I-DEAS Vibro-Acoustics and RAYON Solvers: Features and Capabilities

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Introduction

I-DEAS Vibro-Acoustics is a Computer Aided Analysis (CAA) software product resulting from the integration of STRACO's RAYON Solvers family in the general graphical environment of I-DEAS Master Series of SDRC and IDEAS-TEST of MTS. This CAA engineering tool is developed by STRACO company (France), and is dedicated to numerical modeling and analysis of vibro-acoustics problems. It is composed by an intuitive and easy-to-use graphical user interface, which integrates RAYON solvers family dedicated to the analysis of complex three-dimensional vibrating structures coupled to one or several acoustic fluids and subjected to deterministic or random mechanical and/or acoustic excitations.

Numerical Methods

RAYON solver is based on an unified variational formulation coupling Boundary, Finite and Infinite Element Methods. Those methods can be mixed to solve internal, external or internal-external acoustic problems.

RAYON Boundary Element (BEM) solver address uncoupled acoustic problems as well as coupling structural-acoustic problems. It simplifies model generation because only the boundary of the acoustic domain has to be discretized. This method yields stable and accurate solutions for internal/external problems. Both direct and indirect methods are implemented and managed automatically depending on the number of acoustic domains (single or multi-acoustic domains).

RAYON Finite Element (FEM) solver is well adapted to solve internal acoustic problems. It is used to compute acoustic modes, elasto-acoustic modes, and frequency responses for coupled and uncoupled internal acoustic cavities.

RAYON Infinite Element (IEM) solver is an alternative to BEM for external problems. It is based on unique technology from AT&T Bell Labs and dedicated to model scattered and/or radiated acoustic field in external domain surrounding a radiating structure.

All these solvers share the same graphical user environment and can be mixed to perform efficiently a vibro-acoustic analysis. Typically, BEM/FEM solvers combination is used to solve internal acoustic cavity coupled to an external domain through an elastic structure. IDEAS-Vibro-Acoustics can be used as an integrated task within I-DEAS general environment exploiting transparently other I-DEAS modules (geometry, mesh, test, structure analysis ...) or as a stand alone package interfaced with other pre/post or Structural Analysis software(ABAQUS, ANSYS or NASTRAN).

Analysis Types

Several types of analysis can be performed by I-DEAS Vibro-Acoustics:

- Pure acoustic computation for diffraction and radiation acoustic problems without considering fluid structure coupling effects. This kind of problems usually refer to bodies excited by pure acoustic sources and external problems involving a vibrating structure.
- Modal analysis for internal acoustic problems, which consists in computing pure acoustic or elasto-acoustic modes.
- Coupled analysis for problems involving the interaction between one or several acoustic domains. They can be internal, external or mixed internal-external problems. The structure and fluid meshes may not to be compatibles.

Different Boundary Conditions can be applied in I-DEAS Vibro-Acoustics such as:

Prescribed acoustic pressure.

Prescribed acoustic acceleration, velocity or displacement.

Elastic surfaces (surfaces which in contact with an elastic structure)

Acoustic impedance (sound absorbing material modeling).

Fluid/Fluid interface.

Excitation Types

Multiple deterministic or random excitations can be applied simultaneously in the same problem and managed in a single solver run. The type of acoustic sources available in Vibro-Acoustics are:

Monopole.

Plane Wave.

Diffuse Sound field.

The mechanical loads are defined as part of the structure model.

Computation Results

A broad of physical quantities are computed and post-processed by I-DEAS Vibro-Acoustics:

Vibro-acoustic surface results, which include structural acceleration, mean squared velocity, acoustic pressure, acceleration and intensity.

Vibro-acoustic field results including panel participation factors, modal contributions, transmission loss factor, noise reduction, acoustic pressure, acceleration, and intensity.

Secondary results include acoustic energies radiated in the external domain or absorbed by acoustic materials, kinetic and deformation energy of the structure, injected power by mechanical excitation, radiation efficiency, ...etc.

New Features

2 modules are implemented in the new version of I-DEAS Vibro-Acoustics:

Poro-elastic material module (RAYON-PEM), which is based on a new mixed displacement-pressure formulation fully compatible with the implemented formulation. It allows the automatic integration of porous absorbing components in the passenger and engine compartments of vehicles.

Inverse Boundary Element Method (RAYON-IBEM) module, allowing the identification and the characterization of complex noise sources (engine, exhaust line, tires). This advanced module uses near field acoustic measurements, combined with an innovative Inverse Boundary Element technique based on a generalized wave envelope reciprocity principle for computing acoustic transfer functions.

Application fields

Vibro-Acoustics has been validated in many real life applications such as:

Aerospace applications covering a wide range of vehicles from aircraft to rocket launchers and satellites. They also cover various flight phases, from lift-off to atmospheric cruise flight. In particular STRACO used I-DEAS Vibro-acoustics to perform numerical studies of the European launchers (Ariane family) in cooperation with Aerospatiale (France), European Space Agency (ESA, Holland), "Centre National d'Etude Spatiale (CNES, France), Dornier (Germany) and Contraves (Switzerland). These studies focus on the prediction at the design stage of the Fairing Acoustic Protection (FAP) of payloads from reflected jet noise during take off, (see figure 1 and reference [1]).

Automotive applications covering the vibro-acoustic analysis of separate vehicle components (engine, air conditioning system, exhaust line, tires,...etc) or of the global vehicle by predicting interior noise and exterior performances (see figures2 and 3 and references [2,3]).

I-DEAS Vibro-acoustics can also be used to improve the acoustic characteristics of a wide range of other industrial products, from building applications (windows noise transmission, ...) to factory equipments and electronic devices.

References:

[1] H. DEFOSSE, M.A. HAMDI. "Vibro-acoustic study of ARIANE V launcher during lift-off", Inter-noise 2000; Nice.

[2] M.A Hamdi, H. Defosse, F Damagnes , T. Beauvilain and P. Varet. "Use of Reciprocity Principle in a Hybrid Modelling Technique (HMT) based on Inverse Boundary Element Method (IBEM) for the determination of the optimal spectral characteristics of a complex radiating noise source", Inter-noise 2000; Nice.

[3] J.M. Auger, M.A. Hamdi, G. Amadasi 1E. Girimondi, "Pass By Noise Modelling with Boundary Elements",SAE Noise &Vibration Conf., Traverse City, May 20-22, 1997

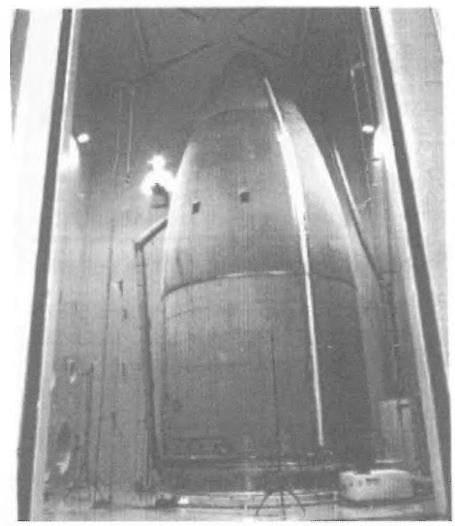

Fig. 1:Firing test

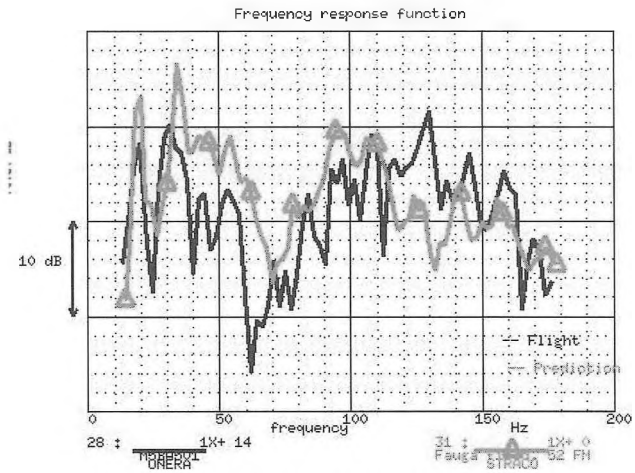

Fig. 2 : Flight/Analysis comparison of V501

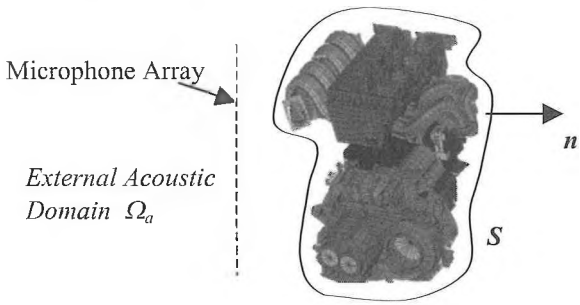

Fig. 2-a: Noise Source enveloped

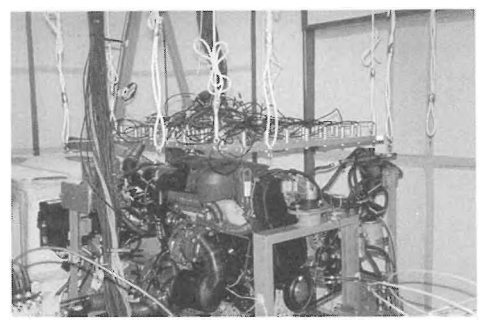

Figure 2-b: Experimental set up of a car engine

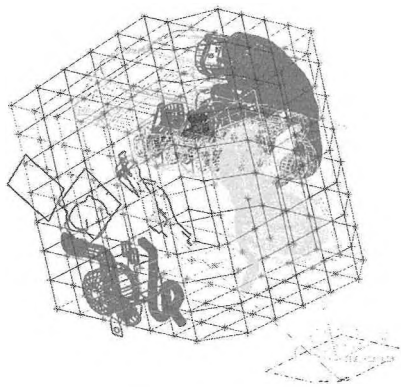

Figure 3-a. Engine IBEM Model

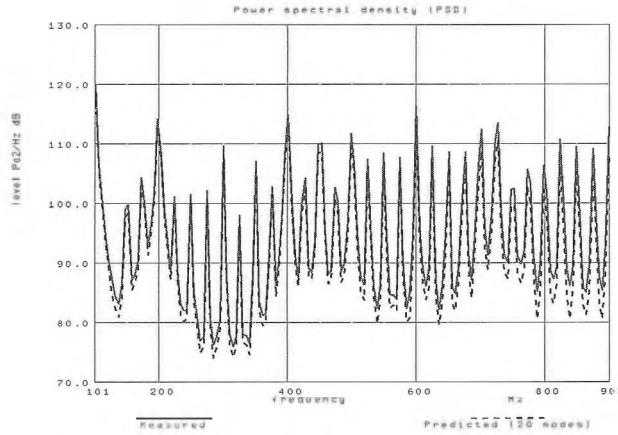

Figure 3-b. Averaged Sound Pressure Level

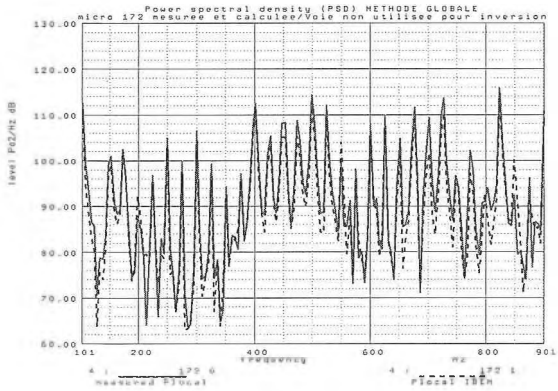

Figure 3-c. Local Sound Pressure Level

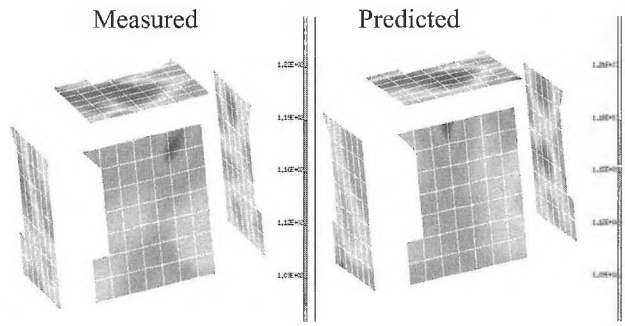

Figure 3-d. Radiated Acoustic Pressure at 600Hz