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Escola de Engenharia de São Carlos

DEPARTAMENTO DE ENGENHARIA MECÂNICA

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pp. doc. Ing. Milan Polívka, Ph.D.
Vice-Dean for Doctoral Study and Science

Dear Prof. Milan Polívka,

First of all, let me thank you for the honor of being invited as a reviewer for the the thesis ***Dynamic Modeling of Macro-Fiber Composite Transducers integrated into Composite Structures***, submitted by ***MSc ZhongZhe Dong*** at the Faculty of Electrical Engineering – Czech Technical University in Prague.

The current review is based both, on a previous assessment of the text and on a final review of the present updated version.

The candidate presents a thesis, that tackles the challenging task of modellig the so called Micro Fiber Composite (MFC) elements, an anisotropic kind of piezoelectric patch, embedded in a composite structure. Moreover, the objective of the thesis is to develop a model reduction scheme that allows the incorporation of such smart materials in a composite strucutre model, without loosing parametric information about the subject, while enabling more efficient simulations for both electro-mechanical and vibro-acoustic problems. This topic presents challenges from technical and scientific points of view and aims at aiding the design of active control system that make use of such devices for sensing and actuation. The contributions of this work can indeed impact the field of structural dynamics, smart structures and noise & vibration control, as having more compact and modular means of representing piezoelectric patches onto a structure can also aid optimization, uncertainty and design refinement tasks.

The objectives of the work are clearly posted. The motivation for the selected piezoelectric elements and comparisons with the state-of-the-art are comprehensive, including other types of MFCs and a broad view on application scenarios. Most of the theoretical remarks have also been addressed in the review and theoretical section of the thesis. My initial concerns related to the experimental validation, which included placement of sensor/actuator, the time domain validation and the overall clarity of plots have been properly addressed and are well reported in the current version of the text.

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The adopted method technically sounds. The candidate starts from fundamental analytical models and derive the piezoelectric electro-mechanical constitutive equations which are valid for the d_{33} and d_{13} MFCs, which are commercially available. Sets of equivalent forces are tested and the accuracy compared. Then, a more general approach, using substructuring techniques is adopted for the inclusion of the MFCs in FEM models of the host structure. The proposed method is proven to deliver enough accuracy although only implemented for rectangular patches. The extension to more general frameworks should not pose any scientific challenges but rather technical and do not limit the conclusions draw at the end of the work. Both methods have been cross checked with commercially available FEM software with coupled structure and piezoelectric elements capabilities.

The proposed numerical methods are checked against two experiments, carried out on (i) a free-free fibber composite plate installed with MFCs and a (ii) vibro-acoustic setup, in which the smart composite plate is the only structural flexible element coupled with a rigid wall acoustic cavity. The good results presented in the experimental campaign adds to the strength of the method numerically tested before.

In my opinion, the work brings novel contributions to the field of smart material modelling for structural dynamics and control. The candidate shows enough maturity when describing the method, ranging from fundamental analytical models of the piezoelectric elements, their coupling with the host structure and generalization via Hamilton's principle. The proposed equivalent force model adds to the methods found in literature and resulted in a peer reviewed publication, first-authored by the candidate in the Q1 - journal *Smart Matererials and Structures*. Finally, the modelling scheme is confronted with experimental results from structural and vibro-acoustic tests.

The author of the thesis proved to have an ability to perform research and to achieve scientific results. I do recommend the thesis for presentation with the aim of receiving a Ph.D. degree, achieving the standards for grating the candidate the desired title.

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