DEVELOPMENT OF THE PELLET CHAINS IN THE ELECTROSTATIC ACCELERATOR LABORATORY OF KYUSHU UNIVERSITY

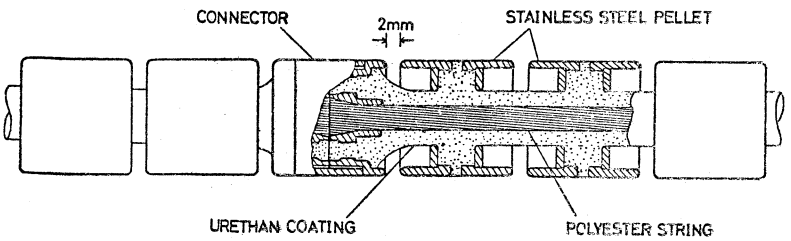
A.Isoya, H.Fujita, K.Kobayashi, K.Kimura and S.Mitarai
Department Of Physics, Faculty Of Science, Kyushu University

A prototype of pellet chains has been tested in 1966 by the Van de Graaff generator of Kyushu University.[1] In this test the pellet chains were operated with an insulation gas of freon-12 of several atmospheres and high enough voltages of 8 to 9 MV could be obtained on the terminal. This type of pellet chains and an associated driving and induction-charging system have been continually used until now with gradual improvements for stable operation. In the recent years, being associated to the construction of the 10 MV tandem in this laboratory,considerable effort has been made in the way of fabrication of the pellet chain.

Fig.1 shows a new model presently used in the tandem accelerator. Cylindrical-shape pellets made of stainless steel are fixed in position on a insulator cord. The insulator cord is made using an extrusion molding method, by which a sheath of thermoplastic polyurethan is formed around a polyester-fibre string. To fix the pellet on the insuletor cord, fused polyurethan is injected into the cavity between the pellet and the center cord through a small hole on the side of the pellet. Injected polyurethan sticks together with the sheath of the center cord to form a circular rib which assures the tightness of pellet position on the cord. The narrow gap between neighbouring pellets gives a perfect surge protection for the insulation. The gap length of 2mm can hold the voltage of more than 50 KV in the atmosphere of SF_6 gas of 10Kg/cm^2(g) and thus the chain can be safely operated under the voltage gradient of 1 MV/30cm. This was realized in the 1 MV pellet-chain generator which has been long used in this laboratory for the test of various components of the high-voltage generator machines. In an actual use in the tandem above-mentioned, the voltage on the gap is only 28 KV.

An experiment has been made for testing the surge protection capability of the electrode-insulator configuration of the present pellet chain. Surges from high voltage sparks were directly applied to a pellet chain gap and the change of resistance between the pellets was measured. It was normally of the order of 5×10^{12} ohms. This value did not change appereciably even after one hundred times sparks passed through the gap in SF_6 gas of 10 Kg/cm^2(g)

Experiences in the last 10 years indicate that the life of the pellet chain is determined mostly by the break of the insulator cord as a result of loosening of the pellets from the center cord. Need of improvement in this point has brought about the above-mentioned more rugged construction. Another important factor which causes the damage to the pellet chain is humidity. Polyurethan is sensitive to humidity and then if the polyurethan cord is wet,



insulation of the cord is easily destroyed by the passage of discharge track inside of the insulator cord. The connection portion of the pellet chain to make a loop was also a weak point in the design of the pellet chain. Several ways for connection have been tried in the past time. A satisfactory solution to this problem which is now being used is shown in the Figure.

For getting a stable driving condition of the pellet chain, free from lateral vibration, high degree of uniformity of the mechanical properties of the chain is required. Thus, elimination of off-centering of the fibre-string in the insulator cord and non- uniformity of the linear density or that of the degree of elongation of the cord by tension becomes an important requirement put in the course of fabrication of the insulator cord. These requirements are rather stringent so that chain cords are now manufactured in our laboratory by using a specially-made polyurethan extrusion machine which has been devised for the present purpose.

The vibration amplitude of the pellet chains during the operation in the present tandem accelrator is rather small. It is within a few mm. SF_6 gas of high pressure gives a strong damping of the vibration. Ripples of the terminal voltage of the tandem was observed to be of a rotation cycle (20c/s) of the driving pulley, being modulated in amplitude with a circulation frequency of the chain loop (~1 c/s). Their peak to peak amplitude is about 10^{-5} times the terminal voltage.

Reduction of the ripple magnitude by a factor of 10 may be possible by improvement of the driving pulley system although no special effort has been made.

Operating conditions and perfomance of the pellet chain system of the 10 MV tandem are shown in the following table.

Size of pellet	15 mmϕ x 15 mm
Linear density of the pellet chain	0.48 Kg/m
Total length of the chain loop	15.4 m
Tension of the chain	20 Kg
Driving speed of the chain	15.7 m/sec
Diameter of the driving pulleys	25 cm
Charging efficiency of the inductor	1.2 μA/kV per inductor
Maximum inductor voltage	~40 KV
Charging current capacity with both inductors at the column base and the center terminal	~80 μA per chain
Ripple of the terminal voltage (peak to peak)/terminal voltage	~10^{-5}

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