INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	BHABEN KALITA
Roll Number	:	146103047
Programme of Study	:	Ph.D.
Thesis Title	:	NONLINEAR DYNAMIC ANALYSIS OF PNEUMATIC ARTIFICIAL MUSCLE ACTUATOR UNDER FORCED AND PARAMETRIC EXCITATIONS.
Name of Thesis Supervisor(s)	:	Prof. SANTOSHA K. DWIVEDY
Thesis Submitted to the Department/ Center	:	MECHANICAL ENGINEERING
Date of completion of Thesis Viva-Voce Exam	:	15/12/2020
Key words for description of Thesis Work	:	Pneumatic Artificial Muscle (PAM), Nonlinear dynamics, Method of Multiple Scales (MMS), Stability, Bifurcations, Excitation, Resonance.

SHORT ABSTRACT

In this work, two physical systems with pneumatic artificial muscle (PAM) have been considered for the nonlinear dynamic analyses. In the first physical system, a PAM and a spring are connected to a mass which is subjected to an external harmonic force with a constant pressure inside the muscle. In the second physical system, a PAM is connected to a mass which is subjected to a time varying pneumatic pressure. The muscle force is expressed as a nonlinear function of pressure. The governing equation of motions are derived for five different cases considering different excitations and resonance conditions. In the first case considering first physical system, the study has been carried out to investigate the dynamics of a harmonically excited system under simple resonance condition. In the second case with the second physical system, a parametrically excited system is studied under the simple and principal parametric resonance conditions. In the third case, the nonlinear dynamics of the second physical system is investigated under principal parametric and simultaneous resonance conditions. In the fourth case, the first physical system is subjected to hard excitation with super- and sub-harmonic resonance conditions. Finally, in the fifth case, the second physical system is studied under parametric and hard excitations, which is subjected to super- and sub-harmonic resonance conditions.

The nonlinear governing equations are solved using the first and second order method of multiple scales. The numerical simulations have been carried out to study the stability and critical bifurcations with the help of time response, phase portraits, trivial state instability regions, frequency response and basin of attraction for different resonance conditions. The different bifurcations viz., saddle node, Hopf and pitchfork along with periodic, multi-harmonic, homoclinic orbits and three periodic orbits leading to chaotic responses are observed. Further, an experimental setup has been developed to characterize the muscle (to obtain the muscle parameters) by using the experimental force-contraction data. Also, a novel PAM has been developed, which is fabricated with the help of silicon rubber and locally available fabrics in this work. Therefore, the developed numerical model and the reduced equations can be used for further analysis of PAM used in various medical as well as industrial applications, which will take a small amount of memory along with less computational time. From the present analyses, the designer or researchers may get to know about the safe operating range along with the effects of various system parameters on the dynamics of the muscle actuation.