A 600KEV ELECTRON RADIATION ACCELERATOR

Zhou Youyi, Wang Xurong
Institute of Nuclear Science and Technology, Sichuan University, Chengdu, 610064, P.R.China

INTRODUCTION

In this paper we describe a 600keV two-body multi-functional electron and positive ion radiation accelerator based on a 400keV Cockroft-Walton, Which was successfully used to accelerate electron and positive ion. The 400 keV horizontal Cockcroft-Walton multiplier existed in the captioned institute was produced in 60s and when it was put into service the multiplier had been employed in times of nuclear experiments,especially functioned as neutron source in a great many neutron data tests. To follow up the study works of coating solidification by radiation undertaken by the institute, the reconstruction of the old multiplier was started in a circunstance of sever shortage of manpower and fund, it was required then that the rebuilt multiplier would not affect the various indexes the old one had, but be able to conduct a great deal of electron radiation works. It was finalized after selections of several alternatives that means of co-usage and swift switch-on/off should be used as many as possible to satisfy the requirements that both positive ion and electron can be accelerated. A multi-functional electron radiation accelerator co-existing with horizontal 600kV positive ion multiplier was built up. Though test on coating solidification of decoration materials, such as colorful surface plaster plate and relief plate, and researches on metal plate, plastic plate,wood and paper coating decorations and radiation workmanship, as well as experiment of brach-linking by radiation for filling materials of petroleum pipings, it is proved that the device is reliable and stable in operation and reaches the pre-set design indexes and satisfies the requirements called for. The multi-functional accelerator reconstructed is very fast in change over from drawing electron to drawing positive ion and vice versa. Without any change in the indexes of the old multiplier.

The electron radiation accelerator is of the following main specifications:

Electron energy 100-600 keV, continuously adjustable
Electron beam current >7 mA
Electron beam scanning width >1200 mm
Electron bean scanning frequency 50-250 rpe, adjustable
Dimension of Scanning frame 4500 x 1400 mm
Fransmitting speed of Scanning frame 0.1-5m/m. continuously adjustable.

DESCRIPTION OF MAJOR COMPONENTS

During the whole process of the reconstruction, the guidance is to make the newly-built accelerator and the old one co-use and meed the needs of generating positive ions and electrons by using simple, swift and reliable switching. DEscriptions of the fundamental elements are given as follows:

1. Co-usage and Switching of HV Multiplier Power Supply

The power supply of the old 400kV Cockcroft-Walton is fed by a two-stage multiplication power resource consisting of a 8 kW step-up transformer, 4 HV capacitors and 4 electron tubles. The filament of the electron tubles are electricity fed by a filament isolated transformer. It used to be difficuit to make conversion of the rectified posive and negative polarities. So the HV supply was replaced by 6 HV rectification silicon rods and 6 HV capacitors. To facilitate the switching of the rectifed vatage polarities connections of both ends of the silicon rods with the capacitors is fixed by screw rods and nuts. After such an innovation, the efficiency of rectification can be increased, and more convenient and reliable conversion of HV rectification polarities can be achieved.

2. Co-adjustment and swift Switching of the Power Supplies of HF Ion Source and Electron Gun System

The power suplies of the high-frequency ion source and the electron gun system are placed in two high voltage large receptacles respectively(the two are of equivalent potential level and connected each other by aluminum piping that accommodates the power cables for all power supplies). Gauges for all power supplies are also mounted on the receptacles. The two sets of power resources co-use one set of controlling, regulating, protecting and monitoring system.

In oreagate co-use the controlling, regulating and protecting devices of the old system, co-usage by regulating the input votage of the two sets of power resources are adopted, i.e. double-pole and double-throw switches are connected with every output ends of the voltage regulators. When the high frequency ion source is to be put into operation, the switches will be positioned on the outputs of the voltage regulators to energize inputs of the power supply of the HF ion source, and meanwhile, the inputs of the power supply of the electron gun system will be tripped, and vice versa.

In this way, the trouble for re-regulation of each sub-resources of power, when conversion of beams is needed, can be eliminated, and the installation of a new set of isolated power supply, regulation, control and protection system for the electron accelerator is not required. This system is also convenient, swift and reliable in operation.

3.Irradiation Scanning System and Irradiation Conveying Device

The electron irradiation scanning system is composed of scanning power supply, scanning magnet, scnning box and drawing window, whose function is to make the accelerated electrons scan horizontally. The scanning angle is 60 degree, scanning width 1200mm and adjustable scanning freqency 50-250

circles/s. Generally the scanning signal is of triangle wave ccurrent. However, it is indicated by theoretical analysis and experimental results that under circumstances of a large horizontal scanning angle and scanning width, an ideal current of triangle wave can not achieve an uniformed current intensity at the drawing window. This is because, the bigger the scanning angle is and the wider the scanning width is, the bigger the liner velocity of electron scanning at a further place from the window center will be, causing decrease of beam intensity. In order to improve the uniformity of scanning, a scanning signal of a compound wave with triangle wave superposed by sine wave is used, and the output voltage, output current wave and frequency of the scanning power supply can be adjusted. So the flexibility for regulation as to achieve a uniformed electron beam at the drawing window is provided. In addition, for preventing the scanning system from fault operation that may run the risk of breaking the titanium film by a concentrated striking of electron beam at the center area of the window, on interlocking protection is furnished between the power supplies of electron gun system and scanning system. It means that the signals of the interlocking protection are taken from the output signals of the scanning power resource. So, when no output is available of the scanning power suply, the power supplies of electron gun system are deenergized, and no electrons can be down out.

The vertical scanning of electron beam is realized by mechanical movement of the irradiation conveying device. The conveying frame is 1400mm wide and 4500mm long. The transmiting speed is continuously adjustable from 0.1m/m to 5m/m. The conveying direction of the frame can be either forward or backward, and conveniently controlled as requested. The gap between the frame and the drawing window can be easily regulated according to thr thickness of the irradiated samples, with max. regulation range of 150mm. The regulations of the device are done in the control room with industrial TV monitoring.

ACCELERATION & FOCUS SYSTEM

The accelerating and focusing system is of vertical configuration. The main acceleration tube is 1100mm long, HV resistors and HV capacitors are utilized to reach 40 sections of equivalent voltages, for forming a equal gradient accelerating tube.

The electrons shot form the filament of the electron gun, other being drown out by the positive pole, will be focused by electrical focusing lens. Then the electrons will be injected into the acceleration tube acted by the guide magnet. In the acceleration tube, a thick lens system is formed by two diaphragm lenses of the inlet and the outlet and the central uniformed field. The electrons, through accelerating and focus in the system will fly through a certain space when moving out of the acceleration tube and form image of the outlet of the scanning magnet. The scanning magnet sweeps the electron beam uniformly with angles of 60 degrees and achieve uniformly intensity-distributed electron

beam at the titanium window. At last, the electrons go through the titanium window and irradiate sample. In order to have an unchanged point position of image formation of the whole system under different energies, i.e. the final image point is kept on the center of the inlet of the scanning magnet, regulation of the electrical focusing lens is available to modify the objective point positions of the electron beam injecting into the acceleration tube, aimming at achieving a focus matching.

By regulation of the potential level of grid pole or that of the positive pole of the electron gus system, the intensity of the elctron beam accelerated can be adjusted.

The magnetic fied of the guid magnet is adjustable. It was found that, when the electron beam is out of the acceleration tube during beam regulation process, its deviation from the central point of the inlet of the scanning magnet is about 5 mm. It coused electron loss when a partion of the electrons struck on the scanning box after scanning. The tracks of electron beam were then corrected by adding a guide magnet after the focusing pole. In this way, the problem of image deviation generated from alignment, acceleration and focus was well resolved.

The whole acceleration and focus system is now of good performance after overall adjustment. As energy varies from 100 keV to 600 keV, the electron beam spot is about 2-3 mm in diameter as measured of the inlet of the scanning magnet.

APPLICATIONS

The following experiments have been conducted since being put into service of the 600 kV multi-fuctional electron irradiation accelerator.

Reseach and tests on irradiation solidification of coatings on decoration materials such as colorful plaster plates, relief plates, metal plates, glass, wood and paper, etc. Experiments of branch-linking by electron irradiation for filling materials of petroleum pipings; Damage-detecting test by electron irradiation on monocrystall silicon. Test on irrdiation of heat-shrink film of polyethylene; Electron irrdiation tests on HgTeCd. Thousands of hours experiments of netron data measurements on the old horizontal 400 kV multiplier.

CONCLUSIONS

The successful operation of the two-body and multi-functional 600 kV electron irrdiator ion accelerator has opened a new way of electron irrdiation applications on the horizontal ion accelerator. Also, it provides a novel and feasible method to extend application field with no affection on the old accelerator and less fund and manpower.

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