8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

An Inverse method for predicting shock levels induced by pyrotechnic separation

***B.Troclet[1], S.Alestra[2], V.Srithammavanh[3], and I.Terrasse[3]**

[1] EADS ASTRIUM ST
Les Mureaux, France
bernard.troclet@astrium.eads.net

[2] EADS Innovation Works
Toulouse, France
stephane.alestra@eads.net

[3] EADS Innovation Works
Suresnes, France
vassili.srithammavanh@eads.net
isabelle.terrasse@eads.net

Key Words: *, Structural Dynamics, Time Domain Inverse Method, Pyrotechnic Shocks, Gradient techniques, Optimization, Implicit Newmark scheme*

ABSTRACT

This paper deals with the development of numerical tools for predicting shock levels induced by pyrotechnic separation of launch vehicles stages. An Inverse method developed at EADS-IW has been used in collaboration with ASTRIUM-ST, to characterize with accuracy forces and moments, in time domain, induced by pyrotechnic devices near the separation system. The characterization is performed from acceleration measurements acquired during ground testing and flight. Then, the idenfied forces and moments, called sources, can be used for the prediction of shock levels at equipment mounted in the launch vehicle stages with better accuracy. The main goal is to to be able to define shock specification levels that units have to withstand during flights, and to point out shock problems, if any, in the early stage of design of launchers.

To identify the time domain shock propagating sources, an inverse method using a structural dynamic code has been developed and validated.

The direct structural dynamics solver is a time marching Newmark implicit integration scheme, taking into account the mass, damping and stiffness matrices of the structure. To improve the performances of the dynamical transient code, the source problem has been decomposed into a base of unitary sources (multilinear process) and the direct code has been parallelized. The computation of the unitary impulse responses with Newmark scheme is done only once before the optimization inverse loop. Doing this, we increase the efficiency of the inverse method at higher frequencies, and the total computations time of the inverse problem is reduced by a factor 10.

The inverse structural dynamic solver is based on an optimal control formulation, with a least square cost function minimization (distance between computed and measured accelerations), using an adjoint system with gradients computation and Quasi Newton optimizer.

Several numerical benchmarks of the direct code (benchmarks between codes, analysis of stability, performance), and of the inverse code (gradients accuracy, optimizer,

minimization loop tests) have been done.

The inverse method has been tested on elementary cases (aluminium plates), for symmetrical and dissymmetrical pyrotechnic separation devices. Acceleration Radial and longitudinal acceleration measurements have been filtered at 90000 Hz.

We can show that the source model based on correlated propagating sources is too much constrained and limited, to obtain sastisfactory restitutions at sensors. The idea to uncorrelate the propagating sources to take into account the non-linear cut-off of the structure, to increase the number of source parameters (space solution dimension) and relax the inverse algorithm, has allowed to improve the results, for the symmetrical and dissymmetrical test cases. The results are satisfying and very promising.

The parallelized inverse multilinear structural dynamics code could be tested and transposed on larger industrial case, for example on Sylda 5 Payload adaptor,

Another point is, to be investigated, to improve the quality of the modelization of shock propagation compared to measurements, by better characterizing the influence of material properties (composite materials), and junctions).

REFERENCES

[1] S. Alestra, I. Terrasse, B. Troclet "Inverse Method for Identification of Acoustic Sources at Launch Vehicle Lift-off, AIAA Journal, Vol 41, Number 10, pages 1980- 1987, October 2003.

[2] B. Troclet, S. Alestra, I. Terrasse, S. Jeanjean, V. Srithammavanh. Identification of Overpressure Sources at Launch Vehicle Lift-off using an Inverse Method. Journal of Spacecrafts and Rockets, Vol 44, Number 3, June 2007.