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Development of S-band Waveguide Valve for PLS 2-GeV Linac

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I. Introduction

Since 1994 we have projected short and middle-term programs to further upgrade the PLS 2-GeV linac ; extensive improvements are currently under way for the high power microwave systems such as klystron, modulator, pulse compressor, resonant ring and waveguide valve, and future facilities to promote availability of the PLS 2-GeV linac. This study on high power waveguide valve is motivated by the requirement for more efficient maintenance and operation of the PLS 2-GeV linac. A waveguide valve with a peak RF power handling capability of 80 MW and a reliable vacuum seal is needed for changing the Toshiba E-3712 klystrons. The deficiency of the waveguide valve in the waveguide network would require venting each module, each time a klystron should be replaced, and cause long interrupt of normal operation. We report here on the design considerations and the mechanical features of our first waveguide valve, the results of our experiments so far, and some of our plans for the near future.

II. Design Consideration and Mechanical Feature

The original SLAC and SLC type waveguide valve were designed on a basic idea using the same circular hole for rf contact and vacuum seal. However, we adopt a new design concept which removes a limitation on power transmission, and embodied it in a completely different structure without coupling mechanism. Essential design points of the PLS waveguide valve are ; (1) to implement the U-shaped waveguide section for a power transmission of more than 80 MW, (2) to implement a viton seal driving module for a reliable vacuum tight, (3) to make a good rf contact for no rf leakage, (4) to supply a clean vacuum environment for a stable operation, and (5) to adopt a robust mechanical structure for a reliable operation. The microwave strurcture for the PLS waveguide valve is composed of an U-shaped waveguide section with two rectangular step gaskets, two H-corner sections brazed with a main vacuum chamber, and a plunger assembly for compressing two copper gaskets. It is necessary to position the U-shaped waveguide section very accurately, especially in regard to rectangular cross section of two H-corners. In order to keep a stable horizontal motion, four grooves on inner surface of the main vacuum chamber and four spring spindles are installed. The position of the U-shaped waveguide section is adjusted and guided with connection plate and two tapered guiding pins. The gap distance between the guiding pins and holes is maintained within 10 μm. The total length of the waveguide in valve is 3.3 times of the guide wave length, λg=15.3 cm. The vacuum structure for the PLS waveguide valve consists of a L-shaped vacuum chamber contained an U-shaped waveguide section, a plunger assembly and a driving module for a vacuum sealing plate. A viton is selected as a polymer seal material considering chemical and mechanical properties, outgassing, and radiation damage. The vacuum seal between the sealing plate and bottom plate is achieved by means of two viton O-rings and press of the U-shaped waveguide section. An opening aperture of sealing plate is placed at the upstream side to prevent the valve chamber from exposing to air during replacement of the klystron tube. Its size is set at 50×15 mm. The maximum differential pressure at opening is specified to 5.0E-7 Torr. Two viton O-rings are installed at the bottom side of sealing plate. The closed trapezium groove is used to have a very good retention of the viton O-ring. The force pressurized on the O-ring seal is 25 N/linear-cm. The torque on the driver mechanism for vacuum sealing is 2.14 kN-mm.

III. Performance Test

After chemical cleaning, the prototype waveguide valve was rf cold-tested. The VSWR and insertion loss at 2856 MHz was less than 1.04 and 0.08 dB, respectively. Then, this waveguide valve was assembled on the high power test stand which is shown in Figure 1. In order to shorten the rf processing time, the waveguide valve was baked *in situ* to 120 ℃ for 18 hr. The 150 MW PLS prototype modulator was used for this experiment. The rf output from the SLAC 5045 klystron was fed to waveguide valve, then terminated by the SLAC rf water load. At the short pulse test of 1 μsec, the power transmission was achieved to 65 MW at 10 Hz after 196 hr of the first rf processing. The first 144 hr was spent to pass through the multipactoring region. In the second step, the pulse width was set to 3.5 μsec and pulse repetition rate was increased from 10 Hz to 50 Hz. The vacuum interlock level was more tightly controlled to be less than 1.5E-8 Torr. It took only 174 hr to obtain a transmission power 65 MW at 3.5 μsec pulse width and 30 Hz PRF. The total propagation energy required to accomplish this was more than 2 GJ. The test was continued up to 60 MW at 40 Hz, then up to 50 MW at 50 Hz. The test was terminated at that moment. In the macroscopic test, we could not find any traces of melting, microprotrusions, crater edges, or cracks. After the second rf processing, the base pressure in the U-shaped waveguide and the working pressure under the highest power loading were 4.6E-9 Torr and 9.6E-9 Torr, respectively. From the power measurements by calibrated crystal detectors, when 65 MW power was transmitted to waveguide valve, the reflected power was about 1.8 MW. Thus, the mismatch loss was measured to be 0.12 dB. This power loss is about two times higher than that of the straight waveguide with equivalent length.

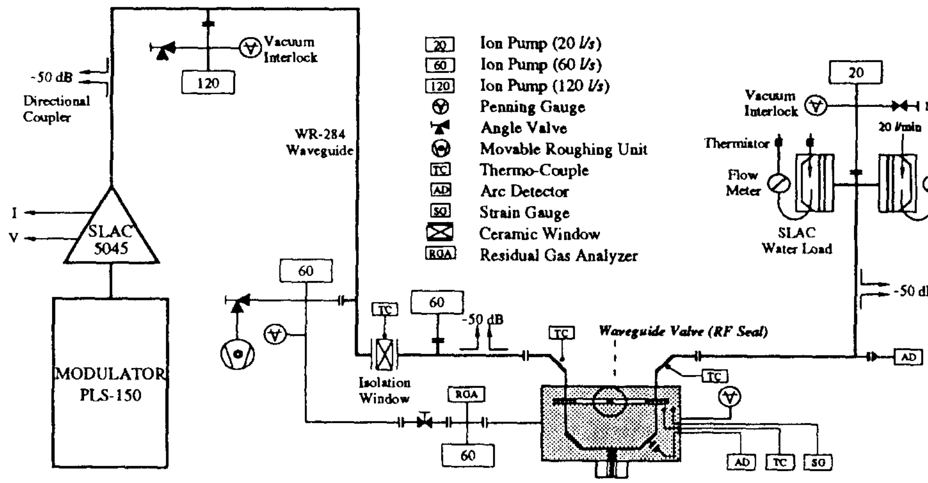

Fig. 1 Diagram of the high power test stand for the PLS waveguide valve

IV. Conclusion

A new waveguide valve has been developed for the PLS 2-GeV electron linac of the Pohang Light Soure. The power transmission of 65 MW at a pulse width of 3.5 μsec and a pulse repetition rate of 30 Hz has been achieved by adopting the step contact structure. The PLS waveguide valve is relatively simple in fabrication, stable in properties, and cheap in cost, in comparison with the existing ones. The use of the PLS waveguide valve is expected to significantly reduce the effort required to recover after klystron change and to greatly contribute in elevating the operating rate of the PLS 2-GeV linac.