Corona and Different Detection Methods

[1] Shraddha H. Amin

[1]Assistant Professor

[1]Electrical Engineering Department,

[1]AIKTC New Panvel, Navi-Mumbai, India

Abstract : Electrical system is reliable only when the insulation of the system is reliable. The main factor that affects the insulation or any di-electric is partial discharge or corona. Corona is a phenomenon that has the capability for degrading insulators, and causing systems to fail. In this paper review of corona with its types and few methods of detection of corona for maintaining reliability of power system operation is given.

Index Terms - Corona, positive corona, negative corona, factors affecting, detection methods.

I. INTRODUCTION

Corona discharge is self sustained form of partial discharge in air that appears around high voltage overhead line conductors, resulting to electron avalanches, local streamer discharge, and surface discharge due to transient gaseous ionization in an insulation system when the voltage stress, i.e., voltage gradient, exceeds a critical value. It is seen as bluish glow in air adjacent to pointed metal conductor that carries high voltage. It is also accompanied by hissing noise along with the glow corona may also led to electromagnetic interference and losses during power transmission. Corona results into degrading of materials, ozone O3 and nitric oxide formation and even toxic gases hazardous to human.

But even it has many issues corona has found a wide application in many processes like separation of metals and non metals from crushed particles of waste printed circuit board [2], removing NOx from flue gas by using pulsed corona discharge, most important and unique application is detection of explosives by positive corona discharge ion mobility spectrometry [3].
Corona process applications emphasize either of the aspects, i.e. energetic electrons producing plasma or ions produced. Applications where ions are used plasma zone will occupy small fraction of total process volume, whereas if electrons are used then most of the volume is filled with plasma.

II. TYPES OF CORONA

Depending on polarity of field and electrode geometric configuration, corona discharge changes its form [1]. In case of needle-plate electrode it is observed positive corona on increasing applied voltage initially forms burst pulse corona, then streamer corona then glow corona is observed and finally spark discharge occurs. In case of negative corona initially trichel pulse corona is observed then pulse less corona and finally spark discharge is observed. Following figure 1 represent schematic of both types of corona on needle-plate system.
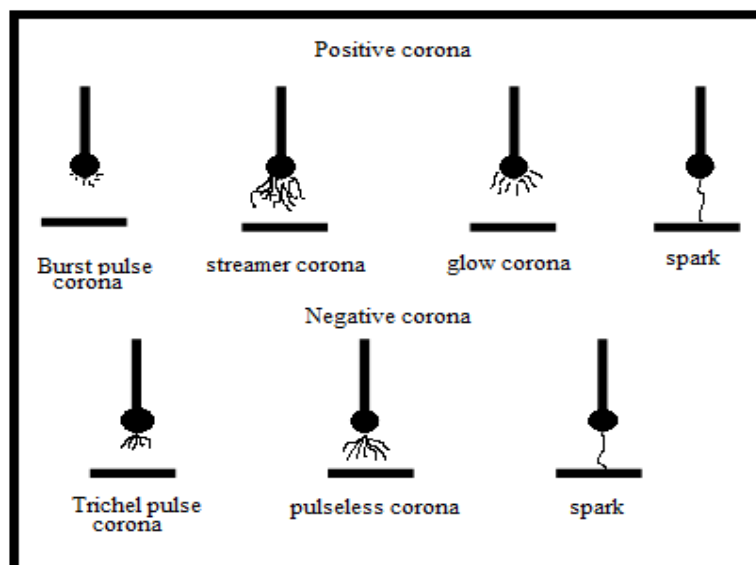

Figure 1 Schematic of Corona Discharge [1]

Negative corona propagation depends on impact ionization of gas molecules whereas positive corona propagates by photo ionization. More or less it is more dependent on type of gas and species present in the gas.

In general discharges can be explained in four ways (a) silent discharge or burst pulse corona (b) radiant or plume discharge (c) discharge by spark (d) arc discharge.

(a) Silent discharge does not produce any kind of noise or luminescence. Here ionized region is electrically charged and electrode repels the ions of same electrical signal producing so called electric wind [5]. If ionization intensifies then area adjacent to gas lit surface layer called corona effect, the rest region of discharge is called black current region.

(b) Radiant or plume discharge occurs when tension of electrodes increase, corona effect takes form of luminescent plume in form of radial beam.

(c) Discharges by sparks is obtained on further increasing tension between electrodes, produces sudden considerable gas ionization, because of channels for driving.

(d) In arc discharge intensity of electric current is too high, but voltage between electrodes is observed to be small. In arc particles are accelerated to high speed so that they reach electrodes with violence, producing physical deformations in them generating new electrons by thermionic emission.

III. FACTORS AFFECTING CORONA DISCHARGE

It is observed by study, corona is affected by electric field distribution, distribution of ionization and voltage current characteristics.

Shape of corona is affected by the polarity of supplied voltage. Also gas pressure determines the size of corona and it is seen that corona shape is inversely proportional to gas pressure.

In the experiment [4] where corona needle was used at air pressure using point plane structure, VORPAL was used as PIC simulation model. The result showed that different ionization region shapes are obtained for different voltage polarities. No change in ionization region shape due to change in needle size and other parameters. Due to applied voltage, maximum effect on ionization is observed, little effect was observed due to needle size and least effect was due to air pressure. But, in case of constant applied voltage, corona current increases when air pressure decreases because of the rise in space charge density.

In case of transmission line factors that affect corona include temperature, system voltage, air density radius of conductor configuration, snow and ice, dirt and dust and adverse weather conditions.

IV. DETECTION METHODS OF CORONA DISCHARGE

Corona can be detected by many methods. One of the simplest methods is by sight and sound i.e. a bluish glow and hissing noise is observed as a sign of corona. But this conventional method becomes very difficult since the glow is visible in the utter darkness; also the popping or hissing noise is barely audible to human ear. Thus there are other techniques which were researched by many people and few of them are briefly described below.

(a) In the research by Stawomit, pawel Et. al. optical signals emitted by corona were analyzed for laboratory model of transmission line. It was observed that for different materials corona discharge intensity was varying. They found that corona discharge was recorded with the help of Spectrophotometer as highest for aluminium and it was least for stainless steel wire. The smoothness of the wire in case of stainless steel was also not affected.

(b) Basically, methods used for detection of corona include visual observation, infrared imaging method, ultra high frequency method. In the work done by Zhenyu, Licheng and others [7] , a non contact live detection method called UV imaging proved to be rapid, direct and secured detection method of partial discharge. One of the observations in this experiment was that, the observation angle of UV images has little impact on UV detection if no obstacles block the line detection.

(c) In case where, there are more than one source of discharge the work done by JM Tarifa, Rey and Robbes can be useful. The principle which is used for detection is pulse characterization. The distribution of energy at different frequencies helps in distinguishing several types of discharges. Spectral Power Ratio (PR) method has proved to be a reliable technique [6].

(d) Corona can also be detected using acoustic emission. It was experimented by Marco Antonio El al using ultra sound strategy [5]. ULD-40 is a corona sensor that transforms ultra sonic pressure in audible signals. This sensor allows the location and identification of corona effect and arches in any type of high voltage installations simply by scanning around the suspected area. In ULD-40 there is ultrasonic level indication in 10 dB or greater indicating there is potential problem in insulator or pollutant in insulator, damaged insulator etc. This method cab be used even in very difficult environments and requires no training. The desired condition is only that the audible measuring equipment should have an output in range of audible freq (20Hz to 20kHz) through ultra sound frequency offset.

V. CONCLUSION

In this paper a brief idea about corona, factors affecting corona is discussed. As per the research, different methods are invented for detection of partial discharge and they are also been proved to be acceptable ones. Adopting any method for detection depends on the field location, type of partial discharge, and availability of advanced facilities. Four methods for detection of corona or partial discharge namely, optical signal method, UV imaging, spectral power ratio method, and

acoustic method were analyzed. Corona detection by ULD-40 i.e. acoustic emission detection method is more easy and reliable tool. Detection by optical signal can also serve as an important method during testing of insulation for best results.

REFERENCES

[1] Chang, J. S., Lawless, P. A., & Yamamoto, T. (1991). Corona discharge processes. IEEE Transactions on plasma science, 19(6), 1152-1166.

[2] Li, J., Xu, Z., & Zhou, Y. (2007). Application of corona discharge and electrostatic force to separate metals and nonmetals from crushed particles of waste printed circuit boards. Journal of Electrostatics, 65(4), 233-238.

[3] Tabrizchi, M., & ILbeigi, V. (2010). Detection of explosives by positive corona discharge ion mobility spectrometry. Journal of hazardous materials, 176(1-3), 692-696.

[4] Li, Y., Liu, L., Cong, P., Wang, H., & Liu, C. (2014). Simulation of corona discharge process in multistage gas switches using VORPAL. IEEE Transactions on Plasma Science, 42(1), 120-126.

[5] Renno, Marco Antonio Martins, et al. "Using Acoustic Emissions for Corona Detection." Advances in Power and Energy Systems, Proceedings of the 12th WSEAS International Conference on Electric Power Systems, High Voltages, Electric Machines (POWER'12). 2012.

[6] Ardila-Rey, J.A., Albarracín, R., Robles, G., & Martínez-Tarifa, J.M. (2015). A new monitoring and characterization system of partial discharges based on the analysis of the spectral power. Ingeniería e Investigación, 35(Supl)/ 13-20.

[7] Li, Z., Li, L., Jiang, X., Hu, J., Zhang, Z., & Zhang, W. (2016). Effects of Different Factors on Electrical Equipment UV Corona Discharge Detection. Energies, 9(5), 369.