Recent Research and Development of Composite Thin-wall Lenticular Tube and Space Applications

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Two deployment architectures are common in space structures. The first is often called the mechanical approach. ATK-ABLE has had success in space with the articulate ADAM MAST[1]. The second approach is to allow the packaging of a structure through material deformations. The successful version of this class of deployable structure is the storable tubular extendale mast (STEM), collapsible tubular mast (CTM), wrap-rib, and coilble mast, etc. Murphey[2] named this class as the distributed strain mechanism, and develop the new called concentrated strain mechanism, in which require large more strain of the order 2-4% with flexure of thin laminate. Though the distributed strain deployable space structures are widely used in reflector, sun shade, solar array, and solar sail etc. The structure has rather low stiffness due to moderate modulus of the selected composite materials. The concentrated strain mechanisn is to try to improve the stiffness by employing the high modulus material of the main structural component, and only local hinge use large strain material[3-5]. On the other hand, it is to change the section from open to close, to reduce flatness, to change the composite constitutent and ply way. This improve the stiffness. Manfred Leipold [9] (DLR) developed close lenticular section with small flatness, which is expected for large solar sail. Our team proposed one which is 361.15mm, close section, small flatness less 0.4, and evaluate the feasibility for 30m×3m solar array in the future space laboratory.

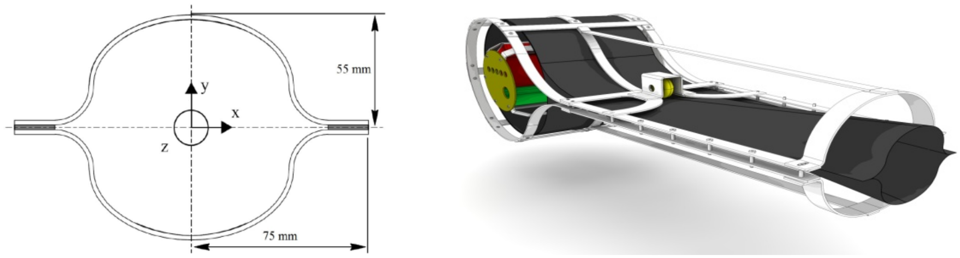

Figure 1 Lenticular section and reeling mechanisn

Due to uncertanties of manufacture procedure and complex behavior of thin-wall composite tube, it is still challenge to predict accurately the structural behavior such as failure mode, progressive failure, strain field, etc. As flatterning and reeling concerned, large deformation appears, even large strain take place. The global buckling anf local buckling limit the loading capacity of the thin-wall tube, the two buckling is complicated and coupling, this make the loading predicition dificculty.

This paper will summarize recent research and development of composite thin-wall lenticular tube in China, especially the work of our team. The feasibility of application in the future space missions is evaluated. The design and manufacture is trade-off with respect to various ply and thickness. The main work focus on the test verification and numerical simulation. The flatterning simulation and experiments of various lenticular tube are investigated through two ways of compression and pulling. The warpping test and simulation also are verified sequentially. The buckling load predictions and tests are carried out. The modal analysis and mode identification is tested. The heat parameter is tested. And finally the vacuum capsule heat simulator is used to verify the heat-structural performance, as well as the the performance simulation carried out. Our work is the basis of future promise space application in China.