Actuator optimization for Active Structural Acoustic Control

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Introduction

In Active Structural Acoustic Control (ASAC) the sound radiation of structures is controlled using structural actuators, such as surface-bonded piezoelectric patches. The performance of a control system is strongly influenced by the location and dimensions of the piezo patches. In order to determine the optimal actuator design, optimization techniques are applied. Special emphasis is on optimization of closed-loop systems, i.e. including control, over a broadband frequency range.

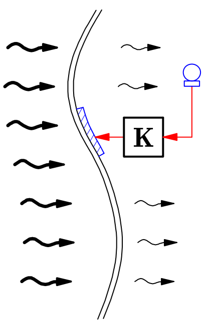

Figure 1 : ASAC example: transmission loss of a plate with piezo actuator, controller $\mathbf{K}$ and error microphone.

Methods

Modelling The Finite Element Method (FEM) is applied to model the structure, piezo actuators and sound radiation. With optimal control theory the control input that minimizes the radiated sound power is calculated.

Optimization Optimization is performed with a Genetic Algorithm (GA). This method only requires evaluations of an object function. Starting with a population of several actuator configurations, the GA simulates a *survival of the fittest* strategy for a number of generations.

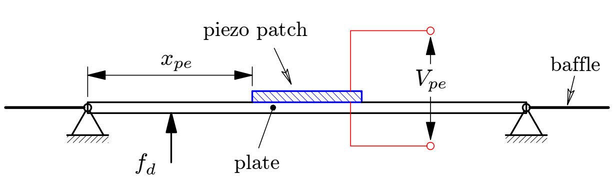

Figure 2 : Plate with piezo actuator.

Results

A test case was defined consisting of a baffled plate, infinitely long in one direction, with one surface-bonded piezo patch (see Figure 2). The plate is excited by a harmonic disturbance force f_d. The actuator location x_{pe} is the design variable.

The object or fitness function is the radiated sound power integrated over a predefined frequency range.

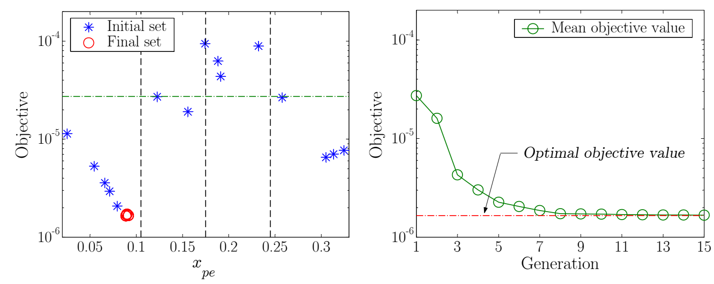

Figure 3 : Summary of optimization results.

Starting with a set of randomly selected design values x_{pe}, the optimal location is found after several generations. Note that several FEM simulations must be performed every generation. Good convergence of the algorithm is illustrated in Figure 3.

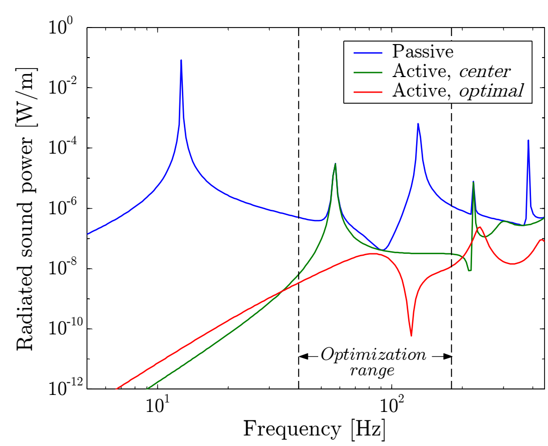

Figure 4 : Radiated sound power improvement.

Figure 4 shows the radiated sound power when no control is applied (passive), and the active response in case the actuator is located at the plate center or at the optimal location. In the optimization range, a significant improvement is observed.

Conclusions

The combined use of FEM models and genetic algorithms for optimization of piezoelectric actuators in ASAC has been illustrated. Issues for further research are extension to 3D structures and optimization of several design variables.