STATUS REPORT AND TUBE UP-GRADE OF HI-13 TANDEM ACCELERATOR AT CIAE

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Abstract

The 72" tubes of HVEC type used on HI-13 tandem accelerator at CIAE are going to be replaced by one 96" and seven 88" tubes of same type after fifteen years' operation. Installation of a portico is also considered in this project. Modification on dead sections, idlers in the laddertron charging system and terminal structure has to be done to accommodate the new tubes. The upgrade project will be completed before the end of next year. A terminal voltage of 16 MV is expected for routine operation after all. The machine has been working better since the modification and improvements on the resistor divider system and laddertron charging system was completed in 1998.

1 INTRODUCTION

The HI-13 tandem accelerator has been in operation since 1986. The accumulated operation time up to now is more than 56,000 hours. Some modification and improvements on the machine have been made during the past years [1]. The accelerator performs much better since then with the highest terminal voltage of 13.08 MV and the longest operation time of 5132 hours in 1999 and the least tank opening of one time in 2000. Although it seems to us that the tandem accelerator is still working fine at present, we have been worrying about the failure of the accelerating tubes for several years since the tubes have been used for fifteen years continuously and stood thousands of sparks. Some ill omen on the tubes has been observed. At the end of 2000, it was decided that it's the time to replace the old tubes with new ones.

2 TANDEM

At the end of 1998, modification and improvements on laddertron and resistor divider system was completely finished. The divider system with a complete set of glass-glaze resistors and a new laddertron developed in the tandem laboratory was installed on the machine simultaneously during the end overhaul of 1998. The subsequent operation of the tandem accelerator has been quite satisfactory. The terminal voltage had been conditioned up to 13.08 MV in a couple of hours with few sparks on January 1999. It had run 5132 hours with more than 4500 hours' beam time and maximum terminal voltage of 12.4MV with beam in the calendar year. In 2000 the machine was working normal with only one time of tank opening for the schedule end overhaul of the year. Inspection and machine operation has shown that the frame structure of the resistor divider system (Fig.1.) is very useful for protecting the divider resistors from damage by sparks. The 1152 glass-glaze resistor units (each has two 600 MΩ resistors, Fig.2.) used in the resistor divider system have been in operation for near three years with the value of the resistors varying within 3 percents and no one damaged[2]. The modified laddertron[3] performs excellently. Two domestic laddertrons have been in use up to now. The first one had been operating for 11,600 hours before disassembly. The second one has been running for more than 12,000 hours with a few adjustments and maintenance and it still runs smoothly at the terminal voltage below 12 MV.

Fig.1. Glass-glaze resistors on the machine

Fig.2. Glass-glaze resistor unit

3 THE OLD TUBES

The tubes used on the HI-13 tandem accelerator are standard 72" inclined accelerating tubes of HVEC type except tube No.1, which has 22 straight electrodes with half gradient of 18 electrodes at the entrance of the tube. Up to now the tubes have been running for more than 50,000 hours with beam at the terminal voltage mostly below 12 MV, standing thousands of sparks. In the past years, each time machine conditioning there are always some strong or weak γ rays detected near the straight section. The accumulated effect of this is that the color of the insulating glass rings at the strait section and the adjacent places where electrode reversals in direction occur is getting dark brown. On another hand, because of sparks some small cracks and pits on the surface of glass rings could be found some where on the tubes. Fortunately it did not effect the tube vacuum at present and the vacuum at both ends of tank can still reach as high as 1×10^{-5} Pa during the normal operation. Though it is difficult to predict the life- time of accelerating tubes it is obvious from our experiences that taking following measures during the tank opening would be of benefit to the life time of the tubes:

1. Always breaking tube vacuum with dry nitrogen.
2. Always keeping the humidity inside the tank as low as possible.
3. Evacuating the tubes as soon as possible after maintenance.

4 TUBE UP-GRADING

The tube up-grade project includes replacement of 72" tubes of eight with one 96" and seven 88" inclined new tubes and associated modification on dead sections, idlers of laddertron charging system and terminal structure.(See Fig.3.)For further increase on the terminal voltage, a portico imported from VIVIRAD will be installed and tested after tube up-grade commissioning and a couple of month test operation.

The 96" and 88" tubes are full inclined VHV type accelerating tubes with BNL terminations. Considering the present injection energy of 150KV in maximum for HI-13 tandem accelerator and beam transmission, the following electrode arrangement for tube No1.is adopted:

1. The first section at the entrance consists seven inclined electrodes of 7^{o} angle, then the direction of electrodes reverses from 7^{o} through 0^{o}, -7^{o} to -14^{o}.
2. Half gradient (by half resistor 600MΩ) is applied at first 19 electrodes and full gradient (by full resistor 1200 MΩ) is applied to remain 77 electrodes.
3. Beams are brought in the tube No.1 at the angle of seven degrees with the central axes.

The major modification in the project is in the dead sections and charging system. New connection boxes, which are made of aluminum alloy, in the dead sections have been designed and reconstructed to matching the extended tubes but no additional ion pumps are going to be placed in the dead sections. To accommodate the extended tubes at the high energy side, the idlers of the laddertron charging system have to be reduced in diameter and moved up so as to keep enough distance between the idlers and the connection boxes of the dead sections. The ion optical components along the beam axis are unchanged except the electrostatic quadruple triplet inside the terminal is going to be moved towards

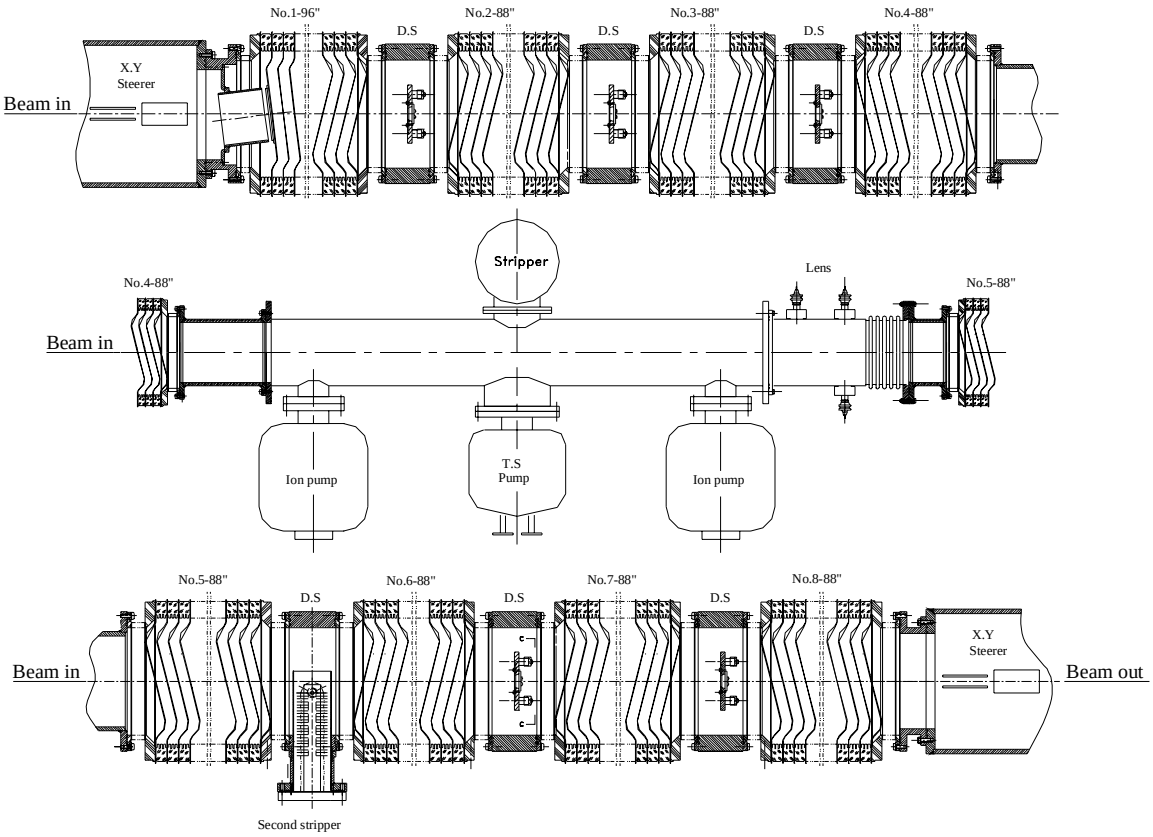

Fig.3 Tube up-Grading Configuration

the terminal stripper by several centimeters.

The HI-13 tandem accelerator is going to be shut down on December of this year to prepare for new tube installation. The column conditioning will be made when the old tubes are moved out from the tank to see its capability of high voltage holding after fifteen years' operation. New tube installation and conditioning will be finished before the end of May in 2002. We hope the terminal voltage of the machine could reach 14.5MV to 15 MV with new tubes. In the following four months the machine will be in operation and then installation of portico starts. The terminal shape will be modified from present cylinder to a concavity cylinder to match the portico. We hope by the end of next year the terminal voltage could be 16MV to 16.5MV with portico.

REFERENCE

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