Recent Advances in the Control of Stresses by Smart Materials

Juergen Schoeftner†, Andreas Brandl† and Hans Irschik‡

†, ‡ Institute of Technical Mechanics
Johannes Kepler University of Linz (JKU Linz)
Altenbergerstr. 69, 4040 Linz, Austria
Email: hans.irschik@jku.at - Web page: http://www.jku.at

ABSTRACT

Following a classical reasoning, structural mechanics is understood as being concerned with the problem of deriving the displacements, strains and stresses that are produced by a given set of loadings, i.e. by imposed forces, eigenstrains, boundary conditions and initial conditions. The successful treatment of corresponding initial-boundary-value problems has constituted the success of structural mechanics in practice. Since the inputs of these problems are taken as known, one may classify them as direct ones from a system-theoretical point of view.

In the last decades, indirect or inverse problems have emerged that are complementary to the direct problems of structural mechanics. A large class of such indirect problems has been motivated by the technological progress that has been gained with respect to the actuating efficiency of smart materials. From the mechanics’ point of view, smart materials are characterized by the presence of eigenstrains, e.g. in case of piezoelectricity these eigenstrains are produced by an electric field. Consequently, the question has arised how to distribute smart materials for suppressing displacements, or for producing desired displacement fields, despite imposed loadings are present. Indirect problems dealing with the control of displacements by eigenstrains have been associated with the notions of shape control, displacement tracking or displacement morphing in the literature.

In the framework of the linear dynamic theory of elasticity, the following different inverse problem is treated in the present paper: We seek for a distribution of control eigenstrains, which, when applied simultaneously together with some imposed loadings, is able to suppress mechanical stresses in a certain part of a structure. We denote this problem as stress control. In contrast to displacement control problems, control of mechanical stresses by smart materials so far has not been in the main focus of international research. Basic theoretical studies concerning necessary and sufficient conditions that must hold for stress control (suppression or generation of desired stress fields) however have been already successfully performed at the Institute of Technical Technics at JKU Linz in the last years, see e.g. [1] - [3].

In the present contribution, these theoretical findings first are extended with respect to the control of stresses in a certain part of the structure only. This question is of a high technological interest, when the part has a weaker strength in contrast to the rest of the structure. We then present some results of laboratory experiments, which demonstrate the appropriateness of the proposed theoretical stress control methodology. To our best knowledge, these are the first successful experimental results that have been gained so far for suppressing stresses in structures by smart piezoelectric materials.

REFERENCES

