89 WM 075-3
July 1989

Analytical Prediction of Transient Breakdown Characteristics of SF_6 Gas Circuit Breakers

F. Endo, M. Sato, and T. Tsukushi
Hitachi Research Laboratory
Hitachi, Ltd.
Hitachi-shi, Japan
Y. Yoshioka and K. Saito
Kokubu Works
Hitachi, Ltd.
Hitachi-shi, Japan
K. Hirasawa
Head Office
Hitachi, Ltd.
Hitachi-shi, Japan

Recently the number of breaking units of puffer type SF_6 gas circuit breakers have been decreased from two to one at 362 kV and from four to two at 550 kV. To attain even more compactness and higher reliability, development of circuit breakers with fewer breaks is continuing. As the number of breaks becomes fewer, the transient insulation recovery during capacitive current interruption becomes more severe because the high transient recovery voltage appears between contacts while their separation is still short. This paper presents a study of transient breakdown characteristics which are obtained while contacts are being opened.

Transient breakdown voltages (V_{BD}'s) of a model SF_6 gas circuit breaker in 300 kV class (Fig. 1) were measured by applying a specially long tail impulse voltage of 6.5/100 ms between the movable and fixed arcing contacts.

As typical results are shown in Fig. 2, transient V_{BD}'s are generally lower than static ones which were measured with fixed contacts and no gas flow. The contact separation is normalized with the separation at contact position II in Fig. 1. This is caused by the high speed SF_6 gas flow in the nozzle. When a gas flows, pressure locally fluctuates due to flow velocity and turbulence. Comparing this fluctuation with Fig. 2, it is clear that transient V_{BD}'s drop from static ones at the contact separation where transient pressure drops from the base pressure, and the degree of V_{BD} decrease nearly equals the degree of pressure drop.

Transient V_{BD}'s between contacts in gas flow can be calculated by using the concept in Fig. 3. Transient gas pressure P in gas flow can be calculated by the Fluid in Cell method which is well-established for compressive supersonic gas flow analysis. The local electric stress E_0 can be calculated with an ordinary computer program for electric field analysis. Special care should be taken to determine the breakdown stress E_f. The contacts mechanically slides with each other and their surface is newly created with every opening and closing. In such a case it is considered that the contacts are not subjected to the conditioning effect and breakdown is governed by the first breakdown probability of new electrodes. Therefore, E_f should be determined from first breakdown stress.

Since P and E_0 vary at all points on the contacts, V_{BD} values should be calculated at any point on them to obtain the minimum V_{BD}. The calculated minimum V_{BD} agrees well with measured ones. Similar calculation and V_{BD} measurement were carried out for five kinds of nozzle shapes, and it was confirmed that calculated transient V_{BD}'s agree well with measured ones.

Finally, capacitive current interruption test was done. Transient insulation recovery characteristics during the test were measured, and are confirmed to agree well with transient V_{BD}'s obtained in the impulse test and with calculated transient V_{BD}'s.

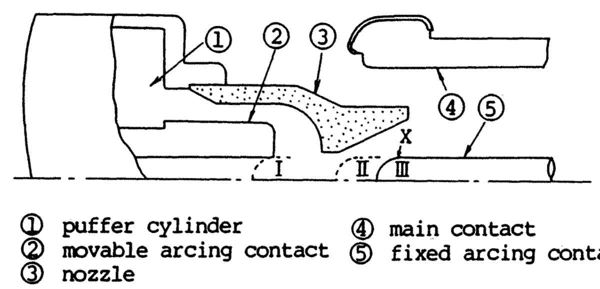

Fig. 1. 300 kV class model gas circuit breaker

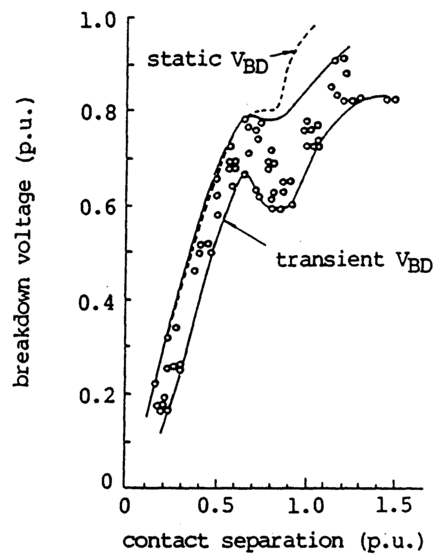

Fig. 2. Transient breakdown voltages between contacts; 1 p.u. = static V_{BD} at contact separation of 1 p.u.

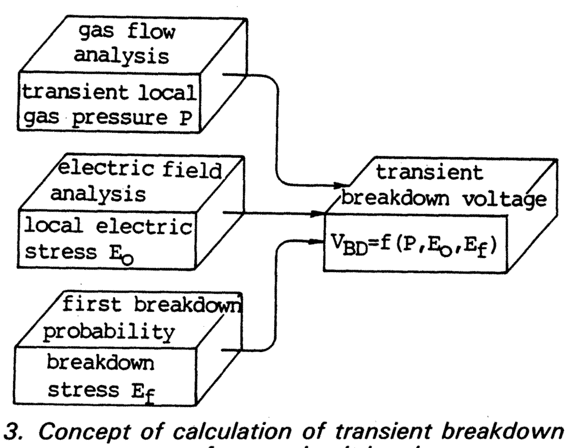

Fig. 3. Concept of calculation of transient breakdown voltages of a gas circuit breaker