VACUUM PROBLEMS OF RF CAVITIES
IN THE PF STORAGE RING

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INTRODUCTION

During operation of the PF storage ring, vacuum pressures near the RF accelerating cavities[1] sometimes increase, and it causes the beam lifetime to shorten. After the routine beam accumulation of 150 mA, the pressures gradually increase, although it does not occur every time, and sometimes get into the 10^{-7} Torr range. Hence the beam lifetime becomes very short. But it gradually recovers as the stored current decreases. This phenomenon depends upon the bunch filling structure[2] around the ring, therefore, it probably relates to the wake fields induced by the bunched beam.

Although we have not yet found its cause, vacuum problems actually occurred on the RF cavities will be described in this report, especially on the flange supporting the tuning plunger. When the cavity is powered by 30 kW in each, temperature at the surface of the tuner flange rises to 90 °C. This can cause a degassing or a thermal fatigue at the welded part. In fact, after baking of the cavity, an air leak was found at the welded point. Problems of this part and a plan for improvement will be discussed.

Temperatures at several points of the tuner flanges and the beam ducts were measured correlatively with the values of the pressures and the beam intensities. It was found no correlation among them.

LEAK AT TUNER FLANGE

In April of 1984, baking of the entire vacuum chambers of ring was carried out because the vacuum of the ring had never recovered after the accident of the leak from a beam line. The accelerating cavities were also baked out. After completion of the baking, cavity pressures of 2×10^{-9} Torr were obtained.

A trouble of the vacuum occurred on a cavity during the conditioning with high RF power. The ionisation vacuum guage placed at upstream of the cavities showed the sudden increase of the pressure up to the range of 10^{-6} Torr followed by the periodic change of the pressure as shown in Fig. 1. The oscillating structure recorded in Fig. 1 has a period of about 8 sec in the beginning, which increases gradually up to 11 sec. The amplitude was almost constant unless the pumping speed of the evacuation system was changed. This phenomenon repeated intermittently as shown in Fig. 2.

A mass spectral measurement on the residual gases was made. The mass spectra were obtained on a ANELVA model AQA-100 MPX quadrupole massfilter which was placed near the ionisation guage. It was found that the peaks at m/e of 14,18,28,32 and 40 became high when the pressure increased. These peaks may be assigned to N, H_2O, N_2, O_2 and Ar, respectively. The result suggests that the increase of the pressure is due to the leak of air.

In order to find out the location of the leak, a leak detection was made by use of a He leak detector (ANELVA model ASM 10). No leak of He was detected by the method of blowing He gas on the vacuum envelope. Then we tried to cover each part of the cavity with he bag. Finally it was found that He gas leaked into the vacuum chamber when the housing of a tuning plunger was covered by a He bag, and that the leak of He coincided with the increase of cavity pressure. Therefore it was concluded that the periodic change of the pressure was due to the periodic leak of air and that the leak was located at the housing of the tuning plunger.

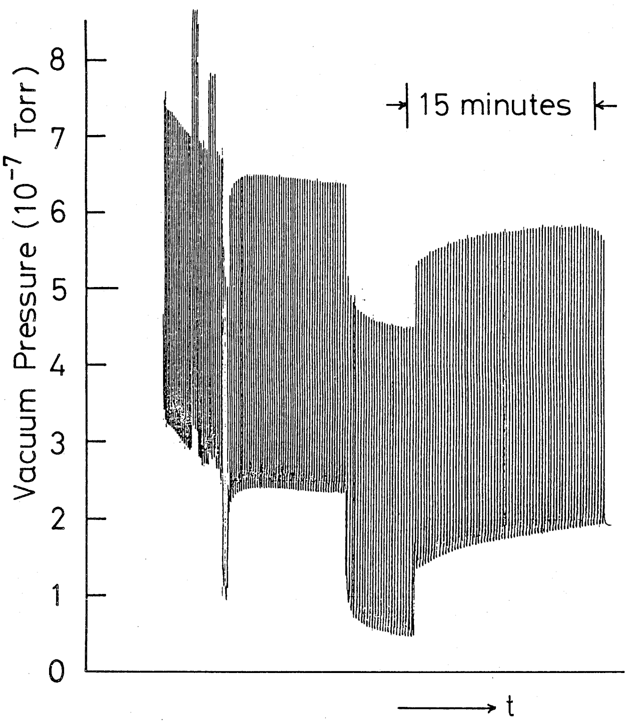

Fig. 1 The periodic change of the pressure near cavity recorded by the ionisation vacuum guage.

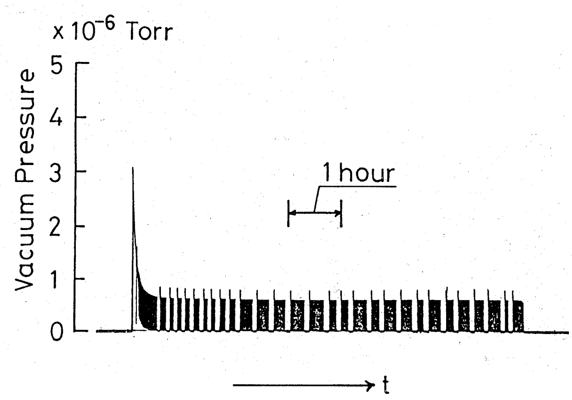

Fig. 2 The periodic change of the pressure recorded for several hours.

Because we could never get rid of this leak, the cavity was exchanged for a spare. In order to probe the cause of the intermittent leak, a detailed investigation of this leak was made. Figure 3 shows the structure of the housing. The housing is composed of three pieces. A port made of copper, C in Fig. 3, is silver-brazed to the cavity body. A nickel-coated transition piece (stainless steel, B in Fig. 3) is silver-brazed to the port. A stainless steel vacuum flange is helium-arc welded to the transition piece.

The leak detection indicated that the leak was located at the vacuum flange and its neighborhood. We found finally that oil-like liquid exuded on the surface of the vacuum side of the welded part between the vacuum flange and the transition piece as shown in Fig. 4.

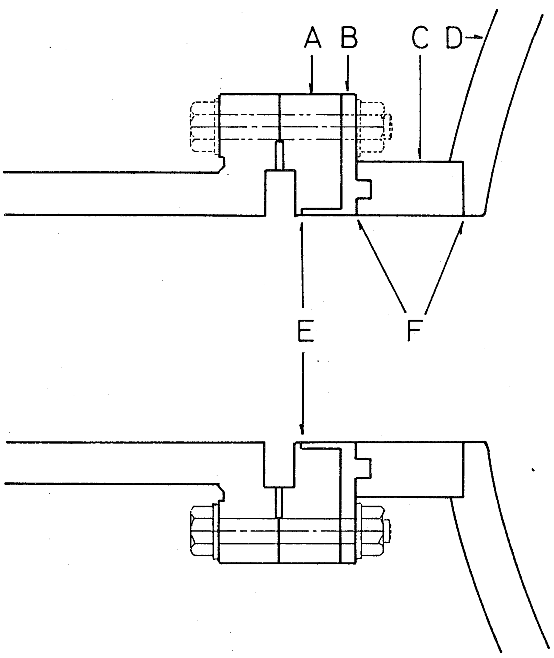

Fig. 3 Schematic drawing of the housing of the tuning plunger. A:vacuum flange, B:transion piece, C:port, D:cavity body, E:He-arc welded part, F:silver-brazed parts

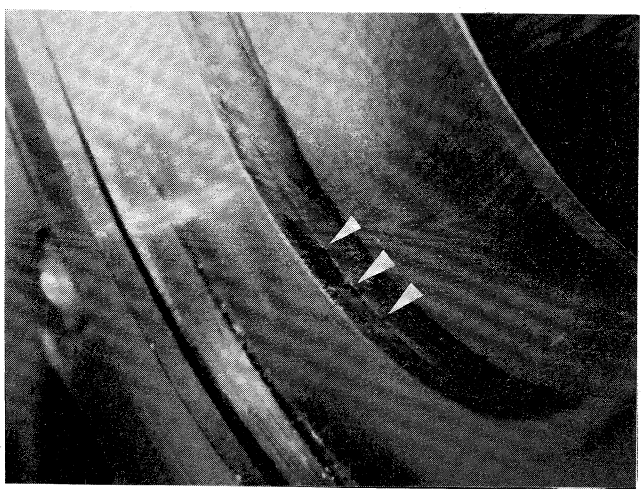

Fig. 4 Photograph of the tuner flange. The oil-like liquid is seen at three points.

The reason for the periodic leak of air might be explained as follows: (1) The pin holes opened at the welded part during the conditioning of the cavity. (2) The welded part had the cracks filled with oil-like liquid. (3) Air penetrated in the liquid and a bubble formed. (4) When the pressure of the bubble exceeded the surface tention of oil-like liquid, the bubble break and then the leak occurred.

The vacuum flange and its neighborhood mentioned above is heated by the RF field. The formation of the cracks or pin holes might be due to thermal fatigue.

The housing of the tuning plunger has somewhat complicated structure so that it is difficult to detect or get rid of a leak. It is necessary to cool the tuner flange with water. Following improvements on this part are progressing: (1) The nickel-coated piece, B in Fig. 3, will be removed. (2) Inner side of the flange, A in Fig. 3, should be made of copper.

DETERIORATION OF VACUUM PRESSURE NEAR CAVITY

Another vacuum problem is the deterioration of the pressure near cavities which gives an important influence upon the beam lifetime. Figure 5 shows an example that the increase of the pressure near cavity causes the beam lifetime to shorten. The pressure, P in Fig. 5, increases abruptly up to the range of 10^{-7} Torr about one hour after the beam accumulation of 150 mA. The beam current, I in Fig. 5, decays rapidly with the increase of the pressure. The lifetime is shortest when the pressure reaches its maximum, and then, recovers as the pressure decreases. This phenomenon does not occur every time. The pressure remains mostly 4×10^{-8} Torr or lower. In this case, the rapid decay as seen in Fig. 5 is not observed.

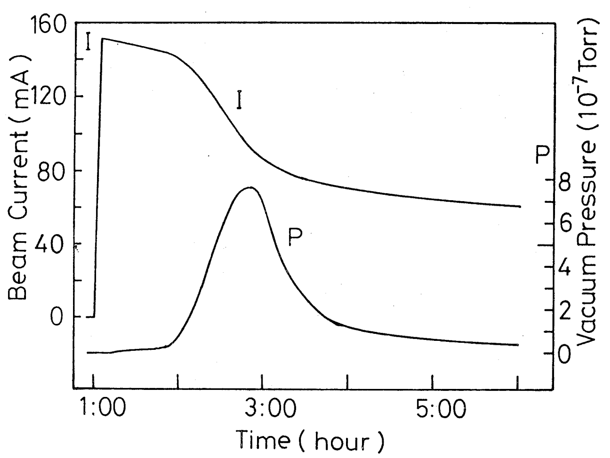

Fig. 5 An example of lifetime shortening due to the deterioration of the pressure near cavities.

The deterioration of the pressure depends upon the bunch filling structure around the ring. It occurs more frequently when the filling shape of RF buckets is more sharp. Therefore it probably relates to the wake fields induced by the bunched beam. The wake fields may heat some part of cavity and make degassing. The temperatures were measured at the several points of the tuner flanges and the beam ducts. It was found, however, that there was no correlation between the vacuum pressure and the measured temperatures.

ACKNOWLEDGMENT

We are very grateful to members of the PF storage ring for operating the machine.

REFERENCES

1. PHOTON FACTORY ACTIVITY REPORT 1982/83.
2. Y. Yamazaki, M. Kihara and H. Kobayakawa : KEK Report KEK 83-17, 1983.