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Automatic regulation of overhead power line wires' sag in wide temperature range

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Overhead power line wires increase their length when heated by increasing environmental temperature or increasing power load. The distance between the wire and the ground or some object under the power line is critical, and it is regulated because of safety concerns. It is possible to reduce the height of the power line towers or increase the distance between them without violating safety norms by using devices for compensation of overhead power line wires' sag (thermal compensators). These devices contain a temperature sensitive element (or several elements) with the shape memory effect and are made of shape memory alloys, such as nitinol. These elements deform – change their shape to some predetermined shape when heated to a certain temperature and create mechanical influence on the wire, tightening it and thus reducing its sag. Some thermal compensators work by environmental heating, others by Joule heating and some by a combination of these factors. Thermal compensators which work by Joule heating usually activate not directly (not using the whole amount of current which flows through the wire). Such thermal compensators (their thermal sensitive element(s)) conduct only a part of the current which flows through the wire. This can be achieved by using ferromagnetic elements or by using thermal compensators with specific designs which conduct some noticeable amount of the current, but they require cutting of the wire, which is not desirable. When the temperature of the thermal compensator (its temperature sensitive element(s)) becomes close to the point of its activation, the mechanical influence on the wire begins to emerge, and when the temperature reaches the point of activation, the mechanical influence becomes the greatest and does not increase further. This is an important functional limitation of such devices – they work in a relatively thin temperature range. One possible way to overcome this limitation is to use several thermal compensators with different activation temperatures installed in one span (fig. 1) which do not require cutting of the wire (for minimal influence on the reliability of the power line), for example, prototype [1] or [2]. For the best functionality, thermal compensators used for such an application should be sensitive to both the current of the power line and the temperature of the environment.

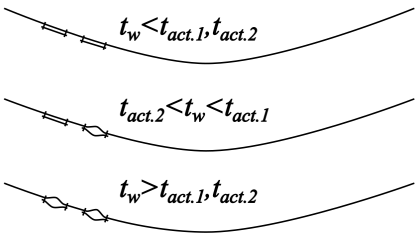

Fig. 1. Overhead power line wire with two thermal compensators with different activation temperatures (t_{act1}, t_{act2}) shown for 3 different temperatures of the wire (t_w)

By utilizing the above-mentioned principle of placement of thermal compensators, we can achieve such a mechanical influence on the power line's wire, which covers a wider range of possible temperatures which require compensation of the wire's elongation (which is caused by the Joule heating and the influence of the environment). The thermal compensators with different activation temperatures should be installed in each span of the power line. The activation temperature points should have enough distance between each other to adequately increase the overall compestation ability of the wire's elongation. The desirable resulting effect is shown on the following figure.

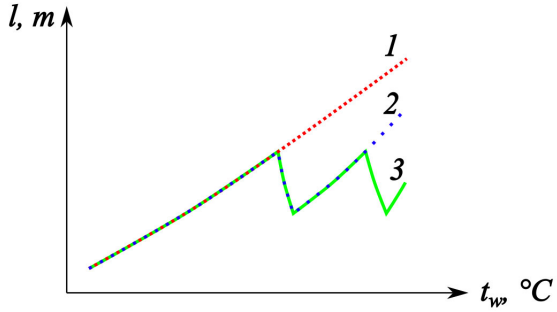

Fig. 2. Approximate graph of the power line wire's sag dependence on the temperature without and with thermal compensators installed

Fig. 2 shows the approximate graph of the power line wire's sag in one span of the power line (*l, m*) dependence on the temperature of the wire (t_w, °*C*) without (1) and with thermal compensators installed in different configurations: 2 – the wire with one thermal compensator, 3 – the wire with two thermal compensators which have different activation temperatures.

We can conclude that by using several thermal compensators with different activation temperatures, it is possible to cover a wider temperature range of the power line operation. At the same time, by using thermal compensators which do not require cutting of the wire, it is possible to minimize negative influence on the power line, such as reducing its reliability by the emergence of new connection points on the wire in places where it was cut. In order to achieve adequate response to the main factors which cause the wire's temperature to increase (environmental influence and Joule heating), thermal compensators which are sensitive to both of these factors should be used.

References

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