Conditioning of RF Cavities for the SPring-8 Synchrotron

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Abstract

Rf cavities and rf input couplers for the SPring-8 synchrotron were conditioned independently at the test station in the storage ring1). And all of cavities and couplers were installed in the synchrotron and conditioned simultaneously. It took two months to achieve the maximum input power of 250 kW per one cavity.

1. Introduction

The rf system of the synchrotron is composed of two 1 MW klystrons and eight five-cell cavities. The resonant frequency of rf cavities is 508.58 MHz and the maximum accelerating voltage is 18.7 MV. The conditioning of the cavities and couplers were carried out with the maximum input power of 250 kW one by one at the rf test-station. After baking for 100 hours at 150 degree C, the time of the conditioning for a cavity and a coupler is a week and three days, respectively. And they were installed in the synchrotron and conditioned simultaneously. The time of the conditioning for all of the cavities and the couplers is four months totally.

2. Rf system for conditioning

Figure 1 shows the rf system of the synchrotron. The rf signal is generated by a synthesized signal generator at the E-station in the storage ring. The rf signal is transmitted by an optical-fiber. An rf switch cuts the rf power by interlock signals caused by such as an extremely high pressure (more than 5×10^{-4} Pa), a large reflected rf power from the cavities (larger than 20 kW) ,an arc in the wave-guide and so on. The interlock signals are latched until a reset signal is received. The rf system is controlled by the host computer of the synchrotron and the VME. The rf input power is changed by the amplitude in the low level and the anode voltage of the klystron. The maximum output power of the klystron is 1 MW. The output power is transmitted through the waveguide system of WR1800 at 1 MW transmission-line and WR1500 at less than 1 MW. A Y-junction type circulator with a 300 kW dummy-load is used to protect the klystron against the reflected rf power from the cavity. The output power of 1 MW is divided into the four cavities by three magic tees. Phase shifters are used to tune the rf phase between the cavities. Directional couplers are used to monitor the input and the reflected power in the waveguide.

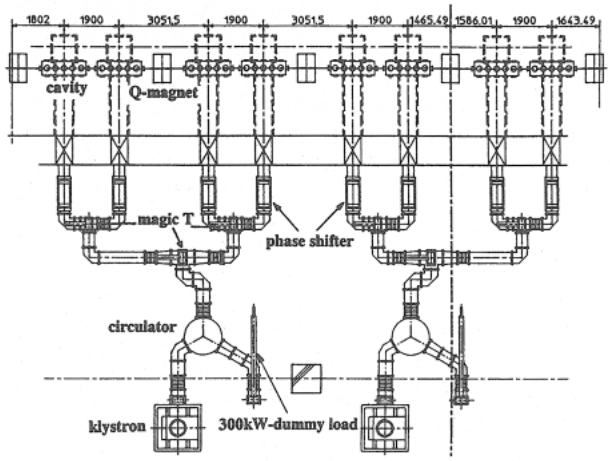

Fig.1 Rf system of the synchrotron

The vacuum system for the eight rf cavities is composed of eight 400 l/s ion pumps and eight 300 l/s turbo molecular pumps (TMP) with roughing pumps. The vacuum pressure is monitored by an ion gauge per a cavity and a cold-cathode gauge (CCG) per two cavities. The CCG has fast response time less than 50 ms and is used for the control of the rf input power in the conditioning. Figure 2 shows the vacuum system of the cavity section.

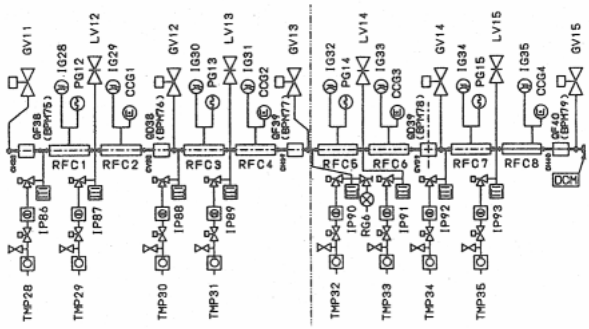

Fig.2 Vacuum system of the cavity section

3. Control for conditioning

The rf input power is controlled by the host computer of the synchrotron and the VME. The host computer sets and monitors the parameter of the rf system. The conditioning program run at the VME. The repetition cycle of the control is 200 ms.

The power is increased when the vacuum pressure of all cavities for a klystron system is lower than the threshold value(PL). If the pressure exceeds the

higher threshold value (PH), the power is decreased. When the pressure is between PL and PH, the input power is kept at the value until the pressure becomes lower than PL. If the power reaches the preset value, the power is kept at the value. If the preset value is lower than the power and if the vacuum pressure is lower than PL, the power is decreased to the value. If the pressure is higher than PL, the power is kept at the value until the pressure becomes lower than PL.

The interlock because of high vacuum pressure (more than $5x10^{-4}$)and reflected power (more than 20 kW) can be reset automatically by the computer to continue the conditioning. If the interlock signal comes from the failure in the klystron power supply, the interlock is not reset automatically.

4. Result

The vacuum pressure of the rf cavities is about $3x10^{-7}$ Pa at 35 degree C with no input power. The value of PL was chosen between $1x10^{-5}$ and $5x10^{-6}$ Pa. The value of PH was chosen between $9x10^{-6}$ and $4x10^{-6}$ Pa. The conditioning of the eight cavities were started in July, and the input power of 200 kW per one cavity is achieved three weeks later. To accelerate the beam from 1 GeV to 8 GeV, the input power is 190 kW generally. In September the maximum input power of 250 kW is achieved successfully. Figure 3 shows an example of the chart of the rf power and the vacuum pressure. At the beginning of the conditioning, input couplers is sparked by the discharge of arc and glow, the vacuum pressure is worse and the rf switch is off by the interlock. Two couplers were broken in the conditioning by discharge, and the very small leakage is broken out. These couplers were exchanged for new ones. After the conditioning, the input power is very stable, the fault rate is a few time per a day. The typical vacuum pressure at the input power of 190 kW is $1x10^{-6}$ Pa.

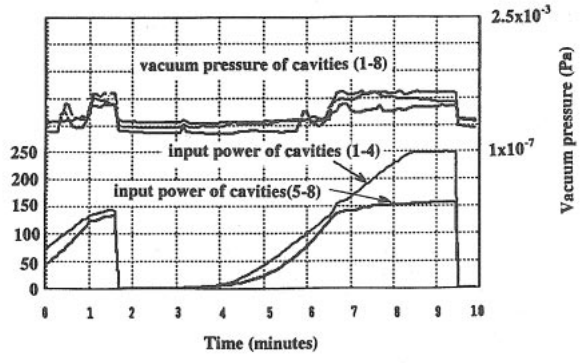

Fig.3-1 Example of the chart of the rf power and the vacuum pressure (short range)

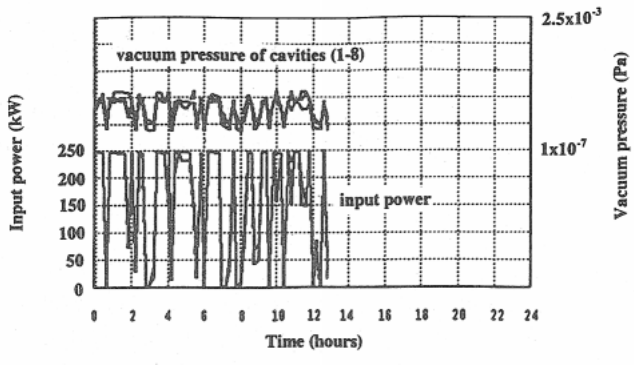

Fig.3-2 Example of the chart of the rf power and the vacuum pressure (long range)

5. Conclusion

The conditioning of cavities for the synchrotron is successfully completed. The computer control system is very useful to shorten the time for conditioning. In December the acceleration of the beam from 1 GeV to 8 GeV is succeeded.

Reference

[1]`Conditioning of RF Cavities and RF Input Couplers for SPring-8` Proceedings of the Fifth European Particle Accelerator Conference (1996) 2047-2049