Experimental Characterization and Numerical Modelling of Wire Rope Isolators

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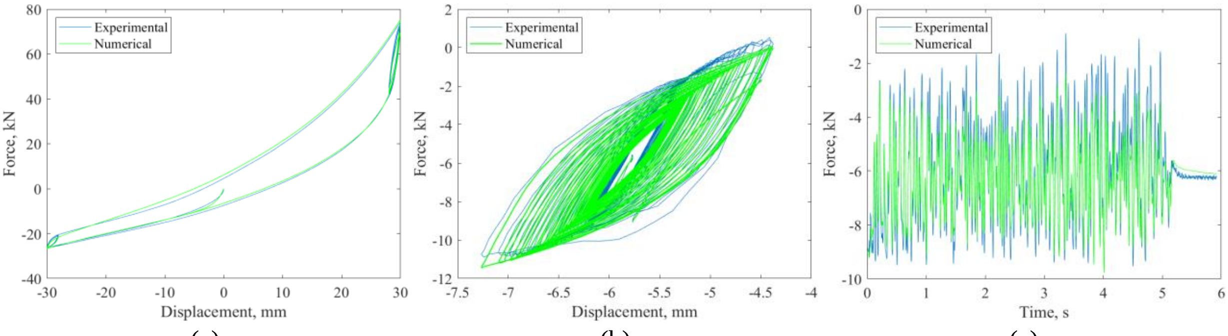
Abstract. The following paper presents a systematic procedure to achieve the experimental characterization of wire rope isolators. Additionally, an innovative development of the Bouc-Wen model is proposed to improve the fitting between experimental and numerical data. The proposed model is then validated through independent sinusoidal and random vibration tests to demonstrate the capabilities of the model in describing the physical non-linear phenomena, such as hysteresis cycles.

Introduction

Wire rope isolators (WRI) are non-linear devices which are commonly used to isolate vibration both during transportation and operation of machineries [1]. Their hysteretic behaviour produces a relevant damping factor, which guarantees a good isolation performance without the need of further dampers. Nevertheless, the conventional linear spring-damper model is not able to describe the actual component behaviour, so that it cannot be used at design stage. Additionally, mechanical properties provided by the manufacturers are generally partial, ambiguous, not rigorous and limited to equivalent stiffness and damping coefficients. These parameters are generally good to predict the quasi-static behaviour of the spring, such as the deflection under the applied weight. Nevertheless, they are not suitable to predict the vibrating behaviour, to describe the hysteresis cycles and to predict the actual filtering capabilities. Thus, more complex models are needed [2]. In this paper, a systematic procedure to experimentally characterize the component behaviour is proposed. The so-called Bouc-Wen non-linear model [3] was considered as reference for this hysteresis problem, and further developed to improve the matching between numerical and experimental results.

Results and discussion

The proposed enhanced Bouc-Wen model is based on nine constant parameters, which must be determined by fitting experimental data of the studied WRI. To this extent, experimental testing was performed along the three main directions of the component, namely principal, longitudinal and transversal. The force-displacement curve of the component, under different loading conditions, was measured by using sensorized hydraulic pistons (i.e. tensile testing machine and customizable hydraulic test-bench). As an example, Figure 1 shows the main results after model fitting, with reference to the principal direction. The blue curves are referred to experimental data, while the green curves are referred to the numerical predicted data. Figure 1(a) shows the results obtained during the static test, which was used to fit the model parameters. The curves prove a really good match in the whole tested region and, thus, the potentiality of the proposed model in representing the physical phenomenon. Figure 1(b) and (c) show the results of independent validation tests, whose data were not used during the parameter optimization process. Figure 1(b) refers to purely sinusoidal loading at 10 Hz (under compression preload) while Figure 1(c) refers to random load (in the range 1-30 Hz). As can be seen, the curves are properly overlapped. This demonstrates that the developed model and the proposed fitting procedure can predict the non-linear behaviour of the studied WRI, properly describing the hysteresis cycles.



(a) (b) (c)

Figure 1: Comparison between experimental and numerical data: (a) static optimization test, (b) sinusoidal test and (c) random test.

References

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