Scientific Journal Impact Factor (SJIF) : 1.711
International Journal of Modern Trends in Engineering and Research
IJMTER
ISSN (ONLINE) : 2349 - 9745
ISSN (PRINT) : 2393 - 8161

COMPARISION OF VOLTAGE REGULATION OF GAS INSULATED TRANSMISSION LINE AND XLPE CABLE

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Abstract— This paper elaborates the fact that the Gas insulated transmission line (GITL) is superior than XLPE cable for high voltage long transmission system. Therefore we obtained the line parameters by simple calculation. Calculations are shown to determine the optimum length and the parameters of the transmission line. Using MATLAB software executing simulation of XLPE cable of a pre defined transmission line length and parameters calculated and observing the output voltage waveform for a particular load. Similarly GITL for same transmission line. So that we obtained the voltage regulation of a transmission line.
Keywords—gas insulated line(GITL), XLPE; style; styling; insert (key words)

I. INTRODUCTION

Electricity is generated in remote areas at the Power plant, at the specific voltage level of individual power plants. Generally Power plants are situated away from the load areas , then it transmitted through a network of transmission system , it may be either overhead or under ground transmission lines. In order to minimize losses, the voltage level of transmission lines are very high. One means of transmission is this Gas insulated line. Gas Insulated Transmission Lines are also used for bulk-power transmission over a long distance. For transmitting high voltage over long distances with some pre-imposed conditions and restrictions are there such as electromagnetic field interaction, charging currents of the capacitance formed between the conductor and the transmission line etc. Over 40 years this technique is used in many countries such as Frankfurt airport area Germany, Yalong River Hydropower Development Company China, Switzerland, Kaprun mountain area Austria, Wehr mountain area Germany, Bangkok switchyard Thailand, and also in Switzerland.

II. SYSTEM DESIGN

A. Gas Insulated Transmission Line

Basically Gas Insulated Transmission Line (GITL) comprises of four main components in its construction *viz.* current carrying conductor, enclosure, insulation medium between the conductor and the enclosure i.e. mixture of SF_6 and N_2 gases, and epoxy resin insulators to fasten the physical connections of the conductor and the enclosure .Usually the connection between the active elements are only a few meters in length. Since the required electrical shapes for enclosure are often complicated, castings are extensively for both active component and for the flanges used for interconnecting lines. Generally the conductor and the enclosure is made up of aluminium to maintain light weigh of the installation.

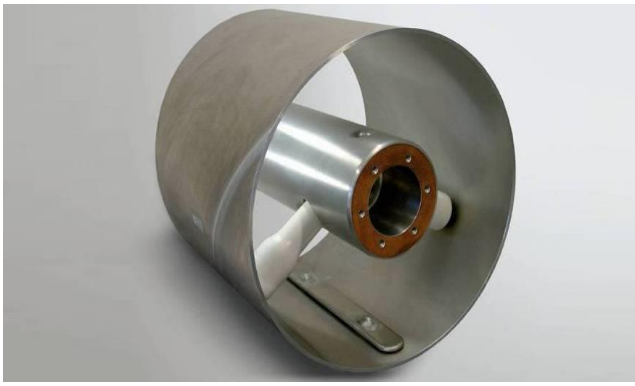

Fig 1: GITL unit

As per Indian standards GITL can be used for transmission levels ranging from 66kv to 400kv with a current level upto 5000A. Worldwide this system is being adopted for voltage levels ranging from 420kV to 550kV with a typical current rating of 3150A also by adopting a conductor and enclosure of more thickness by a small margin the current rating can be easily expanded upto 4000A. the transmission line capacity may reach upto 2200MVA to 3800MVA making the GITL a high end transmission system. The gas pressure in the GITL has a universal standard value of 7 bar abs. making it a low pressure transmission system. The insulating medium being a mixture of 80% nitrogen and the remaining 20% being SF_6 gases.

In order to determine the optimum dimensions of the GITL heat problems caused by joule loss in the conductor and the eddy current loss in the enclosure have to be investigated. Finite-element method (FEM) is a reliable and simple method which couples the electromagnetic and thermal fields. While actually the heat transfer coefficient is various at different locations of the enclosure surface, thus the results are also unsatisfactory. The following table depicts the data of a typical GITL.

TABLE I : TECHNICAL DATA OF GITL

Type	Value
Nominal voltage	420 kV / 550 kV
Nominal current	3150 A / 4000 A
Lightning impulse voltage	1550 kV / 1600 kV
Switching impulse voltage	1050 kV / 1200 kV
Power frequency voltage	630 kV / 750 kV
Rated short time current	63 kA/3s
Rated gas pressure	7 bar
Insulating gas mixture	80% N_2, 80%SF_6

The GITL has many exceptional advantages above other transmission methods. Out of the many advantages some of them are ability to transmit bulk power, high level of ampacities, high overloading ability, low resistive and capacitive drops, absence of external electromagnetic fields, self cooling, non-inflammability, no aging, lower total life cycle cost, auto-reclosure property, etc. A gaseous mixture for insulating purpose have reduced the cost of cable with an advantage of elimination of requirement of phase angle correction even for a long distance transmission line. The transmission line can either be buried under or placed on the ground. This can also be installed in a shared structure as a line running parallel to highway road or a train track.

B. Kilometric parameter calculations for GITL

In the Gas Insulated transmission line, the resistance offered by the outer enclosure should be minimum since a current is induced in it which is almost equal in the magnitude and opposite in angle to the phase current. Therefore the parameters of the line are decided according to the positive sequence circuit. The model of GITL is shown in fig. 3 it shows the different parameters to be calculated for the line.

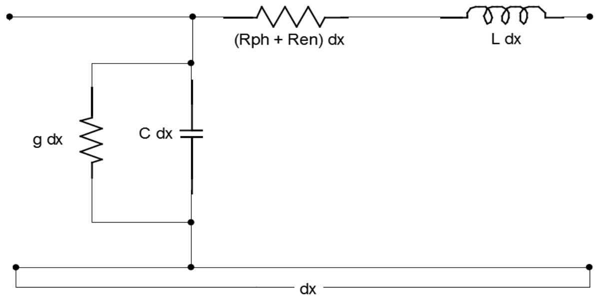

Fig 2: model of GITL for small element 'dx' at positive sequence.

R_{ph} = resistance of the phase conductor per kilometer.
R_{en} = resistance of the enclosure per kilometer.
L = inductance of the circuit per kilometer.
C = capacitance of the circuit per kilometer
g = conductance of the circuit per kilometer.
The cross-sectional view of the GITL indicating the inner and the outer diameter of the phase conductor and the enclosure is shown below.

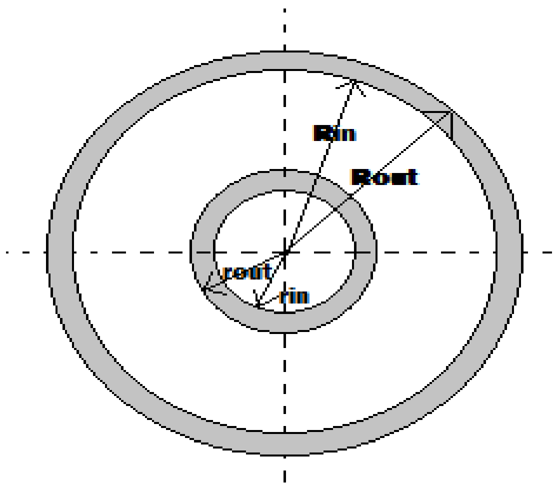

Fig 3 : one phase and enclosure of GITL

Kilometric resistance R

$\mathbf{R_{total}} = R_{ph} + R_{en}$ (Ω/km)
$R_{ph} = \rho_{ph} + S_{ph}$ (Ω/km)
ρ_{ph} = resistivity of the phase conductor ($\Omega mm^2/km$)
S_{ph} = area of the phase conductor
$S_{ph} = \pi (r_{out}^2 – r_{in}^2)$ mm^2
r_{out} = outer radius of the phase conductor (mm)
r_{in} = inner radius of the phase conductor (mm)
ρ_{en} = resistivity of enclosure ($\Omega mm^2/km$)
S_{en} = area of the enclosure
$S_{ph} = \pi (R_{out}^2 – R_{in}^2)$ mm^2

R_{out} = outer radius of the enclosure (mm)
R_{in} = inner radius of the enclosure (mm)

Kilometric inductance, L

$L = L_{ph} + L_{mf} + L_{en}$
L_{ph} = internal inductance of phase conductor.
L_{mf} = inductance due to magnetic field between phase conductor and magnetic field.
L_{en} = internal inductance of conductor.

Kilometric capacitance, C

$C = 2\pi\epsilon_0 / \ln (R_{in} / r_{out})$
ϵ_0 = permittivity of the insulating gas mixture.

TECHNICAL DATA AND DESING FOR GITL

The technical data for GITL is as shown in Table 1. The data is calculated using above equations and is used for designing model of GITL system for simulation purpose.

Table 2 : GITL specification for 400kV system.

PARAMETER	VALUE
Nominal voltage	400 Kv
Frequency	50 Hz
Nominal current	2000-4000A
Capacitance	55nF/m
Resistance	10mΩ/km
Inductance	220µH/km
Typical Lenngth	20-100 Km
Gas Mixture Range	80%-N_2 and 20%-SF_6
Laying options	• Directly buried • In tunnel • On gallery

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

C. XLPE Cable

XLPE is crossed linked polyethylene solid insulation cable. At Indian standards, this cable is used on 33kV with a mixed configuration with overhead line at the distribution level. The cable is generally not used at power transmission line as the size required for high voltages will be very high.

Fig 5 : 400kV XPLE cable.

D. *Kilometric parameter calculations for XLPE cable*

Resistance offered by XLPE cable

$R = R_0 [1 + \alpha (\theta - 20\,°C)]$

R_0 = resistance of the conductor at 20°C

α = 0.0393 for copper

α = 0.0403 for aluminium

θ = operating temperature

Inductance of XLPE cable

$L = 2.10^{-4}.\ln (a / 0.779rl)$ (H/km)

a = phase axis distance (mm)

rl = diameter of conductor over inner semiconducting layer (mm)

The capacitance of the cable is calculated as per the amount of insulation being depending on the operating voltage of the line.

TECHNICAL DATA AND DESING FOR XLPE

PARAMETER	VALUE
Nominal voltage	400 kV
Frequency	50 Hz
Nominal current	2000-4000A
Overloading capacity	$I_s = I_1/(t_s)^{1/2}$ for 0.2 to 0.5sec
Capacitance	0.0113µF/m
Resistance	23.10mΩ/km
Inductance	0.858mH/km
Typical Lenngth	20-100 Km
Laying options	• Directly buried • Overhead transmission line

In the above table

I_s = short circuit current for time t_s

t_s = short circuit duration

I_1 = short circuit current during 1 second

The short circuit time is being taken to be 0.2 seconds

III. SYSTEM SIMULATION

A model of pi type network transmission line is being used for simulation. A linear load is used is used to analyze the voltage sag in different loading conditions. The voltage regulation of the system using XLPE and the system using GITL are analyzed in terms of the voltage regulation in per unit.

The system is designed using the Indian standards with nominal voltage of 400kV and maximum voltage rating of 420kV and the system frequency being 50Hz. The section being of 150 km in length and the line is connected to a 400kV generating system from both the ends. For the transmission line the load is the distribution system. The voltage rating of the system, frequency, length, and the value of the loads are the same for both XLPE system and the GITL system but other parameter differ for the simulation purpose.

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E. Simulation results and discussion

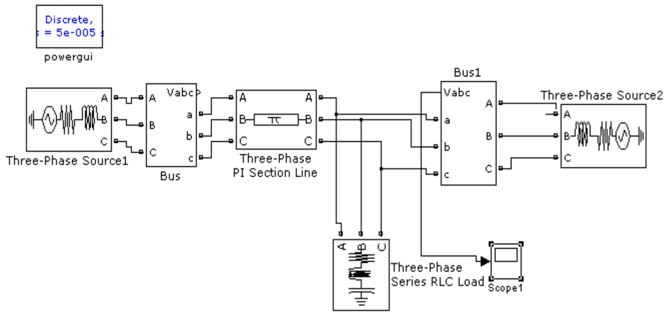

Fig. 6 : simulation model of GITL system

The simulation is done for different loading conditions. The value of the load is being increased to analyze the drop in the voltage in p.u. value. The fig. 8 showing the waveform of the voltage regulation of the GITL system. The base voltage value being taken as 400kV and to achieve the actual value the base value is multiplied with the per unit value. The voltage regulation is the ration of the change in the value of voltage form the no load condition to the full load condition to the voltage at no load conditions and it is expressed as the percentage of the no load condition.

$$\%V.R. = \frac{E - V}{E} X\,100$$

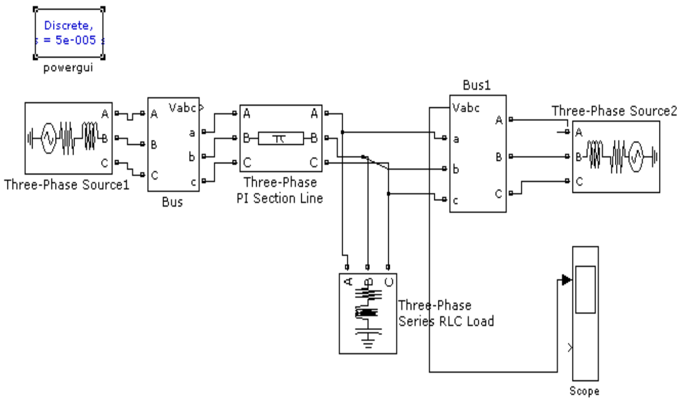

Fig. 7 : simulation model of an XLPE system.

The above figure shows the simulation model of the system using XLPE cables. The simulation is done for various values of the load to determine the change in the voltage regulation. These values of load being the same as that of the values of the simulation for the GITL system. The expression of the actual voltage value and that oh the voltage regu;aiton being same as that for the GITL system as it is a standard form of calculation of the actual voltage value and the voltage regulation.

Volume 02, Issue 04, [April – 2015] ISSN (Online):2349–9745 ; ISSN (Print):2393-8161

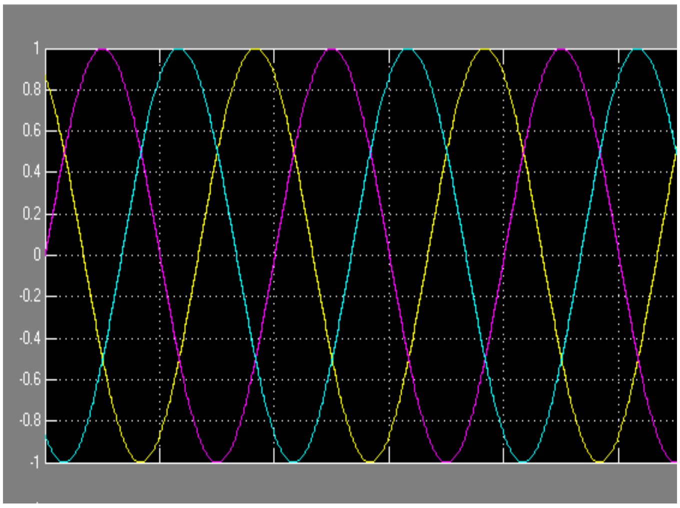

Fig. 8: Voltage regulation of GITL in p.u.

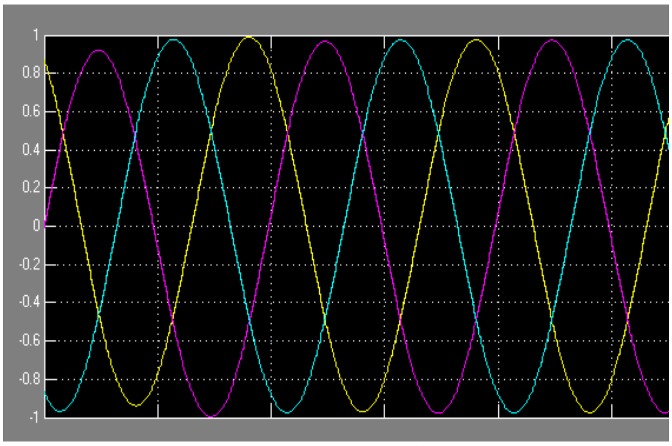

Fig. 9: voltage regulation of XLPE in p.u.

The above figure shows the waveform of the GITL and the XLPE system respectively for a 400MW system being connected across the line. It can be observed form the figure 8 that the voltage is 1p.u. which means the actual output voltage is 400kV and there is no losses in terms of power. However the graph of XLPE shows that the value of the output voltage in 0.97 p.u. approx. which means the actual voltage of the line is 388kV and there are certain losses occurring in the system this means the voltage regulation of the GITL system in 0% and that of the XLPE system is 3% at a load of 400MW. The simulation was carried out for some other load conditions and the values of voltage regulation obtained are as follows.

S.no.	**Load (MW)**	**GITL VOLTAGE (p.u)**	**XLPE VOLTAGE (p.u)**	**Voltage Regulation of XLPE**
1	**400**	**1.0**	**0.97**	**3%**
2	**500**	**1.0**	**0.94**	**6%**
3	**700**	**1.0**	**0.89**	**11%**
4	**800**	**1.0**	**0.85**	**15%**
5	**900**	**0.99**	**0.81**	**19%**

Table 5: comparison of voltage regulation of GITL and XLPE

IV. CONCLUSION

The use of cable is quite limited in India . but with the significant increase in the need of power and growing population it is very difficult to get rid of ways (ROWs) to install new overhead lines with large poles and tower structures. Therefore an alternative to the overhead line is necessary. GITL is a suitable option for the future need considering all the aspects and the results clearly show that there is no need of any compensating device to improve the system profile of voltage. It has been concluded from the simulation that GITL gives far better voltage regulation results in comparison with the XLPE cable at different load conditions. Using the simulation model, the voltage regulation for both the cables can be seen and it can be said that the use of GITL would be advantageous for the future interconnections of transmission system and also for upcoming transmission metwork.
This paper has presented the voltage regulation comparison of GITL and XLPE and is dealing only with the changes in the loading conditions of linear load.

REFERENCES

[1] Siemens, "Gas Insulated Transmission Lines GITL, High Power Transmission Technology", Answers for Energy,2012, pp. 2-7

[2] Roberto Benato, Claudio Di Mario, Hermann Koch, "High Capability Applications of Long Gas-Insulated Lines in Structures", IEEE transaction on power delivery, Vol 22, p 619-626, Jan. 2007`

[3] Harmann D Koch, "Gas Insulaed Transmission Lines (GITL)", 7th International Conference on Properties and Application of Dielectric Materials 2003, vol. 4, pp. 2480-2483

[4] G. Schoeffner and R. Graf. "Suitability of N2-SF6 Gas Mixtures for the application of Gas Insulated Transmission Lines GIL", IEEE Bologna power tech Conference, vol. 2, pp 6,June 2003

[5] T. Hillers, H. Koch Siemens AG. Erlangen, Germany "Gas Insulated Transmission Lines for High Power Transmission over Long Distances", IEEE catalogue No: 98Ex137, Vol. 2, pp. 613-618, Feb. 1998

[6] Hermann Koch, "Future Needs of High Power Interconnections solved with Gas-Insulated Transmission Line (GIL)", Vol. 3, pp. 1851-1855, Feb. 2002

[7] H. Koch, "GAS-INSULATED LINE (GIL) OF THE 2ND GENERATION", AC-DC POWER TRANSMISSION, Conference Publication No. 485 IEE, pp39-43, Nov. 2001