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New modifications in 15 UD pelletron at Nuclear Science Centre

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Abstract. The 15 UD pelletron at NSC has been operational and performed well during the last 11 years. There have been major modifications performed for upgradation of pelletron system over this period. Major upgradations which have been implemented are new resistor network system for voltage gradient, doublet to singlet unit conversion for accelerator units, turbopump based gas stripper system etc. In addition accelerator mass spectroscopy program has also been started. A new multi-cathode source, Wien filter etc. have been procured and will be added soon in the system. An overview of the most significant upgradations undertaken and other activities for the system are being reported in the present paper.

Keywords. Pelletron; accelerator; voltage grading system; unit conversion and accelerator mass spectroscopy.

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1. Introduction

The 15 UD pelletron upgraded using compressed geometry tubes, has been designed for 16 MV terminal potential. The accelerator at NSC has been operational for over the last 11 years for more than 65,000 h. The machine has many novel features like off set and matching quadrupoles, additional foil stripper in the high energy dead section to further increase the energy of the ion beams [1].

During these years considerable efforts have been put to enhance the operational capabilities of the machine. Many development projects have been undertaken for improvements in overall performance of the machine. Major modifications as well as major breakdown activities in these years are explained in the following sections.

2. Major modifications performed in the pelletron

2.1 *Resistance-based voltage gradient system*

The accelerator had corona-based voltage grading system to define the potential both along the column support posts and the accelerating tubes. In the corona-based system, large changes of terminal potential can be achieved only by the use of shorting rods and change

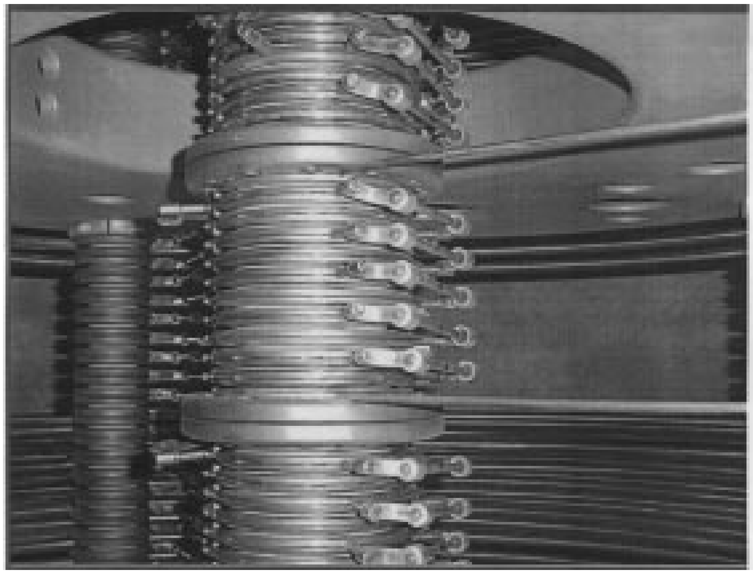

Figure 1. Resistance-based voltage grading system.

of insulating gas pressure. Each unit of the 15 units machine contained 37 tube electrode gaps and 18 column electrode gaps. In the modified resisitor-based voltage gradient system, a single resistor was put across each tube gap and two resistances in series across each column gap (figure 1). A potential of 15 MV can be achieved at a typical charging currents of around 20 μA per chain.

As a result the following improvements in the performance of the accelerator were observed:

1. The high value of resistors used, enabled running of the machine at high potential without overburdening the charging system.
2. Stability of the voltage had improved to the tune of $<$2 kV in 15 MV.
3. No shorting rod was used for a variation of terminal potential from 2.93 MV to 15.3 MV.

2.2 *Conversion of doublet to singlet units in column*

The accelerator column units structure at the time of installation was arranged in double units with each double unit consisting of six tubes having 11 electrodes and one shorter tube of eight electrodes. The 15 UD machine had seven doublets and one singlet unit in both low energy and high energy section. During shorting rod operations for reduction of terminal voltage, it was possible to short only a double unit at a time. In the present configuration (figure 2), the centre point of each eight-gap tube has been connected to a corresponding unit casting plate. In this configuration, each individual unit can be shorted at any stage and it has helped in the unit-wise conditioning as well as in separating out faulty individual units.

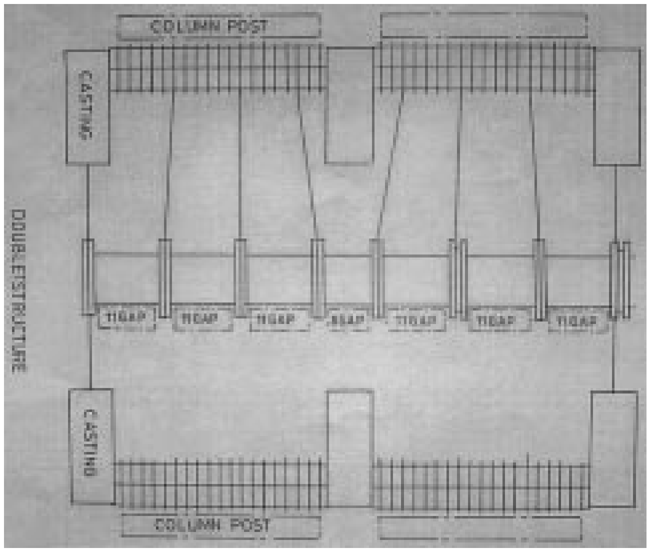

Figure 2. Doublet-to-singlet conversion.

2.3 *Modifications in recirculating gas stripper system*

The accelerator is equipped with both foil and gas strippers. For better beam currents for heavy ions, stripper gas pressure plays an important role [2]. A new recirculating turbo-molecular pump based gas stripper system has been designed and installed in the high voltage terminal of the accelerator. Two turbo-molecular pumps have been installed in place of sublimation pumps and their backing ports have been connected to the inlet line of stripper gas.

The stripper gas emerges from the canal into a large volume pumped by two turbo-pumps and the gas is re-circulating in the stripper canal (figure 3).

Though the differential pumping reduces the gas escape to the accelerator tubes, any loss of gas is compensated for by the introduction of fresh gas.

After the installation of the system, tests were performed to study the effect of this modification on overall vacuum of the accelerator. Following observations were made for vacuum at different points in the new geometry as well as old configuration in table 1.

The gas stripper performance after the turbo-pump installation shows improvements in the analyzed charge state distribution due to better beam transmission through accelerator and better effective thickness of gas stripper (figure 4a). The charge state distribution of gas stripper in new configuration shows similar response as the charge state distribution with foil stripper (figure 4b) [3].

2.4 *New system for stripper position readback*

A new foil counting system has been designed and fabricated. The old stripper foil position readback system had a mechanical counter and a 5 bit DAC. The mechanical counter had slippage problem and the output of DAC was non-linear. The salient features of the new counter are:

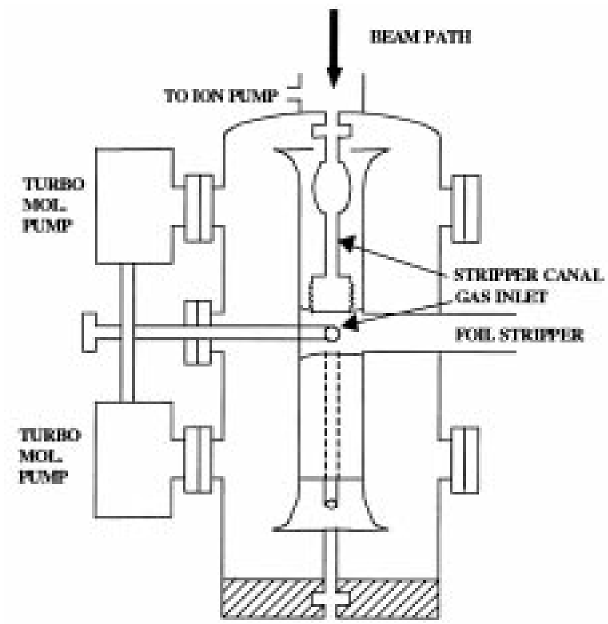

Figure 3. Gas stripper with turbo.

Table 1. Effect of modifications on vacuum in new and old configurations.

Location of vacuum gauges	Pressure with foil stripper (torr)	Pressure with sublimation pumps 200 μ (torr)	Pressure with turbo-molecular pumps 700 μ (torr)
Dead section (D1)	6.8×10^{-8}	2.7×10^{-7}	3.0×10^{-7}
Terminal (T1)	9.3×10^{-9}	2.9×10^{-6}	3.1×10^{-6}
Terminal (T2)	8.0×10^{-9}	6.2×10^{-6}	5.1×10^{-6}
Dead section (D2)	1.4×10^{-9}	1.7×10^{-7}	2.5×10^{-7}

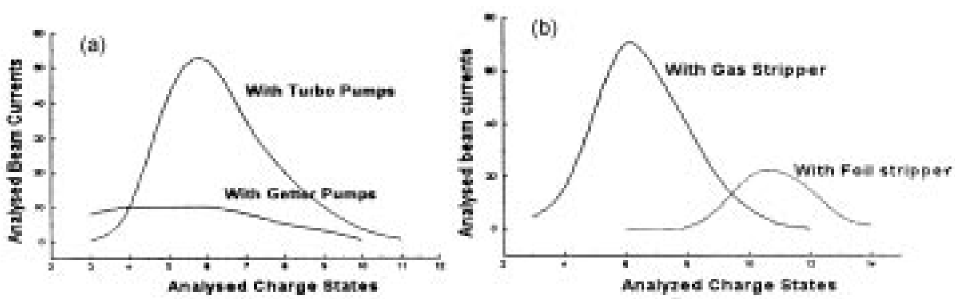

Figure 4. (**a**) Comparison of performance of newly installed gas stripper with old gas stripper and (**b**) comparison of performance of newly installed gas stripper with foil stripper.

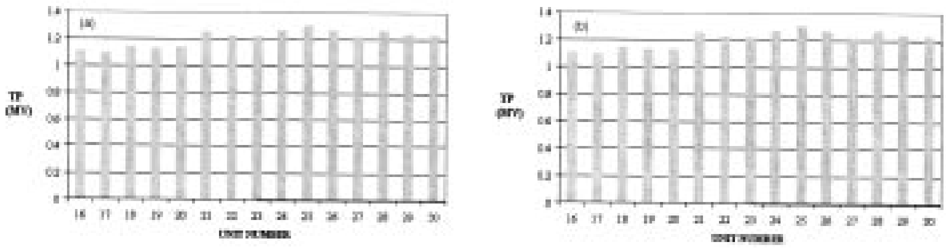

Figure 5. (**a**) Unit-wise conditioning response of the high energy section and (**b**) the low energy section.

1. Avoids the problem of incorrect reading due to slippage as in earlier used mechanical counter.
2. Uses improved 8 bit DAC of better accuracy and linearity as compared to previous 5 bit DAC.
3. Exact position read at control console, hence easy to select proper foil stripper for better beam transmission through machine.

2.5 *Voltage holding performance of pelletron accelerator*

Voltage test of gaps of column support posts were performed. In the atmosphere almost all of them were holding up to 11 kV. After these tests unit-wise conditioning at around 83 psig was performed (figures 5a and 5b) and afterwards gas pressure was increased to 98 psig. Accelerator potential could reach 15.54 MV with full column conditioning at 98 psig. Since then terminal potential above 15 MV is achieved smoothly and beam test at 15.01 MV was performed with oxygen beam.

2.6 *Modifications for accelerator mass spectrometry (AMS)*

Accelerator modification program is also being planned for future usage of pelletron as dedicated system for accelerator mass spectrometry (AMS). One of the beam line is being planned to be used for AMS activities. Major steps which have been taken in this direction as part of pelletron accelerator are procurement of multicathode ion source (MC-SNICS) 40 samples disk and a Wien filter (velocity filter) Model 621, Danfysik, Denmark. The turbopump-based terminal gas stripper and offset Faraday cup at analyzer beam waist position have already been installed. A multianode detector has been developed and tested. In future bouncing system involving injector magnet for fast isotope switching and gas filled magnet for isobaric separation of ions are planned.

The main isotopes which are being planned for future measurements are ^{36}Cl and ^{10}Be.

3. Major breakdowns in the accelerator system

During these years of operation there had been many instances where accelerator system had to be maintained for major breakdowns.

Figure 6. Crack in column support post.

3.1 *Column support post replacements*

In these years of accelerator operation, cracks in column support (figure 6) posts have caused voltage degradation. Till now we have replaced 7 column support posts in total in low energy units as well as unit no. 30 which is situated at the tank bottom.

3.2 *Accelerator tube replacement in unit # 8*

During unit-wise conditioning of unit #8, after a spark, vacuum started deteriorating. The residual gas analyzer indicated the presence of SF_6 gas inside the accelerator tubes and this particular tube had to be replaced with a new tube.

3.3 *Breakdown of fiber optics in low energy section*

An indigenous fiber optic cable connector was developed as a bunch of 16 light links were damaged in low energy dead section (LEDS) due to high voltage spark (figure 7). This caused the loss of control for the devices in LEDS.The developed connector was used to connect the damaged portion of fiber optic cables successfully.

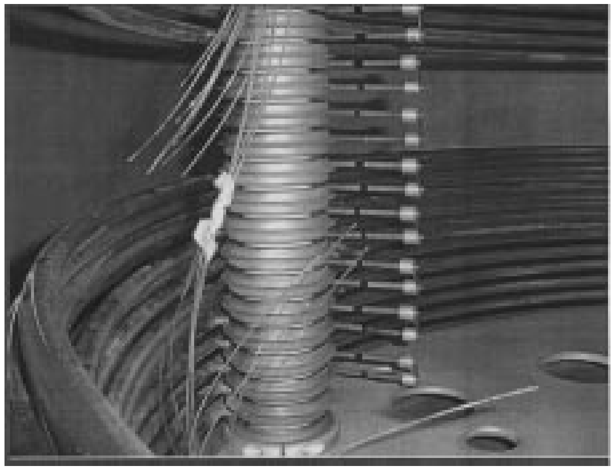

Figure 7. Light link break down.

3.4 *Charging system breakdown*

Due to the loosening of one of the pillow block bearing nut and bolt, the bearing and pulley came out of their mounts. The chain had stopped rotating and pulleys, inductors, bearing etc. got damaged. This whole system was disassembled and a new system was assembled, installed and tested. It has been performing well till date.

4. Future plan

The future plans for pelletron are being looked in terms of high voltage, higher ion beam currents and as soon as this facility is augmented with LINAC in position, pelletron will be operational mainly as AMS facility.

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