A Survey Paper On Extra High Voltage AC Transmission Lines

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Abstract

Modern Power Transmission is utilizing voltages between 345 Kv And 1150 Kv, A.C. The distance of transmission and the Bulk powers have increased to such an extent that Extra High Voltages And Ultra High Voltages (Ehv And Uhv) have become a necessity.There are many problems encountered with such high voltage transmission lines including Electrostatic fields near the lines,Corona losses,Radio Interference,Audible noise,Carrier and Tv Interference, High voltage gradients,Heavy bundled conductors, Control of voltages at power frequency using shunt reactors of the switched type which inject harmonics into the system, Switched Capacitors, Overvoltages caused by Lightning and Switching operations, Long air gaps with weak insulating properties for switching surges,ground-return effects.E.H.V. Cable Transmission Upto 1200 Kv is gaining importance with Oil-Filled,Sf6 Insulation and Pplp, Xlpe.This paper presents the design Of E.H.V. Ac Transmission lines and also covers the theoretical analyses of all problems combined with practical applications.

Index terms – E.H.V,U.H.V,A.C Transmission,Arresters,Overvoltages

I. INTRODUCTION

High voltage is used in electric power distribution,in cathode ray tubes,to generate x-rays and particle beams and high power vacuum tubes and other scientific and industrial applications.Many Industrial-centered countries of the world thrive for a vast amount of energy in which electrical energy forms a major portion.There are several types of energy such as natural gas for domestic and industrial consumption, which form a considerable proportion of the total energy consumption. Thus,we can say that the electrical energy is not the only form in which energy is consumed but it is also an important part nevertheless.Today the world is on the verge of consuming the major portion of its natural resources in a very short spam of time and is already looking for alternative sources of energy excluding hydro and thermal to cater for the rapid rate of consumption which is outpacing the discovery of new resources.This will however does not slow down with respect to time and therefore there exists a need to reduce the rate at which energy consumption is increasing.Therefore,a tremendous need for energy is very urgent in many developing countries and their relation to other countries are sometimes based on the energy requirements.Usually the Hydroelectric and coal or oil-fired stations are located very far from the load centres for various reasons which requires the transmission of the generated electric power over very long distances.This led to the requirement of very high voltages for transmission. Extra High Voltage (EHV) A.C. transmission may be considered to come when the first 380–400 kV line was put into service in Sweden. After then,all the industrializedcountries all over the world have adopted the higher voltage levels. Later it was observed that the impact of such high voltage levels on the environment needed careful attention because the use of high surface voltage gradients on conductors led to the interference problems from powerfrequency to TV frequencies. Thus corona effects,electrostatic fields in the line

, losses,audible noise, carrier interference and radio interference became recognized as steadystate problems which governs the line conductor design, line height, and phase-spacing used to keep the interfering fields within prescribed limits.Use of synchronous condensers due to high line charging currents at load end only became impractical to control voltages at the sending-end and receiving-end buses.Use of Shunt compensating reactors for voltage control at no load and switched capacitors at load conditions became necessary.. All these are still categorized as steady-state problems.However, the single major problem considered with e.h.v. voltage levels is the overvoltages during switching operations which is commonly known as switching-surge overvoltages.

Fig 1:E.H.V Tower

II. DESIGN METHODOLOGY

Following parameters should be carefully considered while designing a E.H.V ac transmission line.

- Collecting preliminary line design data and gathering available climatic data.
- Selecting Reliability level.
- Calculating climatic loading on components.
- Calculating loads corresponding to security requirements.
- Calculating loads according to safety requirements.
- Selecting appropriate correction factors.

vicinity,

- Designing the components for the above load and strengths.

A. Reliability Levels

- Reliability Level ≥ 1
- Higher the Reliability higher is the safety factor and hence, more is the cost.

B. Selection of Transmission Voltage

- Standard voltage – 66,110,132,220,400 KV
- Selection criterion of Economic Voltage

1. Quantum of power is evaluated
2. Length of line
3. Voltage regulation
4. Power loss in transmission
5. Initial and operating cost

C. Economic Voltage of Transmission of Power

$$E = 5.5\sqrt{(km/1.61+(\text{load in kva})/150)}$$

Table 1: Economic Voltage of Transmission of Power

ECONOMIC VOLTAGE DROP	DISTANCE(miles)
765kV	2116
500kV	113
345kV	5910

D. Types of Towers

- Type A Tower :
  Tangent tower with suspension string
- Type B Tower
  Small angle tower with tension string
- Type C Tower
  Medium angle tower with tension string
- Type D Tower
  Large angle tower with tension string
- Type E Tower
  Dead end tower with tension string

- Special Tower

Fig 2: Tower Structure 1

Fig 3 : Tower Structure 2

Fig 4 : Tower Structure 4

E. Selection of Tower Structure

- Single circuit tower/Double circuit tower
- Length of insulator assembly
- Minimum clearances between ground conductors,and between conductors and ground
- Location of ground wires with respect to outermost conductor
- Minimum clearance of the lowest conductor above ground level

F. Selection of Conductor Size

- Mechanical Requirement
- Electrical Requirement

1. Mechanical Requirement

- Tensile strength(for tension)
- Strain strength(for vibration)

2. Electrical Requirement

- Continuous current rating
- Short time current carrying rating
- Voltage drop
- Power loss
- Length of line
- Charging current

G. Insulator Requirement

Insulators are used to support line conductor and it also provides clearance from ground and structure.

Insulator material are as follows;

- Toughened glass
- Fiber class
- High grade electric porcelain

Types of Insulators are categorized as ;

- Disc type

- Strut type
- Long rod insulator

III. PROBLEMS ENCOUNTERED

The problems encountered while using such high voltages are different from those encountered at lower voltages. These problems are:

(a) Increase in Current Density due to increase in line loading by using series capacitors.
(b) Use of bundled conductors.
(c) High surface voltage gradient on conductors.
(d) Corona problems: Audible Noise, Radio Interference, Corona Energy Loss, Carrier Interference, and TV Interference.
(e) High electrostatic field under the line.
(f) Switching Surge Overvoltages which cause more havoc to air-gap insulation than lightning or power frequency voltages.
(g) Increased Short-Circuit currents and possibility of ferro resonance conditions.
(h) Use of gapless metal-oxide arresters which replaces the conventional gap-type Silicon Carbide arresters, for both lightning and switching-surge duty.
(i) Shunt reactor compensation and use of series capcitors, resulting in possible subsynchronous resonance conditions and high shortcircuit currents.
(j) Insulation coordination based upon switching impulse levels.
(k) Single-pole reclosing to improve stability, but causing problems with arcing.

A. Overvoltages

Overvoltages in EHV systems are caused by switching operations.overvoltages due to the release of internally trapped electromagnetic and electrostatic energy in an e.h.v. system which can further cause serious damages to the equipment insulation.These damages could, under many circumstances, be more severe than lightning damage.Therefore,Surge diverters and resistances are included purposely while making switching operations as well as other schemes to reduce the danger to a considerable extent. Investigation of switching overvoltages has acquired very great importance since the transmission voltages are on the increase and line lengths and capacity of generating stations are also increased. It is assumed that the short-circuit capacity of sources is mainly responsible for a large amount of damage to the insulation.

B. Lightning Strokes To Lines

Lightning is considered as one of the major source of danger and damage to e.h.v. transmission lines, resulting in the loss of transmission up to a few hours to complete destruction of a line. This entails a lot of expense to power utilities and consumers.Lightning-protection methods are based on sound scientific and engineering principles and practice;however, extensive damages do take place in power systems in spite of this.Thus,no transmission line design can be considered lightning-proof, nor do designers aim for this goal. Line outages, or a line being taken out of service for a short time,and line designs against these are based on statistical procedures. An acceptable design would be to allow a certain number Nt outages per year per 100 km of line, or other time durations and other line lengths. The possibility of an outage depends on so many factors which are statistical in nature that a worstcase design is neither practical nor economical.It is evident that the number of strokes contacting a tower or ground wire along the span can only depend on the number of thunderstorm days in a year called the 'keraunic level' or also called 'isokeraunic level', and denoted by Ikl. On the basis of a vast amount of experience from all over the world, it is estimated that the number of lightning strokes occurring over 1 sq. km. per year at any location is fairly well given by

ns= strokes to earth/km2 – year = (0.15 to 0.2)Ikl

The actual factor must therefore be determined from observational data in any given region. Also, from experience, the area intercepted by a line with its metallic structures is taken to be proportional to

(a) (height of tower, ht + 2 × height of ground wire at mid span, hg) and
(b) the distance sg between ground wires if there is more than 1 ground wire on the

tower. Combining all these factors, it is estimated that the number of strokes intercepted by 100 km of line per year is given by

Ns = (0.15 to 0.2) Ikl {0.0133 (ht + 2 hg) + 0.1 sg} with hg,and sg in metres.

IV. PROTECTION MEASURES

Several measures are being taken to overcomes the problems faced while using E.H.V ac transmission line.

Lightning arresters which are also called 'surge absorbers' because they are also meant for switching surge protection.Their purpose is to protect primarily the major equipment such as transformers, rotating machines,shunt reactors, and even entire substations. Less expensive protective devices such as rod gaps can be used for protection of transformer and circuit-breaker bushings and open contacts.When substations are to be protected,they are located at the entrance of the incoming and outgoing lines.Modern surge absorbers required for e.h.v. levels are designed to offer protection to the equipments and lines for both lightning overvoltages and currents as well as switching surge over-voltages where the energy involved is much higher.Arresters can be classified into three important types and categorised according to their internal structure.They are ;

(1) Gap type arrester without current-limiting functions;

(2) Gap type arrester with current-limiting capability; and

(3) Gapless metal oxide varistors.

The Gap type arrester is commonly known by different names such as Thyrite, Magnavalve, Autovalve,Miurite.The non-linear resistance material is usually sintered Silicon-Carbide (SiC) and is designed to dissipate the energy in short duration lightning-stroke current and the current at power frequency that will follow this current when the series gap conducts.The current is then finally interrupted at a power-frequency zero.The second type of arrester known as the current-limiting gap type, is the one in which a magnetic action on the arc between the gap establishes a lengthening of the arc with consequent large resistance which is capable of limiting the current.In such type of design,the power-frequency current can be extinguished before it reaches a current zero.Such an arrester can perform switching surge function also.The non-linear resistance is still SiC.The third and the last one,the gapless MOV,is designed for low-voltage low-current electronic circuitary but recently it is sufficiently well developed to fulfill the e.h.v. requirements.

V. E.H.V Testing

All the e.h.v. equipment voltage levels are governed by Standard specification.Equipment manufacturers produce goods not only meant for domestic use but also for export so that a design or testing engineer must be familiar with these specifications from all over theworld.Some of the major specifications are I.E.C., I.S.I., V.D.E., S.A.E., A.N.S.I., B.S.S., C.S.A.., Japan and others.

VI. MERITS AND DEMERITS OF E.H.V ac TRANSMISSION LINE

A. Merits

- Reduction in the Current
- Reduction in the losses
- Reduction of the conductor material required
- Reduction in voltage drop
- Improvement of voltage regulation
- Increase in Transmission frequency
- Increased power handling capability
- The total line cost per MW per km decreases considerably with the increase in line voltage

B.Demerits

- Corona loss and Radio interference
- Line supports
- Erection difficulties
- Insulation needs
- The cost of transformers,switch gear equipments and protective equipments increases with increase in transmission line voltage
- The EHV lines generate electrostatic effects which are harmful to human beings and animals.

VII. CONCLUSION AND FUTURE WORK

In this article,we have outlined the design methodology of EHV ac transmission lines including the various factors required for their designs.This paper also presents the problems encountered while using EHV ac transmission line and it presents the various techniques adopted to overcome these problems.EHV transmission lines uses EHV cables which are used for high voltages and power when necessary.The future work where EHV ac transmission will prove effective follows;

- Support is going for a national EHV interstate transmission grid
- For UHV,fewer lines would be needed and for voltage above 765 kV more lines would be needed.
- It is understood,however,that the completion of this grid requires collaboration among stakeholders,especially transmission owners and operators.

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