Space station research exposing the salty truth of supercritical water transitions

July 26 2013

The high temperature insert is placed in the device for the study of critical liquids and crystallization. Credit: CNES

There is a moment when everything changes. Something familiar crosses a boundary and suddenly behaves in new ways. Take water for example. In middle school science class, you probably learned about saturation points when adding salt to a liquid. Or you discovered the importance of phase changes when going from boiling to steam or from freezing to ice. That moment of change is now being studied at a new level in space.

At sea level, water boils at 212 degrees Fahrenheit, and both liquid and water vapor (i.e., steam) coexist. However, water heated under high pressures (more than 3,200 pounds per square inch, about the amount of pressure in 100 car tires) doesn't boil. Above the critical temperature of 705 degrees Fahrenheit, water behaves like a dense gas where its distinct liquid and vapor phases no longer exist. At this point, any salt in the water no longer is soluble. It separates, or precipitates, from the water and attaches itself to surfaces like heating coils and pipes.

In order to study this phenomenon, the Supercritical Water Mixture (SCWM) investigation currently is running aboard the International Space Station. It is a joint effort between NASA and Centre National d'Etudes Spatiales (CNES), the French space agency.

"By studying supercritical and near-critical water without the effects of gravity, we'll look at how salt precipitates on a very fundamental level," said Mike Hicks, SCWM principal investigator at NASA's Glenn Research Center in Cleveland. "We'll look at some fundamental questions: how is salt actually transported in this medium without the influences of gravity; what happens to the salt/water mixture when taken past the critical point; how does it precipitate; at what point does it start to agglomerate and clump together to where you can actually see little salt particles in the water?"

SCWM experiments began on the space station during the first week of July and will continue for a one-year period in a series of five test sequences, each lasting approximately 15 days.

Testing occurs in the Device for the Study of Critical Liquids and Crystallization's (DECLIC) High Temperature Insert (HTI). DECLIC and HTI were built by CNES and are housed in the space station's Kibo module. SCWM is operated by CNES from its facility in Toulouse, France. Results from the research will be shared between NASA and

CNES.

The Device for the Study of Critical Liquids and Crystallization has two rectangular boxes. The upper box contains the High Temperature Insert and all the diagnostic hardware. The lower box contains the command/control and data storage hardware. Credit: CNES

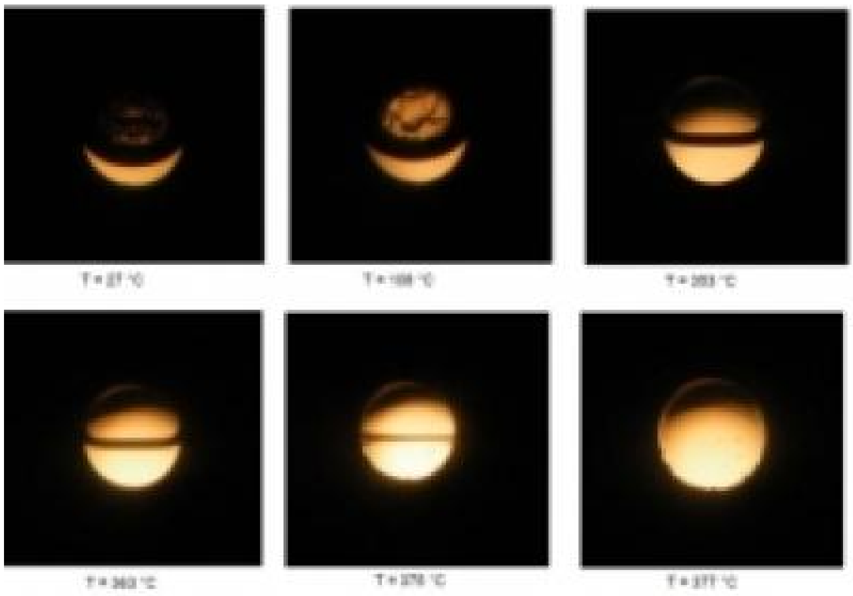
"The salt water experiment was something NASA proposed to the French as an experiment that we would be interested in performing in their DECLIC facility," said Hicks, who also is NASA's SCWM project scientist and project manager. "The French wanted to perform a similar experiment but didn't have the funding to pursue this until NASA joined forces with them. So it is a collaboration of mutual interests. We're looking for ways to handle waste streams in space, and this is just one of the technologies that we're looking at for that."

SCWM research results can be extended easily to ground-based applications. A better understanding about what happens at near-critical and supercritical conditions is important in designing extended-life and low-maintenance systems, such as power plants, waste management and high salinity aquifers.

Use of supercritical fluids in supercritical water oxidation (SCWO) technology has been in place for years. For example, supercritical carbon dioxide is used in dry cleaning and decaffeinating coffee.

Learning how to use water efficiently in its supercritical phase is of great interest to researchers since many of our waste streams—like city sewage, agricultural wastes and paper mill wastes—contain water. SCWO provides a way to oxidize sewage in a closed system that essentially will burn out all the organics in a wet waste stream. The beauty of this process is that the combustion products are relatively benign compared with incineration, which produces a range of sulfur and nitrogen oxides. Typically, the SCWO processing of an organic waste stream will leave behind only carbon dioxide and water.

"SCWM is not just a fundamental science experiment," said Uday Hegde, SCWM co-principal investigator at the National Center for Space Exploration Research in Cleveland. "This is actually something that can be of benefit to NASA, in terms of recycling and waste management systems, and has application to real systems on the ground as well. For example, water reclamation in remote places. It may also prove to be extremely useful for waste processing at the single home or neighborhood level or an entire city. It is a relativity green process compared to incineration."



This shows images of water/saline solution being heated. The temperature and pressure increases through the critical point until there is no distinction between water's liquid and vapor phase. This is evidenced by the disappearance of the thin black line that separates the phases. Credit: NASA

The tendency for salts to "fall out" of solution presents one of the leading challenges of SCWO technology. At ambient temperatures and pressures, salt is easily dissolved in water. However, when water goes to its supercritical state, salt no longer is soluble, and it precipitates out of the water. The salt then adheres to surfaces, building up and corroding systems and fouling pipes resulting in a large maintenance overhead.

Typically, these small particles of salt migrate toward the cooler regions, a process known as thermophoresis. Engineers have a hard time designing reactor vessels that can withstand these tremendously corrosive environments without implementing a costly maintenance program.

"In a very systematic way, we want to study the nature of these precipitates," said Hicks. "That's just the start. There's a tremendous amount of work to be done to make this technology economically viable. It's a wonderful technology except for the fact that it tends to be a maintenance nightmare. Hopefully, we can minimize this by better understanding how to handle the corrosion and fouling problems."

A good understanding of the behavior of salt in near-critical and supercritical conditions would assist designers in building next-generation SCWO reactors. With the knowledge gleaned from SCWM, they possibly could design systems that would operate without large maintenance problems.

Provided by NASA

Citation: Space station research exposing the salty truth of supercritical water transitions (2013, July 26) retrieved 17 April 2024 from https://phys.org/news/2013-07-space-station-exposing-salty-truth.html