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Overhead Transmission Lines Analysis Considering Sag-Tension under Maximum Wind Effect

***[1]Muhammad Zulqarnain Abbasi, [2]MuhammadAamirAman, [3]Akhtar Khan, [4] Mehr-E-Munir**

[1, 2, 3]Department of Electrical Engineering, Iqra National University, Pakistan

Email : [1]zulqar.4338@gmail.com, [2]amir.aman@inu.edu.pk
[3]akhtarkhan@gmail.com, [4]mehre.munir@inu.edu.pk

*Corresponding author : [2]Muhammad Aamir Aman,

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Abstract

Grid stations get generated power from power stations that are ordinarily far; continuous consumption or use of electric power has expanded in most recent couple of years. Transmission system is the system by methods for which power is transmitted from place of generation to the consumers. Overhead wires or conductors are the medium used for transmission of power. These wires are visible to wind, heat and ice. The efficiency of the power system increases if the losses of these overhead wires are minimal. These losses are based on the resistive, magnetic and capacitive nature of the conductor. It is necessary to create or make proper design of these conductors accompanied by proper installation. To balance the working and strength of overhead transmission line and to minimize its capacitive effect the conductors must be installed in catenary shape. The sag is required in transmission line for conductor suspension. The conductors are appended between two overhead towers with ideal estimation of sag. It is because of keeping conductor safety from inordinate tension. To permit safe tension in the conductor, conductors are not completely extended; rather they are allowed to have sag. For equal level supports this paper provides sag and tension estimation with two different cases under maximum operating temperature 45 °C. To calculate sag-tension estimation of ACSR (Aluminum Conductor Steel Reinforced) overhead lines twoe different cases are provided with no and high wind speed effects. Four different span lengths are taken for same level supports. ETAP (Electrical Transient and Analysis Program) is used for simulation setup. The results shows that wind effect has great impact upon line tension and with addition of wind speed the sag of line remains same while tension altered.

Keywords : ACSR, Span, Sag, Tension

I. Introduction

Electrical energy in the wake of being created at producing stations is transmitted to the buyers for usage. This is because of the way that power generating stations are typically built far from the consumers. The system that transmits and conveys control from the makers to the customers is known as the transmission system. The distinction in level between the purposes of support and the most minimal point on the conductor is called as Sag. Keeping the coveted sag in overhead electrical cables is an imperative thought. On the off chance that the measure of sag is low, the conductor is presented to a higher mechanical pressure which may break the conductor. While, if the measure of sag is high, the conductor may swing at higher amplitudes because of the wind and may contact with nearby conductors. Bring down sag implies tight conductor and higher pressure. Higher sag implies free conductor and lower strain. In this manner, an appropriate estimation of sag is computed so that the conductor stays in safe tension limits and retains the sag minimum.

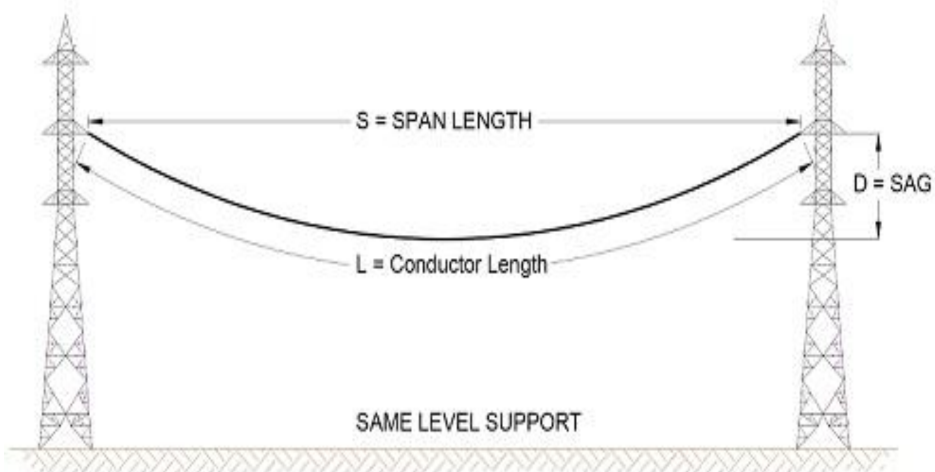

Figure 1. Sag at Equal Level Support

The above figure illustrates that two overhead transmission line towers which are placed at same level. While point ‘D’ is distance between point of support and the lowest point on conductor that is referred as sag and point ‘S’ showing the distance between two towers that is named as span length.

II. Conductor Selection

The conductor is line or cable that has been used to transmit electric power from one place to another faraway place. The conductor can be an Aluminum or Copper. An

Aluminum compared to copper is relatively cheaper and lighter. These advantages make pure aluminum a suitable choice.

The expansion in power prerequisite is turning into an incredible test for the utilities as far as cost and capacity matters, where the current lines have achieved their most extreme breaking point. One of the arrangements is the establishment of a parallel structure like the current power towers, however this is not a sparing arrangement on economic basis. The conductor named All Aluminum Conductor (AAC), Aluminum Conductor Steel Reinforced (ACSR), high temperature low Sag (HTLS) and is mostly used compare to copper because of its weight, price and ratio of strength to the weight. These all makes all three to provide smaller sags and minimum tension and results in short towers level.

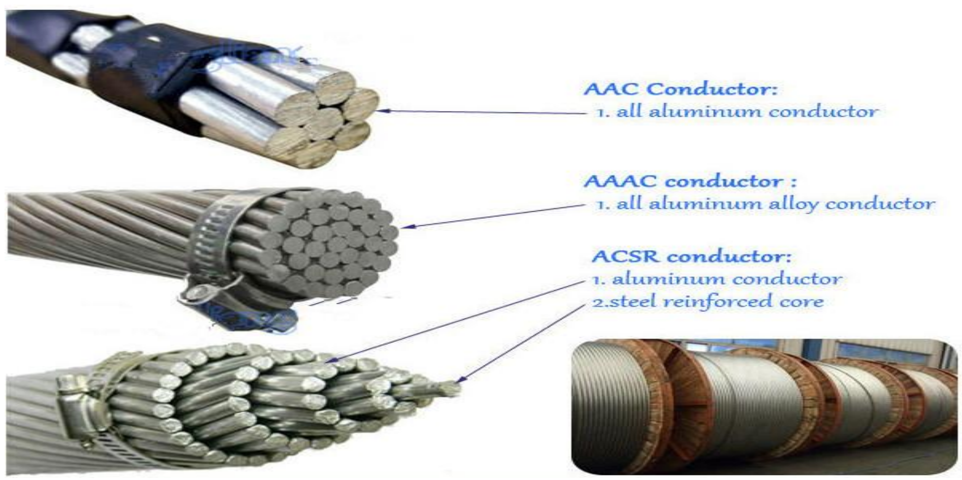

Figure 2. Different types of conductor

III. Aluminum Conductor Steel Reinforced(ACSR)

Aluminum Conductor Steel Reinforced (ACSR), a standard of the electrical utility industry since the mid 1900's, comprises of a strong or stranded steel core encompassed by at least one layers of strands of 1350 aluminum. Truly, the steel amount used to acquire higher quality soon expanded to a considerable segment of the cross-segment of the ACSR, yet more as of late, as conductors have turned out to be bigger, the pattern has been to less steel content. To meet changing necessities, ACSR is accessible in an extensive variety of steel substance - from 7% by weight for the 36/1 stranding to 40% for the 30/7 stranding. Early outlines of ACSR, for example, 6/1, 30/7, 30/19, 54/19 and 54/7 stranding included high steel content, 26% to 40%, with accentuation on quality maybe because of fears of vibration fatigue issues. Today, for bigger than-AWG sizes, the most utilized stranding's are 18/1, 45/7, 72/7, and 84/19, involving a scope of steel substance from 11% to 18%. For the modestly higher quality 54/19, 54/7, and 26/7 stranding's, the steel substance is 26%, 26% and 31%, individually. The high-quality ACSR 8/1, 12/7 and 16/19 stranding's, are utilized for the most part for overhead ground wires, additional long spans, stream intersections, and so on.

IV. Effects of wind on Sag and tension

A weight is put by wind upon conductors will raise the conductor observable weight that results increment in tension. The increase in tension will expand the length of line due to flexible expansion. This expansion in resultant load will achieve a sag in incline direction with vertical and horizontal segments.The maximum working tension usually occurs at the maximum wind and everyday ambient temperature.
So line tension has influenced by wind. For this reason, we apply distinctive wind ranges I-e normal and maximum to analyze the wind affect on line sag and tension.

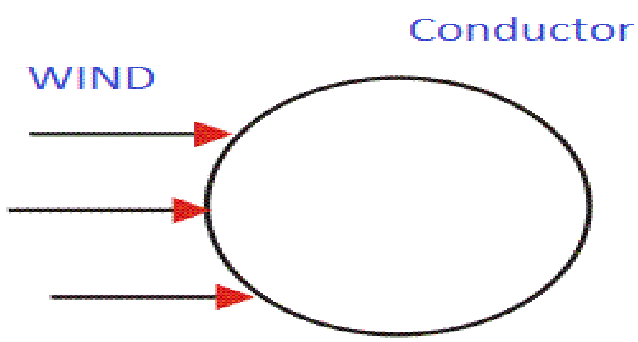

Figure 3. Direction of Wind Force on Conductor

In the above figure the wind is exerting a force on conductor due to which the apparent weight of conductor increase that results increase in tension of line. A wind on the conductor will expand the evident weight of the conductor bringing about an in increment in tension. This expansion will bring about a viable sag in a slanted heading with both even and vertical parts. To check its impact on sag and tension of ACSR overhead line simulation and analysis are performed for maximum wind speed.

V. Methodology

In our research the simulation is performed out on 220kv transmission line. ACSR conductor is chosen for simulation to check the sag and tension under various operating conditions in light of the fact that ACSR have the galvanized steel core that carries the mechanical load and the high immaculateness aluminum carries the current and use the lower thermal expansion coefficient of steel.

The circuit of the selected 220Kv line is simulated and analyzed using ETAP (Electrical Transient Analyzer Program). The ETAP is among the best software for electric power system planning, designing and operation.

ETAP Transmission & Distribution Line Sag and Tension module is an important tool to perform sag and tension calculation for transmission and distribution lines to ensure adequate operating condition for the lines. [45].

For simulation setup, we have considered same level spans with towers height 25m. The configuration of conductors is set as vertical and the spacing between the conductors is 2m. We have considered two cases i.e. Case A and Case B. In case A sag-tension of ACSR is analyzed under maximum operating temperature i.e. 45°C with no wind effect because in summers usually the temperature went up to 45°C. While in Case B the temperature is same as it is in the previous case 45°C but with the addition of wind speed i.e. 50 N/m^2.

VI. Results and Discussion

Case A

In Case A, sag-tension is analyzed under maximum operating temperature i.e. 45°C because in summers the temperature rose up to 45°C due to increase in temperature the metallic body of conductor of overhead lines expand as a result there will be high sag. In table 1 for equal level supports four different span lengths in maximum operating temperature i.e. 45°C are analyzed using ACSR.

Table 1. Maximum operating temperature with no wind effect

Type of Conductor	Span(m)	Wind Speed N/m^2
ACSR	100	0
	150	0
	200	0
	250	0

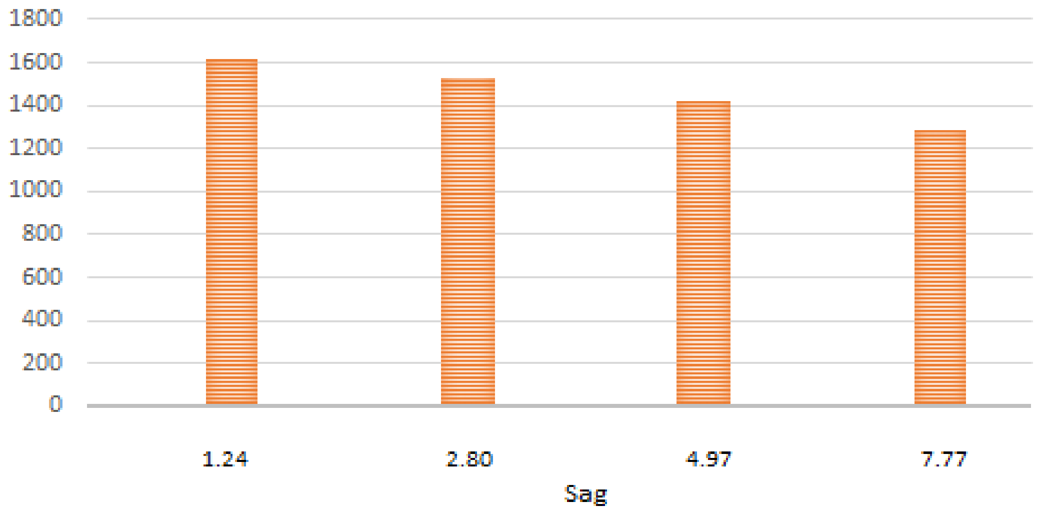

Figure 4.Sag-Tension result of maximum temperature

When the length of span is 100m the sag is 1.01m and tension is 1984. As the length of span increases from 100m to 200m the sag is 4.03m and tension is 1974. Similarly for 300m and 400m the sag is 9.06, 16.1 while tension is 1949 and 1859 respectively. From the above figure it is shown that as the length of span increases the sag likewise increases this is because sag is directly proportional to length of span and inversely proportional to tension.

Case B

In this case, maximum operating temperature with maximum wind speed i.e. 50 N/m2 is analyzed. As the table below showing high operating temperature with maximum wind speed for different span lengths are analyzed.

Table 2. Maximum operating temperature with maximum wind effect

Type of Conductor	Span(m)	Wind Speed N/m^2
ACSR	100	50
	150	50
	200	50
	250	50

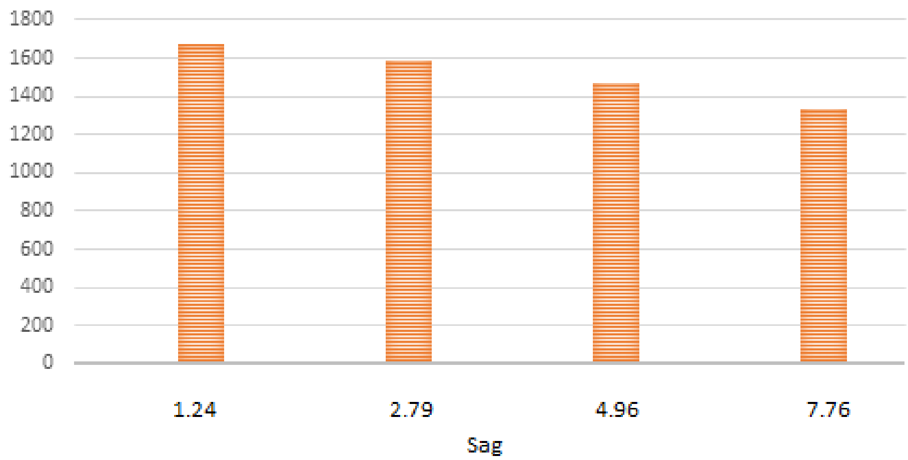

Figure 5.Sag-Tension result of maximum temperature with maximum wind effect

From the above graph when the length of span is 100m the sag is 1.01 and tension is 2012. As the span length increased i.e. 200m the sag is 4.03 and tension is 2002. Moreover for 300m & 400m the sag is 9.06, 16.1 and tension is 1977 and 1885 respectively. The figure shows that with the addition of wind the tension of the line increases while the sag remains unaltered. This is because wind applies a force upon the conductor as a result apparent weight of conductor increases that increase tension.

VI. Conclusion

In the currently implemented transmission lines two different cases are discussed under maximum operating temperature to analyzed sag-tension estimation using ACSR overhead lines. Four different span lengths are selected which are at equal level support. After simulation results following conclusions are made:

In hot sunny days of summer, the temperature is usually maximum i.e. almost 45 °C due to rise in temperature the metallic body of conductor expand as a result there is high sag which will indicate low tension. As the length of span increases the sag likewise increases this is because sag is directly proportional to length of span and inversely proportional to tension.

With the addition of wind in hot summer days, the sag of overhead lines remains unaltered as in previous case but with the addition of wind the tension of line increases this is due to wind applies a force upon conductor as a result apparent weight of conductor increases that increases tension.

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