COMPACT 500 kV TANDEM ACCELERATOR ON THE BASE OF HIGH FREQENCY RECTIFIER AND GAS-FILLED FEEDTHROUGH INSULATOR

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Abstract

The project of compact accelerator of up to 10 kW power and energy of deuteron beam up to 1 MeV is proposed. The specific power of generator made on base of 20 kHz rectifier is 80 kW/m^3. 500 kV potential of generator placed in compressed gas is transferred to the high voltage electrode placed in vacuum through SF_6-filled feedthrough insulator. The characteristics of generator are considered and results of its preliminary testing are given. This accelerator if used with target can work as a fast neutrons source for medical purposes.

INTRODUCTION

The neutron source for fast neutron therapy can be created on base of the direct acceleration facility. The neutron flux with 10^{12} n/s intensity is generated in beryllium target bombarded by the 10 mA deuteron ions beam with 1 MeV energy. [1].

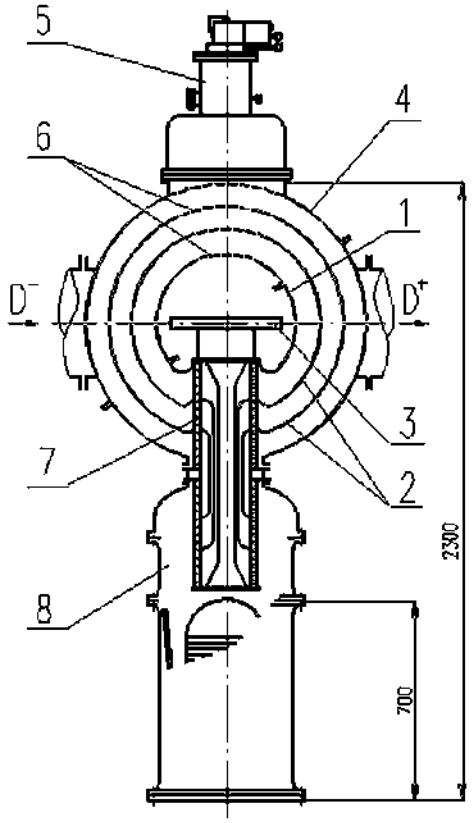

Fig. 1: Layout of tandem-accelerator.

The usability of the ion source being put under ground potential and possibility to accelerate the ions up to energy, corresponding to the double potential of high voltage source make the tandem-type accelerator usage preferable. The experience in creation of such facilities accumulated at BINP [2] allows to propose the design of compact accelerator (Fig. 1).

ACCELERATOR DESCRIPTION

Tandem accelerator has the following characteristics:

Energy, MeV	1
Deuteron current, mA	10
Accelerating voltage per gap, kV	167
Acceleration voltage pulsation under the load, %	0.1
Gas flow in the stripper, ml·Torr/s	~10

There are no accelerating tubes in tandem proposed. The high-voltage spherical electrode 1, surrounding it intermediate electrodes 2 and gas stripper 3 are placed inside vacuum tank 4. The target gas is pumped by cryogenic pump 5 through the profiled covers 6 of intermediate electrodes. Taking into account the full-voltage effect, the number of intermediate electrodes is defined by the amount of energy accumulated in interelectrode gaps and by the allowed overvoltages during breakdowns.

With the gas flux of 10 ml·Torr/s from the stripper and total conductance of vacuum pumping channel 3000 l/s the necessary residual gas pressure required for the reliable operation of high-voltage vacuum gaps is obtained.

There is a possibility to place the 900 mm-height cryogenic pump on one side of the vacuum tank if the height of the facility should be reduced.

The high-voltage and intermediate electrodes create the sufficiently uniform field distribution in accelerating gap. The potential is transferred to high-voltage and intermediate electrodes through the electrodes of feedthrough insulator 7 placed outside the acceleration and beam passage region. Insulator consists of two parts vacuum and gas ones tightened by central tube. This tube transfers the potential of the voltage source 8 to high-voltage electrode. The necessary communications are placed inside the tube.

It is proposed to use a surface-plasma source of H^- ions being developed at BINP [3]. The beam from the ion source after passage through low-energy tract comes into acceleration channel 20 mm in diameter formed by intermediate and high-voltage electrodes. The average field strength in accelerating gaps is ≈ 25 kV/cm. In [4] the possibility of 10 mA beam transmission through the

tube of the stripper 10 mm in diameter and 400 mm length in accelerating fields 30 kV/cm is shown.

The heat-carrier input for the forced cooling of the stripper and the target gas input is realized through the polyethylene tubes placed on the axis of high voltage rectifier.

HIGH-VOLTAGE GENERATOR

The basic parameters of the accelerating voltage generator are the following:

Maximum voltage, kV	500
Power, kW	10
SF_6 gas pressure, MPa	0.2
Accelerating voltage pulsations under the load, %	0.1
Coupling coefficients of the transformer windings	0.68
Efficiency	0.94
Inductance of the primary winding, H	$17 \cdot 10^{-6}$
Inductance of the secondary winding, H	57.4

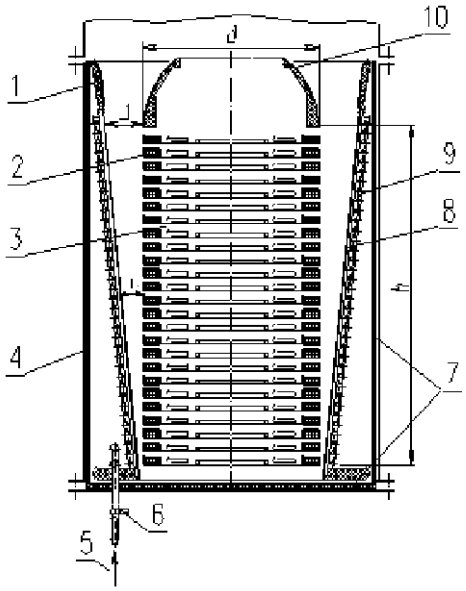

Fig. 2: Generator of accelerating voltage.
1 – ring, 2 – secondary winding, 3 – 50 rectifying sections set, 4 – vessel, 5 – water cooling, 6 – power input, 7 – magnetic circuits, 8 – screen, 9 – primary winding, 10 – high-voltage electrode

The cascade accelerating-voltage generator with inductive coupling and parallel powering of the cascades is a system of identical serially connected rectifiers – generator sections (Fig. 2,3) The rectifiers are coupled with a common primary transformer winding T_p by mutual induction. All sections are assembled following a scheme with doubled voltage.

The generator description is given in details in [7].

FEADTHROUGH INSULATOR

Main parameters:

Voltage, kV	500
Maximal electric field strength, kV/cm	148
Electric field gradient along the surface of insulator, kV/cm	16
SF_6 pressure, MPa	0.3
Divider resistance, GOhm	6.4

Gas filled bushing insulator (Fig. 3) consists of two nonseparable insulating parts, i.e. vacuum 1 and 2 gas ones tightened by the central pipe 3. The absence of organic sealing is the principal feature of this input. Ceramics is connected with Kovar electrodes 4 through copper layings by means of diffusion soldering. The input is placed in SF_6 environment under $3 \cdot 10^5$ Pa pressure. The tightening force is chosen so, that ceramics is always in compressed state. This insulator is additionally pressed by retaining washers 5. The tubes for oil cooling of the stripper 6 and for the target gas input pass inside the central tube.

The potential distribution on the electrodes of insulator is set by two resistive voltage dividers. One of them is placed outside the feedthrough insulator in gas part 7, the second – inside the insulator in vacuum part of insulator 8. The like potentials of dividers are electrically connected by two concentrically placed metal tubes 9 – the electrodes of insulator.

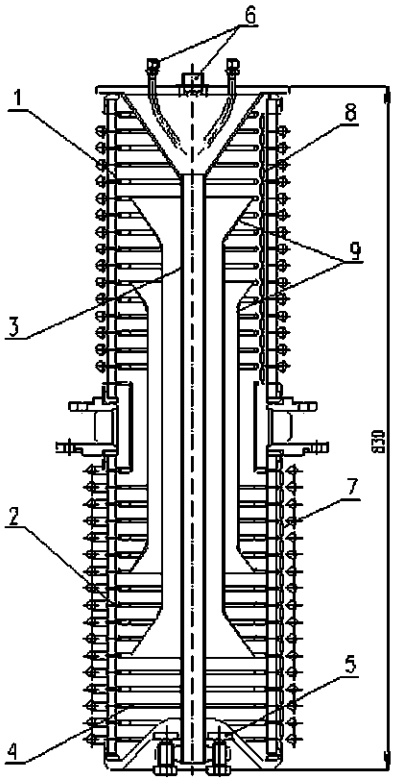

Fig. 3: Feedthrough insulator.

TANDEM

On main feature of tandem layout is that insulator is placed outside the beam passage area. Therefore the scattered particles do not charge the surface of insulator. Besides that, the target gas is pumped out directly through the profiled covers of intermediate electrodes having a big conductance.

The stripper is a thick-wall copper tube of 400 mm length with oil cooling. The calculated diameter of channel is 10 mm and will be defined more precisely after testing. The positioning mechanism is provided.

CURRENT STATUS

Now the generator of accelerating voltage have been finally manufactured. (Fig. 4) It's testing have proved the advisability of transition to high frequency power supply. The following parameters were obtained in SF_6 under $2 \cdot 10^5$ Pa. Idling voltage is 500 kV. The power P = 9 kW was obtained under the load at U_0 = 300 kV. The further increase in power is planned with new more powerful inverter.

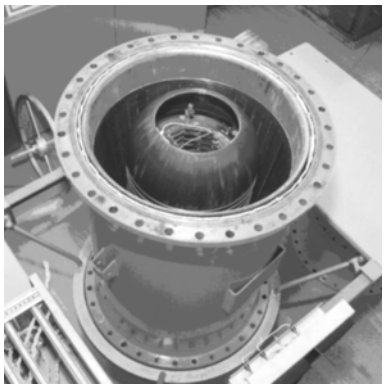

Fig. 4: Generator without lids.

The metal-ceramics parts of bushing insulator were produced (Fig. 5).

Fig. 5: Parts of the insulation.

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