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THIN SHELLS WITH PIEZOELCTRIC TRANSDUCERS: THEORY, NUMERICAL MODELLING AND EXPERIMENTAL VERIFICATION

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Summary: For the modelling of thin elastic shells with attached piezoelectric transducers, we consider a material surface with certain mechanical degrees of freedom in each point. Additionally, electrical unknowns are present within the domain, where the piezoelectric transducers are attached, such that the sensing and actuating behavior can be properly accounted for. The modelling is done in the geometrically nonlinear regime, but the electromechanically coupled constitutive relations are treated within the framework of Voigt's linear theory of piezoelectricity. Owing to the assumed thinness of the shell the influence of shear is neglected in the modeling.

A Finite Element scheme for the solution of the resulting model is implemented and the solutions computed with the present theory are compared to results computed with the commercially available FE code Abaqus. Different examples are presented ranging from large deformations, to snap through instability and to a linear analysis. A very good agreement between the results is obtained, from which the accuracy of the thin shell formulation as a material surface is concluded.

Next, an existing physical shell is modeled within the linearized version of the present theory and the computational results are compared to measurement results from the physical experiment. The agreement is reasonably good; natural frequencies as well as eigenmodes are considered for the comparison. Concerning the eigenmodes the MAC criterion is used.

Finally, the resulting linear time invariant dynamical system for the simulation of the physical shell is imported into Mathematica and different strategies for passive and active control are tested and compared to each other. Concerning passive control methods classical single mode shunt-damping using an optimized RL-network is studied.