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Finite Element Analysis of Fundamental Frequency Responses of the Cylindrical Shell Panel with Cutout

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Abstract

The work deals with the analysis of the vibration characteristic of the composite laminate wit cut out. The work is performed using ANSYS software where the plate model is discretized with the help of isoparametric shell element SHELL-181 having four node is used from the ANSYS's element section for discretization purposes. The free vibration responses is obtained and the responses are equated with that of the earlier published literature. Finally the parametric effect (thickness ratio, boundary condition and curvature ratio) on the vibration responses is discussed in detail.

Keywords: *Composites, ANSYS, vibration analysis*

1. Introduction

Composite materials are those materials which are obtained by the combination two materials. One is the reinforcements and the other is the matrix. The reinforcements are responsible for carrying the loads and the stresses which the composite is subjected to.

The work of the matrix if to distribute the force and stress uniformly among the reinforcement and binds the reinforcement. It also prevents the fibres from external damage. Composite materials are such that they inherit the superior qualities of the combining materials leaving behind the inferior qualities. The properties which are impossible to be obtained from a single material can be obtained from a composite due to its heterogeneous nature. All the properties of the composites are the function of its components, their spatial distribution sequences and particle interaction between them. The excellent stiffness to weight ratio, specific strength and other required properties of fibre reinforced laminates make them first and foremost choice of designers in structural applications. Several types of elements such as plates shells etc. have been successfully implemented in many real life structures which are showing excellent properties.

2. Literature Survey

Now a days many theories have been already been developed by various researcher to fulfill the lacuna of composite material and replaces the uses of the conventional materials. In view of the above, various mechanical characteristic like vibration and bending behavior have been studied throughout the glob by various researcher to confirm the performance of the composite structure in service lifespan. But in real life situation the structures are not regular always. There may be some discontinuity in the form of some cut or hole. So in the following paragraph some of the pioneer work of vibration anlysis of the laminated composites plate with as well as without cut out have been discussed.

In service life the laminated structure are subjected to dynamic loading so the vibration comes to play. Kant and Swaminathan [1] studied the dynamic analysis of sandwich and laminated composites plate analytically using HSDT. Reddy and Khdeir [2] investigated the natural frequency characteristics of composite laminate plates in framework of higher order theory. Reddy and Liu [3] analyze the natural frequency and the bending behavior of spherical and cylindrical shell using HSDT kinematics. Thai and Kim [4] investigated the frequency of the laminate with the help of variables refined plate theory. Reddy [5] proposed a FEM model and analyze the vibration charactristic of the anti-symmetric as well as angle ply laminated plates. Ganapathi et al. [6] obtained the natural-frequency of the composite laminate plate with supported boundary condition applying FSDT. Swaminathan [7] and Patil used the HSDT model with twelve DOF to investigate the vibration analysis of the angle ply anti-symmetric plate. Bhimaraddi [8] analyzed the vibration behavior of the rectangular laminated composites plate using kirchoff and parabolic shear deformation theory. Chakravorty et al. [9]

proposed the FEM analysis of vibration characteristic of the curved composite laminate shell-panel using FSDT. Luccioni and Dong [10] analyze the vibration responses and the stability analysis of the both thick and thin rectangular laminated composites plate using CLPT and FSDT.

Cut-outs in structural members like plates tend to change its dynamic characteristics to some extent. This change is obvious whenever the structure is exposed to large vibrations. Many a times these cut-outs may lead to failure under lower stress and also sometimes due to undesired resonance. So it is utmost necessary to predict the resonant frequencies of these structures with cu-touts. The extensive range of practical applications of cut-outs in plates requires a better appreciative of the vibrations as well as stability properties of laminated plates with cut-outs. Based on the extensive survey of the literature it is viewed that there are limited number of work on vibration behavior of laminated composite using commercial FEM software ANSYS. The FEM based software ANSYS is accepted by the various industries only because it gives the adequate accurate result with less computational cost. So the present work objective is prepare a FE based mathematical model using APDL code in ANSYS for the composite laminated plate with and without cutout to analyze the vibration characteristics. The consequence of material and geometrical parameter and the cut out size will be obtained and discussed on detail. The effect of material and geometrical parameter and the cut out size will be obtained and discussed on detail.

3. Results and Discussion

To achieve the above discussed objectives a proedure of the finite element analysis step in ANSYS is followed. The efficacy of the presently developed model, convergence test has been performed. On the basis of the convergence natural frequency of the shell panel have been found and compared with the available published literate result. The effect of various parameter on vibration behavior of the laminated composite shell panel are found out with the help of solving some numerical examples. The material property and the geometrical property used in the present work is shown in the table 1.

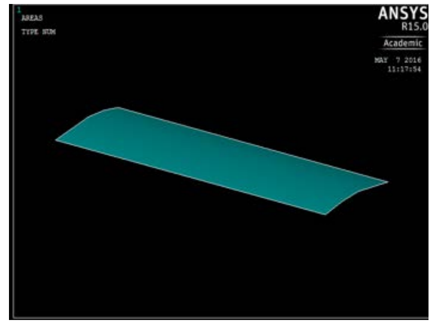

Fig.1. Shell pannel

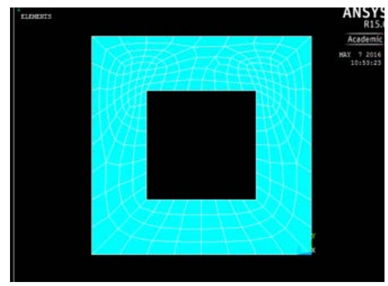

Fig.2. Shell pannel with cut out (front view)

The consistancy test of presently steps has been executed to commute the natural frequency using ANSYS. Figure 3. Shows the vibration characteristic of a four layered, clamped, square cross-ply laminated cylindrical shell panel using the material and geometrical property as in shown Table 1. From the figure, it is depicted that the results are showing good convergence for the presently developed models. The mesh size (7×7) is adequate to find out the vibration characteristic of composite laminate cylindrical shell panel.

TABLE I. Material and geometrical property.

Aspect ratio. *(a/b)*	1
Thickness ratio *(a/h)*	10
R/a	20
Young's modulus in longitudinal direction (E_l)	$40E_t$
Transverse Young's modulus (E_t)	1GPa
z direction Young's modulus (E_z)	E_t
Shear modulus (G_{lt})	$0.6E_t$
Shear modulus (G_{tz})	$0.5E_t$
Shear modulus (G_{lz})	$0.6E_t$
Poisson's ratio (ν_{lt})	0.25
Poisson's ratio (ν_{lz})	0.25
Poisson's ratio (ν_{tz})	0.25

Now, the ANSYS model is utilised to find out vibrational frequency of cylindrical shell and compared with available result. The frequency value of composite laminate cylindrical shell panel is found out and shown in table 2 using the material and geometrical property same as taken in the reference. It is seen in the table 2 that the responses are close to published result.

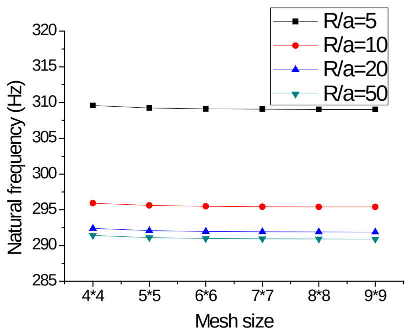

Fig.3. Consistency check

TABLE II. Vibration Comparison

type of lamination	***Thickness ratio (a/h)***	***R/a= 100***	
		Reference [11]	***ANSYS***
0°/90°	10	8.8974	8.9258
	100	9.7108	9.864
0°/90°/90°/0°	10	12.227	11.957
	100	15.199	15.680

3.1 Vibration of the shell panel with cutout with different thickness ratio

The vibrstion of clamped composite laminate shell panel with different size of square cutout at the mid of the laminate area and with different thickness ratio is displayed in figure 4. From the figure it depicts that with increasing the size of cut out natural frequency of laminate is increasing. On the other way with increasing the thickness ratio the frequency responses get decreases.

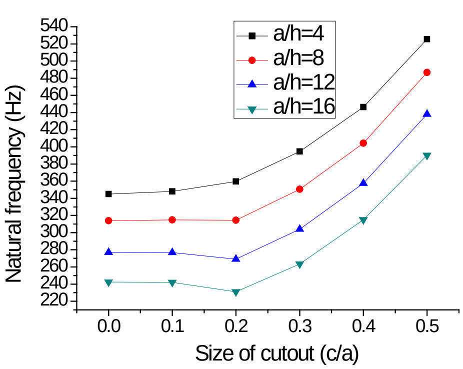

Fig.4. Vibration of shell panel with cutout and differentthicjness ratio

3.2 Vibration of shell panel with cutout and different curvature ratio

Influence of curvature ratio on frequency of clamped composite laminate cylindrical shell-anel with and without cutout is computed and presented in figure 3. With increasing the curvature of the shell panel or with increasing the shallowness of the structure the stiffness decreases and natural frequency too. The same behavior is depicted in the figure 5 where frequency of the clamped composite laminate cylindrical shell-panel with as well as without cutout of is presented.

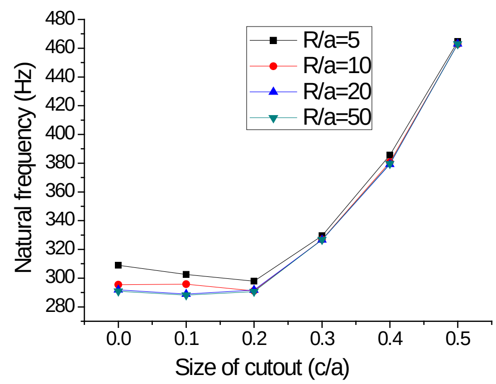

Fig.5. Vibration of shell panel with cut out and different curvature

3.3 Influence of end condition on vibration of composite laminate cylindrical shell-panel with cutout

Natural frequency responses of clamped laminated cylindrical shell-panel with as well as without cutout and different boundary condition has been plotted in figure 6. From the figure it is observe, with increasing the constraints, vibration frequency also increases. Similarly it can also be observed that with increasing the size of cutout frequency also increases. This is because that when the mass of the structure is inversely proportional to the frequency so when the particular mass is removed from the structure frequency get increases.

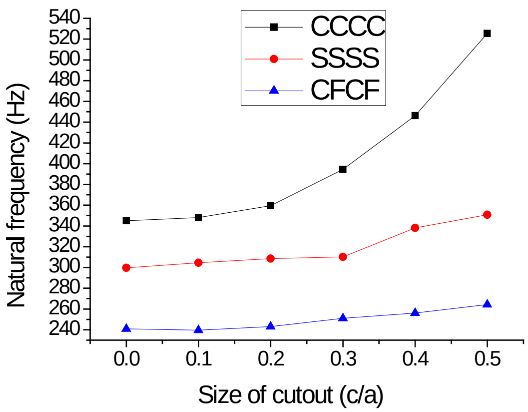

Fig.6. Influence of boundary condition on natural frquency of composite laminate cylindrical shell-panel with cutout.

4. Conclusions

In the present work the vibration frequency of the of cylindrical-shell panel with and without cutouts is obtained using ANSYS software and the responses generated are equated with that of published results. In last on basis of present analysis some conclusions have been drawn and present in following lines:

- First of all the convergence and comparison behavior of the free-vibration characteristics of composite laminate shell panel is computed. It is concluded that the results are showing good convergence and differences are within the acceptance limit.
- The model is authenticated by comparing the frequency with that of available published literature.
- The effect of cutout size indicate that the natural frequency increase with increasing cutout size.
- As the curvature ratio increases, the frequency value decreases.
- Frequency value decrease with increasing the thickness ratio.
- Boundary condition plays an important role laminated structure. It is viewed that with increasing constraint vibration frequency increases.

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