RESULTS OF START OF THE 150 KV MAGNETIC PULSE COMPRESSOR

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Abstract

The powerful pulse generator with target parameters 150 kV, 37 kA and duration of a pulse 150 nsec was described in article [1]. The magnetic cores from amorphous alloys with ratio Br/Bs more than 0.9 were used as the key elements in the generator. We have carried out process of start, adjustment and have obtained the designed parameters. The researches on improvement of electrical durability of installation and the researches of losses in cascades of the generator have been carried out. The greatest attention devoted to the research of work and modernization of the second step of compression, to the reduction of its inductance with the purpose of to reduce built-up time of a pulse. We managed to receive built-up time (at a level from 0.1 up to 0.9) of the generator pulse about 40 nsec.

1 GENERAL DESIGN

The general parameters of the generator are:

Output voltage	150 kV
Output impedance	4 Ohm
Output pulse duration	150 ns
Build-up time	40 ns
Pulsed-oscillator starting time (jitter)	10 ns
Repetition rate	1 pulse/min

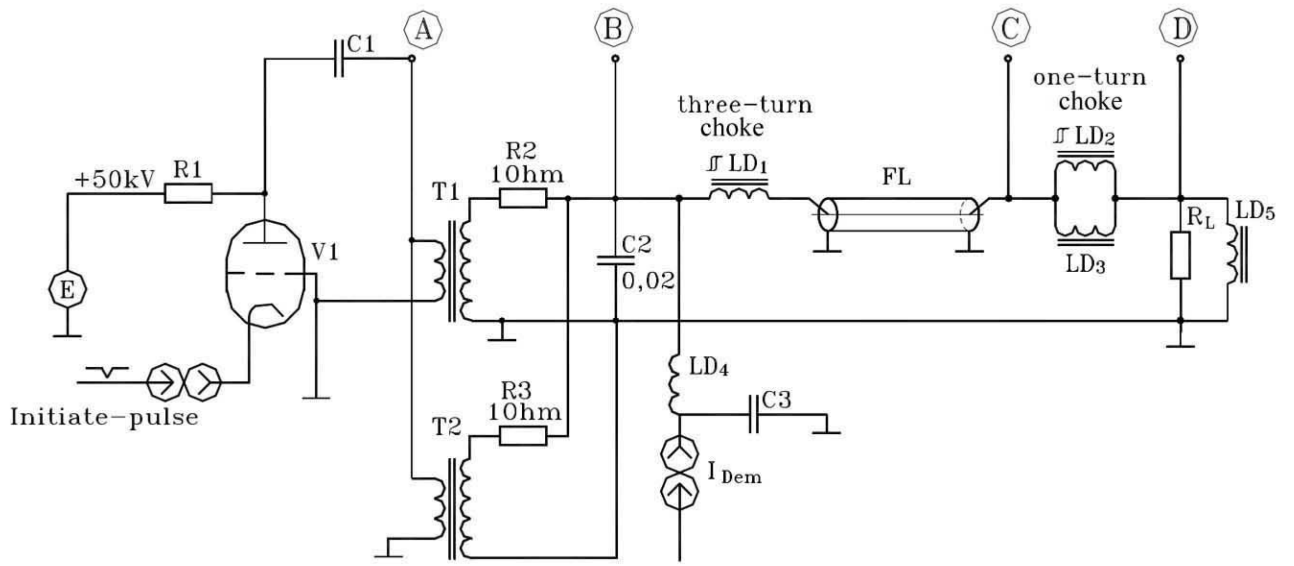

Figure 1: The generator design.

The generator includes an energy store C1, thyratron switch V1 and step-up transformer (there were used two transformers T1 and T2 connected in parallel). The secondary energy store C2 is connected to secondary winding of transformer. By means of saturable choke LD1, energy of the store supplied to pulse forming line (PFL). Charged PFL connects to load R_L by means of second saturable choke LD2. After each pulse, the demagnetization of the cores of the transformers and chokes is performed. After that the induction of all cores is equal to maximum residual induction - Br. The demagnetization pulse current I_{dem} is creating by the demagnetization unit, which is not shown in Fig. 1. The choke LD4 and capacitor C3 forms a filter for the protection of the demagnetization unit from high voltage of the secondary windings of T1 and T2.

The demagnetization current branches on 2 parts. First saturates transformer cores. It magnitude is limited by resistor R2, R3. The second part saturates a circuit of the series connected chokes LD1, LD3, LD4, LD5. The

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choke LD5 shunts a load. It allows reducing demagnetization unit power. As this circuit is saturated after saturation of transformers, it is not necessary to limit this current.

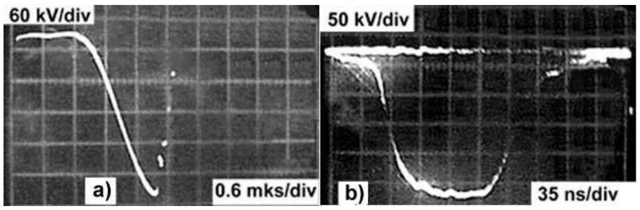

Figure 2: The basic voltage diagrams.

Below there are the results of starting up of the generator.

1.1 Primary circuit

It is the battery of store capacitors (C1) and charged – discharged circuits, connected to it. We had the breakdowns near capacitor buses at the 50 kV voltage level. To achieve calculated high-voltage durability the heating of the oil in pumping out vessels was made. We have achieved breakdown voltage of the oil 65-70 kV (before drying it was 30-35 kV) on VDE0370 measurement, which is equivalent - 58 kV on VTE. We have to improve the high voltage buses and other elements with the purpose to reduce strength of the field, and also to improve the reliability threading joints, as the discharge current exceeded 50 kA.

1.2 The circuit of transmission of energy to the secondary store

We used two transformers connected in parallel in order to receive the necessary power using one of our transformer design and also with desire to reduce the weight of each unit. In Fig. 3 the basic elements of the first step of a generator - primary energy store, thyratron unit, step-up transformer and also choke are shown. Basic work, which was carried out with the transformer, is an optimization of its factor of transformation with the purpose of deriving on the secondary store C2 of necessary voltage - 300-310 kV. In Fig. 2a the oscillogram of voltage on the secondary store C2 is shown. As to duration of charging pulse, this parameter has not caused the problems; i.e. the time was close to calculated one - about 1.5 microsecond. The voltage on C2 had appeared a little less than expected on 10-15%. The research has shown that it was connected to active losses in an outline of transmission of energy. For localization of losses the work of the first stage of a generator with disconnected second stage was investigated and it was shown that the main losses were the losses in capacitors. On resonance frequency (f = 300 kHz) their quality factor Q = 7. Quality factor of the transformer together with buses is 80.

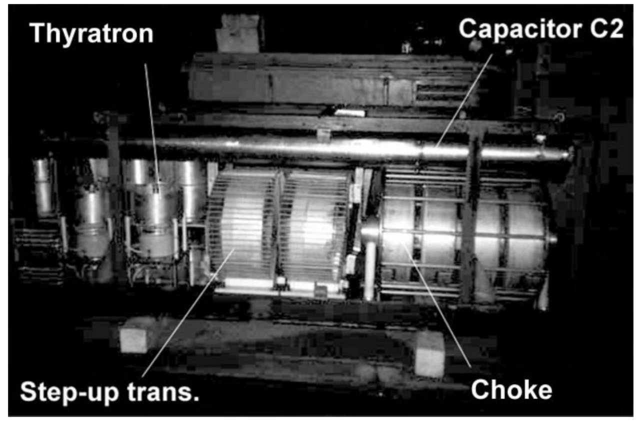

Figure 3: The basic elements of the generator first step.

For achieving the voltage 300-310 kV we have to raise transformation ratio from 7 up to 8.5 and the same time the conditions of transmission of the energy had been improved a little.

The reduced value of capacity C2 to the primary winding of the transformer with new factor became closer to capacity of a primary store, than before.

After testing the efficiency of the first step, which is equal to ratio of energy of secondary and primary stores became 0.7.

1.3 Choke of the first step L1

Choke of the first step has three turns wound around ferromagnetic core with rectangular square loop of a hysteresis (material 9KCP). The cross section of the steel S = 290 cm^2, weight of a material of the core - 200 kg. The choke is realized from 4 in series connected sections. It was made with the purpose of a voltage reduction between choke turns (Fig. 4).

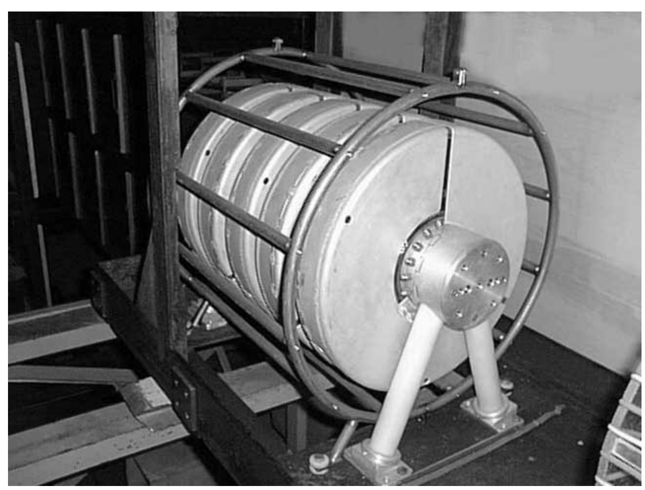

Figure 4: The view of the first step choke.

At the beginning of the work there were the breakdowns between the turns of output section because of non-uniform distribution voltage along sections. After saturation of the choke water line is charged during 0.5

microsecond. The stray capacitance, which is derived by last section on a grounded screen, is charged up to 300 kV. The terminal of the last section connected to a water line after it discharging appears under a zero potential, that means that on winding of the section there is a full voltage - 300 kV. For it elimination the capacity divider was installed, which aligned voltage along sections. Also the clearance between the first and third turns in last section was enlarged. After these changing the choke worked reliable. The calculated time of charging of a water line 0.45 - 0.5 microsecond was obtained without additional regulation and adjustment. The moment of saturation choke L1 approximately corresponded to a maximum of a charge of a secondary store without additional regulations.

1.4 Choke of the second step L2

Originally installed double-turn choke with additional sharpener of voltage was replaced by two connected in parallel single-turn chokes. We used additional material, but simplified deriving a necessary sharpness of the front of impulse. A cross-section of the steel is equal 237 cm^2. Chokes were made from the same type of the ferromagnetic cores, using material 9KCP. The voltage waveform on a load (4 Ohm) is shown in Fig. 2b.

Efficiency of installation as a whole, defined by a ratio of output pulse energy to energy of a primary store is equal about 0.5. If to take into account, that the efficiency of the first step is equal 0.7, it is received, that in the second step the efficiency is 0.7. The reason of losses in the second step was not investigated, since losses were not the defining factor for the installation.

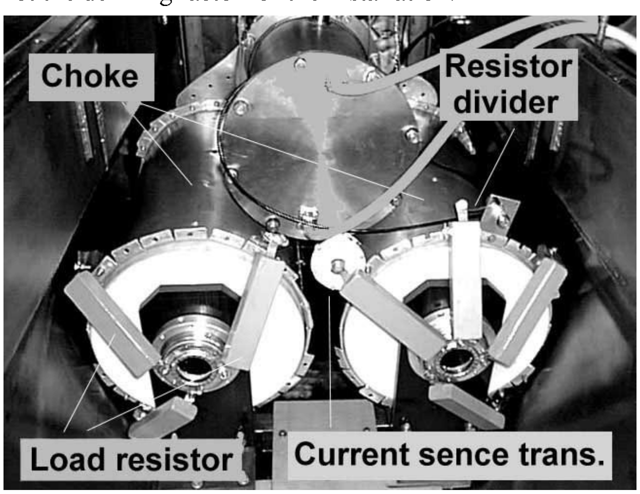

Figure 5: The view of the second step loads area.

Nevertheless, the losses can be explained by some mismatching of the water line and load, and also by incomplete transmission of the energy from a secondary store to PFL. In Fig. 5 the chokes of the second step with an on-line load are represented.

1.5 Diagnostics

In a construction of a generator the measuring voltage dividers and also measuring transformers of a current are installed.

The measuring voltage divider is connected in a parallel way to capacitor C2 (Fig. 3). Two measuring voltage dividers are built in the water line. The resistive divider is connected in a parallel way to the load of the generator. Measuring transformers of the current are installed on the input and output of the PFL. In Fig. 4 the resistive divider and also measuring transformer included in one of six parallel resistors of a load of the type TBO-60 are shown.

2 REFERENCES

[1]G. Mamaev, S. Mamaev, T. Latypov, S. Poutchkov, A. Ctcherbakov, I. Tenyakov, «150 kV Magnetic Pulse Compressor», Vancouver, PAC'97