Active Noise and Vibration Control using Piezoelectric Sensors and Actuators

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Active noise and vibration control can adapt the response of mechanical systems to external disturbances. For instance sound radiation into free space or sound levels in acoustic enclosures can be reduced with active noise control systems. Typical problems, which can be tackled with active vibration control, are enhancement of the comfort in cars or trains and the reduction of vibration levels of flexible robot arms. An active noise or vibration control system typically consists of *sensors* to measure the response, *actuators* to modify the response, and a *controller* to calculate the appropriate actuator signal from the sensor signal.
Materials showing *piezoelectric* behavior produce an electrical charge on the material surface when subjected to a mechanical stress. Furthermore the opposite effect also occurs: when an electric field is applied the material changes its shape and size. For these reasons, piezoelectric materials can be used in active noise and vibration control systems both as sensors and actuators.
In many noise and vibration problems the structural vibration patterns that have to be reduced are determined by bending or transverse modes. In those cases piezoelectric patches, which are bonded to the structure can serve as distributed sensors and actuators (see Figure 1). When a voltage is applied across the electrodes the patch will induce a strain and deform the structure. In the opposite case when the patch is used as a sensor, a strain in the structure will result in an electric field.
In order to successfully implement a control system, the interaction between the applied or measured electric field and the deformation of the structure has to be known. Therefore dynamical models, which describe the piezoelectric coupling, have been developed. A simple test case was studied consisting of a clamped beam with two piezoelectric patches. An analytical model and a finite element model of the system were compared and a good agreement was found. Furthermore the numerical results were validated with experimental results. For the test case a feedback controller was designed to reduce the vibration level of the beam.

Figure 1: Piezoelectric patch bonded to a beam

Reference

[1] Fuller, C.R., Elliott, S.J., Nelson, P.A., (1996) Active Control of Vibration, Academic Press.