Rapid injection molding for fuel cell development

Ballard Power Systems, headquartered in Burnaby, BC, is a leader in the design, development, and manufacture of zero-emission proton exchange membrane (PEM) fuel cells. The company's technology is being deployed in residential fuel cell cogeneration in the Japanese market.

In residential cogeneration, electricity is generated right at the individual home using fuel cells, and heat from the fuel cell is captured to provide hot water for the home. A fuel – natural gas, kerosene and propane are the most commonly used fuels in Japanese households – is chemically "reformed" on-site to make hydrogen. Ballard's (ballard.com) PEM fuel cell then uses the hydrogen to produce electricity. The Japanese government is subsidizing the commercial introduction of residential fuel cell cogeneration systems, including those incorporating Ballard's fuel cell technology. The goal is commercial sales of the systems, without government subsidies, by 2012.

One of the critical steps in commercialization will be reducing the cost of the technology. In pursuit of this goal, engineers at Ballard are closely examining the cost for every aspect of every process. For some parts it has begun turning to The Protomold Company of Maple Plain, MN, which offers a high-quality, low-cost method for making injection molded plastic parts for prototyping and low-volume production. Recently, Protomold produced a part for Ballard's 35 A, liquid-cooled Mark 1030 fuel cell stack, designed for integration into a Ballard partner's system for the residential cogeneration market.

"The Mark1030 fuel cell is actually a number of fuel cells stacked together," said Ballard senior mechanical engineer Geoff Crocker. "We use Belleville springs to compress graphitic plates in the stack into a single unit to maintain contact and sealing.

"We stack the Belleville springs in various configurations. To keep them aligned during compression, we originally ran a machined metal rod through the holes in the middle of the washers and then shrink-wrapped the stack of springs. But the cost of the machined metal and the shrink-wrapping adds up, and if we want to be commercially viable over the long term we need to lower the cost. We knew we would have to use some high-volume process like injection molding."

Defining the concept for the alignment device was easy. Its purpose was simply to hold a stack of spring washers in alignment before and during compression. The obvious way to align the washers would be a tube running through the centres of the stack. But to prevent the tube from sticking out past the end of the stack once the springs were compressed, the engineers wanted one that would shorten along with the stack of springs.

Crocker and senior materials engineer Steve Gabrys went to work. Their solution was two opposing bases with walls and flexible locking arms. The walls support the spring while the flexible arms lock the two bases together. Under compression, both walls and arms slide past each other towards the opposing bases. To control costs, they chose to make a single part that could be used for both components.

"We looked at a variety of configurations," says Crocker. "We used Pro/ENGINEER CAD software to produce 3D models and assembled them on-screen to see how they worked. Between the whiteboard and the computer, we went through about a dozen iterations. The environment in which the design had to work was fairly benign, but we wanted a wall in the uncompressed state to support the springs. The two parts had to snap-fit together, and the arms and cutouts had to interface properly as the springs were compressed. Fortunately, the normal drafting of injection molded parts would provide the clearance we needed for the parts to slide into one another."

For their prototype parts, Crocker and Gabrys specified PA66 nylon resin, which had the strength and durability they needed and the flexibility for the snap fit, all at a reasonable price. According to Crocker, at the quantity they ordered, Protomold's injection molded prototypes actually cost less than a similar number of rapid prototype parts would have. Using the nylon parts for functional testing, they verified their design and moved ahead into limited production.

This article was supplied by The Protomold Company (protomold.com).

Patent pending Belleville spring holders in green ABS shown in photo were created from Pro/ENGINEER 3D files by rapid prototype service provider Protomold. Inset: Ballard and Tokyo Gas utility typical residential PEM power unit. Inset: The Mark 1030 V3 fuel cell is in alignment with the 2008 Japanese government targets of 40,000 h operation.

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