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DEVELOPMENT AND TESTING OF LIQUID-GAS SEPARATION FOR AN ALGAL PHOTOBIOREACTOR SYSTEM FOR FUTURE HYBRID LIFE SUPPORT SYSTEMS

Abstract

Future human space exploration missions require advanced and self-sustaining space systems. Advanced Life Support Systems (LSS) will be key elements of those systems. Since physico-chemical systems cannot produce food, biological processes are needed. A logical step is the development of hybrid LSS, combining physico-chemical and biological processes. The cultivation of edible microalgae in a photobioreactor (PBR) is a feasible approach. At the Institute of Space Systems of the University of Stuttgart a PBR system for in space biomass production is currently being developed. Key features of that system are the automation of analytics, nutrient supply and biomass harvesting. Major effort is made on the microgravity adaptation of system components. In order to evaluate the microgravity adaptation and to get operational experience and reliability data, an experiment was built and tested during parabolic flights. The system concept is successfully tested and technical challenges are identified paving the way for further parabolic flights and in-orbit spaceflight experiments at last. This paper highlights the development and testing of a liquid-gas separator under microgravity conditions. The latter is needed for the separation of gases like oxygen and carbon dioxide from the water-based medium wherein the microalgae are cultivated. Phase separation can be achieved by various methods including permeable membranes and buoyancy effects. Since permeable membranes are sensitive to microalgae accumulation on the membrane's surface during long-term cultivation, a Vortex Separator (VS) is used in the frame of this research. The VS is a cylindrical device wherein the liquid is injected tangentially on the inner surface forcing it into a circular movement enabling liquid-gas separation based on centrifugal forces. When operated in microgravity, a cylindrical shaped gas core forms coaxially to the rotation axis of the VS. Being a passive device with no moving parts, the VS is a promising candidate for oxygen and carbon dioxide separation inside a microgravity qualified PBR system. After a brief description of the system development and the experimental setup, this paper focuses on the presentation of the experiment data from the parabolic flights. The data is based on visual observation of the transparent VS as well as of flow speed and carbon dioxide concentration measurements. The performance of the VS is evaluated by means of gas core stability and carbon dioxide concentration rates. Parameters of interest are the liquid flow speed, the injection nozzle dimensions and the gas core diameter that is related to the VS filling level.