OPERATIONAL EXPERIENCE AND UTILIZATION OF 750 keV DC ACCELERATOR AT RRCAT

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Abstract

A 750 keV DC accelerator based on Cockroft-Walton multiplier has been operational at RRCAT in the energy range of 500-750 keV with a typical beam current of 10 mA. In last two years, the accelerator has been operated for various experiments and for irradiation applications. Recently, we have irradiated various types of uninfested and infested seeds for National Bureau of Plant Genetic Resources. Irradiation was carried out at 500 keV and the dose delivered was in the range of 250-1500 Gy. Dose measurement was done using B3 film dosimeter before the irradiation. Some difficulties faced during the regular operation of the accelerator have been addressed and proposed improvements are presented. The paper describes the operational experience and utilization of this accelerator in the last two years.

INTRODUCTION

At RRCAT, we have a programme of development of electron accelerators for industrial applications. Under this programme, we have developed a Cockroft-Walton based 750 keV DC Accelerator[1] which is in operation at 750 keV, 10 kW power. This accelerator is being used for the R&D in the field of radiation processing[2] e.g. surface irradiation of pulp sheet, medicinal powder, painted metallic sheets, coated wood samples and potatoes[3].

The high energy electron beam is scanned using a scanning magnet to the desired width (maximum scan width being 1 m) and it is then extracted out in air through a thin titanium foil, for irradiation. Figure 1 shows various parts of the DC Accelerator.

The material handling system is a slat type conveyor. It is capable of handling paper pulp sheets, wooden laminates, iron sheets, FRP sheets, etc. kept in trays. Length of the conveyor is 2.6 meters. It has a load capacity of 200 kg. Its speed is continuously variable from 1 m/min to 30 m/min and is reversible. It is driven by an AC servo-motor having a torque capacity of 6.5 N-m. at 2000 rpm.

OPERATIONAL EXPERIENCE AND SYSTEM IMPROVEMENT

Rupture of window foil

The window foil was ruptured in the month of Feb 2010 and loss of vacuum in the accelerating column was encountered. We have replaced the neoprene with a Viton O-rings. During assembly of the foil, the curvature of the foil was obtained using FRP rods .The foil and its joint did not show any leak during leak checking using MSLD in sensitivity of $1x10^{-9}$ mbar l s^{-1}.

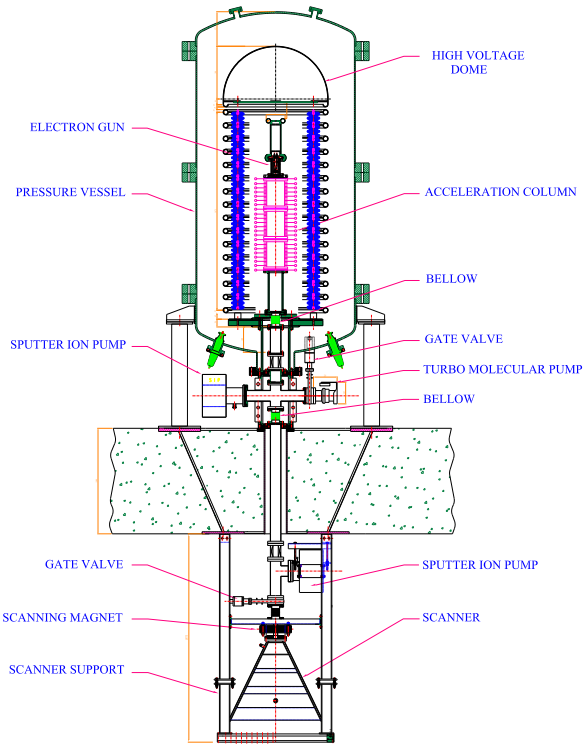

Figure1: Schematic diagram of 750 keV DC Accelerator.

Development of Compensating Inductors

Earlier two compensating inductors were housed in a single unit. It has been now replaced with two independent compensating inductors thereby reducing the length of HV cable. This has increased the reliability of the system.

SF_6 Gas Handling System

A gas handling and filtration system to transfer and filter the gas from pressure vessel to storage vessel and vice-versa is being procured. SS316L pipeline from vessel to gas handling system has been designed and is under fabrication. The system can recover SF_6 gas from accelerator vessel up to 1 mbar and filter it to conform to IEC 60480 standard.

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Issues Related to Ozone

In the existing facility layout, access to the accelerator hall which is situated at the first floor, is through irradiation room. Hence to enter into the hall, one has to wait for ozone to reduce to permitted level of 0.1 ppm. A delay interlock is in place at the door of the irradiation room. A process enclosure is planned around the beam extraction system and the conveyor to confine the ozone. All exhaust air grills in the irradiation room shall be shifted to process enclosure. This will permit access to the accelerator hall immediately after the accelerator is switched off . Ozone measurement will be performed inside and outside the enclosure to find out the decay time for ozone concentration to reach 0.1 ppm in the new layout.

Scanner Isolation

We were facing problem with PVC piping used for cooling beam extraction system. They used to become brittle in the radiation field. We have replace them by metal piping and isolated the scanner to measure the beam current falling on it.

We have installed a camera near to irradiation zone to monitor the irradiation activity from control room.

SEED IRRADIATION

The National Bureau of Plant Genetic Resources(NBPGR), New Delhi carried out irradiation to study the potential of electron beam irradiation as quarantine disinfestation against insects-pests in seeds. We have irradiated uninfested seeds of soybean, chickpea, mungbean, rice, cotton, wheat and brassica; infested seeds of soybean, chickpea, mungbean and wheat with different stages; and adult male and female insects viz: callosobruchus chinensis, callosobruchus maculatus, trogoderma granarium, sitophilus oryzae.

The dose on the product is the function of transmitted electrons from the titanium foil and speed of the conveyor belt. Based on the dosimetry experiments using B3 film at 500 keV, we measured that a beam current of 250 µA and conveyor speed of 30 m min^{-1} delivers dose of 250 Gy in one pass. Higher doses are given to the samples in step of 250 Gy by increasing the number of passes. The dose uniformity at 500 keV is within ±5% for scanning width of 500 mm[4].

The samples to be irradiated is placed at one end of the conveyor belt before switching on the machine. Once the desired energy and emission current is established, conveyor is switched on and the sample is allowed to pass across the electron beam as shown in Figure 2. Irradiation process is monitored through CCT monitor in the control room. The samples are exposed to the doses 250 Gy to 1500 Gy at the energy 500 keV. During each irradiation, machine is switched on for less than 2 minutes. Approximately 50 kg of the seeds were irradiated.

Subsequently the germination and seedling vigour of the irradiated seeds were studied by NPPGR, New Delhi and the doses for the particular seed for the enhancement of these qualities were determined[5][6].

Figure 2: Tray with seeds on the conveyor belt.

CONCLUSIONS

The accelerator is operational in the energy range 500-750 keV with beam power 10 kW and is available to user for irradiation. The DC Accelerator at RRCAT has been used for the various irradiation experiments. Improvements have been made in the facility to improve its operational reliability and maintainability.

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