BEPC KLYSTRON IMPROVEMENTS

Hong Bo, Dong Dong, Tian Shuangmin, Yu Dongsheng,
Zhang Jingru, Zhao Yong, Cao Minghua, Li Gangying
IHEP, Academia Sinica, Beijing, 100039, China

Abstract

An upgrade of the BEPC Linac RF power source is required to achieve an injecting energy of 1.55 GeV. There have been several significant improvements to the klystron tubes: (a) since 1996, the new 65MW klystron is now operating at 45MW in the klystron gallery; (b) the electron gun of the old HK-1 30MW klystron (which is the same version as the SLAC XK-5[1]) has been redesigned to a low gradient gun to decrease the arcing in the gun area[2]. The maximum electricfield gradient has droped from 284KV/cm to 213KV/cm at a beam voltage of 270KV; (c) one KEK PV3030A2 30MW klystron is operational in the BEPC Linac, delivering 29MW at a beam voltage of 278KV.

1 INTRODUCTION

1.1 Injection Upgrade Using 65MW Klystrons

For full energy injection, the BEPC injecting energy must be incresed from 1.3 GeV to 1.75 Gev. However, the first step in achieving this energy level is 1.55 GeV. The 16 (HK-1) 30 MW klystrons were partly replaced by two 65 MW klystrons. One is a SLAC 5045 klystron; the other is manufactured in China. These tubes have been operating at 45 MW and 42 MW for over one year and have achieved the maximum power level of 65 MW and 52 MW, respectively.

1.2 Improvements to the HK-1(30MW) Klystron

Since 1994, the original 30 MW klystrons have been found arcing frequently. The arcing is mainly due to the contamination in the gun area. Another cause of the arcing is the high electricfield gradient in the gun region. The third cause is the rough surface of the oxide cathode. The design of decreasing the high electricfield gradient has been completed and the tube is in production. The second step in gun modification is to use a dispenser cathode instead of an oxide cathode.

1.3 KEK PV3030A2 Klystron on the BEPC Lianc

Four used KEK (PV3030A2) klystrons were also sent to BEPC Linac, due to the lack of 30MW klystrons. The original oil tank was modified to fit the KEK tube. For a two week period, the first tube went through "burn-in" using a water-load. The degree of multipactoring was excessively high due to the output waveguide being exposed to air for 3 years. The final test results were satisfactory: they were measured by a directional coupler and a thermal coupler connected with a water-load. With a beam voltage of 278 KV, the output power was 29MW.

2 60 MW KLYSTRONS

The performanc of all kinds of klystrons on the BEPC is listed in Table 1.

Table 1. The Performance of the BEPC klystrons

	5045	60MW	HK-1	KEK30MW
numbers	1	1	13	1
frequency(MHz)	2856	2856	2856	2856
beamvoltage(KV)	350	350	270	270
beamcurrent(A)	415	415	280	280
rf width(μS)	3.5	3.5	3.5	3.5
rf peak power(MW)	65	52~60	30	30
efficiency(%)	45%	~40%	~40%	~40%
gain(dB)	53	50	50	50
operating beamvoltage(KV)	320	340	240~265	265
operating outputpower(MW)	45	42	17~28	26
lifetime(hurs)	40000	~7000	8000~15000	40000

Three of the 65MW klystrons (Chinese model) have been tested on the test stand. They achieved 55~60MW measured with a water-load at a beam voltage of 350KV. The klystron gallery power of these tubes is now at 42~52 MW. This is due to the limitation caused by inserting components down-stream of the klystrons (i.e. the ceramic disc of the directional coupler, adjacent to the klystron windows, was broken as it could not withstand the high power level). Currently, the lifetime of the tube is 7000 hours and it's still in accumulating.

The 5045 klystron has the same limitation problem mentioned above. Presently this tube is operating in the power range of 45~50MW for system stability. The beam voltage and RF waveforms of these two tubes are shown in fig.1.

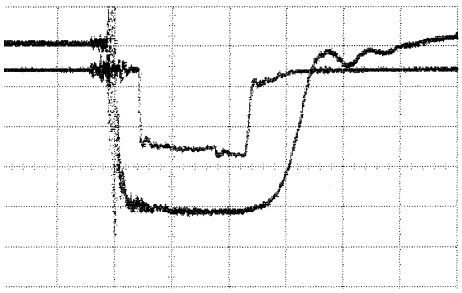


Fig.1 Beam Voltage & RF waveforms of 65MW klystron.

3 GUN REDESIGN of HK-1 KLYSTRON

The HK-1 klystron is the same version as the SLAC XK-5. It has been arcing in the gun region for a long time. Subsequent investigation revealed that the tube failures are due to three specific problems.

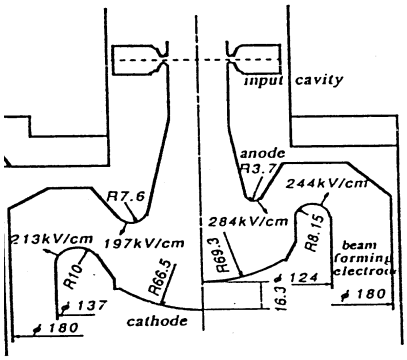
3.1 First Problem - Gun Materials Contamination

Five tubes were opened and checked. The electrodes, especially on the anode, were contaminated with carbide. This is due to copper leakage and ceramic-metal sealing problems, which cause slightly poisoning of the oxide cathode. Heater power must be higher so that the cathode emission material and the materials of the surport assemblies around the filament will be evaporated onto the electrodes.

Now the processing techniques have been improved and the quality control is stricter. Rebuilt tubes show some amelioration.

3.2 Second Problem - Gun High field Gradient

Fig.2 Comparison of gun electricfield distribution



The high electricfield gradient between the focusing electrode and the anode of the XK-5 type tube gun has been reported in some papers [3]. The maximum electricfield gradients around the focusing electrode and anode were 284KV/cm and 197KV/cm, respectively. This problem has been observed in the HK-1 klystron at a beam voltage above 260KV. In order to decrease the field gradient, the gun was redesigned with a larger curvature of anode and focusing electrode. The cathode was also lowered. The structure of the magnet coils won't be changed. By adjusting the 5 focusing coils and the 1 bucking coil, the magneticfields are reformed. This improved gun is similar to the KEK PV3030A2 klystron. The comparison of the electricfield distribution in the gun region is calculated by EGUN as shown in Fig.2 [4]. This tube will be tested in June of 1998.

3.3 Third Problem - Oxide Cathode

A smoother surface dispenser cathode, has more uniform field distribution on the surface because of its metal charactristics. Therefore, it will be installed in the new low gradient gun in order to decrease the electricfield furtherly.

4 KEK (PV3030A2) KLYSTRON at BEPC

In order to increase the energy of the KEKB Linac from 2.5 GeV to 8.0 GeV, the original 30MW klystrons were replaced by 50MW klystrons. Four of these KEK 30MW (type PV3030A2) used (old) klystrons have been shipped to BEPC, one of them has been installed in the gallery. It is presently hepling to achieve an energy level of 1.55 GeV possible.

The PV3030A2 klystron has similar specifications with that of the BEPC HK-1 klystron. However, the outside dimensions are not identical. The gun end section of the tube is longer than that of HK-1, because it has no bucking coil. The connecting structure between the oil tank and the focus coils was lengthened with an interlarded flange.

One of the four tubes has been tested on the klystron test stand. The complete testing system is shown in fig.3. The output power was measured by the temperature difference with a thermal-coupler from a water load and a –50dB directional coupler, inserted between the tube and the water-load.

The RF output conditioning time was much longer than expected because the window output waveguide has been exposed to air for 3 years. Excessive gassing was due to the multipactoring of the ceramic window at a low power level of 0.3MW to 3MW. It took more than 10 days to condition the tube at this power level.

The final testing results on the test stand agreed with the design specifications of KEK. The output power was 29MW at the beam voltage of 278 KV. Currently,

the tube has a stable output of more than 20MW at 265 KV.

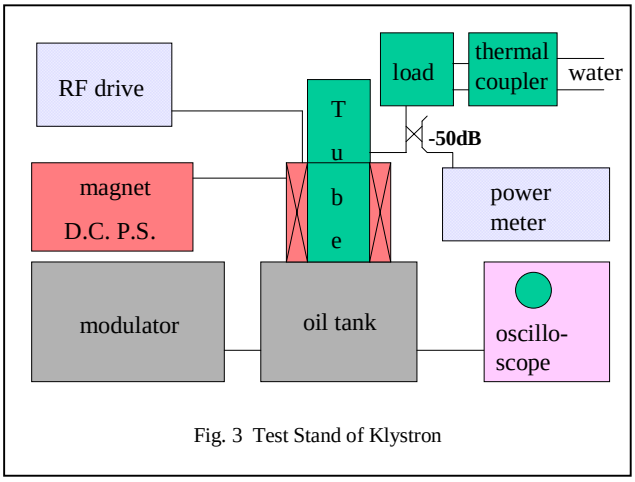


Fig. 3 Test Stand of Klystron

5 ACKNOWLEDGMENTS

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