Two Years of the Synchrotron Radiation Source HiSOR

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Abstract

Beam operation of the synchrotron light source, "HiSOR", at Hiroshima Synchrotron Radiation Center, Hiroshima University, began in FY1997. After that the vacuum system was upgraded to improve the beam lifetime, and the tune survey system was installed. Increasing more steering magnets is prepared for the correction of closed orbit distortion, the stabilization of the beam orbit and related problems. Now the HiSOR is under stable operation for a storage current of 100mA with the lifetime of 10 hours. In the near future, we will get approval from the radiation protection authority for the operation with 200mA.

1 Introduction

The synchrotron radiation source at Hiroshima University, called HiSOR [1], is a 700 MeV storage ring of a racetrack type with a linear and a helical undulator at each straight section [2-4]. The injector is a 150 MeV microtron [5]. The storage ring, together with the injector, was constructed by Sumitomo Heavy Industries Ltd. until the end of FY1996. Initial tuning and operation of the storage-ring/injector system were made by the manufacture, and the operation was taken over to the university staff in September 1997.

Accelerator control system consists of GPIB devices and tracking operation is performed according to the sequence file written in GPIB commands [6]. On executing the sequence file, pattern excitation of each magnet and input of the RF power corresponding to the acceleration energy are carried out; and then the electron energy is increased up to 700 MeV.

An improvement of the vacuum degree by repeating degassing operations every day forced frequently to update the acceleration parameters (sequence file), since tunes of the storage ring were affected by ion trapping depending on the vacuum degree, resulting in the change of acceleration efficiency. A tune measurement system, however, was not fixed to the storage ring, and an operation point was unknown. Therefore it took many hours to update the acceleration sequence.

The beam lifetime with a storage current of 100mA was achieved 4 hours in May, 1998; at that time the accumulated dose was 40 A*hours and the average pressure all over the ring was 1.0E-8 torr.

2 Outline of HiSOR Storage Ring

The HiSOR storage ring is composed of two 180 deg. bend magnets and four quadrupole doublets. The lattice and the beam optics for the HiSOR ring are shown in Figs.1 and 2, respectively. Since the pole gap of the bending magnet is as narrow as 42 mm in order to produce magnetic fields as

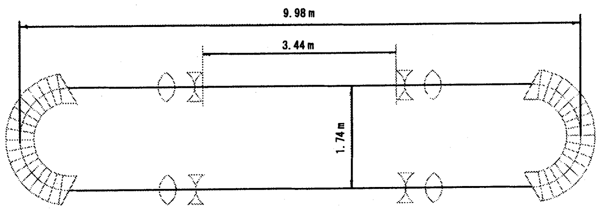

Fig.1 Magnet lattice of the HiSOR storage ring.

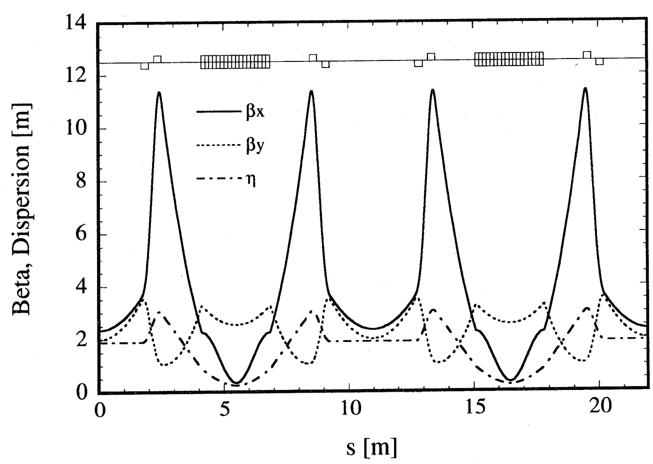

Fig.2 Beam Optics of the HiSOR storage ring.

strong as 2.7T, an edge focusing scheme is employed, giving a suppressed vertical betatron function in the magnet as shown in Fig. 2. The vertical betatron function for the straight section, where the undulator with a gap of 30mm is installed, is controlled by quadrupole doublets at both ends of the straight sections. The main design parameters of the HiSOR ring are listed in Table 1.

Table 1 Specifications of the HiSOR storage ring.

Type	Racetrack Synchrotron
Injector	Racetrack Microtron
Beam Energy at Injection	150 MeV
at Storage	700 MeV

Magnetic Field at Injection	0.6 T
at Storage	2.7 T
Magnet Pole Gap	42 mm
Bending Radius	0.87 m
Circumference	21.95 m
Betatron Tune, Horizontal	1.72
Vertical	1.84
RF Frequency	191.244 MHz
Harmonic Number	14
RF Voltage	220 kV
Stored Current (Normal)	300 mA
Beam Filling Time	5 min
Beam Lifetime (at 200 mA)	>8 h
Beam Emittance	0.4π mm・mr
Critical Wave Length	1.42 nm
Photon Intensity (5 keV)	1.2×10^{11}/sec/mr^2 /0.1%B.W./300 mA
Beam Ports at Bend. Sec.	7×2 with 18° Interval
at Straight Sec.	2
Angular Width of Beam Port	20 mr
Ring Dimensions, Width	3.1 m
Length	12 m
Height	1.8 m
Beam Level	1.2 m
Total Weight	130 ton.

3 Operational Experience in Two Years

History of Vacuum Conditioning

Daily self-cleaning by the synchrotron radiation improved the beam lifetime gradually, but it was extremely difficult to achieve the target lifetime of 8 hours with 100mA only by repeating self-cleaning every day. Then, the vacuum system of the HiSOR ring was upgraded: four sets of ion pumps and five sets of titanium sublimation pumps (TSP) were newly installed. At the same time, a kicker was also installed for the purpose of tune measurements. The main pumps of the HiSOR ring are written in Table 2.

Fig.3 shows improvements of the lifetime and the vacuum degree. In the figure, the pressure measured at two points of the storage ring is plotted. The vacuum degree became about one order of magnitude better. As the result, the lifetime of a 100mA beam reached 6 hours after a month operation, and during the next month the target lifetime of 8 hours was achieved.

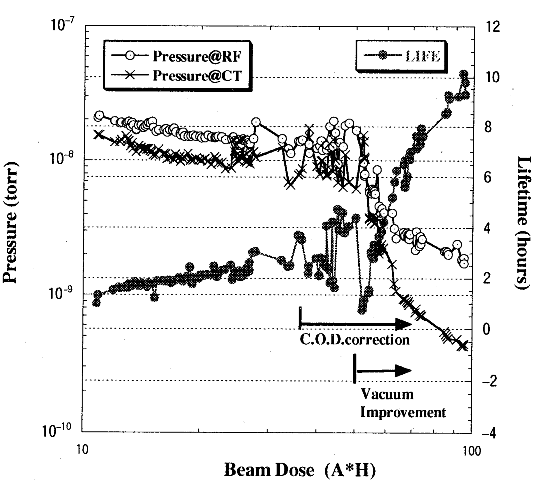

Fig.3 Improvements of the vacuum degree and the lifetime of a 100mA beam, as a function of accumulated dose.

Table 2 Main pumps of the HiSOR storage ring.

Type	Pumping Speed (litters/sec)	Number of Items
Cryosorption pump	20000	2
Ion pump	300	4
NEG pump	1000	6
Turbo pump	550	2
Pumps newly installed		
Ion pump	500	2
	300	2
TSP	1000	5

2.2 Tracking from 150MeV to 700MeV Operations

Tune of the HiSOR ring was measured using the tune measurement system including the installed kicker, and tune of an operation point was investigated. Since it was found that the operation point deviated from the design value, the acceleration parameters were selected so as to bring the operation point close to the design value mostly. The tune

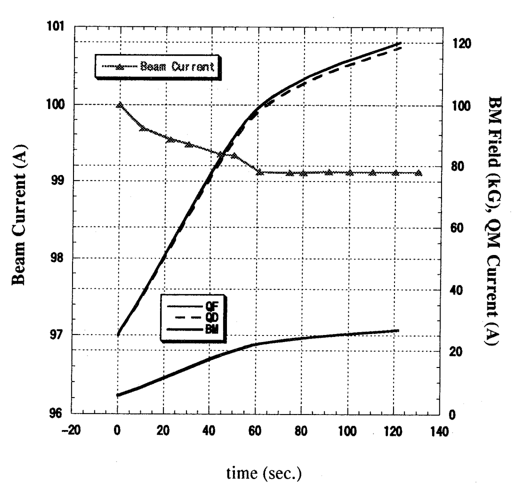

Fig.4 Tracking pattern from 150MeV to 700MeV.

diagram obtained from the tune measurements, the operation points and so on are presented in this workshop [7]. Having become the operation point clear, update of tracking pattern also becomes easy and its acceleration efficiency also improves to about 99%. Fig.4 shows the excitation patterns of the bending and quadrupole magnets, together with the decay of beam current during acceleration from 150MeV to 700MeV.

2.3 C.O.D.Correction

Although it is possible to hold the operation point close to a design value on the tune, the distortion from the design orbit is in a quite severe state, especially for the vertical one. The HiSOR storage ring is equipped with six button monitors (BPM) and two wire monitors as the beam position monitor. Fig.5 shows the beam positions at BPMs before and after the correction of the closed orbit distortion. The average horizontal distortion is bigger, but it becomes better than the vertical one by the correction. The reason why the vertical distortion cannot be corrected still is not clear.

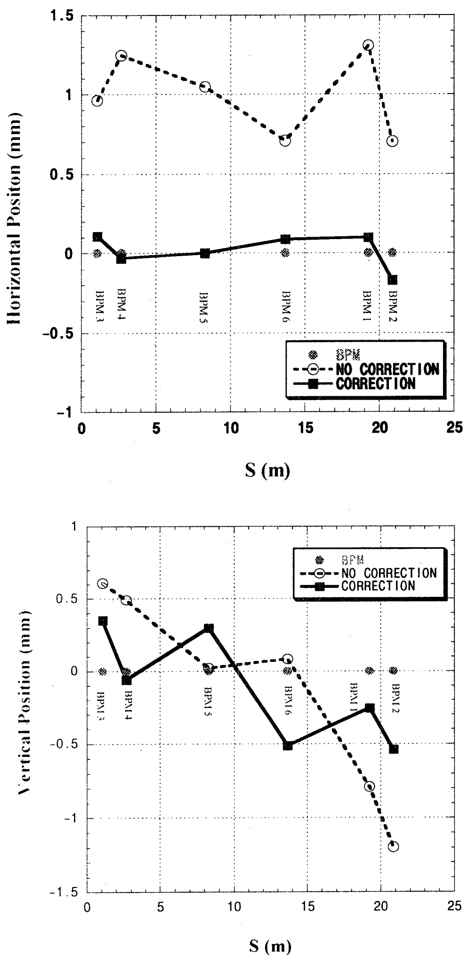

Fig.5 Closed orbit distortions of the HiSOR storage ring for the horizontal (the upper) and the vertical case (the lower).

The HiSOR storage ring has six steering magnets for the horizontal and vertical corrections, respectively. However, these are ones for the purpose to correct the orbit of photon beam from the undulators: they are not at effective positions to correct the beam orbit. Then, it's being prepared to install more steering magnets for correcting the orbit distortion regardless of the use of undulators. Steering magnets will be installed between four doublets of quadrupole magnets, respectively, as there are no space to install at more effective position judging from beam optics.

2.4 Stability of Electron Beam Orbit

Fig.6 shows vertical beam positions averaged through each day, measured with wire monitors at beamlines BL8 and BL16. The results show that the beam position is varying a few hundred micro meters a day. As there is no feedback system for the beam position, it is necessary to try feedback using new steering magnets. Moreover,

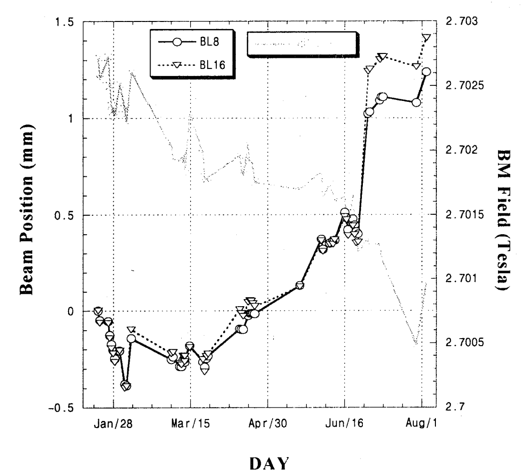

Fig.6 Variation of beam position and BM field with time.

measurements of the beam instability will also be unavoidable, since the storage current is to be made into 200mA mode from the present 100mA mode soon, and the current is to be increased also from now on.

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