

Vortex Phase Separator

Status, Plans, Connections to NASA's Mission and Vision and to the Space Architect's Capability Requirements

1

Organizing principles

NASA 2003 Strategic Plan

- Goal 8. Ensure the provision of space access and improve it by increasing safety, reliability, and affordability.
 - 8.3 Improve the accessibility of space to better meet research, Space Station assembly, and operations requirements.
 - 8.2 Improve the safety, affordability, and reliability of future space transportation systems.
 - 8.6 Create concepts, technologies, and capabilities for transportation beyond low-Earth orbit and define plans to enable affordable future infrastructures.
- Goal 9. Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.
 - 9.2 Develop knowledge and technologies to make life-support systems self-sufficient and improve human performance in space.
 - 9.3 Resolve fundamental low-gravity issues affecting technologies for human space travel beyond low-Earth orbit.

Space Architect Perspective Capability Requirements

- 2.3 Habitation and Bioastronautics
 - Advanced Habitation Systems 2.3.2
 - Environment Monitoring and Control 2.3.4
- 2.6 Space Transportation
 - Vehicle Subsystems (IVHM, GN&C, Avionics, Thermal Management, EMA's, etc.) 2.6.4
 - Launch Infrastructure & Operations 2.6.10

OBPR Organizing Questions

- 3. "What new opportunities can our research bring to enrich lives on earth and expand understanding of the laws of nature?"
 - 3b) Market-driven commercial research that supports national goals, such as contributing to economic growth of the nation through increased GNP and sustaining human capital in the areas of science and technology.
- 4. "What technology must we create to enable the next explorers to go beyond where we have been?"
 - 4a) How can we change spacecraft systems to lessen the required up-mass, volume, and power?
 - 4c) How can we ensure that the crew is living in a safe and comfortable environment?

Requirements

Requirement: nuclear power:
A phase separator is an essential part of a Rankine Cycle system being considered by NASA for high power spacecraft energy conversion systems. (The Rankine system like a steam power cycle only uses potassium.) This is part of the recently created Nuclear Power Initiative for Prometheus and Jupiter Icy Moon Mission.

Requirement: spacecraft: life support: separate gas and liquid. For closed environmental life support space vehicles supporting humans need to recycle as much consumable material as possible (e.g. for water recovery recycle; water-urine recovery system, etc.) Phase separators are already a part of some systems. (e.g. space suits have separators)

Requirement: spacecraft: thermal management & humidity control. For efficient operation of thermal management systems as well as air humidity control systems that remove excess moisture from cabin air, working fluid vapor must be separated from the liquid phase

Hypotheses & Projects

Hypothesis: permeable membranes. Permeable membranes are currently used as separators on the International Space Station. **Downside.** They become ineffective over unacceptably short periods

Hypothesis: phase separator: motor driven Motor driven separators could be used for separating gas from liquid. **Downside:** they have high power consumption and are composed of rotating machinery,

Hypothesis: passive phase separator. It is possible to use the vortex phase separator for high throughput, high reliability separations on space craft. **Downside:** Hasn't been used before for long periods in space so there is some technological risk.

Project: VORTEX PHASE SEPARATOR
Project description: Separating gas from liquid is an important part of many spacecraft systems such as life support, thermal management and power conversion. Phase separation is achieved on earth by gravitationally driven buoyancy forces. Lacking gravity, an alternative separation technology is being developed for space. For systems that have high throughput and require high reliability (i.e. no moving parts), the vortex phase separator is a promising technology.

The CSP vortex phase separator is a device that separates gas from liquid by the action of a vortex induced centripetal acceleration field. Fluid is injected tangentially into a fixed right circular cylinder. The intrinsic momentum of the injected fluid creates and drives a vortex in the cylinder. The vortex rotation produces a centripetal acceleration that drives gas to the vortex core and liquid to the walls. Gas is removed from the core through a co-axial tube and liquid is drawn off along the walls. No moving parts.

Status: This vortex phase separator is presently a part of the Immobilized Microbe Microgravity Wastewater Processing System (IMWWPS) a water purification system built by the Johnson Space Center for Advanced Human Life Support. This is an experiment to use microbes to clean up waste water. The vortex phase separator is part of the processing equipment used to test the microbe system. It is not the subject of the experiment. This hardware is awaiting shuttle flight manifesting for orbital testing.

Project site: The Center for Space Power, Texas A&M, a NASA Research Partnership Center

Knowns and Unknowns

Known The vortex phase separator has been tested in KC-135 for short periods many times.

Unknown The performance over long periods of time in space conditions is untested.

2

3

4

5

6

7

8

9

10

Status: Prototype, V.3
MacroVU® Analytics