VERIFICATION OF TRADITIONAL CLAMP SYSTEMS WITH "HTLS" CONDUCTORS - LABORATORY TESTS

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ABSTRACT

The utilization of high temperature – low sag conductors (HTLS conductors) is being considered as a solution to the congestion problems existing in certain transmission and distribution lines of the Spanish electric network. However, prior to their utilization by the replacement of the traditional ACSR, AAC, AAAC conductors by HTLS conductors, it is necessary to determine their impact in the transmission and distribution network. Taking into account that the main difference between both conductors is that HTLS conductors can work at higher temperatures in comparison to ACSR conductors, the principal objective of the study is to determine how this higher temperature might affect the performance of clamp systems.

CONDUCTORS AND CLAMP SYSTEMS

HTLS conductors can work at higher temperatures than traditional ACSR conductors without either increasing the conductor sag or being necessary the modification of support structures. There are different types of HTLS conductors: ACCS, ZTACIR, GTACSR, ACCR, etc. Depending on the conductor type, its rated tensile strength may be equal or higher than the one of ACSR conductors, being its maximum continuous working temperature between 150 and 210º C. This fact allows to carry between 1.6 and 2 times higher currents in overhead lines with HTLS conductors with the same external diameter as ACSR conductors, being unnecessary to modify either clamp systems or support structures. It must be only determined whether the high temperature of the new conductors has a negative effect on traditional clamp systems.

The clamp systems are the metallic pieces that hold up and/or tie up the conductors in overhead lines, joining the conductor with the insulator string. The purpose of the insulator is to avoid the circulation of electrical current from the conductor to the tower. The dielectric behaviour of insulating material is only stable for a given range of temperatures, and according to the information provided by international insulator manufacturers, these elements work correctly with temperatures under 100º C. In the Spanish grid this limit is never achieved with ACSR conductors, because these work up to a maximum temperature of 85º C. However, HTLS conductors are able to reach temperatures of approximately 200º C. Consequently, if HTLS conductors are to be used, it becomes essential to know the temperature distribution along the clamp system, and particularly, the temperature reached by the insulator string.

The clamp systems identified and analysed, are the single string for single conductor in the suspension case, Figure 1, and in the compression case, Figure 2.

DESCRIPTION OF THE LABORATORY TEST

As a previous step to the laboratory tests, different computer simulations using theoretic models were developed, with the purpose of calculating approximately the temperature distribution in the clamp systems. The materials used in the fabrication of each element of the system are: aluminium alloy in the element of the suspension system in contact with the conductor, cement to keep together the different parts of the insulator, glass in the insulator’s dish and steel in the rest of elements. In thermal terms, the parameters needed to define each material of the clamp systems are included in
Table 1.

TABLE 1 - Thermal parameters.

<table>
<thead>
<tr>
<th>Material</th>
<th>Mass density (Kg/m³)</th>
<th>Thermal conductivity (W/m*K)</th>
<th>Specific heat (J/Kg*K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>2700</td>
<td>200</td>
<td>900</td>
</tr>
<tr>
<td>Steel</td>
<td>7760</td>
<td>50</td>
<td>460</td>
</tr>
<tr>
<td>Cement</td>
<td>2000</td>
<td>0.8</td>
<td>1090</td>
</tr>
<tr>
<td>Glass</td>
<td>2460</td>
<td>0.75</td>
<td>834.6</td>
</tr>
</tbody>
</table>

Once the theoretic models have been adjusted and safety gaps have been established, the laboratory test can be developed.

FIGURE 3 - Laboratory test.

The test consists in connecting 8 meters of HTLS conductor, held up by means of a clamp system to the terminals of a current source, as it is shown in Figure 3. The diagram of the laboratory test is shown in Figure 4. The current source supplies enough power to increase the conductor temperature until the maximum continuous working temperature of the conductor is reached. Simultaneously, by means of thermocouples, the temperature in different points of the clamp system is measured, as shown in Figure 5.

FIGURE 4 - Laboratory test diagram

FIGURE 5 - Thermal sensors in the suspension system

SUSPENSION SYSTEM. LABORATORY TEST

The purpose of the laboratory test is to check if the high temperature of the conductor can increase the temperature of the insulator’s cement to values higher than its critical temperature, of about 100º C.

During the laboratory test electrical power is supplied to the HTLS conductor and, once the stabilization is achieved, the thermocouples set in different points of the clamp system, indicated in Figure 6, provide the temperature value reached at those points. Table 2 shows the results obtained in the laboratory test, as well as the ones previously predicted in the simulations. The test conditions were: no sun, no wind, an ambient temperature value of 23º C, and a conductor temperature of 200º C.

FIGURE 6 - Measuring points in the suspension system

TABLE 2 - Results in suspension system.
The results reveal that, in the case of a conductor temperature of 200º C, cement temperature in the first insulator is 20º C higher than ambient temperature.

Also, it can be observed that the conductor temperature decreases in the proximity of the clamp system. The reasons are the higher surface in contact the air in the proximity of suspension clamps and the decrease of Joule effect.

**COMPRESSION SYSTEM. LABORATORY TEST**

To check if the high temperature of the conductor might generate any problem in the insulator string of a compression system, the temperature it has only been measured in the compression clamp and not in the insulator and the ball socket because, taking into account the results obtained for the suspension system, it was considered that it was not probable for those elements to reach critical temperatures.

HTLS conductors normally use compression clamps with higher section than those used with traditional conductors because these new conductors carry a higher electric power. However, the laboratory test was developed with normal compression clamps, as it was considered a more unfavourable situation, since a smaller section causes a stronger Joule effect, and the reduction in peripheral surface leads to a lower heat dissipation. Figure 7 shows the thermocouples in the compression system and Figure 8 the temperature measuring points.

The results of the laboratory test, and the ones obtained in the simulations, are shown in Table 3. As in the other case, the test conditions were: no sun, no wind, an ambient temperature value of 23º C, and a conductor temperature of 200º C.

Despite the smaller size of the tested compression clamp compared to the one recommended by HTLS conductor manufacturers, these results show the effect of heat dissipation in the clamp, decreasing the conductor temperature near the clamp as well as the temperature of the clamp body as the distance to the conductor increases. That means that the dissipation of heat is greater than the one produced by means of the Joule effect.

**TABLE 3 - Results in compression system.**

<table>
<thead>
<tr>
<th>Component</th>
<th>Simulation temperature (º C)</th>
<th>Laboratory test temperature (º C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N0</td>
<td>---</td>
<td>200</td>
</tr>
<tr>
<td>N 1</td>
<td>128</td>
<td>132</td>
</tr>
<tr>
<td>N 2</td>
<td>112</td>
<td>117</td>
</tr>
<tr>
<td>N 3</td>
<td>95</td>
<td>99</td>
</tr>
<tr>
<td>N 4</td>
<td>90</td>
<td>93</td>
</tr>
<tr>
<td>N 5</td>
<td>106</td>
<td>111</td>
</tr>
<tr>
<td>N 6</td>
<td>120</td>
<td>126</td>
</tr>
<tr>
<td>N 7</td>
<td>131</td>
<td>135</td>
</tr>
</tbody>
</table>

It has observed that the temperature on the limit of the ball socket is about 70º C. Taking into account that this temperature is lower than in the case of the suspension system, it can be ensured that the first insulator temperature in the compression system is lower than the one reached by this same element in the suspension system.

As in the suspension system, the conductor temperature decreases in the proximity to the clamp system. But in this case the effect is stronger because the electrical resistance of the clamp is lower than in the case of the suspension system.

**CONCLUSIONS**

Relating to the comparison between theoretical and test results it can be stated that the models represent the system’s
real behaviour with high reliability, as both results differ from each other by 5%.

On the other hand, it has been checked that in both cases the conductor temperature decreases in the proximity to the clamp.

With a conductor temperature of 200º C, the temperature of the clamps and insulators is between the thermal limits established for its correct performance.

In conclusion, it can be considered that the current clamp systems and insulators are totally compatible with the use of HTLS conductors.

REFERENCES


ACKNOWLEDGMENTS

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