MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures I - Development and Verification (Space Vehicles and Components) (1)

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A STRATEGY FOR FINITE ELEMENT MODEL VERIFICATION OF COMPLEX SPACECRAFT

Abstract

Couple loads analysis is the most effective means to predict the mechanical environment which spacecraft has to experience during launch. The analysis results will be used to assess structure margin of safety. However, the accuracy and reliability of the load prediction is largely influenced by the finite element model (FEM) of spacecraft. On the other hand, during the subsequence satellite development using universal platform, dynamic testing could be partly substituted by numerical simulation based on the precise finite element model, the reduction of real testing will certainly save the money and time. Therefore, precise finite element modeling has become one of the essential issues in the space engineering for years.

Though rapid progresses have been made in finite element modeling and analysis during the past decades, there are various uncertainties and assumptions on boundary condition, physical parameter, structural connection and nonlinearity which may lead to deviations between FEM predicted and experimental dynamic properties. To circumvent the problem, the most promising approach is to update the initial finite element model using experimental data at present.

It is believed that model verification should be performed to obtain the precise finite element model in the early stage of the spacecraft design. A systematic model verification strategy consisted of finite element modeling, modal testing, correlation analysis and model updating is proposed in this paper. An appropriate initial model and accurate experimental data are foundations of model verification. Correlation analysis is used to assess consistency of experimental data and the finite element model. Model updating method based on sensitivity analysis is employed to obtain high-fidelity finite element model by automatically adjusting some of the structural parameters.

As the new generation universal satellite platform of China, DFH-4 is designed for the development of communication, navigation and remote sensing satellites. DFH-4 satellite structure is an assembly of several components. Hence, it is so complex that model verification is a challenge in engineering. By applying the proposed strategy, DFH-4 model verification is successfully performed and the implementation is given in detail. Among the presented studies, modal testing and model updating are supposedly to be the first time successfully implemented on the DFH-4. The verified finite element model is able to accurately reproduce experimental modal data. Deviations between experimental and predicted modal frequencies are less than 5% after updating. The modal assurance criteria of the concerned modes also increase. At last, several valuable suggestions concluded from practice are discussed.