Improved Attachment in a Hybrid Inflatable Pressure Vessel

Care is taken to distribute loads and maintain desired shapes.

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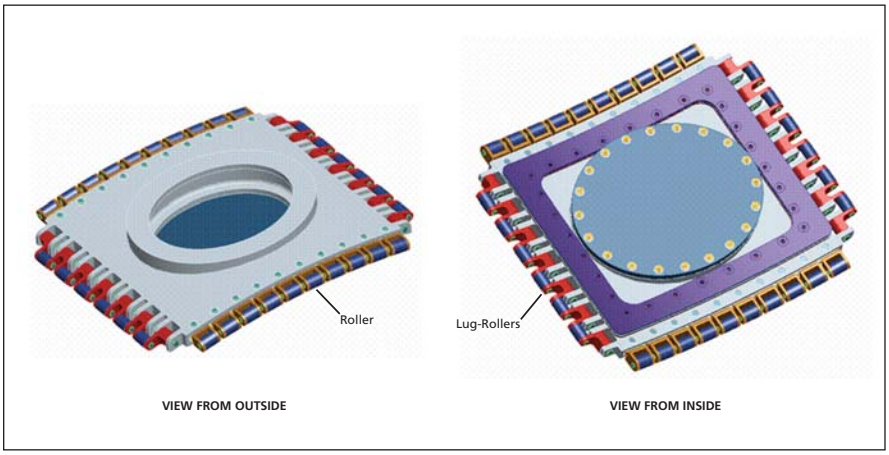
Some modifications that could be made, separately or together, have been conceived as improvements of the generic design of a structure of the type described in "Hybrid Inflatable Pressure Vessel" (MSC-23024/92), *NASA Tech Briefs*, Vol. 28, No. 4 (April 2004), page 44. To recapitulate: The vessel is a hybrid that comprises an inflatable shell attached to a rigid structure. The inflatable shell is, itself, a hybrid that comprises (1) a pressure bladder restrained against expansion by (2) a restraint layer that comprises a web of straps made from high-strength polymeric fabrics. The present improvements are intended to overcome deficiencies in those aspects of the original design that pertain to attachment of the inflatable shell to the rigid structure. In a typical intended application, such attachment(s) would be made at one or more window or hatch frames to incorporate the windows or hatches as integral parts of the overall vessel.

A detailed description of the deficiencies of the prior design, the modification(s) for overcoming each of them, and alternative versions of the modifications would greatly exceed the space available for this article. The modifications can be summarized as being intended to effect the following improvements with respect to attachment to a window or hatch frame:

- Minimizing the number of straps that pass by the frame unattached and unwoven;
- Sizing the straps to distribute the loads as nearly evenly as possible among the straps in order to minimize both (1) distortion of the inflated shell and the frame from their desired shapes and (2) concentrations of stress that could lead to rupture;
- Ensuring that the restraint layer and bladder conform as closely as possible to the desired restraint-layer shape all the way into the rigid frame, minimizing any effects of discontinuities in shape at the attachments;
- Eliminating gaps between adjacent attachments around the frame to prevent protrusion of the inflated bladder through the gaps (such protrusion could lead to rupture of the bladder); and
- Preventing entanglement of unwoven straps during inflation of the bladder from the compact, folded condition to the fully deployed condition.



Rollers and Lug-Rollers that pivot on pin joints in lugs on a frame serve as devices for attachment, to the frame, of straps that restrain an inflated bladder that is sealed to the frame.

As in the design described in the cited prior article, each end of an attached strap is wrapped around a roller on a pin and stitched to itself at a lap seam. The pin can be supported by a lug on the frame; by a lug-roller that is supported by a pin in a lug on the frame; or by a clevis attached to the frame (see figure). A felt buffer can be placed between the bladder and the restraint layer in the attachment region to serve as a smooth backing for the bladder and to cover any gap through which the bladder could potentially protrude. The felt buffer also helps to ensure the proper relative positioning (thereby helping to prevent entanglement) of any unwoven straps with which it is in contact.

It is very difficult to solve the above-mentioned problem of sizing the straps for several reasons: The straps attached to the frame behave differently from those not attached to the frame, the roller-and-lap-seam portion of each strap attached to the frame is about twice as stiff as the portion of that strap away from the frame, and the relatively high stiffness of the frame affects the loads on the straps. Different straps become elongated by different amounts and take up different and changing portions of the overall load during the inflation process. If the attached and unattached straps are not sized appropriately with respect to the frame, then the unattached straps, the attached straps, and/or the frame could become excessively elongated or overloaded prematurely (and, consequently, could fail) during the inflation process. Thus, the problem of balancing loads among the straps and frame is complex and highly nonlinear. A computer program was written to solve this problem and was demonstrated by using it to design a restraint-layer/window interface that subsequently passed a pressure test.

This work was done by Christopher J. Johnson, Ross Patterson, and Gary R. Spexarth of Johnson Space Center. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-24201-1/73-1.