Paper ID: 99557
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23rd IAA SYMPOSIUM ON VISIONS AND STRATEGIES FOR THE FUTURE (D4)
The Modern Day Space Elevator as a Permanent Transportation Infrastructure (3)

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DYNAMIC STRUCTURAL ANALYSIS OF A CLIMBER FOR SPACE ELEVATORS

Abstract

The idea of space elevators present a transformative approach to space transportation and exploration, and they have been the talk in recent years. Understanding the dynamic structural behavior of the climber under varying operational and environmental conditions is very essential for optimizing its design. Unlike static stress analysis, dynamic loading effects which includes vibrations, oscillations, and thermal fluctuations, and these introduces additional complexities that influence material fatigue, structural integrity, and overall performance of the climber. This study aims to conduct a comprehensive finite element analysis (FEA) to evaluate the structural response of a space elevator climber under dynamic conditions. The research also looks into the differences between static and dynamic stress distributions and potential design optimizations. A fully detailed 3D model of the climber is produced and passed into the simulation software; ANSYS, in our case, to investigate the structural, thermal, and stress analysis. The simulation includes both static loads (the sum of gravity and the inertial forces are constant) and dynamic loads (the force defined by the motion of the tether, a change in acceleration, or temperature fluctuations). The tests have shown that the cyclic variation in the loads may be of an effect that is actually 1 order larger (=10x) than maximum static load. Vibrational effects and variable loading rate might be singularly responsible for that. Performance is also accompanied by extra heat loss, mainly due to the changes in the bond between the housing parts that was aimed at life elongation. The life of material under cyclic loading conditions may get prolonged if one replaces the uniform section and smooth reinforced elements with some high stress concentration factor ones.