IMPROVEMENT OF THE STABILITY OF THE VERA ACCELERATOR

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This paper discusses the solution of some problems we had experienced during the last 24 months. Together with NEC we improved the charging system. We located and finally got rid of a parasitic glow discharge which we usually called 'Poltergeist'. Having given the corona needles the right length, the integrated circuits of the corona probe controller have been protected from being damaged by tank sparks. We built a temperature stabilization for the accelerator and increased the terminal voltage stability by a computer program controlling the charging system. There is still the problem of having a lot of dust inside the accelerator, even after short operation periods.

1 Introduction

Since the meeting at Jülich, where we reported on VERA the first time [1], we improved the performance of the 9-SDH-2 accelerator. Our accelerator and all the other components of the facility have been operating well. However, there arose some uncommon problems. For that reason, our report will mainly discuss failures and how to get rid of them.

2 Charging system

Our main subject we talked about in Jülich was one of our charging chains, which was oscillating in both directions, x and y. We checked everything: the alignment of the driving and the terminal pulleys, the adjustment of the suppressor and charging electrodes, the links between the individual pellets, the position of the pick-off pulleys, the chain tension, the power cords feeding the drive motors, etc. In the end, having had no success in finding anything wrong, we decided to remove the chain and all the parts of the 'bad' charging system including the driving motor and the mechanism applying the tension to the charging chain. We sent these parts to NEC. At NEC they found the driving pulley slightly out of balance. The pulley was balanced anew and its sheave was re-cut for better contact with the pellets. The bearings of the driving motor were checked, and the charging system was tested at NEC. The overhauled charging system now runs very smoothly and we can use both chains giving us the possibility to transport about 300 μA to the terminal.

3 Dusty accelerator

When opening the accelerator vessel for maintenance, we find the accelerator structure and the tank wall covered by a lot of brown dust which can easily be wiped away. Mainly the high-energy section where the chains run is affected. We were told by NEC that the dust is due to sparking between the pellets and the sheaves of the driving or terminal pulley. The sparking erodes the conducting black nylon linings of the sheaves. Investigating carefully the surface of the nylon we found erosion marks on, but we still do not believe that this is the only source for the dust in our accelerator. We rather think the dust is also due to cracking products of the SF_6 resulting from sparking between the pellets. Facts are: the sheaves are not all affected to the same extend; the nylon lining of the sheaves is black, the dust is brown or dark yellow; the dust is spread over all the high-energy side, there is no difference between the upper side where the chains run towards the terminal and the lower side were the chains run in opposite direction. Nevertheless we tried to overcome the dust problem by readjusting the pick-off electrodes running the open accelerator by minimizing the visible sparking between the pellets and the sheave. However, since there was no means to quantify the sparking, we could not find a clear minimum. For that reason, we adjusted the pick-off electrodes so that they yield the same suppressor or charging voltage as is applied by the charging power supplies at ground.

4 Parasitic current - Poltergeist

Since the start of VERA a parasitic current intermittently appeared in the balance of currents going up to and down from the accelerator's terminal. We call that parasitic current 'poltergeist'. A computer program was developed to compensate the current loss by adapting the charging current. However, the poltergeist introduced additional noise to the terminal voltage since it was often fluctuating quickly. In the absence of accelerator sparks the poltergeist had a growing tendency and after some time exceeded the charging reserve of our pelletron. The program learned to force sparks to make the poltergeist disappear. Finally, the poltergeist became that high that we couldn't reach a high enough terminal voltage to produce tank sparks. When we opened the accelerator vessel for inspection, we found corona discharge marks on the terminal shell, first opposite the rater sharp edges of the CPO plates. We blunted these edges but the poltergeist came back after the accelerator had been conditioned, and tank sparks became rare. On the next tank opening there were only at the terminal marks opposite the corona probe. After some considerations we concluded that the only possible explanation of the current loss was a parasitic corona discharge very close to the corona probe so that the marks due to the poltergeist were hidden. We first tried to smooth the very bad welding of the probe flange section using sandpaper but we didn't have any success, and the poltergeist came back quickly and the accelerator vessel had to be opened a third time.

Fortunately, the intensity of the parasitic corona discharge was high enough to make a clear picture of the bad welding on the terminal shell. Since we did not want to polish away all the welding, we built an additional shield from stainless steel which covers all the flange and the bad welding but the hole for the corona probe. We have not seen the poltergeist since then.

5 Corona probe

For some time, an integrated circuit of the last amplifying stage before the tube regulating the corona current was often damaged when a tank spark happened, sometimes three times a week. Improving the ground connection of the corona probe controller box didn't yield any success, nor did reducing the distance between the shunt spark gap electrodes. The problem disappeared when we increased the length of corona needles which had burnt down to less than 3 mm (the length suggested by the manual) to about 6 mm as NEC suggested. We found that the length can be between 4 and 6 mm. We now think that accelerator sparks to the grounded corona probe housing did damage the integrated circuit, for several spark marks were visible (the number of marks was almost the same as the number of killed ICs). We also found that one better uses sewing needles which are blunted before mounted the first time. A sharp tip shows a fast initial erosion.

6 Temperature stabilization

At VERA, unfortunately, the temperature of the cooling water is not stable. There is a long term variation between day and night concerning the mean temperature, and there is a short term variation of about 3 degree Celsius when the cooling machine compressors switch on or off. Under some conditions, the variation of the temperature was clearly seen in the $^{13}C/^{12}C$ ratio. The reason for this is a temperature dependency of the generating volt meter used to stabilize the terminal voltage inducing shifts in the beam energy. So we applied a separate temperature stabilization for the accelerator. A temperature sensor in the SF_6 circulation system behind the heat exchanger supplies the signal for a custom made controller which regulates the flow of cooling water through the heat exchanger. The temperature of the insulation gas is now stable within 0.1 degree Celsius.

7 Terminal voltage stabilization

The charging efficiency which is the ratio between terminal voltage and charging voltage can change over time (reasons could be: changes of the chain length, the contact between pellets and pick-off wheels, burning down corona needles, temperature effects). Since the hardware uses only a proportional feedback loop to stabilize the terminal voltage by the GVM, a varying deviation in the 1-kV range remains. To compensate that we wrote a UNIX shell script which adds a slow integrating feedback. The script also updates the charging voltage every 3 seconds to maintain a constant corona probe current and also adjusts the corona probe position to maintain a constant grid voltage of the tube controlling the corona current. The script also calculates the balance of the currents going to and coming from the terminal and logs the result. Using this script we can operate the accelerator for some days at the preset voltage (2.7 or 3.0 MV) having a deviation of only 200 – 250 V RMS.

8 Spark marks on supporting Lucite

At VERA the terminal incorporates a gas stripper where the stripping gas is re-circulated by two turbo molecular pumps placed at the entrance and the exit of the stripper gas canal. The power socket of the turbo sitting at the exit was touching the Lucite (carrying the terminal sheave and the charging, suppressor and pick-off electrodes) and damaged it by rubbing material away due to the vibration of the terminal during operation. We removed some material from the Lucite and from the aluminum of the socket to achieve a gap of 2 mm.
Very close to the socket sits a bolt pressing the Lucite against the terminal structure. Especially between this bolt and the spot where the socket contacted the Lucite we found spark marks, although the turbo pump and the bolt sit on the same electric potential. We supplied a copper band giving good electrical contact between bolt and socket.

9 Finishing remarks

We have had very successful developments at VERA. All the performance of the facility could be enhanced. We are now able to measure $^{14}C/^{12}C$ ratios with an accuracy of 0.3 %. The more stable terminal voltage enables us to go for AMS of even the heaviest elements. We were able to develop detection systems for ^{10}Be and ^{129}I AMS measurements, and we performed measurements with ^{27}Al. However, we know that there will always arise new problems, and we are confident that we can solve them together with the NEC staff which were ready to help us at any time.