Ein Vergleich von Optimierungsverfahren für Anwendungen in der Strukturakustik

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Introduction

In the last decade several papers about the minimization of the radiated sound power of plates were published by Belegundu *et al.* [1]. In these works, the structure of the plate was modified either by placing discredited masses, changing element properties like thickness or applying damping layers on the surface of the structure. These concepts of modification have in common that a further restriction for the structural mass has to be introduced, because optimization will usually favor a heavier structure. If one modifies the structure by optimizing the shell geometry, the effect on the overall mass remains negligible. They optimized the shape of a loud speaker diaphragm. Lamancusa *et al.*[2] considered the thickness of the plate as the design variable and investigated several types of objective function to minimize the radiating sound power from the plate.

Marburg *et al.* published several papers in this field considering the geometry modification concept [3, 4, 5, 6, 7]. He distinguished between local and global modification of the finite element model for the shell.

Optimization of the structural-acoustic applications even for the small cases takes are time consuming. Several questions are still to be answered like which optimization method should we use for a special optimization application and how many function evaluations should we consider?.

Answering to the these questions need to perform a statistical study on the different type of optimization and approximation methods. This paper reports the result of our study at this regard.

Structural-acoustic optimization

The general flowchart for the structural-acoustic optimization is shown in Fig. 1. After initializations, we can consider several different combinations of the approximation and the optimizations methods when it is required. The approximation tools are being used when it is necessary to calculate approximate values for the objective function or its derivatives. The objective function is calculated by an external finite element's solver and forwarded to the optimization program. If the new calculated optimum design points provided by the optimizer are acceptable then the process will be terminated else the new optimum design points will be used to produce the new objective function and the process will be repeated. In our work, we consider two termination criteria, the first one is the maximum allowable total number of function evaluations and the another one is the relative difference in the values of the two consecutive optimum objective functions. The radiated sound power is considered for

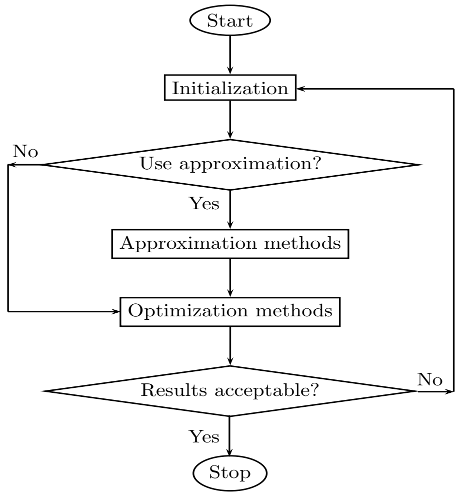

Figure 1: General flowchart for the structural-acoustic optimization process.

a half space problem when the radiation efficiency is one. Indeed we have considered an equivalence radiated sound power level which is proportional with the square of the surface velocity of shell. We assume also that the fluid velocity and the surface velocity of the structure in the normal direction are equal with each other on the boundary of the structure with the fluid, here on the surface of the shell. For more detailed information about the calculation of the objective function see [8].

Numerical example

Fig. 2 shows a square shell from steel with the constant thickness. The hole sides of the shell are constrained with the simply supported boundary conditions. Three uniform harmonic pressure excitations are applied on the plate. All of them have the same excitation frequency bandwidths of 0 to 100 Hz, the same excitation phase and the same unit magnitude. The excitation locations on the shell make a nonsymmetric excitation case. The geometry modification concept can be applied on this plate using nine modification points $(Z_1, .., Z_9)$. The normal geometry modifications at these points are our design vari-

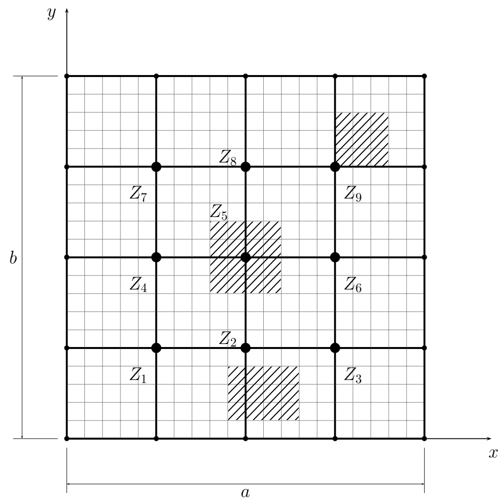

Figure 2: Example for the finite element model, the modification parameters $Z_1, .., Z_9$ and the excitations (dashed) areas.

ables for the optimization process. Several optimization methods like the method of the feasible directions (MFD), a limited memory edition of Broyden-Fletcher-Goldfarb-Shanno method for the bound constrained problems (L-BFGS-B), method of simulated annealing (SA), sequential quadratic programming method (SQP), method of moving asymptotes (MMA), tabu search method (TS), Newton method (Newton) and the mid-range multi-points (MMP) methods are considered for these study. These methods need a set of the start design points to begin their optimization process. We have considered a same initial set of design points containing of the at least 100 design sets which are selected randomly from the search space. Moreover, these initial design points are distributed uniformly on the search space to make sure that our statistical comparison study on the different types of the optimization methods is reliable.

Results

For each optimization method and after each total function evaluation, we have evaluated the average value of the optimum objective function for all of the initial design sets. Then it builds a so called convergence curve for each method, Fig. 3. The results of our study indicate that the mid-range multi-points method is the fastest method for the reduction of the radiated sound power level for this special application in comparison with other considered methods.

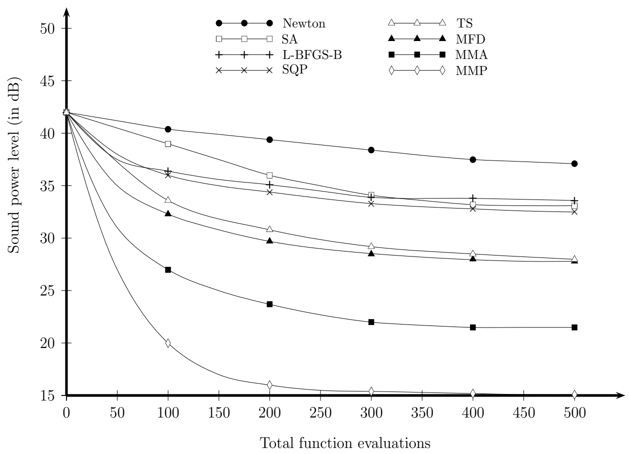

Figure 3: Minimization of the objective function value by the different optimization methods.

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