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Free and Forced Vibration Analysis of Stiffened Cylindrical Shells under Moving Internal Pressure

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Cylindrical shells, Ring & stringer stiffeners, Free vibration, Dynamic analysis, Moving internal pressure.

ABSTRACT: Cylindrical shells are used tremendously in many engineering fields such as ships, submarines, and fuel tanks in airplanes. In many cases, shells are exposed to dynamic loads. One of the dynamic loads in shells is internal moving pressure. Analysis of cylindrical stiffened shells under moving internal pressure are investigated in this research. Equations of motion are based on classic shell theory and derived from Hamilton's method. Boundary conditions are assumed simply support. Displacement components are assumed Fourie double series based on boundary conditions. Equations of motions are solved by Galerkin weighted functions method for calculation of natural frequency and dynamic response of cylindrical shells under moving internal pressure. Codes in FORTRAN are used to derive the natural frequency and dynamic response of cylindrical shells. Results are compared with other references and Abaqus software. The effect of geometrical parameters on natural frequency and dynamic response of cylindrical shells under moving internal pressure are investigated finally and results for stiffened shells and unstiffened shells with different stiffeners are compared.

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1. INTRODUCTION

Pipelines, gun barrels, and rocket launcher's barrels are structures that are subjected to mobile internal pressure, which reinforced pipes can be used.

Hopman [1] examined the vibrations of reinforced cylindrical shells. He obtained the mean effect of the amplifiers and added them to the equation of shell vibrations and compared the theoretical results with his laboratory results. Mustafa and Ali [2] considered amplifiers as separate elements and extracted the equations of the kinetic and potential energy of shells and longitudinal and peripheral amplifiers separately. Rasman [3] examined the dynamic response of a cylindrical shell with a moving internal load. The load moves diagonally and with constant speed. Jafari and Bagheri [4, 5] calculated the natural frequencies of peripheral reinforced cylindrical shells by analytical, numerical, and laboratory methods and compared the results with each other. Duck and Tong [6], using first-order shear deformation theory and stress function with complete motion equations, have investigated the nonlinear dynamic response of functionally graded cylindrical shell. Sophie and Pasha [7] examined the forced vibration of the reinforced cylinder by carbon nanotubes under moving load. Internal pressure moves in a circular motion at a constant speed.

In this research, an analytical solution for free vibrations and dynamic response of reinforced cylindrical shell with peripheral and longitudinal amplifiers separately and together, with simple boundary conditions undermovable internal pressure with a function of pressure and completely general velocity is presented which has not been considered before.

2.METHODOLOGY

The Hamilton method is used to obtain the equations of motion. Fig. 1 shows a reinforced cylindrical shell with stiffeners.

If the convections of w_0, v_0, u_0 are arbitrary points on the shell and u, v, w are the convections of interlay of the shell, their geometric relationship is as follows

$$u_0 = u - z w_{,x}$$
$$v_\theta = \frac{a+z}{a} v - \frac{z}{a} \mathrm{w}, \tag{1}$$
$$w_0 = w$$

Equations of motion are obtained using the Hamilton method with the help of strain and kinetic energies of shell and stiffeners.

The moving internal pressure is as follows

$$q(x,t) = p(t)\,\mathrm{U}\left(x_0(t) - x\right) \tag{2}$$

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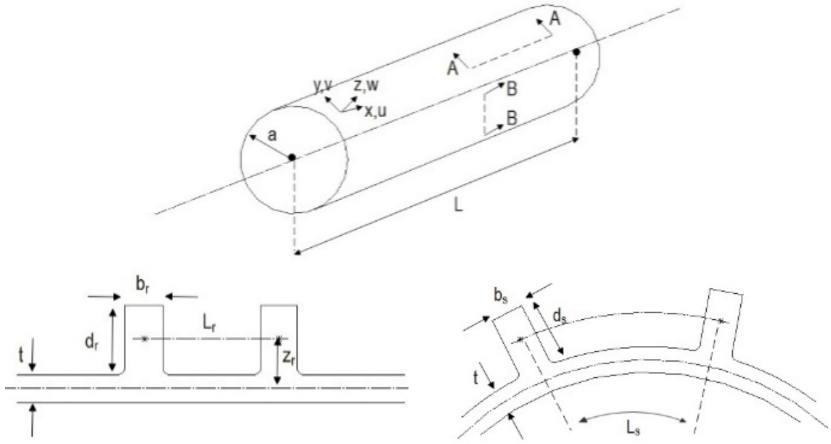

Fig. 1. The geometry of shell and stiffeners

Table 1. Geometry and properties of shells

Length (m)	Radial (m)	Thickness (m)	E (GPa)	ρ (kg/m^3)	υ
1.5	0.05	0.007	207	7770	0.3

Table 2. Geometry and properties of stiffeners

Height (m)	Width (m)	E (GPa)	ρ (kg/m^3)	υ
0.01	0.007	207	7770	0.3

Properties and geometry of shell and stiffeners are in Tables 1 and 2.

The behavior of moving pressure in cylindrical shell are shown in Figs. 2 and 3

Dynamic solutions are obtained by placing pressure in the equations of motion and solving it using the Galerkin method.

3. RESULTS AND DISCUSSION

The results are compared with the results of Abacus software and are closely related to each other. The radial conventions are examined as shown in Fig. 4.

4. CONCLUSION

Rings are effective in reducing the radial convections of cylindrical shells under internal moving load and have little effect on longitudinal convections. Stringers have little effect on radial convection and are effective in reducing longitudinal convection. The effect of rings toward the increase in thickness is greater than reducing radial convections and the effect of stringers toward the increase in thickness is greater than reducing longitudinal convections. For each point of the cylinder, the radial convection is approximately zero until the internal moving pressure is applied to that point, and as soon as the moving pressure reaches that point, the radial displacement immediately increases and then follows the deformation pattern to its previous points.

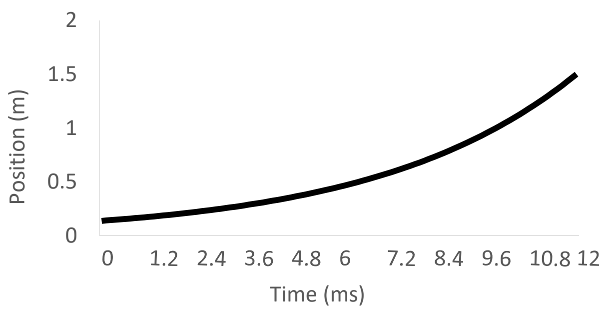

Fig. 2. The situation of internal pressure in the cylinder

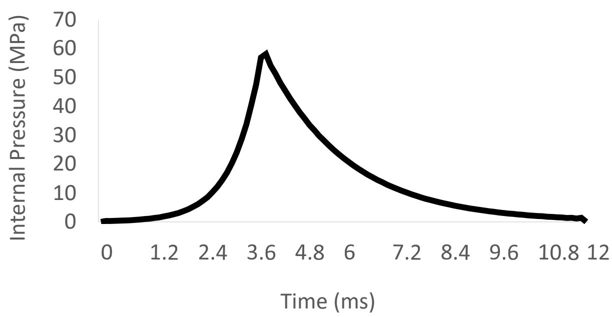

Fig. 3. Pressure diagram in terms of time

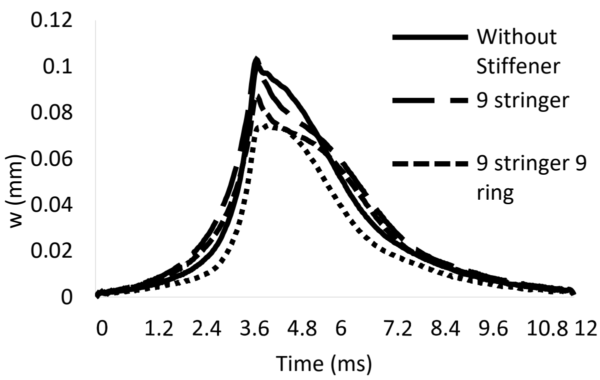

Fig. 4. Analysis of the effect of different types of stiffener on the radial convection of the cylindrical shell

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