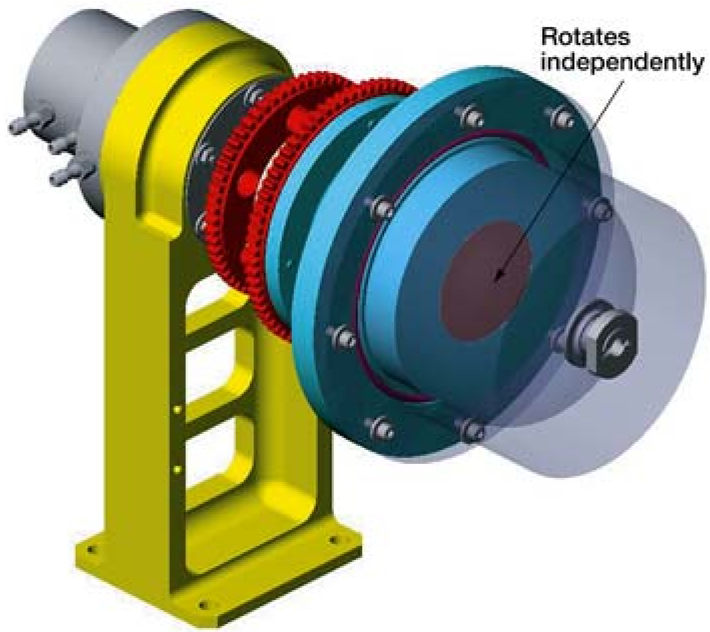
Reduced-Gravity Experiments Conducted to Help Bioreactor Development



A CAD model of the proposed configuration of the HFB-S. The HFB-S has a dome-shaped top and a flat bottom. The inner part of the bottom (see arrow) rotates independently of the dome and acts as a weak centrifugal pump. The resulting flow inside the bioreactor resembles a vortex ring that is rotating about its central axis as well as rotating about the ring axis.

The NASA Glenn Research Center and the NASA Johnson Space Center are collaborating on fluid dynamic investigations for a future cell science bioreactor to fly on the International Space Station (ISS). Project Manager Steven Gonda from the Cellular Biotechnology Program at Johnson is leading the development of the Hydrodynamic Focusing Bioreactor--Space (HFB-S) for use on the ISS to study tissue growth in microgravity. Glenn is providing microgravity fluid physics expertise to help with the design and evaluation of the HFB-S. These bioreactors are used for three-dimensional tissue culture, which cannot be done in ground-based labs in normal gravity. The bioreactors provide a continual supply of oxygen for cell growth, as well as periodic replacement of cell culture media with nutrients. The bioreactor must provide a uniform distribution of oxygen and nutrients while minimizing the shear stresses on the tissue culture.

The HFB-S is being developed with the ability to remove gas bubbles that may inadvertently enter the system during long-duration experiments (~1 to 3 months). The Rotating Wall Perfused Vessel (RWPV) has been used in the past with great success on shuttle flights and Mir missions, but it has occasionally experienced problems when gas bubbles entered the fluid-filled vessel. These bubbles are harmful to the cell science, and bubble removal in the rotating wall perfused vessel is problematic. The HFB-S has a central access port that has been designed to allow for bubble removal under specific operating conditions without detrimentally affecting the cell tissue. A detailed technical objective flight on the space shuttle is being planned to fully evaluate the HFB-S. In addition, ground-based activities are underway to quantify the characteristics of the HFB-S. Computational studies of the internal fluid flow of the HFB-S are being done at the University of Houston by Dr. Stanley Kleis to predict bubble motion as well as other operational parameters. Drs. Charles Niederhaus and Henry Nahra from Glenn's Microgravity Fluid Physics Branch and Dr. John Kizito at the National Center for Microgravity Research have been helping with the fluid analysis and experimental verification.

John Yaniec and Sandra Geffert free-floating the HFB-S package. Stewart Robinson hangs onto the main console in the background while Charles Niederhaus operates the controls to remove the bubble.

Experiments with the HFB-S were conducted in the microgravity environment on the KC-135 reduced-gravity aircraft operated by Johnson and flying out of Cleveland Hopkins International Airport and Houston Airport System's Ellington Field. The first set of flights in July 2002 provided useful data on bubble trajectories that are validating the computational predictions. The latest flights in January 2003 free-floated the apparatus and tested the most recent configuration of the bioreactor while focusing on the bubble removal process itself. These experiments showed that the bubble could be driven successfully to the removal port and purged in microgravity. The last day's experiments had an excellent microgravity environment because of calm air, and the experience gained in previous flights allowed successful bubble removal in 18 out of 35 tries--remarkable given the microgravity time constraints and the g-jitter on the KC-135.

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