ROMEO POWER TECHNOLOGY: BUILDING BETTER BATTERIES

Simulation plays a vital role in the quest to end energy poverty

Large-scale battery systems like the one shown above can provide electricity during brown-out or black-out conditions, store the energy generated by solar or wind farms, and allow consumers to "game the grid" by collecting power during non-peak hours.

Switching on a light when it's dark. Cooling down the room when it's hot. These are just a few of the modern conveniences we take for granted. But according to a 2017 report from the International Energy Agency, safe, dependable power is a precious commodity in many parts of the world. Roughly 14% of our fellow human beings have no access to electric power, and 38% of them—nearly three billion people—rely on "dirty" fuels such as wood or coal to cook their meals.

Romeo Power Technology is on a mission to change this situation. The California-based company says they aim to end global energy poverty by 2023 through the development of cost-effective, sustainable energy storage solutions that can be used virtually anywhere on the planet. It's an ambitious goal, to be sure, but with a little help from SIMULIA the company is well on its way to meeting those objectives.

POWERING THROUGH CHALLENGES

Aside from plugging them in periodically, chances are you haven't given much thought to the rechargeable batteries sitting inside your cell phone or cordless power tool. Despite their ubiquitous nature and seemingly simple construction, however, batteries are actually complex devices, able to survive thousands of charging cycles with little drop in performance. They're also demanding to design and manufacture—especially those large enough to power a motor vehicle, suburban home, or even an entire office building. This latter kind of battery is often based on lithium-ion technology, which is Romeo Power's strength—and deliverable.

"There are multiple challenges in the battery industry right now, and as a structural engineer, I need to focus on all of them," says Saeid Emami, technical specialist at Romeo Power. "One of these is to reduce battery weight wherever possible, not only for vehicular use but to keep transportation costs down. Safety is another big concern. Batteries may short out when subjected to severe vibration, shock, or other abuses. For example a vehicle collision can lead to catastrophic failure, potentially harming the occupants or those nearby. And, of course, everyone wants the lowest cost possible, particularly in the automotive space. It's for these reasons that SIMULIA's Abaqus software has become an invaluable tool for simulating and optimizing our battery designs, allowing us to effectively address each of these needs."

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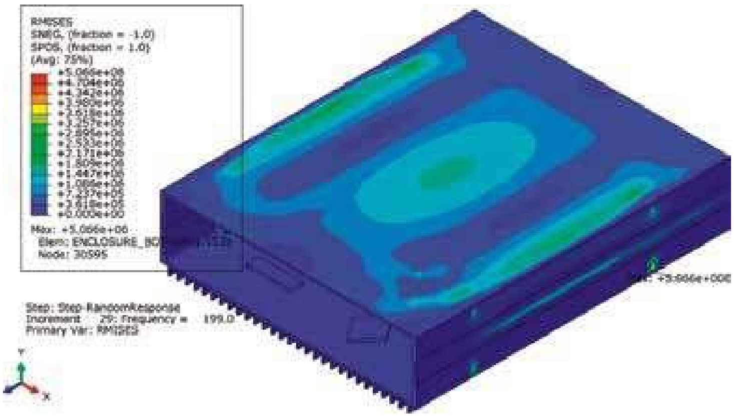


Simulated random vibration is applied to a battery module, just one of many such analyses used by Romeo Power to determine design effectiveness.

GAMING THE GRID

Founded in 2015 by tech entrepreneur Mike Patterson and hardware engineer Porter Harris, Romeo Power today employees more than 200 people, many of them engineers and designers like Emami. The main facility in Vernon, California, boasts 113,000 square feet of manufacturing space, much of it automated, giving Romeo Power the ability to produce four GWh (gigawatt hours) of storage capacity per shift. That's enough power to keep the lights burning in several million homes long enough to eat dinner with the family or watch a favorite show (and maybe even enough to send a 1982 DeLorean time machine hurtling back to the future).

With an "intelligent battery management system" and safety standards comparable to those used on spacecraft (Harris once worked for SpaceX), Romeo's electric vehicle (EV) battery packs are found in everything from motorcycles and automobiles to forklifts and four-wheel drive utility vehicles. Similarly, the Saber brand of portable energy systems can be used to charge laptops, cell phones, cameras, and drones with up to 90 watts of waterproof, shockproof, standby power for those on the go. And while the application is distinctly different, the company's stationary storage solutions are designed to collect and store power in much the same way—although in this case on a much larger scale from existing electrical grids—supplying energy to buildings and homes in the case of blackouts or reducing utility costs during times of peak demand.

Accomplishing all this hasn't been easy. As discussed earlier, batteries are far more intricate than is suggested by their unpretentious shapes. Emami describes a building block-like structure of cells, modules, and packs, each of which must be modeled for complete understanding of their behaviors, both individually and collectively. Shock, vibration, damage, fatigue—these are a few of the many conditions that he and the Romeo Power design team rely on Abaqus to simulate.

Says Emami, "SIMULIA and especially Abaqus are helping us to model these and other failure modes, predicting what will happen if there's penetration during a crash, for example, or the effect that vibration can have on cell positions within the pack. It's a very important part of our work."

PACKING IT IN

A lithium-ion battery pack may contain hundreds or even thousands of such cells, each one about the size of a single conventional battery in your remote control. Depending on their location within the pack, voltage levels may vary from cell to cell, causing performance issues. Internal conditions such as temperature and humidity also play a factor, and as packs get bigger, stress due to loading becomes an even greater concern, potentially leading to short circuits, fire, or mechanical failure. Each of these conditions is modeled, the results analyzed, and individual cell and pack designs modified based on the results.

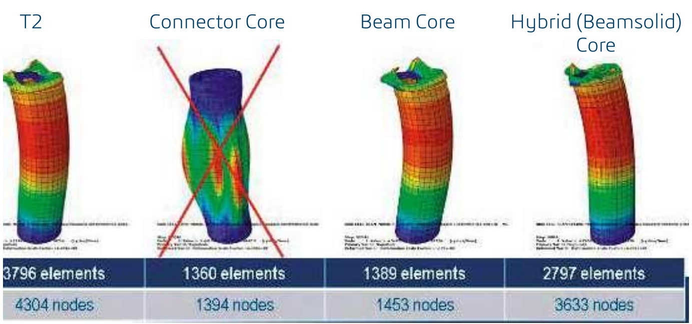
As with many engineering feats, a delicate balance between weight, cost, and capability must be achieved if the design is to be successful. "One of the major challenges is the conflict between the structural integrity, of course, and the overall weight of the battery modules," Emami says. "At the same time, we must be very cognizant of safety, a consideration that overrides all others. We develop different strategies to tackle each of these problems, and then use Abaqus to validate the results wherever possible."

UNRAVELING JELLY ROLLS

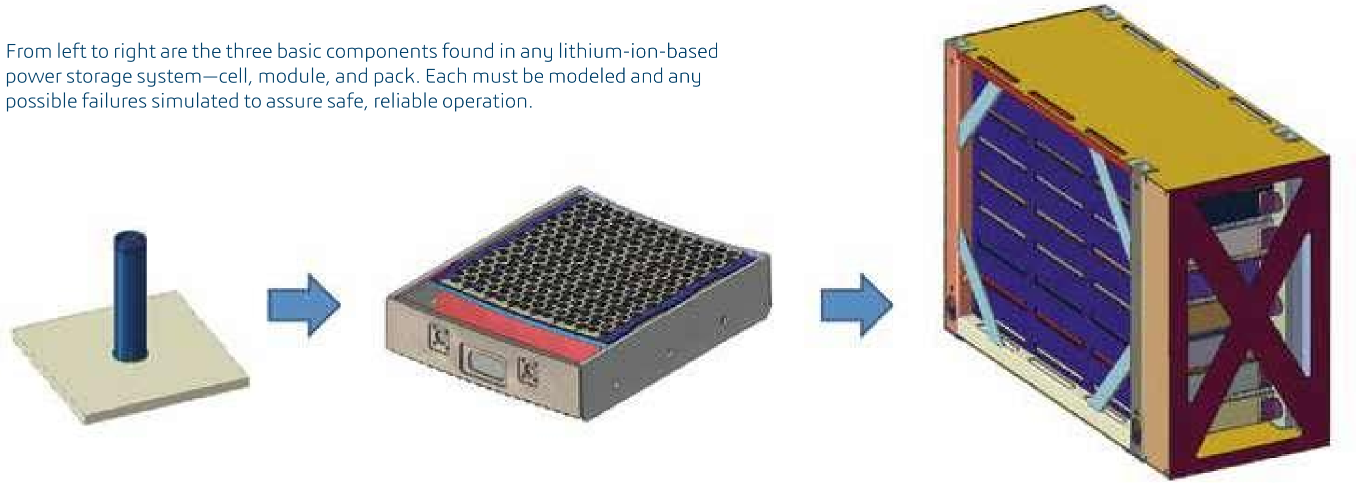
One example of this is predicting internal short circuits. The Romeo Power engineering team has constructed a "jelly roll" model to represent individual battery cells, and uses it to characterize their behavior during overcharge or crush situations, nail penetration testing (a standard in the battery industry), and thermal extremes.

In cases where suitable material models are unavailable, the team mimics reality by modeling battery cells as crushable foam with elastic enclosure, building them up to the module or pack level as needed to meet simulation requirements.

Abaqus is also used to demonstrate the effects of explicit events, such as dropping the battery pack, and implicit testing



These Abaqus simulations illustrate the effectiveness of using different core materials for battery cell construction—here, the results of a modal study showing the first mode of vibration for different meshing strategies. For instance, the crossed out "Connector Core" model does not constrain the casing well and as such, its first mode of vibration introduces an unrealistic vibration, i.e. at a very low frequency, clearly visible in the casing of the cylindrical battery cell.



From left to right are the three basic components found in any lithium-ion-based power storage system—cell, module, and pack. Each must be modeled and any possible failures simulated to assure safe, reliable operation.

of steady-state electrical conditions. Further, Emami and his colleagues are currently working with support engineers at Dassault Systèmes to develop a 'co-simulation" electrical-structural model combining explicit and implicit events like these.

"There are just so many potential problems with battery modules and structures that need to be tackled in order to meet our design goals of lighter, safer, and less expensive," Emami says. "Rather than wait for failures to occur, we started using Abaqus early in the company's history, analyzing structural integrity as well as the behavior of the different electrical and mechanical components under various types of loading. We knew that if Abaqus predicted a problem of any kind, it was a sure sign that the battery could fail."

A BRIGHT FUTURE

What does any of this have to do with helping those in the world without access to batteries or other forms of electrical power? Interestingly enough, that's exactly what prompted Romeo Power Technology founders Mike Patterson and Porter Harris to begin the company in the first place.

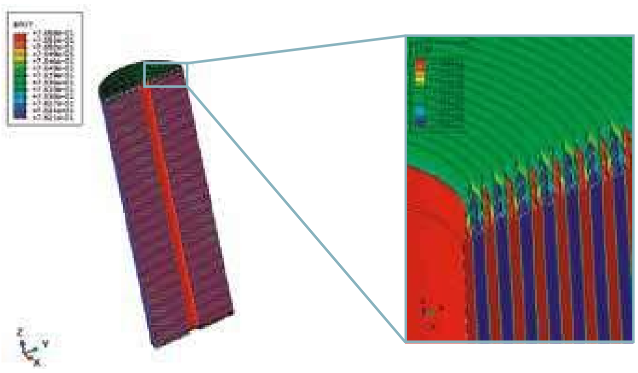
Both had spent time in Haiti and India, and were determined to make life better for the people in these and other energy-poor countries. Their initial attempt to do so failed, however—after building a prototype solar-powered storage unit, they soon discovered that it was too expensive for their intended customer base, despite the fact that the storage unit was constructed of relatively low-cost components.

Not long after this disappointing start, the two were approached by a number of companies looking for alternative sources of EV batteries. Realizing that a profitable business was probably the best way to fund further development of off-the-grid power sources, Patterson and Harris launched Romeo Power, never forgetting their vision of ending energy poverty once and for all.

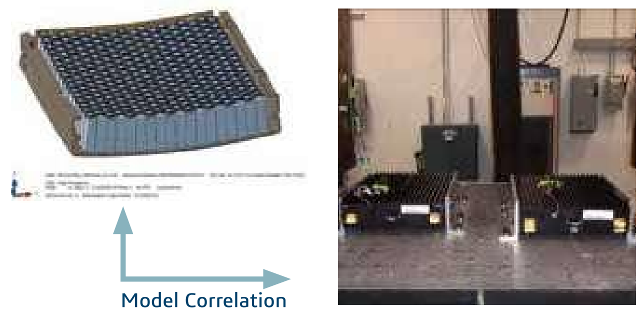
As for Emami, he's quite happy to be part of the Romeo Power team. "We have a group of very bright, committed people who, working together, have developed the most efficient batteries for their size available on the market today," he says. "Despite this early success, we're constantly looking at novel ways to improve battery efficiency. These include the potential of using composites and other materials in order to reduce battery weight, for instance, and finding ways to increase cell density. Whatever path we take, I'm sure that Abaqus and the other parts of the SIMULIA software suite will help us with whatever design challenges come our way."

For More Information

https://romeopower.com



Batteries we take for granted are actually complex assemblies, prone to a host of potential failures that could lead to short-circuiting, shortened product life, and runaway thermal events.



Like any good engineering company, Romeo Power routinely validates simulation results through real-world testing methods.