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Study of Particle Contimation in Gas Insulated Busducts with Various Insulating Gas Mixtures at High Voltages

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Abstract - Gas Insulated Substations (GIS) is a compact, multi-component assembly enclosed in a ground metallic housing which the primary insulating medium is compressed sulphur hexafluoride (SF6) gas. But SF_6 was found to be a green house gas contributing to the global warming of the atmosphere and also highly toxic Gas Insulated Substations (GIS) can be used for longer times without any periodical inspections. Conducting contamination (i.e. aluminium, copper and silver particles) could, however, seriously reduce the dielectric strength of gas-insulated system

Diluted SF_6/N_2 and SF_6/N_2O mixtures could be a substitute to pure SF_6 as insulation medium for high voltage gas insulated systems. They promise to have a lower environmental impact than a system insulated with pure SF_6 for the same rating. The main issue concerning the practical use of such mixtures is their behaviour in the presence of particle contamination. In this paper, particle movement of metallic particle contaminants is determined in Gas Insulated Busduct (GIB) with Sulphur Hexafluoride and Nitrogen gas mixtures as insulating medium at power frequency voltages of 100KV and 145KV. The results are analyzed and presented.

Key words- Metallic particle contamination, Gas insulated busduct, SF_6 gas, Gas mixtures

I. INTRODUCTION

Gas insulated Substations have found a broad range applications in power systems over the last three decades because of their high reliability Easy maintenance, small ground space requirements etc.,. In our country also few GIS units have been in operation and a large number of units are under various stages of installation. Although GIS has been in operation in several years, some of the problems are needful attention. These problems include VFTO during switching operations or earth faults and transient enclosure voltages and particle contamination.

Gas insulated substations have various advantages. **B**ecause of the entire equipment being enclosed in enclosures, filled with pressurized SF6 gas, installation is not subject to environmental pollutions, as experienced along coastal areas or certain types of industries. Such installations are preferred in cosmopolitan cities, industrial townships, etc., where cost of land is very high and higher cost of SF6 insulated switchgear is justified by saving due to reduction in floor area requirement. It is not necessary that high voltage or extra high voltage switchgear to be installed outdoors. Since most of the construction is modular and the assembly is done in the works, one site erection time both for supporting structures and switchgear is greatly reduced.

Several authors conducted experiments on insulating particles. Insulating particles are found to have little effect on the dielectric behaviour of the gases [1-8]. However the presence of atmospheric dust containing conducting particles, especially on the cathode, reduces the breakdown voltage. Conducting particles placed in a uniform ac field lift-off at a certain voltage. As the voltage is raised, the particles assume a bouncing state reaching a height determined by the applied voltage. With a further increase in voltage, the bounce height and the corona current increase until breakdown occurs [9].The lift off voltage is independent of the pressure of gas. After the onset of bouncing, the offset voltage is approximately 30% lower than the lift-off voltage. The breakdown strength of SF_6 under non-uniform electric field like metallic particle condition, is extremely susceptible and leads to lower the breakdown voltage. Furthermore, from the view point of environmental protection, as SF6 has strong greenhouse effect, the use of SF_6 should be carefully controlled. Thus, it is needed to develop the alternative dielectric gas or gas mixtures having better insulating characteristics and no greenhouse effect. In

this paper particle movement with SF_6 and N_2/N_2O mixtures has been simulated and results

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have been presented in a single phase isolated conductor GIB.

II. MODELING TECHNIQUE

Fig. 1 shows a typical horizontal single phase Gas Insulated Busduct. The enclosure is filled with SF6 gas at high pressure. A particle is assumed to be at rest at the enclosure surface, just beneath the busbar, until a voltage sufficient enough to lift the particle and move in the field applied. After acquiring an appropriate charge in the field, the particle lifts and begins to move in the direction of field having overcome the forces due to its own weight and air drag.

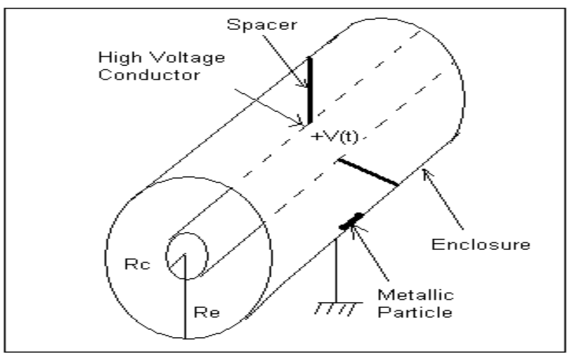

Fig. 1 Typical 1-Ø Gas Insulated Busduct (GIB)

The simulation considers several parameters like the macroscopic field at the surface of the particle, its weight, and Reynold's number, coefficient of restitution on its impact to enclosure and viscosity of the gas mixture. During return flight, a new charge on the particle is assigned based on the instantaneous electric field.

III. THEORETICAL STUDY

The motion equation is given by

$$m\frac{d^2y}{dt^2} = F_e - mg - F_d \qquad (1)$$

Where,' y' is the direction of motion of the particle moving in vertical direction in mm and 'Fd' is the drag force and is always opposite to the direction of motion. A wire like particle with hemispherical ends, which is moving in SF_6 Gas, will encounter two types of drag force components like drag due to skin friction and drag due to shock acting along the sides of the particle. Charge acquired by horizontal wire,

$$Q_{hw} = 2\pi \in_0 rlE \qquad (2)$$

Lift of field for Horizontal wire particle:

$$E_{L0} = 0.84\sqrt{\frac{rg\rho}{n}} \qquad (3)$$

The motion equation of the particle on the enclosure is given by

$$m\frac{d^2y}{dt^2} = F_e - mg - (F_{d1} + F_{d2}) \qquad (4)$$

IV. SIMULATION OF ELECTRIC FIELD IN GAS INSULATED BUSDUCT WITH AND WITHOUT GAS MIXTURES

In this paper particle movement with SF_6 and N_2/N_2O mixtures has been simulated and results have been presented in a single phase isolated conductor GIB. The viscosity of a mixture of two gasses can be approximately calculated from the equation.

$$\mu = \frac{\mu_1}{1+\dfrac{\dfrac{x_2}{x_1}\left\{1+\sqrt{\dfrac{\mu_1}{\mu_2}\left(\sqrt{\dfrac{m_2}{m_1}}\right)}\right\}^2}{\dfrac{4}{\sqrt{2}}\sqrt{\left(1+\dfrac{m_1}{m_2}\right)}}} + \frac{\mu_2}{1+\dfrac{\dfrac{x_1}{x_2}\left\{1+\sqrt{\dfrac{\mu_2}{\mu_1}\left(\sqrt{\dfrac{m_1}{m_2}}\right)}\right\}^2}{\dfrac{4}{\sqrt{2}}\sqrt{\left(1+\dfrac{m_2}{m_1}\right)}}}$$

V. SIMULATION OF PARTICLE MOTION

Computer simulations of the motion of metallic particles were carried out on GIB of 55mm inner diameter for each enclosure and 152mm outer diameter with 132kV and 220kV applied to inner conductor. A conducting particle motion, in an external electric field will be subjected to a collective influence of several forces. The forces may be divided into

Electrostatic Force (Fe)
Gravitational Force (mg)
Drag Force (Fd)

Software was developed in MATLAB considering the above equations and was used for all simulation studies.

VI. RESULTS AND DISCUSSIONS

The simulation study has been carried out on the motion of metallic particles in a single phase gas insulated busduct of 55mm inner diameter and 152mm outer diameter with power frequency voltages of 100kV and 145kV applied to inner conductor. Table I and Table II shows the maximum movement of metallic particle contaminants for the mixture of SF_6 and N_2/N_2O respectively. From Table. I it is observed that for an applied voltage of 100 kV for pure SF_6 i.e. 0% N_2 or N_2O the maximum movement was recorded as 41.679 mm and 15.452mm for Aluminium, and Copper particles respectively and 69.607 mm and 24.398 for aluminium and copper particles respectively for 145 KV applied. For 05% N_2 and 95% SF_6 mixture it was observed that the maximum movement for Aluminium and Copper particles for the same voltage are 41.634 mm and 15.181 mm respectively at 100kV. Similarly at 145kV it was observed to be 68.610 and 27.413 mm respectively. It can be clearly observed that the maximum movements for these particles varies very minimum with the change in mixture proportions. But the optimum mixture can be somewhere around 5-10% of N_2/N_2O in SF_6 gas. This gives good reduction in the particle movement so that at this condition the GIS operation can be reliable. Also it is observed that the movement of the particles is higher at high voltages. Further it is to be noted that the copper particles experience less movement when compared to the aluminium particles due to their higher density.

Table-I: Maximum movements of metallic particles (l=10mm, r=0.25mm) at various voltages for various proportions of SF_6-N_2 gas mixtures

% of		Maximum movement(Y_{max})			
SF_6	N_2	100 kV		145 kV	
		Al	Cu	Al	Cu
100	0	41.679	15.452	69.607	24.398
95	05	41.634	15.181	68.610	27.413
90	10	41.255	15.201	68.877	25.029
85	15	41.635	15.363	68.943	27.814
80	20	41.449	15.168	68.966	24.624
75	25	41.478	15.349	68.561	27.415
70	30	41.600	15.403	69.012	24.389
65	35	41.437	15.316	68.932	27.733
60	40	41.440	15.316	68.922	27.734
55	45	41.437	15.314	68.929	27.735
50	50	41.697	15.489	69.081	25.979
45	55	41.734	15.621	68.667	26.229
40	60	41.732	15.621	68.672	26.229
35	65	41.734	15.622	68.670	26.227
30	70	41.685	15.593	68.644	26.819
25	75	41.417	15.481	68.972	24.141
20	80	41.531	15.253	68.929	26.866
15	85	41.422	15.329	69.028	27.430
10	90	41.257	15.200	69.092	25.029
05	95	41.562	15.223	69.108	24.718
0	100	41.135	15.418	69.004	27.678

% of		Maximum movement(Y_{max})			
SF_6	N_2O	100 kV		145 kV	
		Al	Cu	Al	Cu
100	0	41.679	15.452	69.607	24.398
95	05	41.634	15.181	68.610	27.413
90	10	41.255	15.201	68.877	25.029
85	15	41.635	5.363	68.943	27.814
80	20	41.449	15.168	68.966	24.624
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10	90	41.257	15.200	69.092	25.029
05	95	41.562	15.223	69.108	24.718
0	100	41.135	15.418	69.004	27.678

VII. CONCLUSIONS

A model has been formulated to simulate the movement of wire like particle in a single phase common enclosure GIB in the presence of gas mixtures. The results have been presented and analyzed in this paper. Distance travelled in the radial direction is found to be reduced when small amounts of N_2/ N_2O are mixed with SF_6. This reduces the effect of green house gases.

VIII. ACKNOWLEDGMENT

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REFERENCES

[1]. S. Yanabu H. Okubo S. Matsumoto H. Aoyagi N. Kobayashi,"Metallic particle motion in a 3-phase SF6 gas insulated bus" IEEE Transactions on Power Delivery, Vol. PWRD-2, No. 1 1987

[2]. Arora, A.; Koch, H." Design features of GIS", IEEE Power Engineering Society General Meeting, 2005. Issue,Vol. 1, Page(s): 927 - 929

[3]. H. Anis and K. D. Srivastava "Free conducting particles in compressed gas insulation" IEEE Transactions on Electrical Insulation Vol. EI-16 No.4, August 1981,p 327

[4]. M. M. Morcos, K. D. Srivastava, "On electrostatic trapping of particle contamination in GITL systems" IEEE Transactions on Power Delivery, Vol. 7, No. 4, 1992.

[5]. Amarnath, J. Singh, B.P. ; Kamaksaiah, S. ; Radhakrishna, C. "Determination of particle trajectory in gas insulated bus duct by Monte-Carlo technique" Annual Report Conference on Electrical Insulation and Dielectric Phenomena, 1999

[6]. Holmberg, M.E., Gubanski, S.M. "Motion of metallic particles in gas insulated systems",Electrical Insulation Magazine, IEEE ,Volume:14 , Issue: 4, 1998 pp5 - 14

[7]. Indira, M.S. Ramu, T.S.,"Experimental studies on the mitigation of chance outages in GIS due to conducting particles", Eleventh International Symposium on High Voltage Engineering, 1999.,Conf. Publ. No. 467,Volume:3 ,pp236 - 239

[8]. Rajasekhar Goud, J., Sahu, K.B.M. ; Amamath, J. ; Singh, B.P. ; Srivastava, K.D.,"Determination of random movement of particle in gas insulated busduct "12th Interantional symposium on Electrets, 2005. pp392 – 395

[9]. G.V. Nagesh Kumar B.P. Singh J. Amarnath K.D. Srivastava, " Electric Field Effect on Metallic Particle Contamination in aCommon Enclosure Gas Insulated Busduct" *IEEE Transactions on Dielectrics and Electrical Insulation*,*2007*, *Vol. 14*, *No. 2*.

[10]. Rao, M.V.G. Kumar, G.V.N. ; Amarnath, J. ; Kamakshaiah, S. ; Srivastava, K.D., " Analysis of particle movements in a single phase gas insulated busduct with various operating conditions", 13th International Symposium on Electrets, 2008.

[11]. Rao, M.V.G. Kumar, G.V.N. ; Amarnath, J. ; Kamakshaiah, S. ; Srivastava, K.D., "Simulation of Particle Trajectories in a Three Phase Common Enclosure Gas Insulated Busduct with Monte Carlo Technique", Annual Report Conference on Electrical Insulation and Dielectric Phenomena, 2008. pp 594 – 597