THE IDK-6/9MEV LINEAR ELECTRON ACCELERATOR AND ITS APPLICATION IN THE CUSTOMS INSPECTION SYSTEM

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Abstract

A linear electron accelerator IDK-6/9MeV has been designed for operation as a source of ionizing radiation in a customs inspection system intended for inspection of large-scale cargos. The main operating mode of the accelerator is the X-ray mode with an energy of 6 MeV, which ensures the penetrability more than 300 mm (for steel). The operating mode of the accelerator can be quickly changed for 9 MeV, which allows the objects under study to be discriminated based on the organics/non-organics criterion using the "two energies" method.

A triode electron source with cathode and grid modulators is applied in the accelerator. A system of collimators located at the output of the accelerating device serves to form a fan-shaped X-ray beam in the vertical plane with an opening angle of 46^0 directed towards the detector line. The accelerator is equipped with a computerized system of protective interlocks and control, which makes possible its operation both in the setting mode and as a component of the whole customs inspection system.

IDK-6/9MEV LINEAR ELECTRON ACCELERATOR

Up-to-date equipment for inspection of the cargos transported abroad are nowadays a mandatory requirement to ensure a high throughput, efficiency and quality of inspection at customs checkpoints. Customs inspection of large-scale containers and trucks is the most complicated procedure as it involves labor and time – consuming handling operations. Design features of vehicles can also be used to hide smuggled goods. An X-ray customs – inspection system allows an image necessary for the identification of a large-scale container or vehicle to be obtained within several minutes. In the case of any suspicious goods observed on the obtained image or non-compliance of the actual cargo with that described in the cargo customs declaration, a manual inspection can be assigned.

The linear electron accelerator IDK-6/9MeV has been designed as a source of ionizing radiation to be used in a customs inspection system intended for inspection of large-scale cargos and vehicles (Fig. 1).

Figure 1: The IDK-6/9ÌeV accelerator in a customs inspection system.

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The IDK-6/9MeV linear electron accelerator generates the X-ray radiation with energies of 6 and 9 MeV.

The main operating mode of the accelerator is the X-ray mode with an energy of 6 MeV, which ensures the penetrability more than 300 mm (for steel). If more accurate identification of objects under inspection is necessary, the operating mode of the accelerator can be quickly changed for 9 MeV. This allows the objects under inspection to be discriminated based on the organics/non-organics criterion using the "two energies" method [1].

A 950 mm - long standing-wave accelerating structure, which allows the acceleration of electrons up to 9 MeV, is applied in the IDK-6/9ÌeV accelerator. The working vacuum in the accelerating structure is provided by two ion pumps installed near the electron source and target unit. Energy is changed by changing the accelerated electron beam pulse current loading of the accelerating structure. If necessary, the energy can be adjusted by changing the level of the microwave power supplied to the accelerating structure from the MG6090 magnetron generator. A triode electron source with cathode and grid modulators applied in the accelerator ensures the accelerator change-over from one energy to the other by adjusting the amplitude of the beam current pulse. Optimization of the X-ray dose rate on the detector line is also possible by changing the beam current pulse length separately for each operating mode of the accelerator. The magnetron modulator used in the accelerator allows the pulse voltage across the magnetron cathode to be smoothly controlled in the 40-48 kV range. This makes possible the 2-3 MW pulse power to be obtained at the magnetron output with a pulse length of 5 μsec and pulse repetition rate of 200 Hz. A possibility to adjust the magnetron output power allows the operating mode of the accelerating structure to be optimized when the accelerator is set for boundary X-ray energies, and the output power decrease caused by the magnetron aging can be compensated in the process of operation. The operating frequency of the accelerating structure varies in the process of operation as the equipment is warmed-up. The magnetron frequency is tuned to the operating frequency of the accelerating structure by means of an AFT system operating on the principle of minimizing the RF power pulse reflected from the structure. The setting mode provides for the manual control of the magnetron frequency.

The accelerator is equipped with a computer-controlled system of protective interlocks and control made on the basis of the Siemens S7-300 logical controller. This system allows the accelerator operation to be controlled and its complete functionality to be ensured. The control system of the accelerator realizes protective interlocks, measures analog operating parameters of the accelerator, switches on and off necessary units and components of the accelerator in accordance with the control program and sends commands to the power supply sub-system to set up necessary parameters. Special-purpose modules are controlled by means of the RS-485 digital serial interface. The control system is designed for remote control via the Industrial Ethernet interface and is a part of the whole customs inspection system. The system provides for a log book, in which operating parameters and main events occurring during the accelerator operation are entered. When operating the accelerator in the automatic mode, an operator usually gives the four following commands: "Warm up the accelerator", "Start the inspection", "Start the inspection in the additional mode" and "Switch the accelerator off". In so doing, status messages and main parameters are sent to the operator's workstation. For fine setting of the accelerator parameters and for the setting of operating modes, a setting mode is provided for. In this mode, setting of separate parameters of the accelerator can be done, detailed control of the accelerator operating stages and obtaining of a wider range of the accelerator operating parameters.

A system of collimators located at the output of the accelerating structure serves to form a fan-shaped X-ray beam in the vertical plane with an opening angle of 46^0 directed towards the detector line.

Structurally the accelerator consists of four parts, in particular, the irradiator cabinet, water cooling and temperature control unit, control cabinet mounted on a gantry moving along an object inspected, and control panel located in the operators' room. The irradiator cabinet houses the main units of the accelerator: the accelerating device with an electron source and target unit, magnetron modulator, electron source modulator, ion pumps, waveguide line, power supply units, actuator components of the control system and a system of collimators.

Nowadays, works on the accelerator updating are underway. The main objectives are:

- to ensure the accelerator operation in the "dual energy" mode;
- to make simpler the schematic and design of the accelerator;
- to ensure higher reliability and stability of the accelerator equipment operation.

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