REASONS FOR FAILURE OF TRANSMISSION LINES AND THEIR PREVENTION STRATEGIES

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Abstract- Transmission line towers, though designed per code provisions, may fail during mandatory testing required in many countries, which leads massive damage to power system. Different types of premature failures that are observed during various full-scale testing of transmission line towers and their results are discussed in detail. Importance of design assumptions and connection detailing in overall performance of towers were studied. Importance of secondary member design and connection detail in overall performance of the tower was studied. Non-linear finite element analysis is useful in understanding the system behavior and for prediction of failure pattern and ultimate load. Based on the test results the importance of studying the failures is highlighted. The need for implementing various failure prevention strategies in transmission line towers has also been emphasized lucidly.

Keywords-: *transmission lines, operation, failure, prevention, strategies.*

I. INTRODUCTION

An electric power system consists of generators, transformers, transmission lines etc. Most of the faultswhich occurin the transmission lines can cause flow of heavy current associated with the short circuits. Due to which there are increased chances of fire, damage to the equipments, and imbalance of the power supply etc. Thus there is need for protective system to be installed in the electric power system which can protect the transmission lines and various equipments from getting damaged. Transmission lines stand forth as lifelines of humans by enlightening their daily lives. Their hampered transmission can darken our brightening, awakened and easy going activities and can land us into a disastrous situation presenting a grim scenario of day. Despite presence of various reasons of failure of transmission lines, installation of new methods of prevention of transmission lines can benefit a power system by improving transient stability, increasing power transfer capability, preventing huge loss of energy and eliminating the need for more parallel and uneconomical transmission methods. In need of power saving options and in dearth of much of the available studies on transmission lines, this paper is an attempt to eventually present a meta-analysis having following objectives.

II. AIMS AND OBJECTIVES

1. To highlight the most important reasons of failure of transmission lines.
2. To emphasize various prevention strategies for transmission lines.

III. METHODOLOGY

A systematic review of various papers, reports and articles available on transmission lines was done and finally a meta- analysis showing the reasons of failure of transmission lines and their best preventive strategies is being presented here.

IV. RESULTS

Reasons for failure of transmission lines

FACTORS OF A TRANSMISSION LINE FAULT

The transmission lines are mostly exposed in the air to the harsh environment of nature which produces various types of failures. Thundering, rain, lightning phenomena, flashover, winter ice , fog, fog stick on the insulator, and pollution cause poor contact insulators and transmitters.

1. Typhoon factors

Transmission lines, mostly situated in complex terrain the long lines, surrounded by green forest block, strong winds blow the transmission lines, the wind of the so-called transmission line partial flashover, this failure of line fault-prone form of the normal power supply of the power system hazards is quite large, and in the event of failure, caused by wind partial trip. Strong source of wind and low spread of the voltage poles lead to collapse of the pole, which creates the discontinuity in the power transmission. Hence, causing fault in the power system.

2. Lightning factors

Lightning frequency in the River Delta region, in the spring, summer is very high. Thunder and lightning cause transmission line failure, causing the accident trip of the substation, the cause of the accident is basically because of the lightning over-voltage resulting in short circuit this led to the failure of the lines.

3. Overlying ice factors

Transmission Line Icing caused by line break accident although this fault only occurs in the winter, but can be seen from the results of the accident thatin the event of the ice cover the intensity of work, repair and maintenance takes relatively longer time as compared to the other places. Moreover repair and maintenance is not easy for the maintenance staff. The formation of ice cover is because of cold weather, air and humidity and when ice cover is formed the overall weight of the transmission line increases which led to the failure of the line.

4. Filthy factors

Pollution flashover of transmission linesdamages the insulation coating. It will result in flashover incidents caused by such accidents, mainly due to the insulator surface is not scheduled to dust, especially wind and rain days, the accumulation of dust on the insulators and line will cause dirty ionization Flashover occurs.

5. External damage factor

Various factors can cause the external damage to the transmission lines , such as gale days, broken trees, large tracts of trees fallen on the road, increase the load on the line to be broken and theft of low voltage lines,collision of automobiles with the poles the occurrence of such incidents is one of the reasons for the creation of the fault in the transmission lines.

V. PROTECTION STRATEGIES

Transmission lines have to be protected for a smooth working of the power system and to reduce the risk of damage to the normal working components. Some of the measures for prevention of the lines are discussed in the following points:

1. Improve the quality of the electrical design

Improvement in the quality of the electrical design will maximize the security. The design of various electrical equipments is according to the operation without considering the surrounding of installation. The design of transmission lines such as towers, conductors, insulators, and auxiliary fittings remains same throughout the transmission of the power system without considering the surrounding conditions. The calculation and selection of Ray devices is very important to the designers who just only mechanically copy, copy the typical design and design specifications. As mentioned above, lightning factor after the accident of the lightning cause the fault, which can be protected by adopting specific design, the designer according with local surrounding take the appropriate lightning protection measures, copying the design specification, resulting in protection from the lightning factor. Later in the installation of surge arresters on towers, the accident was rarely the same time, the power lines must also be reasonable design in order to better exercise its duties. In the design work of the transmission line there is great need of careful calculations, site survey and line path selection of the topography and line the path. These measures possibly avoid all kinds of accidents, to ensure the normal operation of the transmission line.

2. Lightning protection measures

Lightning protection and grounding work is undoubtedly more important for the transmission line, generally select the lightning conductor transmission line lightning over-voltage protection, it is the most commonly used anti- Ray device. But we can also reduce the tower grounding resistance, to achieve the purpose of lightning protection.

3. Tower location and the correct choice of the rod

Initially it should be quickly and carefully investigated the climatic conditions and terrain, try to avoid erecting tower in adverse terrain and geographical location, and should strengthen the mechanical strength of the tower, try to use a steel bar or strengthen the type of concrete pole cross arm can be thicker.Selecting a different structure for the cross arm installed on the pole in theice prone areas. Structure of the insulator should be with the hydrophobic properties of the coating.

4. Prevention of pollution flashover

Pollution Flashover cause number of accidents and the impact leads to the creation of fault. The prevention of lines with pollution flashover is to improve the power system for the safe use of electricity distribution, continuing the important work of the electricity by increasing the creep age distance and the use of synthetic insulators can effectively prevent the pollution flashover occurred, or the use of anti-pollution flashover coating, thereby limiting the occurrence of leakage current accident.

5. External damage prevention

External damage to the transmission line, the strong winds make the trees fall overwhelming line. Furthermore, it is increasingly rampant theft and frequent traffic accidents. So it should be to optimize the electrical design and power transmission lines so as not to too close and woods, to take full account of brought to the tree growth rate "hazard" and the road to keep the proper distance, and in accordance with the specific location of the tower, additional protection pier, and finally painted with eye-catching protective signs.For external damage to the transmission line fault analysis, may take the following steps to protect the transmission lines:

Increase the protection of power facilities and efforts to do the publicity and education work of the electricity users and the establishment of a strict line inspection system.

To constantly improve the electricity regulations to strengthen the power of law enforcement efforts. Co-organized with the relevant departments of electrical safety a speech contest and knowledge contests and other activities to promote electrical safety regulations, so that we fully understand the dangers of electricity, so that those desperate daunting, quit.

To develop practical methods and measures, and implementation of practical work.

Training and to build a tough, good tough fight, a professional technical team is to protect the transmission lines necessary to ensure safety.

VI. RECOMMENDATIONS THE PROBLEMS MENTIONED IN THE PAPER CAN BE PREVENTED BY ADOPTING THE FOLLOWING METHODS:

a. Transmission line structure

Tabular structure should be preferred instead of the lattice type or H-type transmission structure. Reasons that made tabular transmission structure preferable over other structure are tabular structure can be built in 30 feet long section in wide range of diameter sizes and material thickness. Tabular structure can be supplied with a hot dip galvanized coating or metallic paint specifically formulated for excellent weathering over an extended period of time.

b. Type of conductor to be used

Aluminum conductors reinforced with steel (ACSR) were used in the transmission lines but they can be replaced by the modernconductor that offers reduced thermal sag is known as ACCC ("Aluminum Conductor Composite Core"). In lieu of steel core strands that are often used to increase overall conductor strength, the ACCC conductor uses a carbon and glass fiber core that offers a coefficient of thermal expansion about 1/10 of that of steel. While the composite core is nonconductive, it is substantially lighter and stronger than steel. Its lighter weight allows the incorporation of 28% more aluminum (using compact trapezoidal shaped strands) without any diameter or weight penalty. The added aluminum content helps reduce line losses by 25 to 40% compared to other conductors of the same diameter and weight, depending upon electrical current. The ACCC conductor's reduced thermal sag allows it to carry up to twice the current compared to AAC ("All Aluminum Conductor") or ACSR ("Aluminum Conductor Steel Reinforced").

c. Distance and shape of the poles

By decreasing the distance between the poles more strength can be provided to the transmission line system. Using a triangle shaped cross arm in the ice prone area will decrease the accumulation of the ice on the pole which does not lead to the increase of the overall weight of the transmission pole. Increasing the thickness of the cross arm and using tabular structure will increase the strength of the power distribution system.

d. Installing lightning arrester

A lightning arrester is placed where wires enter a structure, preventing damage to transmission lines within and ensuring the safety of individuals near them. Lightning arresters, also called surge protectors, are devices that are connected between each electrical conductor in a power system, and the Earth. They prevent the flow of the normal power or signal currents to ground, but provide a path over which high-voltage lightning current flows, bypassing the connected equipment. Their purpose is to limit the rise in voltage when a communications or power line is struck by lightning or is near to a lightning strike.

e. Corrosion evaluation methods for power transmission lines

The power transmission design of individual components has changed but the materials of construction remained virtually the same. Thus, by using steel and cast iron (bare, painted or galvanized), aluminum alloys and copper alloys. To enhance the corrosion resistance of these materials various treatments, coatings and inhibitors are applied which enhance the life of the transmission lines.

f. The transmission line design process

Recent developments in surveying technologies have allowed the industry to re-think about the station-elevation-offset formats that designers have traditionally used for transmission line profile modeling. This method of surveying is some form of three-dimensional geographical information system (GIS) type representation. Data are usually collected in electronic format, and the transmission line software is capable of reading the data intelligently in any form. Total Station, Geographical Positioning System (GPS), Photogrammetric, electronic topographical maps (USGS), and scanned or digitized existing profile drawings have all been employed to develop quick and relatively accurate land models for transmission lines. This can be efficiently use for the detection of the fault in the transmission line throughout the stretch of the line.

g. Using Underground transmission lines

Underground cables take up less right-of-way than overhead lines, have lower visibility, and are less affected by bad weather. However, costs of insulated cable and excavation are much higher than overhead construction. Underground lines are strictly limited by their thermal capacity, which permits fewer overloads or re-rating than overhead lines. Thus, we can use underground transmission lines in areas where the environmental condition is not suitable for overhead transmission line.

CONCLUSION

By analyzing the prevention methods of transmission line. It can be concluded that the need of protective system is an important part of power system. Transmission line protection method from fault mentioned in the paper can be achived by adopting the methods mentioned mentioned. Electrical power plays a very importent role in the country's economy and hence the need for prevention of transmission line increses many more times then that of any other type of energy.

REFERENCES

[1] M. A. Adamiak, G. Alexander, and W. Premerlani .Advancements in Adaptive Algorithmsfor Secure High-Speed Protection,. 23rd Annual Western Protective Relay Conference,Spokane, Washington, October 15.17, 1996.

[2] D. Hou, A. Guzman, and J. Roberts, .Inovative Solutions Improve Transmission LineProtection,. 24th Western Protective Relay Conference, Spokane, WA, October 21.23,1997.

[3] E. O. Schweitzer III and J. Roberts, .Distance Relay Element Design,. 19th AnnualWestern Protective Relay Conference, Spokane, Washington, October 20.22, 1992.

[4] G. Benmouyal and J. Roberts, .Superimposed Quantities: Their True Nature and TheirApplication in Relays,. Proceedings of the 26th Annual Western Protective RelayConference, Spokane, WA, October 26.28, 1999.

[5] G. Benmouyal and J. Mahzeredjian, .A Combined Directional and Faulted Type SelectorElement Based on Incremental Quantities, IEEE PES Summer Meeting 2001, Vancouver,Canada.

[6] A. Guzman, J. Roberts, and D. Hou, .New Ground Directional Elements Operate Reliablyfor Changing System Conditions,. 23rd Annual Western Protective Relay Conference,Spokane, Washington, October 15.17, 1996.

[7] Instruction Manual for Digital Frequency Relay Model BE1-81 O/U, Basler Electric Highland, Illinois. Publication: 9 1373 00 990. Revision: E. December 1992.

[8] A. G. Phadke and J. S. Thorp, .Computer Relaying for Power Systems,. Research StudiesPress Ltd. 1988.22

[9] A. G. Phadke, J. S. Thorp, and M. G. Adamiak, .A New Measurement Technique forTracking Voltage Phasors, Local System Frequency, and Rate of Change of Frequency,.IEEE Transactions on Power Apparatus and Systems, Vol. PAS-102, No. 5, May 1983.

[10] P. J. Moore, J. H. Allmeling, and A. T. Johns, .Frequency Relaying Based on InstantaneousFrequency Measurement,. IEEE/PES Winter Meeting, January 21.25, 1996, Baltimore,MD.

[11] IEEE PSRC Working Group: J. Esztergalyosetal.Single-Phase Tripping and AutoReclosing of Transmission Lines IEEE Committee Report.

[12] M. J. Pickett, H. L. Manning, and H. N. V. Geem, .Near Resonant Coupling on EHVCircuits: I-Field Investigations,. IEEE Transactions on Power Systems, Vol. PAS-87,No. 2, February 1968.

[13] M. H. Hesse and D. D. Wilson, .Near Resonant Coupling on EHV Circuits: II-Method ofAnalysis,. IEEE Transactions on Power Systems, Vol. PAS-87, No. 2, February 1968.

[14] C. F. Wagner and R. D. Evans, .Symmetrical Components as Applied to the Analysis ofUnbalanced Electrical Circuits,. McGraw-Hill, New York, 1933.

[15] D. L. Goldsworthy, .A Linearized Model for MOV-Protected Series Capacitors,. IEEETransactions on Power Systems, Vol. PWRS-2, No 4, Nov 1987, pp 953.95

[16] E. N. Kimbark, .Suppression of Ground-Fault Arcs on Singe-Pole Switched EHV Lines by Shunt Reactors,. IEEE Transactions on Power Apparatus and Systems, Vol. 83, March 1964.

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