Analysis of Electric Field in the Inter Phases Region of Three-phase Gas Insulated Switchgear

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Abstract—This paper deals with electric field characteristics in the inter-phases region of three-phase gas insulated switchgear (GIS). The electric field in a three-phase construction of a simplified GIS model was analyzed. The results show that in the inter-phases region the direction and the magnitude of electric field vector varies with the location of the observation point while in the phase-enclosure region the direction of the electric field vector tends to linear and constant. There is no zero electric field on the particle tip of a particle in the inter-phases region, except S90 particle. There is zero electric field on the particle tip of a particle in the phase-enclosure region every half cycle of applied voltage. The maximum electric field of the particles on the inter-phases region generally is higher than one of the particles on the phase-enclosure region. The electric field vector locus in the inter-phases region varies: linear, elliptic, or circular while one in phase-enclosure region is constant and linear.

Keywords—electric field, inter-phases region, phase-enclosure region, three-phase, GIS, particle position

I. INTRODUCTION

Discharge and breakdown phenomena in the insulation material under single-phase voltage are well-known and well established art. However, those in the insulation material under three-phase voltage are far less understood [1-7]. In the other hand the application of three-phase power apparatus in the electric power system has been increasing. The design of three-phase in one tank such as three-phase power cable and three-phase gas insulated switchgear has been applied in the electric power system [8-9].

Discharge is initiated by increase of the electric field in the part of insulation. Three-phase in one tank power apparatus differs with single-phase one mainly in the configuration and the applied voltage. The differences result in the differences in the electric field between single-phase and three-phase equipment. The testing of three-phase equipment by injecting single-phase power source on one phase gives different electric field characteristics with ones in the real application. It may lead incorrect interpretation of the insulation condition of power apparatus. Therefore, knowledge in the three-phase electric field characteristic is useful for understanding discharge process in three-phase power apparatus.

The characteristics of the electric field in three-phase equipment have been reported recently [10-14]. The rotating electric field and the elliptical nature of the electric field vector locus are the examples of special characteristics under three-phase voltage. The special characteristics mainly occur in the inter-phases region. Therefore this paper discusses the electric field characteristics in the inter-phases region of three-phase power apparatus and the comparison with the electric field in the phase-tank or phase-enclosure region.

II. MODEL OF THREE-PHASE GIS

The GIS model is arranged in isosceles triangle configuration as shown in Fig. 1. The GIS model consists of a tank model with 75mm in radius, 300mm in length, and 2mm in thickness; and three-phase conductor with 12.5 mm in radius. A cooper needle electrode was put on the conductor or on the tank an artificial partial discharge (PD) source. The particle radius was 50um. The particle length was 5mm. The particle position is normal to the surface of the conductor or the tank. The particle was put inside the tank at the middle of the tank. The particle positions and their notations in the cross section of the tank are shown in Fig. 2. Particle position is notated with a big character and an index in front of the character, \(P \alpha\). The character is used to explain the particle position at R, S, T conductors or on the tank. Particle on R, S, T conductor, and particle on the tank or on the enclosure (E) is notated as R, S, T, and E, respectively. The index \(\alpha\) is used to explain the particle position (in degree) relative to the positive x axis in the counter clock wise direction. For example, \(S_{270}\) means the particle at S conductor, 270° or -90° from positive x axis.

![Fig. 1 Layout of GIS model in isosceles triangle configuration](image-url)