Experimental study and modelling of fretting-fatigue-corrosion of galvanised steel in power lines.

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Abstract

Electrification and energy transition is challenging all the Transmission System Operators (TSO) with a significant increase demand for electrical energy. RTE is the French TSO responsible for trading electricity with its European neighbors and operating and maintaining the French grid. Electricity is partly transmitted by overhead conductors (unburied lines supported by pylons). At present, the lines are designed to be renewed after 85 years of service, which implies major renewals by 2030-2035. RTE is therefore seeking to develop tools within its R&D asset management department to prioritize the replacement of lines. ACSR (Aluminium Conductor Steel Reinforced) cables are one of the cable technologies used to transport electricity. They are constituted of galvanized steel strands in the core and aluminium strands around the edge to ensure good mechanical properties and electrical conductivity respectively. The strands are subject to fatigue due to their own weight and the action of the wind. In addition, this assembly allows slight relative movement between the wires, resulting in fretting within the conductor. The combination of these mechanical loadings, known as fretting-fatigue, induces cracking and wear and is particularly critical compared to fatigue alone. Finally, since the cable is not insulated from the environment, rain and condensation induce the presence of water in the conductor, inducing corrosion. The aim of this study is to characterise the effect of fretting-fatigue-corrosion on the conductor strands near suspension clamps (critic zones). Another, objective is to observe the influence of the aqueous environment on the corrosion products in a contact or on crack propagation. The development of a fretting-fatigue-corrosion test rig was a part of this thesis. In order to apply representative loadings and lead the tests parameters, a so-called 'global' finite element simulation of a clamp/conductor system was carried out. It models one meter of a 51 wire strand. The contacts in the strand at the exit of the clamp are detected and the forces are extracted for each wire. This post-processing provides a distribution of the

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contact parameters in the strand. With these results, fretting-fatigue tests on steel-steel contacts in ambient atmosphere and fretting-fatigue-corrosion tests in salt solution are carried out to understand the effect of mechanical loading (normal force, displacement amplitude, fatigue stress...) and atmospheric parameters on the lifetime of a contact (frequency effect, solution...). The evolution of the galvanized layer in the contact is also observed. All these data are used to install a 'local' modelling of a single contact which is representative of the specimen in the test bench. This modelling is based on a finite element model combined with post-processing using a non-local approach and multiaxial fatigue criteria. The purpose of this model is to estimate the lifetime of a contact in a conductor.