Vacuum System for the Cooler Ring TARN2

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Abstract

A new type Non-Evaporable Getter (NEG) pump was designed to obtain a better vacuum pressure in the cooler ring TARN2. This pump is activated by a mantle heater from outside of the pump chamber. With this pump, an average pressure of $1x10^{-8}$ Pa has been achieved during the beam time of atomic physics experiments. Change of the vacuum pressure in the ring from 1988 to 1997 is also presented .

1 Introduction

The cooler/synchrotron for light and heavy ions with an electron cooling system,TARN2 was constructed for the study of accelerator technology in 1988. Experiments on the electron cooling, the beam extraction and the beam acceleration were successfully performed[1-3].

In early years, only the vacuum pumps used at the former storage ring TARN1 were available to evacuate the vacuum chamber of the ring. In 1991, the first upgrade for the pump system at TARN2 was performed by newly adding titanium getter pumps and sputter ion pumps in order to promote the study of atomic physics. As a result, an average vacuum pressure on the order of 10^{-8} Pa was achieved during the beam time[4]. However, a further better vacuum was required to obtain sufficiently long beam times for collision experiments between molecular ions and electrons. To realize the purpose, a further trial was made to improve the vacuum by utilizing a new type NEG pump.

For the atomic physics experiments, molecular ions such as HD_2^+, HeH^+ and HeD^+ were injected in the ring and an average vacuum pressure of $1x10^{-8}$ Pa was maintained during the beam time[5]. History and status of the vacuum system at TARN2 are also reported.

2 Pump system

The TARN2 ring has a circumference of 78 m and is hexagonal in shape with six long straight sections. In the straight sections, electrostatic inflectors for the ion injection (Straight section:S1), a dc current transformer and a bump magnet (S2), nondestructive profile monitors (S3), an electron cooling device (S4), an rf knock out electrode (S5), an rf cavity and a bump magnet (S6) are located. The vacuum chamber at the electron cooling section can be isolated by a pair of all-metal gate valves. Stain less steel 316L was used as the material for vacuum chambers.

The pump system consists of Titanium Getter Pump (TGP) , Ion pump (IP) and Turbo-Molecular Pump (TMP). TGP and IP were located in straight sections and dipole magnet chambers. Total pump speed of TGP and IP after the first upgrade in 1991 was 30000 l/s. The turbo-molecular pumps with a pumping speed of 500 l/s are installed at the long straight sections of S1, S3 and S5. Roots pumps located at S3 and S5 are used only at the time of pumping down from the atmospheric pressure in order to evacuate quickly in the intermediate flow region.

The pressure was measured by B-A type ion gauges. Quadrupole mass filter was used for the residual-gas analysis. The pump system of the ring is shown in Fig. 1.

3 NEG pump

In advance of the second upgrade, we measured the performance of the ion pumps used in the ring by the build-up method The result of experiments suggests that these ion pumps are still useful for the pumping of rare gases and methane in 10^{-8} Pa region. Therefore, the pumps having a high pumping speed for hydrogen gas was mainly required. As a result, the new type NEG pump developed at Stockholm[6] was chosen and newly added. This pump is heated from outside of the pump chamber by a mantle heater. The activation by heating from outside is reasonable because it removes molecules on the surface of the pump chamber along with the activation.

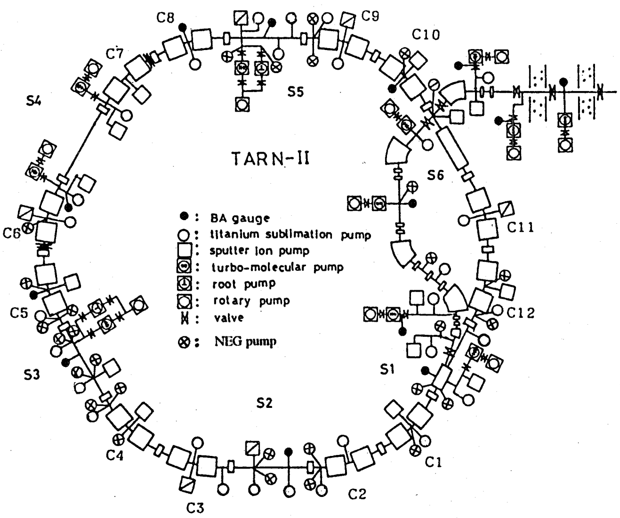

Fig.1 The pump system for the TARN2.

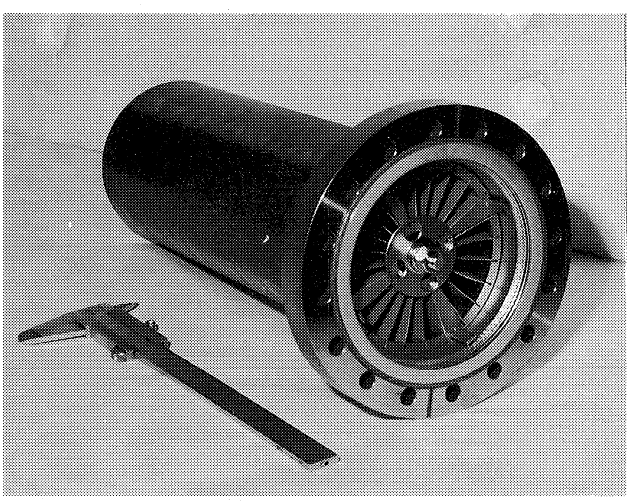

Fig.2 Photograph of the NEG pump.

This pump has cylindrical shape with a diameter of 100 mm and a length of a 300 mm and is mounted on a CF 152 flange. 24 leaves of NEG strip (which are 30 mm wide, 269 mm long and 0.5 mm thick) are inserted into the cylinder. Low temperature type ST707 NEG strip which has activation temperature of 400℃ is used. A pumping speed of 400 l/s for hydrogen is expected at one pump after activation at 300℃ for 30 min[6]. During operation, the most effective activation process was investigated. Photograph of the NEG pump is shown in Fig.2.

4 Application of the NEG pump to the system

Thirty-one units of this pump were installed in the ring. A sum of pumping speed of the NEG pumps for hydrogen amounts to 12000 l/s. This value means the increase by 40% of the total pumping speed after the first upgrade. In the section S3, more NEG pumps (eight units) were installed in comparison with those at other sections, because non-destructive beam profile monitors which must be kept at a low temperature of about 100℃ during baking was located in this region.

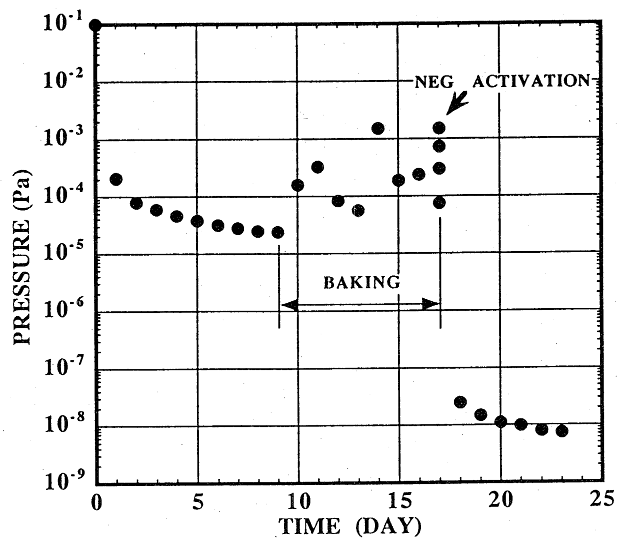

Fig.3 Pumping-down curve at S3 chamber.

Pumping-down curve at S3 chamber in the ring is shown in Fig.3. Baking was performed with sheath heaters at temperatures of 350℃ (TGP), 250℃ (IP) and 100-300℃ (chambers). Dipole magnet chambers were baked by a dc current passage through the chamber walls around the ring at 1000 A. The temperature was 150℃ in the central part of the dipole chamber. Baking time as long as eight days were needed for sufficient outgassing treatment, because gas load exceeding the pumping speed of TMP was imposed by baking. Baking temperature was controlled by slide regulators to keep the vacuum pressure lower than the order of 10^{-3} Pa. We aimed to get a vacuum pressure of the order of 10^{-5} Pa at the end of the baking when the full heater power was supplied. Activation of NEG pump was performed after three-days heating at 150℃ and at the end of all baking process by gradually stepping up to 400℃ during 30 min.

Fig.4 shows the vacuum pressure at S3 after the first upgrade in 1991. The pressure gradually decreased to the order of 10^{-9} Pa after the second upgrade by NEG pumps in 1994. It was found that this type NEG pump is useful to our system.

Mass spectrum of the residual gas at S3 is shown in Fig.5. About 95% of H_2 and a few% of CO, CO_2, CH_4 and H_2O are observed.

The change of the vacuum pressure at the beam time from 1988 to 1997 is shown in Fig.6. The pressures have been measured at eight positions in the ring. A 1/e beam life time of 3 sec was measured for $^4HeH^+$ (12.5MeV) at an average vacuum pressure of $1x10^{-8}$ Pa.

4 Conclusion

The new type of NEG pumps activated from out-side of the pump chamber was successfully applied to the cooler ring. The average vacuum pressure of $1x10^{-8}$ Pa has been maintained during the beam time of atomic physics experiments.

Features of this type of NEG pump are summarized as follows;

(1) Simple structure without ceramic feed-through for activation.

(2) Effective outgassing of absorbed molecules on the inner surface of the pump chamber during activation.

Acknowledgment

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References

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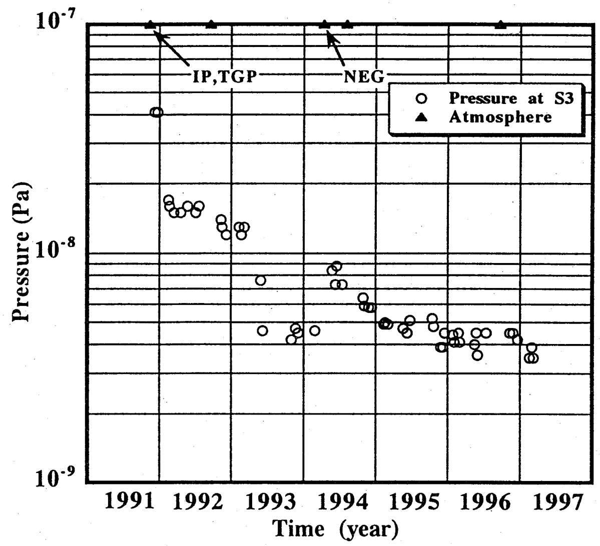

Fig.4 Vacuum pressure at S3 before and after upgrade by NEG pump.

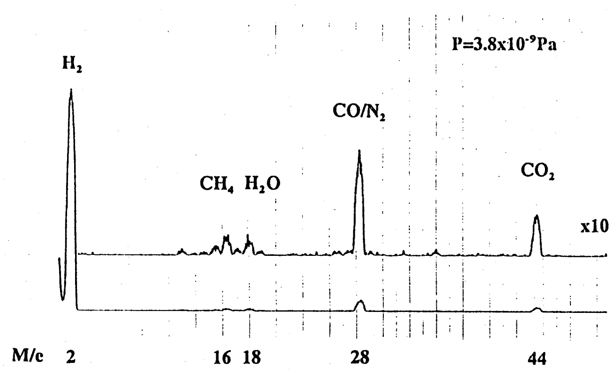

Fig.5 Residual gas spectrum at the S3 chamber.

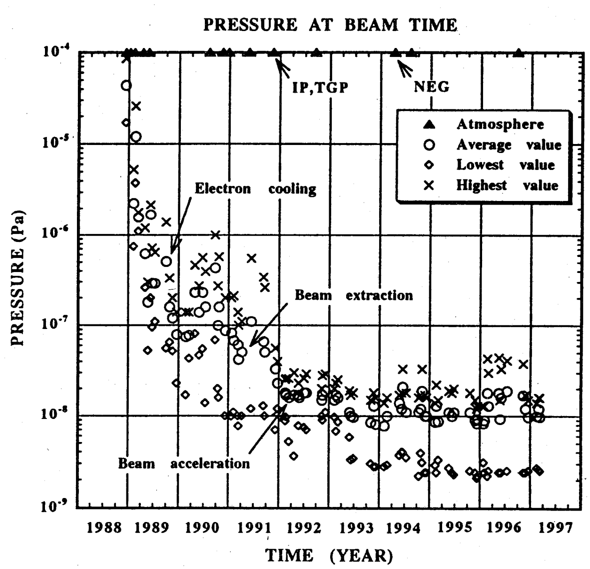

Fig.6 Change of the vacuum pressure at beam time.