Vibration behavior analysis of functionally graded annular piezoelectric plate for free-free boundary conditions

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Abstract: Functionally graded piezoelectric material has very enormous application in the field of engineering and science. It is very useful for smart device like micro electric mechanical system, nano electro mechanical system. In the present work the effect of diametric ratio has been observed for functionally graded piezoelectric circular plate for free-free boundary conditions. d15 effect has been utilized for exited shear induced flexural vibration. Due to complex nature of shear vibration these effect is less utilized. Plate has been readily polarized and electric effect is applied along the thickness direction.

Keywords: Piezoelectric materials, d15 effect, Radially Polarized

Introduction

Functionally graded piezoelectric materials is widely used material. Functionally graded material has been used in drone for making it self-powered. Functionally graded piezoelectric materials are using in gas liter and in gas stove for auto ignition. This plate can be use in crack detection in the pipes and rail wheel. Piezoelectric materials are used to measure change in pressure, acceleration. Piezoelectric materials can be used in high temperature environment. It can be stored energy and can also release released energy when required. Electric energy can be generated by using piezoelectric materials and this energy can be utilized in power harvesting system. In the present work be are analyzing the behavior of shear vibrations for the piezoelectric plate for free-free boundary conditions for different-different parameters. I am analyzing the effect on natural frequency when diametric ratio is increasing.

Model Description

Functionally graded piezoelectric materials is widely used material. Functionally graded material has been used in drone for making it self-powered. Functionally graded piezoelectric materials are using in gas liter and in gas stove for auto ignition. This plate can be use in crack detection in the pipes and rail wheel. Piezoelectric materials are used to measure change in pressure, acceleration. We are taking a round piezoelectric disc as shown in figure 1. Thickness of this plate is 1mm and inner diameter is 2mm and outer diameter is 24 mm. This model is created by using modeling software.

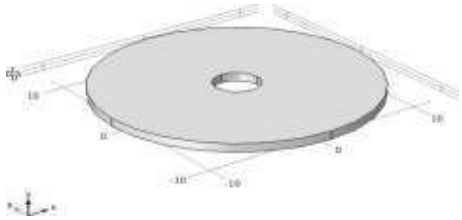

FIGURE 1. Functionally graded piezoelectric circular disk (Do=24mm, Di= 2mm, t=1mm)

Result and Discussion

In this study, Eigen frequencies of functionally graded circular disks have been evaluated for free-free, conditions. Hare the meaning of free-free boundary conditions is that inner surface of the plate is free and outer surface of the plate is also free, Power law is used to vary the property in thickness direction. Upper surface of the plate is PZT-4 rich while inner surface of the plate is PZT-5H rich. Properties of the plate constantly varying

Analysis of Eigen frequency of FGPM disk for measuring the effect of diametric ratio for free-free boundary condition

Table 1 shows the effect of natural frequency of FGPM disk for free-free boundary conditions. From

this table it can be observed that the natural frequency of the disc is decreasing when the diametric ration is increases. 'n' denotes nodal diameter, 's' denotes nodal circle hare, N is the power law index. Power law index N is 0.5 in this analysis. Thickness of the plate is 1 mm and outer diameter of the plate is 24 mm while inner diameter is varying constantly. Here in we are analyzing the behavior of vibration of natural frequency second column of table showing the natural frequency for two nodal diameter and zero nodal circle, third Colum of the table showing the natural frequency of four nodal diameter and zero nodal circle and last column of the table showing the zero nodal diameter and 2 nodal circle. These results can be utilizing for developing new application of piezoelectric materials. Natural frequency of this circular plate showing increasing slop.

TABLE 1. Natural Frequency (kHz) for a free- free FGPM disc, D=24, h=1mm, N=0.5

N=0.5	(n, s) (2,0)	(n, s) (0,1)
1	5.058	8.981
2	5.000	8.873
3	4.934	8.459
4	4.863	8.306
5	4.548	7.625

Graphical Representation of natural frequency when the diametric ratio increases for free-free boundary conditions

From figure 2 it can be observed that natural frequency of FGPM disc increasing for zero nodal diameter and two nodal circle. And natural frequency is decreasing for 0 nodal diameters and for one nodal circle, natural frequency is decreasing for four nodal diameters and for zero nodal circle and natural frequency also decreasing for zero nodal circle and two nodal circle. The large effect on the natural frequency can be observed for 2 nodal diameter and zero nodal circle

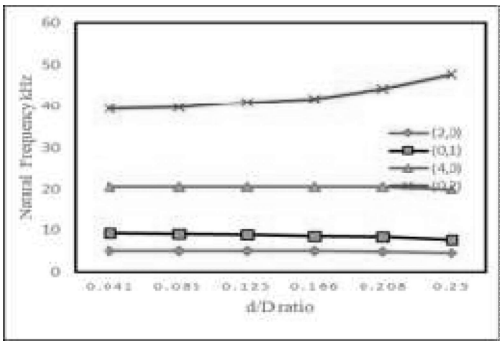

Figure 2. Variation of natural frequency with d/D ratio for free- free annular plate

Mode shape of natural frequency when the diametric ratio increases for free-free boundary conditions

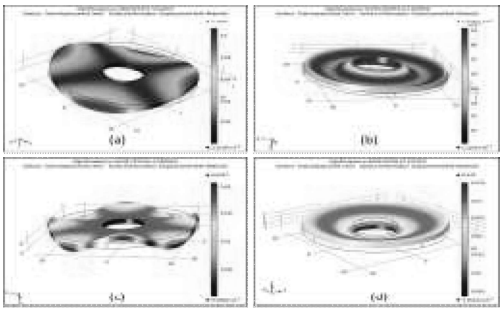

Figure 3 Mode shape of the free-free annular FGPM plate (D=24mm, d=7mm, and h=1mm): (a) (2, 0) mode at 4.669 kHz, (b) (0, 2)mode at 51.959 kHz, (c) (4, 0) mode at 20.548 KHz, (d) (0, 1) mode at 8.106 kHz

Conclusion and Future Directions

Eigen frequency for the FGPM plate has been evaluated, and a comparative study of different geometrical parameters has been conducted with power law variation. It is observed here that natural frequency slightly creases when the value of the power law index increases. This FGPM circular disk can be used in ultrasonic motors, drones, and many smart devices. Here, the natural frequency is higher for fixed-fixed boundary conditions than the free and fixed-free boundary conditions. The free-free plate's natural frequency is much less than the other boundary condition for the same nodal circle and nodal diameter. The natural frequency obtained here is believed to be useful for designing smart systems based on FGPM round disks by exited shear vibration. Shear-induced flexural vibration for varying power law index on the elastic foundation can be explored in future work

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