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WPŁYW TEMPERATURY ŚREDNIEJ NA SŁOWACJI NA MAKSYMALNĄ WARTOŚĆ PRĄDU W PRZEWODNIKU

Streszczenie: System zasilania jest tworzony przez urządzenie do wytwarzania, transformacji, przesyłania i dystrybucji energii elektrycznej. W artykule opisano wyznaczenie maksymalnej dopuszczalnej wartości prądu przewodnika ACSR 680/73 na podstawie średniej temperatury na Słowacji. W niniejszym artykule opisano metodę wyznaczania maksymalnej dopuszczalnej wartości prądu dla przewodu ACSR 680/73, która obejmuje badanie oddziaływań środowiskowych, które mogą mieć wpływ na maksymalny dopuszczalny prąd dla przewodu ACSR 680/73.

Słowa kluczowe: Obciążalność linii energetycznych, maksymalnej dopuszczalnej wartości prądu, ACSR przewodnik, temperatury otoczenia

INFLUENCE OF AVERAGE TEMPERATURE IN SLOVAKIA ON THE MAXIMUM CURRENT VALUE OF THE CONDUCTOR

Summary: Power system is formed by a machine for generation, transformation, transmission and distribution of an electric energy. This paper describe determining maximum allowable current value of the conductor ACSR 680/73 based on the average temperature in Slovakia. In this paper is described a method for determining maximal allowable current value for conductor ACSR 680/73, which include the study of environmental impacts that may affect the maximum allowed current for ACSR 680/73 conductor.

Keywords: Ampacity of power lines, maximum permissible current value, ACSR conductor, ambient temperature

1. Introduction

Extensive development of renewable sources requires expansion of transmission capacity of power lines. Despite the fact that power lines are an integral part of the system but their expansion is in common interests.

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For these reasons, it is necessary to seek other means of safeguarding the power transmission system. One possibility is using operational methods which we monitor the temperature of the electrical wire and ambient influences. These indicate the actual permissible current.
To determine the allowable current of the conductor is necessary to determine all factors influencing temperature of the conductor. Subsequent calculation can be determined at any given time under the conditions of maximum load capacity.

2. Construction of ultra high voltage power lines

In practical terms, for the line of 400 kV voltage level are used trunked conductors where one phase consists of three conductors each technically and electrically connected at a distance, thereby enhanced radius of the conductor of one phase [1].
As conductors of transmission lines are used aluminum cables with steel core. Their advantage is greater mechanical strength, that allows cable to be used for long distance. Among their other advantages include greater flexibility, more uniform structure. Material error may degrade the entire wire, but using ACSR ropes, breaking of one wire will not damage the entire conductor [1].
The conductor may also include an optical fiber to provide device communication [1].
Parameters of the examined conductor are in the table below.

Table 1 Parameters of the examined conductor [4]

Parameters	ACSR 680/73
Rope diameter (mm)	35,8
Rope cross-section (mm2)	761,69
Nominal weight (kg.km-1)	2556,12
Specific gravity (MN.m-3)	0,03291
The maximum permissible stresses (MPa)	93,072
Elastic modulus (MPa)	69447
The coefficient of thermal expansion (1/°C)	19,46
Rated DC resistance (Ω/km)	0,0433

3. Powerline ampacity system

Conductor ampacity is defined as the maximum permissible load current, which can transmit the conductor without compromising its function. This distortion is mainly caused by exceeding the maximum permissible temperature [2].
The ampacity depends on the electrical and mechanical properties of the conductor material, thermal insulation properties (the cables), ability to dissipate within the conductor generated and received from nearby heat, ambient weather conditions [2].
It is therefore apparent that the ampacity is mainly influenced by the thermal condition of the conductors, because it determines the elongation conductors and therefore sag of power line over the terrain. In determining the maximum transmission capacity we use a method that is based from thermal equilibrium between the conductors and the environment [3]. At steady state (1) can be expressed as equality heat gain = heat loss [4][5].

$$P_J + P_M + P_S + P_i = P_C + P_r + P_W \quad (1)$$

where:

P_J is heat losses in the conductor (W),

P_M is magnetic heating of magnetic field variations AC (W),

P_S is solar radiation (W),

P_i is heating from the corona (W),

P_C is cooling by heat convection (W),

P_r is radiant cooling (W),

P_W is cooling from water evaporation (W) [4] [5].

Power lines designed by the current applicable standard EN 50341 are controlled by the designed maximum conductor temperature within the project documentation. Recommended temperature of conductor is 70 ° C. If it is the highest phase current conductor, it is possible to calculate the actual temperature conductor [6] [7].

The calculation is performed for the following conditions:

- the current conductor is the highest loaded,
- the ambient temperature is 35° C,
- wind speed is 0.5 m/s at 45° angle of impact,
- global temperature solar radiation is 1000W/m^2,
- absorption coefficient is 0.5,
- emissivity coefficient is 0.5.

4. Effects of environmental conditions on the actual current ampacity of power lines

The Slovak Republic belongs to the northern temperate climatic zone with regular alternation of the seasons with an even distribution of rainfall during the year. The climate is influenced by the prevailing western airflow that brings wet ocean air of moderate zones. It moderates temperature amplitude of day and year and brings atmospheric precipitation. Continental air of moderate zones brings warm, sunny and less humid summers and cold winters with low rainfall [8].

The air temperature is the major climatic factor, as well as the main factor affecting the actual current load of conductor.

In a long-term measurement of air temperature in the region of Slovakia warmest zone is Danubian lowland with average air temperature in January -1 to -2 °C, in the month of July 18 to 21 °C. The annual average of this area is in the range of 9-11 °C. The Eastern plains, the average temperature is slightly lower. The basins and valleys of is average annual air temperature 6-8 °C. In the upstream basins below 6°C. For the altitude of 1000 meters above sea level average value reaches the interval 4-5°C, at a height of 2000 meters above sea level around -1°C. The average temperature during the months of June to August is shown in Figure 1 and during the months of December to February is shown in Figure 2

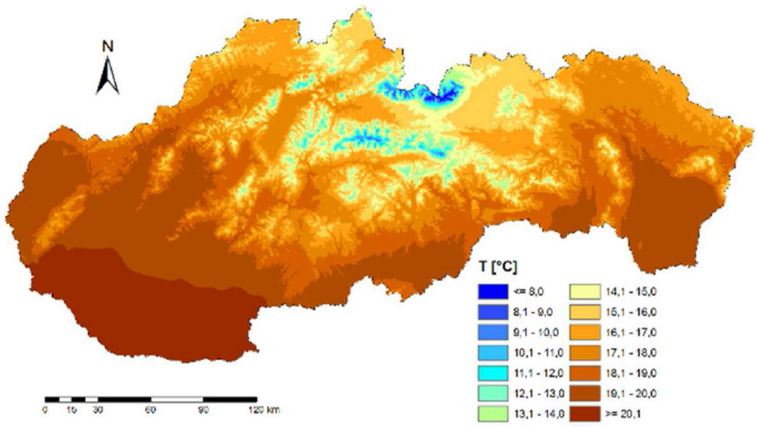

Figure 1 Average air temperature from June to August [8]

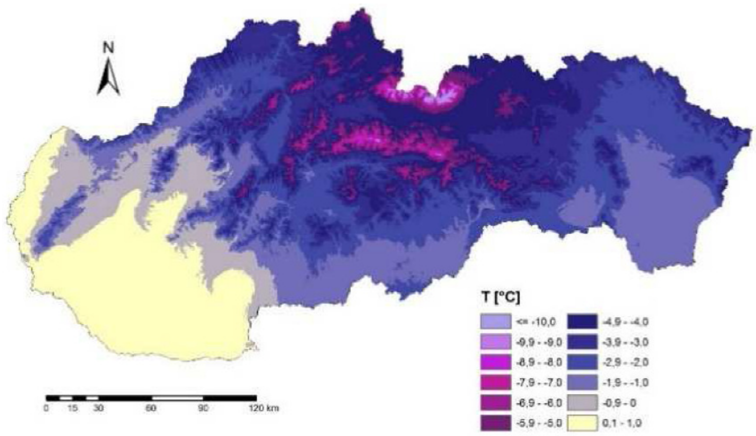

Figure 2 Average temperature from December to February [8]

To determine impact of natural radiation to the maximum allowable current capacity of conductor we use average temperature for summer season (Figure 1) and winter season (Figure 2).

As is shown in the Figure 3 and Figure 4, current capacity given by a calculation accordance to the ambient conditions intended by a standard is 632,02 A for the one conductor in three beam connections (Red line). In terms of size of current capacity in the summer season, there is a decrease current value from 902,30 A to 795,50 A. For the winter season, there was a decrease of current capacity from 1038,09 A to 965,50 A.

As we see from the Figure 3, for ambient temperature 8°C is current capacity value higher against the current capacity given by a standard about 42,78%. Due to an increase of ambient temperature to 20°C occur a change in difference between current

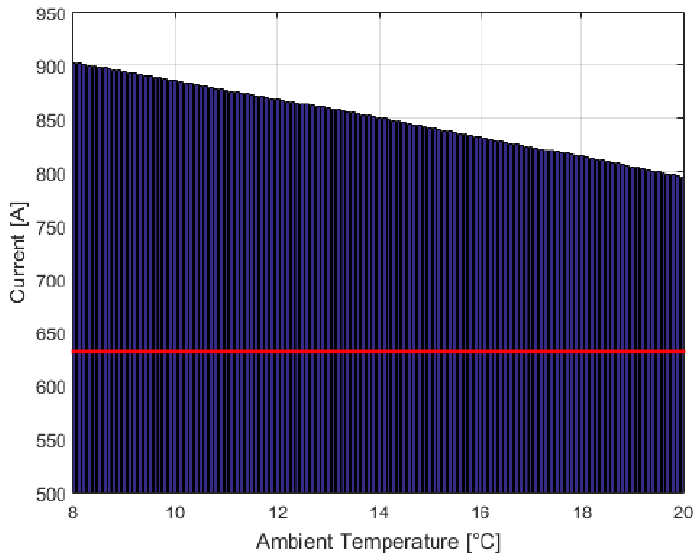

Figure 3 Comparing resulting current capacity based on the average temperature in summer season

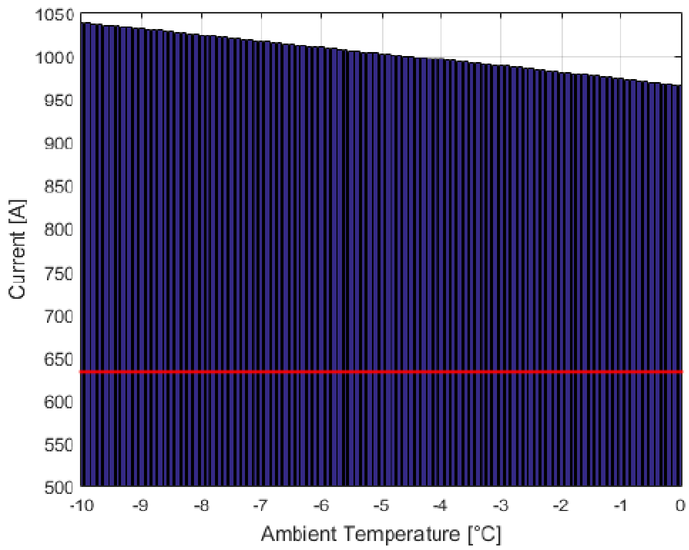

Figure 4 Comparing resulting current capacity based on the average temperature in winter season

At a lower temperature an increase of current capacity occurred. For average ambient temperature in Slovakia conditions -10°C was current value equal to 1038,09 A what is higher compared to the current value given by a calculation with ambient conditions accordance a standard about 64,29%.

In the second point of examining range 0°C is current capacity equal to 965,50 A, what is about 52,80% higher than current value given by a calculation with ambient conditions accordance a standard.

5. Conclusion

Power lines are the most important part of power systems. Their role is not substitutable and their construction determines the size of the current capacity. As every construction of electricity facilities is subject to the standard, also construction of power lines and design is subject of standard. Current capacity of the conductors depends also on ambient conditions, which are described in standard EN 50341. These ambient conditions are given for the worse case that can occur. As it is known these ambient conditions or their combination are very rare in nature.

This article described method to determining the current capacity for ACSR conductor 680/73 in accordance with the average ambient conditions in Slovakia. Results show that ambient conditions have essential influence on the actual value of current capacity. If we can accurately determine the ambient conditions in real time, we can determine the current capacity under these terms and adapt operation of power system or power lines.

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