View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Elsevier - Publisher Connector

Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 86 (2016) 333 – 336

Procedia Computer Science

2016 International Electrical Engineering Congress, iEECON2016, 2-4 March 2016, Chiang Mai, Thailand

The effect of controlling stray and disc capacitance of ceramic string insulator in the case of clean and contaminated conditions

Norrawit Tonmitr[a*], Kittipong Tonmitr[b], Eiji Kaneko[a]

[a]Department of Electrical and Electronics Engineering, Faculty of Engineering, University of the Ryukyus, Japan

[b]*Department of Electrical Engineering, Faculty of Engineering, Khonkaen University, Thailand*

Abstract

Due to their flexibility against the tension force and the easiness of maintenance characteristics of overhead transmission line, one of the biggest problems when using ceramic string insulator is the non-uniform voltage distribution on each insulator disc that connected on the string. This paper analyzes the effect of controlling stray capacitance (K_{csc}), disc capacitance (K_{cdc}) and contaminated pollution (K_{ccp}). In this paper research study considerations, the Electricity Generating Authority of Thailand (EGAT) 115kV overhead transmission line power towers are simulated in EMTP/ATP drawing and the results were analyzed. As it was found that in the clean condition, when the constant (K_{csc}) was conducted and adjustment when K_{csc} value has low value (decreases), the string efficiency would be high value (increases) for instances K_{csc}=0.01 string efficiency=99%, K_{csc}=0.50 string efficiency=64%. When the constant (K_{cdc}) was adjusted; if K_{cdc} is low, the string efficiency will also be low for instances at K_{cdc}=0.01 string efficiency=33%, K_{cdc}=0.50 string efficiency=40%. Nevertheless, K_{cdc} adjustment utilizes the appropriate value gained from factory that the k=0, so the value will be 90% higher. As for the contaminated condition, when the constant (K_{csc}) was adjusted as shown in Fig.11, if K_{csc} value is low, the string efficiency will be high for instances K_{csc}=0.01 string efficiency=99%, K_{csc}=0.05 string efficiency=65%. When the constant (K_{cdc}) was adjusted; if K_{cdc} is low, the string efficiency will also be low for instances at K_{cdc}=0.01 string efficiency=17%, K_{cdc}=0.50 string efficiency=40%. Considering on K_{ccp}, for example K_{ccp}=0.01 string efficiency=82% K_{ccp}=0.50 string efficiency=55%.

© 2016 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the Organizing Committee of iEECON2016

Keywords: Contamination, Efficiency of string, Overhead lines, Pollution, String Insulator

1. Introduction

The Equivalence of Insulator String Circuit Parameter

As for the experimental investigation behavior of insulator, if it is not contaminated and clean, there is none practical leaking and the electrical insulating material acts looks like a capacitance.

* Corresponding author. Tel.: +81-80-6486-6644; fax: +81-98-895-8708.
E-mail address: chutzpaclub@gmail.com

1877-0509 © 2016 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the Organizing Committee of iEECON2016
doi:10.1016/j.procs.2016.05.090

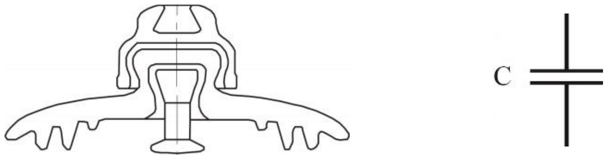

Fig. 1. Simplified illustration of clean insulator circuit[3]

Due to the analysis program, variation in the stray capacitance (K_{csc}) and disc capacitance (K_{cdc}) condition have been conducted. And primitive circuit parameters will be investigated. Calculation of the self-capacitance of each insulator, stray capacitances between cap and energized conductor, caps and ground, as well as each insulator cap and the other caps. The insulator string have been drawn utilizing EMTP for the analysis. The real transmission line consists of tower, insulator string and conductor. The primitive circuits have been illustrated where C_s is stray capacitance and C is disc capacitance.[4,5,6]

2. The Research Procedures

Simulation procedures of seven disc suspension ceramic porcelain insulator (clean condition). In this case uses the data of three phases 115kV overhead transmission line system, the type of cemented cap insulator with disc diameter of 10 inches.[4,5,6]

The primitive circuit of seven disc suspension ceramic insulator (clean condition) has been drawn as shown in Fig. 2. Normally, capacitance between steel cap, pin and disc ceramic porcelain insulator value is 10 to 40µF. Stray capacitance generally varies with the space and diameter of steel cap/pin of the insulator string and steel tower structure. The capacitance value can be measured by accuracy capacitance bridge. The stray capacitance value is 1-8µF.

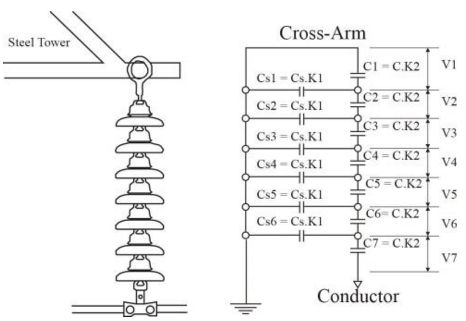

Fig. 2. Simplified primitive circuit of seven disc suspension ceramic insulator in clean condition

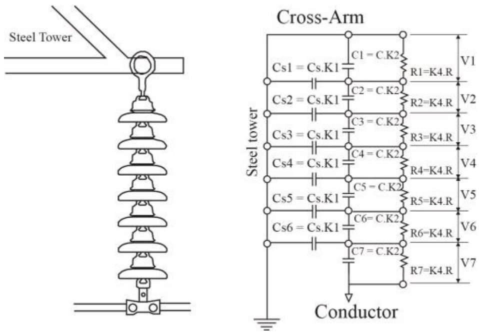

Fig. 3. Simplified primitive circuit of seven disc suspension ceramic insulator in contaminated condition

In case of seven disc suspension ceramic porcelain insulator (clean condition)/(contamination)

1) Using the value of cap, disc ceramic porcelain insulator and pin capacitor is C_1= C_2= to… C_7= 30pF. /Using contaminated pollution resistance value is 4,400MΩ.

2) Using the value of the stray capacitance between steel cap/pin and steel tower (C_s) is 3pF. / Using the value of cap, disc ceramic porcelain insulator and pin capacitor is C_1= C_2= to… C_7= 30pF. Using the stray capacitance value between steel cap/pin and steel tower (C_s) is 3pF.

3) Try to control stray capacitance by increasing the stray capacitance factor K_{csc} form 0.01, 0.03, 0.05, 0.07, 0.10, 0.20, 0.25, 0.30, 0.40, and 0.50 by using $K_{csc}= C_{s1}/C_s$ (clean condition)

Try to control stray capacitance by increasing the stray capacitance factor K_{csc} form 0.01, 0.03, 0.05, 0.07, 0.10, 0.20, 0.25, 0.30, 0.40, and 0.50 by using $K_{csc}= C_{s1}/C_s$ (contamination)

4) Run EMTP/ATP, collect data and plot graph. Same methodology for both clean & contamination.

5) After that using the value of cap, disc ceramic porcelain insulator and pin capacitor is C_1= C_2= to… C_7= 30pF. Same methodology for both clean & contamination.

6) Using the value of the stray capacitance between steel cap/pin and steel tower (C_s) is 3pF. /Same.

7) Try to control cap, disc ceramic porcelain insulator and pin capacitance by increasing the controlling cap, disc ceramic porcelain insulator and pin capacitance factor K_{csc} form 0.01, 0.03, 0.05, 0.07, 0.10, 0.20, 0.25, 0.30, 0.40, and 0.50 by using $K_{cdc}= C_1/C$ (clean & contamination)

8) Run EMTP/ATP, collect data and plot graph. Same methodology for both clean & contamination.

9) Try to control contaminated pollution by increasing the controlling contaminated pollution factor K_{ccp} from 0.01, 0.03, 0.05, 0.07, 0.10, 0.20, 0.25, 0.30, 0.40, and 0.50 by using equation. $K_{ccp}= R_1/R$ (only contamination)

3. Results

The result of voltage across each insulator when varied K_{csc} and K_{cdc} after modeling by using EMTP program shown as Fig. 4-8.

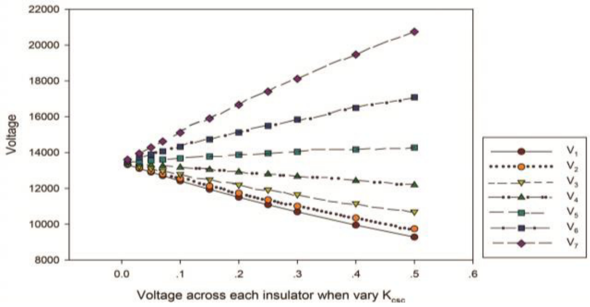

Fig. 4. Controlling stray capacitance factor K_{csc} (clean condition)

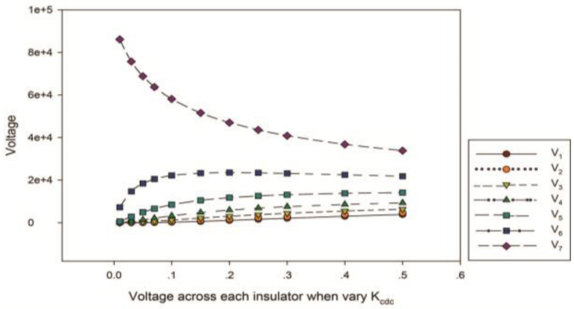

Fig. 5 Controlling cap, disc and pin capacitance factor K_{cdc} (clean condition)

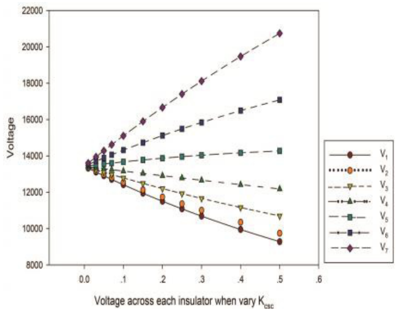

Fig. 6. Controlling stray capacitance K_{csc} (contaminated condition)

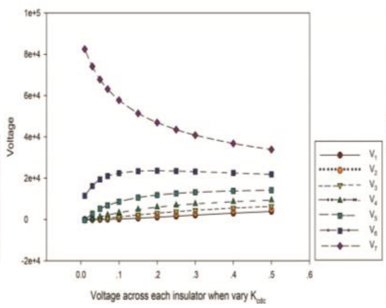

Fig. 7 Controlling cap, disc and pin capacitance factor K_{cdc} (contaminated condition)

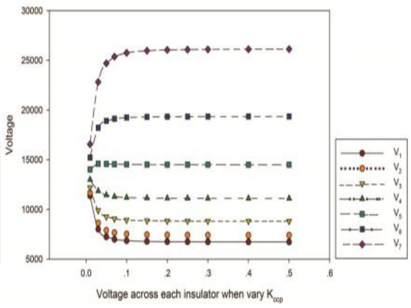

Fig. 8 Controlling Factor K_{ccp} (contaminated condition)

After data has been collected from this simulation, using the string efficiency equation.

$$\frac{voltage\ \ across\ \ the\ \ string}{number\ \ of\ \ unit\ \ x\ voltage\ \ across\ the\ unit\ adjacent\ \ to\ line\ conductor} \quad (1)$$

4. Discussion and Conclusion (Effect of controlling index constant K_{csc}, K_{cdc} and K_{ccp})

According to the experimental results, it was found that when controlling stray capacitance index constant (K_{csc}) and controlling the disc ceramic porcelain insulator and pin capacitance index constant (K_{cdc}). Voltage distribution of the ceramic insulator string were in same direction results both for clean and contaminated condition.

When the K_{csc} has a low index value, this method controls the string capacitance by controlling the index value of the K_{csc}. The voltage distribution of ceramic insulator string to equally distribute voltage in each porcelain and after increasing the index of string capacitance index K_{csc}. The voltage distribution of ceramic insulator string was a difference gradually increasing in each porcelain. Such as in a case of adjusting the value of a low value index constant K_{csc}. The string efficiency is higher than control the index stray capacitance value in case of high value of K_{csc}.

When K_{cdc} has a low index value, distribution voltage of ceramic insulator string was rapidly increasing value. After increasing the value of K_{cdc}, distribution voltage of ceramic insulator string was slightly different and these difference could be easily to distinguish. For the controlling of the index constant could be conclude that, when index constant of control capacitance has to be adjusted in high index value of K_{cdc} the string efficiency was higher than in case of adjusted the disc index in low value of K_{cdc}.

Table 1. The percent of string efficiency when controlling factor K_{csc}, K_{cdc} and K_{ccp}

K	Clean condition		Contaminated condition		
	controlling stray capacitance(K_{csc})	controlling cap, disc ceramic and pin capacitance(K_{cdc})	controlling stray capacitance(K_{csc})	controlling cap, disc ceramic and pin capacitance(K_{cdc})	controlling contamination polluted(K_{ccp})
0.01	98.72	15.59	98.72	15.09	81.12
0.03	96.29	17.74	96.30	16.53	58.84
0.05	94.01	19.51	94.01	17.82	54.37
0.07	91.87	21.07	91.87	19.01	52.93
0.10	88.88	23.11	88.89	20.64	52.14
0.15	84.46	26.04	84.46	23.07	51.71
0.20	80.58	28.57	80.59	25.25	51.56
0.25	77.16	30.82	77.17	27.25	51.50
0.30	74.13	32.87	74.13	29.10	51.46
0.40	68.96	36.50	68.97	32.46	51.42
0.50	64.73	39.67	64.74	35.45	51.41

According to the comparison of the overhead lines ceramic string insulator in case of clean and contaminated condition. It was obvious that the controlling contaminated pollution index value (K_{ccp}) was results in a difference of voltage distribution of ceramic insulator string more than the other case such as The effect of controlling the index constant K_{csc}, K_{cdc}. For the controlling contaminated pollution (K_{ccp}) voltage distribution of ceramic insulator string was different gradually increasing when K_{ccp} was up to 0.07, it was very rapidly change in the voltage distribution of ceramic insulator string. Therefore, it was concluded that the controlling contaminated pollution (K_{ccp}) has the most distinction of clean and contaminated condition.

References

[1]Tonmitr, N., Tonmitr, K., Kaneko,E.,The Comparison of the String Suspension Porcelain (5-6-7 insulators)/string Efficiency in Case of Dry and Wetted Water Contamination Condition Applied Mechanics and Materials, Vol 781 (2015), pp 280-283.doi:10.4028/www.scientific.net/AMM.781.280

[2]Tonmitr, N., Kaneko, E., Tonmitr, K., Kaewrawang, A. and Suksri, A., The Measurement of the Voltage Distribution along High Voltage Suspension Porcelain (5-6-7 insulator)/string in Case of Clean Condition. Applied Mechanics and Materials Vols. 752-753 (2015),pp 1133-1138. doi:10.4028/www.scientific.net/AMM.752-753.1133

[3] Dhalaan, S.M.A.; Elhirbawy, M.A., Investigation on the characteristics of a string of insulator due to the effect of dirt, Transmission and Distribution Conference and Exposition, IEEE PES; September., 3, 915 – 920. doi: 10.1109/TDC.2003.1335059. (2003)

[4]. Dhalaan, S.M.A. Elhirbawy., M.A., Simulation of voltage distribution calculation methods over a string of suspension insulators, Transmission and Distribution Conference and Exposition, IEEE, PES; 3, 909 – 914. doi: 10.1109/TDC.2003.1335058. (2003)

[5]. IEC Standard 60507,Artificial pollution tests on high voltage insulators to be used on A.C. systems. (1991)

[6]. IEC Standard 60060-1, High voltage test technique, Part 1: General Definitions and test requirements.(1989)