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Analysis of Corona Effect on Transmission Line

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Abstract: *The effect of Corona on high voltage transmission line is one of the cause of power loss in power system and this is uneconomical and undesirable. The study of Corona and factors responsible for the loss is investigated through sample calculation based on Peek's formula and Peterson, the distance between generating station, frequency and load center as well as the amount of power to be handled. The study of an Extra High Voltage (EHV) line of about 1200Kv is used and the problems posed in using such high voltage are analyzed. The interest in corona loss and it advantage will find this research useful. This paper will also include the factor affecting Corona losses, application of Corona and the benefit of Corona, all these will be considered here. This paper will also present the relations between power loss due to Corona and Corona parameter using Matlab program to analyze and suggests some possible steps taken to minimize the phenomenon.*

Keywords: Corona, *Visual critical voltage, Disruptive critical voltage, w.f. Peek's method and Peterson's method and matlab/simulink*

I. INTRODUCTION

When an alternating potential difference is applied across two conductor, whose spacing is large in comparison with their diameter then the atmosphere Air surrounding the conductors is subjected to electrostatic stresses at low voltage there is no change in the condition of atmosphere Air around the conductor, However, when the potential difference is gradually increases a stage arrived when a faint luminous glow of violet color appear together with a hissing noise, these phenomenon is called visual corona and is accompanied by the production of ozone which is ready detected because or it characteristic odor. [1]. The glow is due to the fact that the atmosphere Air around the conductor becomes conducting due to loss of energy which increases very rapidly once the visual critical voltage is Exceed the power loss due to corona is heavily depends upon weather condition during humid and moist climate corona loss is much increased the energy loss accompanied by the phenomenon called the corona. A violet glow is observed around the conductor it also produced ozone which can be readily detected by it characteristic odour.When in an insulation system, the voltage gradient (voltage stress) exceeds a critical voltage, the air molecules surrounding the high voltage transmission line conductors become ionized (transient gaseous ionization) resulting in partial discharges. Corona loss occurs if the line to line voltage exceeds the corona threshold. The conductive region is not high enough to cause electrical breakdown or arcing to any nearby objects [2]. Corona can occur within voids of an insulator, at the conductor or at the insulator interface. Rough surfaces are more liable to corona because the unevenness of the surface decreases the value of the breakdown voltage. It can be detected due to its visible light in form of purple glow consisting of micro arcs and its sound can be heard through its hissing and cracking sound [3]. The smelling of the presence of ozone production is noticed during corona activity [4]. The effects of corona are cumulative and permanent and the failure can occur without warning. In insulation system, corona discharges result in voltage transients. The effects of corona associated with the operation of high voltage transmission lines include radio interference, audible noise, gaseous effluents (Ozone and Nitrogen oxide) and shock potential. Conductor voltage, diameter and shape, dusts, water drops, and surface irregularities such as scratches are factors that affect the performance and conductor's electrical surface gradients. The energy loss due to corona is transformed into sound, radio noise, chemical reactions of the air components and heat [5]. Corona reduces the reliability of insulation system thereby degrading insulation and causes system failure due to dielectric breakdown. The study becomes necessary because of the prevailing negative effect of corona parameters on the power loss of high voltage transmission lines. The power loss under fair weather conditions and under stormy weather conditions when investigated analyzed and simulated using MATLAB programs gives the results, which help us to take necessary measures to minimize the power loss under fair and stormy weather conditions. High quality insulated and good service design underground high transmission cables can help to eliminate the loss due to corona effect The advantage of corona is that the sound generated during corona activity can be used to build high accuracy audio speakers and also it has no mass to be moved to create the sound so that transient response is improved. The controlled corona discharge can be used for filtrations and printing

In transmission line corona has become one of the major problem that causes power failure in our society and needed to be under consideration there phenomenon called corona, this occur when the voltage between conductor of an over head line Exceed the disruptive critical value a hissing noise is accompanied by a violet glow appear. The physical state of the atmosphere as well as by the condition of the line the corona is affected by the following factor

- Atmospheric factor
- Size of Conductor factor
- Spacing between conductor factor
- Line voltage factor

So many power failures we are experiencing now a day is caused by corona loss.
This research will study the two vital methods that are used in the calculation of corona and power loss. The two methods are

- W.F. Peek's method
- Peterson's method

According to peek's method the power loss due to corona under fair weather condition can be determined. And Peterson method which as to do with stormy weather condition the disruptive critical voltage (dcv) is taken as 0.8 time that of the fair weather value.

II. FORMATION OF CORONA

The corona discharges observed at the surface of a conductor are due to the formation of electron avalanches which occur when the intensity of the electric field at the conductor surface exceeds a certain critical value. There are always a few free electrons in the air as a result of radioactive materials in the earth's crust and bombardment of the earth from other space. As the conductors become energized on each half cycle of the AC voltage wave, the electrons in the air near its surface are accelerated by the electrostatic field. The electrons having an inherent negative charge are accelerated towards the conduction on its positive half cycle and away from the conduction on it negative, half cycle. Corona is formed when the voltages of a conductor passes the disruptive critical voltage and disappear when the voltage descends through the same value. This occurs on each conductor in every half cycle and developed a pulsating frequency.

2.1 Factors Affecting Corona

The following factor affect corona, these are:

- Atmosphere
- Size of Conductor
- Spacing between conductor
- Line voltage

2.1.1 Effect of Corona

The presence of corona can reduce the reliability of a system by degrading insulation, over a long period of time. These effects of corona are cumulative and permanent and failure can occur without warming. The causes of corona are:

- Light
- Ultraviolet radiation
- Sound (hissing or cracking) as caused by explosion gas expansion
- Ozone
- Nitric and various other acid
- Salt, sometime seen as white powder deposit

2.1.2 Benefits of Corona

- The sound generation effect of corona can be utilized to build accuracy audio speaking
- The major advantage is that there is zero mass that need to be moved to create the sound so that transient is improved.

2.2 Visual Critical Voltage

In the case of parallel wires it is found that visual corona does not begin at the voltage V_{do} at which the disruptive gradient of air goes is reached. But at a higher voltage V_{uo} called the visual critical voltage.
The visual critical voltage is defined as the minimum phase to neutral voltage whichglow and appears all along the line conductor thus, when corona begins the potential gradient g_v at the conductor surface is higher than the disruptive gradient g_o. According to Peek's which states that the disruptive critical voltage must be so exceeded that the stress is greater than the breakdown value up to a distance of $0.3\sqrt{\delta r}\ cm$from the conductor. Thus, visual corona will occur when the breakdown value is attained at the distance $r+0.3\sqrt{\delta r}\ cm$ from the axis, instead of the distance r, this required that the voltage 60 neutral be $.1+\frac{(0.3)}{\sqrt{\delta r}}$ time the disruptive critical voltage.

Thus the visual critical voltage is

$$V_{vo} = g_o\delta m_{vr}\left(1+\frac{0.3}{\sqrt{\delta r}}\right)\log_e \frac{d}{r} \text{Kv to neutral} \qquad (1)$$

Where m_v is a roughness factor which is the unity for smooth conductor.

III. ANALYSIS OF CORONA EFFECTS

This aspect of analysis will deal with two vital methods; these are:

- W. F. Peek's method (1929)
- Peterson method

According to Peek's formulas the power loss under fair weather condition can be expressed mathematically as:

$$P_UFW_C = \frac{k}{\delta}(f+28)\sqrt{\frac{R}{d}}\left(\frac{V_l}{\sqrt{3}} - vd_o\right)^2 x10^{-5} \text{ Km/phase} \qquad (2)$$

Where PU is the power loss
F is the supply frequency in Hz
WC is the weather condition

K	=	is the constant which varied with the ratio of $\frac{Vph}{Vdo}$
δ	=	Is the air density correction Factor
R	=	Radius of the Conductor
D	=	diameter of the conductor
V_L	=	is the line voltage
Vdo	=	is the disruptive critical voltage to neutral in Kv
EDCV	=	is the disruptive critical voltage
$\sqrt{3}$	=	Is the three phase (AC) supply voltage

Under stormy weather conduction Vd_o is taken as 0.8time it fair weather value and power loss due to corona is given by expression below

$$P_c = \frac{224}{\delta}(f+25)\sqrt{\frac{r}{d}}(V_{ph} - 0.8Vd_o)^2 \text{ x } 10^{-5} \text{ Kw/km/phase} \qquad (3)$$

$P_{pet} = \frac{21x\ 10^{-6}x\ f v^2}{\log_{10}(d/R)^2}$ which can be applied in calculating problem under stormy weather conduction

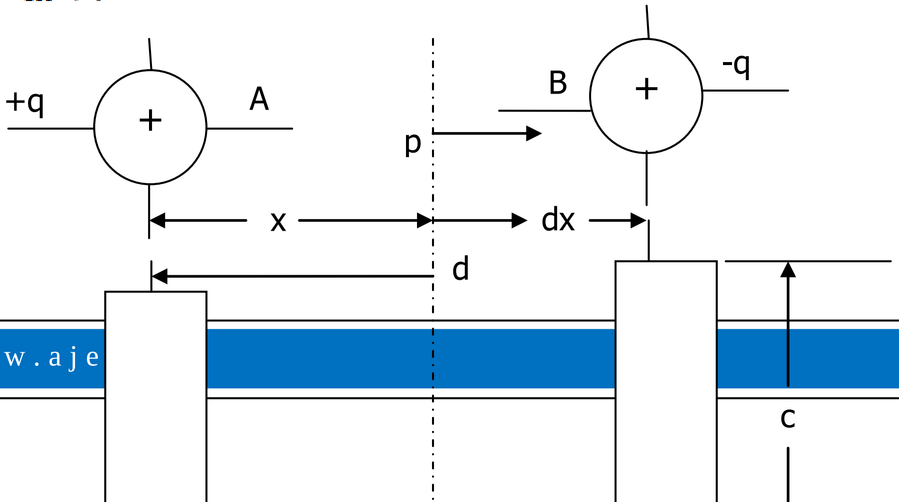

Fig: 3. Disruptive Critical Voltage

Let us consider the two-wire line in fig 1 where
r = radius of the line conductor
d = the distance between their center
q = charge per meter of conductor length is given to A When a negative charge of q coulombs per meter of conductor length is induced on conductor B consider point P at the distance of x meters from conductor A Electric field intensity at point P due to charge on conduction
A $=\frac{q}{2\pi\varepsilon_o x}$ acting toward B

B $=\frac{q}{2\pi\varepsilon_o(d-x)}$ P due to induced charge on conductor B

Resultant electric field intensity at point P

$$E_x = \frac{q}{2\pi\varepsilon_o x} + \frac{q}{2\pi\varepsilon_o(d-x)} = \frac{q}{2\pi\varepsilon_o}\left(\frac{1}{x}+\frac{1}{d-x}\right) \quad (4)$$

PD between conductor A and B

$$V = \int_r^{d-r} E_x\,dx = \int_r^{d-r} \frac{q}{2\pi\varepsilon_o}\left(\frac{1}{x}+\frac{1}{d-x}\right)dx \quad (5)$$

$$= \frac{q}{2\pi\varepsilon_o}\left[\log_e x - \log_e (d-x)\right]_r^{d-r} \frac{q}{\pi\varepsilon_o}\log_e\frac{d-r}{r}$$

Since r is very small as compared to d_1

$$V = \frac{q}{\pi\varepsilon_o}\log\frac{d}{r} \quad (6)$$

Gradient at any point x from the centre of the conductor A is given by

$$E_x = \frac{q}{2\pi\varepsilon_o x}\left(\frac{1}{x}+\frac{1}{d-x}\right)\frac{q}{2\pi\varepsilon_o}\frac{d}{x(d-x)} \quad (7)$$

Substituting for q we have

$$E_x = \frac{\pi\varepsilon o v}{\log_e\frac{d}{r}} \cdot \frac{1}{2\pi\varepsilon_o} \cdot \frac{d}{x(d-x)} \quad (8)$$

Where v is voltage between two conductors

$$E_x = \frac{V}{\log_e\frac{d}{r}} \cdot \frac{d}{x(d-x)} \quad (9)$$

In case of 3-phase system

$$V = \frac{VL}{\sqrt{3}} \quad (10)$$

From the expression for the potential gradient it is clear that for a given transmission system, the potential gradient increase as x decrease i.e the potential gradient is maximum when x=r, the surface of the conductor, and this value is by where g_{max} is the maximum gradient
E_{max} is the maximum field intensive.

$$E_r = E_{max} = \frac{Vd}{r(d-r)\log_e\frac{d}{r}} = \frac{V}{r\log_e\frac{d}{r}} \quad (11)$$

$g_o = \frac{Vdo}{r \log_e \frac{d}{r}}$ (12)

Where Vdo= is disruptive critical voltage

$Vd_o = g_o \delta m_o r \log_e \frac{d}{r}$ (13)

M_o = the irregularity factor
R = the radius
d = conductor spacing
δ = Air density factor
Irregularity factor which may be taken as unity value between 0.98 – 0.93 and 0.87-0.80
According to Peek and Peterson methods power loss can be express mathematically as

$Pc = \frac{234}{\delta}$ (f +25) $\sqrt{\frac{r}{d}}$ $(V_{ph}-V_{do})^2$x 10^{-5}k.w/km/phase (14)

OR

$Pc = \frac{21x\ 10^{-6} + (vph)^2}{(loge\ \frac{d}{r})^2}$ (15)

Pc = Under stormy weather condition
V_{do} = 0.8 time it fair weather conductive

$Pc = \frac{234}{\delta}$ (f +25) $\sqrt{\frac{r}{d}}$(vph – 0.8v$d_o)^2$x10^{-5}kw/km/Ø (16)

For visual critical voltage to neutral

$V_{uo} = g_o mor\left(1 + \frac{0.3}{\sqrt{\delta r}}\right) \log_e \frac{d}{r}$kv (rms) (17)

Where $K = \frac{Vph}{Vdo}$ = Exceed 1.8 (18)

The above equation is used in calculating the Air density factor.

Table 3. Sample Corona Loss Calculation based on Peek's Formula

Symbol	Parameter	Sample Value
K	Fixed constant	234
D_{ga}	Disruptive gradient in air	21.2kv/kw
M_d	Irregularity factor for disruptive critical voltage	0.85
M_v	Irregularity factor for visual corona inception voltage	0.72
T	Temperature of the surrounding	45°C
P	Atmospheric pressure	750 tons
δ	Air density correction factor$\delta = \frac{0.386p}{273+t}$	0.9104
R	Radius of conduction	0.54cm
D	Conductor spacing	300cm
F	Frequency	50Hz
V_L	Line to line voltage	132
E_{dcv}	Disruptive critical voltage$D_{ga}\delta R_{hog}$ (d./R)	55.98kl
L	Length of the conductor	100km
Pufwc	Corona loss under fair weather condition	347.37kg
Puswc	Corona loss under stormy weather condition	838.54kw
Evcv	Visual inception corona voltage$D_{ga}\delta$ M_{VR} Log (d./R)(1+0.3/sqrt(δ R)	55.98kv to neutral

3.1 Disruptive Critical Voltage (DCV)

The value of Vd_0 is known as disruptive critical voltage and is defined as the minimum phase to neutral voltage at which corona occur and held good for fair weather condition its value is considerable reduces during bad atmospheric condition such as fog, sheet, rain and snow storm. The disruptive critical voltage can be expresses mathematically as $Vd_o = g_o \delta m_o r \log_e \frac{d}{r}$

Where

Vd_o = Disruptive Critical Voltage
M_o = Irregularity Factor
f = Supply frequency
d = Spacing of conductor
r = Conductor Radius
δ = Air Density Correction Factor
g_o = Dielectric Strength Of Air

3.2 Effect of Dielectric Strength of Air

The dielectric strength of air g_o can be varied using the following value. 21, 23, 25, 27, 29, 31, 33, 35 based on Peek's sample table. Substituting the above value into these equation $Vd_o = g_o \delta m_o r \log_e \frac{d}{r}$ gives the values as stated in table 1.2

Table 3.1 Dielectric strength of air versus Power loss

Dielectric Strength Of Air (g_o)	21	23	25	27	29	31	33	35
Power Loss	54.8	60.1	65.3	70.5	75.7	80.9	86.1	91.3

Power loss due to corona loss versus the dielectric strength of air the above table shows that corona loss increases with the decrease in the density of air.

Under the fair weather condition the value of the dielectric strength of air is reduced but during bad weather condition the phenomenon seem to increase in this project we are going to consider fair weather condition when the dielectric strength of a air (g_o) will be decreases during these fair weather condition the corona loss is reduced the following value can be varies during fair weather condition by descending other: 35 33, 31, 29, 27, 25, 23, 21. Based on Peek's sample table the disruptive critical voltage can be expressed mathematically as $Vd_o = = g_o \delta m_o\ r \log_e \frac{d}{r}$

Where
Vd_o = Disruptive Critical Voltage
g_o = dielectric strength of air
M_o = Irregularity Factor
d = Spacing of conductor
r = Conductor Radius

TABLE 3.2 Dielectric versus Power loss

Dielectric Strength Of Air (g_o)	35	55	31	29	27	25	23	21
Power Loss	91.3	86.1	80.9	75.7	70.7	65.2	64.5	54.8

Dielectric strength of air versus power loss due to corona loss. The above table shows that corona loss decrease with the increase in the density of air under fair weather condition the value of the dielectric strength of air is reduced. In a plain area the corona loss is reduced.

3.3 Effect of System Frequency

It is obvious that corona loss varied directly as the system frequency, that is the higher the supply frequency, the higher the corona loss. And this system frequency can be varied using the following value 10, 15, 20, 25, 30, 35, 40, 45; this value can be calculated using the equation below.

$$Pc \frac{243}{\delta} (f + 25) \sqrt{\frac{r}{d}} (vph - 0.8Vd_o)^2 \times 10^{-5}$$

Where Pc =is the power loss
δ = Air Density Factor
r = Conductor Radius
d = spacing of Conductor
Vp_h = Voltage to Neutral in Kv

The table below shows that the higher the supply frequency, the higher the corona the D.C. corona loss is less than that of A.C. corona loss. The effect of corona on A.C. line generates third harmonic component that increase the corona loss.

TABLE 3.3 The Supply Frequency versus power loss

Supply Frequency	10	15	20	25	30	35	40	45
Higher Power Loss	30.1	34.4	38.7	43.0	47.4	51.6	55.9	60.28

But when the supply frequency is lower the corona effect will be decrease. The D.C. Corona is less than that of A.C corona loss generate third harmonic component that decrease the corona loss.

3.3.1 Effect of Supply Frequency

It is obvious that, corona loss varied directly as the supply frequency, but when the supply frequency is lower, the effect of corona is reduced. The D.C corona is less than that of the A.C corona loss, line generate third harmonic component and decrease the corona loss. And this system frequency can be varied using the following value base on Peak sample cable as follows 45, 40, 35, 30, 25, 20, 15, 10. This value can be calculated using the expression below:

$$Pc \frac{243}{\delta} (f+25) \sqrt{\frac{r}{d}} (vph - 0.8Vd_o)^2 \times 10^{-5}$$

Where Pc =is the power loss
δ = Air Density Factor
r = Conductor Radius
d = spacing of Conductor
Vp_h = Voltage to Neutral in Kv

Thus, by calculating, and substituting the values of frequency (f) into the equation we have lower power loss as stated in table below

The table below shows that the lower the supply frequency the lower the corona loss the d.c corona loss is less than that of A.c corona loss. The effect of corona on a.c lines generated third harmonic component that decrease in corona loss.

TABLE 3.4 Supply Frequency versus power loss

Supply Frequency	45	40	35	30	25	20	15	10
Lower Power Loss	60.28	55.97	51.66	47.44	43.1	36.75	34.45	30.14

Supply frequency versus power loss

3.4 Effect of Line Voltage: The electric field in the space around the conductor depends mainly on the potential difference between the conductors greater the potential difference, greater is the electric field and, therefore, greater is the power loss with the increase in system voltage is small but when Vp_h is large and compared Vd_o corona loss increase at a very fast rates with increase in system voltage. These simple means at low voltage there is no corona. These simple means at low voltage there is no corona effect but at high
where Vp_h is the supply voltagevoltage the corona effect appear. This power loss can be calculated using the formula $Pc \frac{243}{\delta} (f+25) \sqrt{\frac{r}{d}} (vph - 0.8Vd_o)^2 \times 10^{-5}$ kw/km/phase where

δ = Air Density Factor
r = Conductor Radius
d = spacing of Conductor

This voltage can be varied based on Peek's table. This supply voltage can be varied based on Peek's by using the following value 132, 142, 152, 162, 172, 183, 194, 202

Substituting the parameter into the equation above

$$Pc \frac{243}{\delta} (f+25) \sqrt{\frac{r}{d}} (vph - 0.8Vd_o)^2 \times 10^{-5} \text{ kw/km/phase where}$$

Table 3.5 Line voltage versus power loss

Line Voltage	132	142	152	162	172	182	192	202
Power Loss	49.1	62.8	81.5	98.5	114.3	132.3	157.1	181.0

The above table shows that when the line voltage increase to such a value that electrostatics stresses developed at the conductor surface make the Atmospheric air surrounding the conductor the corona effect will appear or occur.

Decrease in corona is the condition when the line voltage and the power corona loss is reduced this can be calculated by varying the line voltage based on Peek's table by varying the following value 132, 122, 112, 102, 92, 2, 72, 62

The above value can be calculated by using the formula below:

$$Pc \frac{243}{\delta} (f + 25) \sqrt{\frac{r}{d}} (vph - Vd_o)^2 \times 10^{-5} \text{ kw/km/phase}$$

The table below shows that when the supply frequency is decreased the corona loss is decreased or absent

Table 3.6 Line Voltage versus Power Loss

Line Voltage	132	122	112	102	92	82	72	62
Power Loss	49.1	36.9	26.9	17.9	9.12	5.12	2.2	0.307

The above table shows that at low voltage the effect of corona will be reduced and the corona effect will not appear.

3.5 Visual Critical Voltage

In the case of parallel wire it is found that visual corona does not begin at the voltage Vd_o at which the disruptive gradient of air g_o is reach, but at a higher voltage Vv_o called the visual critical voltage. Visual critical voltage is defined as a minimum phase to neural voltage at which glow appear all along the line conductor.

3.6 Effect of Conductor Spacing

Under fair weather, condition at various spacing between the conductor this can be varied. The higher the spacing of the conductor the lower the corona loss or absent. The spacing between the conductor can be varied based on Peek's table, the following value can be varied 300, 320, 340, 360, 380, 400, 420, 440.

The effect of corona in the transmission line can be reduced by increasing the conductor spacing and this can be calculated by using visual critical voltage

g_o = Dielectric strength of Air

δ = Air Density factor

d = Spacing of Conductor

r = Conductor Radius $\frac{2.395\, p}{275\, t}$

At 300 = $21.1 \times 0.9104 \times 0.72 \times 0.54 \left(1 + \frac{0.3}{\sqrt{0.9104 \times 0.54}}\right) \log e \frac{300}{0.54}$

= $7.468 \times 1.427 \times 6.3199 = 67.0k_v$

At 320 = $21.1 \times 0.9104 \times 0.72 \times 0.54 \left(1 + \frac{0.3}{\sqrt{0.9104 \times 0.54}}\right) \log e \frac{320}{0.54}$

= $7.468 \times 1.42 \times 6.384 = 67.69k_v$

At 340 = $21.1 \times 0.9104 \times 0.72 \times 0.54 \left(1 + \frac{0.3}{\sqrt{0.9104 \times 0.54}}\right) \log e \frac{340}{0.54}$

= $7.468 \times 1.42 \times 6.446 = 68.35k_v$

At 360 = $21.1 \times 0.9104 \times 0.72 \times 0.54 \left(1 + \frac{0.3}{\sqrt{0.9104 \times 0.54}}\right) \log e \frac{360}{0.54}$

= $7.468 \times 1.42 \times 6.5022 = 68.95k_v$

At 380 = $21.1 \times 0.9104 \times 0.72 \times 0.54 \left(1 + \frac{0.3}{\sqrt{0.9104 \times 0.54}}\right) \log e \frac{380}{0.54}$

= $7.468 \times 1.42 \times 6.556 = 69.52k_v$

At 400 = $21.1 \times 0.9104 \times 0.72 \times 0.54 \left(1 + \frac{0.3}{\sqrt{0.9104 \times 0.54}}\right) \log e \frac{400}{0.54}$

= $7.468 \times 1.42 \times 6.607 = 70.06k_v$

At 420 = $21.1 \times 0.9104 \times 0.72 \times 0.54 \left(1 + \frac{0.3}{\sqrt{0.9104 \times 0.54}}\right) \log e \frac{420}{0.54}$

= $7.468 \times 1.42 \times 6.652 = 70.58k_v$

At 440 = 21.1 x 0.9104 x 0.72 x 0.54 (1 + $\frac{0.3}{\sqrt{0.9104 \times 0.54}}$) loge $\frac{440}{0.54}$

= 7.468 x 1.42 x 6.7029 = 71.08

Table 3.7 Conductor spacing versus power loss

Conductor Spacing	300	320	340	360	380	400	420	440
Power Loss	67.0	67.7	68.4	68.9	69.2	70.1	70.6	71.1

The table above shows that under the fair weather condition at various spacing between the conductors corona is inversely proportional to the spacing between conductors. If the spacing is made to be very large corona loss may be absent. But when the spacing between the conductor is closed especially under fair weather condition at various spacing between the conductor the corona effect will be increase and this can be calculated by varying the following value 300, 280, 260, 240, 220, 200, 180, 160 based on Peek's table
Using visual critical voltage formula
$Vd_o = g_o \delta m_v r(1 + \frac{0.3}{\sqrt{\delta r}}) \log_e \frac{d}{r}$ kv (rms) where

g_o = Dielectric strength of Air
δ = Air Density factor
d = Spacing of Conductor
r = Conductor Radius $\frac{2.395\ p}{275\ t}$

Table 3.8 Conductor Spacing Versus Power Loss

Conductor Spacing	300	380	260	240	220	200	180	160
Power Loss	67.0	66.3	65.4	64.6	63.5	62.5	61.5	60.6

The above table shows increase in corona when the spacing between conductor is closed especially under fair weather condition the corona effect will increased the can result in power loss.

3.7 Effect of Conductor Radius

The electrical field intensity decrease with the increase in radius of conductor. Hence with conductor of large radius, electric field intensity decrease resulting in lower in power loss. The conductor radius can be varied by using the following value
Radius R= 0.54, 0.56, 0.58, 0.60, 0.62, 0.64, 0.66, 0.68
Using the visual critical voltage equation
$Vd_o = g_o \delta m_v r(1 + \frac{0.3}{\delta r})$ loge $\frac{d}{r}$ kv (rms) where

Where
g_o = Dielectric strength of Air
δ = Air Density factor
m_v = Irregularity factor
r = Conductor Radius of the conductor

Table 3.9 Conductor radius versus power loss

Conductor Radius	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68
Power Loss	67.3	69.1	71.3	72.5	74.2	75.83	77.1	79.1

But when the electric field intensity increase with the decrease in radius of conductor hence with conductor of small radius, electric field intensity increase resulting in higher corona power loss.

The conductor radius can be varied by using the following value 0.54, 0.52, 0.50, 0.48, 0.46, 0.44, 0.42, 0.40. using the visual critical voltage equation
$Vu_o = g_o \delta m_v r(1 + \frac{0.3}{\sqrt{\delta r}}) \log_e \frac{d}{r}$kv (rms) where

The table below shows that he electric field intensity increase with the decrease in radius of conductor, hence small radius increase electric field intensity resulting in larger corona power loss.

Table 3.9.1 Conductor radius versus power loss

Conductor Radius	0.54	0.52	0.50	0.48	0.46	0.44	0.42	0.40
Power loss	67.3	65.6	63.9	62.1	60.3	58.4	56.7	54.8

IV. DISCUSSION OF RESULTS/GRAPHS

4.1 Analysis of Result

Using matlab to analyze, it was observed from the analysis that the effect of line voltage largely affects the corona effect. According to table3.5, it is observed that when the line voltage is increased to a certain value, the electrostatics stresses developed at a conductor surface thereby making the atmospheric air surrounding the conductor to conduct. The corona effect will appear and this is displayed in the graphs of figure4 shown below:

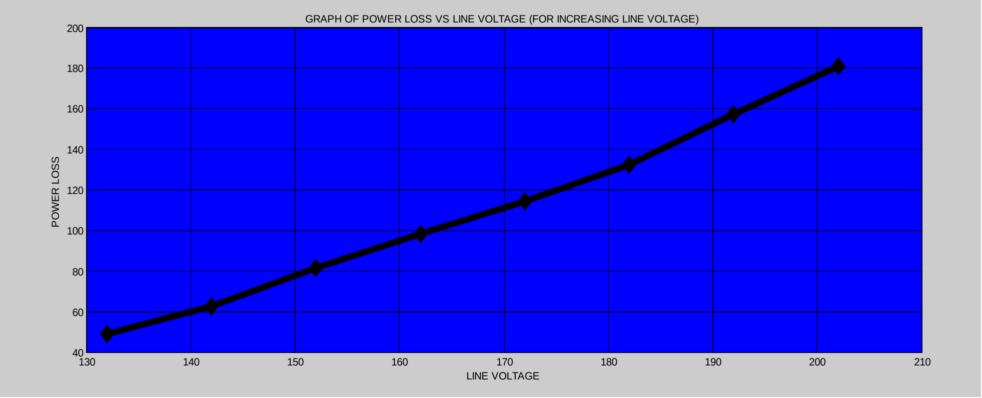

Fig 4. Graph of Power Loss versus Line Voltage (for increasing line voltage)

This effect can also be reduced, it is also observed that the effect of line voltage can be reduced according to tables 3 it was observed that when the line voltage is decrease to such value that electrostatic stress developed at a conductor surface is make the atmospheric air surround the conductor is reduced (i.e) at low voltage there is no corona effect and this can be display in the graphs of figure 4.1 below.

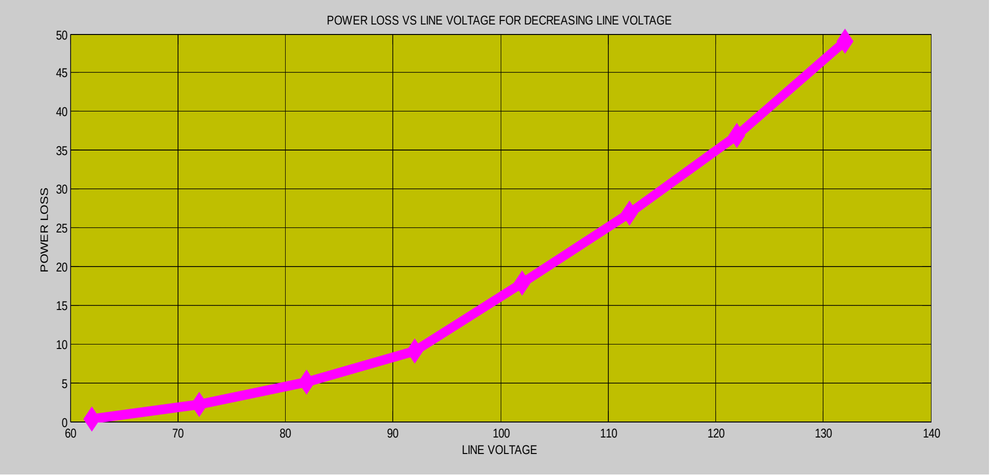

Fig. 4.1 Graph of Power Loss versus Line Voltage (for decreasing line voltage)

4.1.2 Effect of system frequency: It is obvious that corona loss varied directly as the system frequency. It is observed from the analysis in chapter3 that the supply frequency largely affect the corona effect. According to tables 3.1,it is also observed that the higher the supply frequency the higher the power loss and this can be displayed in the graphs of figure 4.2

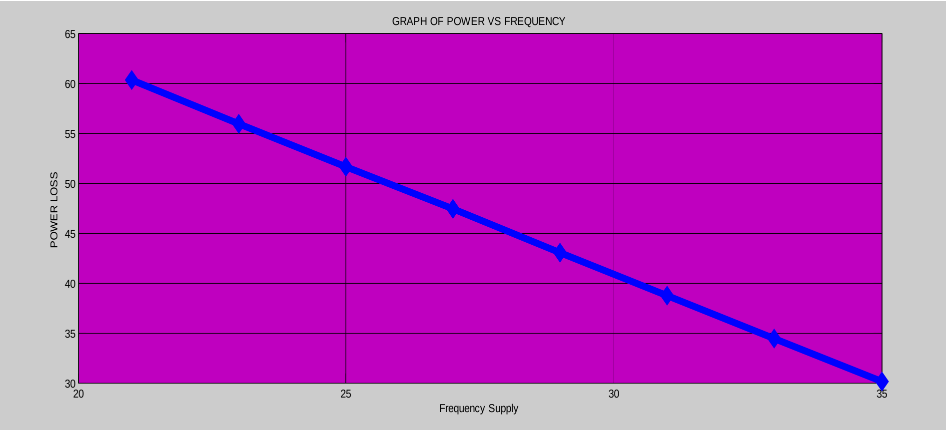

Fig. 4.2 Graph of Power Loss versus System Frequency (for increasing the frequency)

It is also obvious that corona loss varied directly as the system frequency from the analysis it is observed that the lower the supply frequency the lower the corona loss and this can be displayed in the graphs of figure 4.3

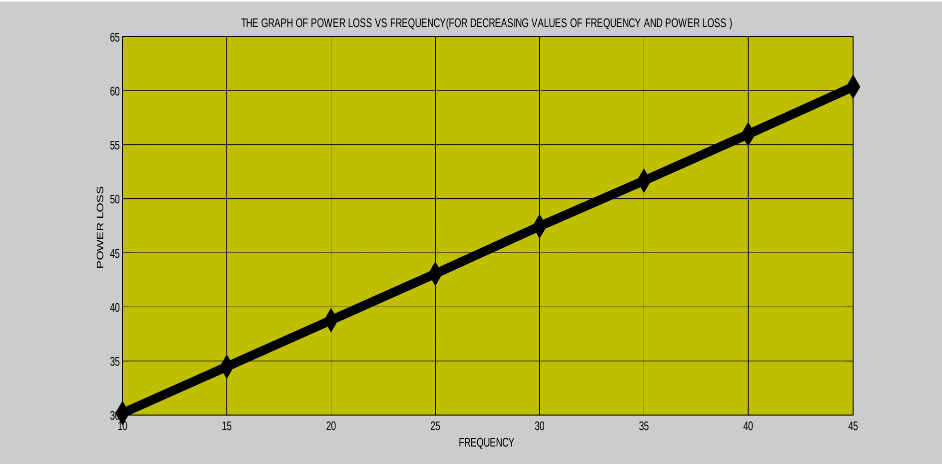

Fig. 4.3 Graph of Power Loss versus System Frequency (for decreasing the Frequency)

4.1.3 Effect of conductor radius: From the analysis according to table 3.9 shows that the electric field intensity decrease with the increase in radius of conductor. Hence large radius decrease electric field intensity resulting in lower corona and power loss. In addition, this can be displayed in the graphs of figure4.4

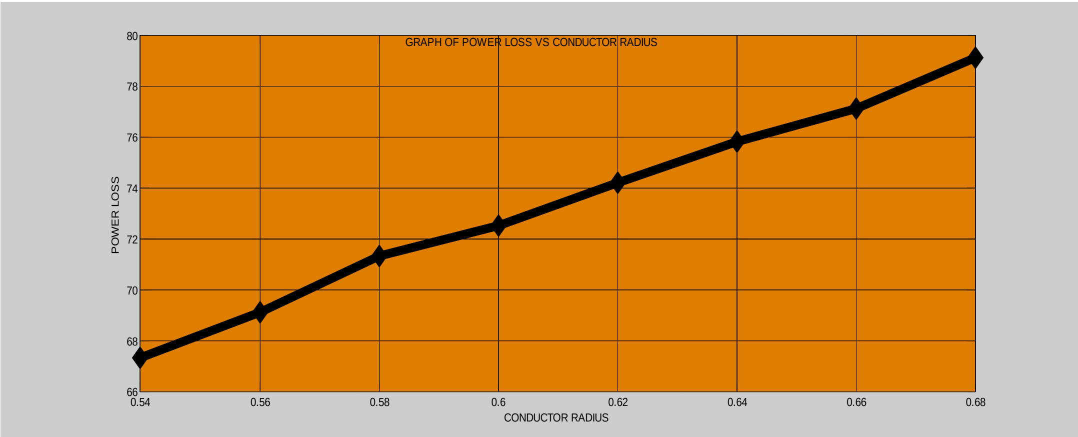

Fig. 4.4 Graph of Power Loss versus Conductor Radius (for increasing the conductor radius)

4.1.4 Effect of conductor radius: From the analysis according to table 3.9 shows that the electric field intensity increases with the decrease in radius of conductor. Hence small radius increase electric field intensity resulting in large corona power loss. Moreover, this can be displayed in the graphs of figure4.5

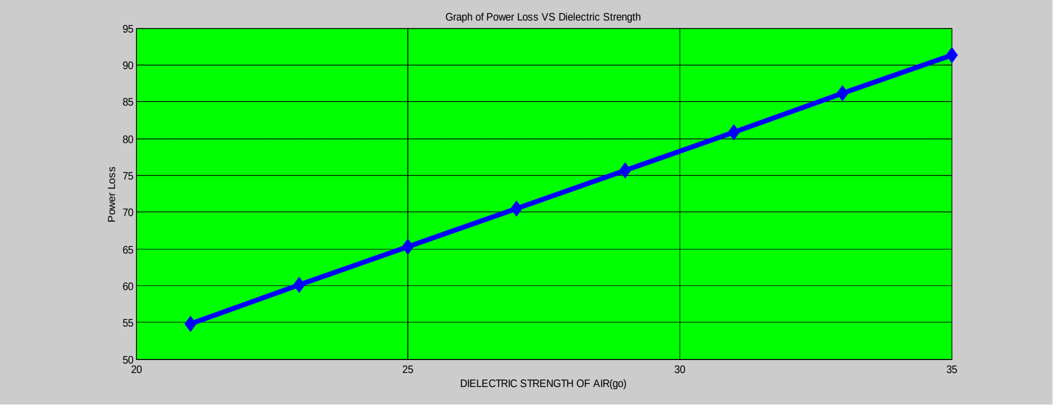

Fig. 4.5 Graph of Power Loss versus Conductor Radius (for decreasing the conductor radius)

4.1.5 Effect of dielectric strength of air: From the analysis according to tables 3.1 it is observed that corona loss increase with the decrease in the density of air it is also observed that during bad weather conduction the phenomenon seem to increase which result to power loss and this can be displayed in the graphs of figure4.6

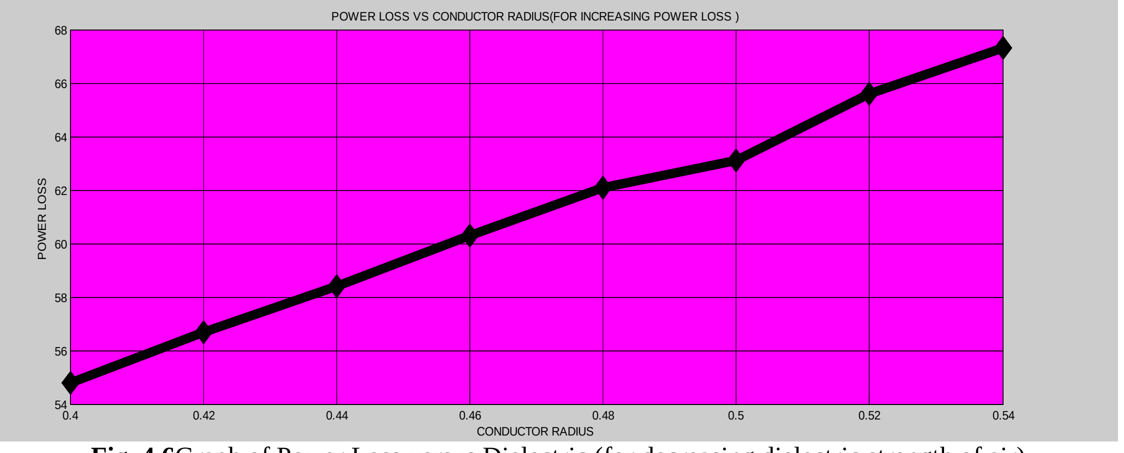

Fig. 4.6 Graph of Power Loss versus Dielectric (for decreasing dielectric strength of air)

It is also observed from the analysis according to tables 3.2 that under fair weather condition the value of the dielectric strength of air is reduced, this phenomenon decrease with the increase in the density of air and under a fair weather condition the value of the dielectric strength of air is reduced in a plan area. And this can be displayed in the graph in figure4.7

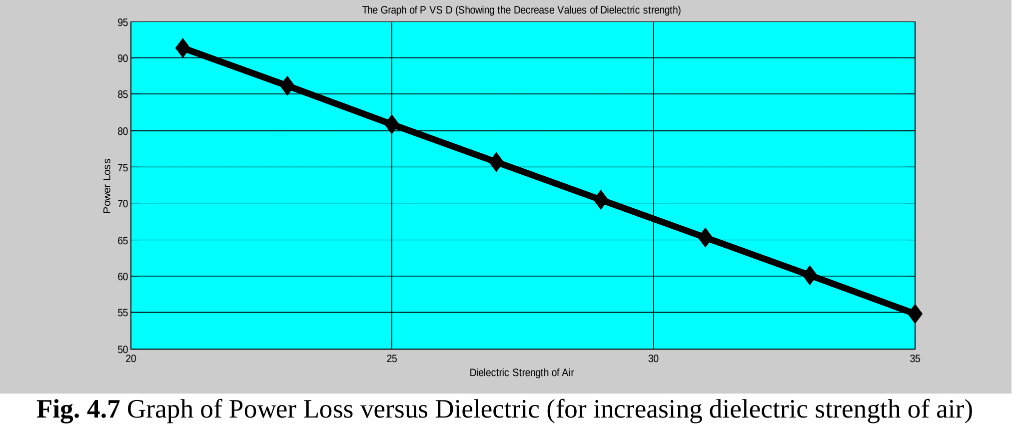

Fig. 4.7 Graph of Power Loss versus Dielectric (for increasing dielectric strength of air)

4.1.6 Effect of conductor spacing: From the analysis according to tables 3.7 it is observed that under the fair weather condition at various spacing between the conductor corona is inversely proportional to the spacing between conductor if the spacing is made to be very large corona loss may be absent and this can be display in the graphs of figure4.8

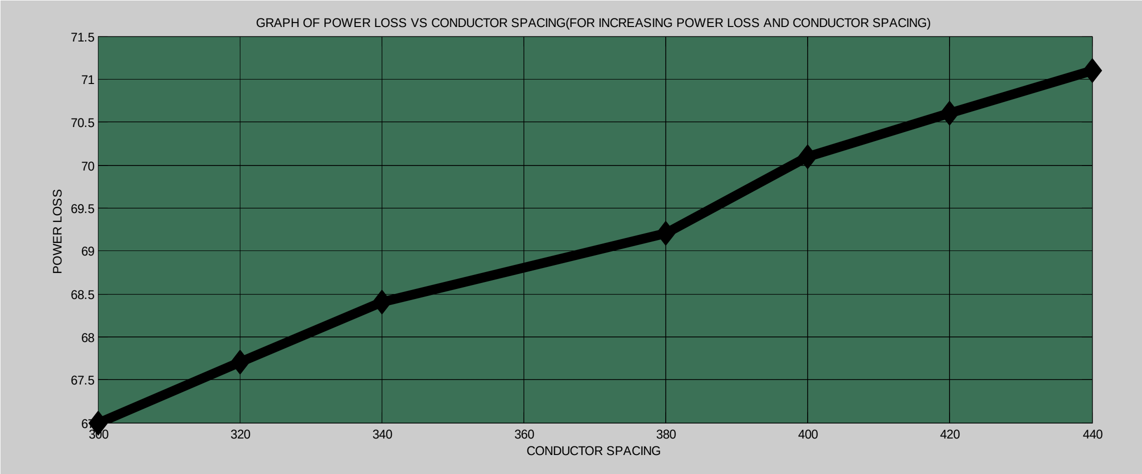

Fig. 4.8 Graph of Power Loss versus Conductor Spacing (for increasing conductor spacing)

It is also observed from the analysis according to tables 3.8 it is observed that when the spacing between conductor is closed especially under fair weather condition the corona effect will increased this can result in power loss and this can be displayed in the graphs of figures4.9

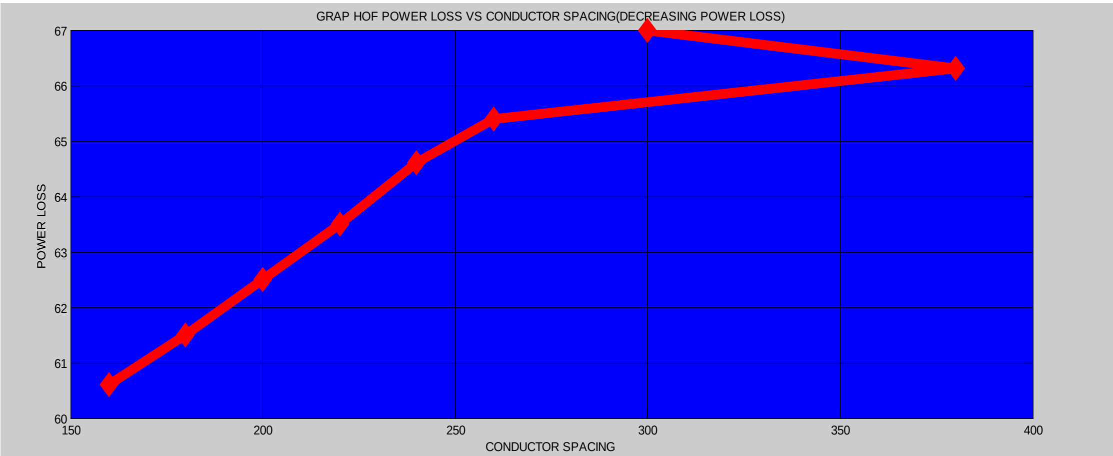

Fig. 4.9 Graph of Power Loss versus Conductor Spacing (for decreasing conductor spacing)

V. CONCLUSION

Like any other fault in transmission line, corona has some disadvantages but these disadvantages is due to weather condition, this partial discharge do likely occursunder the stormy weather condition and under fair weather condition because of this adverse effect research has been carryout in other to put a preventive measured to minimized these effect in the transmission line. This partial discharge also as some advantage and application in engineering. Using Matlab program for the sample analysis, it is found that in wet conditions, the value of corona loss is more than that of the dry season. Underground cables with good insulation design can prevent power loss since this will not be much affected by changing in weather conditions.The atmospheric condition like pressure and temperature, Corona loss is a function of air density coronation factor and the higher the value the less the corona loss, at low pressure and high temperature the value of disruptive critical voltage is small and corona effect and loss is dominant. Corona should also be encourage, in engineering as it has the advantage and application Government and higher institution of learning and research should takes corona as the vital aspect of study in electrical engineering. It is also observed that this phenomenon is very much evident in transmission lines of 100kv -220kv. Is inadequate to handle the problem so extra. High voltage line of about 1200kv should be use. It also recommend that maximum of 8 sub conductors should be used for 1150-1200kv line.

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