STATUS OF THE KOMAC PROJECT

B.H. Choi, J.M. Han, Y.S. Cho, J.H. Lee, P.K. Joo, K.R. Kim, Y.K Kim, J.W. Park, H.J. Kwon, C.K. Park, KAERI, Daejon, Korea, K.H. Chung, KAPRA, Chungnam, Korea

Abstract

KAERI (Korea Atomic Energy Research Institute) has been performing the project named KOMAC (Korea Multi-purpose Accelerator Complex) since 1997. The final objective of the project is to build a 20-MW (1 GeV, 20 mA, cw) proton linear accelerator to study on basic researches, industrial applications, and nuclear transmutation. As the first phase, the low energy accelerator up to 20 MeV is being developed in the KTF (KOMAC Test Facility) program. The low energy accelerator consists of an injector, RFQ, CCDTL, and RF systems. The proton injector of 50keV and the LEBT have been developed, and the 3MeV RFQ and the 1MW RF system are under installation. The hot model of CCDTL is being tested. Many spin-offs of the accelerator technologies have been developed in parallel for industrial applications including a conductive surface treatment of polymers with the injector technology. For the second phase of the KOMAC project which is to extend to 250MeV, a feasibility study and a proposal have been prepared. Some details of the KOMAC project status will be presented.

1. INTRODUCTION

KAERI is proposing to build a high power proton linear accelerator of 1GeV and 20mA under the KOMAC program[1]. The key issue of the KOMAC design is to accelerate both H+ and H- to 1GeV while partially extracting H- at 100 and 250MeV. The major H+ beam (18mA and 1GeV) will be used for nuclear waste transmutation and nuclear physics experiments while utilizing the minor H- beam (2mA) for the basic research and medical therapy study. The 100MeV beam will be used for fast neutron generation, solar proton simulation studies and obtaining nuclear data, and the 250MeV beam for deep-sited tumour therapy study and new isotope production. We are planning to extract the partial (0-100%) H- beam at 100 and 250MeV by employing magnetic strippers. We have divided the project into 3 development phases .of 20MeV, 250MeV and 1GeV including beam utilization and application at each phase. Figure 1 shows the schematic layout of the KOMAC linac

2. KTF (KOMAC TEST FACILTY)

In the 1st phase, we are developing a cw accelerating structure up to 20MeV under KTF (KOMAC Test Facility) project in which 50keV proton injector, LEBT, 3MeV RFQ and 20MeV CCDTL are under development. The proton injector has been already developed, and the 3MeV RFQ is being assembled for the test. It will be operated in 10% duty pulse mode and then extended gradually in cw operational mode. The plan and status of KTF are shown in Figure 2, 3 and 4 respectively.

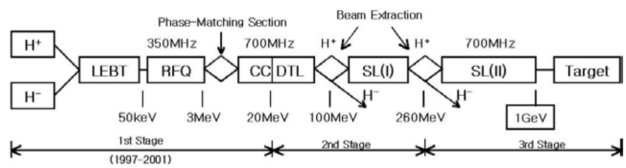

Figure 1: Schematic Layout of the KOMAC Linac

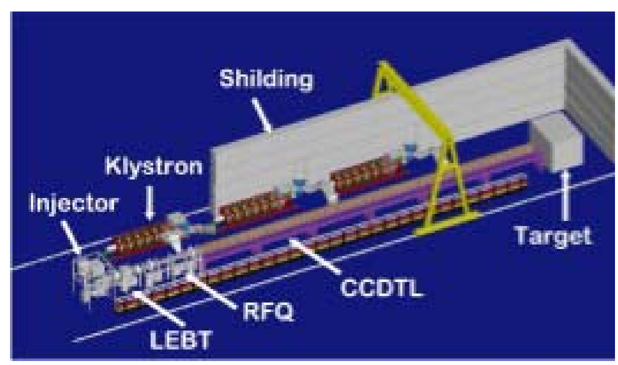

Figure 2: Plan of KTF 20MeV Accelerator

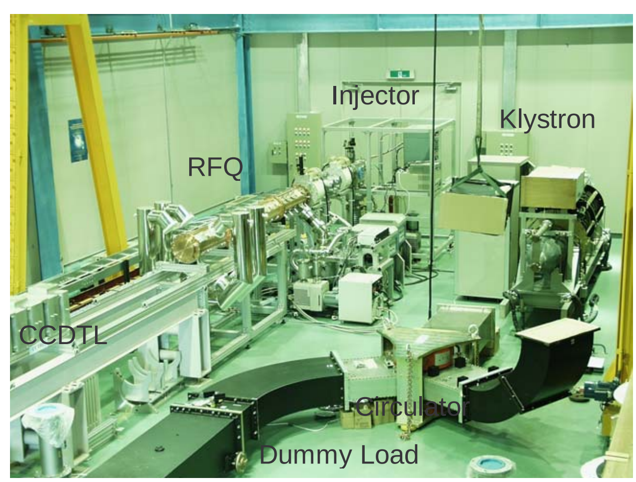

Figure 3: Status of KTF Accelerator

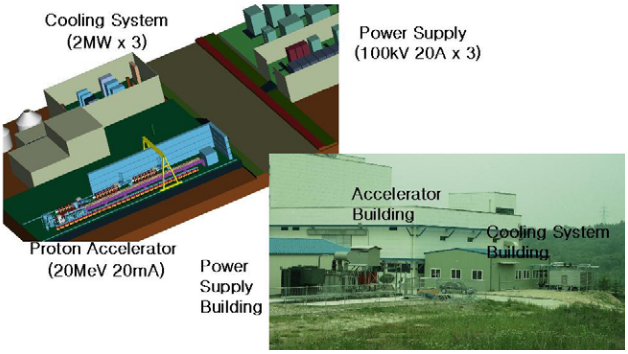

Figure 4: Utility Plan and Utility Buildings

2.1 The Proton Injector [2] and LEBT

In order to deliver 20 mA proton beam at the final stage, KOMAC requires the ion source with the proton beam current of 30 mA at the extraction voltage of 50 kV. Normalized rms emittance of the beam mrad is also needed less than 0.3 π mm for good admittance into RFQ.

The proton injector with a duoplasmatron ion source can provide a beam of 50 mA, 50 kV with 150 V, 10 A arc power. The extracted beam has a normalized emittance of 0.2 π mm mrad at 90 % beam current and proton fraction of over 80 %. The beam can be extracted without any fluctuation in beam current for 4 hours. The cathode lifetime is about 40hr.

Low-energy beam transport (LEBT) consists of two solenoids, two steering magnets, diagnostic and beam control system to transports and matches the H^+, 20mA beam from the ion source into the RFQ. The key element of the LEBT design is to minimise beam loss. Two solenoid magnets are 20.7cm-long, 16cm inner diameter, are surrounded by a low carbon steel and provide dc fields of about 0.5T on their axis

2.2 RFQ [3]

The KTF's RFQ has been designed and fabricated. Design tools of the 3MeV RFQ are PARMTEQM and QLASSI for the beam dynamics, ANSYS for the thermal and stress analysis, SUPERFISH and MAFIA for the cavity design.

Table 1: Design Summary of the RFQ

- Structure : 350MHz, 4-Vanes
- Length : 324cm
- Input/Output Energy : 50kV/3MeV
- Input/Output Current : 21/20 mA
- Transmission : 95%
- Total Structure Power : 350kW
- Surface E : 1.8 Kilpatrick

In the KTF RFQ, an average RF power is 417kW, which is supplied by one klystron of 1MW CW. The output of the klystron is divided to supply two RF ports of 210kW each.

The RFQ is a four-vanes type and consists of 56 tuners, 16 vacuum ports, 1 coupling plate, 4 RF drive ports, 96 cooling passages, and 16 stabiliser rods as shown in Fig.5. The RFQ cavity made of OFH-Copper consists of 4 sections of 81 cm long. It was machined and brazed in a vacuum furnace. The vacuum of the cavity was tested. Its pressure reached to 2.1×10^{-8} Torr. The electrical test results for the RFQ cavity equipped with a coupling plate and stabilizer rods show that the operation mode frequency is 349.4 MHz without tuning and 350.0 MHz with tuning [4].

The KTF RFQ will dissipate RF power of 417kW in average which includes the beam and wall loading. The RFQ RF source consists of a LLRF system [5] and a klystron amplifier of 350MHz, 1MW cw delivered by THOMSON-CSF Ltd. The RF power is transmitted to the RFQ cavity through the WR2300 waveguide, a RF window and an input coupler [6]. The third section in the RFQ cavity has two RF feeds. Two types of the input RF couplers, a coaxial-type and an iris-type, were studied and fabricated. The measured VSWR for the coaxial coupler is 1.02:1. We are constructing the RF system and its power system. A low duty test of the RFQ is planned in early next year.

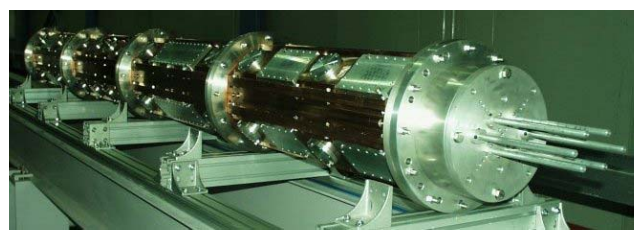

Figure 5: 3MeV RFQ

2.3 CCDTL [7]

The KTF's CCDTL will accelerate the 3MeV 20mA proton beam to the energy of 20MeV. The duty factor of operation for the 1st stage is 10% and is increased gradually to 100%.

Table 2: Design Summary of the CCDTL cavity

- Structure : 700MHz , CCDTL
- Length : 25m
- Aperture Diameter : 10/15mm
- No of EMG : 130 (8 $\beta\lambda$ FODO)
- Total Structure Power : 1.15MW
- Structure Power per length : 50kW/m avg.
- Surface E : <0.9 Kilpatrick

Its cold models are fabricated to check the design, the coupling coefficients, the tuning and the fabrication methods. The measured resonant frequency is 700.8 MHz without air and humidity compensation. The measured Q value of the cavity without brazing is 87% of the calculated Q by SUPERFISH without any surface cleaning. The super-drilled coolant path is well fabricated.

The field profile is measured with bead perturbation method. The field measurement system is shown in Fig. 6. A 2mm diameter and 2mm long alumina cylinder is used for the bead. The measured field profile in a cavity shows good agreement with the calculated profile. But, the field uniformity in the multi-cavity is not good. It is necessary to increase the field uniformity by the fine tune of the cavity. This will be done with the brazed copper cold model that will be fabricated. Quadrupole magnets for CCDTL have been fabricated and tested with good agreement with the design values of 3.8kG/cm.

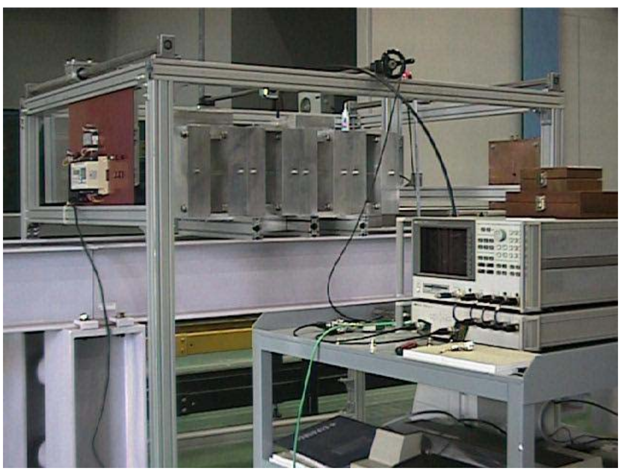

Figure 6: Test of CCDTL

3. KTF BEAM APPLICATIONS

Programs of various applications using KTF's proton beams are being prepared based on requirements of the potential users in Korea. With the low energy beam using the injector and RFQ technologies, the proposed applications are the surface modification of polymers, the carrier lifetime control of power semiconductors, the proton micro machining for the Micro-Electro-Mechanical System, the detection of landmines and explosives, the neutron radiography, and the boron neutron capture therapy (BNCT). At the 20MeV range, the radioisotope production is considered as a main application. Other applications are the thin layer activation, the fusion reactor material test, and the small-scale transmutation experiment.

The applications of the low energy beams of 50keV and 3MeV have been progressed. The mass production technique of anti-electrostatic plastic for a semiconductor package tray was developed using an ion irradiator using the high current injector technology. The explosive detection system by proton induced nuclear reaction and the carrier life time control technique of the power semiconductor are under development. For the application of the movable neutron radiography and BNCT, a Li target system is designed to produce about 10^{13} neutrons/sec by using 2~3MeV/10mA proton beam.

For the radioisotope production, the nuclear reactions suitable to KTF will be surveyed for the radioisotopes, such as ^{67}Ga, ^{81m}Kr, ^{111}In, ^{123}I , ^{133}Xe, ^{197}Hg, ^{201}Tl, ^{81}Rb, ^{18}F, ^{11}C, ^{13}N, ^{15}O, ^{68}Ge, ^{74}As, ^{82}Sr, ^{28}Mg, ^{62}Fe, ^{95m}Tc, ^{47}Sc, ^{67}Cu, and ^{125}Xe. Also the cross section will be measured experimentally at the proton energies below 20MeV.

4. KOMAC 2nd PHASE PROGRAM

The KOMAC 2nd phase program to build the 250MeV linac was proposed to the Korean Government in 1999. It was selected as one of candidate projects for the National Frontier R&D Program in July 2001. The goal of the project is to build 250MeV linac and 1GeV RCS (Rapid Cycling Synchrotron). Especially, the RCS is added to the original plan of 1999 to support a neutron science program as a spallation neutron source.

The KOMAC User Group was formed to support the KOMAC user program last March. About a hundred of experts from the fields of material science, life science, nuclear science, physics and industry have joined in the group. And 21 pre-proposals for utilization and the applications of KOMAC in 15 fields were proposed.

Evaluation and selection processes for the national project will be done in end of this year.

ACKNOWLEDGEMENT

This work was supported by the Korea Ministry of Science and Technology.

REFERENCES

[1] B.H.Choi et al, "Overview of the KOMAC Project", Proceedings Of the 3rd International Conference ADTTA'99 (1999).

[2] Y.S.Cho, et al, "'High-current ion source development for the Korea Multipurpose Accelerator Complex", Rev. Sci. Instr., 71, 969(2000).

[3] J.M. Han et al., "Design and Fabrication of the KOMAC RFQ", Proceeding of PAC99, New York, (1999).

[4] J.M. Han et al., "3.0MeV KTF RFQ Linac", this proceeding.

[5] J.M. Han et al., "LLRF System for the KTF RFQ Linac", this proceeding.

[6] J.M. Han et al., "RF Coupler Design for the KTF RFQ Linac", Proceeding of PAC2001, Chicago, (2001).

[7] Y.S. Cho et al, "Cold Model Test of The KOMCA CCDTL Cavities", Proceeding of EPAC2000, Vienna, (2000).