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Dynamic Analysis of a Rotating Space Tubular Extendable Boom with Tip Load Using One-dimensional Unified Formulation

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Tubular extendable booms, featured by small stowed volume, light weight and large magnification ratios, have greatly promoted the development of spacecraft deployment missions. This paper studies the dynamic characteristics of a rotating tubular extendable boom made by tape spring. The boom deploys a tip load, the MEMS sensor, away from the spacecraft to detect the space environment such as temperature and magnetic field. The dynamic characteristics of the rotating boom are studied by a one-dimensional unified formulation, enhancing the capabilities of beam elements to detect shell-like solutions for the boom. Results show that the natural frequencies of the boom generally increase with the rotating angular velocity. However, they diminish rapidly at the critical velocity, where the first order natural frequency is close to zero and the structure suffers from resonance and large deformation. In addition, the mass effect of the tip load has a serious negative impact on the natural frequencies of the boom, especially the low-order ones. A heavier tip load tends to result in lower natural frequencies and critical velocity. While larger base radius can improve the dynamic characteristics of the rotating boom. The results obtained from this paper can provide reference for the design and control of tubular extendable booms.

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