Concentric Nested Toroidal Inflatable Structures

Interior volume can be partitioned more flexibly than in single larger structures.

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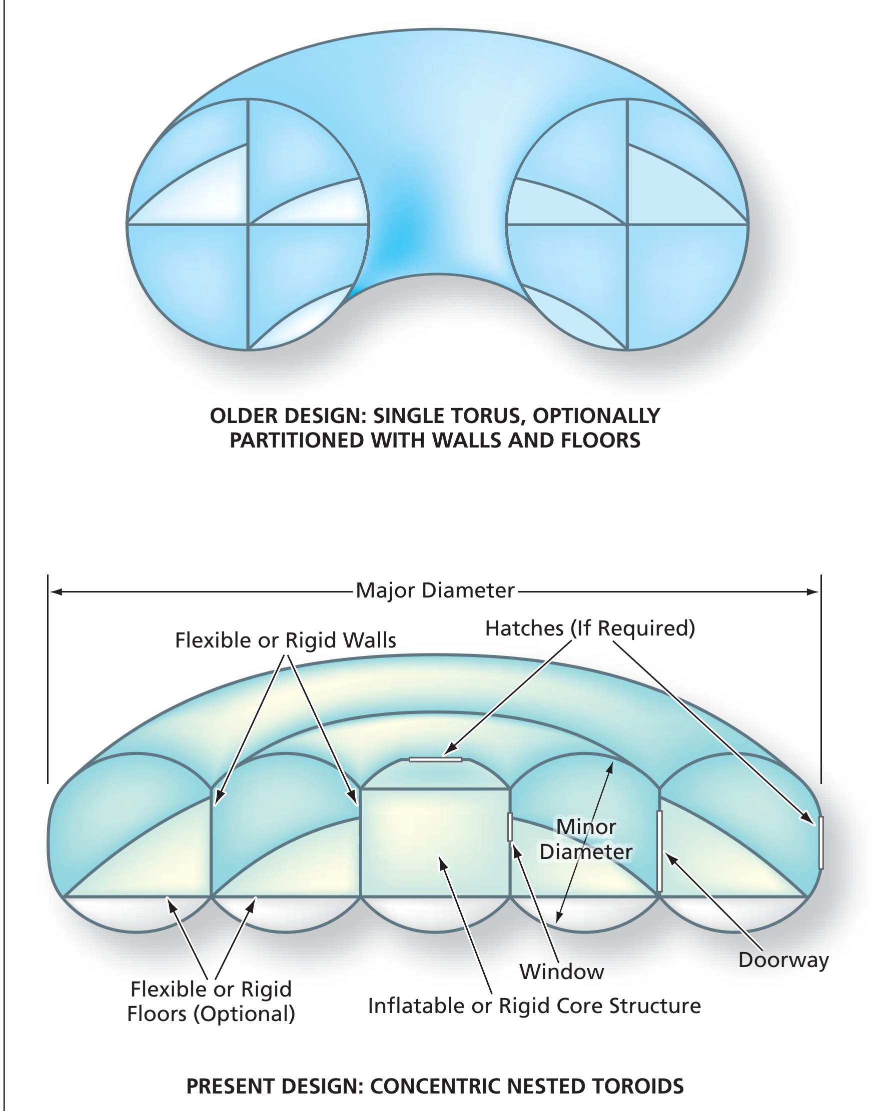
Assemblies comprising multiple limited-height toroidal inflatable structures nested in a concentric arrangement have been invented to obtain more design flexibility than can be obtained in single taller, wider toroidal inflatable structures (see figure). Originally intended for use as containers for habitats for humans in outer space or on remote planets, these and related prior inflatable structures could also be useful on Earth as lightweight, compactly stowable, portable special-purpose buildings that could be transported to remote locations and there inflated to full size and shape.

In the case of a single inflatable toroidal structure, one important source of lack of design flexibility is the fact that an increase in outer diameter (which is sometimes desired) is necessarily accompanied by an increase in height (which is sometimes undesired). Increases in diameter and height can also cause difficulty in utilization of the resulting larger volume, in that it can become necessary to partition the volume by means of walls and floors, and features (e.g., stairs or ladders) must be added to enable vertical movement between floors. Moreover, ascending and descending between floors in a gravitational environment could pose unacceptable difficulty for the inhabitants under some circumstances.

Another source of lack of design flexibility in a single toroidal inflatable structure is that for a given inflation pressure, an increase in the outer diameter of the structure necessarily entails an increase in the maximum stress in the structure. Because it is necessary to keep the maximum stress within the load-bearing capability of the structural materials, consistent with other aspects of the design, this may translate to a limit on the outer diameter.

In an assembly comprising concentric nested toroidal structures, an increase in outer diameter does not necessarily entail an increase in height or a maximum stress in excess of the load-bearing capability of the structural materials. The minor diameters of the nested toroid can be chosen to partition interior spaces optimally, without necessitating the addition of walls or floors. Inasmuch as the maximum stress in a nested inflatable toroidal structure is a function of its minor diameter and the minor diameter is typically small enough that the load-bearing capability of the structural materials is not exceeded, there is no longer a limit on the outer diameter of the assembly: instead, the assembly can be expanded, without limit, by simply adding concentric inflatable toroidal structures having suitable minor diameters and successively larger major diameters. The minor diameters need not be equal: The



An **Assembly of Concentric Toroidal Inflatable Structures** offers advantages over a single taller, wider toroidal inflatable structure.

diameter of each concentric inflatable toroidal structure can be chosen according to the specific purpose(s) to be served by that structure.

Adjacent concentric inflatable toroidal structures can be separated by a flexible or rigid wall that bears the vertical (axial) load between the bottom and the top to prevent undesired axial expansion and thereby to help to maintain the desired overall shape of the assembly. The walls can incorporate penetrations, including windows and hatches. In an extreme case, a wall can be removed if it is replaced with rigid bars that are (1) attached to the tops and the bottoms of the adjacent toroid and (2) connected together with circumferential tension-bearing members. Rigid or flexible floors can be integrated into the inflated toroidal structures. Preferably, the floors in adjacent toroids should be joined to the wall between the toroids at the same level.

This work was done by Christopher J. Johnson, Jasen L. Raboin, 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-24215-1.

Investigating Dynamics of Eccentricity in Turbomachines

Rotordynamic and hydrodynamic forces are measured under prescribed rotor-whirl conditions.

Marshall Space Flight Center, Alabama

A methodology (and hardware and software to implement the methodology) has been developed as a means of investigating coupling between certain rotordynamic and hydrodynamic phenomena in turbomachines. Originally, the methodology was intended for application in an investigation of coupled rotordynamic and hydrodynamic effects postulated to have caused high synchronous vibration in the space shuttle's high-pressure oxygen turbopump (HPOTP). The methodology can also be applied in investigating (for the purpose of developing means of suppressing) undesired hydrodynamic rotor/stator interactions in turbomachines in general.

The methodology and the types of phenomena that can be investigated by use of the methodology are best summarized by citing the original application as an example. In that application, in consideration of the high synchronous vibration in the space-shuttle main engine (SSME) HPOTP, it was determined to be necessary to perform tests to investigate the influence of inducer eccentricity and/or synchronous whirl motion on inducer hydrodynamic forces under prescribed flow and cavitation conditions. It was believed that manufacturing tolerances of the turbopump resulted in some induced runout of the pump rotor. Such runout, if oriented with an inducer blade, would cause that blade to run with tip clearance smaller than the tip clearances of the other inducer blades. It was hypothesized that the resulting hydraulic asymmetry, coupled with alternating blade cavitation, could give rise to the observed high synchronous vibration.

In tests performed to investigate this hypothesis, prescribed rotor whirl motions have been imposed on a 1/3-scale water-rig version of the SSME LPOTP inducer (which is also a 4-blased inducer having similar cavitation dynamics as the HPOTP) in a magnetic-bearing test facility. The particular magnetic-bearing test facility, through active vibration control, affords a capability to impose, on the rotor, whirl orbits having shapes and whirl rates prescribed by the user, and to simultaneously measure the resulting hydrodynamic forces generated by the impeller. Active control also made it possible to modulate the inducer-blade running tip clearance and consequently effect alternating blade cavitation. The measured hydraulic forces have been compared and correlated with shroud dynamic-pressure measurements.

This work was done by Daniel Baun of Concepts NREC for Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32563-1.