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ADAPTIVE TUNED MASS DAMPER TO SUPPRESS VIBRATION OF TENSION-STABILIZED STRUCTURES

Abstract

Tension-Stabilized Structures realize a large structure by light weight and low cost. In addition, their developable and flexible property is very useful in space. Many applications such as a flexible solar paddle, solar sail developed by ISAS/JAXA, and the sun tower developed by NASA have been studied. The structure like a string of a gutter, an example of tension-stabilized structure, had little flexural rigidity. Tension makes great contribution to the out-plane rigidity of the string. If the string deforms, the direction of the tension changes and then out-plane component occurs. It is noted that the strain along the string is very small, when the deformation is small. The strain is proportional to the second power of the deflection angle. This means that tension-stabilized structure has little damping when its deformation is small. Therefore any damping device is necessary for the structure. Many researchers have proposed many passive, active, and semi active devices to damp the vibration of strings. However, most of them can not directly make a damping force along the string. Therefore, the vibration becomes smaller, their efficiency become lower, because component force always involves the product by the deflection angle. In order to solve this problem, this research proposes an adaptive Tuned Mass Damper (TMD) as the damping device. It is expected to be more efficient than past damping devices, because TMD can be put on everywhere and directly make damping force on the transverse direction. According to past researched of TMD, the efficiency of damping by TMD strongly depends on the natural frequency and the damping ratio of TMD. So it is most important issue to tune these parameters optimally. If these parameters are not in the right values, the efficiency is very low. Therefore, if the natural frequency of main system changes from predicted value, the TMD becomes "mis-tuned state" and the efficiency becomes very low. Unfortunately, the natural frequency of the tension-stabilized structure is easy to change, because the tension is changed by the deformation. Then, this research proposes to add an adaptive function that the natural frequency of TMD is changed to reply the change of the vibration frequency. The present research is divided into 4 parts. At first, nonlinear governing equations of the tension-stabilized structure are developed. This formulation makes it clear that the change of tension and nonlinear structural damping are raised by deformation. Secondly, optimal tuning method of the adaptive TMD using modal masses is development. Thirdly, the numerical simulation to show the effect of the TMD is performed. Finally, experiment is demonstrated. Then it is concluded that the adaptive TMD is very useful for suppressing the transversal vibration of tension-stabilized structure.