

# PROGRESS STATUS OF HIGH POWER KLYSTRON DEVELOPMENT FOR KOMAC\*

H. S. Kim<sup>†</sup>, K. H. Chung, Seoul National University., Seoul 151-742, KOREA  
 H. J. Kwon, KAERI, Daejeon 305-353, KOREA  
 K. O. Lee, KAPRA, Churwon 269-843, KOREA  
 S. J. Noh, Dankook University., Seoul 140-714, KOREA  
 W. H. Choi, KAIST, Daejeon 305-353, KOREA  
 S. K. Ko, Ulsan University, Ulsan 680-749, KOREA  
 H. J. Lee, Cheju University, Cheju 690-756, KOREA

## Abstract

The high power klystron whose design specification is 1 MW CW at 700 MHz for driving the CCDTL of KOMAC (KOREA Multipurpose Accelerator Complex) proton accelerator is under development by the KAPRA (Korea Accelerator and Plasma Research Association). The components for preliminary study were designed, fabricated and assembled. The test facility was set which included power supplies, low level RF system, high power RF delivery system with matched termination, cooling system and so on. In this paper, the development status including high power klystron test facility and test result is presented.

## 1 INTRODUCTION

The purpose of the development of the 700 MHz, 1 MW CW klystron amplifier is to acquire various experiences in the domestic design and parts fabrication of the MW grade klystron amplifier, which are essential in proper and efficient operation of high power RF system. 700 MHz, 1 MW CW klystron tube is however, commercially available from several companies, it is worth while to develop for the man-power training and educational purpose. For the design of the klystron tube, several computer codes were used to design the tube and predict the performance of the tube [1]. The design parameters for the 700 MHz 1 MW CW klystron for the KOMAC CCDTL and the overall drawing are shown in Table 1 [2] and Figure 1, respectively

Based on the design study, the main components of the klystron tube, such as electron gun, RF cavity, collector and supporting structure were fabricated. The components are under the assembly stage, and will be tested at the KTF(KOMAC Test Facility) at KAERI(Korea Atomic Energy Research Institute).

## 2 COMPONENTS DESCRIPTIONS

### 2.1 The Electron Gun

The electron gun was designed using electron trajectory program E-gun code [3]. The electron gun was a triode type with a modulating anode.

Table 1: Design Parameters for the KOMAC klystron

Parameter	Value
Operating frequency (MHz)	700
Output RF power (kW)	1,000
Maximum beam Voltage (kV)	100
Maximum beam current (A)	20
Efficiency (%)	> 60 %
Power gain (dB)	~ 40
Number of cavities (Incl. 2 <sup>nd</sup> Harm.)	6
Drift tube radius (mm)	30
Beam radius (mm)	~ 20
Focusing magnetic field (G)	250 ~ 300
Collector dissipation (kW)	1,000

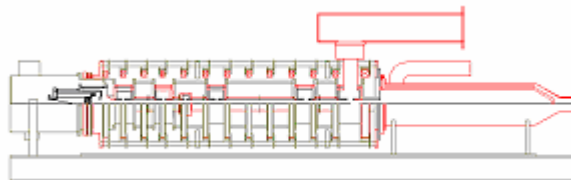


Figure 1 : Overall Drawing of the MW CW Klystron

For a long lifetime and conservative design, cathode peak loading was limited below  $0.6 \text{ A/cm}^2$  and peak operating electric field below  $7 \text{ kV/mm}$ . When the beam voltage was 95 kV and the modulating anode voltage 51 kV, beam current of 16.6 A was achieved through the code running. Dispenser cathode from Spectra-Mat was adopted as a cathode material. The fabricated electron gun components are shown in Figure 2.

### 2.2 Focusing Electromagnets

The electromagnets for focusing the electron beam were designed and fabricated. Total number of the magnets is fourteen, including one bucking coil for fine tuning of the magnetic field near the cathode. The magnetic flux density at the beam drift region was 2.3 times of the Brillouin value, which was 110 gauss. In the vicinity of the output cavity, the magnetic flux density was raised to about three times of the Brillouin value in order to counteract the increased space charge forces in the heavily bunched beam.

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<sup>†</sup>nuke21@snu.ac.kr

The electron beam trajectory under the designed magnetic field is shown in Figure 3 and the fabricated electromagnets are shown in Figure 4.



Figure 2 : Fabricated Electron Gun Components

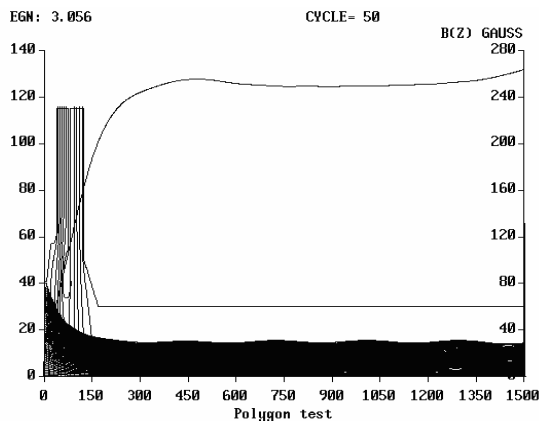


Figure 3 : Electron Beam Trajectory

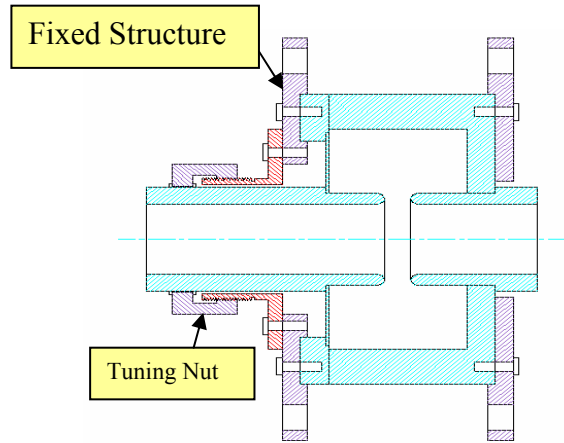


Figure 5 : Schematics of the cavity tuning



Figure 6 : Fabricated RF Structure



Figure 4 : Fabricated Electromagnets



Figure 7 : Pre-assembled RF cavity

### 2.3 RF Structure

The geometries of the resonant cavities were determined to maximize the  $r/Q$  of the cavity using the SUPERFISH code. The klystron had six cavities including one 2<sup>nd</sup> harmonic cavity for higher efficiency. The second cavity was tuned to lower frequency and penultimate cavity to higher frequency than the center frequency for a better efficiency also. Cavity tuning was accomplished by capacitive method.

As shown in Figure 5, small displacement of the cavity nose-cone was made by thin cavity wall and tuning nut. From the SUPERFISH simulation, it is verified that  $\pm 1$ mm displacement is enough for 10 MHz tuning range. RF structure was fabricated with copper and for the mechanical stability each cavity was supported by stainless steel flange. For the resonant frequency monitoring during the tuning, the RF vacuum feedthroughs were installed at each cavity. The fabricated

RF structure and pre-assembled RF cavity are shown in Figure 6 and Figure 7 respectively.

### 2.4 Collector

For the design of the collector, the beam power dissipation on the collector was calculated. The initial beam power is about 1.6MW (95kV, 16.6A) and considering the efficiency as 60%, the total power to be dissipated in the collector is about 640kW. The inner radius of the collector was determined to be 10cm to make the peak power dissipation per unit area below 200W/cm<sup>2</sup>, which is rather conservative value. Required coolant flow was about 1500 l/min and the number of the cooling fin was 72ea. The inner jacket of the collector was fabricated from the one piece bulk copper and cooling fins were machined directly on the surface of the inner jacket. The fabricated collector and the stainless steel outer jacket are shown in Figure 8.



Figure 8: Fabricated Collector

### 2.5 Supporting Structure

The supporting structure was fabricated. RF structure and the electromagnets are supported independently. Alignment was achieved with the reference of the base plate. Base plate was fabricated with steel and to minimize the effect on the magnetic field, it is separated from the magnets 150mm off. Other parts of the supporter are made of stainless steel. The fabricated supporting structure is shown in Figure 9.



Figure 9: Fabricated Supporting Structure

## 3 TEST FACILITIES

The required test facilities such as high voltage power supply, circulator, dummy load and low level RF amplifier are prepared in the KTF at the KAERI [4]. The specifications of the high voltage power supplies for the KTF klystron are 100 kV, 20 A with the conditions that the voltage peak to peak ripple is less than 1 % and energy deposition in the klystron at the tube arc is less than 20 J. The power supply that meets the above conditions has been designed, manufactured and tested by KAERI. The circuit diagram of the power supplies that includes high voltage power supply, modulating anode power supply and heater power supply is shown in Figure 10.

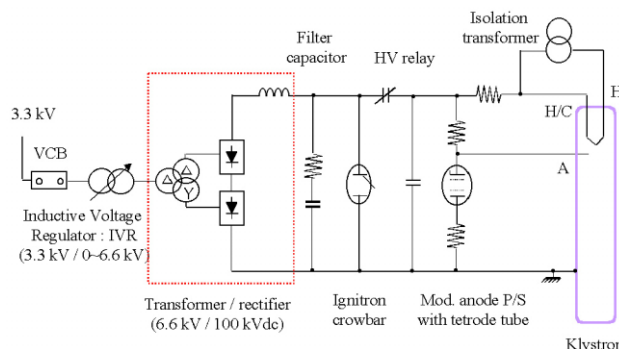


Figure 10: Circuit of high voltage power supply

## 4 SUMMARY

The main components of the KOMAC klystron such as the electron gun, electromagnets, RF structure and collector were designed and fabricated. The components assembly is under way and will be completed in near future. The required test facilities are prepared in the KTF at KAERI.

## 5 ACKNOWLEDGEMENTS

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