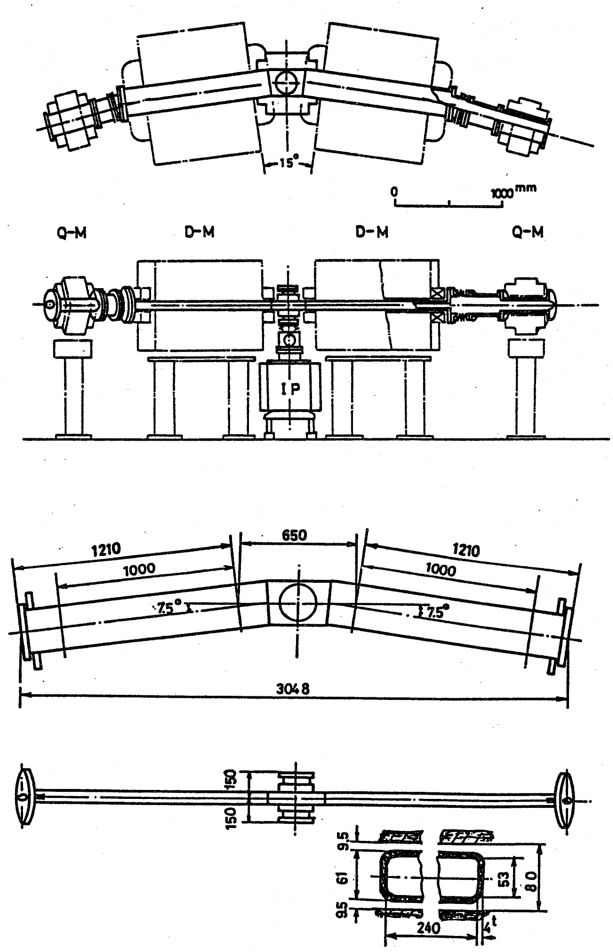

Fig. 1 The chamber of the dipole magnet section.

Pump system

The parameters and arrengement of the pump system of TARN-II are shown in Table 1 and Fig. 2. The ion pumps of 800 l/s and 400 l/s and the titanium sublimation pumps of 1500 l/s are assembled to pump ports of the dipole magnet chambers. The ion pumps of 800 l/s are equipped at inflector chamber, S1, and beam cross point of TARN-II ring and transport line for the purpose of reinforce of pump speed. The turbo-molecular pumps of 500 l/s are located at S1, S3 and S5 correspond to symmetrical position of the ring. The mechanical booster pumps are equipped in roughing pump station of S3 and S5 in order to reduce back diffusion of oil vapour.

Vacuum pressure of the ring is measured by Bayard-Alpert ionization gauges with modulator and the gauges are equipped with near pump ports of the dipole magnet chamber. The residual gas of the chamber of the ring is measured by quadrupole mass analyzer.

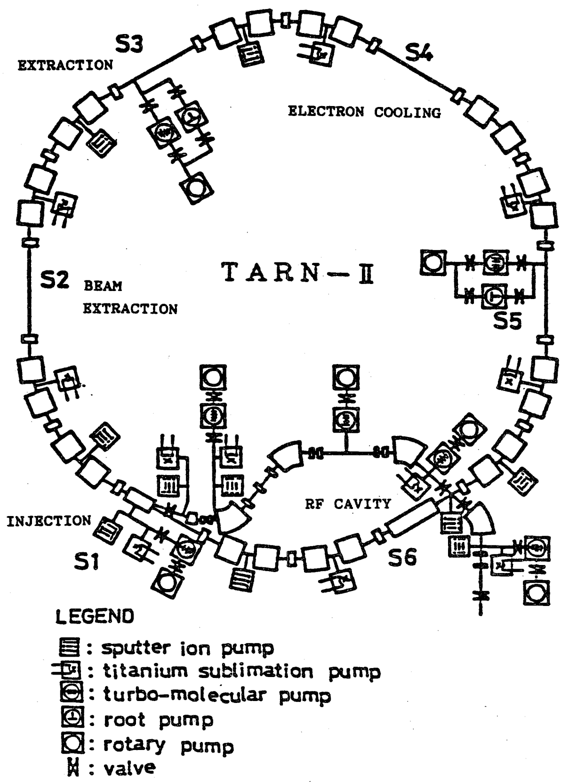

Fig. 2 The vacuum system of the TARN-II.

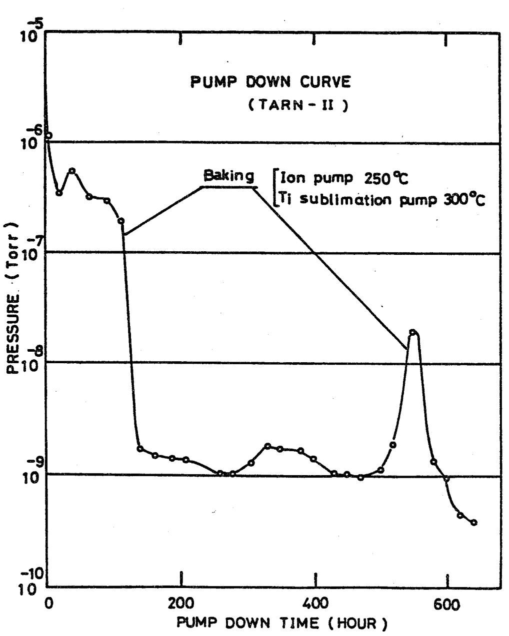

Fig. 3 The pump down curve of the TARN-II.

Baking

The chambers of the dipole magnets are baked by means of supplying DC current through themselves, so the all chambers of the ring are insulated electricaly from the ground. The baking of the other chambers and the pumps are done by sheath heaters or mantle heaters. The glass wool sheets of 25 mm in thickness are used for the heat insulation of chambers.

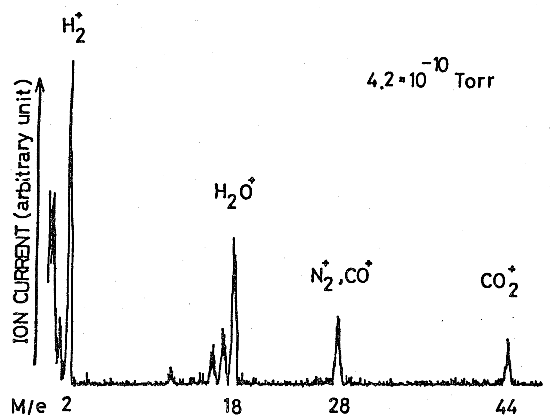

Fig. 4 The residual gas spectrum of the TARN-II.

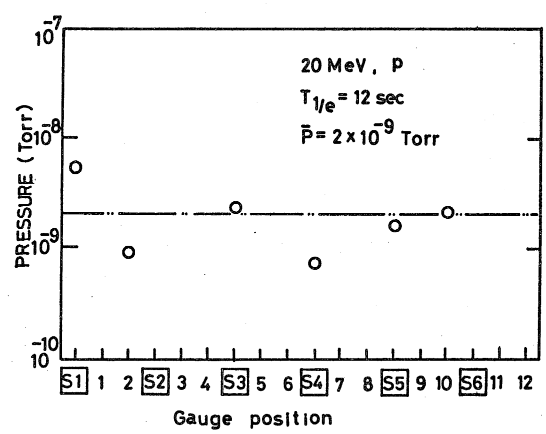

Fig. 5 The vacuum pressure of the TARN-II at the beam experiment.

Results and Conclusion

A characteristic of typical pumping down is shown in Fig. 3 and the vacuum pressure has attained to 4 x 10^{-10}Torr at good region. The vacuum gauge settled at six position around the ring are indicated the value between 2×10^{-9} to 4×10^{-10}Torr. Also, a spectrum of the residual gas is shown in Fig. 4. For example, the vacuum pressure at beam experiment is shown in Fig 5. In this time, the beam life time of 12 sec was measured from the beam accumulation experiment for 20 MeV proton beams. The beam signal of the electrostatic monitor is shown in Fig. 6. From the beam life time, the average pressure is estimated at 2 x 10^{-9} Torr.

At present, the baking process does not applied to the vacuum system except pump stations. The required vacuum of the order of 10^{-11} Torr will be attained easily after high temperature baking of 300°C.

The following important problems about vacuum system must be equipped:

1) Application of the high temperature baking of 300°C.
2) Well-equipped centralize controle of vacuum system.
3) Improvement of differential pumping system at the beam transport line.

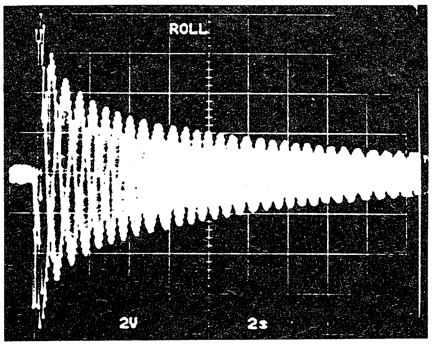

Fig. 5 The beam signal of the electrostatic monitor. The scales are 2 sec/div (horizontal) and 2 v/div (vertical).

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