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# CHANGES ON INSULATOR SURFACE UNDER THE INFLUENCE OF STRONG ELECTRIC FIELD IN VACUUM

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The measurements of flash-over voltages on solid insulators, placed in vacuum have shown the initial flash-over occur at voltages considerably lower than this obtained after multiple flash-over. It can be proved that the initial flash-over voltage increase is mainly connected with gas desorption from the insulator electrodes surfaces. As the surface is being cleaned of gas particles the insulator sparking voltage is increasing, hence the energy of particles bombarding the insulator surface is also increasing.

Having passed some critical values the energy is sufficient to decompose the surface. The character of this changes depends upon material and energy released on the surface. Long lasting strong electric field acting in vacuum makes also electrodes material to deposit on the insulator surface.

## Experiment Apparatus and Techniques

Experiments were made with samples of radio porcelain; sample shapes are shown on fig. 1.

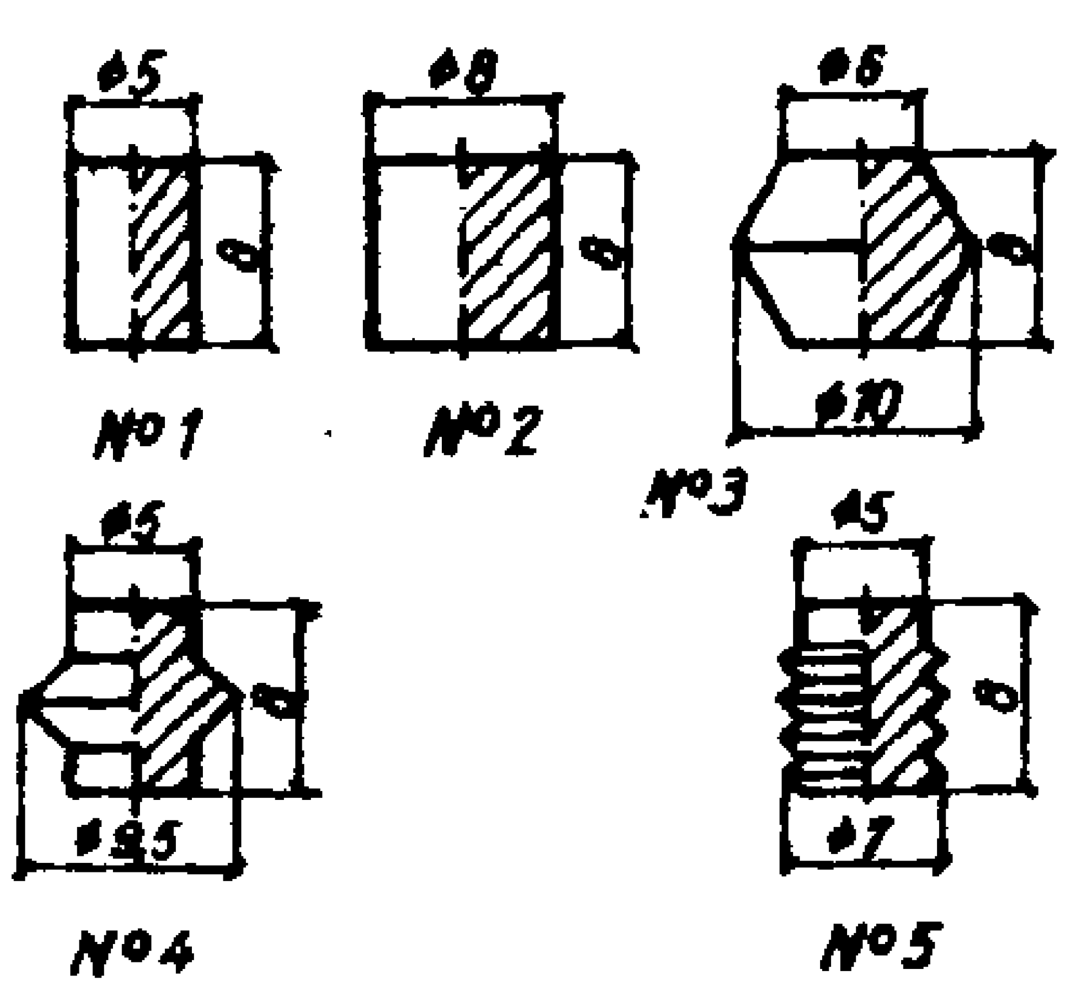


Fig.1. Sample shapes

A discharge chamber was made of glass and electrodes were made of stainless steel [3].

The flash-over voltages measurements for AC voltage 50 Hz provided the characteristics U=f(n) - flash-over voltage vs flash-over number. The flash-over voltage was measured also at impulse voltages lasting 1 microsec./ 50 microsec. To insure that the gases adsorbed on insulator surface have influenced the phenomenon, a portion of samples were surface cleaned. In order to do that they were heated in vacuum, than treated by electric field also in vacuum, and than influenced by both the process together.

After voltage tests the sample surfaces were checked visually under the microscope, analysed by an electronic microprobe and spectral analysed.

## Results

The results of the flash -over voltage measurements for samples of various shapes at a AC voltage are shown on fig.2.

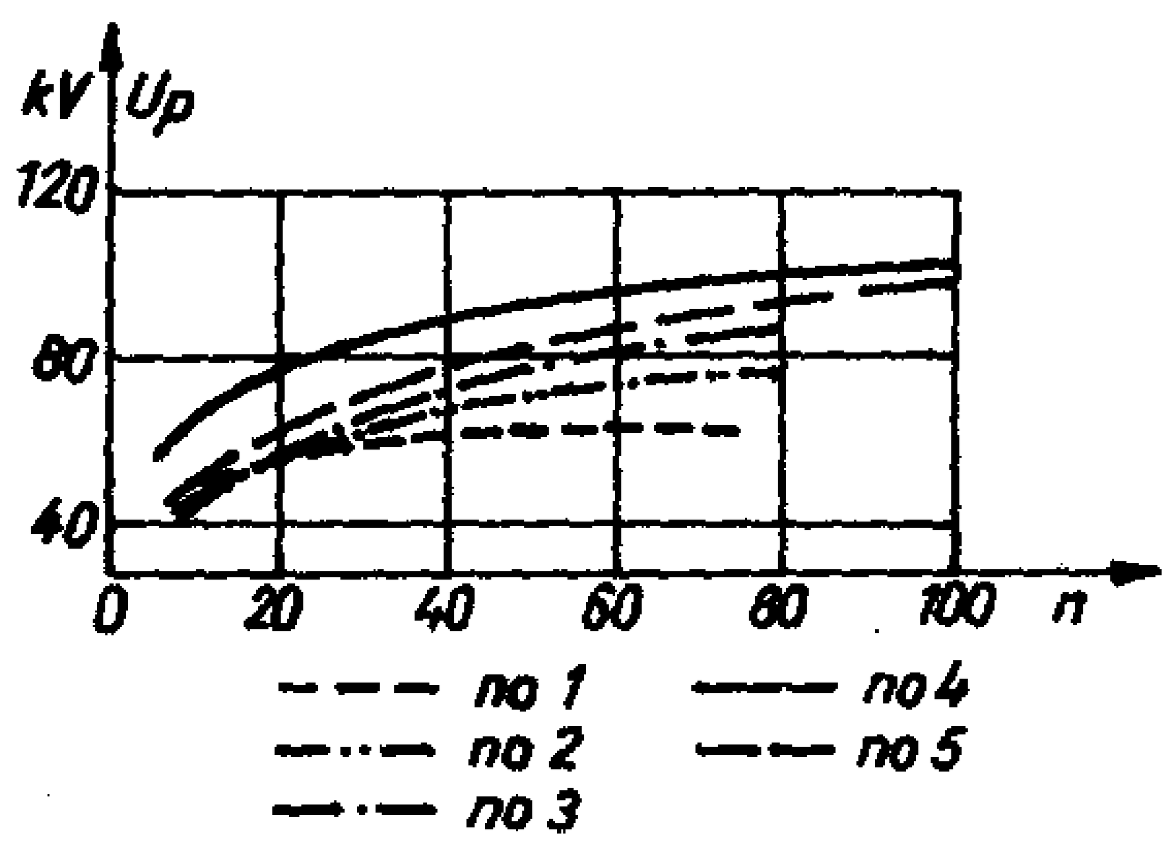


Fig.2. Sample shape influence on flash-over voltage

The maximal flash-over voltage was obtained for sample no.4 with single petticoat, the minimal voltage, however, was obtained for simple cylindrical sample. In general it can be said that the greater insulator surface is protected against bombarding by particles accelerated in electric field the higher is the flash-over voltage.

For every characteristics U=f(n) shown above it can be distincted two parts - the first, considerably increasing and the second, stationary. It was assumed the voltage variations in the former were caused by gases adsorbed on the surface. In order to confirm this assumption samples were cleaned by heating in vacuum and treating by electric field smaller than resistible. The influence of heating at temperature 670 K for 2 hours on the surface resistivity at AC voltage is shown on fig. 3.

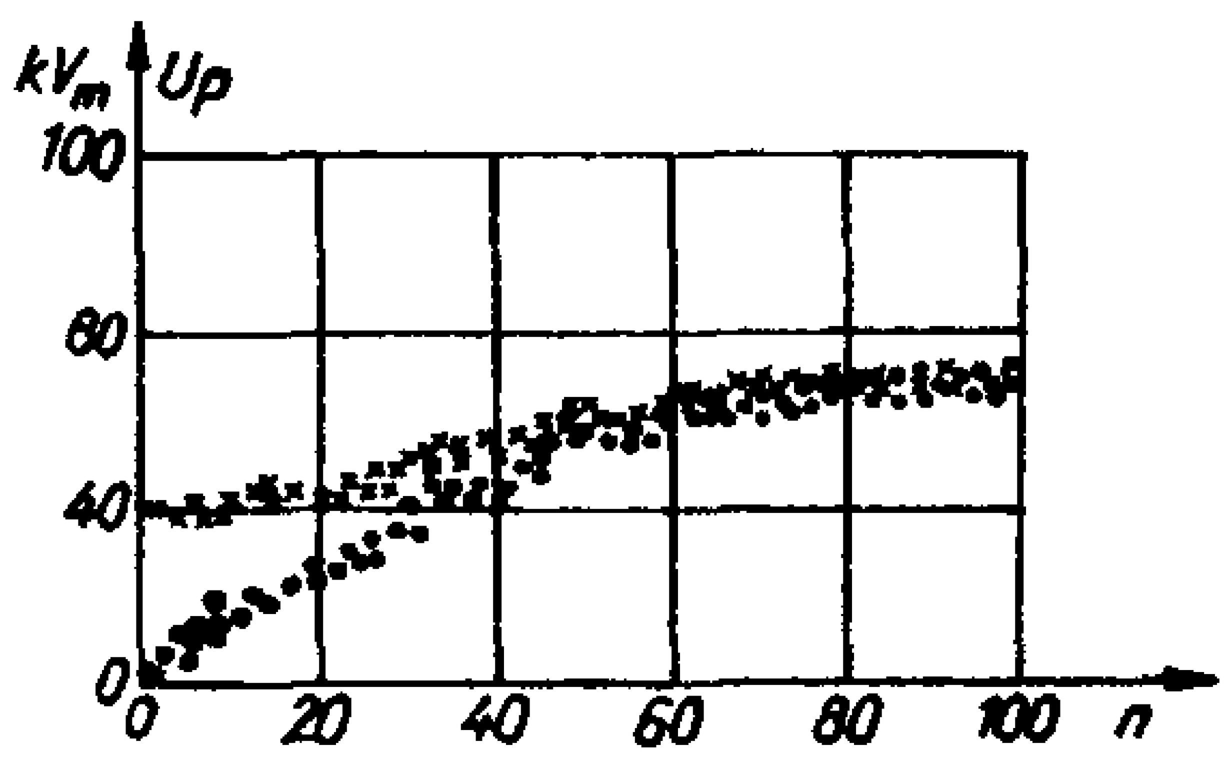


Fig.3. Flash-over variations at succeeding flash-overs on a sample heated in vacuum at temperature 670 K for 2 hours. Tests for AC voltage 50 Hz.

Fig. 4 ilustrates the relationship between keeping the sample in electric field of various constant intensity at temperature 500 K and flash-over impulse voltage.

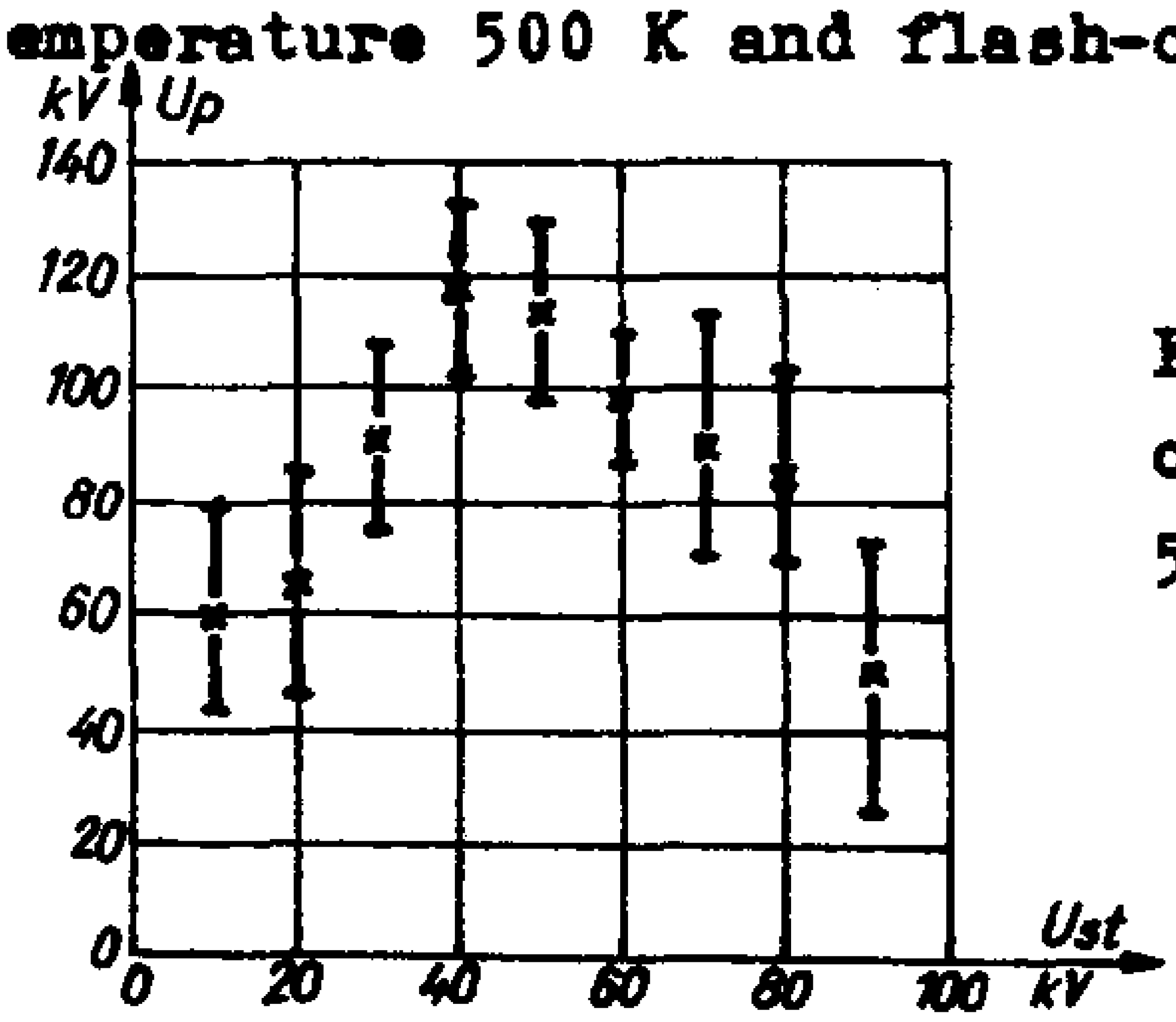


Fig.4. Constant voltage influence on impulse flash-over voltage at 500 K.

The results obtained shown that the surface cleaning from adsorbed gases results in flash-over voltage increase in the first part of the curve U=f(n). However exceeding the optimal conditions ( temperature and voltage )decreases the surface resistivity. The surface spectral analysis has shown the insulator surface coating by electrode material is responsible for this decrease.

The sample visual check after removing from the measuring chamber has shown dark spots appeared on surface of contact with the electrode and on petticoat surface.

After examining with aid of microscope it appeared that the dark spot has completely different structure from the remaining part of ceramics. There is a tangible difference between the typical granular structure of ceramics and glassy structure of the spots. See fig. 5. The electronic microprobe analysis has shown that the silicon concentration on the dark spot surface is greater than on remaining part of the sample. See fig. 6.


Fig.5. Dark spot edge on ceramics surface


Fig.6. Silicon contents on the surface from fig. 5.

In the spot centre an area can be seen which is quite different to the remaining part of the spot and is surrounded by an edge, see fig. 7. This area has very smooth surface. The spot centre is free from the electrode particles, which are distributed radially on the remaining spot part.


Fig.7. Dark spot centre area

## CONCLUSIONS

The insulator surface bombarding with particles stream of great energy in vacuum causes insulator material decomposition and vapour generation in which flash-over may occur. The flash-over at ac voltage has a short pulse form decaying spontaneously. It may be related to dark spots on the insulator surface. The spot centre area is bombarded by electron stream from the cathode. This area is melted and evaporated. In plazma generated in such way, the electrode melts and pressure increases in this area, vapours blow up and condense on the insulator and electrode surface. Therefore the electrode material radial tracks appear always outside the spot centre area. The observations prove the flash-over action discrabed in [4].

## References


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