Adjust of the dynamic model of a beam with large deformation by experimental modal analysis

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Abstract

The use of long and flexible probes in space exploration is convenient so that you can explore places of scientific interest that are hard to reach. In addition, longer and higher arms can provide information of broader horizons. However, these types of systems presents difficulties regarding the vibration control. This paper proposes a simplified numerical model of a long and flexible beam that will be used for the design of this system controller. Moreover, the numerical results are compared with the experimental ones.

Key words:

Flexible beams with variabe cross sections, Finite Element Method, Vibration of Guyed Beams.

Introduction

Long and flexible arms can be used in space probes aiming to reach areas of scientific interest that are difficult to access. The vibration control system must be considered for the design of these arms, due to its low stiffness. To develop the controller, the dynamic characteristics of the structure must be determined, which is the goal of this project. The proposed system is a long and flexible beam whose tip is pulled by a cable (Image 1) in order to control the structure positioning and vibration.

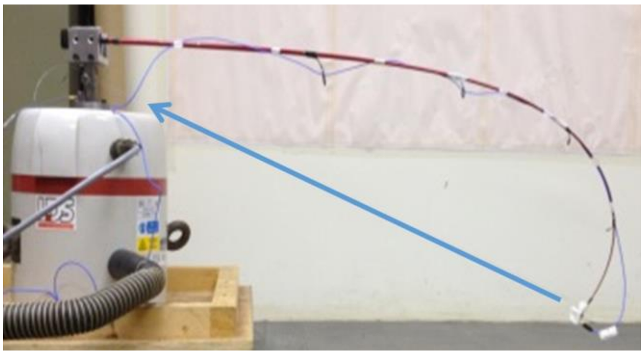

Image 1. A long and flexible tip pulled beam.

It's proposed a simplified numerical model of the structure and the results are compared with the experimental data.

Results and Discussion

The beam is modeled through a small number of finite elements adapted along the deformed geometry of its baseline curve. A 3-D finite beam element is used to mesh the structure model[1]. Such a beam element is used to respond to axial, bending and torsion deformations. The element's stiffness and mass matrices are obtained from the potential and kinetic energy functions.

The influence of the pulling cable attached to the extremity of the beam, consists in adding a localized stiffness to the system which is modeled as a truss element.

A numerical analysis was done for six different configurations of the beam, which is controlled by the cable length.

Subsequently, for the experimental analysis, it was chosen a fishing rod made of fiberglass, due to its ability to withstand large deformation and the properties of this material behave in the linear field.

An electromagnetic shaker was used to excite the structure and accelerometers, for the data acquisition. The difference between the numerical and experimental results of the natural frequency for the six configurations can be seen in chart 1.

Chart 1. Difference between numerical and experimental results for the six configurations.

Vibration Modes	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)
3	10,00	14,43	15,79	20,00	14,44	8,99
4	5,71	30,48	24,62	24,67	33,33	10,56
5	13,46	129,23	13,08	22,50	25,45	19,09
6	10,00	11,48	14,44	36,25	60,45	41,54
7	1,93	5,45	4,18	11,40	5,40	1,20
8	2,46	6,00	5,45	4,36	1,27	2,69
9	2,21	1,89	0,95	17,50	13,63	9,50
10	2,42	2,32	2,00	10,57	6,07	2,92

The natural frequencies obtained by the shaker validated the results above 5Hz. The natural frequencies below 5 Hz were obtained with an impact hammer, which was performed experimentally in another project.

Conclusions

The results were sufficient and the numerical model were applied to the vibration control design of the beam end. These results were used to produce a published journal article [2].

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