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ANALYSIS STABILITY CONTROL AND CALCULATING PERIODIC OSCILLATION OF A SINGLE-LINK FLEXIBLE MANIPULATOR

Abstract

In robot manipulators operating at high speeds, the elastic vibration of links is inevitable. The present paper deals with problem of analysis stability control and calculation periodic oscillation of a single-link flexible manipulator. First, linearize the motion equations of flexible robot around the basic motion based on a Taylor expansion. Then, analyze the stability control and calculate the periodic oscillation based on Floquet stability theory. The proposed procedure is demonstrated and verified by the model of a flexible single-link manipulator.

Keywords:

flexible manipulator, linearization, Taylor expansion, stability control, periodic oscillation.

1. Introduction

Recently, flexible robots have been used in space technology, nuclear reactors, medical engineering, and many other fields. Flexibility, small volume, high speed, and low power consumption are advantages over rigid robots. However, the elastic displacements created by flexible links are the main cause of questions about position accuracy, structure stability and vibration. Some scientists have done research to solve those problems. However, the research results obtained are still relatively small and need to be studied further.

Bayo et al. [1] and Asada et al. [2] have proposed two different algorithms for calculating the torques required to move the end effector of flexible manipulators. A brief description about the development of stable and vibration analysis of flexible manipulators has been depicted here.

The assumed mode method has been used to study the stability and vibration of flexible manipulators. Chiou and Shahinpoor [3] analyzed the stability limitations for force-controlled two-link flexible manipulator and compared it with the model considering rigid body dynamics. Poppelwell and Chang [4] determined the natural frequencies of single link flexible manipulator when the center of the payload does not coincide with manipulator end. Coleman [5] analyzed the vibration eigen-frequency of a flexible slewing beam with a payload attached at one end using wave propagation method. The results showed that the large frequencies are asymptotically identical to those for the clamped free beam independent of the payload. Li et al. [6] investigated the accurate modes of a flexible-link and flexible-joint manipulator. Yigit [7] investigated the stability of independent joint PD control for a two-link rigid-flexible manipulator. For the flexible manipulator investigated in this paper, the fundamental frequency is primarily influenced by the payload mass, while the second frequency is primarily influenced by the payload inertia. Choura and Yigit [8] analyzed the control of a two-link rigid-flexible manipulator with a moving payload mass. Ata et al. [9] investigated the effect of different sets of initial and boundary conditions on the joints torques of two-link flexible manipulator. The elastic deflection for each link has been computed using the assumed mode method for four modes of vibration. Simulation results have been presented to analyze the effect of boundary conditions on the required hub torque for both the links. Ding and Shen [10] demonstrated that assumed mode method have a good accuracy to predict the displacement of the endpoint of the manipulator by comparing the results obtained by assumed mode method and absolute nodal coordinate formulation. It has been concluded that the AMM is not efficient for analyzing the strength of robotic manipulator.