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Effect of desert environmental conditions on the flashover voltage of insulators

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Abstract

In Egypt, the insulators of overhead transmission lines and substations are often subjected to the deposition of contamination substances from the desert. This can lead to serious reduction in insulator effectiveness, resulting in flashovers and outages of electricity supply. It is important to mention that a remarkably high rate of interruption of 500 and 220 kV transmission lines, in Egypt, are recorded during spring seasons in desert areas where occasional sandstorms occur (Khamassine). This interruption in the power system will lead to the delay of the development of the community.

The flashover characteristics are thoroughly investigated for porcelain insulators exposed to natural sandstorms, as well as to simulated sandstorms with and without charged grids.

Test results show that neither natural nor artificial sandstorms affect the fast flashover voltage if the sand particles are not charged, whereas charged particles of sands reduce the flashover voltage of the insulators. To a higher extent, this reduction in flashover voltage will be greater as the grid is charged with DC voltage.

Keywords: Environmental conditions; Pollution; Flashover voltage; Insulators; Transmission lines

1. Introduction

To a large extent, the type of environmental conditions will significantly affect the insulators of overhead transmission lines [1,2].

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The desert climate is characterized by sand storms or hurricanes which contain very high speed sand particles. These sand particles hit the surface of any material and cause some erosion of it. A sandstorm in a desert is an important factor, which decreases the reliability of the transmission line [3]. The decrease in reliability could occur as a result of the conductor swinging, which could decrease the spacing between the phases, or due to the decrease in the specific breakdown voltage of the polluted air gaps.

Regarding the pollution of the insulators in the desert, it has been generally concluded that:

- The early morning dew in the desert represents a major source of wetting the insulators.
- Sand storms increase the pollution of the insulators severely, the worst conditions occurring when sand storms are accompanied or followed by high humidity, or by rainy or misty weather.
- Pollution layers accumulated on insulators during sandstorms can be of larger grain size and have higher salt content than those accumulated under normal desert weather. The sandstorm pollution is usually carried by strong winds from distant regions.

The effect of desert climatic conditions on the flashover voltage of conventional insulators is thoroughly investigated using a simulator of sandstorms.

2. Experimental set up and techniques

A string of porcelain insulators, as shown in Fig. 1, but with five units, is selected for this study, each unit having 55 cm leakage path, 15 cm suspension length and 33 cm shed diameter. The string is energized with AC voltage and suspended 1.5 m above the set up device, which blows a quantity of sand, completely controlled by a shutter. The sand is blown by using four cylindrical turbines, which storm the air, carrying the sand upwards on the energized insulator string.

The sand grain size is selected to be less than 250 μm using multi-sieves, and the velocity of the sand storming air onto the insulator is 10 m/s. The set up device used for the experimental work to simulate the artificial sand storm is shown in Fig. 2.

Fig. 1. The insulator string.

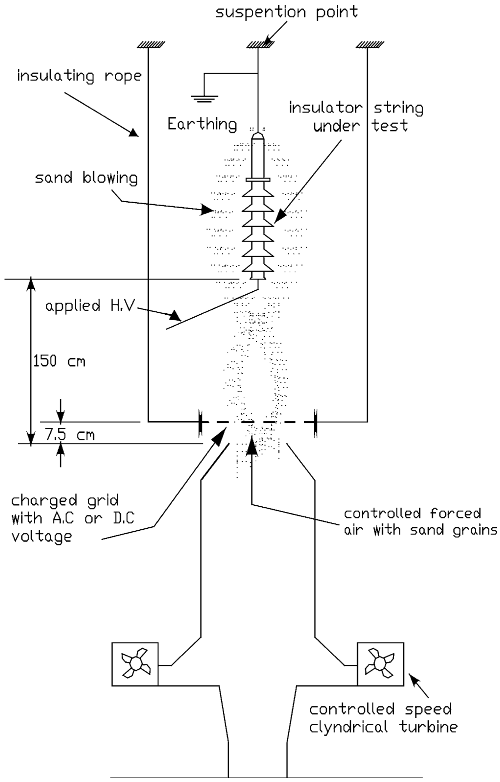


Fig. 2. The set up device used for artificial sand storm.

3. Results and discussion

3.1. Effect of the blown sand on the flashover voltage of the insulator string

The insulator string is suspended vertically, whereas the storming sand is blown upwards from the set up device, so as to cover the string completely. Subsequently, the AC high voltage is applied on the insulators gradually until flashover voltage occurs. The same procedure is repeated using natural sand storms horizontally, with a sand speed of 11 m/s. Flashover voltage values of the string with storming air, as well as with blown sand (both artificial and natural), are shown in Fig. 3.

The natural case of study was measured during natural sand storms, which usually occur in Egypt during Khamassine. The measuring was taken during these natural storms [1] and recorded for the purpose of comparison in this study. The artificial studies are those studied using the set up device mentioned to simulate the sand storm.

Fig. 3 shows the flashover voltage of the string under different conditions, with only storming air of 10 m/s speed (representing wind without sand (case A)), with artificial sand storm of 10 m/s speed with uncharged sand (case B) and, finally, for natural sand storm of 11 m/s speed (measured and recorded during a natural and actual sand storm (case C)).

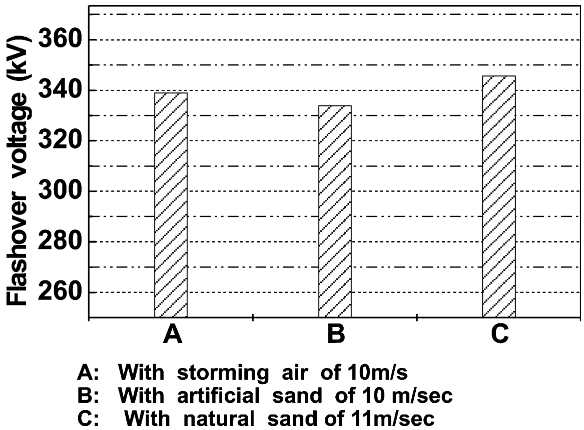


Fig. 3. Flashover voltage of string insulator with and without blown sand (natural and artificial sandstrom).

From the results shown in Fig. 3, it can be deduced that to a lesser degree, the uncharged sand particles reduce the flashover voltage of the insulators, whereas the natural sand storms, being horizontal at a fast speed, dissipate the formed arc along the string and cause higher flashover voltage of the string (case C).

3.2. Effect of charged grid on the flashover voltage of insulators

Occasional sand storms (Khamassine) represent the main problem of interruption of high voltage overhead transmission lines. This occurs when sand particles are electrically charged due to their long exposure to an electric field, resulting in covering the whole string with charged particles after which a complete flashover occurs.

For simulating the effect of the charged particles on the flashover voltage, a charged grid is placed 7.5 cm apart from the sandstorm set up device. The grid is electrically energized with AC voltage with power frequency 50 Hz with values of 3, 5 and 7 kV, respectively. The test results are shown in Fig. 4. Finally, the experiment has been repeated with applying a DC voltage of 5 kV on the grid. For both conditions (applying AC and DC voltages to the grid), the AC voltage applied to the insulator string under test was gradually raised until flashover voltage occurred while the sand is blowing on the string. Fig. 5 shows a comparison of the results obtained for the different conditions of study, namely with and without uncharged sand blowing on the insulator and with sand blowing while the grid is charged with 5 kV AC and, finally, with the grid charged with 5 kV DC.

From the test results shown in Fig. 4, it can be deduced that the flashover voltage of the string decreases as the grid voltage increases. However, as expected, the reduction in flashover voltage is significantly higher as the grid is charged with DC voltage, as shown in Fig. 5.

The results obtained show that in the case of applying AC voltage with power frequency of 50 Hz on the grid, the flashover voltage of the insulator is decreased. Moreover, it is found that the flashover voltage of the insulator is lower for the case of applying a DC voltage to the grid compared with an AC voltage having the same value of voltage. This is because the effective value

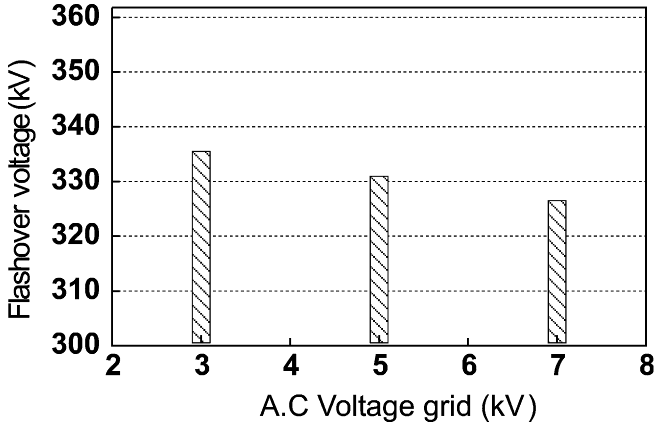
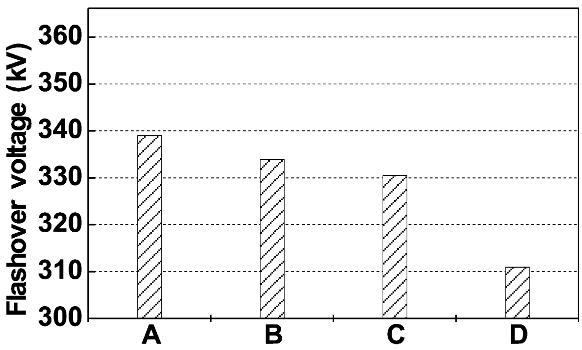


Fig. 4. Flashover voltage of the string under the effect of the charged grid of AC voltage.



A: Without sand blowing
B: With sand blowing
C: With sand blowing&charging grid with 5 kV A.C
D: With sand blowing&charging grid with 5 kV D.C

Fig. 5. Effect of charging grid with AC and DC voltages on flashover voltages.

of AC is lower than that of the DC value (the effective value of the AC voltage $= 1/\sqrt{2}$ Emax. (in the case of a sinusoidal wave)).

4. Conclusion

To a large extent, insulators show a significant change in electrical performance when exposed to desert environmental conditions. Either natural or artificial sandstorms affect fast flashover voltage. Charged sand particles reduce the flashover voltage of insulators. To a higher extent, this reduction in flashover voltage will be greater as the grid is charged with DC voltage.

References

[1] Zarzoura HEM. In: A new approach to the insulator contamination measurements in desert, 78. New York: IEEE; 1987-A. p. 121–6.

[2] Arafa BA et al. Experience of using polymer insulators in Egyptian environment. CIGRE Regional meeting for the African continent. 27–30 September, 1997, Cairo, Egypt.

[3] Besztercey G, Karger J, Szaplonczay P, Kimata R. Erosive wear of electrically insulating rubber compounds by solid particles. 11th ISH. London, 1999. p. 4.176.p_1.