Study Committee B2

Overhead Lines

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Plastically compacted steel - aluminium wires for new overhead lines

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Motivation

- Due to the increase in energy consumption in large cities and regions, shift of the maximum consumption of electrical power for the period of maximum temperatures (the period of the decrease in throughput)there is often a problem of insufficient capacity of power transmission lines.
- Paper discusses the problems associated with the use of new solutions related to the use of high-temperature wires of a new design for high-voltage power transmission lines 35-750kV, installation methods, standardization and calculation of operational efficiency. The main part of the research is connected with plastically compressed wires for high-voltage power transmission lines with the analysis of power and energy losses as well as corona losses due to streamer discharge, aerodynamic and ice loads, and the example of the design and construction of a new 6 kV transmission line with a capacity of 6 MW are presented.

Method/Approach

- Steel-aluminum plastically compacted overhead wires have an almost smooth outer surface and are manufactured using modern competitive technology, in terms of the cost of the final product. Plastically compressed conductors have a number of advantages that are usually characteristic of more expensive conductors made of profiled wires. Such advantages are the reduction of vibration loads and self-damping of vibrations. Intensive ice formation leads to icy loads of 6-750 kV overhead transmission lines and is one of the urgent problems of the electric power industry in countries with appropriate weather conditions. Due to the almost smooth outer surface, close to the conductors of segmented Ω- and Z-shaped aluminum wires, vibration and galloping of the conductors, as well as ice coating can be reduced. At the same time, high-strength conductors ASHS conductors have greater torsional rigidity, lower probability of galloping, increased vibration resistance and self-extinguishing ability even compared to conductors made of segmented Ω- and Z-shaped aluminum wires, since high-strength conductors have a developed contact surface of adjacent wires not only inside one layer of wires, but also between layers. Plastic deformation of conductors not only significantly increases the mechanical strength, but also reduces the elongation several times during operation.

Objects of investigation

- Results of the design and construction of a new 6 kV transmission line with a capacity of 6 MW

Experimental setup & test results

Name and designation of the parameter	Numerical value		
	ASCR-120/19	ASHS-128/36	ASHT-128/36
Reference linear active resistance at 20 °C, r_{20}, Ohms/km	0,249	0,225	0,2282
Linear active resistance at 0°C r_0, Ohms/km	0,22908	0,207	0,20994
Wire diameter dw,м	0,0152	0,0152	0,0152
Permissible temperature $\Theta perm$,°C	90	90	150
Ambient temperature Θamb,°C	40	40	40
Maximum permissible current $Iperm$, A	302	318,62	624,95

Discussion

- Calculation of limit currents at temperatures below 45°C is produced without taking into account the influence of solar radiation. Absorbed solar radiation in the middle latitudes can heat conductors by 2-3 °C, for conductors operating in the temperature range of 60-70 °C and above. In southern latitudes, standard wires operate in emergency mode even without loading. The ASHT wire is able to withstand a large load under equal environmental conditions compared to the ASCR wire. The difference in the permissible load for the compared high-temperature conductors to 100%. The high-temperature wire provides a reserve of throughput and its specified values when heated, without requiring an increase in cross section.

Conclusion

- This paper also shows the use of compacted wire when it is necessary to significantly increase the throughput without increasing the cross-section. Plastic deformation maximizes space filling with minimal cost.
- Plastic deformation of wires not only significantly increases the mechanical strength, but also reduces the elongation several times during operation. Due to its design features, the high-temperature ASHT wires is several times cheaper than analogues with a long-term permissible temperature of 150 °C.

Study Committee B2

Overhead Lines

10362_2022

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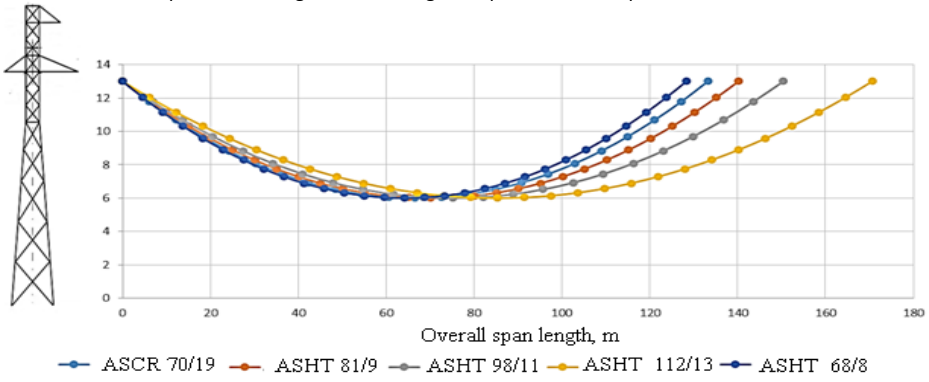
Comparative analysis of the overall spans of wires for overhead lines 6-35kV

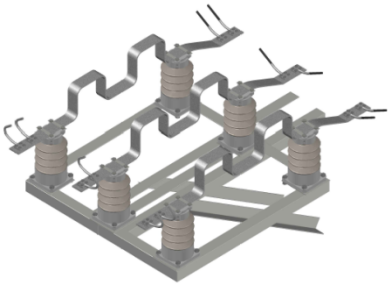
Plastic deformation of wires not only significantly increases the mechanical strength, but also reduces the elongation several times during operation. Due to its design features, the high-temperature ASHT wires is several times cheaper than analogues with a long-term permissible temperature of 150 °C.



Results of the design and construction of a new 6 kV transmission line with a capacity of 6 MW

- The power supply of the facility with a capacity of 6 MW was completed in 2021 by the construction of two 6 kV power transmission lines in the Volgograd Region of Russian Federation. As a result of a technical and economic comparison, a high-temperature wire ASHT 150/23 was chosen.
- This new technical solution significantly reduced costs

Specially designed device for connecting a high-temperature wire and a cable



Study Committee B2

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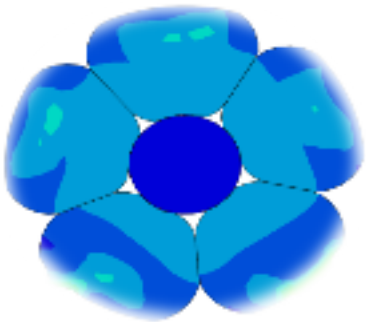
Plastically compacted steel - aluminium wires for new overhead lines continued

An example of an effective alternative to standard ASCR in new construction ASHS and ASHT 128/36 and reconstruction 112/13+ overhead lines

Wire	Breakingload, kN	Max. tensile, daN	CrosssectionAl, mm2	R,for 20˚C, Ом/км	Iperm, A (ASCR, ASHS)	Iperm, A (ASHS)	Ø. mm	Weight 1 km, kg	Spanlength, m
ASCR 120/19	**41,5**	**1868,4**	**118**	**0,244**	**418**	-	**15,20**	**471,0**	**299**
ASHS(T) 112/13+	**41,9**	**1970,2**	**123,09**	**0,234**	**453**	**613**	**13,50**	**433,4**	**312**
ASHS(T) 128/36	**77,1**	**3456,7**	**128**	**0,225**	**493**	**669**	**15,20**	**645,9**	**384**
ASHS(T) 98/11	31,4	1413,4	98,17	0,293	392	531	12,60	354,0	272
ANHS 118,55 6101 T4-290	33,9	1524,6	118,55	0,274	487	-	13,00	330,7	284



Option with a plus tolerance for the diameter of aluminum wires

- The permissible temperature for compacted wires of 150 °C is the dependence of the permissible current load on the air temperature for ASCR and ASHT wires under conditions of maximum operating temperature is 80 °C and 150 °C, respectively. The continuous permissible current for a high-temperature wire is 30-35% higher than the value for a standard wire of the same diameter.
- The breaking force of the core, if necessary, can be changed, in agreement with the customer. Greater compression does not lead to a change in the design and diameter, nor to excessive stresses and deformations of the elements.

Conclusion

- researched wires in the new construction or reconstruction of overhead lines with the use of high-capacity wires allows you to provide a reserve of current load. use bullet points with clear statements.
- The increase in the carrying capacity of the wires is provided by their higher operating temperature compared to conventional steel-aluminum wires.
- Due to increased resistance to temperatures above 100 °C, wires can carry a higher current load under normal conditions.
- The use of plastically compressed conductors is justified for the case with high ambient temperatures.
- In turn, the resulting effect in reducing technical losses allows us to talk, among other things, about decarburization and reduction of the carbon footprint, since it is required to produce less electricity in order to compensate for technical losses in electrical networks and as a result, emissions into the environment are reduced.
- The complex correct use of plastically compressed wires during the construction of new 6-750 kV overhead lines can significantly increase their reliability when exposed to the entire range of climatic loads, increase throughput, and reduce final capital costs.
- In conditions of shifting load peaks to the summer, the use of high-temperature wire ensures the stability of the power system without increasing costs.