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STRUCTURE CONCEPTS AND CHARACTERISTICS OF ADVANCED LIGHTWEIGHT SOLAR CELL ARRAY SYSTEMS

Abstract

From early phase of space structure researches there have been two major concepts for space structure systems, namely deployable structure concept and erectable one. There have been so many ideas of large scale space structure system including large space antennas, solar sails, and so on. Presently there are appearing many space antennas of ten meters scale based on deployable structure concept. As for large space structures of hundred meters scale, only the International Space Station is realized; it also includes deployable solar cell arrays. It is based on erectable structure concept to finish its complete construction, a vast amount of resources and long period have been necessary. To realize large and efficient system in future, it is necessary to use deployable and lightweight modules suitably. Membrane structures with inflatable tubes are effective to be their basic modules. Inflatable tubes work as actuators to deploy folded membranes, and as supporting members after deployment. And hierarchical modular systems which consist of the same basic modules can realize large system. To realize very large structure systems over several kilometers scale for solar power generation, the use of membrane modules is exactly suitable.

In this paper as a first step, one-dimensional membrane modules with inflatable tubes are treated; there are three folding ways of inflatable tubes, roll-up folding, zigzag folding, and modified zigzag folding improved unstable deployment behavior of tubes with regular zigzag folding. As a second step, two-dimensional modules folded through two folding ways. One folding way is Miura folding adequate to treat membranes in orthogonal coordinates, and the other is spiral folding adequate in polar coordinates. Through combined use of them, a lot of hierarchical modular systems can be considered, and are arranged systematically.

Several kinds of laboratory scale handmade conceptual models are manufactured. As one-dimensional modules with inflatable tubes, membranes are folded in zigzag and roll-up foldings. Tubes are folded in three types of folding tubes, roll-up folding, zigzag folding, and modified zigzag folding. Deployment experiments through adjusting air pressure are tried. As a result, it is clarified that membranes with modified zigzag folding tubes deploy more smoothly than those through zigzag folding tubes. Membranes with roll-up folding tubes deploy at first smoothly, but at the last phase of their deployment their behaviors become unstable as seen in the case of membranes with zigzag folding tubes. Two-dimensional modules with inflatable tubes roll-up folding and/or zigzag folding are also manufactured and tested.