PRESENT STATUS OF ACCELERATORS IN AICHI SYNCHROTRON RADIATION CENTER

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Abstract

Aichi Synchrotron Radiation Center was opened for public use on March 26, 2013. The circumference of the storage ring is 72 m with the electron energy of 1.2 GeV, the beam current of 300 mA. The beam is injected from a booster synchrotron with the energy of 1.2 GeV as full energy injection and the top-up operation has been carried out routinely with stored current of 300 mA since opened for public use. There are four 5 T superbends of which bending angle is 12 degrees in order to generate hard x-rays. The superbends are running without any trouble with cryocooler maintenance. A new pulsed sextupole magnet has been testing for beam injection.

INTRODUCTION

Aichi Synchrotron Radiation Center [1] is the newest synchrotron radiation facility in Japan, which had been referred to by the tentative name of Central Japan Synchrotron Radiation Facility [2]. Aichi Synchrotron Radiation Center is the principal facility of the project “Knowledge Hub Aichi” of Aichi prefecture, to establish a new research center for technological innovations in collaboration with universities, research institutes, local government and industries.

The construction was started in 2010 and the facility was opened for public use on March 26, 2013. The accelerators have been operated about 1400 hours stable in a year. Eight of the synchrotron radiation beamlines have been operational for public use and other two beamlines are under construction.

ACCELERATORS

Figure 1 shows the layout of the accelerators and synchrotron radiation beamlines. The injector linac of 50 MeV and the booster synchrotron has been located in the inside of the storage ring. The accelerators are surrounded by the concrete shield and located in the center of the experimental hall of the facility.

The parameters of the accelerators are listed in the Table 1 [3-5]. The circumference of the storage ring is 72 m with the electron energy of 1.2 GeV, the beam current of 300 mA and the natural emittance of about 53 nmrad. The beam is injected from a booster synchrotron with the energy of 1.2 GeV as full energy injection and the top-up operation has been carried out routinely with stored current of 300 mA since opened for public use. The storage ring consists of four triple bend cells. Eight of the twelve bending magnets are normal conducting ones. Four of them are 5 T superconducting magnets (superbend [6]) of which bending angle is 12 degrees. The superbends are the key equipment of the facility in order to generate hard x-rays even at a relatively low energy of 1.2 GeV electron storage ring [2-5].

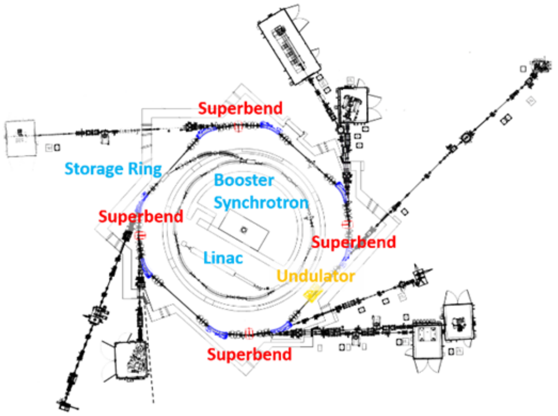

Figure 1: Layout of accelerators and beamlines.

Table 1: Parameters of Accelerators

Storage ring	
Electron energy	1.2 GeV
Circumference	72 m
Operating current	300 mA
Natural emittance	53 nm-rad
Betatron tune	(4.73, 3.18)
RF Frequency	499.702 MHz
Harmonic number	120
Natural energy spread	8.4×10^{-4}
Normal bending magnets	1.4 T, 39°
Superbend	5 T, 12°
Booster synchrotron	
Electron energy	50 MeV – 1.2 GeV
Circumference	48 m
Current	～1 mA
Repetition rate	1 Hz
Injector linac	
Beam energy	50 MeV
Charge	～ 1 nC/pulse
Pulse length	～ 1 ns
RF frequency	2,856 MHz
Repetition rate	1 Hz

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The parameters of the superbend are shown in Table 2. The superbends are running without any trouble with cryocooler maintenance once per year.

Table 2: Parameters of Superbend

Return York	C-shaped
Conductor type	NbTi/Cu
Cryo-system	2-stage 4K-GM cryocooler
Operating current	~100 A
Peak magnetic field	5 T
Bending angle	12°
Warm bore gap	42 mm

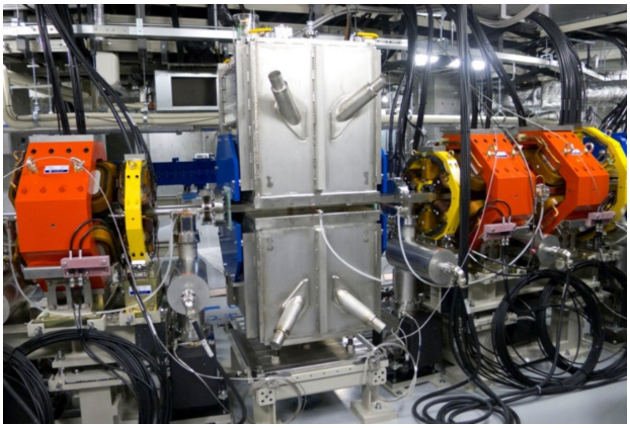

Figure 2: Photo of a superbend.

The refrigerators of the superbends are 4K-GM type cryocooler. We do not use refrigerant such as liquid helium or liquid nitrogen. In the cryostat of the superbends, the reservoir tank for the refrigerant is not equipped.

We have to replace the cryocooler once par year for the maintenance. Figure 3 shows the temperature of a superconducting coil of a superbend at the time of the replacement of the cryocooler. Until just before the replacement of the cryocooler, the cryocooler is running. Just after the replacement, the temperature is higher than 40 K. Immediately running the cryocooler after the replacement, the temperature falls below 4 K in about 15 hours.

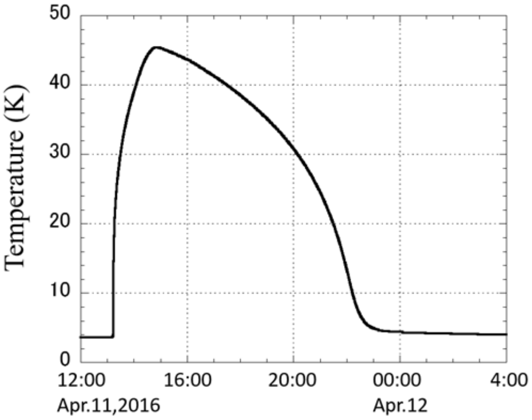

Figure 3: Temperature of a superconducting coil of a superbend at the time of the replacement of the cryocooler for maintenance.

We have four straight sections in the storage ring. One is used for a septum magnet for beam injection, other one is used for an RF cavity, so that there are two straight sections for insertion devises. An APPLE-II type undulator is installed in the straight section for VUV experiments. Table 3 shows the parameters of the undulator and Fig. 4 is a photograph of the undulator.

Table 3: Parameters of Undulator

Type	APPLE-II
Number of period	33
Period length	60 mm
Minimum gap	24 mm
Maximum K	
Linear	3.4
Vertical	2.0
Helical	1.7

Figure 4: Photo of the undulator.

MACHINE STATUS

Aichi Synchrotron Radiation Center is operated about 170 days in a year for user time. Mondays are assigned to the study of the accelerators and apparatus of synchrotron radiation beamlines. From Tuesday to Friday, the accelerators are operated for users. User times are 10:00 to 14:00 and 14:30 to 18:30. With the increase of users, there is also a case where the user time from 18:30 to 22:30.

In the routinely operation, the linac emits 50 MeV electron beam with about 0.7 nC per pulse at 1 Hz. The booster synchrotron accelerates the beam to 1.2 GeV and then injects the beam to the storage ring with the efficiency of about 30 %. The beam charge in the storage ring is increased by about 0.2 mA/s. In Fig. 5, the beam current in the storage ring is indicated from March 1 to March 4 in this year. The beam current is kept at 300 mA with the

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top-up operation. Figure 6 shows the beam current under typical top-up operation in 10 minutes. The fluctuation of the beam current during the top-up operation is about 0.2 %.

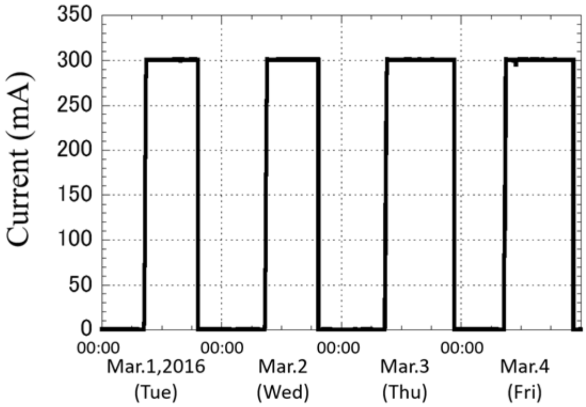

Figure 5: Beam current in the storage ring of ordinary user time in one week.

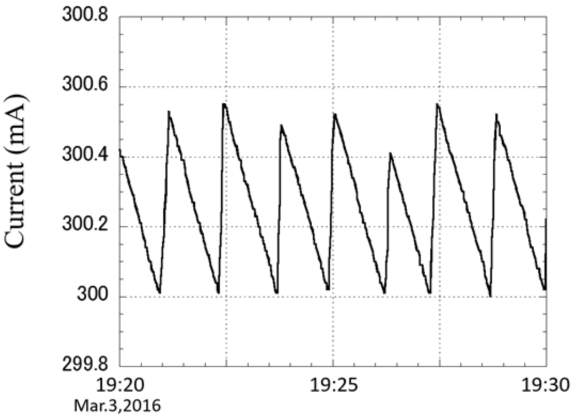

Figure 6: Beam current under typical top-up operation.

DEVELOPMENT OF PULSED SEXTUPOLE INJECTION

We have introduced a pulsed sextupole magnet [7, 8] in one straight section of the storage ring in October last year in order to reduce the movement of the stored beam during the injection [9, 10]. Figure 7 is a photo of the magnet.

In the conventional injection method, we use four pulsed dipole magnets and make a bump orbit over a half the circumference of the storage ring. So that, during the injection at some beam lines constructed in the bump orbit, we cannot use synchrotron radiation. Furthermore, because the local bump orbit is not closed, the orbit of the sored beam moves in 20 % ~ 30 % of the beam size over the whole circumference.

After installing the pulsed sextupole magnet, we have continued to test the magnet. The beam injection by using the sextupole magnet was successfully achieved with the injection efficiency about 30 % from booster synchrotron, however there is oscillation of the stored beam of the order of several mm lasting about 100 micro-second. We should decrease the oscillation amplitude of the stored beam for the routine operation.

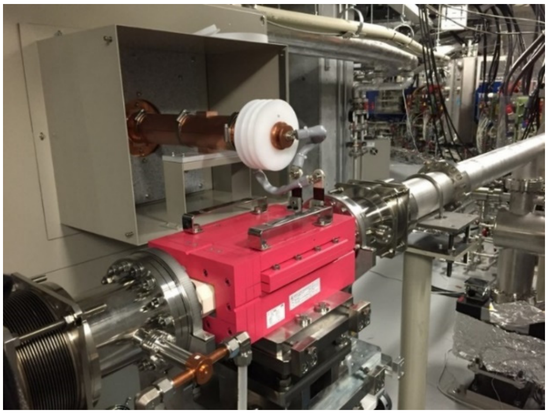

Figure 7: Photo of the installed pulsed sextupole magnet.

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