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Technical paper

Corrosion Study of Galvanized Ultra High Strength Steel Reinforced Overhead Transmission Conductors

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Abstract

Overhead high voltage transmission conductors used worldwide are produced in several configurations. A multi-strand conductor of the type ACSR330 is typically used for 275 kV overhead transmission lines. The conductor is composed of 7 inner strands of Ultra High Strength Galvanized Steel for the mechanical support of the conductor and 26 strands of high conductivity Aluminum wires meant for power transfer over long distances. During the use, weather conditions and power fluctuations tend to degrade the properties of these conductors. In the present work, study of the state of galvanization and oxidation of an ACSR330 conductor is undertaken with a view to understand the effectiveness of the loss in corrosion protection and changes in the zinc coating on the galvanized steel strands after use for 25 to 30 years. The Scanning Electron Microscopy (SEM), X Ray Diffraction (XRD) and Energy Dispersive Analysis through X rays (EDAX) provide a very useful insight into the state of the conductor and gives important information to the strategic decision maker, whether or not to replace the conductor. It was observed in the present study that the zinc coating diffuses inside the steel strand under temperature and time effect. This unique study on the used conductors also reveals that the morphology of the coating and its interface structure changes significantly compared to an unused conductor of the same age.

Keywords: *Corrosion; Ultra High Strength Steel; Galvanization; Overhead Transmission Conductors.*

1. Introduction

The conductors used in high voltage transmission lines comprise of 20% to 30% of the total cost of the transmission line and pose as the critical part of the transmission line in terms of performance, useful life security and safety issues (Thrash R. *et al* 2007). Selection of the best conductor for a transmission line depends on several factors such as power requirements, terrain, ambient conditions, cost of conductor, supporting structure, governmental and environmental constraints. The most common types of overhead conductors are either composed of aluminum alloy strands wrapped around each other, e.g, All Aluminum Conductor (AAC) or All Aluminum Alloy Conductor (AAAC) or they are composed of Steel Reinforced Aluminum Strands (ACSR). The steel wire strand used to reinforce the conductor is typically composed of a high strength steel coated with zinc to provide a good corrosion resistance but possess poor conductivity. Over the years the high strength steel has been replaced by the ultra-high strength steel and the corrosion protection is enhanced by placing these strands at the inside of the conductor. Special grease is also used to avoid any water penetration towards these steel strands. The construction of an ACSR330 conductor which was investigated in this work is presented in Figure 1 and its properties are given in Table 1.

As can be understood, the integrity of the inner steel core wires is critical for the functioning of the conductor, which bear the weight of the conductor. These steel wires are galvanized and covered with grease for double protection against corrosion. Other major phenomena which can affect the properties of these steel wires is creep due to high temperature during the full loading and time effect. This can also create a longterm annealing effect which has been studied by other researchers (Hou X. *et al* 2013). ACSR type conductors' deterioration as a function of temperature is also studied by researchers (Lee D. D. *et al*, 2016, Lee D. D. *et al* 2011) where they discussed this problem under high heat conditions such as when forest fires take place in the vicinity of the high voltage lines. They reported that the galvanized steel wires faced melting of the surface zinc layer and eventually corrosion took place through atmosphere. Corrosion of galvanized steel wires for overhead high voltage conductors has also been a subject of investigation by researchers (Zhang J. K. *et al* 2010, Schwabe P. H., Pike D. 1988, Lyon S. B. *et al,* 1987). In their research, laboratory scale tests under accelerated environment containing NaCl solutions were conducted. The corrosion mechanism was found to be a mixed mode, including pitting, crevice and galvanic corrosion. Presence of sulphate ions in addition to the chloride ions in the environment is also observed to be a source of accelerated corrosion.