OPERATIONAL STATUS OF POHANG LIGHT SOURCE

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Abstract

The PLS, a 2-GeV dedicated electron synchrotron light source, has been in normal operation mode for users since September 1995. It consists of 2-GeV electron linear accelerator, which works as a full energy injector, and a storage ring. The linac is 150-m long and has 42 accelerating sections. The storage ring has a 12-cell TBA type lattice with 4 rf cavities. The construction of PLS was started in 1988, and the installation was completed in August 1994. From then until December 24, 1994, which we call the first commissioning phase, we succeeded in stacking the 2-GeV electrons up to 300-mA in the storage ring. After baking out the vacuum chamber, the second commissioning was performed from April to July 1995. In 1996, the user beam time reaches about 2,800 hours among 4,800 hours of the accelerator operation time. We present the current operational status of PLS in this paper.

1 INTRODUCTION

The PLS, a third generation light source, consists of a 2-GeV linac and a storage ring [1]. The project started in 1988 and the construction was completed in 1994.

1.1 Linac

The PLS linac is working as a full energy injector to the storage ring. It consists of 11 klystrons and modulators, 10 pulse compressors, 42 accelerating structures including those for the preinjector.

The 1-ns long output electron beam from the 80-kV e-gun passes through the bunching system. The prebuncher is a reentrant type, standing-wave cavity, and the buncher is a travelling structure with four cavities including the input and output coupler cavities. The beam is compressed into three micro-bunches. This bunched beam passes through 42 accelerating structures and get the 2-GeV energy from microwaves of 2,856 MHz in the structures. The required accelerating gradient of the main linac is at least 15.8 MV/m. Considering one or two klystrons as stand-by, it requires an accelerating gradient of 17.8 and 19.8 MV/m, respectively. In order to achieve this accelerating gradient, we adopt high power klystrons of 80-MW maximum output and SLAC-type pulse compressors with TE015 operation mode. In addition, we require the RF pulse length at least 4 ms for a higher energy multiplication factor from pulse compressor cavities.

The beam transport line (BTL) for connecting the storage ring and the linac consists of 5 bending magnets, 24 quadrupoles, 5 vertical correctors and 8 horizontal correctors. The 2-GeV electron beam leaving the linac is bent to 20 degrees horizontally by two bending magnets toward the injection area of the storage ring. After the beam travels about 65-m behind the end of the linac, it is bent upward to the beam plane of storage ring which is 6-m higher than that of the linac.

1.2 Storage ring

The PLS storage ring lattice is a triple bend achromat structure with 12 superperiods and 280.56-m circumference. Each superperiod has a mirror symmetric configuration. Each half superperiod contains six quadrupoles; three in the dispersive section and three in the non-dispersive section.

Since the completion of its construction in 1994, the PLS storage ring underwent the commissioning in two phases; the first one from September 1 to December 23, 1994 and the second one from April 4 to July 21 1995. The maximum current reached to more than 300-mA at 2- GeV during the phase I commissioning. However, the beam lifetime was less than 50 minutes at 100-mA because of poor vacuum. During the machine shut-down from January to March 1995, which was between the two commissioning periods, all the chambers were baked out. When the phase II commissioning started, the beam lifetime was 2 hours at 100-mA, and at the end of the commissioning, it reached to 10 hours at 100-mA. The total dose attained during this commissioning was about 114 ampere hours.

On September 1, 1995, the PLS finally opened for user service mode. However, on October 19, there was water leakage from the flange in No.1 sector, and we could not supply the beam to users for 40 days. Total beam storage time during 1995 was 3,329 hours. From September to December in 1995, the beam was stored for 1,944 hours. In this period, the beam was available to users for 1,142.4 hours, and the average beam availability to users was 64%. If the vacuum failaure from the water leakage be excluded, the availability would be about 95% [2].

2 STATUS, STUDY AND ACTIVITIES

As the main subject of the beam physics study, both the conventional ion trapping and the new Fast Beam-Ion Instability have been studied. For analytic study, the theory of two beam instability is applied. Even though this linear theory cannot describe the instability growth

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correctly, it can properly describe the beginning stage of the instability.

As of December 1996, the accumulated operation time of the linear accelerator after the start of the commissioning in 1994 is about 7,960 hours. Until then, the total accumulated high voltage run-time of the linac klystron-modulator system has reached average 23,460 hours per module, and the average accumulated klystron heater time reached 23,746 hours. We expect more than 30,000 hours of the tube lifetime because the operation power level is approximately 65-80% of the rated power level. The operating time of 1996 is 6,432 hours and the availability is increased to 94% from 85% in 1995 [3]. The improvement of the availability is due to the modification of heater circuits not to be interrupted by the instant unnecessary heater power interruption in case of the momentary klystron vacuum change which is recoverable almost immediately.

The vacuum system of the PLS linac performed with average loaded microwave energy of 45.3 GJ per module in 1996. The average pressure was maintained about at 1.1 $\times 10^{-8}$ Torr in the klystron gallery under the high power microwave loadings of average 54 MW peak power per module with 4.1 ms pulse width and 10 Hz repetition rate. With 45°C cooling water supply, the outgassing rate of the system has been about 9.0×10^{-13} Torr·l/sec·cm^2. The residual gas consists of mostly hydrogen (62%) with minor molecules of H_2O, Ch_2OH, CO, C, N, and O_2. A total of 26 faults with 20 hours of the down time in the vacuum system appears to have MTBF (Mean Time Between Failure) of 181.8 hours and the system availability of 99.5%.

Most activities of the storage ring control system engineers have been devoted to the development of the machine diagnostics programs and the beamline control programs. They include the development of the data acquisition system for the X-ray fluorescence microprobe beamline and the upgrade of the existing data aqcuisition system as well as the development of the required console computer software.

The R&D and upgrade activities of the beam diagnostics system are focused on the longtime analysis of the closed orbit data, beam-based alignment (BBA) of the quadrupole magnet-BPM pairs [4,5], development of the transverse feedback system [6], and the construction of a diagnostic beamline.

In January 1996, the vacuum pressure of storage ring was $(1\sim3)\times 10^{-9}$ Torr at 100 mA of beam current. And the specific pressure rise due to the photon induced desorption was about 2×10^{-11} Torr/mA. The pressure rise is still decreasing and it reaches to $(4\sim6)\times 10^{-12}$ Torr/mA in December 1996 [7].

3 OPERATION STATUS

At the normal operation period, such as user beam time, beam line alignments and the storage ring tuning, electron beams are injected into the storage ring three times a day.

From January 8 to June 23, 1996, seven shifts were planned and performed for user beam times. Each shift consists of a ten-day run in user service mode and a two-day turn-off for the maintenance followed by a two-day run for machine study. For this period, the total planned machine operation time is 2,640 hours, in which 1,819 hours are assigned to users. Among the scheduled beam time for users, 1,715.23 hours have been practically devoted to users which corresponds to 94.3% of the availability.

The machine was shut-down from February 16 to March 10 to install a new front-end for the X-ray lithography beamline owned by LG Semicon. Also, we had the regular summer shut-down in July and August for system improvements and regular preventive maintenances.

After the shut-down, the user experiments resumed in September with five public beamlines. Two of them received their first users. Seven user shifts were scheduled until the end of 1996. Of the 1,416 hours of this beam time, 1,338 hours were actually provided. It corresponds to 94.5% of availability. Tables 1 and 2 summarize the results of beam operations during the user service modes of operation in 1996 and 1997.

Table 1. Summary of user service mode I

Run	Period	Planned	Supplied	%
96-1	1/8~1/26	423h 58m	401h 45m	94.8
96-2	2/5~2/12	264h	257h 36m	96.9
96-3	3/27~4/4	195h 26m	185h 52m	95.1
96-4	4/10~4/21	264h	252h 48m	95.7
96-5	5/1~5/9	192h	174h 08m	91.0
96-6	5/15~5/23	192h	167h 07m	92.1
96-7	6/12~6/23	288h	275h 58m	93.7
96-8	9/11~9/22	288h	265h 25m	94.2
96-9	9/30~10/15	360h	335h 23m	95.0
Sum		2467h 24m	2316h 02m	93.8

Table 2. Summary of user service mode II

Run	Period	Planned	Supplied	%
96-10	10/18~11/7	192h	184h 44m	96.7
96-11	11/13~11/20	192h	185h 53m	97.9
96-12	11/27~12/4	192h	183h 24m	97.4
96-13	12/3~12/16	192h	173h 09m	92.6
97-1	1/11~1/19	216h	199h 05m	92.2
97-2	1/25~2/3	240h	226h 36m	94.4
97-3	4/5~4/14	240h	222h 15m	93.7
Sum		1464h	1376h 06m	95.0

4 MACHINE UPGRADE

During the 1996 summer shut-down, a couple of major reinforcements have been added to the system for greater stability and reliability.

In the linac, optical cables were installed for timing system upgrade and the klystron heater interlock circuit has been modified, so that klystron and thyratron could be stable even in the case of instantaneous power failure. Also, the thermal shield blanket was installed for the microwave main drive line, which is made of copper tube (coaxial line) and was found responsible for the unstable beam energy drift caused by the automatic intermittent circulation of air.

In the storage ring, several suspect points of the vacuum chamber have been scrutinized and rebaked while some new devices were installed for performance enhancement; a kicker for the transverse feedback system, and new coils for the four quadrupole magnets damaged last January by interlock failure.

One more RF station was added to the storage ring. Total four cavities powered by independent power source, TV klystron, provide 240 kW of RF power, which is enough to store 400-mA of beam current at 2.0-GeV [8].

5 BEAMLINES

In 1996, three more beamlines have been installed and the total number of beamlines becomes 6. There is one more beamline for the beam diagnostics which was installed in 1996. All of them are bending magnet beamlines as listed in Table 3.

Table 3. Working beamlines

Beamline	Areas of Research	Year of Installation
Whitebeam	X-ray Microprobe	1996
Photoemission	Surface Science	1994
NIM	Atomic & Molecular Science	1995
EXAFS	Chemical Engineering	1996
X-ray Scattering	X-ray Diffraction	1994
Lithography	Semiconductor (LG)	1996

During the first half of 1996, total 34 experiments have been conducted using the three operational beamlines (photo-emission, NIM, and X-ray scattering beamlines). In the last four months from September to December, a total of 35 experiments have been conducted at five beamlines.

6 FUTURE PLAN

In the year 1996, there was no big change in the PLS beam state. Most parameter values were maintained without any significant change. But, it does not mean that the PLS is in a stable and fully tuned state. Rather we would like to say that it reached a phase I; the PLS is capable of storing a stable beam of 100 ~ 130 mA with lifetime more than 10 hours, and major lattice parameters are reasonably close to the design values [2]. We should make a transition to phase II, in which it is possible to store a stable beam of a few hundred mA with a lower emittance, and the machine itself is fully understood.

To achieve this phase and to serve the reliable photon beams to the users, we have some machine upgrade plans. Among them, the installation of beam position monitors in the linac and BTL for energy feedback system, beam based alignment, and the installation of longitudinal feedback system are included.

Adding to these, the installation of the 12th klystron-modulator module is being under progress and the U7 undulator is ready for its installation. As for the beamlines, SAX and X-ray diffraction beamlines are expected to be installed in 1997.

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