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Editorial

Hysteresis in Engineering Systems

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1. Hysteresis Introduction

The phenomenon of hysteresis in engineering systems has been with us for ages and has been attracting the attention of many investigators for a long time. The reason is that hysteresis is ubiquitous. It is encountered in many different areas of science. Examples include magnetic hysteresis, ferroelectric hysteresis, mechanical hysteresis, superconducting hysteresis, adsorption hysteresis, optical hysteresis, electron beam hysteresis, etc. However, the very meaning of hysteresis varies from one engineering area to another, from paper to paper, and from author to author. As a result, a stringent mathematical definition of hysteresis is needed in order to avoid confusion and ambiguity. Such a definition will serve a twofold purpose: first, it will be a substitute for vague notions, and, second, it will pave the road for more or less rigorous treatment of hysteresis. The aim of this Special Issue is to gain new, unique knowledge about the hysteresis in engineering systems. Another goal is gathering the main contributions of academics and practitioners in mechanical, aerospace, and civil engineering to provide a common ground for improvements approaches of Hysteresis in Engineering Systems in mechanical, structural, electrical, materials, and other engineering fields. Studies concerning sensor technologies, vibration-based techniques, artificial-intelligence-based methods, and related fields are all welcome, both numerical and experimental.

Understanding the phenomenon of hysteresis and the mechanism of hysteretic behavior is important in the design and analysis of numerous types of engineering systems. Hysteretic behavior is observed in the study of magnetic fields, the dynamic response of many structures under high-intensity cyclic or random loadings, in the force–displacement relationships of vibration-control systems, and in the dynamic response behavior of various connections and fasteners, to cite a few examples. Over the past few decades, a large body of work has been published on the development of mathematical models that can reproduce this behavior for various engineering design and analysis applications, as well as those predicting, for instance, the energy absorption or dissipation characteristics of various hysteretic materials. In recent years, an increasing body of work has also been published on the use of various data analysis methods for modeling and analyzing this highly nonlinear behavior. Hysteresis loops describe the system response of a sample exposed to one of different load types such as stresses in mechanical systems, magnetic field in magnetic system, and current in electrical system, etc. The shape of a hysteresis loop can be diagnostic of the systems. Magnetic systems tend to produce narrow loops, whereas mechanical systems cause wider hysteresis loops. A typical hysteresis loop of different systems modeling is shown in Figure 1.

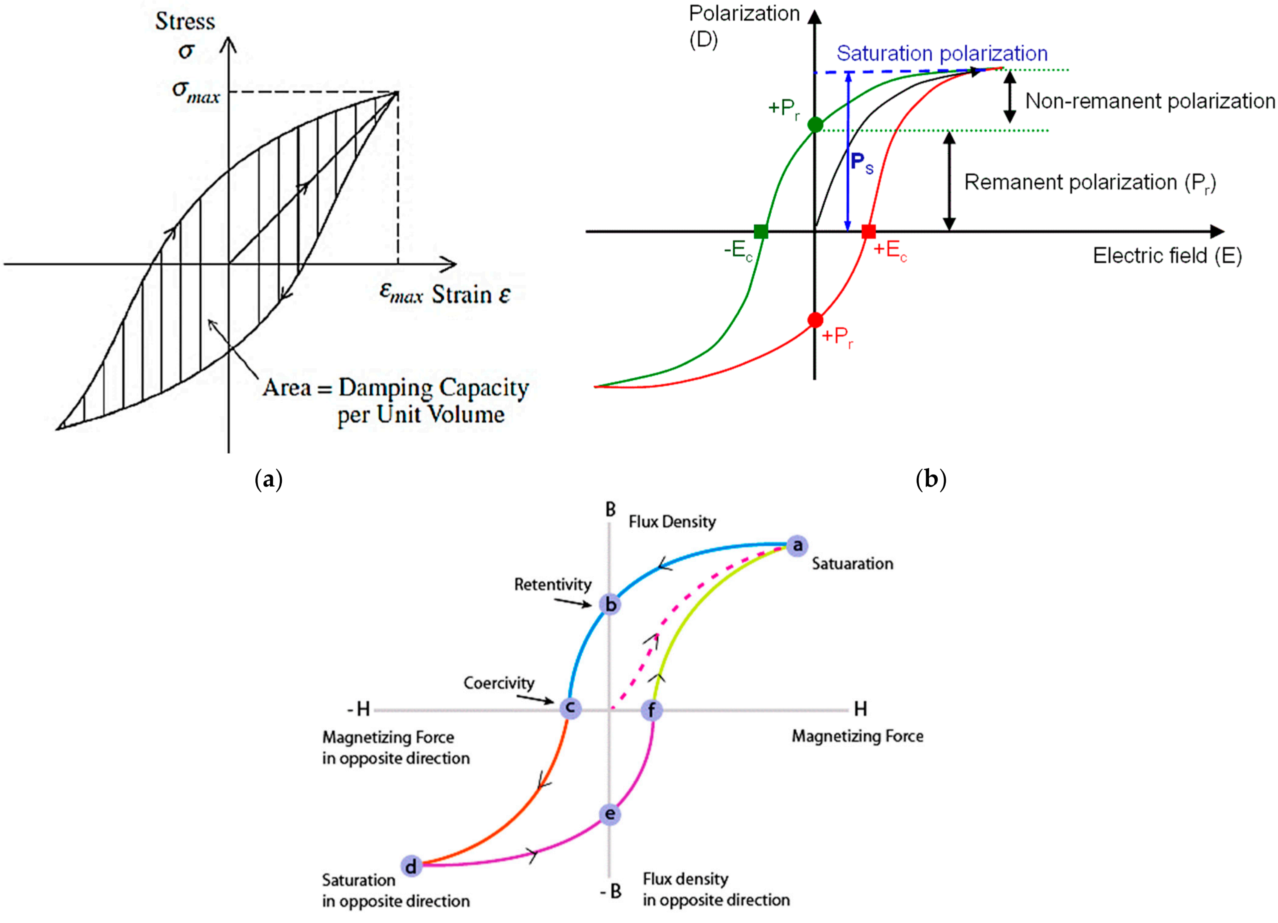

Figure 1. Hysteresis loop of different systems modeling: (**a**) Mechanical damping system; (**b**) Electrical system; (**c**) Magnetic system.

2. Objectives

The main objective of this proposed Special Issue is to collect contributions from active researchers in the field of hysteresis and from structural, electrical, materials, and other engineering fields. It will act as a platform for sharing, for instance, the latest developments in this field, including new modeling techniques, or the system identification of complex hysteresis models. Given the interdisciplinary nature of this topic, the proposed Issue will be a collection of contributions from scholars in several fields and will cover topics such as: Nonlinear phenomena in hysteretic systems [1]; Hysteresis in the study of magnetic fields [2]; Analytical models for predicting and analyzing hysteretic behavior [3]; The role of hysteretic restoring force on modal interactions [4]; Hysteresis in mechanical systems modeling and dynamic response [5–7]; Hysteresis modeling applications in electrical engineering [8]; Advances in hysteresis modelling [9]; The use of smart materials in the modelling of hysteresis systems [10]; Hysteresis and its measurement [11]; Artificial-intelligence-based methods for modeling hysteresis [12,13]; System identification of hysteretic systems [14–17]; Hysteresis in seismic analysis [18,19]; Study of the Bouc–Wen–Baber–Noori model and its applications [20]; the Prandtl–Ishlinski model for modeling asymmetric hysteresis [1,13]; Hysteresis in control systems [18,19]; and Random vibration of hysteretic systems [21].

Hysteresis in a system is often the macroscopic effect of complex phenomena taking place on a smaller scale. While studying the causes of hysteresis requires microscale experiments and models, hysteresis itself can often be studied directly at the system scale. It is therefore customary for researchers in fields where hysteresis is observed to engage in modeling and experiments at both scales. Whereas the study of hysteresis in the field of magnetic materials is well established and can be considered a standard subject, this is not the case in the field of mechanics, where hysteresis is also relevant.

3. Conclusions

To the knowledge of the guest editors of this Special Issue, hysteresis in engineering systems may be a desirable or undesirable characteristic of a system. Hysteresis may be intentionally designed into a system to reduce sensitivity to noise or time lag. In addition, entering artificial intelligence (AI) techniques into hysteresis modeling and simulation proves that the error of the modeling can be reduced, the precision can be improved, and the effect is better than conventional ones. In this Special Issue, we aimed to collect contributions from active researchers in the field of hysteresis in mechanical, structural, electrical, materials, and other engineering systems. It will act as a platform for sharing such knowledge. Furthermore, researchers may give transparent views and indices for their research areas through the challenges and opportunities. In short, this sharing can help researchers to develop new ideas, particularly in the early stages of this research field. It is hoped that the hysteresis models undertaken in this Special Issue will bring much needed clarity into this area and will make it appealing to the broader audience of inquiring researchers.

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