21/08/19

14. CORONA

*Corona:- It is the phenomenon at which the air around the conductor is ionised.

→ let us consider a single phase 2-wire system. When "A" low alternating voltage is applying across 2-conductors. Then there is no change in state of the area around the conductor.

→ If the applied voltage is gradually increased reaching to it's maximum value of 30 kv/cm (or) 21.1 kv/cm (RMS value), the air around the conductor starts conducting with hissing sound, dark violet glow appears around the conductor this effect is known as Corona

→ The glow is uniform through out the length of conductor. If the conductors are smooth and polished, If not the glow appears only at rough points

→ During the Corona, the following effects will be obtained.

1. voilet glow is absorbs the conductor.
2. The hissing sound is produced.
3. Corona is accompanied with a power loss.
4. When corona presence the effect of corona will increases.

27/08/19

* Electric Stress:-

→ let us Consider a Single phase System Consisting of 2- Conductors A & B with radius "r" m. Spacing at "D" m.

→ The charges of Conductor A & Conductor "B" is Q_A, Q_B.

→ let a point "p" is Considered b/w two Conductors at a distance of "x" m from the Conductor "A" then the Electric field intensity is given by:

$$E_x = \frac{1}{2\pi\varepsilon}\left[\frac{Q_A}{x} + \frac{q_B}{D-x}\right]$$

$$= \frac{1}{2\pi\varepsilon}\left[\frac{Q}{x} - \frac{q}{D-x}\right] \quad \left[\because \begin{array}{l} Q_A = Q \\ Q_B = -Q_A - q \end{array}\right]$$

The potential difference b/w the two Conductors.

$$V = \int_{r}^{D-r} E_x \, dx.$$

$$= \frac{q}{2\pi\varepsilon}\int_{r}^{D-r}\left(1/x - \frac{1}{D-x}\right)dx.$$

$$= \frac{q}{2\pi\varepsilon}\left[\left[\ln x\right]_{r}^{D-r} - \left[\ln(D-x)\right]_{r}^{D-r}\right]$$

$$= \frac{q}{2\pi\varepsilon}\left[\ln(D-r) - \ln r - \ln(D-D+r) + \ln(D-r)\right]$$

$$= \frac{q}{2\pi\varepsilon}\left[\ln(D-r) - \ln r - \ln r + \ln D-r\right]$$

$$= \frac{q}{2\pi\varepsilon}\left[2\ln(D-r) - 2\ln r\right].$$

$= q/_{2\pi\varepsilon}\, 2 \ln\left(\frac{D-r}{r}\right)$

$= q/_{\pi\varepsilon} \ln\left(\frac{D-r}{r}\right)$

$\therefore$ potential difference ~~Electric strain~~; $V = Q/_{\pi\varepsilon} \ln(D/r)$ $[\because D >> r]$

$\therefore$ Charge $(q) = \frac{V\pi\varepsilon}{\ln(D/r)}$

Electric field intensity is denoted by "g" and it is max on the surface of the conductor.

$$g_{max} = q/_{2\pi\varepsilon}\left[\frac{1}{r} + \frac{1}{D-r}\right]$$

$$g_{max} = q/_{2\pi\varepsilon}\left[\frac{D-\cancel{r}+\cancel{r}}{r(D-r)}\right] \quad [D>>r]$$

$$g_{max} = q/_{2\pi\varepsilon}\left[\frac{D}{r(D-r)}\right] = \frac{q}{2\pi\varepsilon}\left[\frac{\cancel{D}}{r\cdot \cancel{D}}\right]$$

$$\boxed{g_{max} = \frac{q}{2\pi\varepsilon r}}$$

But $Q = \frac{V\pi\varepsilon}{\ln D/r}$

$$g_{max} = \frac{V\cancel{\pi\varepsilon}}{\ln(D/r)\cdot 2\cancel{\pi\varepsilon} r}$$

$$= \frac{V}{2r\ln(D/r)}$$

The potential difference on the surface of a conductor is. $V_0 = V/2$; $\therefore g_{max} = \frac{V_0}{r\ln(D/r)}$

$$\boxed{V_0 = g_{max}\, r\ln(D/r)}$$

* Critical ~~Disereption~~ Disruptive Voltage :-

→ It is the minimum voltage at which the ionization of air takes place is known as "Critical diserptive Voltage."

→ This voltage is Equals to breakdown strength of the air.

∴ Critical disreptive voltage is given by

$$\boxed{V_0 = g_{max} \ln (D/r)}$$

$$\Rightarrow \boxed{V_{D0} = g_0 \, r \ln (D/r)}$$

Where,

V_{D0} = The Critical disruptive voltage.

g_0 = The potential gradient

→ The above Eqn is true for polished smooth Conductor at atmospheric pressure of 76 cms of mercury, 25°c of temperature.

→ The Critical disruptive voltage for Rough and dirty Conductors is given by $\boxed{V_{D0} = g_0 m_0 \delta r \ln (D/r)}$

Where,

M_0 = Irregularity factor = 0.8 for bad Weather Condition

= 1 for fair Weather Condition

→ The Critical disruptive voltage for Rough and dirty Conductors is given by. $V_{DO} = 9 \cdot 0 m_0 \delta r \ln(D/r)$

Where,

M_0 = irregularity factor = 0.8 for bad Weather Condition
= 1 for fair Weather Condition

δ = air density factor = $\frac{3.92b}{273+t}$

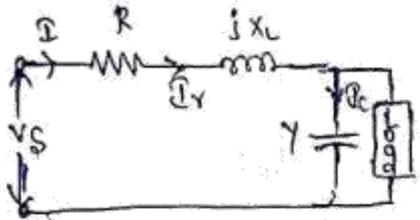
Where,

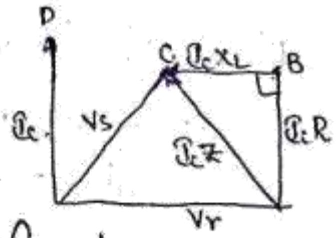
b = Atmospheric pressure
T = Temperature. = 1 fair Weather Condition

Ferranti Effect:-

→ It is the Phenomenon in which the receiving End voltage is greater than Sending End voltage. under no load (or) light load Condition.

→ To determine the Raising voltage, let us Assume the total line Capacitance presented at the End of light.





At No load. Current passing through Capacitor.

$I_c = Y \cdot V_r = jYV_r$.

from the Circuit diagram,

$V_S = V_r + \text{drop}$

$V_S = V_r + I_r(R + jX_L)$.

At No load,

$I_c = I_r$.

$V_S = V_r + I_c(R + jX_L)$.

$V_S = V_r + jYV_r(R + jX_L)$

$V_S = V_r + jRYV_r - YV_rX_L$

Here, R = low

$V_S = V_r - YV_rX_L \Rightarrow \boxed{V_r = V_S + YV_rX_L}$

SAG :-

The difference in levels b/w the points of support and the lowest point of the conductor is known as sag.

→ The following factors will effect the sag in over head system.

(i) Weight of conductor.
(ii) length of span
(iii) Working tensile stress (or) strength
(iv) Temperature

Calculation of Sag at equal tower heights:-

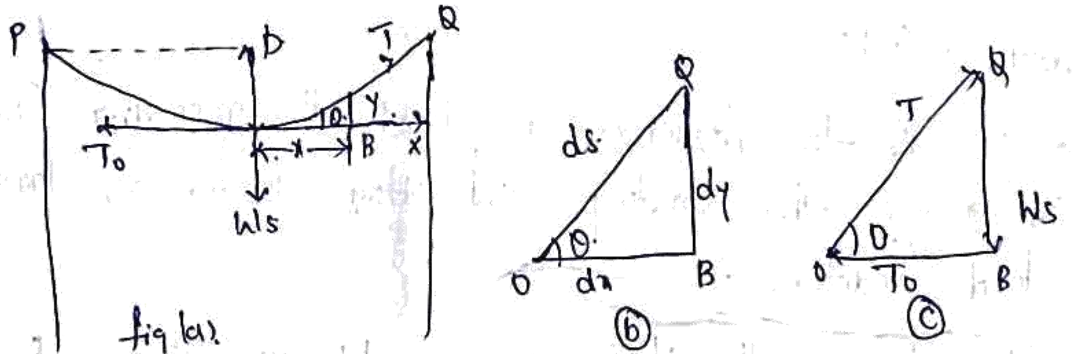


fig (a)

Where,

L = length of conductor.
W = Weight of conductor.
D = maximum sag in meters
T = Tension at point "A" of conductor.
T_0 = Tension at point 'O' of conductor.
S = length of conductor of small section OA

from fig ⓑ & ⓒ

$$\tan\theta = \frac{dy}{dx} \quad ; \quad \tan\theta = \frac{Ws}{T_0}.$$

$$\frac{dy}{ds} = \frac{Ws}{T_0} \quad ; \quad Ws/H.$$

$$ds^2 = dx^2 + dy^2 \Rightarrow ds = \sqrt{dx^2 + dy^2}$$

$$ds = dx\sqrt{1 + (dy/dx)^2} \Rightarrow dx = \frac{ds}{\sqrt{1 + \left(\frac{Ws}{H}\right)^2}}.$$

Integrating the above eq

$x = H/W \cdot \sinh\left(\frac{Ws}{H}\right)$.

$S = H/W \sinh\left(\frac{Wx}{H}\right)$.

Now, $\frac{dy}{dx} = \frac{Ws}{H}$

$dy = \frac{W}{H} \cdot H/W \cdot \sinh\left(\frac{Wx}{H}\right) dx$

$dy = \sinh\left(\frac{Wx}{H}\right) dx$.

Integrating the above Equation,

$y = H/W \cosh\left(\frac{Wx}{H}\right) + B \rightarrow (1)$

At $x=0$ then $y=0$

$0 = H/W + 0 \rightarrow \boxed{B = -H/W} \rightarrow (2)$

Substitute Eqn (2) in (1)

$y = H/W \cosh\left(\frac{Wx}{H}\right) - H/W$.

$y = H/W \left(\cosh \frac{Wx}{H} - 1\right)$

$y = H/W\left(\cancel{1} + \left(\frac{W^2x^2}{2H^2} + \frac{W^4x^4}{24H^4} + \cdots - \cancel{1}\right)\right]$

Neglect Higher order terms

$y = \cancel{H/W}\left[\frac{W^{\cancel{2}}x^2}{2H^{\cancel{2}}}\right]$

$= \frac{Wx^2}{2H}$. $H = T$

$\boxed{y = \frac{Wx^2}{2T}}$

~~At~~ The Sag at Bottom of Conductor

$y = \frac{W(l/2)^2}{2T} = \frac{Wl^2}{8T}$.

$\therefore$ The Sag at Equal tower heights

$\boxed{y = \frac{Wl^2}{8T}}$

→ problems formulas

length of Conductor $(W) = \sqrt{(W_w)^2 + (W_c)^2}$

* Weight of Wind = air pressure x projected area.

→ projected Area = Area. Weight of the conductor.

$\pi d^2/4$.

* Weight of Conductor = Specific gravity x volume of Conductor

* Tension (T) = max tensile stress x Area

* Sag $= \frac{Wl^2}{8T}$.

Resultant Weight $= \sqrt{(W_c + W_i)^2 + (W_w)^2}$

Tension (T) $= \frac{\text{Breaking Stress} \times \text{Area}}{\text{Safety factor}}$

Area $= \pi d^2/4$.

Weight of Conductor = Specific gravity x volume.

* Weight of ice $(W_i) = 913.5 \times \pi t(d+t)$.

* Weight of wind $(W_w) = P \times (d+2t)$.

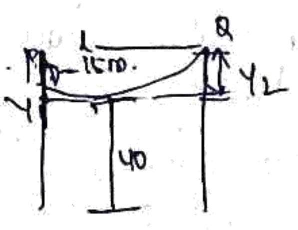
* $\cos\phi = \frac{W_c + W_i}{W}$

$\sin\theta = \frac{W_w}{W}$.

* Deflecting torque $= \frac{Wl^2}{8T}$.

* Vertical Sag $= y \times \cos\theta$.

* horizontal Sag $= y \times \sin\theta$.

→ 

Resultant Weight $(W) = \sqrt{(W_c)^2 + (W_w)^2}$

* Weight of Wind = Air pressure x projected Area.

* Sag w.r.t to lowest tower weight

$$y_1 = \frac{W x_1^2}{2T}$$

difference in height $(h) = y_2 - y_1$.

$$x_1 = \frac{L}{2} - \frac{Th}{WL} \; ; \; x_2 = \frac{L}{2} + \frac{Th}{WL}.$$

Now, Tension(T) = $\frac{\text{ultimate strength x Area}}{\text{Safety factor}}$

$$= \frac{8000 \times 2}{4} = 4000 \text{ kg}.$$

$x_1 = ?$, $x_2 = ?$, $y_1 = ?$, $y_2 = ?$

⇒ lowest tower height = y_1 + ground clearance.

→ highest tower height = y_2 + ground clearance.

Apply KCL at node 'P'

$$I_2 = i_1 + I_1$$

$$V_2 \omega C = V_1 \omega mC + V_1 \omega C.$$

$$V_2 = V_1 (1+m)$$

Apply KCL at node 'Q'

$$I_3 = i_2 + I_2$$

$$I_3 = V_2 M \omega C + V_2 \omega C.$$

$$V_3 = V_1 [m^2 + 3m + 1].$$

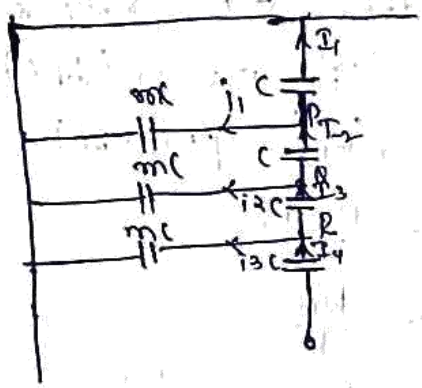
⇒ Apply KCL at node "R"

$$I_4 = i_3 + I_3$$

$$V_4 \omega C = V_3 M \omega C + V_3 \omega C.$$

$$V_4 = V_1 [m^3 + 5m^2 + 6m + 1].$$

String Efficiency :-



⟹ String Efficiency is used to calculate the potential difference along the String with 'n' no-of units

let "C" → The mutual Capacitance b/w links

mC = Shunt Capacitance b/w the links and Earth

m = Capacitance to ground.

V_1 - Voltage across the 1st unit.

14/09/19

* Factors Effecting on Corona :-

⟹ The following factors Will Effect the Corona loss in the over head System.

(i) Electrical factors
(ii) Atmospheric factors.
(iii) factors Subjected to the Conductor.

(i) Electrical factors :-

(a) Supply frequency :-

from the Peak's formula, We know that Corona loss

$$P_c = 244\left[\left(\frac{f+25}{8}\right)\sqrt{r/D}\,(V_{ph} - V_{do})^2 \times 10^{-5}\right] \text{ KW/Km/ph.}$$

$$P_c \propto (f+25)$$

$$P_c\uparrow \propto f\uparrow$$

from the above Eqn it is observed that When Supply frequency is increasing the Corona loss also Will increase.

(b) line Voltage :-

$$\uparrow P_c \propto (V_{ph} - V_{do})^2 \uparrow$$

from the above Eqn, It is observed that a the operating voltage increasing the Corona loss also increase.

(c) load (or) line Current :-

→ As the load Current increasing temperature of the Conductor is also increases it Prevent deep falling of Snow and dust on the Surface of the Conductor, This increases disruptive voltage and decreases Corona loss.

$$\downarrow P_c \propto (V_{ph} - V_{do}\uparrow)^2 \downarrow$$

(ii) Atmospheric factor :-

(i) Air Density factor :-

We know that Critical disruptive voltage is given by,

$$V_{do} = g_0 m_0 \delta r \ln(D/r)$$

$$\uparrow V_{do} \propto \delta \uparrow$$

$$\downarrow P_c \propto (V_{ph} - V_{do}\uparrow)^2 \downarrow$$

⟹ It is observed that as the air density factor will increase the Critical disruptive voltage also increases

Due to this Corona loss will Reduce (or) Decrease

(b) Rain, Dust & Snow :-

⟹ The Critical disruptive voltage decreases due to dust particles deposited on the Conductor during the bad weather Condition which Causes in increasing the Corona loss.

$$\uparrow P_c \propto (V_{ph} - V_{do}\downarrow)^2 \uparrow$$

(iii) Factors Relating to the Conductor :-

(i) Conductor diameter

⟹ We know that,

$$P_c \propto \sqrt{r/D}$$

from the Critical disruptive voltage,

$$V_{do} = g_0 m_0 \delta r \ln(D/r)$$

$$\uparrow V_{do} \propto r \uparrow$$

$$\downarrow P_c \propto (V_{ph} - V_{do}\uparrow)^2 \downarrow$$

from the above Relations, It is observed that as the radius of Conductor ↑ the Critical descruptive voltage also increases. which Causes to reduce the Corona loss.

∴ If the diameter of Conductor is high, the Corona loss is lower.

(iii) Spacing b/w the Conductors :-

⇒ from the Peaks formula, we know that

$$P_c \propto \sqrt{r/D}$$

$$\uparrow V_{do} \propto \ln(D/r)$$

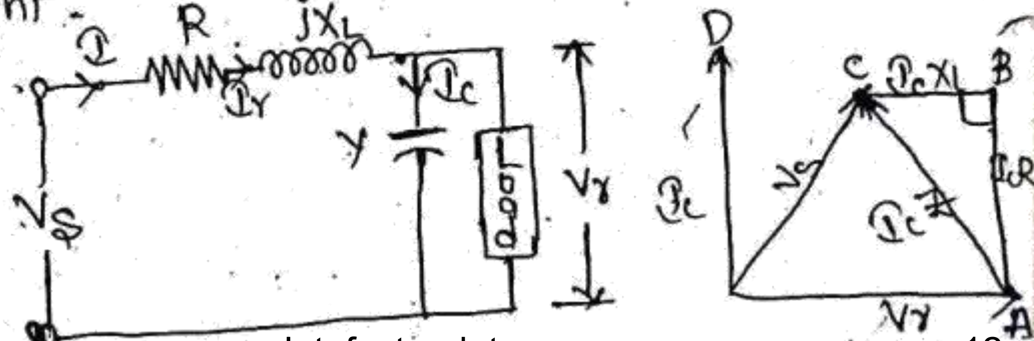
$$\downarrow P_c \propto (V_{ph} - V_{do}\uparrow)^2 \downarrow$$

→ from the above Relation, It is observed that as Spacing b/w the Conductors is increasing the Corona loss will reduce.

Ferranti Effect :-

→ It is the phenomenon in which the receiving End voltage is greater than Sending End voltage under no load (or) light load Condition.

⇒ To determine the Raising voltage, let us Assume the total line Capacitance presented at the End of light.



$\Rightarrow$ At No load, Current Passing through Capacitor.

$$I_C = Y \cdot V_r = jYV_r$$

from the Circuit diagram,

$$V_S = V_r + \text{droop}$$

$$V_S = V_r + I_r (R + jX_L)$$

At No load,

$$I_C = I_r.$$

$$V_S = V_r + I_C (R + jX_L)$$

$$V_S = V_r + jYV_r (R + jX_L)$$

$$V_S = V_r + jRYV_r - YV_rX_L$$

Here, R = low.

$$V_S = V_r - YV_rX_L$$

$$\boxed{V_r = V_S + YV_rX_L}$$