CHARACTERIZATION AND CONDITIONING OF RF SYSTEMS OF THE SIAM PHOTON SOURCE

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Abstract

The characteristics measurements of the RF systems of the accelerator complex of Siam Photon Source have been carried out. Degradation has occurred in the components including the RF cavities after the storage of the system without use for more than six years. This report emphasizes the procedure of the system inspection and the results. It is found that the system still can be used in spite of some degradation of the components.

1 INTRODUCTION

A synchrotron radiation research project, referred to as the Siam Photon Project is underway at National Synchrotron Research Center (NSRC) in Thailand. The light source used is the modified SORTEC source. The machine reassembly has been completed about 6 years after the dismantling of the original SORTEC accelerator complex.

The details of the Siam Photon Source are presented elsewhere [1,2]. The basic parameters of the storage ring of Siam Photon Source are given in table 1. At SORTEC laboratory, the accelerator complex was used for microlithography researches, and the storage ring structure was optimized for this purpose. At NSRC, however, the light source is to be used for general advanced scientific researches and the machine structure should be optimized for this. Because of this the machine structure and some operation parameters have been changed. Four long straight sections were added to the ring for the future use of insertion devices. The magnet lattice structure was changed to the DBA lattice. The natural beam emittance is reduced one seventh as small as that of the original SORTEC machine. The vacuum system is completely renewed. The structure of the high energy beam transport line (HBT), that connects the booster with the storage ring, is changed, although the magnets of the SORTEC HBT are used as a part of the magnet system of HBT of Siam Photon Source. The control system is also completely renewed, in accordance with the advance in computer technology [3]. The alignment work of the storage ring is also reported in this conference [4].

The deterioration of various machine components is expected to occur during a long period of their storage without use. This changes the characteristics of the machine. In the case of the storage ring, the alterations in the operation parameters also enhance the change in the characteristics of the machine. Thus, after the setup of the machines, their characteristics have to be investigated, and problems that are found have to be solved. Beam dynamics calculation have been carried out and are presented elsewhere [5,6].

Table 1: Basic operation parameters of the storage ring

Beam energy	1 GeV
Average current	300 mA
Ring circumference	81.3m
Harmonic number	32
Momentum compaction	0.0214
Natural emittance	72 π nm rad
Average β_x, β_y	7.072m, 6.598m
Synchrotron tune	0.003319
Betatron tune ν_x, ν_y	4.76, 2.8

The RF cavity of the booster synchrotron is of the re-entrant type with a resonance frequency of 118MHz. The storage ring is equipped with a similar RF cavity with the same resonance frequency. The RF powers at operation are 5kW and 12kW for the booster synchrotron and the storage ring, respectively. The linear accelerator (linac) operates at a resonance frequency of 2.856GHz. The RF power is 20MW. The linac consists of two pre-bunchers, one buncher and two traveling-wave-type acceleration tubes that accelerate electrons up to 40MeV. The booster synchrotron accelerates the electrons up to 1GeV before they are injected into the storage ring. All the work necessary for the commissioning of the RF systems such as aging (long period warm up and preliminary operation), conditioning (parameter adjustments), baking, important test measurements and test operations has been carried out so far.

This paper gives a brief report on the reconstruction, test measurements and operation of the RF components of the Siam Photon Source.

2 THE LINEAR ACCELERATOR

The main components of the linac are a klystron, an electron gun, two pre-bunchers, one buncher, two traveling-wave-type acceleration tubes and different kinds of focusing magnets. A schematic drawing of the linac is given in Fig. 1. The linac was that of the SORTEC source and used here without reformation. It

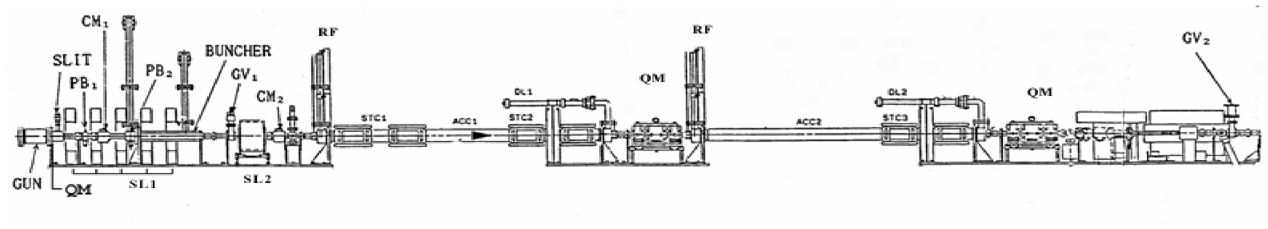

Figure 1 : Basic structure of the linac; QM: Quadrupole magnet, PB: Prebuncher, CM: Current monitor, GV: Gate valve, STC: Steering coil, RF: RF input, Acc: Accelerator tube, SL : Solenoid

was designed and build by Mitsubishi Electric. A small quadrupole magnet is installed upstream to the pre-buncher. It modifies the beam profile. A group of solenoids around the pre-bunchers and buncher suppress the divergence of the electron beam. Another solenoid is placed just upstream to the first acceleration tube. Three pairs of steering magnets are placed in the acceleration tube portion. One pair out of three steering magnet coils is not used.

In 1998, the linac was assembled temporarily in the laboratory zone of the NSRC building and the vacuum chamber was evacuated. This setup was necessary to protect the vacuum chamber against corrosion. It was kept in this state for two years until it was assembled at its final location in the underground hall of the Siam Photon laboratory building.

After the reassembly work was finished, test measurements and aging were carried out. Low power measurements have been performed with a Network Analyzer, while the reflected power was measured around the resonance frequency with a frequency interval of 2MHz. These reflection spectra were measured at the input parts of the two pre-bunchers, the entrance of the second acceleration tube and at the position of the wave guide at klystron output part.

From the obtained reflection spectra it is found that the reflection rate varies between 5.1% and 7.8% at the klystron output part. The reflection rate is about 7% at the resonance frequency. This reflection data appear to indicate that a relatively high power is reflected back to the klystron. The power reflected back from the second acceleration tube shows large fluctuations varying between 0.5% and 2.3%. The power reflected back from the two pre-bunchers varies between 23.8% and 57.3%. Both reflection spectra have similar smooth shapes with a maximum at the low frequency limit and a minimum around the resonance frequency.

For degasing treatment of the linac chambers with microwaves the klystron power was controlled to increase gradually, while the vacuum pressure was monitored. The electron gun was switched off during this procedure. It took around one month until the full RF power could be supplied. The pressure inside the tube was stable at around 10^{-5} to 10^{-6} Pa. The aging of the electron gun was carried out for a few days, until the operation voltage of 90kV could be supplied to the gun without discharge.

3 THE RF SYSTEM OF THE BOOSTER SYNCHROTRON

The RF system of the booster synchrotron was reassembled by Toshiba. The RF cavity installed in the synchrotron is shown in Fig. 2. It has a tuner which can be controlled manually through the control system. The proper operation of the power supply was examined up to the maximum power of 10kW for four hours, by supplying the power to a test dummy load.

After the assembly of the RF system was finished, low power measurements were carried out to find out the characteristics of the fundamental mode of the RF cavity. The obtained values were compared with values found by computer simulation, using the code named MAFIA. The change of the resonance frequency due to the movement of the tuner is qualitatively in agreement with the theory. The results are summarized in table 2.

Table 2: Measured characteristics of the booster synchrotron RF cavity

Resonance frequency	118MHz
Variable frequency range of tuner	500kHz
Unloaded Q-value (measured)	15134
Unloaded Q-value (calculated)	18685
R_s/Q	83.21Ω

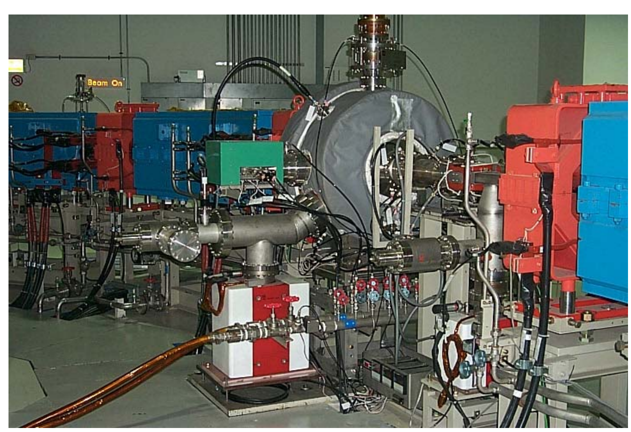

Figure 2: The RF cavity of the booster synchrotron inside the ring

4 THE RF SYSTEM OF THE STORAGE RING

The RF cavity of the storage ring has one manual and one automatic tuner. The automatic tuner is controlled by a phase lock loop during operation. The optimum position of the manual tuner for minimizing the effect of coupled-bunch instabilities was searched [7]. The angle of the coupling loop was adjusted to bring the coupling constant to its operation value of 1.77. Low power measurements of the characteristics have been carried out with the RF cavity after it was installed into the ring. The measured results and basic operation parameters are summarized in table 3. More details are reported elsewhere [8,9].

Table 3: Parameters of the RF system of the storage ring

Gap voltage	100kV
Variable frequency range of tuner	500kHz
Resonance frequency	118MHz
Unloaded Q-value (measured)	9610
Unloaded Q-value (calculated)	24974
R_s/Q	173.96Ω
RF power	14kW
Radiation loss per turn	32keV

The RF cavity was baked for 24 hours at 150°C. By this baking the base pressure around 10^{-8} Pa was attained. The RF cavity wrapped in coverings for baking is shown in Fig. 3. The mass spectrum of the residual gas after baking is shown in Fig. 4. It is recognized that the residual gas is mainly composed of hydrogen, water and carbonmonoxide.

Figure 3: The RF cavity installed in the storage ring during baking

5 DISCUSSION

The Siam Photon Source was not in use for about 6 years. The long period of the storage of the dismantled

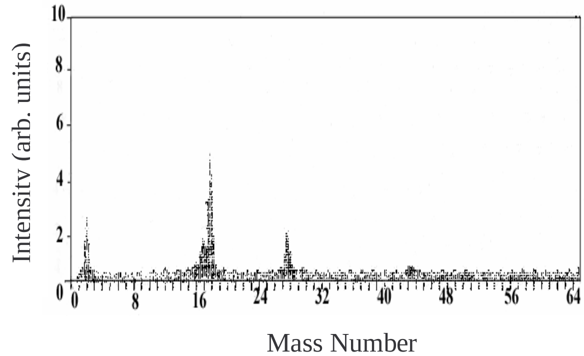

Figure 4: Mass spectrum of the residual gas after baking

machine components after the dismantling has lead some components part to deterioration and they had to be repaired or replaced. In the case of the linac, the measured reflection rates are high, but the klystron is protected by a circulator. In other words, this means that the power loss is large, and the throughput of the system is not high enough. In addition it is possible that a part of the reflected power enters the klystron. However, the reflected power is still below the level that causes damages of the klystron. At present, further adjustment work of the RF system is underway. Moreover, more practical measurements and adjustments will soon be carried out with electron beams in the system.

The measurements of the characteristics of the RF cavity of the storage ring and the comparison of the results with the calculated values show that the Q-value of the RF cavity has decreased as compared with that of the SORTEC ring, while the Q-value of the RF cavity of the booster synchrotron remained high. The difference may be attributed to different fabrication procedures of both cavities.

In conclusion, the aging of the RF systems of the linac and the baking of the Rf cavity of the storage ring have been implemented quite successfully and these accelerator components are ready for operation.

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