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XLPE Insulated High Voltage Underground Cable Assessment of Leakage Current Studies

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***Abstract*—**The insulation assessment on high voltage underground cables by circuit model simulation. It is used in studying and comparing the normal and the failure of cables in order to understand the behaviors current magnitude and phase shift of insulation damage. The calculation of current magnitude and phase shift was used Proteus Program and Microsoft Excel. The results both from water trees and electrical trees show that the phase shift has no change whereas the magnitudes of currents are more decreasing with water trees, when the voltage and frequency are increasing. On contrary with electrical trees are higher voltage and frequency, the higher magnitudes of current.

***Keywords*—** water trees, electrical trees, magnitude of current, phase shift.

I. Introduction

THE Cross-linked polyethylene (XLPE) insulation system is an important and usage in high voltage system. The XLPE has become the globally preferred insulation for power cables, both for distribution and transmission system application. This insulation system provides cost efficiency in operation and procurement, as well as lower environmental and maintenance requirements when compared to oil impregnated paper systems.

The XLPE cable has high electric strength, mechanical strength, high-aging resistance, environmental friendly, easy installation and higher operating of long term temperature. It can be laid with no drop restriction. Several of flame-retardant and non-flame retardant XLPE cable can be manufactured with three technologies (peroxide, silence and irradiation crosslinking).

The damage of XLPE cable is caused by water treeing, electrical treeing, partial discharge and so on [1]. On the other hand, mince of cable causes the aging such as: Thermal, mechanical and electrical stress impacting the electrical insulation [2]. By which, the studying of assessment in XLPE high voltage cable is very interesting and valuable. The studying of leakage current is conducted by the creating of electric circuit simulation in order to understand the relationship characteristic of each failure type in function of applied voltage and frequency that can evaluate the insulation conditions. This will be applied to assess exist cable system.

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II. Methodology

A. Electrical trees

Electrical trees are dark, branch-like structure with readily apparent channels. Carbonization is often evident; thus, these do not change appearance as noticeable as water trees on drying or wetting [3]. There is substantial evidence that a water or electrochemical tree may transform [4] into or initiate [5], an electrical tree, and that a dielectric failure is imminent after this event

Electrical tree occurs due to the erosion of material at the tip of the spark. Erosion results in the roughening of the surfaces, and hence becomes a source of dirt and contamination. This causes increased conductivity resulting either in the formation of a conducting path bridging the electrodes or in a mechanical failure of the dielectric, as shown the figure1.

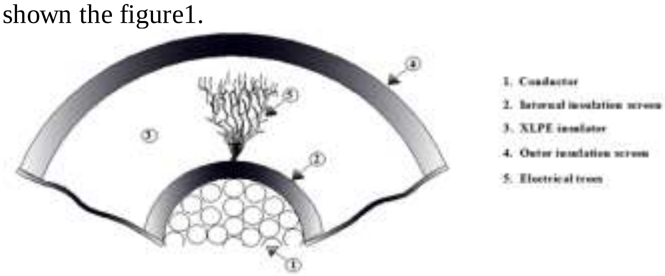

Fig. 1: The electrical trees in XLPE cable

B. Water trees

Water trees has diffuse structures with a bush or fan-like appearance. Typically, they are in the 0.1 to 1 mm size range and usually “rooted” at an interface between the insulation and another substance. Water trees are known to disappear on drying process, reappear on rewetting, and are rendered permanently visible by various water-soluble dyes most commonly, methylene blue, as shown the figure 2.

Degradation of XLPE cable by water trees gives rise to harmonics in the leakage current [6]. They provides an extremely good indication of the state of degradation. And arise as a result of the nonlinear voltage current characteristic. An equivalent circuit which incorporates this nonlinearity of water trees faithfully reproduces the leakage current waveform obtained in experiments. When a voltage at a frequency differing from commercial frequencies is superposed, a degradation signal occurs at a characteristic frequency.

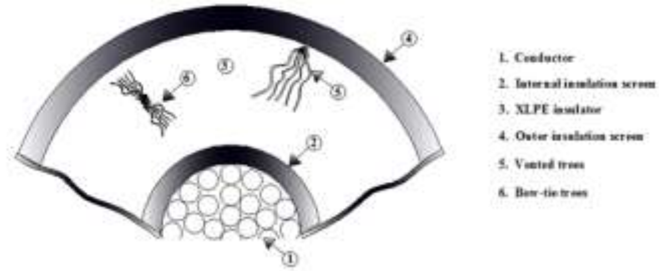

Fig. 2: The water trees in XLPE cable

C. Leakage current behaviors

The equivalent circuit of water trees and electrical trees on XLPE insulation were determined with the parameters. As show in the figure 3 and 4.

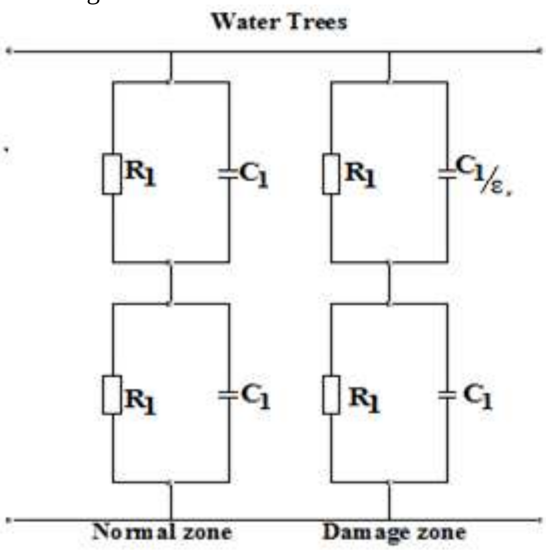

Fig.3: The equivalent circuit of water trees

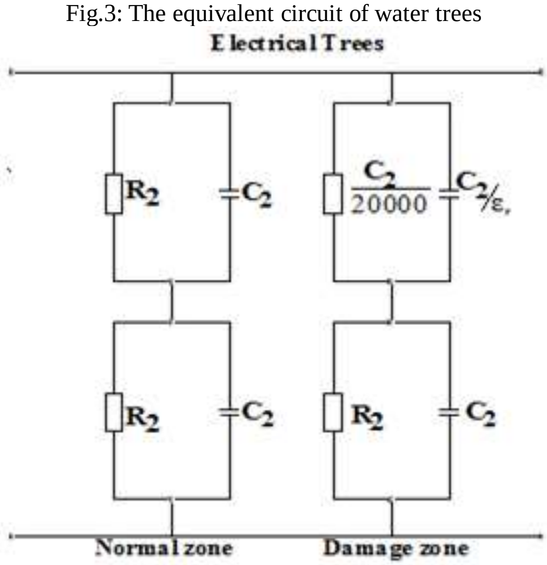

Fig.4: The equivalent circuit of electrical trees

According to the natural of water trees and electrical trees in XLPE insulation, they capacitances and resistances are different changes. Therefore, the leakage current behaviors in faction of voltage and frequency can use determine the damage

III. Result and Discussion

The damage parameters of water tree were taken from the assumption length about 10 cm whereas the parameter electrical tree were about 1 cm as figure 5, and 6.

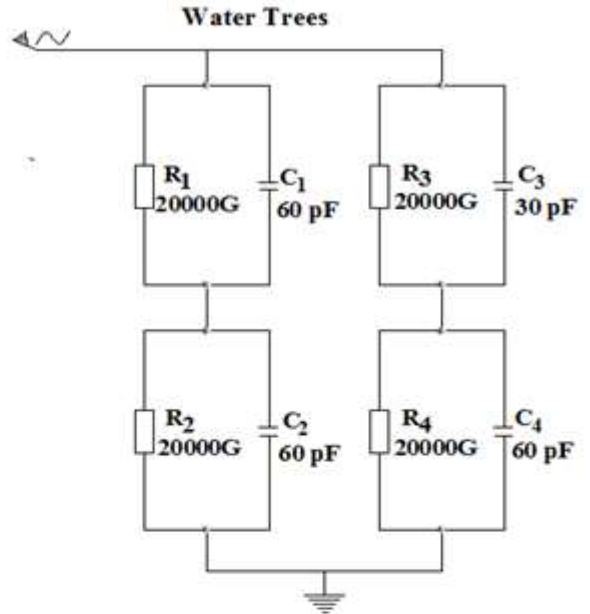

Fig.5: The circuit model of water trees

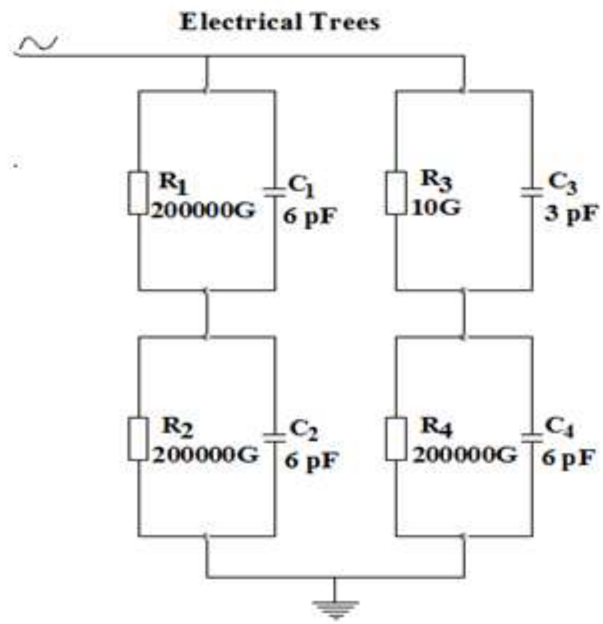

Fig.6: The circuit model of electrical trees

The magnitude of current and the phase shift can be calculated by using Proteus and Excel program. The results are compared between perfect and damage cable. For both cases the frequency with 10, 50, 200 and 500 Hz and voltage source of 10, 30 and 50Vrms, were varied to obtain the different results as show in table I and table II, for water trees and electrical trees, respectively.

TABLE I
THE DIFFERENT OF CURRENT AND PHASE SHIFT OF WATER TREES

Phase shift (degree)				
Voltage (RMS)	Frequency (Hz)			
	10	50	200	500
10	2.25	0.45	0.11	0.04
30	2.25	0.45	0.11	0.04
50	2.25	0.45	0.11	0.04
Magnitude current (nA)				
Voltage (RMS)	Frequency (Hz)			
	10	50	200	500
10	-9	-45	-180	-450
30	-27	-135	-540	-1350
50	-45	-225	-900	-2250

TABLE II
THE DIFFERENT OF CURRENT AND PHASE SHIFT OF ELECTRICAL

Phase shift (degree)				
Voltage (RMS)	Frequency (Hz)			
	10	50	200	500
10	2.25	0.45	0.11	0.04
30	2.25	0.45	0.11	0.04
50	2.25	0.45	0.11	0.04
Magnitude current (nA)				
Voltage (RMS)	Frequency (Hz)			
	10	50	200	500
10	2.70	13.49	54.01	135.06
30	8.10	40.46	162.02	405.19
50	13.51	67.43	270.04	675.31

IV. CONCLUSION

The leakage current behaviors of water trees and electrical trees can be specified under the variation of voltage and frequency. To study the current magnitude and phase shift found that:

- The water trees, more increasing the voltage source and frequency, less the current magnitude and phase shift can be observed.
- The electrical trees, the voltage source and frequency, less the phase shift was decreased but higher the current magnitude can be observed.

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