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Conditioning of Positive Inflector Voltage for The Injection of Negative Ions at TARN-II

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Abstract

An ultrahigh vacuum of the order of 10^{-8}Pa has been kept to obtain sufficient beam life times for the beam experiments at TARN-II. Recently, positive high voltage was applied to inflector electrodes to inject H^- ion beam in the ring. In this case, vacuum pressure rose up to the order of 10^{-6}Pa and residual gas components of CO and CO_2 remarkably increased. We tried to get a required inflector voltage at normal vacuum pressure by conditioning the electrodes. As a result, vacuum pressure was improved to 1.2×10^{-8}Pa at high voltage of +44 kV.

1. Introduction

An ion storage/cooler synchrotron with an electron cooling system TARN-II has been operated for the studies of atomic physics and accelerator technology[1]. Vacuum pressure of the order of 1×10^{-8}Pa is required to get sufficient beam life times for the beam experiments. The ring has a hexagonal shape with six long straight sections and has a circumference of 78 m. Ion beams from an SF cyclotron are transported through a beam line and injected into the ring by an electrostatic inflector system which was originally used at the former storage ring TARN [2,3]. Recently, positive high voltage, as well as usual negative voltage, was applied to the inflector electrodes to inject H^- ion beam. Initially vacuum pressure increased to the order of 10^{-6}Pa. We tried to get the inflector voltage required to inflect the beam at a normal vacuum pressure by conditioning the electrode.

2. Electrostatic inflector

The inflector system is composed of successive one pair of electrode with an arc length of 300 mm and a gap of 8 mm. A mean radius of curvature is 5005 mm and an inflection angle is 6.9°. The septum electrodes are made of tantalum foils of 0.1 mm thick and are earthed to ground potential. The high voltage electrodes are made of stainless steel and supported by ceramic insulators. Designed maximum electric field at the gap is 100 kV/cm. Three beam probes are inserted at upstream, middle and downstream of the electrodes. The inflector system is shown in Fig. 1.

3. Conditioning

Usually, vacuum pressure of the order of 10^{-8}Pa has

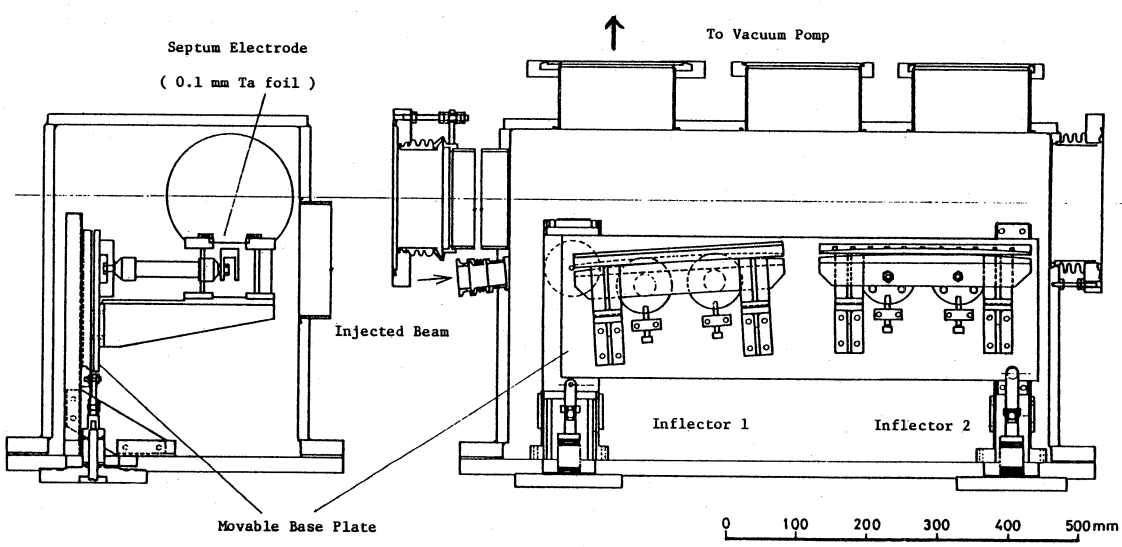

Fig. 1. The plan and side view of the electrostatic inflector.

been kept at the beam time in which negative high voltage of about 30 kV was applied to the electrodes (for example 10 MeV-HeD$^+$). However, when positive high voltages were applied to the electrodes, a huge amount of outgassing occurred and the vacuum pressure at the long straight section (S1) in which inflector electrodes are equipped increased to the order of 10^{-6}Pa. Main outgassing was observed at the downstream inflector (inflector 2) and any change of vacuum pressure was not observed while a high voltage of +60 kV was applied to the upstream electrode (Inflector 1).

In order to improve the deterioration of vacuum, two aging processes were applied to the electrodes.

1) positive high voltage aging.

When a high voltage of +60 kV at the inflector 1 was applied, electric leakage current was lower than 0.1mA and any change of vacuum pressure was not observed. On the other hand, at the inflector 2, a high voltage was applied gradually to +45 kV. At this voltage, electric leakage current was 1.3 mA and vacuum pressure increased to 10^{-6}Pa. After recovery of vacuum pressure to the order of $1x10^{-7}$Pa, the high voltage was increased to 48 kV. Such a conditioning was performed at the interval of about 10 hours per day. An example of vacuum pressure during conditioning is shown in Fig. 2. Vacuum pressures when high voltage swiched on and swiched off are shown by (A,B,C) and (1,2,3), respectively.

Improvement of the vacuum pressure by conditioning is shown in Fig. 3 (A). Vacuum pressures of HV on and HV off shown in Fig. 3 correspond to the pressures

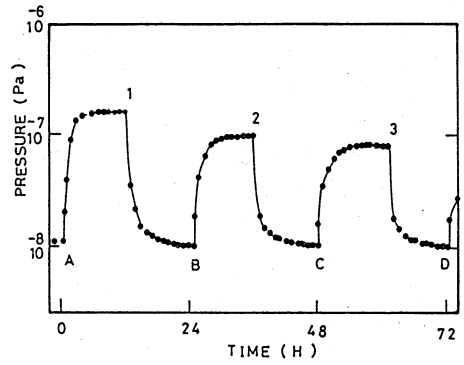

Fig. 2. An example of vacuum pressure at an aging time.

at (1,2,3) and (A,B,C) in Fig. 2. The accumulation time while high voltage was applied to the electrodes was shown as aging time. The total conditioning time of 100 hours was achieved with positive high voltage. The vacuum pressure was then decreased from 10^{-6}Pa to $6.3x10^{-8}$Pa at high voltage of +48kV and from $1.4x10^{-7}$ Pa to $1.2x10^{-8}$Pa at +44 kV.

2) Negative high voltage aging.

Total conditioning time of 200 hours was achieved while a high voltage of -60kV were applied to the both electrodes, inflector 1 and 2. Results are shown in Fig. 3 (B). The vacuum pressure decreased from $3.5x10^{-7}$Pa to $7.2x10^{-8}$Pa at a high voltage of -60 kV and from $1.5x10^{-8}$Pa to $1.0x10^{-8}$Pa at -30 kV.

In the case of positive high voltage aging, residual gas spectra at the high voltage on (A) and

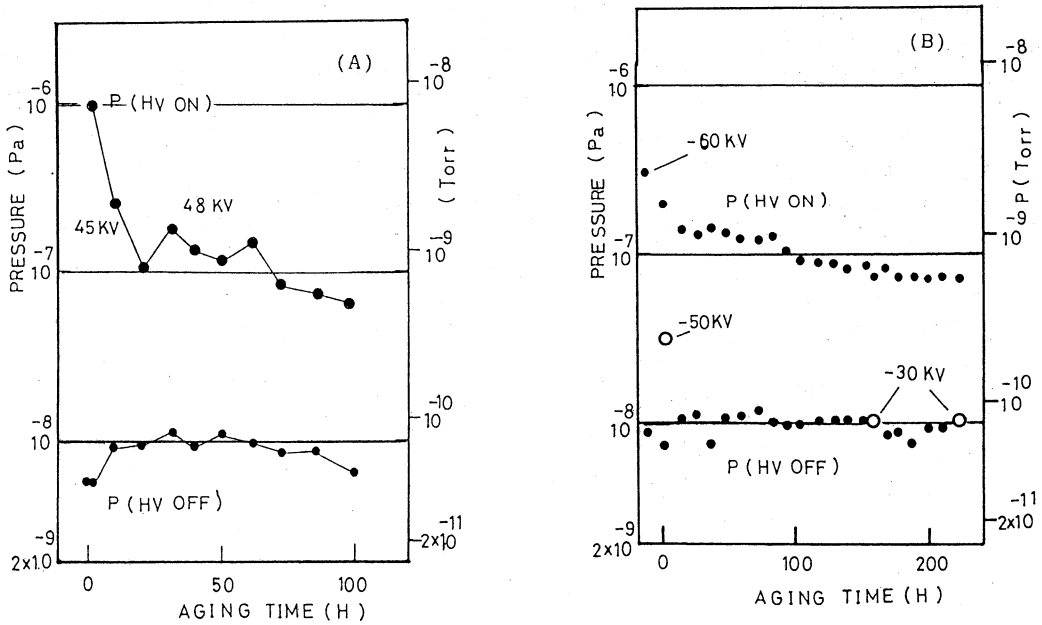

Fig. 3. Improvement of the vacuum pressure in the inflector chamber by appling positive (A) and negative (B) high voltages.

off (B) were measured. Results after aging times of 30 hours are shown in Fig. 4. Variations of the residual gas components by the aging are listed in Table 1. Ratios of ion current at HV on and HV off ,I(on)/I(off), are remarkable for the outgas components of CO and CO_2 at the aging time of 30 hours. However, the ratios decreased by a factor of 4 after 85 hours.

Table 1 Variations of the residual gas components by the aging

Gas	Aging time(H)	Ion current(au) HV off	HV on	I(on)/I(off)
H_2	30	3.0×10^{-7}	10.0×10^{-7}	3.3
	85	3.0×10^{-7}	3.7×10^{-7}	1.9
CH_4	30	3.4×10^{-9}	2.6×10^{-8}	7.6
	85	3.5×10^{-9}	1.0×10^{-8}	2.9
H_2O	30	5.5×10^{-9}	4.6×10^{-8}	8.4
	85	5.0×10^{-9}	1.3×10^{-8}	2.6
CO	30	1.2×10^{-8}	1.7×10^{-7}	14.2
	85	1.3×10^{-8}	5.0×10^{-8}	3.9
CO_2	30	6.7×10^{-9}	1.1×10^{-7}	16.4
	85	7.0×10^{-9}	3.0×10^{-8}	4.3

We deduce that some oil vapor condensed on the electrode and the insulator, because the temperature of the inflector was lower than other parts of the vacuum chamber during the baking time.

4. Conclusion

1) When positive high voltage was applied to the inflector electrode to inject H^- ion, remarkable outgassing occurred and vacuum pressure increased to the order of 10^{-6}Pa.

2) Improvement of vacuum pressure was achieved by conditioning the electrodes with positive and negative voltages. For example, vacuum pressure was improved from 1.4×10^{-7}Pa to 1.2×10^{-8}Pa at operation voltage of +44 kV.

3) We deduce that high residual gas components of CO and CO_2 come from pump oil which sticked to low temperature place during baking time. Baking at a temperature as uniform as possible for the whole system is important.

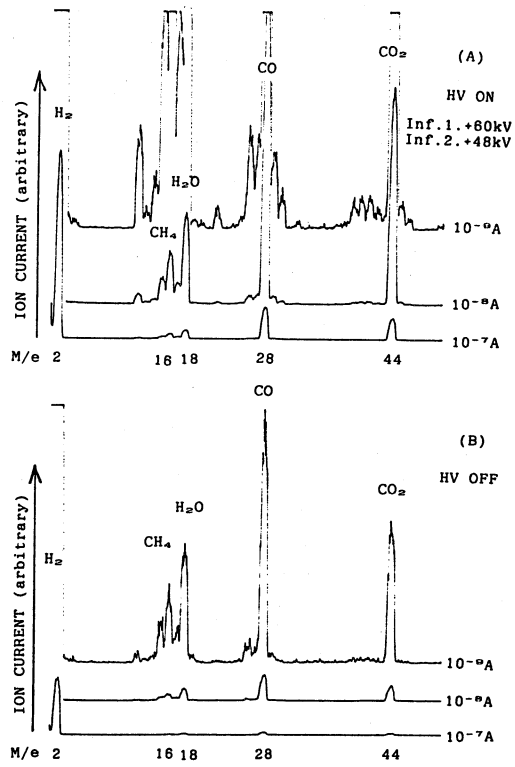

Fig. 4. Mass spectra of the residual gas in the chamber at positive high voltage on (A) and off(B) after aging time of 30 hours.

References

1] K.Chida et al., "Present status of TARN-II vacuum system" Vacuum 44(1993)539

2] T. Hattori et al., "Beam Transport System from the INS-SF Cyclotron to TARN" INS-NUMA-25(1980)

3] F.Soga et al., "Beam Transport and Injection System from the SF Cyclotron to the TARN-II Synchrotron Cooler Ring" INS-T-494(1990)