INFLUENCE OF VIBRATION OF CONTACTS ON FURTHER OPERATION OF HIGH-VOLTAGE SWITCHES

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1. Introduction

Nowadays, there is a big variety of different types of high-voltage switches operating in the power plants. For instance: oil, air, vacuum and insulated gas, that have to correspond to different requirements after taking into operation and after major and current repairs, maintenance and installation of new equipment. These requirements are presented and their technical characteristics are checked and saved in the test reports. These characteristics include the time difference between closing of the contacts (from the first vibration-closing to the termination of the vibration of the contacts) [1].

When the contacts clash to each other the kinetic energy is released and the contacts' springs begin to fluctuate. It is so called vibrations of the contacts phenomenon. During the vibrations, the contacts are dispersed at a slight distance, with electrical breakdowns occurring in the insulation gaps.

During the switching process, the possibility of the simultaneous closing / opening of contacts there is a short-term operation mode, during which the over-voltage can occur during multiple times. With the increase of the rate of non-simultaneous closing of the contacts, which depends partially on the vibration of the contacts, the over-voltages increase.

Contacts in the case of a collision can bounce in the absence of a sufficient damping effect. In this case, the breakage of arc current occurs with the occurrence of single and many high-frequency breakdowns. The characteristics of contact vibration have mechanical nature and can be evaluated with the help of oscillograms of high-speed characteristics. These oscillograms are the most informative for representing the test results.

Figure 1 shows a graph of the dependence of the oscillation from the time for the oil type circuit breaker MKP-110M-1000/630.

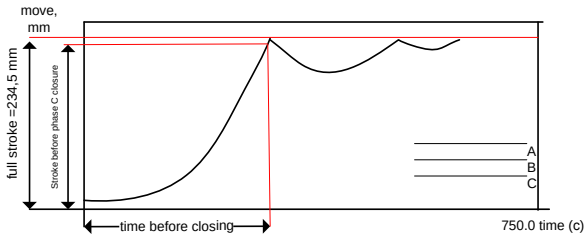

Fig. 1. Dependence of the oscillation from time.

The oscillation-like movements of the traverses at the end of the movement occur because of the failure of the oil buffer and the lack of pressure. Such a type of the failure of the switch is quite harmful because when the oil buffer stops to operate, the switch mechanism gets large dynamic loads that can lead to its breakage.

Figure 2 represents the oscillogram of the switching process in the air circuit breaker (type VVN-110-6-31,5 / 2000).

As shown in Figure 2, the vibration of the contacts occurs when the air circuit breaker was switched on. The reason of this vibration of contacts for these particular types of switches is the loss of mechanical characteristics of the springs belonging to moving and fixed contacts and the reduced use of mobile contacts.

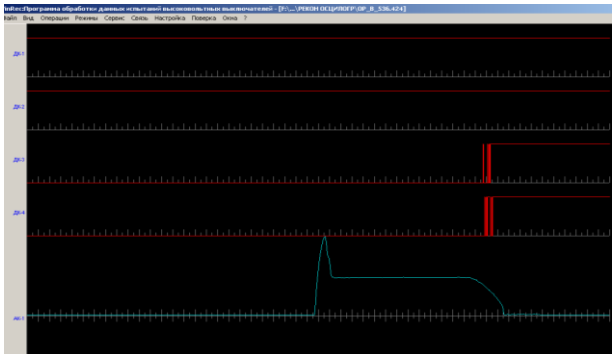

Fig. 2. Switching oscillogram for the air circuit breaker (type VVN-110-6-31,5 / 2000).

The switches mainly use a spring drive. During the switch-on operation and the switch-off at the end of the motion of the moving contact, the residual kinetic energy of the switching springs is spent on the shock absorber during on or off operation. Therefore, the level of vibration of the contacts of the circuit breakers is very small.

When the contacts vibrate, the electric arc re-lights up, inside the arc the temperature can vary from 6000 to 10,000 ° C inside the plasma. The high-voltage arc has a characteristic of a blue hue, which is represented by the light of copper ions, which evaporates from the contacts. The side effect of evaporation is the precipitation of metal vapor on the insulation elements, which reduces the electrical strength of the insulation gap.

Also, with the re-ignition of the electric arc, the surface and the roughness of the contact surface increases, which leads to an increase in the transient resistance of the direct current of the contacts and their heating. The maximum increase in temperature due to the presence of contact can be calculated from the equation:

$$\Delta \nu_k = \frac{\Phi_x}{\sqrt{kS\lambda F}} \qquad (1)$$

where, S is the perimeter of the section, F is the cross-sectional area of the current line, k is the heat transfer coefficient, λ is the specific heat conductivity of the medium, Φ_x is the value of the heat flux according to the formula:

$$\Phi_x = \frac{1}{2} I^2 R_k , \qquad (2)$$

where, I is the current flowing through the contact; R_k – transient resistance of contacts, which is determined by:

$$R_k = c_k \rho H_B^{0.5} p_k^m , \qquad (3)$$

where, ρ - specific resistance, Ohm·cm·10^{-8}; H_B - metal hardness by Brinel, kg/sm^2; $P_к$ - contact pressure, kgs.

Coefficient q - depends on the treatment of the contact surface. In calculating the contacts of the switch should come from a coarse and very rough sweep, with which respectively c_k = 2÷3. The power factor m depends on the contact pressure and the working surface of the contact. In the case of explicit plastic deformation, m=0,5 can be taken.

As can be seen from formula (1), the maximum increase in the heating temperature of the contact joints depends to a large extent on the heat flux, which in turn depends on the transient resistance of the contacts. The transient resistance depends on the roughness of the contacts, which appears during both the burning of the electric arc and the vibration of the contacts during the commutation of the nominal currents.

Conclusions

The reliability of the operation of high-voltage switches greatly depends on the level of vibration of moving contacts. The main causes of vibrations are the loss of initial technical characteristics of the springs of moving contacts and the lack of contact pressure, improper operation of the oil buffer, and others.

All these defects during the operational work can be determined from the speed characteristics. It is quite promising to improve the developed method of controlling the speed characteristics by checking the current of the test signal, which passes between the contacts of the switch when it is switched on or off.

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