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# Reduction of power loss from corona phenomena in high voltage transmission line 115 and 230 kV

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**Abstract**

The Power Loss from Corona Phenomena in High Voltage Transmission Line 115 and 230 kV were studied the effects of various elements that affect the power loss from corona in high voltage transmission line between Khon Kaen and Nakhon Ratchasima and the method to reduce power loss due to corona. This paper clarifies Peek's and Peterson's formula by utilizing Matlab program with the effect from different variables including conductor spacing, conductor radius and a system voltage. The Peterson's formula was suitable for the two systems than that of Peek's formula under the condition of phase voltage to corona inception voltage ratio. In the 115kV system uses 795 MCM ACSR conductor with 1.447 cm radius and the spacing was 320 cm could generate a less power loss, and the 230kV system uses 1272 MCM ACSR conductor with 1.75 radius, the spacing was 500 cm could generate a less power loss. When simulated to solve the conductor radius and the spacing that would have the less power loss. In 115kV system, the suitable was 1.36 cm radius and 266 cm spacing and in 230 kV system the suitable was 0.85 cm radius and 660 cm. It therefore could reduce power loss by selecting the conductor radius and the conductor space increasing or protecting the system from the lightning.


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## 1. Introduction

Nowadays, the electricity is considered as necessary resources in daily life and household, business, as well as industry. The electricity from the power plant parts through the Electricity Generating Authority of Thailand (EGAT). The electricity transmissions of the EGAT are high-voltage transmission systems via high voltage transmission lines on steel towers. In the Northeast, it was found that a loss of power derived from the production to transmission line because of the internal impedance lines and load on the electrical system. It was also found that there was a loss of power due to the phenomenon of corona with high energy electrons ran out of the area with high electrical stress collided with gas molecules in the air caused to disintegration and loss of energy or power[1]. The loss of power that could be affected by a power that has been insufficient to distribution and may result into the state's black out. Therefore, the authors interest to study losing in the phenomena of Corona. Studying and clarifying the loss from corona by Peek's and Peterson's equation with different variables including weather, conductor radius, spacing and system voltage. A study conducted by using the typical transmission line Khon Kaen - Nakhon Ratchasima, the transmission line connecting to the control center and the province due to a large area and a lot of electricity consumer. This research studied to reduce the corona loss in the 115 kV and 230 kV transmission line.

## 2. Corona Loss

The ionized charges near the conductor surface take energy from the supply system and thus there is a loss of some energy due to corona[1]. This is resistive loss. It is not possible to derive any formula for the exact loss that occurs due to corona. Several researchers gave empirical formulas based on the experiments for calculating the corona loss[2, 3].

### *2.1. Peek's formula*

The empirical formula for corona loss under the fair weather condition is[4]

$$P_c=\frac{212.4}{\delta}(f+25)(V_p-U_c)^2\sqrt{\frac{r}{d}}\times 10^{-5} \tag{1}$$

where $P_c$ is power loss due to corona phenomenon in kW/km/phase, $V_p$ is phase-to-neutral voltage in kV, $U_c$ is disruptive critical voltage in kV can be defined as[5] (2), $f$ is supply frequency in Hz, $r$ is radius of conductor in cm, $d$ is equivalent conductor spacing in cm and $\delta$ is air density correction factor can be defined as (3)

$$U_c=21.1\, m_0\, \delta \ln\frac{d}{r} \tag{2}$$

$$\delta=\frac{0.386P}{273+T} \tag{3}$$

where $P$ is air pressure in torr, $T$ is temperature surrounding conductor in ℃ and $m_0$ is irregularity factor

It was found that formula given by Peek gives correct results under the condition including corona loss is predominant, frequency lies between[4] 25 and 120 Hz and the ratio $V_p/U_c > 1.8$.

### *2.2. Peek's formula*

If the ratio of the phase voltage to the disruptive critical voltage is less than 1.8, Peterson formula will be used for determining the corona loss as[4]

$$P_c=2.094f\left(\frac{V_p}{\log\frac{d}{r}}\right)^2 F\times 10^{-5} \tag{4}$$

where $F$ is a function of $V_p/U_c$

## 3. The Experiments

The experiments simulation in this study was using Khon Kaen - Nakhon Ratchasima transmission line under fair weather condition with average maximum temperature was 32.8 ℃ and the air pressure was 760 torr. In 115 kV system using 795 MCM ACSR conductors, radius was 1.447 cm and average conductor spacing was 320 cm. This system has the total length of transmission line about 563.8 km. In 230 kV system using 1272 MCM ACSR conductors, radius was 1.75 cm. Simulation varies parameters.

### *3.1. Disruptive critical and visual inception corona voltage*

Irregularity factor for stranded conductor is 0.86 for disruptive critical voltage[5] and 0.72 for visual inception corona voltage.

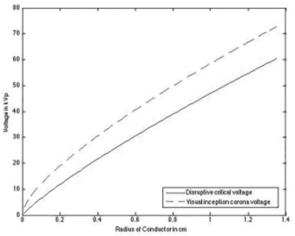

Fig. 1. Disruptive and inception corona voltage in 115 kV system

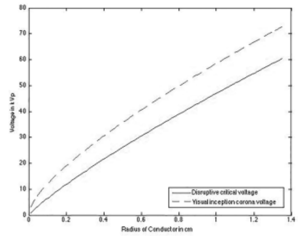

Fig. 2. Disruptive and inception corona voltage in 230 kV system

As illustrated in figure. 1 and figuer. 2, found that disruptive critical voltage and visual inception corona voltage would increases when the radius of adding more lines. And visual inception corona voltage was more than disruptive critical voltage. Therefore the big conductor, corona would hardly appears.

### *3.2. Conductor Spacing*

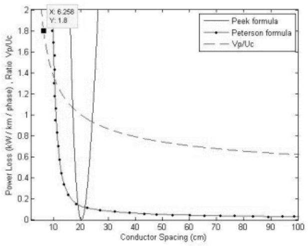


Fig. 3. Loss and Vp/Uc vs Conductor spacing in 115 kV system

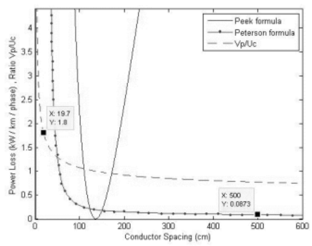


Fig. 4. Loss and Vp/Uc vs Conductor spacing in 230 kV system

As shown in figure. 3 and figure. 4, found that Ratio of $V_p/U_c$ will be less than 1.8 where the conductor spacing was more than 6.26 cm and 19.7 cm, respectively. Therefore, the Peterson's formula was more suitable for 115 kV and 230 kV system. Power loss decreased when adding more of the conductor spacing. At the operating point of two systems, 320 cm for 115kV and 500 cm for 230 kV, the power loss very slowly decreased, thus 320 cm and 500 cm conductor spacing was suitable for 115 kV and 230 kV, respectively

### *3.3. Radius of Conductors*

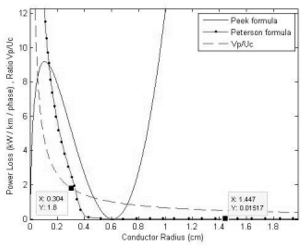


Fig. 5. Loss and Vp/Uc vs Conductor radius in 115 kV system

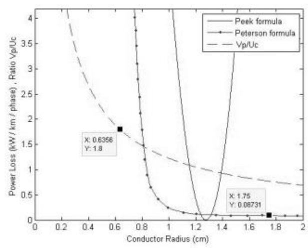


Fig. 6. Loss and Vp/Uc vs Conductor radius in 230 kV system

As described in figure. 5 and figure. 6, found that ratio of $V_p/U_c$ will be less than 1.8 where the conductor spacing was more than 0.3046 cm and 0.6356 cm, respectively. Therefore, the Peterson's formula is more suitable for 115 kV and 230 kV system. Power loss decreased when adding more of the conductor spacing. At the operating point of two systems, 1.447 cm for 115kV and 1.75 cm for 230 kV, the power loss very slowly decreased, thus 1.447 cm and 1.75 cm conductor radius was suitable for 115 kV and 230 kV, respectively

### *3.4. Conductors Spacing and Radius*

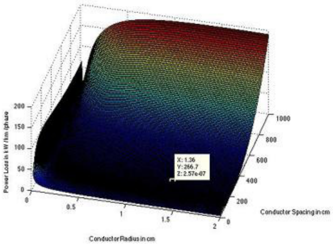


Fig. 7. Loss vs Conductor radius and Spacing in 115 kV system

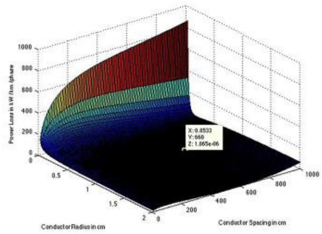


Fig. 8. Loss vs Conductor radius and Spacing in 230kV system

In figure. 8 and figure. 9, the radius of the conductors and the spacing that were lost in minimal for 115 kV system was 266 cm spacing and the radius was 1.36 cm. For 230 kV system the spacing and radius were 660 cm and 0.85 cm, respectively.

### *3.5. System Voltage*

Varying line-to-line voltage. Considering the 115 kV and 230 kV has the following results in figure. 9 and figure. 10, respectively.

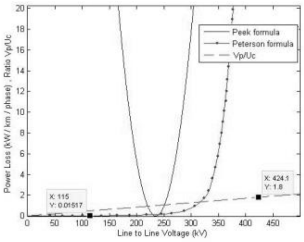


Fig. 9. Loss and Vp/Uc vs Line to Line Voltage in 115 kV system

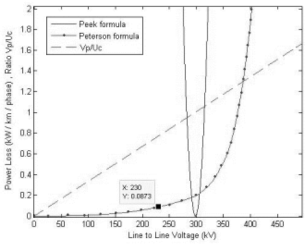


Fig. 10. Loss and Vp/Uc vs Line to Line Voltage in 230 kV system

Power loss decreased when line-to-line voltage was higher. At the operating point of two systems, the power loss very slowly increased but it quickly increased at the higher voltage around 350-400 kV. In conclusion, if there was a surge in the system, power loss due to corona was higher.

## 4. Conclusion

From the simulation results to determine power loss due to corona by Peek‘s and Peterson‘s formula to estimate the power loss by varing any parameters in formula including conductor spacing, conductor radius, line-to-line voltage and varies parameters to make the power loss in each voltage system. As from the experiments found that the Peterson‘s formula was more suitable for 115 kV and 230 kV system than that of the Peek‘s formula. The power loss decreased when adding more of the conductor spacing and the radius. The 795 ACSR conductor, 1.447 cm radius, and 320 spacing generated a few power loss for 115 kV system and the 1272 ACSR conductor, 1.75 cm radius, and 500 spacing generated a few power loss for 230 kV system voltage. It could not find the minimum power by Peterson’s. For Peek’s formula, the radius of the conductors and the spacing that were lost in minimal for 115 kV system was 266 cm spacing and the radius was 1.36 cm. For 230 kV system was 660 cm spacing and 0.85 cm radius. The surge in system can make power loss due to corona is higher. It can reduce power loss by increasing the conductor radius and the spacing or protecting the system from the surge.

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