Combined approximation method applied to reduced non-linear vibro-acoustic problems

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ABSTRACT

The vibro-acoustic modeling using with the finite element method (FEM), still remains costly in numerical computing. This is due to the formulation choice that leads to a non-symmetric problem and/or a very large number of degree of freedom [1]. The non-linear behavior commonly found with vibration of thin structures, makes numerical resolutions more complicated. The reduced order method is used to overpass the numerical computing cost.

The classical reduced order method is known to not be suitable to non-linear problems. This is due to the modal superposition principle that is not valid any more.

The combined approximation method [2] is a reduced order method that was developed in the past for optimization and robustness studies via reanalysis. It consists on building a reduced order basis issued from the modal basis of the initial problem enriched by a function taking into account the modification of the problem. This function is developed in a Taylor decomposition to avoid inversing the current stiffness matrix.

In this paper, this method is adapted to geometrical non-linearities by considering the non-linear problem as a perturbation of the initial linear model. With thin structures [3] as plates or beams a coupling behavior between in-plane and bending displacements appears starting on large displacements. The initial basis should then take into account this effect.

By considering a light fluid as the air, coupling vibro-acoustic effect will modify specially the acoustic behavior. A structural reduced order basis is built on by using the combined approximation method. The acoustic basis is built on by using the eigenvectors of the conservative acoustic model. To take into account the coupling problem, these vectors are enriched by the static response of the fluid due to the presence of the structure.

A temporal response of a thin plate supported on a closed cavity is modeled to show on the efficiency of the method. Results show a high precision level compared to the full finite element model, but it shows also that the error produced by the reduced order model will be related to the level of non-linearity. In fact, by varying the excitation level, this error will vary too.

References

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