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Dynamic Response of Circular Cylindrical Shells under Impact Loads by Spectral Element Method

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Abstract

In this paper, the method of spectral element to specify the natural frequencies and the dynamic response of circular cylindrical shells with arbitrary boundary conditions under impact loads has been developed. Displacement filed is expressed in modal form in circumferential direction and exact solution in longitudinal length is extracted in frequency domain that leads to dynamic stiffness matrix evaluation and dynamic solution in the time domain has been specified using IFFT. In the following, natural frequencies for cylindrical shell are calculated and compared with some other results reached in the past. Also, shell displacements under impact load are plotted. Making use of the smallest number of elements in spectral element method, and a really big saving of the volume and cost of the computations for reaching some results so close to the precise results makes this method superior to other numerical methods.

Keywords: impact load, spectral element method, dynamic stiffness matrix, natural frequency.

1. INTRODUCTION

Cylindrical shells have very high and extensive application in industries such as airplanes, marine crafts and construction buildings. Thus, surveying the dynamic attitude of cylindrical shells is one of the most major issues and of designers' high interest. A lot of research has been conducted on the dynamic attitude of cylindrical shells so far, and as a result, a great variety of solution methods have been offered. One of the best book published in the shell field is written by Flugge[1]. Finite element method is one of the strongest and most frequently used solutions that have been being used by researchers and engineers for many years. Using FEM method can be led to acceptable results when the mesh size is smaller than the wave length. As guidance, mesh size must be 10 to 20 times as small as the smallest wave length (the greatest frequency) to have FEM lead to credible results [2]. Based on this reason, in problems where high frequencies are produced, the number of mesh rises so high that it leads to calculation errors, and on the other hand the calculations will be so expensive. In finite element method, generally, polynomial functions in time domain are used and it can't provide all essential frequencies, but if there is an access to the frequency shape functions of the structure, there's no need to apply mesh and it's possible to access all the frequencies, which is known as Dynamic Stiffness Matrix Method (DSM) method. The Dynamic Stiffness Matrix is produced in frequency domain and through an exact solving of the differential equation of motion, and it includes stiffness and damping effects, and also the mass of the structure. Due to the absence of necessity of mesh, DOFs and the cost of calculations decrease, and the preciseness of calculations is so high that sometimes, it's called the precise method.

The great variety of solution methods used in solving of dynamic differential equation of motion in plates are in time domain. To mention the most famous ones of them, we can name modal analysis and solution by Fourier series. In another technique it's possible to represent the answer of the differential equation of some the shells based on Super position through applying an unlimited number of Wave modes including all frequencies. In this method a great number of Fourier coefficients is calculated in frequency domain and finally, the answer is gained by means of inverse Fourier transform. This method is called SAM. In this method the continuous or discrete Fourier transform is used. In cases where the load function is