MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (5)

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DEVELOPMENT OF A SMA (SHAPE MEMORY ALLOY) BASED, PNEUMATICALLY ACTUATED ADAPTIVE STRUCTURE FOR ELIMINATING CONTACT CLEARANCE

Abstract

Spacecrafts usually work in a thermal and mechanical loading environment, and the contact clearance between loading-bearing structures plays an important role in the vibration characteristics and dynamic responses. As a result adaptively eliminating the contact clearance needed to be considered in structural design. For the cabin component with large-scale shells and cone-shaped surface, traditional methods of eliminating clearance, such as shimming or bolting, could not be utilized since the operating space near the gap area is not adequate. Moreover, the gap after assembly can't be accurately predicted in advance due to the manufacturing dispersion of the parts and assembly defects. So an adaptive structure is needed to fill the contact clearance of arbitrary distance. This article proposed a pneumatic mechanism which could eliminating the contact clearance of arbitrary distance. This mechanism was activated after the large-scale structures were assembled, which allowing the assembly clearance being large enough to decrease the difficulty of assembling large-scale cabin parts. When the spacecraft is in running state, this mechanism was triggered on periodically, and the clearance resulted from the heat expansion or material abrasion could be removed. This mechanism consisted of driving module, actuating module and control module. In the actuating module, a plunger was used to fill the contact clearance, and a SMA (Shape Memory Alloy) ring was designed to lock or unlock the plunger. For the driving module, cold pressurized air was sprayed to activate the SMA ring and unlock the plunger, and the pressurized air of normal temperature was used to push forward the plunger and fill the clearance. The pneumatic driving approach ensured that the support load from the plunger was constant, and the supported shell structure of spacecraft would not fail under excessive load. Prototype of the mechanism was fabricated and experiments were conducted. The results indicated that the pneumatic driving system was able to provide load for eliminating the clearance, the SMA ring could lock the plunger when the atmosphere temperature is above 293 K, and the cold pressurized air could activate the SMA ring to unlock the plunger when the atmosphere temperature is below 263 K. Present work demonstrated that this adaptive structure functioned well. Potential applications included large-size cabin structure with complex assembly procedure, and spacecraft of which the thermal and mechanical loading environment was continuous varying or unpredictable.