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Research and Development of Switching Performance of Gas Insulated Disconnecting Switch of Switchgear.

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The article is connected with development of compact gas insulated switchgear 126 kV class with disconnecting switch of free burning type. Special attention was derived to bus-transfer current switching test according to IEC 62271-102 standard requirements.

Standard IEC 62271-102 (figure 1) gives clear interpretation of choosing of bus-transfer voltage for air insulated disconnectors (intended for air insulated substations - AIS) and gas insulated disconnectors (intended for gas insulated substations - GIS). For classical gas insulated switchgears (GIS) 126 kV class with gas insulated busbars the value of bus-transfer voltage is 10 V. For air insulated disconnectors value of bus-transfer voltage is rather higher and equal 100 V (figure 1).

B.4.106.2 Rated bus-transfer voltage

Rated bus-transfer voltages are given in table B.1. Other rated-bus transfer voltages may be assigned by the manufacturer.

Table B.1 – Rated bus-transfer voltages for disconnectors

<table>
<tr><th>Rated voltage U_r
kV</th><th>Air insulated disconnectors
V r.m.s.</th><th>Gas insulated disconnectors
V r.m.s.</th></tr>
<tr><td>52
72,5
100
123
145
170</td><td>100</td><td>10</td></tr>
<tr><td>245
300
362</td><td>200</td><td rowspan="2">20</td></tr>
<tr><td>420</td><td rowspan="2">300</td></tr>
<tr><td>550
800</td><td>40</td></tr>
</table>

Figure 1 – Standard rated bus-transfer voltages, IEC 62271-102

Nevertheless, in special cases when developed apparatus represents the intermediate hybrid element between GIS and air insulated assembly, the bus-transfer voltage may be rather higher than bus-transfer voltage of GIS with gas insulated busbars.

Developed gas insulated disconnector is the switch with SF_6+CF_4 gas mixture as insulating and arc quenching medium that is intended for using on air insulated substations. So, disconnector under consideration is a special case of application and switching performance of such gas insulated disconnector should be paid much attention. More than that IEC 62271-102 current limit of 1600 A is believed too low and commutation voltages are also rising because longer busbars in air substations for special cases. For this reason the designers of disconnectors have to meet the user's requirements.

Article describes stages of development, research of insulating ability and switching functions of gas insulated disconnecting switch with applying of numerical simulations and experimental results analysis. The article contains next results:

1. 3D simulation of combined disconnecting-earthing switch was used for development. Numerical simulation of electric field strength and optimization of critical electric field strength were provided. Fundamental insulation function of disconnecting switch with minimal contact gap is provided and proved by dielectric tests.

2. Switching performance of designed apparatus is proved by switching tests provided according to IEC 62271-102. Current, arc voltage, resistance, conductance, volt-ampere characteristics are presented at 10/20 V and 100 V. Mathematical prognostic functions of arcing time depending on performed number of making-breaking cycles are presented by approximation equations.

Obtained experimental results during 1600 A bus-transfer current switching at 10-20 V are in good accordance with available published data. At the moment there is no a lot of data concerning switching at high operating voltage values. It is confirmed that switching of 1600 A at 100 V of bus-transfer voltage is accompanied by arcing time increasing from one switching cycle to another. Switching of 1600 A at 100 V of bus-transfer voltage is accompanied by significant contact degradation depending on the grain size (powder type) of arc contact material after 100 switching cycles. Increasing of operating voltage from 10/20 V up to 100 V results in high arcing times.

Experimental results during bus-charging current switching (2A at 73 kV) and no-load transformer switching tests are presented. Analysis of arcing time scatter and contacts condition are presented. Some offers and recommendations of test methodic of gas insulated disconnecting switches are proposed.

Conclusions.

1. Numerical simulation of electric field strength is performed and presented. Numerical 3D simulation - is a powerful and reliable means of design, development, optimization and research of insulation capability of disconnecting switch. 3D simulation is rather accurate than 2D simulation and should be used for simulation tasks with asymmetry of electric field distribution.
2. Bus-transfer current switching duty is a difficult multi-factor process that depends from constructive parameters – type of interrupter, operating speed of contacts, contact gap, contact material properties. Bus-transfer current switching process depends on value of bus-transfer current, voltage level, power factor. These parameters define energy, emitted by the arc, arcing time and contact erosion.
3. Arc processes at different arc voltage are investigated. Switching of 1600 A at operating bus-transfer voltage 10 and 20 V does not result to contact erosion.
4. Switching of small currents at high voltage (charging current and no-load transformer switching does not result to contact erosion. Type of interrupter, opening contacts speed, material composition and production technology are main parameters, influenced on arc cooling and interruption.

5. Breaking of bus-transfer current at high operating voltage levels is actual task. For air insulated substation disconnectors 245-362 kV class bus-transfer voltage value is 200 V, for disconnectors 420-800 kV class bus-transfer voltage value is 300 V. For disconnectors 245-800 kV class magnetic arc-quenching type interrupter is preferable.

Key words: *disconnecting switch, insulation, electric field strength, arcing time, erosion.*