CORONA LOSS REDUCTION IN 132KV TRANSMISSION LINE

A Thesis submitted in partial fulfillment of the requirements for the Award of Degree of
Bachelor of Science in Electrical and Electronic Engineering

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Certification

This is to certify that this thesis entitled "**Corona loss reduction in 132KV Transmission line**" is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on November 2018.

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Dedicated to

Our Parents

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List of Abbreviations

PGCB	Power Grid Company of Bangladesh
BPDB	Bangladesh Power Development Board
IPP	The Independent Power Producers
RPP	Rental Power Plants
REB	Rural Electrification Boards
DPDC	Dhaka Power Distribution Company
DESCO	Dhaka Electric Supply Company
WZPDCO	West Zone Power Distribution Company
AC	Alternating Current
DC	Direct Current
NTL	Non-Technical Loss
HVDC	High Voltage Direct Current
HVAC	High Voltage Alternating Current
RCC	Reinforced Cement Conceit
ACSR	Aluminum Conductor Steel Reinforced
AAC	All Aluminum Conductor
AAAC	All Aluminum Alloy Conductor
ACAR	Aluminum Conductor Alloy Reinforced
ASC	Aluminum Stranded Conductor
ISCS	International Annealed Copper Stranded

List of Symbols

δ	Air density factor
K	Fixed Constant
D_{ga}	Disruptive gradient in air
M_d	Irregularity factor for disruptive critical voltage
M_v	Irregularity factor for visual corona inception voltage
T	Temperature of the surrounding
P	Atmospheric pressure
V_c	Critical Disruptive Voltage
g_0	Breakdown strength of air
d	Spacing between conductors
r	Conductors radius
m_0	Irregularity factor
T	Temperature
B	Barometric mercury pressure
V_v	Visual Critical Voltage

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ABSTRACT

Developing populaces and industrialization make tremendous requirement for electrical vitality. Tragically, power isn't constantly utilized in vast interest in a similar area it is been created. Along these lines, long links or wires are utilized to transmit the produced power either through Underground or Overhead framework technique, which is re offered to as Transmission of Electrical Energy. This transmission those not happen without experiencing misfortunes, which is the spirit point of this report.

The impact of Corona on high voltage transmission line is one of the reasons for power misfortune in influence framework and this is uneconomical and unfortunate. The investigation of Corona and elements in charge of the misfortune is explored through example estimation dependent on Peek's recipe. The enthusiasm for crown misfortune and it preferred standpoint will discover this exploration helpful. This paper will also include the Transmission and Distribution System of Electrical Energy, Transmission line losses, Corona loss, Theory of Corona formation, Corona Effect of Transmission Line, Factors Affecting Corona, Advantages of corona, Disadvantages of corona, Reduce Corona Loss, all these will be considered here. This paper presents probability to diminish the crown control misfortunes in overhead transmission lines. Crown control misfortunes can be lessened by expanding the breadth of the conductor; the goals were to decide the crown influence misfortunes rely upon conductors' distances across.

CHAPTER 1
INTRODUCTION

1.1 Introduction

Electrical vitality is the most essential type of vitality in the present world. It is a vitality that drives the economy of any general public or nation and makes the regular subject glad. Power is been created from the power station, should be transmitted to the end clients, through transmission and appropriation lines. This transmitted vitality isn't without misfortunes, yet the ability to transmit at negligible misfortunes is the thing that this report involves to x-plate.

Transmission of power and energy must be done at minimum technical and non-technical loses which are referred as Total Losses during transmission the electric power losses through transmission lines are various and depend on many parameters. The power grid is getting longer and more sophisticated in all aspects including technical and economical angles of view. Privatization of the generation of power supply sectors increased significantly the economical optimization of the power supply generation and transmission, which increases the importance of studying and solving the issues of power losses. Corona phenomena or corona discharge is one kind of losses that occur in high voltage transmission lines. Many studies where done to explain the way that corona discharges behave and to parameterize and calculate it. It is not an easy task to overlap the mathematical models with the practical real readings due to several real life changes of those parameters and also to the nature of gas ionization process which is very relative to the corona phenomena. First part of this thesis shades some light on the transmission and distribution system**,** the second part discusses the Transmission line losses. Thirdly part discusses the various definitions of corona or corona discharges and Advantages and disadvantages of this phenomenon. The fourth part includes theoretical explanation about the effect of conductor size in corona loss, the fifth part focus on the effect of conductor spacing, this sixth part describes the fact of skin effect for corona loss. Finally a summary of obtained results is presented together with applicable recommendations.

1.2 Power Sector problem in Bangladesh

Key Problems are:

1. Voltage variety and Load shedding.
2. Operating Inefficiency.
3. System loss.
4. Unadjusted tariff structures and ineffective billing procedures.
5. Limitation and Ineffectiveness of the Electricity Acts and Magistracy.

1.3 OBJECTIVES

1. To study the power system status in Bangladesh.
2. To investigate the nature of technical and non-technical losses in power system.
3. Calculation of corona losses in transmission line.
4. To establish a technique to reduce the losses.

1.4 Scopes

Scope of the thesis proposal is

- Develop the corona loss in transmission line.
- By using the ACSR conductor skin effect is negligible.
- Overall system efficiency is improved.

1.5 Methodology

The transmission and dissemination misfortunes information of BPDB, PGCB, DPDC (DESA), DESCO and REB are gathered. Their framework exhibitions are resolved as far as rate. At that point different minimization strategies are concentrated to lessen the transmission, dispersion and non-specialized misfortunes in electrical influence framework in Bangladesh.

1.6 Thesis Outline

This Project/thesis is organized as follows:

Chapter 1	Describes the problem of power loss and way to solution of the problem.
Chapter 2	Describe the Transmission and Distribution system of Bangladesh and occurring problem.
Chapter 3	Describes the Classification transmission losses and the affecting factor of those losses.
Chapter 4	Describes the explanation about corona loss, Depending factor of the loss and how to minimize the loss.
Chapter 5	Describes the Graphical representation of the conductor size and corona loss.
Chapter 6	Describes the Effect of transmission line Tower for corona loss.
Chapter 7	Describes the Skin effect and corona loss relation.
Chapter 8	Describes the overall calculation and result.
Chapter 9	Conclusions

CHAPTER 2

TRANSMISSION AND DISTRIBUTION SYSTEM OF ELECTRICAL ENERGY

2.1 Introduction

Power System is an integrated network that interconnects the installations for generation, transmission and distribution of electricity. In Bangladesh power is produced at 50 Hertz recurrence and at an ostensible voltage of 11 KV (Kilo Volts) or 15 KV to be ventured up through transformers to 132 kV or 230 kV for bolstering to the framework i.e. a high voltage transmission organize that transmits the ability to network substation transformers to be ventured down at 33 kV. The 11 kV and 0.4 kV for delivery to the consumers of various categories. In Bangladesh presently the state owned Bangladesh Power Development Board (BPDB) generates about 75% of the power supplied. The Independent Power Producers (IPPs) and Rental Power Plants (RPPs) which are mainly the joint ventures of local and multinational companies generate the remaining 25% and sell it to BPDB through the grid. BPDB in its turn sells power to the distribution entities. However, a few small IPPs supply power directly to Rural Electrification Boards (REB) 33 kV distribution network. The grid system is owned and operated by a public company named Power Grid Company of Bangladesh (PGCB) Limited. The responsibility of distributing electricity across the country is shared by various public companies like BPDB, REB, DHAKA POWER DISTRIBUTION COMPANY (DPDC), Dhaka Electricity Supply Company (DESCO), West Zone Power Distribution Company (WZPDCO) each having respective franchise area.

Electrical power could be transmitted and distributed as AC or DC. In AC transmission system could be three phase three wire and Distribution system could be three phase four wire. The parts of a modern AC power system are below:

1. Generating Station
2. Step-up sub-station
3. Transmission line
4. Switching station
5. Step down sub station
6. Primary distribution line
7. Service transformer bank or distribution transformer
8. Secondary Distribution line

2.2 Classification of Transmission and Distribution System

Primarily transmission system is two types

a) High voltage DC system
b) High Voltage AC system

Distribution system is also two types

a) Low voltage DC system
b) Low voltage AC system

The popular electrical power transmission system is AC three phase three wires and in distribution system AC three phase four wires. There are more types of transmission and distribution system such as:

1. DC system:
   i) DC two wire
   ii) DC two wire main point earthed
   iii) DC three wires system
2. AC System:
   i) Single phase AC System:
      a. Single phase two wire

b. Single phase one wire with other wire point earthed

c. Single Phase three wire

ii) Three phase AC System:

a. Three phase three wire system

b. Three phase our wire system

The Transmission line and Distribution line both are used to carry power or electricity from one place to the other. The difference between transmission and distribution line are explained on the basis of the factors like the basic usage of the transmission and distribution line, their working supply phase, voltage level and level of conduction.

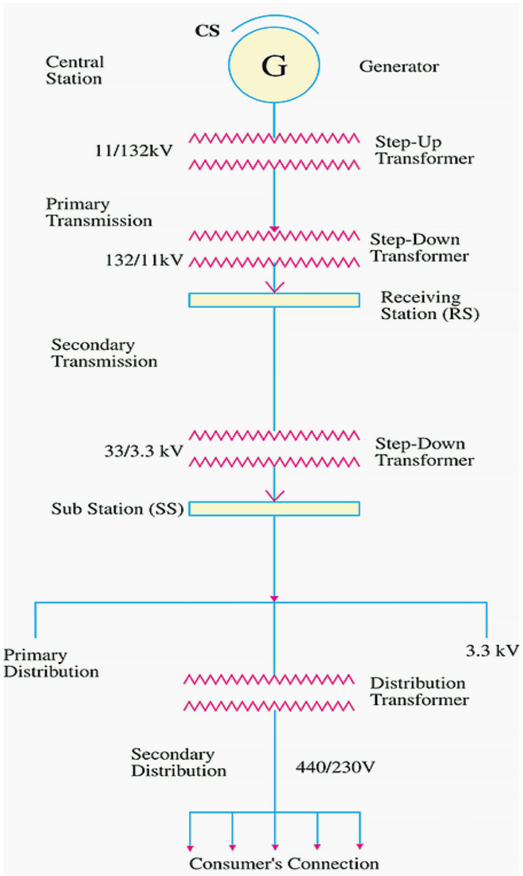

Fig -2.1: Generation to distribution system single line diagram

2.3 Advantages and Disadvantages of DC Transmission

Advantages:

- There are two conductors utilized in DC transmission while three conductors required in AC transmission.
- There are no Inductance and Surges in DC transmission.
- Due to nonattendance of inductance, there are very low voltage drop in DC transmission lines comparing with AC
- There is no concept of Skin effect in DC transmission. Therefore, small cross sectional area conductor required.
- A AC System has a large potential stress over DC system for same Voltage level. Therefore, a AC line requires more insulation.
- In DC System, There is no interference with communication system.
- In DC Line, Corona losses are very low.
- In High Voltage DC Transmission lines, there are no Dielectric losses.
- In DC Transmission system, there are no difficulties in synchronizing and stability problems.
- DC system is more efficient than AC, therefore, the rate of price of Towers, Poles, Insulators, and conductor are low so the system is economical.
- In DC System, the speed control range is greater than AC System.
- There is low insulation required in DC system (about 70%).
- The price of DC cables is low (Due to Low insulation)
- In DC Supply System, the Sheath losses in underground cables are low.
- DC system is suitable for High Power Transmission based on High Current transmission.
- In DC System, The Value of charging current is quite low, therefore, the length DC Transmission lines is greater than AC lines.

Disadvantages:

- Electric power can't be produce at High (DC) Voltage for commutation problem
- For High Voltage transmission, we cannot step the level of DC Voltage.

- There is a limit of DC Switches and Circuit breakers
- Motor generator set is used for step down the level of DC voltage and the efficiency of Motor-generator set is low than transformer.
- So the system makes complex and costly.
- The level of DC Voltage cannot be change easily.

2.4 Advantages and Disadvantages of AC Transmission

Advantages:

- DC Circuit breakers is costly than AC Circuit breakers.
- The fixing and upkeep of AC substation is simple and modest than DC Substation.
- The voltage Level of AC may be change step up and Step down by transformers

Disadvantages:

- The conductor size of AC line is larger than DC Line.
- The Cost of DC Transmission lines are lesser than AC Transmission lines.
- The losses in AC system are more or Skin effect
- In AC Lines, there is Capacitance, so continuously power loss when no load on lines or Line is open.
- Other line losses are due to inductance.
- More insulation required in AC System
- Also corona Losses occur In AC System,
- There is telecommunication interference in AC System.
- There are stability and synchronizing problems in AC System.
- AC System is not efficient than DC System.
- There are also re-active power controlling problems in AC System.

2.5 Transmission Line

A transmission line is a system of conductors that transfers electrical signals from one place to another.

Transmission line is two types base on operating voltage

1) **Primary Transmission**

The electric power at 230KV or 132KV is transmitted by 3 phase 3 wires overhead line, this is called primary transmission.

2) Secondary transmission line

After the primary transmission line the voltage is reduced from 132KV to 33KV by a step down transformer and transmitted again, this is called secondary transmission.

Fig-2.2: Transmission line

2.6 Distribution Line

A distribution line is a line or system for distributing power from a transmission system to a consumer.

Distribution line is two types base on operating voltage

1. **Primary distribution**

   After the secondary transmission line the voltage is reduced to 11KV. The 11KV line runs across the important roadside of the city. This is called primary distribution.

2. **Secondary distribution**

   After the primary distribution line the voltage is reduced to 400V. The 400V is use for domestic purpose. This is called Secondary distribution.

Fig-2.3: Distribution line

2.7 Summary

This chapter describes transmission and distribution of electrical energy, Classification of Transmission and distribution system. The advantage and disadvantage of AC and DC Transmission line. The Transmission voltage is 230KV to 33KV and the distribution voltage is 11KV to 230V. DC system is more efficient than AC. DC System there is no interference with communication system.

CHAPTER 3

TRANSMISSION LINE LOSSES

3.1 Introduction

A transmission line is utilized for the transmission of electrical power from producing substation to the different dissemination units. It transmits the rush of voltage and current starting with one end then onto the next. The transmission line is comprised of a conductor having a uniform cross-area along the line. Airs go about as a protecting or dielectric medium between the transmitters. The electrical tower is used for supporting the conductors of the transmission line. Towers are made up of steel for providing high strength to the conductor. The Resistance, inductance, and capacitance and shunt conductance are the main parameters of the transmission line. These parameters are uniformly distributed along the line. It is also called the distributed parameter of the transmission line. Power must be transmitted from vast power plants to the customers by means of broad systems. The transmission over long separations makes control misfortunes. The real piece of the vitality misfortunes originates from Joule impact in transformers and electrical cables. The vitality is lost as warmth in the conductors.

Waste of electrical energy due to inherent inefficiencies or defects in the distribution or transmission system is called line loss.

The average values of power losses according to a typical transmission and distribution system is below,

- 1-2% – Step-up transformer from generator to Transmission line
- 2-4% – Transmission line
- 1-2% – Step-down transformer from Transmission line to Distribution network
- 4-6% – Distribution system transformers and cables

The general losses between the power plant and purchasers is then in the range somewhere in the range of 8 and 15%. The losses of Transmission line are including

- **Conductor loss**
- **Radiation loss**
- **Dielectric heating loss**
- **Coupling loss**
- **Corona loss**

The Transmission and Distribution Losses are also classified two types:

- **Technical Losses**
- **Non-Technical Losses**

3.2 Technical Losses

The specialized losses are because of vitality disseminated in the conductors, hardware utilized for transmission line, transformer, sub transmission line and dispersion line and attractive losses in transformers. Technical losses are possible to compute and control, provided the power system in question consists of known quantities of loads. Technical losses are normally 22.5%, and directly depend on the network characteristics and the mode of operation. These losses have a major indirect effect of the loss of investment in the system. Energy dissipation in conductors and types of equipment used in all parts of transmission and distribution causes the technical losses. When load quantities of the power system under analysis are known technical losses cannot be calculated but also controlled. Advancement of specialized losses in power transmission and circulation networks is a designing issue, including great apparatuses of influence frameworks arranging and demonstrating. The driving foundation is minimization of the net present esteem of the aggregate venture cost of the transmission and dissemination framework in addition to the aggregate expense of specialized losses. Specialized misfortunes are esteemed at age costs.

There are two categories of technical power losses;

a. Permanent / Fixed Technical losses
b. Variable Technical losses

3.2.1 Permanent Losses

The permanent losses in the dissemination lines represent between a quarter and a third of the aggregate specialized misfortunes. These are typically as warmth and commotion and happen at whatever point the transformer is empowered. The settled losses are not impacted by the measure of load current streaming; But instead by

- Corona Losses
- Leakage Current Losses
- Dielectric Losses
- Open-circuit Losses

3.2.2 Variable Technical Losses

Variable losses change with the measure of power dispersed and all the more exactly, relative to the square of the current. Thusly, a 1% expansion in current prompts an expansion in losses of over 1%. In distribution networks between 2/3 and 3/4 loss is technical losses. Including variable losses are

- Joule losses in lines in each voltage level
- Impedance losses
- Losses for contact resistance.

Specialized misfortunes happen amid transmission and conveyance and include substation, transformer, and line related misfortunes. These incorporate resistive misfortunes of the essential feeders, the dispersion transformer misfortunes resistive misfortunes in auxiliary system, resistive misfortunes in administration drops and misfortunes in kWh meter. Misfortunes are inborn to the appropriation of power and can't be dispensed with. Specialized misfortunes are because of flow streaming in the electrical system and create the accompanying kinds of losses:

(i) Copper losses those are due to I^2R losses that are inherent in all inductors

(ii) The result of the heating effect is dielectric losses which occur between the dielectric material and conductors

(iii) Induction and radiation losses that are produced by the electromagnetic fields surrounding conductors. Technical losses are possible to compute and control, provided the power system in question consists of known quantities of loads.

The causes of technical losses are:

(i) Harmonics distortion
(ii) Earthing problem in consumer end
(iii) Long single phase lines
(iv) Unbalanced loading
(v) Overloading and low voltage
(vi) Poor standard of equipment’s.
(vii) Low power factor
(viii) Transformers installed far from load centers
(ix) Bad workmanship
(x) Haphazard installation of distribution systems to cope with demands to new areas
(xi) Lacking size of conductor

3.3 Non-Technical Losses (Commercial Losses)

Non-technical losses represent an avoidable financial loss for the utility. Although it is clear that the amounts of electricity involved in non-technical losses are being consumed by users that do not pay for them. Theft of power is energy delivered to customers that is not measured by the energy meter for the customer. This can happen as a result of meter tampering or by bypassing the meter. Losses due to metering inaccuracies are defined as the difference between the amount of energy actually delivered through the meters and the amount registered by the meters.

The causes of Non-Technical Losses are:

(i) Meter tempering
(ii) Errors occur in technical losses computation
(iii) Tapping on Low Transmission lines
(iv) False meter reading
(v) Illegal connections
(vi) Ignoring unpaid bills
(vii) Faulty energy meters
(viii) Errors and delay in meter reading and billing
(ix) Payment is not paid by customers.

Non-Technical losses in the influence area are nearly non-existent or unimportantly little in created nations, as the majority of the populace can stand to pay duties reflecting expenses of supply. Conversely, albeit blended, the circumstance will in general be altogether unique in creating nations.

➢ Conductor Losses

A conductor loss is because current flows through a transmission line and a line has a finite resistance there is an un-avoidable power loss. This is called conductor loss. Conductor loss can reduce by increasing diameter of conductor and use short transmission line. Conductor loss depends somewhat on frequency because of a phenomenon called the skin effect.

➢ Dielectric Heating Losses

A difference of potential between two conductors of a metallic transmission line causes dielectric heating. Heat is form of energy and must be taken from the energy propagating down the line. For air dielectric transmission lines the heating is negligible. The dielectric heating loss is increases for solid core.

➢ Radiation Losses

On the off chance that the division between conveyors in a metallic transmission line is obvious part of wavelength. The electrostatic and electromagnetic fields that encompass the conductor. Cause the line to go about as though it were a receiving wire and exchange vitality to any adjacent conductive material. The vitality transmitted is called radiation misfortune and relies upon dielectric material conduit separating and length of transmission line. It diminishes by appropriately protecting the link e.g. STP and coaxial has less radiation misfortune. It is likewise straightforwardly corresponding to the recurrence.

➢ Coupling Losses

Coupling loss occurs whenever a connection is made to or from transmission line or when two sections of transmission line are connected together. Mechanical connections are discontinuities which are locations where dissimilar materials meet. Discontinuities tend to heat up, radiate energy, and dissipate power.

➢ Corona loss

Corona loss is the one of the major power loss in transmission lines. Essentially, corona loss is caused by the ionization of air molecules near the transmission line conductors. These coronas do not spark across lines, but rather carry current in the air along the wire. Corona discharge in transmission lines can lead to hissing noises, a glow, and the smell of ozone. The color and distribution of this glow depends on the phrase of the AC signal at any given moment in time. Positive coronas are smooth and blue in color, while negative coronas are red and spotty. Corona loss only occurs when the line to line voltage exceeds the corona threshold.

3.4 Summary

This chapter describes the transmission line losses. Also describes the Technical losses, Non-Technical Losses such as Conductor loss, radiation loss, heating loss, dielectric loss, coupling loss and corona loss.

CHAPTER 4

CORONA LOSS

4.1 Introduction

When an alternating potential difference is applied across two conductors whose spacing is large as compared to their diameters, there is no apparent change in the condition of atmospheric air surrounding the wires if the applied voltage id low. However, when the applied voltage exceeds a certain value, called critical disruptive voltage, the conductors are surrounded by a faint violet glow called corona. The phenomenon of corona is accompanied by a hissing sound , production of ozone , power loss and radio interference .The higher the voltage is raised , the larger and higher the luminous envelope becomes and greater are the sound , the power loss and the radio noise . If the applied voltage is increased to breakdown value, a flash –over will occur between the conductors due to the breakdown of air insulation.

The phenomenon of violet glow, hissing noise and production of ozone gas in an overhead transmission line is known as corona.

If the conductors are polished and smooth, the corona glow will be uniform throughout the length of the conductors, otherwise the rough points will appear brighter .With DC voltage, and there is difference in the appearance of the two wires. The positive wire has uniform glow about it, while the negative conductor has spotty glow.

4.2 Theory of Corona Formation

Some ionization is always present in air due to cosmic rays, ultra violet radiations and radioactivity .Therefore, under normal conditions, the air around the conductors contains some ionized particles and neutral molecules .When pd is applied between the conductors, potential gradient is set up in the air which will have maximum value at the conductors surfaces. Under the influence of potential gradient, the existing free electrons acquire greater velocities.

When the potential gradient at the conductor at the conductor surface reaches about 30 KV per cm the velocity acquired by the free electrons is sufficient to strike a neutral molecule with enough force to dislodge one or more electrons from it. This product another ion and one or more free electrons which is turn are accelerated until they collide with other neutral molecules, thus producing other ions. Thus, the process of ionization is cumulative. The result of this ionization is that either corona is formed or spark takes place between the conductors.

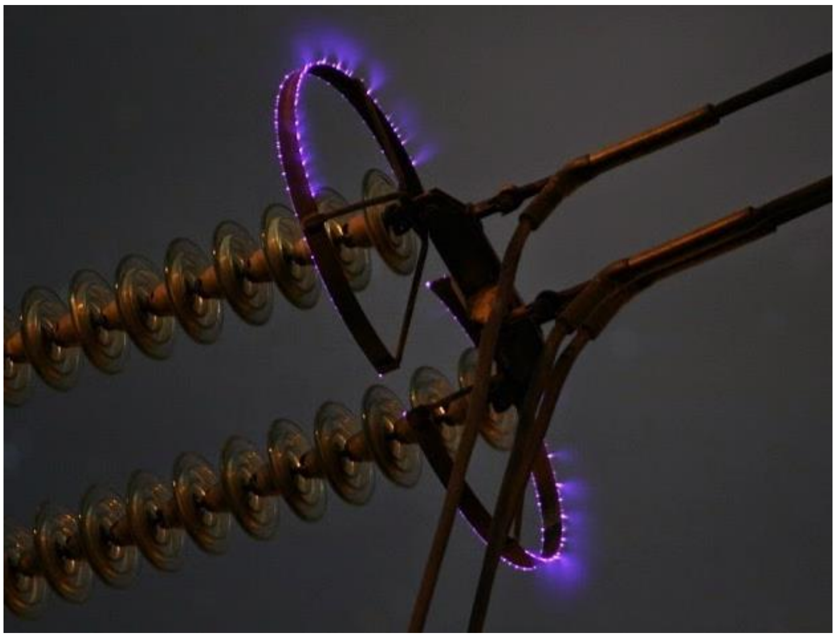

Fig- 4.1: Corona Discharge in Transmission Line

4.3 Corona Effect in Transmission Line

The effects of corona can be summarized as below

- A violet glow is observed around the conductor
- Produces a hissing noise
- Produces ozone which can be readily detected by its odor
- The glow is maximum over rough and dirty surfaces of the conductor
- Accompanied by a power loss
- Charging current under corona condition increases because the corona induces Harmonic currents.

4.4 Factors Affecting Corona

Since corona occurs due to the ionization of the air surrounding the line conductors, it is affected by physical state of the atmosphere as well as by condition of the line. The corona is affected by the following factors:

1. **Atmosphere:** corona is caused by the bombardment of molecules, with subsequent dislodging of electrons, by the ionized particles. Corona will thus be affected by physical state of the atmosphere. The voltage gradient for the breakdown of the air is proportional to its density. In the stormy weather the number of ions may be more than normal, and as such corona may occur at much less voltage compared to fair weather.
2. **Conductor:** the corona is considerably affected by the size (diameter), shape (stranded or smooth) and surface condition (dirty or clean) of the conductor. The corona decreases with the increase of diameter of conductor. A stranded conductor gives rise to more corona than solid conductor. For stranded conductors, the shape of the x-section is a series of arcs of circles each of much smaller diameter than the conductor as a whole.
3. **Conductors Spacing:** with the increase in spacing between the conductors the electro-static stresses are reduced and therefore, the corona effect is reduced. If the spacing between the conductors is made very large as compared with their diameters, they may not be any corona effect.
4. **Line Voltage:** line voltage largely affects the corona. At low voltage, there is no corona effect, but when line voltage is increased to such a value that electro-static stresses developed at the conductor surface make the atmospheric air surrounding the conductor conducting, corona effect appears.

4.5 Advantages of Corona

Corona has many advantages and disadvantages. In the correct design of a high voltage overhead line, a balance should be struck between the advantages and disadvantages. Here are some of the advantages of corona phenomenon:

- On long HV transmission lines, the current corresponding to corona discharges under traveling high voltage surges has the beneficial effect of reducing the surge peak and front steepness. Thus their stresses on the power system insulation are relieved.

- On the formation of corona the sheath of air surrounding the conductor becomes conductive and there is a virtual increase in conductor diameter and due to this virtual increase in conductor diameter the maximum potential gradient or maximum electro-static stresses is reduced. Thus probability of flash-over is reduced and system performance is improved.
- Well-known applications based on corona are for example Van de Graf generators, electrostatic precipitators, electrostatic printers, electrostatic deposition, ozone production, ionization counting, electrostatic motor car painting, biological applications as sterilization and many others.
- System performance is improved.

4.6 Disadvantages of corona

The most important disadvantages of corona presence in high voltage transmission lines, whose need to be considered are Corona effect in transmission lines.

- Definite loss of power, although this is not important except under abnormal weather conditions.
- Non-sinusoidal voltage drop due to non-sinusoidal corona current and these may cause some interference with neighboring communication circuits due to electromagnetic and electrostatic induction effect.
- Third harmonics are produced
- Owing to the formation of corona, ozone gas is produced which chemically reacts with the conductor and causes corrosion,
- Audible noise is combined with corona.

4.7 Disruptive Critical Voltage

The phenomenon of corona plays an important role in the design if an overhead transmission line. Therefore some terms are important as critical disruptive voltage, discussed below:-

The minimum phase-to neutral voltage at which the corona occurs is called Disruptive critical voltage.

Mathematically,

$$V_c = m_0 g_0 \delta \log_e \frac{d}{r} \quad kv/phase$$

Where,

V_c = Critical Disruptive Voltage

g_0 = Breakdown strength of air

In 76 cm pressure and temperature of 25^0C is 30 KV/cm (max) Or 21.2 KV/cm (R.M.S)

d = Spacing between conductors

r = Conductors radius

m_0 = Irregularity factor

Where,

= 0.98 to 0.92 for dirty conductor

= 0.87 to 0.8 for stranded conductor

= 1 for polished conductor

V_c = Critical disrupt line voltage

δ = Air density factor

= $\frac{3.92b}{273+t}$

Where,

b = Barometric mercury pressure (cm)

t = Temperature ℃

d = 1 (Standard condition)

As per as surface condition if conductor, the expression is multiplied by the regulating factorm_0.

Finally, after consider overall, the critical disruptive voltage.

$$V_c = m_0 g_0 \delta \log_e \frac{d}{r} \quad kv/phase$$

4.8 Visual Critical Voltage

Visual critical voltage has been seen that in case of parallel conductors, the corona glow does not begin at the disruptive voltage V_c but at a higher voltageV_v.

Visual Critical Voltage is defined as the minimum phase- natural voltage at which corona glow appears all the line conductors.

In mathematically,

$$V_v = m_v g_0 \delta r \left(1 + \frac{0.3}{\sqrt{dr}}\right) \log_e \frac{d}{r} \quad KV/Phase$$

Where,

V_v = Visual Critical Voltage

g_0 = Breakdown strength of air

In 76 cm pressure and temperature of $25^0 C$ is 30 KV/cm (max) Or 21.2 KV/cm (R.M.S)

d = Spacing between conductors

r = Conductors radius

m_v = Irregularity factor

Where,

= 0.72 to 0.82 for Rough conductor

= 1 for polished conductor

V_v = Visual Critical line voltage

δ = Air density factor

$= \frac{3.92b}{273+t}$

Where,

b = Barometric mercury pressure (cm)

t = Temperature ℃

d = 1 (Standard condition)

4.9 Power Loss Due to Corona

Presence of corona is always buildup by energy loss which s dissipated in form of light, heat, should and chemical action. When disruptive voltage is exceeded, the power loss to corona is given by,

$$P = 242.2 \times \left(\frac{f+25}{\delta}\right) \times \sqrt{\frac{r}{d}} \times (v - V_c)^2 \times 10^{-5} \quad \textbf{Kw/Km/Phase}$$

Where,

f = supply frequency in Hz.

V_p = Phase to neutral voltage in rms.

V_c = Disruptive - voltage per phase in rms.

The total power loss will be the three times of the referred power loss.

4.10 How to Reduce Corona Loss

Corona can be reduced by the following methods discussed below.

1) **By increasing conductor size:**

   If the size of conductor is increase, then the voltage at which corona occurs is raised and hence for corona effects takes place. This is one of the best methods to reduce the corona loss, for this purpose, ACSR conductors which has larger-cross sectional area are used in transmission line.

2) **By Increasing Conductor Spacing:**

   If the space between the conductors is increased, the voltage at which the corona occurs is raised and therefore corona effects can be eliminated. But there is some problem in increase conductor spacing which is cost of support will be increase.

3) **Using bundled conductors /Using corona rings**

   Bundled conductors are used in electrical transmission system above 220 KV. Up to 220 KV, single stranded conductors are used. But it is not possible to use single stranded conductor above 220 KV systems. For these high voltage systems, hollow conductors can be used to optimize the flow of current. But maintenance and erection of hollow conductors is not economical. Bundled conductors are used instead.

4.11 Summary

Corona loss is the other major type of power loss in transmission lines. Essentially, corona loss is caused by the ionization of air molecules near the transmission line conductors. These coronas do not spark across lines, but rather carry current (hence the loss) in the air along the wire. This chapter describes the theory of corona formation, corona effect in transmission line, Factors affecting corona, Advantages of corona, Disadvantages of corona, reduce corona loss.

CHAPTER 5

EFFECT OF CORONA LOSS IN TRANSMISSION LINE CONDUCTOR

5.1 Introduction

Due to their function, conductors are considered to be the most important components of overhead lines. Construction cost of a new overhead line, material and installation, can mount 40% of the total capital costs of the line. The choices of overhead lines depend upon power delivery requirements, line design requirements and environmental considerations. Delivering power is limited by the current carrying capacity, which in turn is affected by electrical resistive and corona losses. Line design considers the distances to be spanned and the corresponding type of conductors, sag and clearance. Power losses, resistive and corona, account for the bulk revenue losses of the transmission system. Corona plays a major role in the life cycle of electrical elements in general and of conductors in particular, both as an indicator of electrical and mechanical faults and as an active reagent. Therefore, when designing overhead lines it is necessary to take into consideration the electrical field effect (EMF) which is the prerequisite for corona to develop, and when maintaining lines it is mandatory to use corona cameras that can see those discharges.

A conductor is one of the most important components of overhead lines. Selecting a proper type of conductor for overhead lines is as important as selecting economic conductor size and economic transmission voltage.

5.2 Conductors Materials

Copper was the preferred material for overhead conductors in earlier days, but aluminum has replaced copper because of the much lower cost and higher weight of the aluminum conductor compared with a copper conductor of the same resistance. Following are some materials that are considered to be good conductors.

- **Copper**:

  Copper includes a higher conductivity as well as higher tensile power. Therefore, copper mineral within difficult attracted stranded type is a good choice with regard to cost to do business outlines. Copper includes a higher present denseness meaning much more present transporting capability for each device cross-sectional region. Consequently, copper mineral conductors possess fairly scaled-down cross-sectional region. Additionally, copper mineral is actually long lasting and it has higher discard worth. Nevertheless, because of its more expensive as well as non-availability copper mineral is actually hardly ever employed for cost to do business energy outlines.

- **Aluminum:**

  Aluminum provides concerning 60% with the conductivity regarding birdwatcher, meaning for your identical level of resistance the particular dimension regarding and also metal conductor is approximately 1. 26 instances as compared to in which of your birdwatcher conductor. Nonetheless, a great metal conductor provides practically 50 percent the particular fat regarding and also comparable birdwatcher conductor. Furthermore tensile durability regarding metal will be lower than in which is regarding birdwatcher. Contemplating blended aspects regarding expense, conductivity, tensile durability fat and so forth, metal possesses a side above birdwatcher. As a result, metal will be trusted regarding expense conductors.

- **Cadmium-Copper:**

  Cadmium-copper other metals include around 98 in order to 99% associated with copper mineral or more to at least one. 5% associated with cadmium. Add-on around 1% associated with cadmium in order to copper mineral boosts the tensile power through as much as 50% and also the conductivity is actually decreased just through regarding 15%. Consequently, cadmium copper mineral conductors can be handy with regard to extremely lengthy covers. Nevertheless, because of higher price associated with cadmium, this kind of conductors might be uneconomical oftentimes.

- **Other Materials:**

  There are numerous different metals and combinations that lead power. Silver is more conductive than copper, yet because of its staggering expense, it isn't useful in the vast majority of the cases. Aroused steel may likewise be utilized as a conductor. In spite of the fact that steel has high rigidity, steel conductors are not reasonable for transmitting power proficiency because of the poor conductivity and high obstruction of steel. High quality combinations, for example, phosphor-bronze additionally be utilized at times at outrageous conditions.

5. 3 Types of Conductors

As it is as of now made reference to above, aluminum conduits have an edge over copper components of cost, conductivity, elasticity weight and so on. Aluminum conveyors have totally supplanted copper channels in overhead electrical cables on account of their lower cost and lower weight. In spite of the fact that and aluminum channel has bigger width than that of a copper transmitter of same obstruction, this is really preference when crown is contemplated. Crown diminishes significantly with increment in the conductor measurement. Following are four regular kinds of overhead conductors utilized for overhead transmission and conveyance to convey created control from producing stations to the end clients.

Usually, all sorts associated with conductors have been in stranded type to be able to boost the versatility. Strong cables, aside from really small mix sectional region, are extremely hard to take care of as well as, these people often crystallize in the stage associated with assistance due to dogging within wind gusts.

- AAC: All Aluminum Conductor
- AAAC: All Aluminum Alloy Conductor
- ACSR: Aluminum Conductor Steel Reinforced
- ACAR: Aluminum conductor Alloy Reinforced

5.3.1 AAC: All Aluminum Conductor

Fig – 5.1: All Aluminum Conductor

This sort may also be additionally known because ASC Aluminum Stranded Conductor. This consists of strands associated with EC quality or even Electric conductor quality lightweight aluminum. AAC conductor offers conductivity regarding 61% IACS worldwide Annealed copper mineral stranded in spite of using a great conductivity, due to the fairly bad power, AAC offers restricted use within tranny as well as non-urban submission outlines. Nevertheless, AAC is visible within cities with regard to submission exactly where covers are often brief greater conductivity is needed.

5.3.2 AAAC: ALL Aluminum Alloy Conductor

Fig – 5.2: All Aluminum Alloy Conductor

These types of conductors are manufactured from lightweight aluminum metal 6201 the industry higher power Aluminum-Magnesium-Silicon metal. This particular metal conductor provides great electric conductivity along with much better mechanized power. Due to AAAC lighter in weight pounds when compared with ACSR associated with equivalent power as well as present capability. AAAC can be utilized with regard to submission reasons. Nevertheless, it's not generally favored with regard to tranny additionally. AAAC conductors can be used within seaside places for their superb deterioration opposition.

5.3.3 ACSR: Aluminum Conductor Steel Reinforced

ACSR includes a strong or even stranded metal primary along with a number of levels associated with higher wholesomeness lightweight aluminum cables covered within spin out of control. The actual primary cables might be zinc covered metal Galvanization or even lightweight aluminum films tend to be slim and therefore are put on safeguard the actual metal through deterioration.

Fig – 5.3: Aluminum Conductor Steel Reinforced

The actual main metal primary offers extra mechanized power and therefore sag is actually considerably less compared to other lightweight aluminum conductors ACSR conductors can be found in an array of metal content material through 6% in order to 40% ACSR along with greater metal content material is actually chosen exactly where greater mechanized power needed for example water traversing ASCR conductors are extremely broader employed for just about all tranny as well as submission reasons.

5.3.4 ACAR: Aluminum Conductor Alloy Reinforced

Fig-5.4: Aluminum Conductor Alloy Reinforced

ACAR conductor is actually created through covering follicle associated with higher wholesomeness lightweight aluminum upon higher power Aluminum-Magnesium-Silicon metal primary. ACAR offers much better electric in addition to mechanized qualities compared to equal ACSR conductors. ACAR conductors can be utilized cost to do business tranny collection in addition to submission outlines.

5.4 Bundled Conductors

Tranny from additional higher voltages goes by a few difficulties for example substantial corona reduction as well as extreme disturbance along with just one conversation outlines whenever just one conductor for each stage can be used. The reason being from EHV degree the actual electrical area gradient in the area of the solitary conductor is actually higher sufficient in order to ionize the encompassing atmosphere which in turn causes corona reduction as well as disturbance difficulties. The actual electrical area gradient could be decreased considerably by using several conductors for each stage within near closeness.

5.5 Calculating Conductor Loss

The corona loss is depending on conductor size. When the conductor size is increase corona loss is reduce.

Table-5.1: 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	45^0C
P	Atmospheric pressure	750 tons
δ	Air density correction factor	0.914
R	Radius of conduction	0.54cm
D	Conductor spacing	300cm
F	Frequency	50Hz
V_L	Line to line voltage	132KV
E_{dcv}	Disruptive critical voltage	55.98kl
L	Length of the conductor	160Km
P_{ufwc}	Corona loss under fair weather condition	1622.4Kw
P_{uswc}	Corona loss under stormy weather condition	3690Kw
E_{vcv}	Visual inception corona voltage	55.98kv

The power loss due to corona is given by

$$\mathbf{P = 242.2 \times \left(\frac{f+25}{\delta}\right) \times \sqrt{\frac{r}{d}} \times (v - V_c)^2 \times 10^{-5}} \quad \textbf{Kw/Km/Phase}$$

In fair weather the relation between conductor radius and corona loss,

Table -5.2: Conductor radius and corona loss

Conductor radius (r) cm	Single phase loss (kw)	Three phase loss (kw)
0.50	4.51	13.53
0.52	3.93	11.79
0.54	3.38	10.14
0.56	2.87	8.61
0.58	2.39	7.17
0.60	1.95	5.85
0.62	1.55	4.65
0.65	1.03	3.09
0.67	0.74	2.22
0.70	0.38	1.14

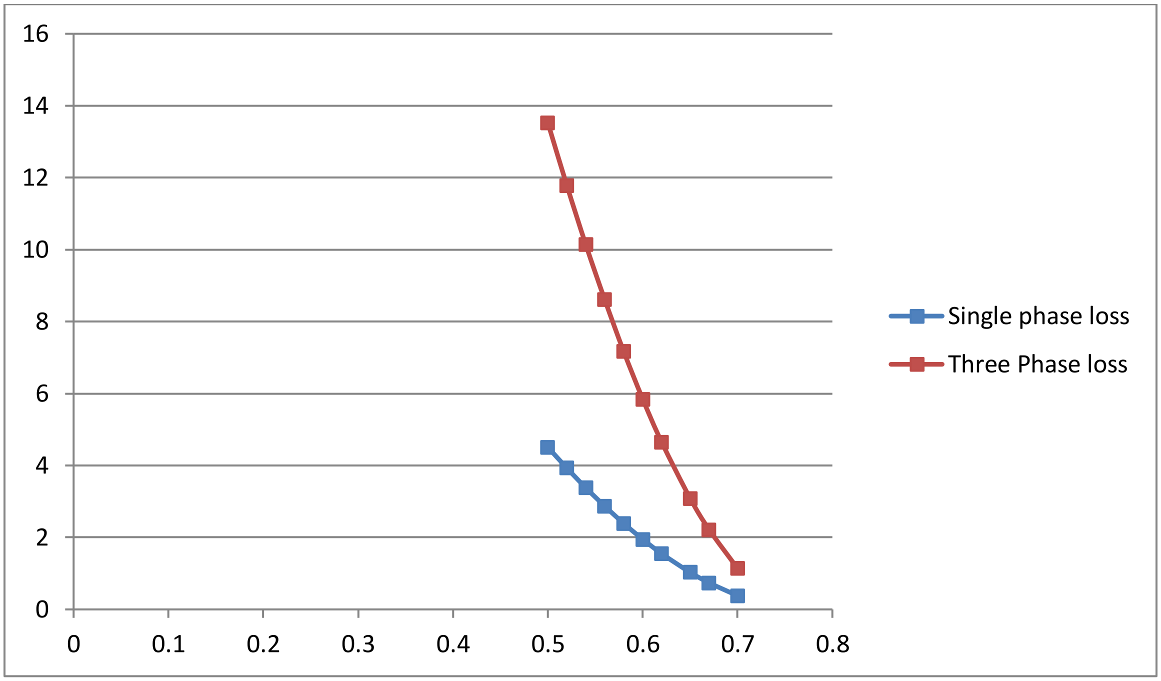

Fig -5.5: Graphical representation of Single and Three phase loss respect to radius in fair weather

In stormy weather the relation between conductor radius and corona loss,

Table -5.3: Conductor radius and corona loss

Conductor radius (r) cm	Single phase loss (kw)	Three phase loss (kw)
0.50	9.44	28.32
0.52	8.84	26.52
0.54	8.25	24.75
0.56	7.67	23.01
0.58	7.09	21.27
0.60	6.53	19.59
0.62	5.98	17.94
0.65	5.19	15.57
0.67	4.69	14.07
0.70	3.97	11.91

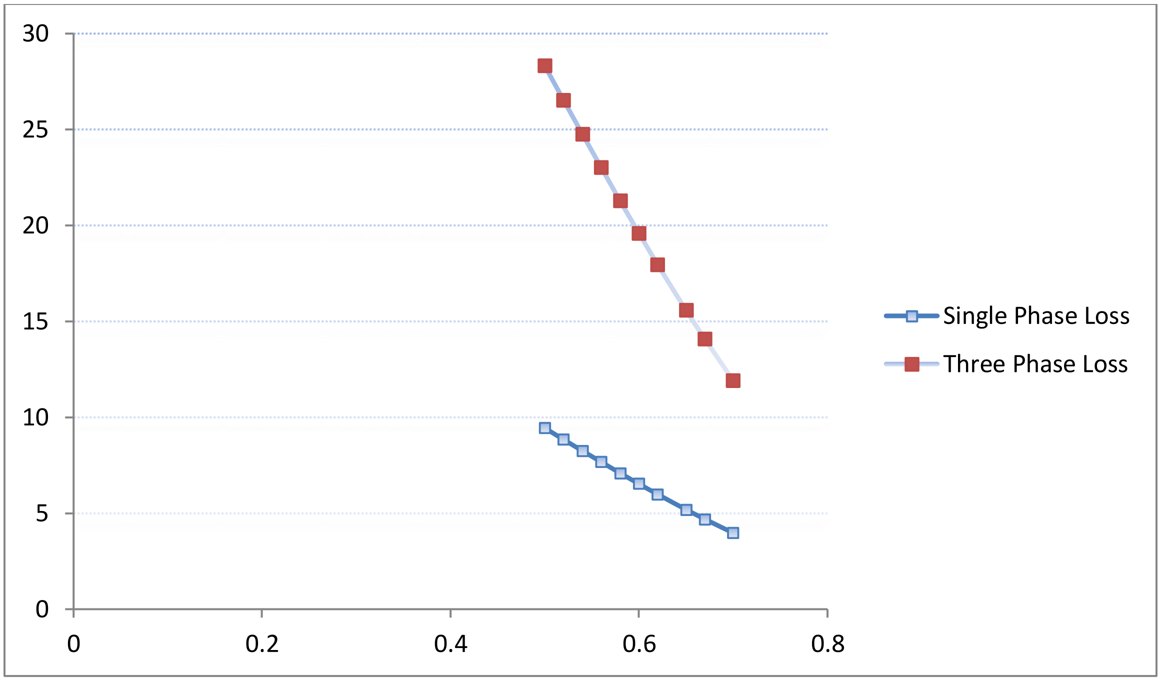

Fig -5.6: Graphical representation of Single phase and Three phase loss respect to radius in Stormy weather

When conductors size is increase at a time the critical voltage is increase as a result corona loss reduce. At this situation conductor spacing is constant to 300cm. As a result the loss is reducing to 69.52%. On the other hand the conductor cost is increase because of increase the conductor size. The conductor cost is increase 5%.

5.6 Summary

This chapter describes the effect of corona loss in transmission line conductors. Also describes the conductors Materials, Various Types of Conductors. ACSR Grossbreak conductor is use for minimize the loss. By the increasing the conductor size the loss is reduce 69.52% But cost of conductor is increase 5%.

CHAPTER 6

EFFECT OF TRANSMISSION LINE TOWER

6. 1 Introduction

In most nations, the requirement associated with electrical power energy usage offers ongoing to improve, the actual price associated with need becoming higher within the building nations. Tranny structure outlines tend to be among most significant existence collection framework. Tranny systems are essential with regards to delivering electrical power in order to numerous elements of the country. It's resulted in the actual improve within the creating associated with energy channels as well as major improve within energy tranny outlines in the producing channels towards the various edges exactly where it’s required. Interconnections in between techniques will also be growing to improve dependability as well as economic climate. Tranny collection also needs to steady as well as very carefully created so they don't fall short throughout organic catastrophe. It will additionally comply with the actual nationwide as well as worldwide regular. Within the preparing as well as style of the tranny collection, numerous needs need to be fulfilled type each structural as well as electric perspective. Type the actual electric perspective, the most crucial necessity is actually padding as well as secure clearances from the energy transporting conductors in the floor. The actual cross-section associated with conductors, the actual spacing in between conductors, and also the area associated with floor cables with regards to the conductor’s may choose the look associated with systems as well as fundamentals.

The actual main aspects of the tranny collection contain the actual conductors, floor cables, padding, systems as well as fundamentals. More often than not tranny outlines are made with regard to blowing wind as well as glaciers within the transverse path. Nevertheless, the actual Indian native sub-section is actually vulnerable to reasonable in order to serious earthquakes seismic lots might be essential since the tranny collection systems and also the wires might encounter greater fore as well as anxious throughout floor movement. Nevertheless, the actual main issue from the tranny collection throughout higher earthquakes might be how the big displacements don't triggered the actual wires to the touch one another or even any kind of encircling items, leading to energy failing as well as mishaps.

6. 2 Types of Towers

Picking the best option kinds of structure with regard to tranny outlines depends upon the particular landscape by which the actual collection traverses. Encounter offers, nevertheless, proven which any kind of combos from the subsequent kinds of systems are usually ideal for the majority of the outlines:

- **Suspension towers:**

  Suspension systems are utilized mainly upon tangents however frequently are made to endure perspectives within the fall into line in order to 2 levels or more as well as the blowing wind, glaciers, as well as broken-conductor lots. When the tranny collection traverses fairly toned, Featureless landscape, ninety % from the collection might be made up of this kind of structure

- **Tension towers:**

  Because they should avoid the transverse fill in the aspects of the actual collection pressure caused through this particular position, as well as the typical blowing wind, glaciers as well as damaged conductor lots, they're always weightier compared to suspension systems.

Table-6.1: Types of tower

Small angle towers (0” to 15’) with tension string	Deviation of 0” to 15”.
Medium angle towers (0” to 30”) with tension string	Deviation of 0” to 30”.
Large angle towers (30” to 60”) with tension string	Deviation of 30” to 60”.
Dead-end towers with tension string	To be used as dead-end (terminal) tower or Anchor tower

6.2.1 Types of Tower basic on current

- HVAC transmission tower
- HVDC transmission tower
- Railway traction line tower
- Tower for different type of current

6. 2.1.a HVAC Transmission Tower

- 3 phase energy techniques are utilized with regard to higher voltage 66KV as well as over as well as extra-high voltage 110 or even 115KV as well as over; usually 138 or even 230KV as well as over within modern techniques AIR CONDITIONING tranny outlines.
- The towers must be designed to carry three or multiples of three conductors.
- The towers are usually steel lattices or trusses wooden structure are used in Canada, Germany and Scandinavia in some cases and the insulators are either glass or porcelain discs.

6. 2.1.b HVDC Transmission Tower

- HVDC transmission lines are either monopole or bipolar systems.
- With bipolar systems a conductor arrangement with one conductor on each of the tower is used.
- For single-pole HVDC transmission with ground return, towers with only one conductor can be used.
- The towers are designed for later conversion to a two-pole system. In these cases, often conductors on both sides of the tower are installed for mechanical reasons.

6. 2.1.c Railway Traction Line Tower

- Towers used for single phase AC railway traction lines are similar in construction to those towers used for 110 KV-three phase lines.
- Steel tube or concrete poles are also often used for these lines.
- The towers of railway traction lines carry two electric circuits, so they have four conductors.
- Each circuit occupies one half of the cross arm. For six electric circuits arrangement of the conductors in three levels.

6. 3 Types of Tower Basic on Line Support

- Wooden Poles
- RCC Poles
- Steel Tubular Poles
- Steel Towers

The supports for and overhead line must be capable of carrying the load due to:

- Conductors
- Insulators
- Wind load on the support itself

6. 3. 1 Wooden Pole:

Fig- 6.1: Wooden pole

- Made of chemically treated wood.
- Used for distribution lines especially in areas where good quality wood are available.
- Very economical but susceptible to decay.
- To protect from decay, poles have zinc or aluminum cap at the top.

6. 3. 2 RCC Poles:

Fig- 6.2: RCC pole

- Made of reinforced concrete cement.
- Stronger than wood poles but more costly.
- Very long life and need little maintenance.
- Bulky and heavy.
- Widely used for distribution lines up to 33 KV.

6. 3. 3 Steel Tubular Poles

Fig-6.3: Steel Tubular Pole

- Stepped pole manufactured from a single tube, the diameter being reduced in parallel steps.
- More costly than RCC and wood poles.
- Have light weight, high strength to weight ratio and long life.
- Widely used for lines up to 33 KV.

6. 3. 4 Steel Towers:

Fig-6.4: Steel tower

- Used for lines of 66 KV and above.
- Very long life and high degree of reliability.
- Can withstand very severe weather conditions.
- Overhead HV, EHV, and UHV mostly use of supporting steel towers.

6. 4 Selection of Tower Structure

- Single circuit tower/ double circuit tower.

- Length of the insulator assembly
- Minimum clearances to be maintained between ground conductors, and between conductors and tower.
- Location of ground wire/ wires with respect to the outermost conductor.
- Mid-span clearance required from considerations of the dynamic behavior of conductors and lightning protection of the line.
- Minimum clearance of the lowest above ground level.

6.5 The different Parts of a Transmission Tower

Following are the different parts of a transmission tower,

- Peak of the tower
- Cage or hamper of the tower, that supports the cross arm.
- Cross arm for carrying conductors.
- Tower body, includes bracing
- Legs of the tower

6. 6 Tower Configuration

Picking a the greatest describe and also the bracing program designs plays a role in an excellent degree within building a cost-effective as well as less dangerous style of the tranny collection structure. For any specific structure settings chosen, the actual describe made the decision will fulfill each electric as well as structural needs simultaneously the actual settings ought to be affordable.

The tower outline diagram comprises

- Tower height considered from ground level
- Length of the cross-arm, and phase spacing
- Tower width at (i) base (ii) top hamper
- Bracing pattern considered

6. 7 Determination of Tower Height

The factors that govern the height of the tower are:

- Minimum permissible ground clearance (h1)

- Maximum sag of the lowermost conductor wires (h2)
- Vertical spacing between conductors (h3)
- Vertical distance between ground wire and top conductor (h4)

6. 7. 1 Minimum Permissible Ground Clearance (h1)

With regard to security, energy transporting conductors across the route from the tranny collection ought to preserve minimum clearance in order to floor, freeways highways, streams, railways monitors, telecommunication outlines, additional energy outlines, and so on. The actual clearance over floor will not really end up being under the next numbers as well as the elevation from the close by hurdles. The values of minimum ground clearance for the various voltages ranging from 66kV to 400 kV, are

66kV – 5.47m

132kV – 6.10m

220kV – 7.01m

400kV – 8.84m

6. 7. 2 Maximum Sag of The Lowermost Conductor (h2)

The power carrying conductors sags due to its self-weight and the sag is maximum, when the temperature is maximum and when there is no wind condition. The maximum sag occurs at the mid-section between the two towers in open country

$$\text{Max Sag}=\frac{qWt^{\mathbf{2}}}{8f}$$

q = loading factor

W = weight of the conductor/m/cm2

L = span length in meters.

f = working stress of conductor

6. 7.3 Spacing of Conductors (h3)

They must be sufficient up and down room between your conductors so they don't contact one another throughout powerful lots for example throughout higher earthquake as well as higher blowing wind. The next may be the up and down clearances usually permitted in the middle from the period between your conductors.

Table- 6.2: Vertical leeway reasonable of the center of range

Span(m)	Vertical clearance permissible of the middle of span.(mm)
200	4,000
300	5,500
400	7,000
500	8,500

6. 7.4 Vertical clearance between ground wire and top conductor

The actual up and down spacing in between conductors and also the planet cables is actually ruled through protect position, we. at the. position that the collection becoming a member of the floor cable and also the outermost conductor can make using the up and down that is needed to safeguard the actual conductors' cables and also the tranny structure type the actual immediate illumination cerebral vascular accidents. Usually the protect position differs through 25o in order to 30o that rely on the entire settings from the tranny structure as well as the quantity of voltage the actual tranny collection bears.

6.8 Calculating tower loss

The power loss due to corona is given by

$$P = 242.2 \times \left(\frac{f+25}{\delta}\right) \times \sqrt{\frac{r}{d}} \times (v - V_c)^2 \times 10^{-5} \quad \text{Kw/Km/Phase}$$

Table-6.3: Relation between conductor spacing and power loss

Spacing (cm)	Single phase loss	Three phase loss
300	4.35	9.83
305	4.21	9.68
310	4.16	9.53
315	4.07	9.39
320	3.98	9.25
325	3.90	9.12
330	3.82	8.98
335	3.61	8.86
340	3.67	8.74

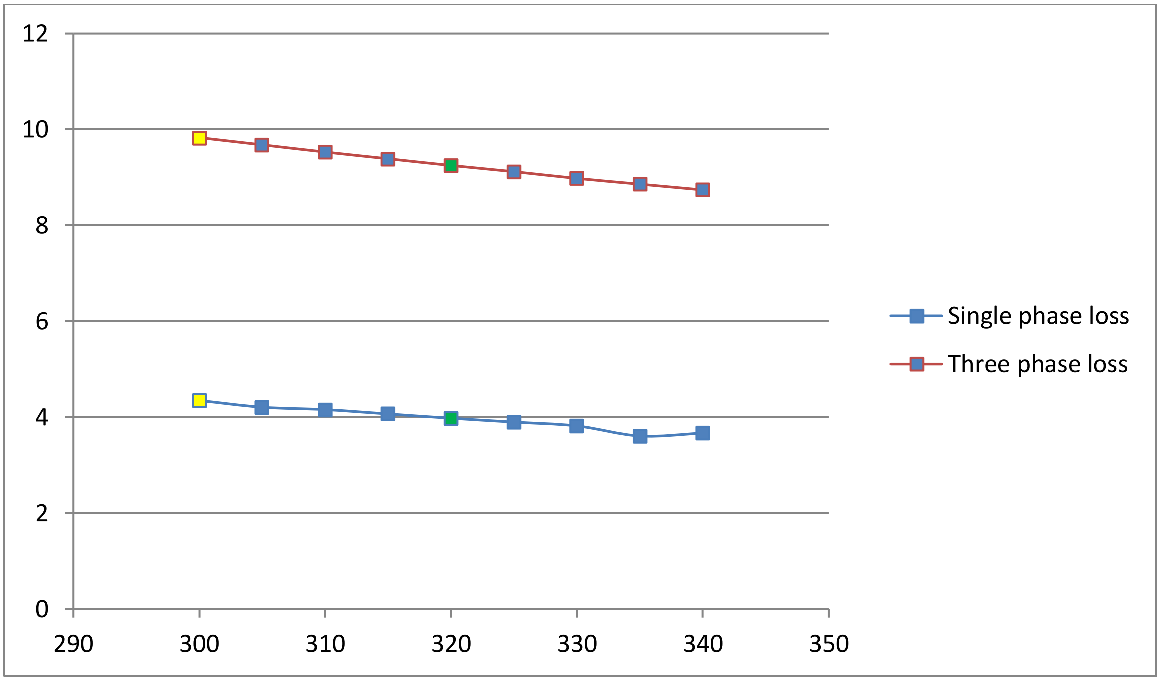

Fig- 6.5: Graphical representation of single phase and three phase loss respect to conductor spacing

6. 9 Summary

This chapter describes the effect of corona loss in transmission line tower. Also describes Types of towers, Selection of Tower Structure, The different parts of a transmission tower, Tower configuration, Determination of tower height.

CHAPTER 7

SKIN EFFECT IN TRANSMISSION LINE

7.1 Introduction

When a conductor is carrying steady direct current, this current is uniformly distributed over the whole X-section of the conductor. However, an alternating current flowing through the conductor does not distribute uniformly, rather it has the tendency to concentrate near the surface of the conductor. This is known as skin effect.

7.2 Skin Effect and it Explanation

The tendency of alternating current to concentrate near the surface of a conductor is known as skin effect.

Because of impact, the actual efficient section of cross-section from the conductor by which present moves is actually decreased. As a result, the actual opposition from the conductor is actually somewhat elevated whenever transporting a good alternating electric current. The reason for pores and skin impact could be very easily described. The actual strands close to the middle tend to be encircled with a higher permanent magnetic flux and therefore possess bigger inductance compared to which close to the area. The actual higher reactance associated with internal strands leads to the actual alternating electric current in order to circulation close to the area associated with conductor. This particular crowding associated with present close to the conductor area may be the pores and skin impact.

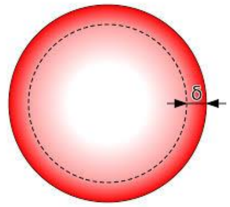

Fig-7.1: Skin Effect

7.3 Factors Affecting Skin Effect

The skin effect depends upon the following factors:

- Nature of material
- Diameter of wire
- Frequency
- Shape of the wire

7.4 Causes Skin Effect

- A solid conductor, assumed to be consisting of large number of strands each carrying a small part of the current.
- The inductance of each part of the strand varies depending on its position.
- The strands near the Centre are surrounded by a greater magnetic flux having large inductance than at the surface.
- The effective area of the cross-section of the conductor is reduced due to this skin effect.

7.5 Methods of reducing skin effect

The skin effects can be reduced by the following method

- **Frequency:** Skin effect increases with the increase in frequency.
- **Diameter:** It increases with the increase in diameter of the conductor.
- **The shape of the conductor:** Skin effect is more in the solid conductor and less in the standard conductor because the surface area of the solid conductor is more.
- **Types of material:** Skin effect increase with the increase in the permeability of the material.

7.6 Summary

This chapter describes skin effect in transmission line. Also describes the skin effect explanation, Factors affecting skin effect, causes skin effect, Methods of reducing skin effect, Equation for calculating skin effect resistance.

CHAPTER 8

RESULT AND CALCULATION

8.1 Introduction

Corona loss depends on the conductor diameter and conductor spacing. This chapter presents possibility to decrease the corona power losses in overhead transmission lines. Corona power losses can be reduced by increasing the diameter of the conductor and conductor spacing. The skin effect loss is also depends on diameter but this loss is negligible.

8.2 Conductor Cost

By increasing the diameter of conductor the cost of conductor will be increase. That means the cost of conductor is proportional to diameter. The graphical representation is below.

Table: 8.1 Relation between diameter and percentage cost

Diameter (cm)	%Cost
0.54	0%
0.56	1%
0.58	2%
0.60	3%
0.62	4%
0.65	5%
0.67	6%
0.70	7%

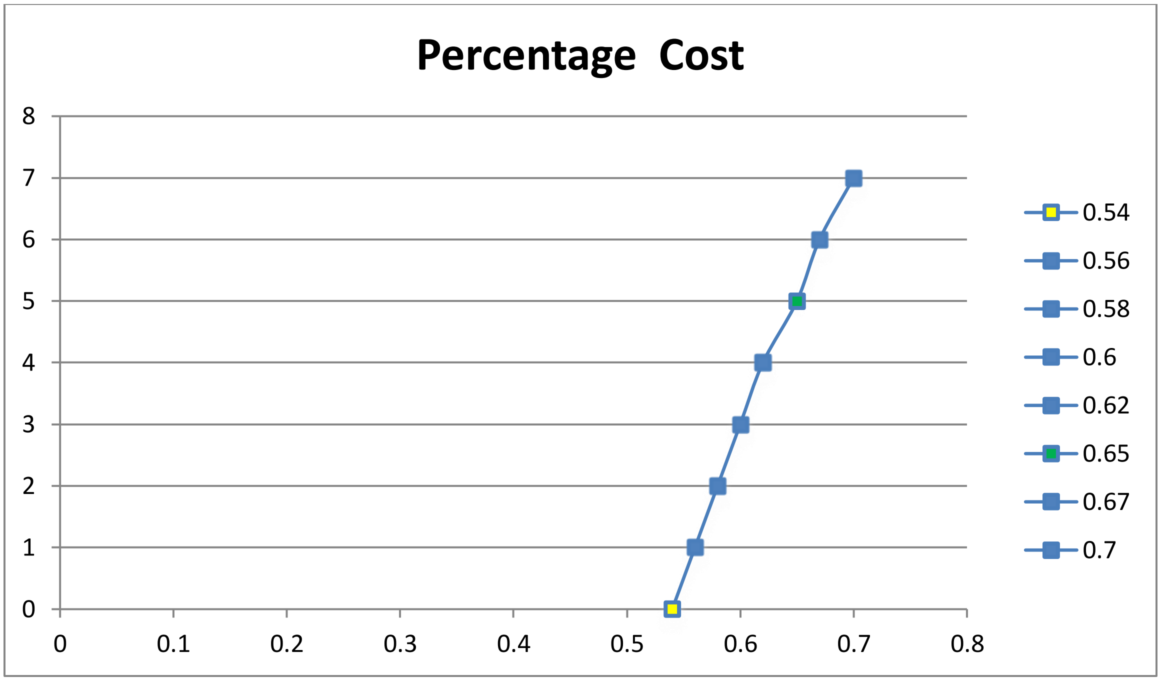

Fig-8.1: Graphical Representation of diameter and percentage cost

Therefore the conductor cost is increase 5% from the reference cost.

8.3 Tower Cost

By increasing the tower height the cost of tower is increase. The graphical representation of height and tower cost is below.

Table- 8.2: Relation between height and Percentage cost

Height (m)	Percentage Cost (%)
28	0%
28.25	2.08%
28.5	4.16%
28.75	6.25%
29	8.33%
29.25	10.41%
29.5	12.5%

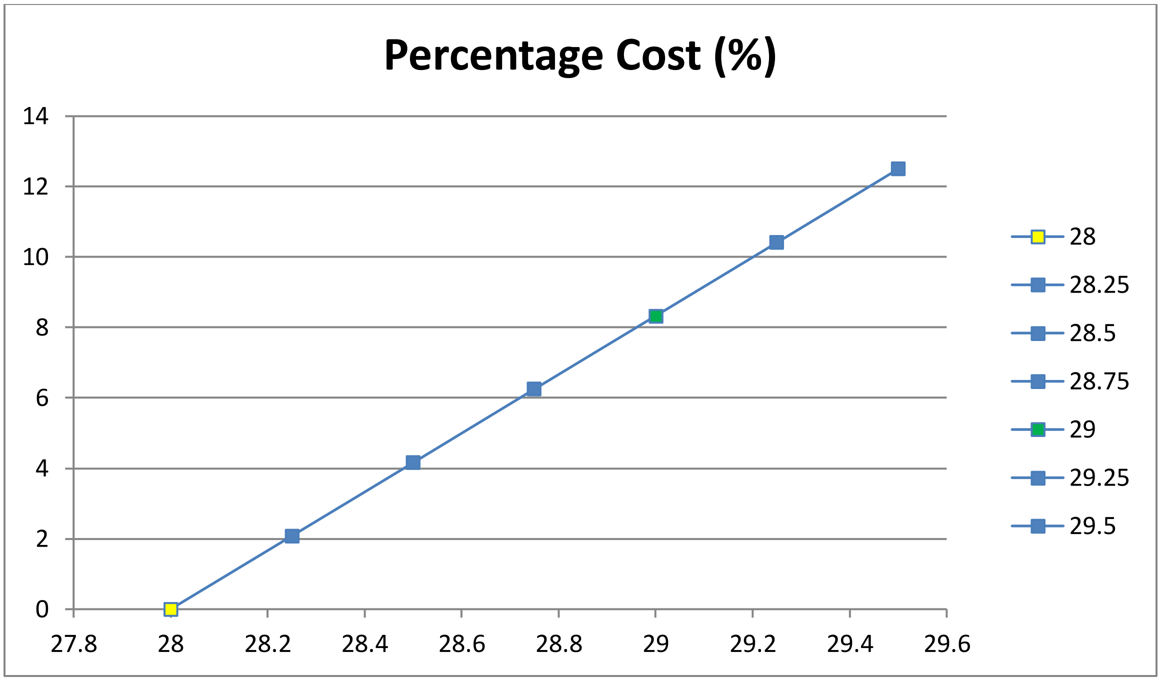

Fig- 8.2: Graphical representation of height and percentage cost

Therefore, the tower cost is increase 8.33% from the reference cost.

8.4 Skin Effect Loss

By increasing the diameter of conductor the skin effect loss is increase. The amount of skin effect loss is very poor. The relation of diameter and percentage resistance is below.

Table- 8.3: Relation between diameter and Resistance

Diameter (cm)	Percentage Resistance
0.54	0%
0.58	0.0000103%
0.62	0.0000115%
0.65	0.0000206%

Therefore, the percentage resistance is increase 0.00206% from reference resistance. The resistance is proportional to power loss. So the power loss is also negligible.

8.5 Reduce Corona Loss

By increasing the conductor size the corona loss is reduce. The graphical representation of the diameter and percentage corona loss.

Table-8.4: Relation between diameter and percentage corona loss

Diameter (cm)	Percentage Corona loss reduction
0.54	0%
0.56	15%
0.58	29.28%
0.60	42.30%
0.62	54.14%
0.65	69.52%

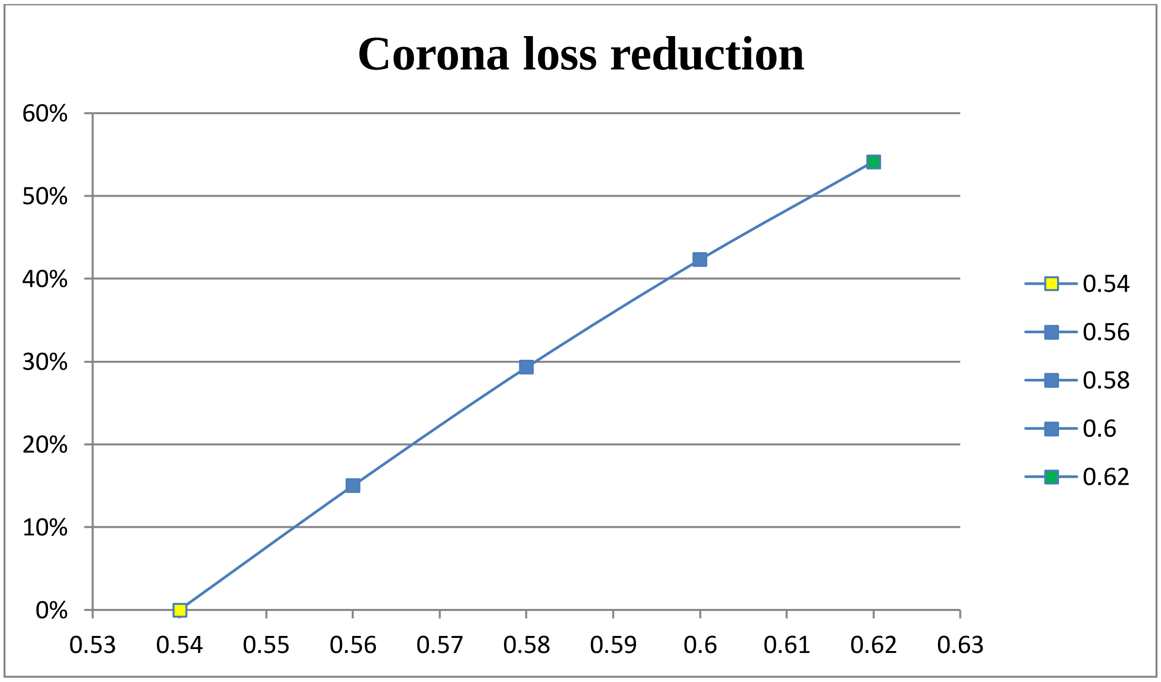

Fig-8.3: Graphical representation of Diameter and percentage corona loss reduction

The main purpose of this thesis is to reduce the corona loss of a 160Km transmission line which operating voltage is 132KV. Therefore, the corona loss is reducing 69.52% from the reference loss.

Table-8.5: Result table

Conductor Cost	5%
Tower Cost	8.33%
Skin Effect Loss	0.0000206%
Corona loss reduction	69.52%

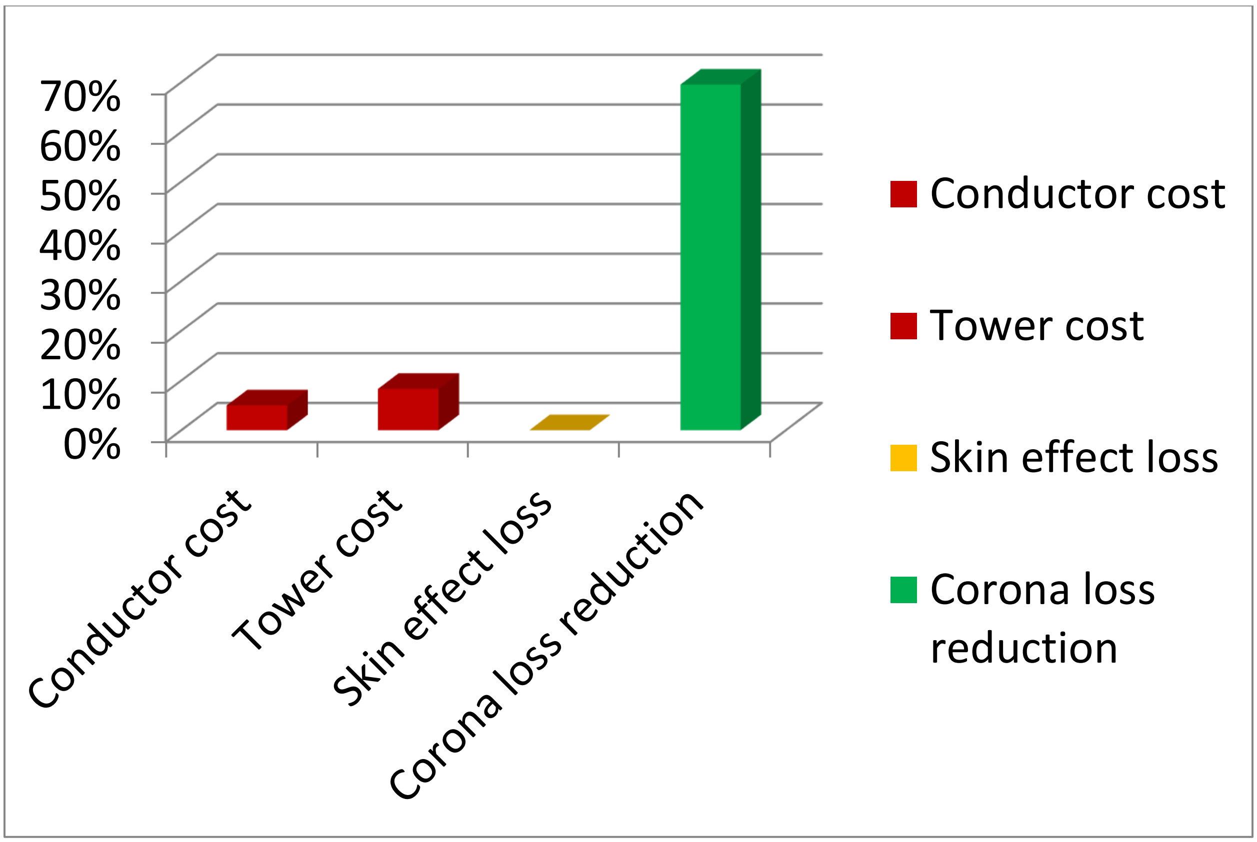

Fig-8.4: Graphical representation of Overall result

8.6 Summary

In this chapter describe the overall cost and the reduce loss of the 160km Transmission line. The total cost (Conductor and tower) of the line increase 13.33% and the skin effect loss is increase very negligible 0.0000206%. But the total corona loss is reducing 69.52%. Therefore the overall system loss is Minimize.

CHAPTER 9

CONCLUSIONS

9.1 Conclusions

Corona within tranny collection leads to energy reduction decreasing tranny effectiveness. The entire energy reduction could be more within poor atmospheric situation because cooperated reasonable climate. With this document may be offered the results associated with conductor size as well as conductor spacing within crucial bothersome voltage as well as within the corona deficits. The end result implies that corona deficits tend to be bigger, in which the crucial bothersome voltage is actually much less. Therefore the actual distinction between your working voltage as well as crucial bothersome voltage may be the biggest. Throughout the bad climate, the actual crucial bothersome voltages tend to be much less, and therefore the actual corona energy deficits tend to be bigger. An extremely effective calculates to lessen corona deficits would be to boost the size from the conductor. However the actual corona reduction is actually decrease through the growing the actual conductor spacing.

9.2 Limitations of the Work

The limitations of the work

- After a certain period increase of conductor size the corona loss is also increase.
- After a certain period increase the conductor spacing the cost will be increase.
- After a certain period increases the conductor size the cost will be increase.

9.3 Future Scopes of the work

The scopes of the work is

- To calculate the corona loss when design a new transmission line.
- To study the cost of the conductor for the transmission line.
- Finding the relation with conductor size and skin effect loss in transmission line

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