Introducing a Stack of Eccentric Rotors to Semantically Modify Nonlinear Flexible Beam Continua to Considerably Enhance Irreversible Mechanical Energy Flow

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Abstract. A cantilever elastic beam is coupled to a stack of coaxial eccentric rotors to explore experimentally how an embedded multi-stable subsystem creates a nonlinear dynamics environment to support irreversible flow of mechanical energy. Recorded by means of wireless MEMs sensors is the physics fact that the tangential acceleration of the eccentric rotor is strictly positive during phases of irreversible energy flow. Sliding over the surfaces of support stators, the introduced stack of eccentric rotors enhances by speeding up a natural irreversible flow of strain energy from the flexible continuum into the interacting coaxial eccentric rotors. The complicated landscape of products of static equilibria continua speeds up the flow of mechanical energy. This coupled system is a representative of an interesting class of meta-structures: modification of nonlinear elastic continua by embedded multi-stable mechanical subsystems generating contact-induced nonlinear friction forces.

Introduction

In this work explored is the challenging issue of *creating experimental evidence that a specific coexisting static equilibria environment*-formed by a stack of eccentric rotors-embedded in a continuum enables a natural irreversible energy flow. Conceived as a paradigmatic meta-structure, Fig. 1 depicts a modification of nonlinear elastic continuum with a stack of coaxial eccentric rotors to (1) explore the role of a complicated environment of continua of static equilibria in creating irreversible energy flow and (2) explore the role of contact-induced nonlinear frictional forces in shaping this irreversible energy flow phenomena. Previous exploratory work reveals that *the eccentric rotor* traps by irreversible flow mechanical energy stored initially in a flexible elastic beam [1]. We meet the challenge to acquire the right datasets to extract useful information.

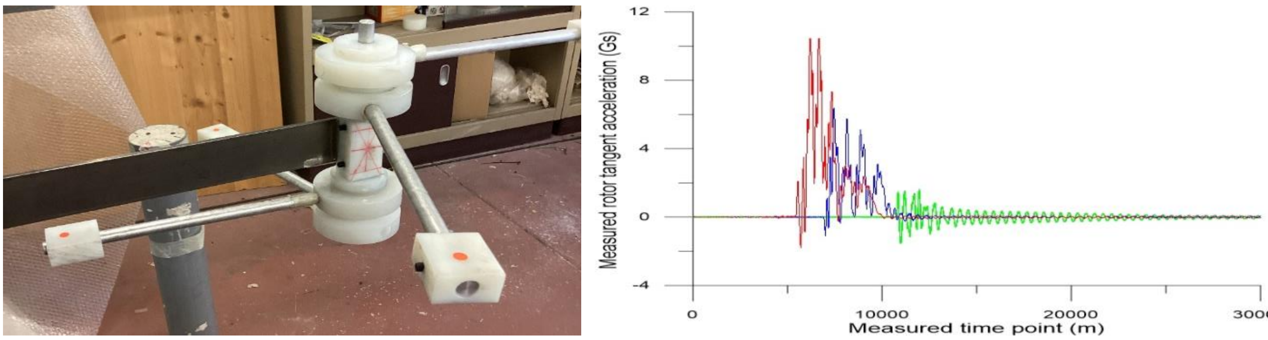

Figure 1: Lab set-up of conceived physical meta-structure (NTUA Nonlinear Dynamics Lab Unit) to explore experimentally dynamics underlined by irreversible energy flow from an elastic beam into an interacting stack of coaxial eccentric rotors in contact with stators. Observation: the tangent acceleration component of the eccentric masses is a strictly positive quantity with pulse-like behavior (right) during energy flow. Interplay of geometric nonlinearities and polygenic nonlinear contact-induced friction.

The methodology followed is acquirement (by state-of-the-art MEMs sensors) of triaxial acceleration datasets followed by systematic reduction analysis with Advanced Proper Orthogonal Decomposition (APOD) tools [2] to gain knowledge on the interplay of geometric nonlinear and friction-induced forces in an environment of coexisting continua of static equilibria. Dynamics phenomena with irreversible energy flow as observed in the specific class of free motions initiated after releasing instantly the beam tip, initially displaced slowly to store strain energy in the elastic continuum. Observed is the physics fact that the four eccentric rotors as a mechanism, initially at a random static equilibrium, start spinning abruptly-and-randomly while the vibration amplitude of the flexible continuum domain decreases quite fast to a small amplitude vibration. The dynamics characteristics of the irreversibly energy flow-energy dissipation phenomenon is imprinted in the local tangential acceleration signal of the eccentric mass in localized and pulse-like pattern, Fig. 1, when energy is flowing. Moreover, energy flows irreversibly when wave motions are created in the elastic continuum domain.

References

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