COMISSIONING OF THE LINEAR ACCELERATOR-INJECTOR OF TNK FACILITY

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Abstract

The industrial storage facility has been developed and manufactured at Budker INP SB RAS. It contains an 80 MeV electron linear accelerator-injector and two electron storage rings: the lesser 450 MeV booster ring and the main 2.5 GeV storage ring. In 2002, the work on the accelerator assembling was begun. On December, 25 of this year the accelerator was started up, and the current at the linear accelerator output was obtained.

The linear accelerator schematic together with a description of the 6 meter long accelerating DAW structure which operates at 2.8 GHz, are presented in the paper. The first results of the accelerator start-up are as follows: the accelerated electron current of ~50 mA with the energy of ~55–60 MeV.

INTRODUCTION

The industrial storage facility (TNK) has been developed at Budker INP SB RAS in 1985. It includes an injector on the base of 80-100 MeV linear accelerator, and two storage rings: lesser booster for energy of 450 MeV and main ring for energy of 2.5 GeV.

Design parameters of the electron beam at linac output are listed in Table 1.

Table 1:

Beam energy	80 MeV
Energy spread	1 %
Beam pulsed current	~ 80 mA
Pulse duration	18 ns
Transverse emittance	0.1 mrad·cm
Repetition rate	1 Hz

By the year 1988, equipment for two linear accelerators has been produced at INP SB RAS [1]. The first linac was commissioned in 1992 at specialized SR complex in "Kurchatov Institute", Moscow [2,3]. The second one has been made for TNK complex in Lukin State Research Institute for Problems in Physics, Zelenograd. In 2001, decision about assembling was made, and commissioning of the injector in Zelenograd was scheduled for the end of 2002. In September 2002, linac accelerating structure was assembled at building ways in TNK building (Fig. 1), and forevacuum was achieved. A waveguide channel was re-designed, manufactured, and shipped in November, 2002. In the beginning of December, the disc ceramic window was manufactured at INP branch in Protvino, and assembling of the waveguide connecting linac with "Olivin" klystron station was started.

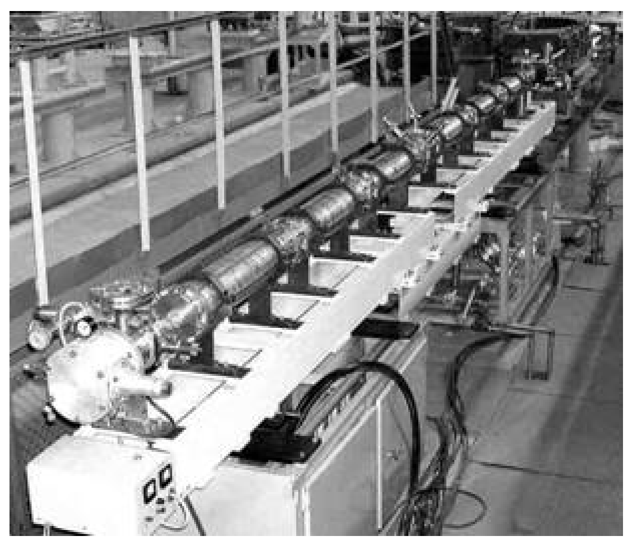

Figure 1: Linac accelerating structure at building ways.

LINAC SCHEME, PARAMETERS AND RESULTS OF PREINJECTOR START-UP

Functional diagram of the linear accelerator-injector of TNK facility is shown in Fig.2. The linac operates in energy accumulation mode for pulse duration of ~8 μs with excitation of a standing wave in the accelerating structure. Beam injection from a gun is come about at the end of this RF pulse.

RF power supply is provided by "Olivin" klystron station at 2798.6 MHz. A pulsed diode electron gun

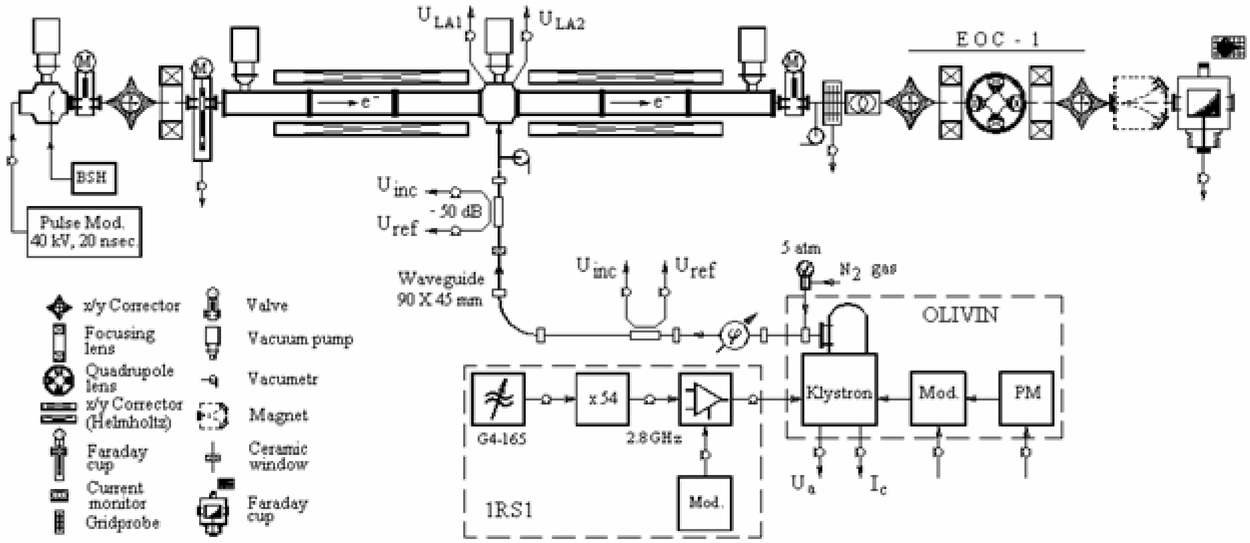

Figure 2: Functional diagram of 80-100 MeV electron linear accelerator-injector for TNK facility.

(40 kV/3.5 A/18 ns, repetition rate up to 5 Hz) located coaxially with the linac and separated from it by the valve is used as an electron source. The accelerated beam from the linac output is transported by EOC-1 channel into the booster storage ring. The current pulse is a ~18 ns packet which consists of ~50 microbunches. The beam current is measured at linac input and EOC-1 output.

In 100 MeV electron linear accelerator creation, the development, simulation, and manufacturing of the biperiodic accelerating structure with disks and washers (Andreev structure, DAW) [4,5] as regular brazed one meter long sections were on principle new. The six meter long linear accelerator was then constructed from theses sections. Attachment was realized by indium seals. DAW accelerating structure represents a single resonant volume with high Q-factor due to strong resonant coupling between cells. Power input is provided by the waveguide [6] at the linac center. Accelerating structure parameters are listed in Table 2 [6].

Oscillograms on Figs. 3–5 represent the practical results and injector start-up chronology.

Oscillograms in Fig.3 show the beginning of linac accelerating structure conditioning on December 21, 2002. The multipactor is observed in the central part of the structure near the coupling hole between the central cavity and waveguide power input.

Figure 4 presents the result of 3-day conditioning, when a stable linac operation was achieved, which allowed us to increase the incident RF power level from the klystron into the waveguide up to 8.5 MW.

That power was enough to transport the beam along the whole accelerating structure. The ~55 MeV accelerated beam at the linac output was obtained on December 25, 2002.

Figure 5 shows the accelerating voltage oscillogram (K1) and Faraday cup capacitance voltage (K2) loaded on ~300 kΩ resistor (at the gun current pulse duration of ~18 ns). The beam current front position is in the linac accelerating field maximum.That was the first observation of electrons accelerated on December 25, 2002, on the Faraday cup.

That result was replicated on December 26 immediately after the operating regime program loading and starting the whole RF system without additional conditioning.

Table 2:

Linac accelerating structure	DAW
Oscillation mode in linac	$\pi/2$
Oscillation type	E_{02}
Linac length	6 m
Operating frequency	2798.6 MHz
Effective shunt impedance	95±3 MΩ/m
Characteristic impedance	3.4±0.1 kΩ/m
Unloaded Q-factor	28000±100
Structure time constant (loaded)	~1.8 μs
Coupling coefficient in structure	43 %
Kinetic energy at 18 MW power level	90 MeV
Esmax/Eacc ratio (overvoltage coefficient)	~5.5
Achieved field strength on accelerating structure surface Esmax	~790 kV/cm
Accelerated pulsed current (for 100% particles)	0.6 A
Linac frequency drift	~50 kHz/^{o}C
Linac heating stabilization temperature	33±0.1 ^{o}C

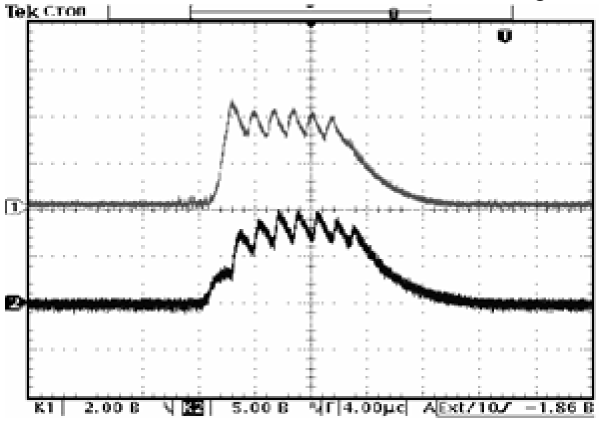

Figure 3: Start of the conditioning: upper line – voltage in the linac central part (Ucav); lower line – reflected wave voltage amplitude (Uref).

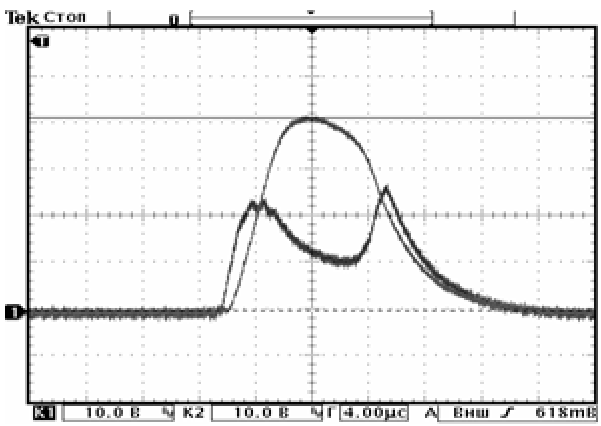

Figure 4: 25.12.02. After 72-hour conditioning: upper line – voltage in the linac central part (Ucav); lower line – reflected wave voltage amplitude (Uref).

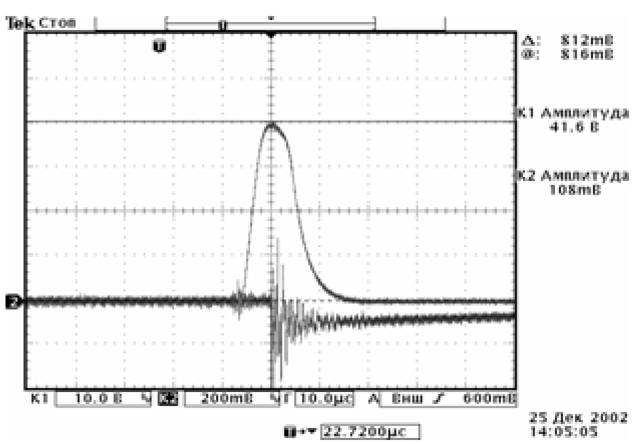

Figure 5: 25.12.02. HERE COMES THE BEAM! Uanode=190 kV. K1 – structure voltage Ucav, K2 – Faraday cup voltage. Scanning of 10 μs/grad.

CONCLUSION

Shipping of the linac equipment according to schedule allowed us to assemble and tune the injector on the base of the linear accelerator undertime. The accelerated electron current of ~50 mA with the beam energy not less than 55 MeV was obtained at the linac output on December 25, 2002.

So, at present time two unique linear accelerators with biperiodical DAW structure created at our Institute successfully operate.

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