CHAPTER-1

INTRODUCTION

1.1 GENERAL

In recent years, there has been an increasing interest in the development of light weight smart or intelligent structure for space applications. In these structures, the load-bearing substrate is made of composite materials for higher strength-to-weight ratio and stiffness-to-weight ratios. These structures are integrated with distributed piezoelectric materials. The piezoelectric materials act as sensors and actuators because of the direct and converse piezoelectric effects respectively. The intelligent structures when coupled with suitable control strategies and circuits have self monitoring and self-controlling capabilities.

The piezoelectric materials bonded on the structure acts as both sensor and as actuator to monitor and control the response of a structure. Application of voltage to the actuator introduces force on the base structure, which is proportional to the displacements or velocities measured by the sensors. This actuator force gets added to the stiffness force or damping force, to change the stiffness and damping characteristics of the structure. These changes if properly adjusted can reduce the amplitude of vibration. The piezoelectric materials distributed on the structures act as sensors and actuators. The intelligent structures when coupled with suitable control
strategies and circuits have self monitoring and self-controlling capabilities. The structures which are capable of self monitoring and self adapting, using bonded/embedded sensors, actuators and control system are known as smart structures.

The conventional form of external passive damping is not preferred, as the addition of a damper increases the overall system weight, which is undesirable. This has led to extensive research in to active control of vibrations. In active control of vibrations, the effect of unwanted disturbance is cancelled by deliberate addition of another disturbance, equal in magnitude but opposite in sign.

In the recent past, the numerical modeling of the piezoelectric constants that couple normal strains and shear strains with transverse electric field is the subject of interest. The piezoelectric materials are popularly considered as smart or active elements due to their good frequency bandwidth, low cost, fast energy conversion. They can also be easily shaped in to any size for surface bonding or embedding.

The smart composite structures are exposed to vibrations during the service life of high speed aircrafts, rockets, and launch vehicles. The drag force causes buckling and dynamic instabilities in the structures. Therefore the vibration control and shape control of smart laminated composites by piezoelectric actuation plays an important role.
1.2 OBJECTIVES OF THE WORK

The active vibration control of beams and plates has been reported in the literature using finite element and theoretical analysis. But the limited work has been carried out on Active vibration control of cylindrical shell structures. The vibrations developed in smart structures along with MFC actuators can be obtained using numerical methods. But these methods must be experimented to convert the theoretical concept into a promising technology. Hence there is a need to develop smart structure concepts to use the piezoelectric actuation effectively to control different vibration modes i.e.; elastic modes (bending or torsion) by selecting the type of control, displacement or velocity.

The following are main objectives of the present work

- Development of numerical method using the first order shear deformation theory to obtain vibration modes of composite cylindrical shell structure.
- To couple both electrical and mechanical actuation in the numerical formulation
- Development of four noded facet shell element with capability of actuation and sensing of active vibrations.
- To design vibration controllers for estimating the voltages required to control the vibrations.
• Development of numerical method, which can be used in the shape control of the shell panel under in-plane load.

1.3 ORGANIZATION OF THESIS

The research work carried out under the proposed title is presented in seven chapters. A detailed description of each chapter is briefly outlined below:

Chapter 1, presents a general introduction to smart structures, importance of the problem, motivation for the work and organization of the thesis.

A detailed review of the current smart structure technology combined with published literature is presented in chapter 2. The research articles in this fascinating area related to Piezoelectricity and piezo ceramic actuators, FE formulation with piezoelectric coupling, vibration control using MFC actuators, buckling of composite cylindrical shell panels are presented.

Chapter 3, presents theory related to smart structures and the formulation of facet shell element used to simulate the structural model, constitutive relations of composite and piezoelectric lamina. A four-noded composite facet shell element based on coordinate transformation is presented.
The results obtained from developed finite element are validated in chapter 4, with that of ANSYS (FEA) package and experiments conducted on shell structure.

In chapter 5, a brief introduction to active control is given. A state feedback and output controls are discussed in detail. Modal control scheme is presented employing system states such as displacement and velocity. Active vibration control procedure is presented with LQG control simulation. The results obtained from numerical studies are critically reviewed.

Chapter 6, presents the detailed description of experimentation conducted to control the active vibrations.

From the experimental results important conclusions are drawn in chapter 7. Also, recommendations are made for the future work.