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ELECTRONS INJECTORS WITH CATHODE DIAMETER OF 6÷15 mm AND NEW CUP ENERGY INPUT ON THE WAVE E11 FOR ACCELERATORS

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Abstract

JSC "RPC “Istok" named after A.I.Shokin” has created a number of electron injectors with voltage of 20-60kV and cathode diameter of 6-15mm of diode and triode designs. Injectors use the impregnated cathodes; the injector design allows rapid replacement of cathode assemblies. Injectors have been widely used in linear electron accelerators in Russia and Ukraine, in particular, in the sterilization accelerator center of JSC "MRTI RAS", Moscow, in the accelerator of the Russian Eye and Plastic Surgery Centre, Ufa. Have been proposed new input energy windows on the E11 wave, providing significant levels of transmission of the pulse power at high average power levels. Have been created two types of windows at 10-cm range, in which the ceramic disk made of ecologically clean alumina ceramic with diameter of 103mm and thickness of 13mm is used. In the first type of windows the heat transfer is provided from the peripheral portion, and in the second type of window – both from peripheral and central portions of the ceramic disk. These windows are used in accelerator of FSUE "NIIEFA" (St.Petersburg), installed at Izhora mill for testing the welding seals of atomic reactors and in accelerator of JSC "MRTI RAS".

INTRODUCTION

The reliability of modern electron linear accelerators are largely determined by the reliability of its main units - electron injector and the microwave energy input to the accelerating structure.

In this work we consider the design of electrons injectors with different cathodes diameters and new microwave energy input to the accelerator, which were used in the accelerator complexes in Russia and Ukraine.

ELECTRON INJECTORS FOR LINEAR ELECTRON ACCELERATORS

JSC «RPC «Istok» named after A.I.Shokin» has been creating electron injectors, which are used in many accelerator complexes for many years.

"Istok" has its own technological base for the production of injectors, since cathodes and high voltage insulators used in the injectors are also created at "Istok".

The impregnated cathodes are used as cathodes in the injectors that fully ensure performance of the cathode in a vacuum of 10^{-2}-10^{-3} Pa, obtaining in the accelerators. Besides, to improve the cathode operating reliability, in the cathode assembly is applied a modern technology of impregnated cathodes - technology for application of osmium coating to the cathode.

Consider the electron injector that is based on cathode of Ø15 mm.

The basic requirements for the electron injector are the cathode current of 5 amps and the operating voltage of 60 kV.

Figure 1 shows a photo of the injector and cathode holder with filament output. The feature of an injector design is that it allows making replacement of a cathode assembly with focusing electrode. Mounting of the cathode assembly is performed using three screws - two screws secure the cathode assembly to the holder, and the third screw secures the filament output of cathode to the injector filament input.

Figure 1: Photo of injector and cathode holder.

Another feature is that the input part of the accelerating structure belongs to injector, and is its anode.

Such injector is used in the accelerator complex of JSC "MRTI RAS", which is operated in the mode of commercial operation since 1994.

Figure 2: Irradiated devices on conveyor in the accelerator complex of JSC "MRTI RAS".

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Using this accelerator complex the sterilization of a wide range of medical products for the European territory of Russian Federation (Fig. 2) is conducted.

Also note that in the accelerator complex of JSC "MRTI RAS" is used a super-power chain of amplifying klystrons KIU-15M - KIU-17, created by "Istok" [1].

Figure 3 presents the picture of the injector with anode voltage of 30 kV for electron accelerators for inspection and examination complexes [2]. A distinctive feature of the injector is that on the cathode diameter of 8 mm is imposed a special mask of square cells. This allows sending a poorly focused electron beam to the conversion tungsten target, transforming the energy of the electron beam in the slowing-down radiation, and, thereby, to ensure reliable operation of the target and accelerator.

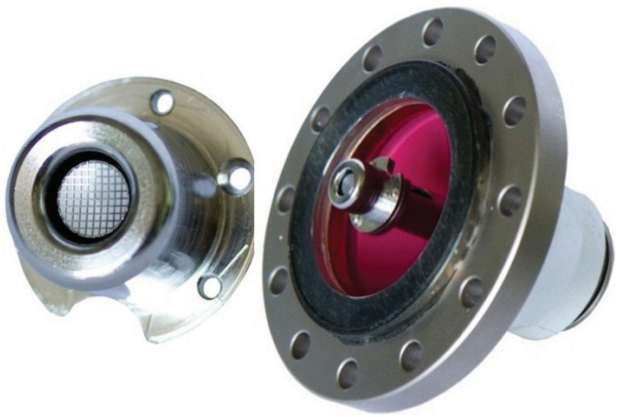

Figure 3: Photo of an injector with a mask on the cathode.

The electron injectors of diode and triode design with cathodes diameter of 6 mm, 8 mm, 11.4 mm, which are used in many accelerator complexes of Russia and Ukraine, were also created at "Istok".

For example, the injector with cathode diameter of 6 mm is used in the accelerator in All-Russian center of eye and plastic surgery, Ufa.

I'd also note that "Istok" created a unique cathode assembly with belt cathode [3, 4] with the length of the emitting part of 320 mm and a width of 6 mm for electronic sealed-off gun [5] - a direct action energy accelerator of 160-200 keV (Fig. 4).

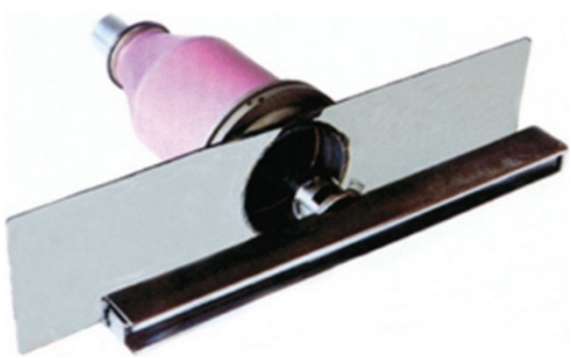

Figure 4: Injector with belt cathode 6x320 mm.

NEW MICROWAVE ENERGY INPUT FOR THE ACCELERATOR ON E_{11} WAVE

The urgent task now is to create a safe working microwave energy input for the accelerator. Such inputs should provide significant levels of transmission of the pulse and average power, be constructively useful and easy to manufacture.

To solve this problem "Istok" proposed [6, 7] and created cup microwave energy input for the accelerator on E_{11} wave. Fig. 5 shows a schematic drawing of an input on the E_{11} and wave distribution of the electric field.

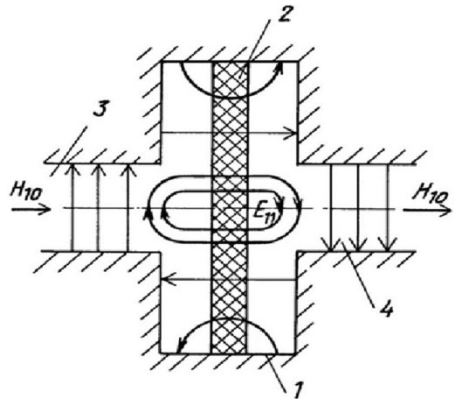

Figure 5: Schematic drawing an input on the E_{11} and wave distribution of the electric field.

Cup window contains a segment of the circular waveguide 1 in the middle part of which is a ceramic disc and two rectangular waveguide sections 3 and 4.

The microwave power coming on the input rectangular waveguide 3 on the wave H_{10} is converted at the junction of waveguides 3 and 1 into the wave E_{11} of circular waveguide 1. The microwave power which passes the ceramic partition 2 on the wave E_{11} is converted at the junction of waveguides 1 and 4 into wave H_{10} and transmitted into the accelerator.

The calculation results and experimental studies indicate that these inputs the thickness of the ceramic disc and a circular waveguide length several times greater than on conventional cup inputs on the wave H_{11}.

That allows:

To significantly improve the junction reliability of the ceramic disk with the metal wall of the circular waveguide, and hence, increase the heat resistance of the cup input.

To significantly increase the dielectric strength of cup input as when the microwave power on the wave E_{11} is transmitted through the input, the electric field is perpendicular to the dielectric partition and the probability of breakdowns through the partition thickness is negligible. This leads to the possibility of transmission through the input of large amount of pulse power.

To significantly increase the level of continuous power, as the maximum heating of the cup input does not occur in the center of the ceramic disc, but near to its periphery that facilitates the removal of heat.

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Since most of the electron accelerator operating at 10-cm wavelengths, the cup input at the wave E_{11} are created for this range. The alumina ceramic BK 94-1 with diameter 103mm and 13mm thickness is as a ceramic disk.

"Istok" established a technology for such waveguide microwave inputs. For this purpose was established a technology of fabrication of ecologically clean, constructively useful and easy to manufacture thick-walled ceramic discs with large diameter by pressing with the introduction of modifying nano-additives ensuring uniformity of structure.

Figure 6 shows a photo of the input, which has been successfully used in the accelerator complex of JSC «D.V. Efremov Institute of Electrophysical Apparatus» (Saint-Petersburg), installed at the Izhora factory for testing of atomic reactors welds and in the sterilization accelerator complex at JSC "MRTI RAS".

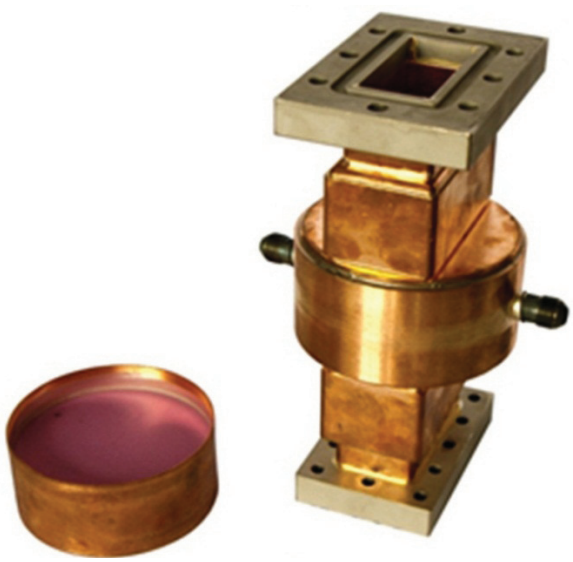

Figure 6: Cup input on E_{11} wave.

Although in the Central part of the ceramic disk (Fig. 5) the heat is produced slightly, when big levels of average power are passing through the input, the heat generation in the central part of the ceramic disk can be significant.

In order to increase the transmitted average power through microwave input, on both sides in the central part of the ceramic disk there are grooves, in which copper tubes are solded. Through these tubes (Fig. 7) the coolant passes. These grooves do not reduce the mechanical strength of the ceramic disk due to its large thickness, characteristic for the wave E_{11}.

Thus, in this cup input is conducted the effective cooling due to the heat removal not only from the peripheral part of the ceramic disk, but also from its central part.

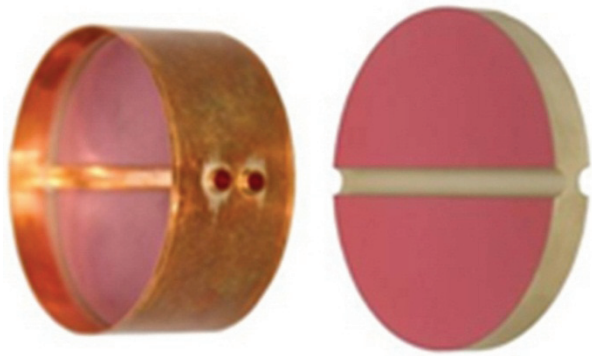

Figure 7: Ceramic disk with tubes for cooling.

CONCLUSION

"Istok" created a number of electron injectors with the cathode diameter of 6-15mm and voltage from 20 to 60 kV.

"Istok" suggested and created the cup microwave energy input for the accelerator on wave E_{11} using ceramic disc of large thickness from ecologically pure alumina ceramics.

Electron injectors and microwave energy inputs have found application in many accelerator complexes in Russia and Ukraine.

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