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An Approach for the 3D Dynamic Mathematical Modelization of Big Structures with Special Respect to ARIANE 5

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Abstract

With special respect to ARIANE 5, solutions are outlined that allow an improvement of the mathematical modelization and calculation in structural dynamics. Substructuring and the application of modern component mode synthesis methods (e.g. Craig-Chang) are necessary. However, most of the methods result in modal degrees of freedom (DOF) of the interfaces and demand a high effort to couple the substructures. In this paper, a general method is described that allows to overcome the disadvantages of the modal interface DOFs. As a result, the coupling of substructures is reduced to a simple addition of matrices. The methods of Craig-Chang and Hurty resp. Craig-Bampton are special applications of this method. All reduced matrices of the substructures are real and symmetric. In a second section, special aspects of modelization are discussed. Structural aspects that are taken into accout are the viscoelastic material behaviour of the propellant of the solid rocket booster, the idealization of fluids and shells and the fluid-structure-interaction including the stiffening effect of the tank pressure. Finally, the coupling between axial, lateral and circumferential wave modes of the launcher ARIANE 5 is no longer neglectable. The mathematical representation of the interfaces between adjacent substructures is of some importance. A hybrid description of the DOFs of the complete launcher by grid point displacements and Fourier series is possible and offers an additional way to reduce the number of DOFs.

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1 Introduction

Today, there exist powerful tools - software and hardware - for an improved dynamic analysis of big structures. However, in most of the applications the quality of the dynamic analysis is not restricted by the available tools. Restrictions are given by the tremendous amount of data and the necessity to handle mathematical models of substructures that are created in different companies and countries.

In order to reduce the large amount of data and to improve the analytical results simultaneously, three items are taken into account:

- The application of advanced substructure techniques that allow for physical interface DOFs,
- special aspects of the idealization of axisymmetric components of the substructures (solid and liquid propellants, shells) and
- the mathematical description of degrees of freedom of the interfaces by grid points and Fourier series simultaneously.

Figure 1 illustrates some substructures of the launcher ARIANE 5. For example, there are the axisymmetric main stage with liquid propellants, the booster EAP230 with high damped viscoelastic solid propellants and the upper stage EPS including several prestressed propellant tanks.

In a first section, a general method for the reduction of the dynamic mathematical models of the substructures is outlined. A presentation of special aspects of substructure modelization follows. At last, a hybrid mathematical description of the interfaces DOFs is discussed.