A Design of Analysis Influence of Channel Flow Instability Against Andongan On Sutt 150 Kv

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Abstract. A Transmission lines air generally use ACSR type conductors. Increased demand for electrical energy, the effort to increase the transmission line capacity is done by optimizing the current carrying capacity of the existing transmission line, but the problem that arises in this optimization is the increase in voltage and the portion of the conductor. This study aims to determine the effect of channel flow instability on the conductor temperature, the conductor section, andongan angle and conductor voltage, which is then useful for the construction of the transmission line construction structure in accordance with the mechanical properties of the conductor used. The calculation in this study uses the heat balance equation to calculate the conductor temperature. The Basic Span Length method is used to determine the equivalent span length.

1. Introduction.
Increasing demand for electricity is increasing, causing the need for additional transmission line capacity in line with the expansion of the capacity of power plants. The focus of the problem in this study is that the increase in current carrying capacity can lead to an increase in the voltage of conductors and andongan, therefore it is necessary to examine mechanical problems as a result of changes in channel flow (Wibowo P, et al. 2017). In order to know how the characteristics will be useful in designing the transmission line construction. Problems with mechanical performance include how the channel current influences temperature, conductor voltage, and conductor size (Solly et al, 2018). Air transmission lines generally use ACSR (Aluminum Conductor Steel Reinforced) conductors which have a permissible working temperature limit of 90 °C. Considering the increased demand for electricity, the effort to increase the capacity of the existing transmission line is done by optimizing the current carrying capacity of the transmission line (Singla Marwaha, 2006). When a conductor wire is stretched between two points, the wire will follow the curved line of the two points, because the weight itself will bend downward. When the weight that causes the conductor's voltage is too large it will cause the conductor wire to break or it can also cause the buffer tower to be damaged and collapsed. The conductor voltage that arises is also affected by the loads on the conductor wire such as wind, snow, rain water and so on. Changes in the carriage (due to the voltage of the conductor, the length of the wire and temperature) that is too large, can also cause danger to all objects under it[4]

2. Literature Review.
An air channel is a transmission channel that transmits electricity through wires suspended from transmission towers or poles by means of insulators. The transmission line design will depend on several things such as:
1. The amount of power that must be transmitted.
2. Distance and type of field that must be passed.
3. Fees available.
4. Other considerations, for example urban problems and the possibility of future burden growth. In Indonesia, the government has uniformed high voltage lines, namely:

   Nominal Voltage (kV): 20 - 70 - 150 - 275 - 400 - 500

   The main components of the transmission line are poles or transmission towers, conductors or conductors as energy conductors, and insulators[2].

2.1. Tower Transmission

   The transmission tower or pole is a support structure for transmission lines, which can be in the form of steel towers, steel poles, reinforced concrete poles and wooden poles. Steel poles, concrete or wood are generally used in channels with relatively low working voltage (below 70 kV) while for high voltage or extra high transmission lines steel towers are used. Broadly speaking, according to the form or construction, the transmission tower can be divided into 3 types, namely:

1. Steel construction tower.
2. Tower of Manesman.
3. Wooden tower.

   According to its function, transmission towers are divided into types such as the following:

1. Tension tower.
   - The transmission tower with this function, besides being a weight barrier also retains the tensile force of the High Voltage Air Line (SUTT) wires.
2. Suspension pole.
   - This type of tower serves to support or support it must be strong against the gravity of electrical equipment that is on the pole.
3. Angle tower.
   - This tower is a tension pole that functions to receive pulling force due to changes in the direction of the High Voltage Air Line (SUTT).
4. Dead-end tower.
   - The tower with this type is a tension pole that is planned in such a way that it is strong to resist the pulling force of the wire from one direction only. This final pole is placed at the end of the High Voltage Air Line (SUTT) that will enter the switch yard of the Substation.
5. Transposition pole.
   - The tower with this type of function is a tension pole that serves as a place to move the layout of the phase of the high-voltage Air Line (SUTT) wire.

   The main parts of the transmission pole are composed of pole frames, travers, foundations and fuses. The mast frame is part of the pole to support electrical equipment which is generally made of steel, wood or concrete which is planned in such a way that it is strong against the forces acting due to the conductor's pull, wind and the gravity of the electrical material on the mast frame. Part of the transmission tower that is used for the attachment or isolator stand and the place of ground wire is called travers. The tensile strength of the travers is adjusted by the tensile strength of the pole which has been calculated so that it is strong against the tensile force of the phase conductor of the transmission line. The foundation consists of a concrete mortar or river stone structure or a mount that strengthens the pole stand. The volume of the foundation is planned in such a way as to be able to withstand the load of the bearing that works on the transmission tower. To strengthen the position of the pole and withstand the bending force that occurs at the pole due to the pulling force of the conductor, a chuck is used. According to its shape, this shell can be divided into two types, namely the line guy and the press brace.
2.2. Installation Wire
The types of conductive wire commonly used in transmission lines are copper with 100% conductivity (100% Cu), copper with a conductivity of 97.5% (Cu 97.5%) or aluminum with a conductivity of 61% (Al 61%)[5]. Various types of aluminum conductors can be known from the following symbols:

AAC "All-aluminum conductors", made entirely of aluminum
AAAC "All-aluminum-alloy conductors", made entirely of aluminum alloy
ACSR "Aluminum conductor, steel-reinforced", aluminum conductor reinforced with steel
ACAR "Aluminum conductor, alloy-reinforced", aluminum conductor reinforced with mixed metals

Each wire can be made from a single wire (fig 2.a, for small sections, up to 16 mm²), steel or wire wires (fig. 2.b, for sections of 10 mm² or more). Wires for air conduct are often made of aluminum because they are cheaper than copper. On the other hand, the type of aluminum resistance is greater, causing a greater voltage loss. Except that the tensile strength of aluminum is lower, so to enlarge this tensile strength is used a mixture of aluminum (aluminum alloy) and reinforced with a steel wire core in the middle (fig 2.c). This steel wire holds tensile strength when mounted on poles. Load current can be said to be large flowing on aluminum material on the outside. Although there is no insulation on the wire, this does not mean that there is no maximum current that can be carried through the wire. If the current is too large so the wire becomes hot, the tensile strength decreases. Even worse when it starts to melt(Solly Aryza, et al, 2017).

![Diagram of wire construction](image)

**Figures 2. Wire Construction**
For high voltage transmission channels, where the distance between two poles / towers is far (up to hundreds of meters), a higher tensile strength is needed. For this reason, ACSR conductor wire is used.

Table 1. Current distribution capacity for various air duct conveyors

| Types of deliveries | Flow Capacity at Circular Temperatures of 40 °C (A) | Maximum Temperature for Continuous Loading 90 °C | Maximum Tolerable Temperature 100 °C |
|---------------------|----------------------------------------------------|-----------------------------------------------|-------------------------------------|
|                     | Nominal size (mm²) | Maximum Temperature for Continuous Loading 90 °C | Maximum Tolerable Temperature 100 °C |
| Hard-Drawn Copper Stranded Cable | 200 | 660 | 740 |
|                     | 150 | 540 | 610 |
|                     | 100 | 420 | 470 |
|                     | 75  | 350 | 395 |
|                     | 55  | 290 | 320 |
|                     | 38  | 225 | 245 |
|                     | 22  | 160 | 175 |
| Aluminum Cable Steel Reinforced | 610 | 1070 | 1210 |
|                     | 520 | 960 | 1090 |
|                     | 410 | 840 | 940 |
|                     | 330 | 720 | 810 |
|                     | 240 | 600 | 670 |
|                     | 160 | 460 | 510 |
|                     | 120 | 390 | 440 |
| Hard-Drawn Aluminum Alloy Stranded Cable | 300 | 620 | 695 |
|                     | 240 | 535 | 600 |
|                     | 150 | 395 | 450 |
|                     | 100 | 310 | 345 |
|                     | 55  | 215 | 235 |
|                     | 38  | 165 | 185 |
| Hard-Drawn Aluminum Stranded Cable | 150 | 420 | 475 |
|                     | 100 | 330 | 365 |
|                     | 70  | 265 | 285 |
|                     | 55  | 230 | 250 |

3. Method of Research.
   A. Following are specific data on ACSR conductors used: 
   Type of Conductor: HAWK
   The actual cross section: 291.6 mm²
   Nominal delivery diameter: 21.8 mm
   Number of wires / diameters (in mm): 26 / 3.5 Al 7 / 2.75Stl
   Wire weight per unit length: 997.87 kg / km
Resistance (20 ° C): 0.2669 ohm / km
The nominal conductor voltage: 1800 kg
Elastic Modulus: 7700 kg / mm²
Coefficient of Expansion Length: 18.9 x 10^-6 / ° C

B. As the research material is SUTT 150 kV North Sumatra area on the Sigli-Banda Aceh line transmission using a HAWK ACSR conductor along 184 km.

Tools used:
one laptop unit Intel Core 2 Duo T5750 @ 2.00 GHz 2GB RAM and assisted by Matlab 6.1 software.

The course of research:
The stages of the implementation of this research are as follows:
1. Conduct simulation and calculation of HWK 240mm² ACSR conductor usage on 150 kV high voltage (SUTT) air line on Sigli-Banda Aceh route, by taking a tower sample that has the same high structure as a simulation. The parameters calculated are temperature, conductor tension, maximum conductor tensile stress, maximum and andongan angle conductor
2. Do the same for deliverers
3. The ACSR on the tower pole is not the same height.
4. Analysis of the results of calculations and comparing between the two deliverers (cable data analysis with actual installed in PLN).
5. Make conclusions from research results.

4. Analysis Result.
The research was carried out by calculating the temperature, the tensile stress of the conductor, the maximum conductor tensile stress, the maximum conductor and andongan angles due to changes in the
current flowing in the conductor wire using the Matlab.6.1 software to the HAWK 240mm2 type ACSR. The calculation of the HAWK 240mm2 type ACSR conductor with a diameter size that is close to the same as the actual ACSR conductor installed at PLN is carried out with the aim as a reference / comparator in the analysis. The method used in this study is to use the conductor temperature analysis equation, to obtain the relationship of current conductivity and conductor temperature. While to calculate the mechanical performance of the conductor includes the maximum conductor, the maximum type of conductor and andongan angle using the Catenary Equation method and the Basic Span Length method.

4.1. Conductor Temperature Analysis

![Graph of the relationship of the increase in channel current to the conductor temperature](image)

**Figures 4.** Graph of the relationship of the increase in channel current to the conductor temperature

The heat generated in the conductor is affected by temperature and heat by electricity losses as a result of the current flowing in the conductor. The calculation in this study is to use Hawk type ACSR conductors with specific data in accordance with those used in the field. It can be seen from the graph that the increase in channel current will be followed by an increase in temperature. If the maximum temperature permitted for this conductor is 90 ° C, the maximum current allowed to flow is 698.4 amperes.

4.2. Analysis Of The Influence Of The Channel Of The Channel Towards The Same Transmission Tower

Increasing the flow of the channel will result in a change in the size of the conductor. When the channel current increases, it results in a rise which then follows with an enlargement at the angle of the conductor. This can be seen in Figure 7 and Figure 8 below, which shows the graphs of the calculation of Andongan and the angle of the conductor. Taking into account the maximum permissible temperature limit for ACSR conductors of 90 ° C, the maximum load achieved is 13.1510 meters.
Changes in channel current also cause a decrease in the conductor voltage. This is because the increase in the current causes an increase in the conductor temperature, this increase in temperature causes expansion of the conductor which then increases the portion of the conductor. Increasing the load on this conductor causes the conductor voltage between transmission towers to decrease.

5. Conclusion.
1. An increase in the channel current results in an increase in the conductor temperature which is then followed by an increase in the value of the carriage and a hump angle and a decrease in the conductor voltage.
2. Taking into account the maximum permissible temperature limit for 240 mm2 HAWK type ACSR conductors of 90 °C, the following conclusions are obtained:
   • The maximum conductor line is 698.4 amperes.
   • The maximum conductor voltage is 906.9936 kg.
   • The maximum conductor piece is 13.1510 meters.
   • The maximum carriage angle is 4.9053 °.
3. Changes in the channel current of HAWK 240 mm2 ACSR type from 0 amperes to 750 amperes resulted in an increase in conductor temperature of 232.97%.
4. The size of the 240 mm2 HAWK ACSR conductor achieved at a temperature of 90 °C is 13.1510 meters. This result is different from the results of calculations carried out by PLN, which is 11.16 meters. The emergence of differences in the results of these calculations is caused by differences in the technical data of the conductor used because PLN uses a HAWK ACSR conductor 291.6 mm2.
5. With the increase of the HAWK 240 mm2 ACSR conductor from 13,0678 meters to 13,1626 meters, it can be seen that the extension of conductors becomes longer even though only 0.801%.

6. The increase in the channel current also results in a decrease in the conductor voltage. Based on a maximum temperature of 90 °C, the conductor voltage that occurs is 906,9936 kilograms. The results obtained are also different from the results of calculations carried out by PLN, which is equal to 1365 kilograms. This difference in results is caused by several things, including:
   • Calculations made by PLN are still in water or in conditions without the influence of wind.
   • The calculations made in this paper are on 240 mm2 HAWK ACSR conductors, while the calculations performed by PLN are on Hawk ACSR conductors 291.6 mm2.

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