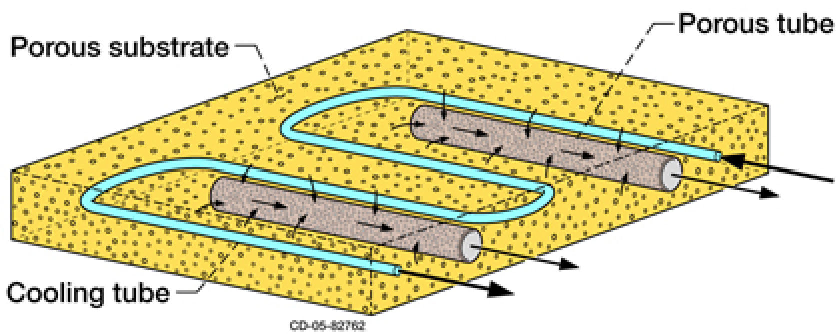
Condensing Heat Exchanger Concept Developed for Space Systems

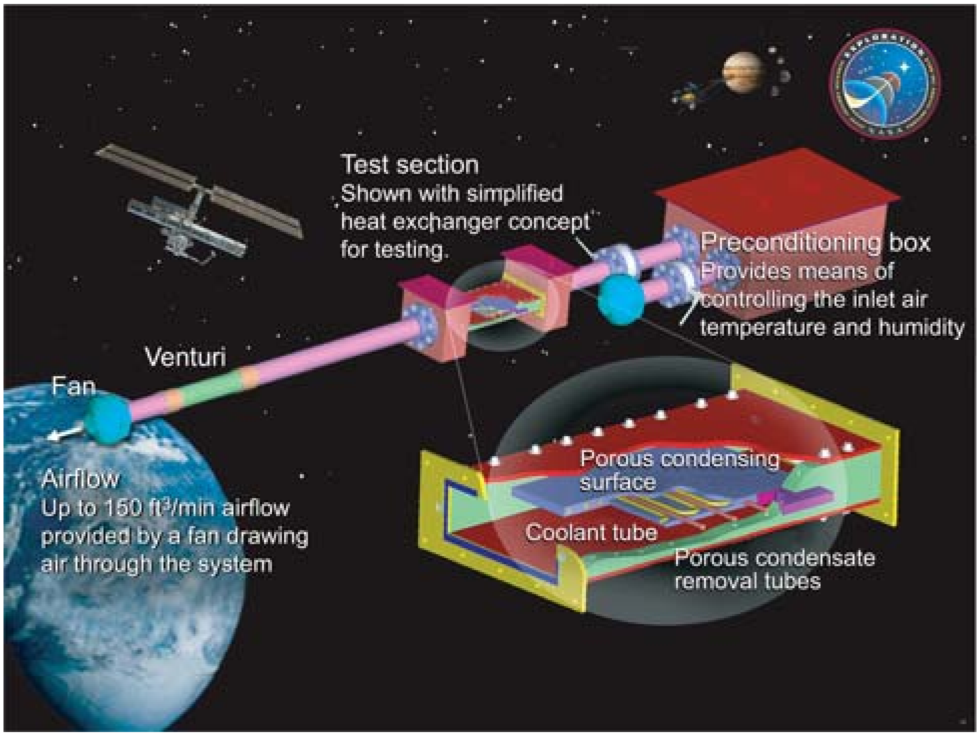
The current system for moisture removal and humidity control for the space shuttles and the International Space Station uses a two-stage process. Water first condenses onto fins and is pulled through “slurper bars.” These bars take in a two-phase mixture of air and water that is then separated by the rotary separator. A more efficient design would remove the water directly from the air without the need of an additional water separator downstream. For the Condensing Heat Exchanger for Space Systems (CHESS) project, researchers at the NASA Glenn Research Center in collaboration with NASA Johnson Space Center are designing a condensing heat exchanger that utilizes capillary forces to collect and remove water and that can operate in varying gravitational conditions including microgravity, lunar gravity, and Martian gravity.



Condensing heat exchanger design concept based on composite porous media.

The CHESS concept for a condensing heat exchanger involves the use of a highly conductive porous substrate as the cold surface over which moisture condensation occurs. The condensed water vapor is removed through another embedded porous tube insert via a suction device. The thermal properties, porosity, and wetting characteristics of the porous materials are judiciously chosen so that efficient condensation is promoted and, at the same time, air penetration into the suction tubes is avoided. Other engineering concerns, such as priming and the startup and shutdown transients, also influence the selection of the porous media used in the design. The preceding figure illustrates the CHESS condenser design concept.

To test this concept and develop empirical heat- and mass-transfer correlations, NASA is building a ground-based test facility at Glenn. The following figure shows the integrated testbed. This testbed can provide a conditioned moist airstream over the wide range of conditions anticipated for future space missions. In addition, the test section can be rotated with respect to the gravity vector to simulate, in a simple way, the effects of varying gravity on the condenser performance. The test article and the testbed are instrumented to acquire relevant data during the experiments. These data are being used to develop correlations and to validate the theoretical and numerical modeling studies currently underway. In addition, future space-based flight experiments are planned to evaluate the performance of the condensing heat exchanger in a microgravity environment.



Ground-based integrated testbed for the CHESS Project, including advanced life support with temperature and humidity control and moisture removal.

Long description of figure 2. Illustration showing fan (up to 150 cubic feet per minute airflow provided by a fan drawing air through the system), venturi, test section (shown with simplified heat exchanger concept for testing), preconditioning box (which provides means of controlling the temperature and humidity), porous condensing surface, coolant tube, and porous condensate removal tubes.

The proposed method will provide a robust, lightweight passive condenser and liquid separator with no moving parts, and it will be operationally simple. It could be used for temperature and humidity control on the International Space Station and all advanced manned missions, a lunar habitat, a Martian habitat, and a Mars transit vehicle.

Find out more about this research:
Glenn's Microgravity Fluid Physics Research at http://microgravity.grc.nasa.gov/6712/research.htm
Thermal Control Element at http://advlifesupport.jsc.nasa.gov/thermal/

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