Modeling a Nonlinear Flexible Mechanism Using ADAMS/Flex and Nonlinear Co-rotational FE-Techniques

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Introduction

In this presentation we discuss the simulation of a spatial mechanism with kinematic loops and lightweight and/or slender components typically designed as a transmission element for fast motion (shaking and positioning mechanisms). High structural flexibility of the links may result in considerable deformations which should be taken into account by an appropriate mechanical model and discretisation scheme of the elastic components. In the following two modelling possibilities of ADAMS and an independant method are investigated and compared under various aspects.

Description of Mechanical Models

ADAMS/Flex linear:
A link is modelled in the finite element program ANSYS and is transferred to the ADAMS model using the modal approach. This approach is often used when small, linear deformations and high frequencies can be found in the system and the mass distribution is important.

ADAMS/Flex nonlinear:
The link is substructured as a collection of rigidly connected beam elements. Each of this elements is modelled according to the above linear modal approach. This provides a simple and efficient way to take into consideration nonlinear dynamical effects such as centrifugal stiffening.

Co-rotational FE-Approach:
The elastic links are modelled as geometrically nonlinear Timoshenko beams which are discretized by a co-rotational FE-method. This provides a nonlinear framework in which reliable linear elements can be used with respect to the rotating frame and the nonlinearity of the large deformations is introduced via the rotation of this frame. Assembling of the elements to a single link and coupling of the separate links (via rigid joints) to the whole mechanism is embedded in a fast order N recursive Newton-Euler algorithm for building the equation of motion in minimal coordinates.

Simulation Results and Comparison

For the purpose of validation and comparison the classical Spin-Up maneuver of a highly flexible beam is considered as a first example.

In a second step the simulation of the above mechanism is carried out with an imposed constant angular velocity on the driver.

The work with the linear ADAMS/Flex formulation makes an a posteriori validation of the deformation hypothesis indispensable. For increasing angular velocities the results of the simulation may contradict their own deformation assumptions and a nonlinear method has to be used.

When using the nonlinear ADAMS/Flex method a refinement of the substructuring results in an increase of the systems elastic degrees of freedom. To obtain a model with the same number of variables it will be necessary to reduce the elastic d.o.f. of a single beam element. For this some of the fixed normal (boundary) modes have to be neglected. This technique is investigated in detail and its results are compared to those of the fully nonlinear co-rotational formulation.

It will be shown that for different angular speeds of the mechanism different approaches are the best to use and therefore strengthen their reliability.

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