Modeling Asymmetric Hysteresis:
Continuous Development using Experimental Data

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Abstract. Asymmetric hysteresis is tackled using experimental data generated at Sapienza University of Rome. With improved testing apparatus, richer datasets produce more comprehensive views of the asymmetric hysteresis behaviors, making it possible to further advance the proposed Masing model in terms of the Masing rules.

Introduction

The investigated device exhibits asymmetric hysteresis due to coupled geometric nonlinearities and inter-wire frictional dissipation. The testing device comprises two plates connected by two continuous steel wire ropes. The restoring force is acquired by means of a Zwick-Roell testing machine run in displacement control mode. One plate is cyclically moved with displacement histories while the other plate is fixed. A load-cell measures the restoring force provided by the ropes assembly which exhibits an asymmetric response for positive and negative displacements. Sample input and output time histories are given in Fig. 1(a) and (b), respectively.

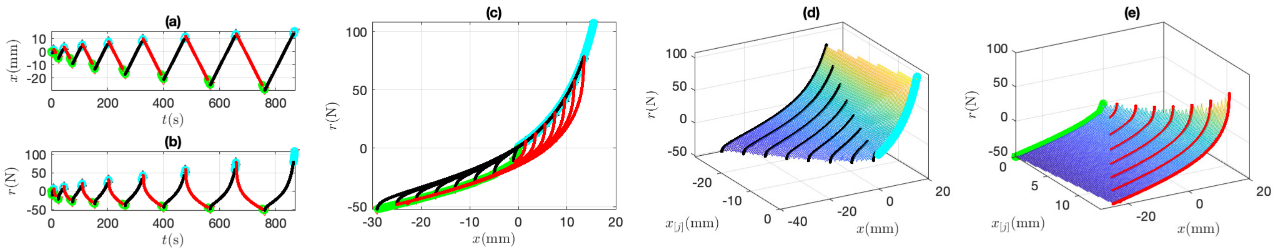

Figure 1: Experimental (a) input and (b) output time histories and (c) corresponding hysteresis loops - using identified reloading and unloading branches in black and red, respectively, and virgin loading and unloading curves in cyan and green, respectively, and (d) and (e) the proposed surfaces regressed from reloading branches and virgin loading curve, and from unloading branches and virgin unloading curve, respectively

The acquired asymmetric hysteretic responses have been studied with various modeling approaches. The number of parameters to be identified can be computationally demanding for the classical Preisach models. The work of [3] shows that the Masing models are Preisach models. As a simpler model than the classical Preisach model, Masing model has been investigated by the authors starting from [5]. In terms of Masing models, an early paper [4] provided the inspiration for later developments of models for softening hysteresis systems, among which the so-called "extended Masing model", as reviewed in [1], is the starting point for [5] and the current study.

Results and discussion

In the extended Masing model, Masing Rule 1 deals with the relationship between the virgin loading curve and all other reloading and unloading curves, while Masing Rules 2 and 3 address the closure and fate of minor loops relevant to nonlocal memory. Employing Masing Rules 2 and 3, reloading and unloading branches as well as virgin loading curves are identified from experimental data, as illustrated in Fig. 1(a) to (c) using one particular dataset. A direct adoption of Masing Rule 1 is not possible given the asymmetric and hardening features, however the explicit functions as proposed in [5] by extending [2] are further developed in this study; see Fig. 1 (d) and (e) for sample results.

References

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