EI Contrôle de la pollution acoustique intérieure (2SC5792), ST5

CentraleSupélec

Optimization problem

1 Project

The goal is to minimize the acoustical energy

1. of a concert hall or an amphitheater
2. of an office ;

with a perforated wall, *i.e.* it is needed to find the optimal distribution of a porous material of a fixed quantity in the wall which minimize the noise inside (or maximize the sound absorption). Or, the same type of problems,

3. to minimize the acoustical energy inside of an aircraft reactor by optimizing the distribution of the liners inside.

A Phyton program is given to solve the Helmholtz problem for a domain with a Dirichlet boundary on the top, the complex Robin condition in the bottom, and the homogeneous Neumann conditions on the left and the right.

For one (or all) of these applications, the goal is to find (numerically) an optimal (more precisely an ϵ-optimal) shape of a wall the most efficient in the range of frequencies of the interest to dissipate the acoustical noise.

To be able to do it, the work is in a team presenting a sturt-up.

The new products are the non-absorbing walls of a particular shape (not necessarily plane) with absorbing inclusions of one or several porous materials of a fixed quantity.

In the context of liner optimization, it is possible (optional for strong in theory persons) to develop the theoretical analysis of the convected Helmholtz equation (only possible for the track "Theoretical Analysis") with Robin or/and second order boundary conditions. The study of its well-posedness, the existance of optimal shape and the energy derivative over the distribution of absorbing inclusions. For more details see Edunao.

Plan of the project :

First day To give the name to the sturt-up, to define the objectifs, the applications to develop and the main strategy and organization. In addition, to define

- the state of the art ;
- the model(s) to consider,
- Theoretical study : considering that one boundary is open-air (the wave go through without coming back) derive the energy over the form and compare the result with the analogous result with a reflexive boundary [1].
- the plage of frequencies of the interest, dimensions, noise sources ;
- formulate the properties of the chosen model, what it is known about its solution ;
- formulate optimization problem ;

1. To model the open-air type of boundaries, it is convient to consider the Sommerfeld radiation condition of the form $\frac{\partial v}{\partial n} - ik \operatorname{Tr} v = 0$ with the notation $u(x,t) = e^{-ikt} v(x)$ for the propagative wave.

- to choose porous material(s) and its quantity ;
- find numerically the corresponding complex coefficient(s) $\alpha(\omega)$ for the porous matherial(s) ; to compare the performances if several ;
- find energy derivative over the distribution of the porous inclusions ;
- formulate/consider the numerical gradient descent method.

Second day — Study the energy on the chosen plage of frequencies for fully absorbent wall of the plane shape and to define the local maxima ;
- Study the same question for different shapes of fully absorbent walls ;
- Compare the energy of the initial distribution of the porous material in a reflective one.
- Optimize numerically for one or several the must problematic frequencies (at which there is a maximum of the energy) ;

Third day — Analyze the obtained results to compare to the effecient performances on the fixed range of frequencies ; to compare to a fully absorbing wall ;
- to optimize the energy at once at several different frequencies ;
- to study which quantity of the porous material gives the most optimal result ;

Fourth day — To continue the analyze of the performances ;
- To conclude which product to produce/develop.

Fifth day Defense by team the afternoon (slides 20 min, each person speaks, 10 min questions)
- To finalize everything
- Preparation of the defense
- Finalization of the rapport by team.

Each day from 15h to 16h45, each team/start-up presents during 15 min the current state of the work (main results of the day, difficulties, strategy, ..).