Combined field grading and flied shielding for double breaking vacuum chambers under lightning impulse stress

Benjamin Kühn[1], Michael Kurrat[1], Dietmar Gentsch[2]
[1] Institute for High Voltage Technology and Electrical Power Systems, Technische Universitaet Braunschweig, Schleinitzstraße 23, 38106 Braunschweig, Germany
[2] ABB AG, Calor Emag Mittelspannungsprodukte, Oberhausener Str. 33, 40472 Ratingen, Germany

ABSTRACT

In higher voltage levels sulphur hexafluoride (SF6) is a common insulating and switching medium. In medium-high voltage levels vacuum has advantages compared to SF6. In order to expand the operation voltage levels of vacuum interrupters (VI) two approaches are possible, the enlargement of the single gap and the series arrangement. Due to the digressive dielectric strength of vacuum in dependence of the contact gap, the enlargement of the single gap is limited for operating voltage levels above several 100 kV. The usage of two VIs in series arrangements enables theoretically switching operations in higher operating voltage levels. To ensure a symmetric load of both VIs in the series arrangement a symmetric voltage distribution is one of the main challenges. In switched off position the arrangement has to stand the stress of high lightning impulse voltages according to standards. The voltage distribution over the series VIs is influenced by external electrical fields leading to asymmetries resulting in failure of one of the series arrangements and thus trigger a complete breakdown. The most common approach to ensure a uniform voltage distribution is the usage of external grading capacitors.
The presented research proposes a new approach for a combined external electrical field-shielding and grading for a series connection of two VI. This arrangement is based on an additional surrounding shield arrangement in a separate outer vacuum chamber to compensate additional grading capacitors.
As a first step different copper shield arrangements were built up as integrated units into an additional vacuum chamber around the main chambers. In order to investigate the coupling mechanisms between the shields the arrangement is tested in an electric field simulation in COMSOL software. To determine the potential distribution in the double breaking double chamber VI, the interrupter was simulated in open switch position under a transient lightning impulse voltage with following boundary parameters:

- Series VI arrangement without additional shields and symmetric external electrical fields
- Series VI arrangement without additional shields and asymmetric external electrical fields
- Additional copper shields and symmetric external electrical fields
- Additional copper shields and asymmetric external electrical fields

It is a one pole simulation and the distances were chosen on the basis of GIS. Here the potential drift of the floating middle part of the double breaking VI (without plasma) is most important. To evaluate the quality of the shielding/field guarding, the potential shifting of the floating middle part of the double breaking VI was determined.
Finally a combined field grading and field shielding for double breaking VI was developed and a build-up as a prototype for practical investigations. The current research gives first results for designing shields in an additional vacuum chamber surrounding the double breaking VI.