Ecole Doctorale
Energie Matériaux Sciences de la Terre et de l'Univers

PhD proposition

Passive vibration control in mechanical systems using nonlinear dynamical absorbers and taking into account uncertainties

Keywords: Passive control, nonlinear absorbers (non linear energy sinks), vibrations, dynamical systems, uncertainties, asymptotic methods, polynomial chaos.

General context. With the tightening of the economic context and the regulations on acoustic emissions, industrialists need to design mechanical systems increasingly efficient and respecting a certain level of acoustic comfort.
In mechanics or in acoustics, vibration control is a very active research field. Today, three major types of technologies are used predominantly in the industry: the passive dissipation control, the passive control using tuned linear absorbers and the active control, each method having its technical advantages and disadvantages. For fifteen years, the use of nonlinear absorbers (also known as Nonlinear Energy Sinks, NES), typically mass-spring-damper systems with a purely nonlinear stiffness, has shown its effectiveness as an alternative to mitigate vibrations while reconciling the advantages of the technologies cited previously. Most of the theoretical and numerical studies on this topic are dedicated to academic systems with a small number of degrees of freedom (the book [1] gives a complete overview of the work on this subject). Moreover, some experimental studies exist but industrial applications remain marginal. The design of such devices for industrial applications is therefore a major research issue.

Issues. The design of mechanical systems with a purely nonlinear stiffness (or with a linear stiffness which can be neglected with respect to the nonlinear one) already constitute an industrial challenge. Moreover, nonlinearities in the system to protect or the absorber itself often generate a high sensitivity of the coupled system behavior to its parameters. The originality of this work is to study the efficiency of nonlinear absorbers to reduce the vibrations of industrial mechanical systems, taking into account the parameter uncertainties of the system to damp but also of the absorber itself.

Objective of the PhD work. The aim of the thesis is to be able to design a robust nonlinear absorber, i.e. which keeps its performance throughout its life cycle despite uncertainties that it (and the system to protect) may face. Uncertainties would be taken into account using advanced methods based on the polynomial chaos theory. Indeed, the computation time of the classic Monte Carlo method which takes into account uncertainties can quickly become prohibitive when systems under study have many degrees of freedom and uncertain parameters. This research is part of a long-term approach) on the optimal and robust design oriented towards industrial applications.

Detailed work. The research work is oriented towards friction systems applications (e.g. brake systems [2-3]). It is based on methods and expertise(s) developed () in previous works (see ref. [4-6]), such as (1) the analysis of the behavior of mechanical systems subjected to dynamic instability due to frequency coalescence, coupled or not to nonlinear absorbers and (2) the development of non-intrusive methods based on the polynomial chaos theory, developed to study robustly the dynamic behavior of friction systems.

The successful candidate will (1) get familiar with the theoretical concepts needed for the study of nonlinear and/or uncertain systems (asymptotic methods, multiscale analysis, polynomial chaos theory...) and with the numerical implementation of these concepts. (2) Perform and complete a literature review of the state of the art about nonlinear absorbers, polynomial chaos and possible

works which treat these two aspects simultaneously. (3) Develop analytical/numerical methods to study uncertain mechanical systems coupled to nonlinear absorbers.

Point (3) will be the major part of the thesis. The PhD student will develop methods on systems with a small number of degrees of freedom while keeping in mind that these methods should be applicable to industrial systems.

Validation of the research work. This work has an interest in both fundamental and applied sciences. From a scientific point of view, it will associate the study of the particular behavior of nonlinear absorbers with the analysis of uncertain systems. The expertise of the supervisor and the co-supervisor of the thesis in these domains suggests a relatively fast validation of the thesis results. From a technology standpoint, it will offer industrialists first a passive control system and secondly (in a longer term) robust design tools.

Candidate profile. The candidate should hold a university degree (Master of Science or equivalent) in mechanics including necessarily a research internship. He/she should be comfortable with mathematical developments and program writing (programming languages as Matlab, Mathematica or Python)

Salary. 1400 € net per month. Possibility of additional teaching payment from the second year of the PhD (under conditions).

Workplace. The PhD student will conduct his/her research in the Laboratory of Mechanics and Rheology ("Laboratoire de Mécanique et Rhéologie", LMR EA 2640) on the Blois campus of INSA Centre Val de Loire, France.

Applications. To apply, the candidate must first e-mail a detailed CV and an application letter to the contacts given hereafter.

Contacts

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References

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