Building Better Batteries for Cars and Spacecraft

The NASA engineer responsible for the batteries needed for spacewalks now is working at the Department of Energy's National Renewable Energy Laboratory to help design safer lithium-ion battery packs for sky walkers and automobile drivers alike.

"We at NASA share the same challenges that DOE and NREL have in developing batteries for cars," said Eric Darcy, the battery group leader at the National Aeronautics and Space Administration's Johnson Space Center.

Whether it's "manned space travel or manned automobiles," the hurdles are the same, Darcy said. "Designing a safe, very large and lightweight battery pack for the confined space of manned vehicles is challenging."

“In the future, battery-powered automobiles are expected to grab a big share of the market away from gasoline-fueled vehicles. Lithium ion batteries are the technology of choice because of their high energy and power densities,” Ahmad Pesaran, Energy Storage Group Leader at NREL, said. “But the batteries must be able to withstand abuses that could lead to thermal runaway and potentially fire,” he continued.

Thermal runaway can happen when an increase in temperature changes conditions in a way that leads to a further increase in temperature, a kind of feedback that can lead to catastrophe. The increase in temperature leads to an increase in the reaction rate, which leads to further increases in temperature. The disastrous release of methyl isocyanate gas from a Union Carbide plant in Bhopal, India, in 1984, was precipitated by a thermal runaway.

Researchers in NREL's Energy Storage Group are modeling and testing how well the risk of catastrophic thermal runaway can be mitigated in lithium-ion cell/battery designs. "We're privileged to have Eric working with us for nine months," Pesaran said.

“NREL researchers expect the partnership to help them design next-generation battery packs for cars. Darcy's contributions are helping NREL's integrated network model to analyze the qualities of multi-cell battery pack systems and observe their responses to stress,” NREL engineer Gi-Heon Kim said. "These kinds of model tools are crucial for car industries to properly perform thermal and safety assessment of their battery pack designs."

NREL and NASA engineers have invented specially designed small "coins" made of primarily aluminum and copper, that when implanted into lithium ion cells will induce an internal short circuit on demand. The ability to accurately replicate internal shorts in battery cells is crucial to finding out how hot a battery can get when one of its cells fails because of a rare manufacturing defect. Those defects

happen only about one time in 1 million in the field, but because of their catastrophic consequences, NASA and NREL need to lengthen those odds if lithium-ion batteries are to become the workhorses of space walks and automobile transportation.

Darcy brings 23 years of experience in putting together batteries for manned spacecraft. With the retirement of the Space Shuttle Program, and the uncertainty of when a replacement will be available, NASA needs a new-generation, longer life spacesuit battery pack that will support dozens of walks based from the Space Station.

"Eric brings the perspective and broad experience base of the aerospace industry," says NREL researcher Kandler Smith. The aerospace industry doesn't share the same cost constraints of the automotive industry, "but the processes employed for battery risk assessment and design for reliability are directly applicable."

NREL researchers have characterized the conditions under which an internal short circuit in a spacesuit battery can lead to a thermal runaway, which can cause a catastrophic explosion.

NASA has been developing a new spacesuit battery for three years, preparing for the time when the current short wet life battery packs of the shuttle-to-space-station era would require replacement.

"We now need at minimum, a five-year battery, and with that comes a whole new chemistry, lithium-ion," Darcy said. "That carries with it the risk of it rupture and fire," Darcy added. "That's why we've teamed with NREL to characterize the small range of conditions under which this battery can go into thermal runaway."

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