THE PRESENT STATUS OF THE VACUUM SYSTEM IN KSR

H. Tongu, T. Shirai, T. Sugimura#, Y. Iwashita A. Morita# and A. Noda
Nuclear Science Research Facility, Institute for Chemical Research, Kyoto University
Gokasho, Uji-city, Kyoto 611-0011, Japan

Abstract

In order to reduce the aging time for the beam storage, improvement and upgrade of the vacuum system for KSR had been carried out at the end of 2001. Then the beam storage with high current without the acceleration is realized. The beam lifetime ware studied. It is considered that the beam lifetime decrease appreciably by the ion trapping

1 INTRODUCTION

The electron accelerator in ICR (Institute for Chemical Research) consists of an electron storage ring, KSR (Kaken Storage Ring), and an electron linac as its injector. KSR is a compact ring whose circumference and length of the long straight section are about 25.6m and 5.6m, respectively. Electrons with the energy of 100MeV is injected into KSR and then accelerated to 300MeV (storage mode) or slowly extracted without acceleration (stretcher mode) [1] [2].

The vacuum system of KSR has attained the average vacuum pressure of about $5x10^{-8}$ Pa without any beam injection. It, however, becomes about $1x10^{-6}$ Pa at the storage beam current of 5mA after the beam acceleration up to 300MeV because the synchrotron radiation generates the photodesorption gas. The beam lifetime is about 10 minutes at the storage beam current of 5mA, while the maximum current up to now with the storage mode is only 10mA. It is required to realize the beam lifetime of a few hours for the light source application.

Although it has been mainly utilized as a stretcher ring of the output beam from 100MeV electron linac, its commissioning as a synchrotron light source is also performed in parallel. Therefore improvement of the vacuum system and the machine study of the high storage current without the acceleration has been continued for the acceleration up to 300MeV and the beam storage.

2 VACUUM SYSTEM

The evacuation system was improved to extend the beam lifetime. As shown in Fig.1, six sputter ion pumps (SIP) with the pumping speed of 60 l/sec were replaced with ones with the pumping speed of 200 l/sec at arc sections. SIP of the pumping speed of 200 l/sec has been added at another long straight section. The operation time for the aging will be reduced by this modification.

In the present status of KSR, two ion clearing electrodes had been installed at the downstream parts of

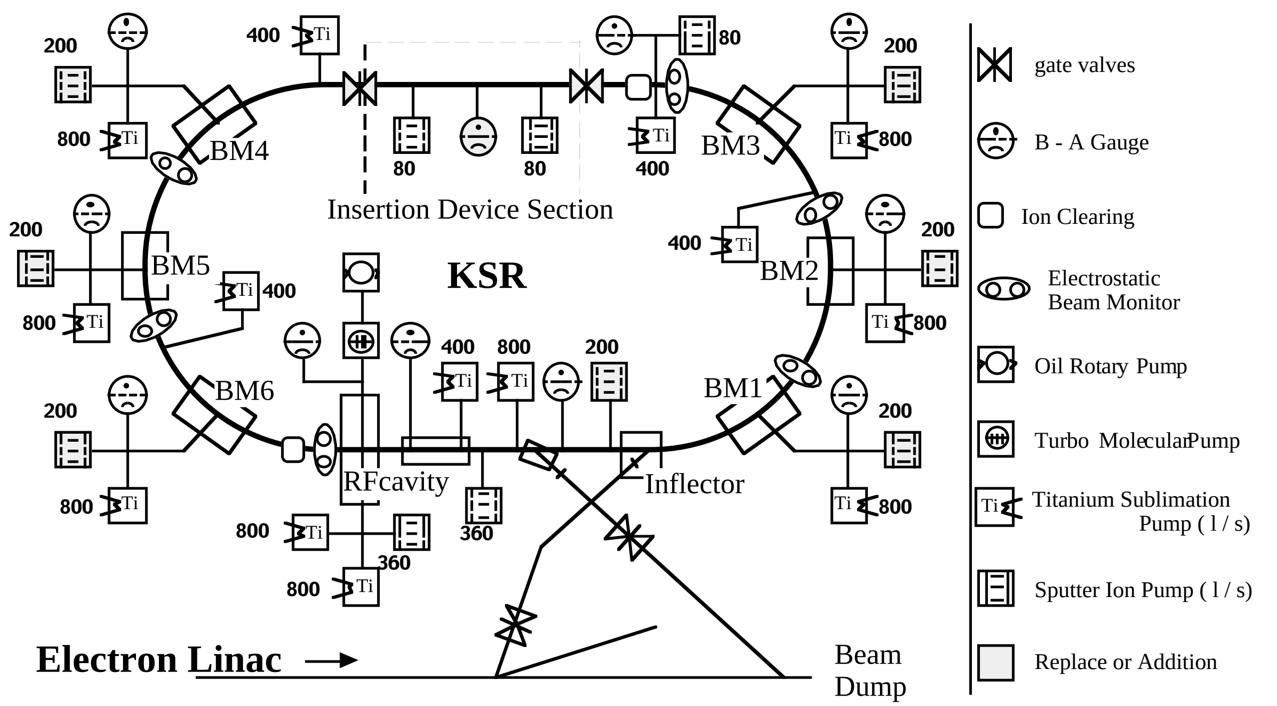

Fig.1 Layout of the vacuum system

Present address: KEK, Tsukuba, Ibaraki, Japan

BM3 and BM6 as shown in Fig.1. However the measured beam lifetime was shorter than estimated value. Also the beam instability was observed by the profile of the synchrotron radiation light. Therefore it was considered that the ion trapping occurred. The electrodes of the electrostatic beam monitors at the downstream parts of BM1, BM2, BM4 and BM5 are prepared to utilize as the ion clearing.

The insertion device section has been separated from other sections by two gate valves as shown in Fig.1. The vacuum systems of the insertion device and other sections can be disconnected by this modification. Therefore the aging of the arc sections will receive little influence during the study at the insertion deice section.

3 BEAM LIFETIME

As above described, data of the lifetime and so on with the acceleration up to 300MeV couldn't be obtained but data with the injection beam of about 100MeV were measured several times. The maximum storage current attained before the modification of the vacuum was about 60mA, while it has raised up to 80mA after the modification. Measured beam lifetime is shown in Fig.2.

The ion clearing is an effective method to extend of the beam lifetime as shown in Fig.2. It is certain that the ion trapping bring about the beam loss in KSR.

The beam size measured at the same time shown in Fig.3. Value of the vertical beam size is different too much with the situations of the ion clearing as compared with the horizontal beam size. The tune shift of about 0.001 is observed [3].

The beam life is limited by several factors such as the vacuum pressure, the Touschek life and so on in addition to the ion trapping. The beam lifetime with the Touschek effect is much longer than the one by the vacuum pressure in the present status of KSR.

It is assumed that the influence of the ion trapping with the low beam current is little, and the scattering with the residual gas is the dominant factor of beam loss. Thus the photodesorption yield is estimated about 3×10^{-5} by increase of pressure in the beam storage. Estimation of the beam lifetime is possible with the scattering process model as below[4].

(1) The beam loss occurs when electron goes out acceptance by the collision with the residual gas.

(2) The collision cross-section consists of factors as follows [5].

- Rutherford scattering on nuclei (elastic collision)
- Møller scattering on electrons (energy exchange)
- Bremsstrahlung

(3) The trapped ions are located with the Gaussian distribution in the same size as the electron beam.

(4) Amount of the trapped ions (*Ni*) is expressed by amount of electrons (*Ne*) and the neutralization factor (*n*).

$$n = Ni \, / \, Ne$$

(5) The beam loss by the ion trapping occurs the same process as the collision with the residual gas.

Therefore the beam lifetime (*t*) can be expressed by

$$1 \, / \, t = v \cdot d \cdot A$$

where v, d, and A are speed of electron, density of the collision gas and the collision cross-section.

Measured and estimated the beam lifetime and the vacuum pressure are shown in Fig.4 and Fig.6. The beam lifetime with six ion clearings of the applied voltage of 500V is nearly in the line of n=0.03 when the beam

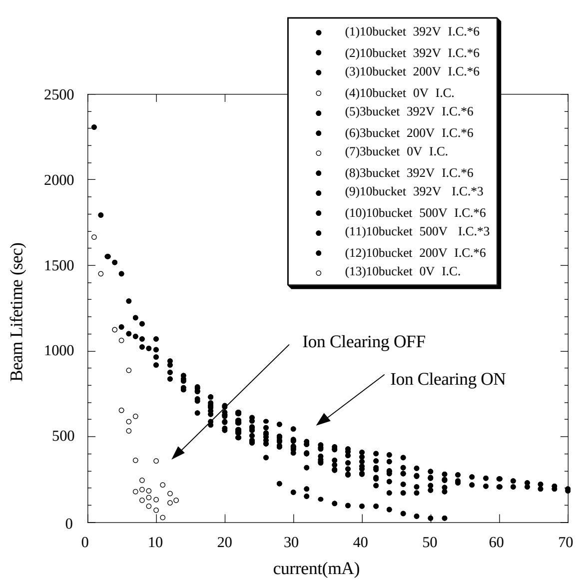

Fig.2 Measurement beam lifetime.

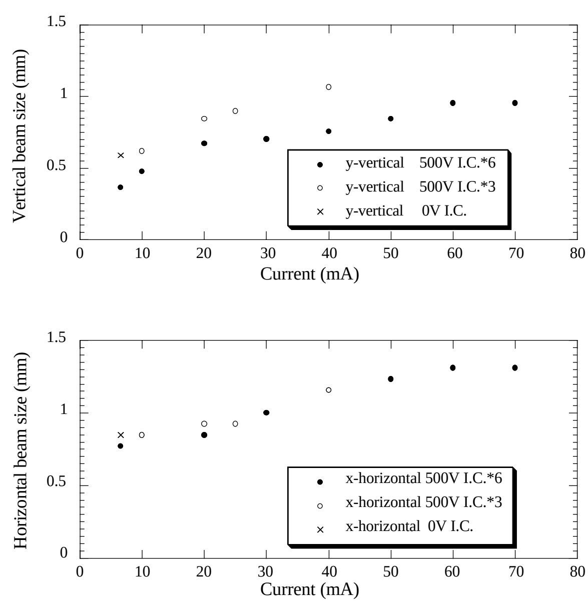

Fig.3 Beam size.

current is up to about 40mA. Then it goes down to the line of n=0.1 The beam lifetime is measured about 380sec while the storage current is about 40mA with six ion clearings of the applied voltage of 500V. Then the beam lifetime is estimated about 560sec while the storage current is 40mA without the ion trapping.

The beam loss with only 3 ion clearings rapidly occurs by the storage current of about 20mA then ions of n=1 are trapped. The beam lifetime with the applied voltage of 200V is a little shorter than the case of 500V by any storage current.

4 CONCLUSION

The above process is assumed to include only effects of the residual gas and the ion trapping. There are other factors that the beam life is limited. But the relation between the beam lifetime and the ion clearing can be given according to Fig.4 the following

(1) The relation between the beam lifetime and the storage current are two patterns. According to increase of the storage current, amount of the trapped ions increases like tendency of the estimation. Another pattern has rapidly the beam loss with some beam instability.

(2) The maximum storage current that the fast beam loss occurs is limited by amount of the Ion clearing (available area of the Ion Clearings).

Thus it is considered that the storage current of 100mA is able to accumulated when the Ion Clearings are added. But large improvement of the beam lifetime cannot be hoped. Now machine time for R&D of the beam instability is scheduled. It is expected that the study is useful for the beam acceleration.

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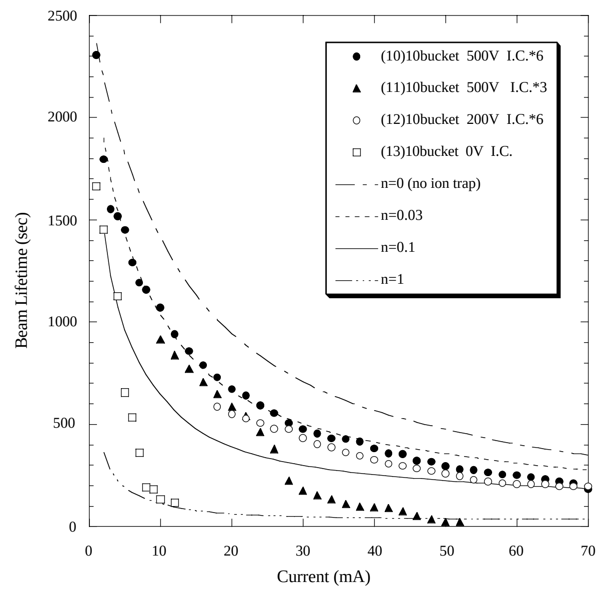

Fig.4 Estimation of the ion trapping for the beam lifetime

Table 1 Typical value (sec) of the beam lifetime according toFig.4. Measured value is values with six ion clearings of the applied voltage of 500V

neutralization factor	Storage current (mA)			
	60	40	20	5
n=0	399	561	929	1787
n=0.03	363	499	811	1387
Measured values	250	382	670	1149
n=0.1	201	251	378	912
n=1	37	42	60	168

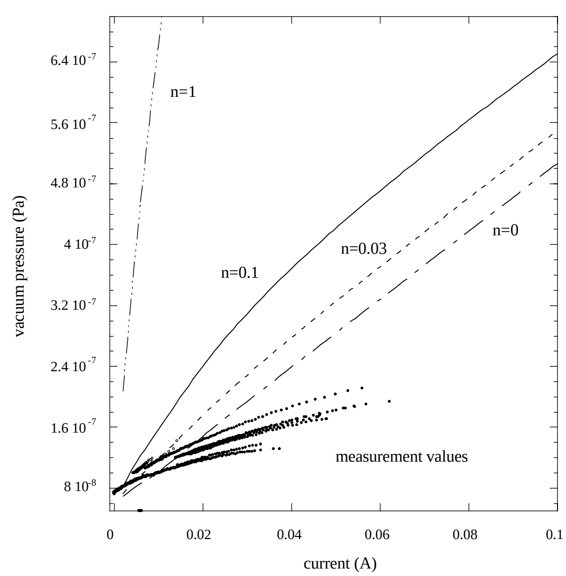

Fig.5 Estimation of the ion trapping for the vacuum pressure