

# INTERACTIVE COMPUTER PROGRAM IN COMBINATION WITH FINITE ELEMENT ANALYSIS SOFTWARE FOR THE REDUCTION OF RESONANT VIBRATION IN THE STRUCTURAL MATERIALS

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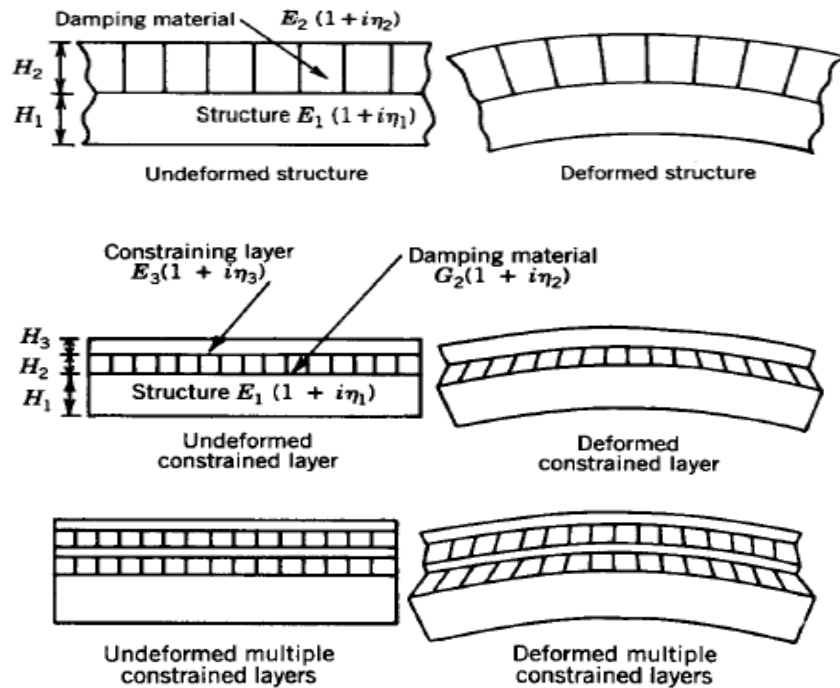
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**ABSTRACT:** One of the most important applications of the computer program is therefore using damping calculation program as a sub-routine in Finite Element calculations when designing damping treatments. One can analyze damping treatment on component level as well as on system level with FE models. The DCP and MSC-Nastran combination extends over traditional approaches and allows multi-disciplinary optimization where other design targets are taken into account when the damping treatment is designed.

## 1. INTRODUCTION

Most engineering structural materials have little internal damping capabilities and therefore exhibit high resonant vibration levels. Finite element analysis has been applied for variety of engineering application [1-4]. Structural damping material layers can be attached to the structural surface to decrease the vibration level, see Fig-1. The dynamic deformation in the structural damping material, due to the vibration, consumes vibration energy and transforms it into heat [5]. Structural damping treatment can be applied successfully on most surfaces that vibrate



and/or radiate sound, for example an oil pan or a fan cover.

Fig-1 Surface damping treatment

Typical damping materials show a high internal damping that changes rapidly with frequency and temperature [6]. It is therefore necessary to design the damping application with respect to temperature and frequency to obtain the best result. A large number of design alternatives must be examined to find the best damping capabilities for the structure. Fast simulation tools are needed to get apt results.

In this work damping calculation Program has been used in combination with MSC-Nastran to design the structure to get an optimum loss factor.

## 2. ANALYTIC MODELING OF DAMPING MATERIALS

The main purpose of the analytic characterization is to present the damping characteristics of a damping material in a form that can be readily using parameters and to describe the damping material. The vibration response is damping controlled at resonance, good knowledge of the structural damping does therefore allow the design engineer to predict the vibration response of a component. Standardized measurements are made in an environmental chamber to describe the properties of the damping material by parameters [1]. The loss factor and the Young's/shear modulus for the damping material are calculated from the geometry and material properties of the base beam and the measured resonance frequency and composite loss factor. This is a graphical presentation of loss factor and modulus. Analytical expressions can be made by the temperature-frequency superposition principle, which is a form of curve fitting. When both frequency and temperature are considered one get parametric expressions that describe the damping material.

## 3. SURFACE DAMPING TREATMENT

Surface damping treatments are usually classified in according to whether the damping material is subjected to:

- Extensional (free-layer damping treatment, FLDT)
- Shear deformation (constrained-layer damping treatment, CLDT)
- Multiple constrained-layer damping treatment, MCLDT).

Equations found in the literature are based on assumptions such as the loss factor of the base structure being zero, but since the computers of today are quite powerful, one does not have to rely on assumptions like that.

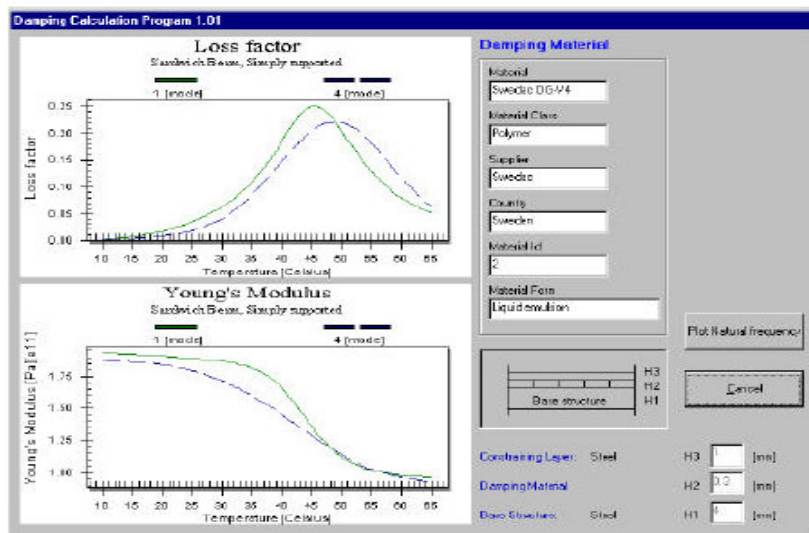


Fig-2 An example of output from DCP

## 4. DAMPING CALCULATION PROGRAM (DCP)

There are two types of applications for the DCP:

- The first is, if a damping material is known and the best result can be achieved using this material in a composite structure. The result of calculation is the loss factor and the Young's modulus (shear modulus for single viscoelastic material) of the composite structure as shown in Fig 2.
- The other is, if the result of requirement is known and the database can be searched for the damping materials that achieve the required result. A search run finds all material in the database that fulfills the specific conditions.

Calculations can be made for the following treatments and generic structures with a damping layer:

- Oberst beam/plate
- Modified Oberst beam/plate
- Constrained-layer damping treatment
- Multiple layer
- Single Viscoelastic layer

The Damping Calculation Program is constructed as a three-tier system and contains three different parts/programs. The three programs are the *Interface Program*, the *Control Program* and the *Calculation Program*, which can be seen in Figure 3. One task was to make the program available in batch-mode and to be able to control its execution on PC from a Unix-based computer. This makes the possibility of linking damping layer design into Finite Element Models and to make use of external software in optimization of damping treatment. The *Calculation Program* (ActiveX Server) does all the calculations and returns the result either to an external file or into a graphical user interface. The first of two control parts is the *Interface Program*, which is used when running the program on the PC. The other part is the *Control Program*, which is a “non-interface-program” developed to run in batch-mode. It works exactly as the *Interface Program*, which means that it communicates and runs the *Calculation Program*. But instead of an interface, it declares the variables for the calculations by an input-file, which is a text-file and can be generated by the *Interface Program*.

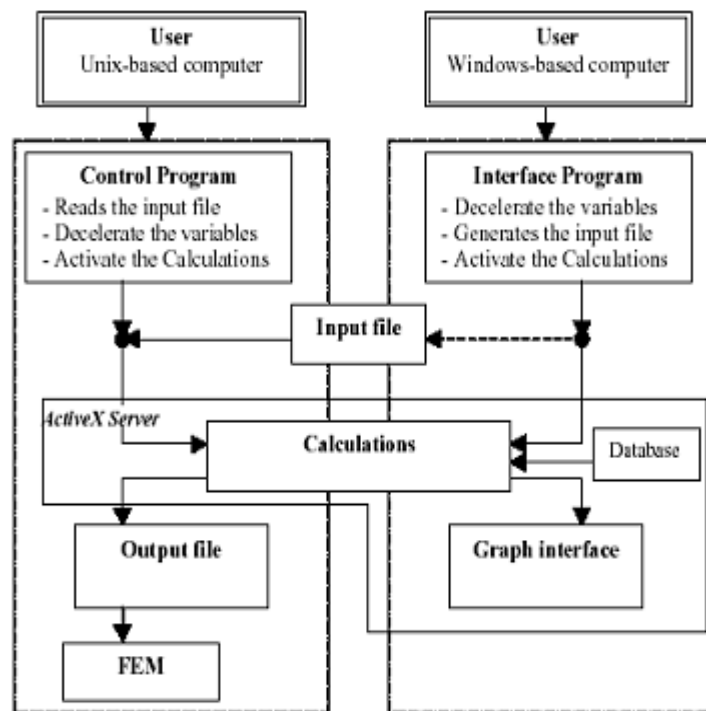


Fig-3 The program structure

## 5. FINITE ELEEMENT MODEL

When the result of the calculations are to be implemented into a Finite Element model, (FEM), the program has to run on a PC by the *Interface Program* to get the inputs (geometry, damping material, temperature, frequency) stored as an ASCII file. Then, when the program is run in batch-mode by the Unix-based computer, the *Control Program* reads the input-file (ASCII) to the *Calculation Program*. The *Calculation Program* calculates the composite Young’s modulus, the loss factor and the cross section’s moment of inertia and writes it to an output-file. This data is thereafter used as material parameters and cross section parameters in the FE model.

With FE models one can analyze damping treatment on component level as well as on system level. As an example of calculations on system level, we have designed an oil pan consisting of two different materials see Figure 4. The Power Injection Method (PIM) was used,  $P_{in} = \omega \eta E_{pot}$ , Where  $P_{in}$  is the mechanical power input from the force shown

in Figure 4(a),  $\omega$  is the angular frequency,  $\eta$  is the system loss factor and  $E_{pot}$  is the structures total dynamic potential energy.

The result of the PIM calculations, when temperature and frequency are varied is shown in Figure 5. The result is computed within the hour for 160 cases. The number of cases can be reduced by help from DOE for more complicated cases.

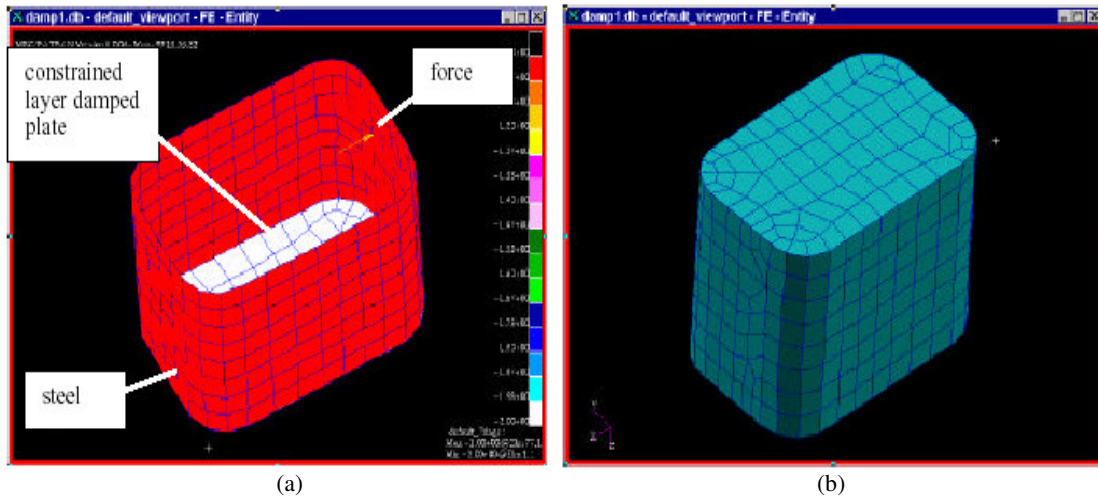


Fig-4 Model of an oil fan

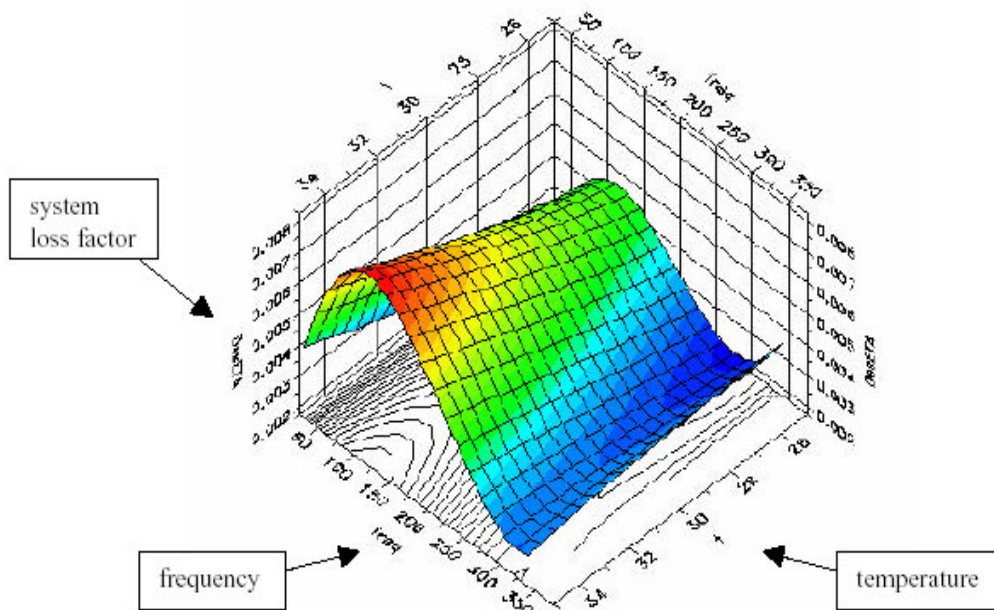


Fig-5 Example of how the global loss factor,  $\eta$ , for an oil pan containing only a section covered with damping material that varies with temperature and frequency. The damping application was designed using DCP, MSC-Nastran. The surface is a result of 160 calculations.

## 6. CONCLUSIONS

DCP design the loss factor for a damped cross-section. Making the best solution for most real structures often a more realistic model requires. One of the most important applications of the computer program is therefore using DCP as a sub-routine in Finite Element calculations when designing damping treatments. One can analyze damping treatment on component level as well as on system level with FE models. LMS Optimus expands the capabilities to optimize the treatment even further. The DCP, MSC-Nastran and Optimus combination extends over traditional approaches and allows multi-disciplinary optimization where other design targets are taken into account when the damping treatment is designed.

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