An Effective POD-based ROM for Harmonic Response Analysis and Optimization of Stiffened Shells

† Yuwei Li, Bo Wang, Peng Hao, and Kuo Tian

State Key Laboratory of Structural Analysis for Industrial Equipment, Department of Engineering Mechanics, Dalian University of Technology, China

†Corresponding author: liyuwei@mail.dlut.edu.cn

Abstract

Stiffened shells have been widely used in the fuel tank and interstage of launch vehicles because of high specific stiffness and strength. To obtain resonant frequencies or anti-resonant frequencies of stiffened shells, harmonic response analysis is often carried out. However, the harmonic response analysis based on detailed finite element models was time-consuming and expensive, especially in optimization involving hundreds of reanalyses. This paper presents an effective reduced order model (ROM) based on proper orthogonal decomposition (POD) to improve the efficiency of harmonic response analysis. In offline phase, frequency analysis is performed based on a full-order model (FOM), and eigenvectors of stiffened shells are calculated at various sample points in the parameter space. Furthermore, snapshots are assembled from these eigenvectors, and a global reduced order basis(ROB) is determined. The offline phase has some relatively heavy computations but they are done once-for-all. In online phase, the harmonic response analysis can be carried out to predict resonant frequencies or anti-resonant frequencies of stiffened shells. And anti-resonance frequency design can also be performed along with optimization methods to minimum dynamic response of stiffened shells under harmonic excitation. Finally, an illustrative example demonstrates the effectiveness and efficiency of the presented framework.

Keywords: Stiffened shells; Harmonic response analysis; Reduced order model; proper orthogonal decomposition; anti-resonance frequency design