PhD Position

Hybridation and energy pumping: towards a new class of vibration absorbers.

Carnot Institute Engineering@Lyon - HYPE Project

Context :

Passive linear tuned vibration absorbers have been widely used in a large range of applications for decades. This is mainly due to their ease of implementation. However, their performance is naturally limited in terms of efficiency, reactivity and adaptability. During the last decade, recent developments have improved the performance of passive linear absorbers either by hybridizing them with active control or by adding and exploiting non-linear effects.

Purely active systems do not have the limitations of passive absorbers, but they require a significant amount of energy and always face the problem of stability. In recent years, the hybridization of active and passive systems has sought to combine the best of both worlds: stability, performance and reduced energy costs.

Nonlinear vibration absorbers, generally known as NES (Nonlinear Energy Sink) [1], or NLTVA (Nonlinear Tuned Vibration Absorber) [2], have been the subject of numerous studies in nonlinear dynamics. These studies have shown that, compared to the classical linear tuned mass damper (TMD), an NES can be effective over a wide frequency band and, above all, does not allow energy to be returned to the primary system with which it is associated. However, these NES still have some disadvantages, the most important being a static design and a triggering threshold.

In this multidisciplinary context, the LaMCoS and LTDS laboratories focus on active control and nonlinear systems to define new classes of dynamic absorbers [3-10].

Description of the project:

The objective of this thesis is to overcome the limitations of currently available vibration absorbers by developing **hybrid nonlinear dynamic absorbers, benefiting from the advantages of passive nonlinear systems and active systems**.

The theoretical and technological challenges for this new concept of hybrid nonlinear absorber are numerous: development of efficient reduced models, strong coupling between passive nonlinear parts and active parts, development of adapted control laws, optimization of multiphysics energy transfer, stability problems, …

With the help of phenomenological models, we will try to describe the dynamics of the assembly, to optimize the active and passive parts so that they work in synergy in order to obtain a maximum and robust damping of the vibrations. This active control can be of different types: variability of the potential wells, adaptability of the non-linearity, adaptability of the triggering threshold, ... The experimental facilities present at LaMCoS laboratory will allow the fabrication of prototypes as well as the experimental validation of the developed concepts.

Keywords : Vibration absorbers, nonlinear dynamics and vibrations, hybrid control, smart structures.

Skills required: Master degree in mechanical engineering.

The PhD student will have strong skills in structural vibrations, system control and multiphysics modeling, with a solid background in mechanical engineering. He/she will be able to work in a partnership context, in interaction with industrialists, within a multidisciplinary team including other PhD students as well as specialists in mechatronics and non-linear dynamics.

Location: INSA LYON - LAMCOS CNRS UMR 5259 (Dynamics and Control of Structures group)
Duration: 36 months **Start:** January 2022

Supervisors:
Sébastien BAGUET (Associate Prof., INSA Lyon, LAMCOS UMR CNRS 5259)
Simon CHESNE (Associate Prof., INSA Lyon, LAMCOS UMR CNRS 5259)
Claude Henri LAMARQUE (Full Prof., ENTPE, LTDS UMR CNRS 5513)
Alireza TURE SAVADKOOHI (Associate Prof., ENTPE, LTDS UMR CNRS 5513)

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The **Contact and Structure Mechanics Laboratory LaMCoS** (http://lamcos.insa-lyon.fr/) and in particular the DCS group (Dynamics and Control of Structures) is interested in the reduction of vibrations by the use of passive or active systems. Recently, linear hybrid systems, combining the best of passive and active systems, have been developed and tested with success. Based on this success, the team is looking to propose new concepts of innovative vibration absorbers by integrating nonlinearities. These innovations are based on another proven competence of the team in numerical modeling, dynamic response computation and bifurcation analysis of nonlinear dynamic systems.
The **laboratory of Tribology and System Dynamics LTDS** (http://ltds.ec-lyon.fr/) via its team DySCo (Dynamics of Complex Systems) and one of its groups (DNLCS: Nonlinear Dynamics - Control - Rotating Systems) develops methods of model reduction, methods of passive control especially with nonlinear energy sinks (NES) and deals with both stationary nonlinear dynamics, as well as multi-scale modulated regimes allowing the shaping of nonlinear dynamics for the localization of energy by nonlinear coupling. Numerical approaches and analytical methods for nonlinear design are accompanied by the development of prototypes and demonstrators allowing a development of its activities from low TRL to high TRL (patents, in situ prototypes).

Requested documents of application:

- A complete curriculum vitae
- A cover letter clearly indicating how the candidate's profile and skills match the requirements of the position (2 pages max)
- Names and contact information of 2 or 3 references (including email addresses and relationship to the candidate)
- Transcripts from your last two years of university
- By e-mail to Sébastien BAGUET (sebastien.baguet@insa-lyon.fr), Simon CHESNE (simon.chesne@insa-lyon.fr), Claude Henri LAMARQUE (Claude.Lamarque@entpe.fr) and Alireza TURE SAVADKOOHI (Alireza.TURESAVADKOOHI@entpe.fr).
- Indicate exactly "HYPE thesis application" in the subject line.

References :

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