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Fretting Fatigue Phenomena on an all Aluminium Alloy Conductor

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Abstract This paper concerns about a failure analysis of an electric all aluminum alloy conductor (AAAC) damaged and broken for fretting fatigue phenomena induced by aeolian vibrations.
Life of electric conductors is often reduced by various degradation mechanisms such as repeated bending, fluctuating tension, distortion, fatigue, wear and corrosion phenomena. However the main limiting factor of the electrical conductors is related to aeolian vibrations in the high frequency range (between 5 to 50 Hz). Conductor oscillations may lead to fretting fatigue problems (otherwise called fretting wear) caused by wind excitation, mainly in the suspension clamp regions, spacers or other fittings. The induced aluminium wire fracture imply a drastic reduction in the transmission line service. Vibration dampers are considered the most effective method to extend service life of electric conductors, as they are the means to reduce fretting damage of aluminium wires.
The aim of the present work is to investigate the failure of an AAAC conductor of a 400kV overhead transmission line (twin conductors) located in Touggourt Biskra (Algeria); the damaged and broken conductors were operated in-service only for six months without spacers or dampers.
Three different types of conductors have been taken as experimental samples: the in-service broken conductor, another in-service damaged conductor and a new conductor from warehouse as terms of comparison. Samples have been analysed to identify the root cause of the failure and to verify the conformity of the conductor elements to the international standards. The investigation has outlined the morphology of the fretting damage: in all cases the fractured wires have shown typical static deformation marks and dynamic fretting wear tangential marks associated with intense presence of Al_2O_3 debris.

Introduction

Overhead electrical conductors consists of many wires twisted together to make a complex structure combining axial strength and stiffness with flexibility in bending [1]. It is well known in the electrical power industry that wind vibrations are first damage cause of conductors. Because of aeolian vibrations, overhead transmission line service life is often drastically reduced. Wind vortex produce up and down oscillations in the high frequency range (between 5 to 50 Hz) increasing up to the resonance frequency of cable [2-3]: it causes alternating bending stresses in cable strands and it leads to fretting fatigue/wear phenomena among cable wires above all in the suspension clamp regions, spacers or other fittings. This damage leads to partial or complete failure of the overhead transmission line [2-4].

Fretting fatigue phenomena

Fretting fatigue damage occurs when two contacting wire surfaces are subjected to a normal clamping force and they undergo a relative movement on the two surfaces due to a cyclic tangential shearing. Fretting damage causes formation of microscopic elliptical marks on the wire surfaces and it produces particle debris that originate from chemical reaction between the abraded surface substances and the external environment. The oxidation products consist of blackish aluminium oxide - Al_2O_3. From fretting wear zones sometime originate fretting-fatigue phenomena due to the applied axial forces [5]. Fretting fatigue phenomena are influenced by many parameters: wideness of oscillations, value and distribution of contact pressure, type of wire material, condition of contact