Improved design of nonlinear energy sink: application to chatter milling control

Keywords

Mechanical engineering; Dynamics; Nonlinear Energy Sink; Manufacturing, Chatter; milling; Experiment

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General context

The nonlinear dynamics of structures is a growing field, in academic research, because it helps to explain new phenomena. The vibration mitigation is also an important challenge for chatter reduction in manufacturing of lighter structures, especially in 5 axis milling [1]. Thus, the introduction of nonlinear absorber seems to be a way forward. The concept of vibration absorber was proposed in 2001 [2], and realized at the first time in 2005 on a mechanical system [3]: the idea is to use a mass-spring-damper with a nonlinear stiffness in order to attenuate vibrations by transferring energy. Energy pumping mechanism consists in irreversibly transferring vibratory energy from a master system to an essentially nonlinear coupled auxiliary system – namely the Nonlinear Energy Sink NES – by triggering resonances between related nonlinear normal modes [4]. These nonlinear absorbers seem to have a decisive advantage because they operate over a wide frequency range.

Objects of research

The work is related to chatter reduction on manufacturing process, in the continuity of work undertaken in the team [5-7]. However, the optimal design of the NES for delayed system, the conditions of occurrence of energy pumping and the experimental implementation are major scientific challenges that require novel developments to offer reliable dynamic absorbers for manufacturing process.

In the first time, the student will work on the state of the art about nonlinear dynamics, vibration absorbers modeling and about chatter reduction in the context of manufacturing.
A second step of the PhD is to model and optimize the design of the NES, for delayed system. The idea is to better understand and to improve the prediction of the reduction of the chatter. For this, the candidate will use the theoretical tools developed in the team (asymptotic methods, method of multiple scales).
Finally, the robustness of the method and the new design developed will be tested experimentally by original measurement available in the laboratory. An application referred is chatter during milling process. An experimental bench for chatter in turning was developed on the team.

Collaboration

The PhD will take place in the laboratory Institut Clément Ader UMR CNRS 5312. The student will work in the team “Mechanical Systems and Microsystems Modelling” (MS2M).

Motivation and competence

The approach should link the development of specific models, the use of theoretical and experimental tools (CNC machine) for observing, understanding and studying mechanical phenomena. Pre requested in dynamics/manufacturing are required for this PhD. Thus, the candidate will complement its core competencies in modeling and/or experimentation.

Reference

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非线性能量阱的优化设计：颤振控制应用

关键词

工程机械；动力学；非线性能量阱；颤振；设计；实验

导师信息

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背景介绍

结构的非线性动力学是一个不断发展的热点领域，在学术研究中，它有助于解释新的现象。在轻型结构的制造中，尤其是在 5 轴铣削工艺中[1]，减少颤振也成为一个重要的挑战。因此，引入非线性吸收器代表了其中一个重要发展方向。这类减振器的概念最初是在 2001 年提出[2]，并在 2005 年首次在机械系统上实现[3]：其想法是使用具有非线性刚度的质量-弹簧-阻尼器模块，通过能量转移的方式来消除振动。能量泵送机制通过触发耦合非线性模态之间的共振，将振动能量从主系统不可逆地传递到另一个非线性固连的附加系统--即非线性能量阱 NES[4]。这些非线性吸收器的工作频率范围很宽，这使得它在减振能力上具有显著的优势。

研究目的

该研究致力于减少制造过程上的颤动，并且团队开展持续的研究 [5-7]。然而，对于延迟系统的 NES 的优化设计，能量泵送机制的触发条件和实验开展仍然是一个重大的科学挑战，这需要新的研究的和发展，为制造过程提供可靠的动态吸振器。

第一步，学生将致力于学习关于非线性动力学，振动吸收器建模和了解在制造业背景下的消除颤动的技术现状。
第二步，博士生会对延迟系统建模并且优化 NES 的设计。候选人将使用团队开发的理论工具（渐进方法、多尺度方法）来更好地了解，减少颤振，以及改善对它的预测。
最后，通过实验室的原始测量进行实验测试来验证方法的鲁棒性和优化设计。为此团队已经开发出车削过程中颤动的实验台，来研究所提到的铣削过程中的颤振。

国际合作

博士生的研究工作将会在 Institut Clément Ader UMR CNRS 5312 进行，所在的团队是“Mechanical Systems and Microsystems Modelling” (MS2M)

能力要求

由于需要结合特定模型，使用理论和实验工具（数控机床）来观察，理解和研究机械现象，因此候选人需要在动力学或者制造方面预先有一定了解。候选人将完善其在建模和实验过程的核心能力。

参考文献

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