Report PhD manuscript of ZhongZhe Dong

Title: Dynamic modeling of macro-fiber composite transducers integrated into composite structures

By Prof.Paul Sas

The thesis of ZhongZhe Dong deals with the modelling of laminated composite plates on which spatially distributed microfiber composite (MFC's) patches are mounted. Those MFC patches can be used as actuator/sensor in (semi)-active control configurations to optimize the structural dynamic behavior, or as transducer in energy harvesting applications. As shown by the literature review of the candidate, 'smart' systems using piezo patches have been studied for decades, showing among others their potential to reduce vibrations and noise of lightweight systems. Due to the system complexity and material cost, applications are up to now limited to simplified demonstrators or one-off high budget applications in defence/space. The more recent MFC piezo patches have in that perspective some potential, compared to standard piezo's the basic configuration is similar, but they offer high performance on a cost competitive base.

When modelling such systems analytical methods are limited to simple configurations, for more realistic configurations full finite element models (FEM) are necessary, but the large size of such models is a handicap for their use in practical design optimization and prohibits on-line applications, therefore reliable reduced models are required. The PhD work of ZhongZhe is a contribution to this field, the Equivalent Substructure Modeling (ESM) approach he developed is a low order model for piezoelectric composite structures that preserves the stability of the original system. It is based on earlier work published by Deraemaeker, where the principle of equivalent forces is used to characterize the inverse piezoelectric effect, ZhongZhe extended this method such that also the direct piezoelectric effect can be included, which is a relevant contribution to the state of the art. He validated his approach by comparing the results with full FEM simulations and experimental results. This was done for different MFC configurations. Although the chosen configurations are limited to small patches the results sufficiently illustrate the validity and the potential of the proposed ESM method for applications such as energy harvesting and shunt damping.

In the final chapter ZhongZhedong demonstrates the use of the ESM approach for vibro-acoustic applications, for this he extended the ESM approach with structural acoustic coupling and validated the approach on the KU Leuven soundbox. The soundbox offers an optimal environment to conduct coupled vibro acoustic experiments. The results obtained by ZhongZhedong illustrate the validity of the choosen coupling approach and its potential for on-line simulations of MFC patches in vibro-acoustic applications, as such they are a relevant contribution to the state of the art in the related field.

Although the syntax and spelling of ZhongZhedong's written English is far from perfect he proved in his PhD manuscript to have an ability to perform research and to achieve scientific results. I therefore do recommend the thesis for presentation with the aim of receiving a Ph.D. degree.

11/12/2018 **Prof.Paul Sas**