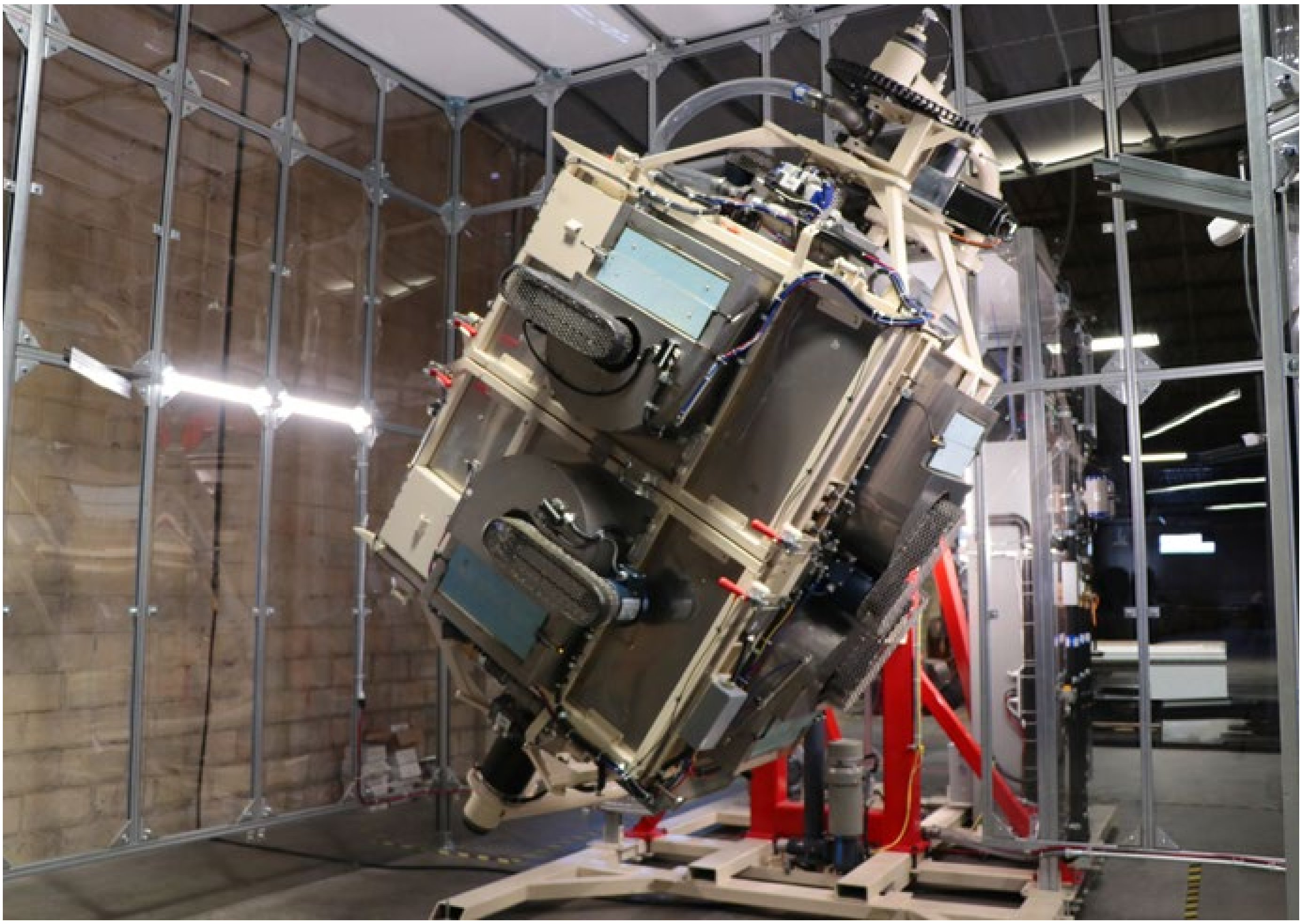
New Era for Rotomolding?

Innovative technology and equipment offer superior process control and produce better parts with higher repeatability and reproducibility

By Peggy Malnati



Ripple Engineering's patent-pending technology is said to consistently make better rotomolded parts, regardless of weather, shift, or operator experience. By combining active vent technology--which can be retrofitted to existing tools--with special rotomolding equipment (shown above), processors gain far better control of both internal mold pressures and temperatures, features that can be manipulated to reduce cooling cycles significantly and repeatedly mold more consistent parts. Courtesy of Ripple Engineering

New developments by Kansas City, Mo., startup Ripple Engineering address two of the most frustrating challenges with rotational molding (rotomolding): long cycle times and poor part repeatability and reproducibility (R&R). Ripple's technology—involving a new rotomolding machine and unique vent technology—holds promise for helping transform this versatile molding method from art into a true science.

From Customer to Machinery OEM

Ripple Engineering's technology was developed in response to frustrations that founder and president Ben Ismert experienced in his previous job as the president of a company that designed and sold large underground water-storage tanks. "We spent years as designers and marketers of rotomolded parts," Ismert recalls. "Our frustrations grew as we battled parts that warped, were out of tolerance, couldn't hold water, took too long to mold, or were delivered late owing to complicated machine scheduling. The more questions we asked our vendors, the more we realized that our livelihoods were at the mercy of outdated machinery, inconsistent quality, and the 'black magic' of rotomolding. We had good designs that were hindered by bad process quality." That got Ismert and some outside consultants tinkering with ways to improve quality and shorten molding cycles, primarily by monitoring and controlling temperature inside the tool. Armed with some ideas, he left his previous employer and started Ripple in 2015. After Ismert assembled a development team, they spent the next two years investigating ideas, molding parts, and getting them third-party tested. "As we looked for ways around both process and equipment limitations to improve quality, we took everything we learned during that period, made some pivots, refined the technology, and eventually sold our first machine last year," adds Ismert. "Our first machine took longer to build than we liked, but that's typical when you're creating something that's the first of its kind. We learned better ways to build our second machine—which we'll deliver this summer—and put into action some feedback potential customers provided."

Pressure-Cooled Rotomolding

A key aspect of Ripple's patent-pending technology involves use of an active vent, which not only lets gases escape from inside the rotating mold but also permits monitoring and control of both internal tool temperatures and pressures. The vent opens automatically at the start of the cooling cycle, allowing large volumes of low-pressure, chilled air to be blown inside the part. This greatly reduces cooling times—up to 78 percent for 0.250-inch/6.35-millimeter-thick PE parts with non-chilled air and 82 percent lower with chilled air, and 70 percent reductions on PA parts with chilled air. "The higher the temperature delta or the thicker the part, the shorter the cooling cycle is when internal cooling is used versus no internal cooling at all," explains Ismert. Warpage also is reduced since both inside and outside of parts are cooled simultaneously and at the same rate, helping ensure even shrinkage. Furthermore, by cooling parts faster, it slows down and reduces crystallization—at least in the semi-crystalline materials Ripple has tested, as verified by differential-scanning calorimeter (DSC) and scanning electron micrographs (SEMs)—and that, in turn, increases impact strength. For example, with a common PE grade, 27 percent impact improvements were measured while for a medium-density PE (MDPE) grade, a 48 percent increase was seen. Not surprisingly, lower crystallization comes with a tradeoff: slightly lower chemical and environmental stress-crack resistance. However, with better process control, molders can manipulate the cooling cycle to take advantage of whichever property is more important for a given application.

Another aspect of Ripple's technology is new processing equipment offering state-of-the-art process control more akin to that found on injection molding rather than rotomolding machines. A touchscreen interface shows processors exactly what's happening throughout the molding cycle, which is controlled by temperature rather than time, so regardless of the season, consistent parts can be produced. Machines are connected to the Cloud, allowing for remote troubleshooting. Once ideal molding and cooling conditions are recorded, a given "recipe" for a specific mold is saved for easy repeatability. Still other features include the ability to

Because pressure-cooled rotomolding chills both the outside and inside of parts simultaneously, shrinkage rates are consistent, which reduces warpage. On the left is a part produced with Ripple Engineering's technology, while the part on the right, made of the same material and produced on the same tool, was cooled using the traditional method (on the outside only). The latter part exhibits significantly more warpage. Courtesy of Ripple Engineering

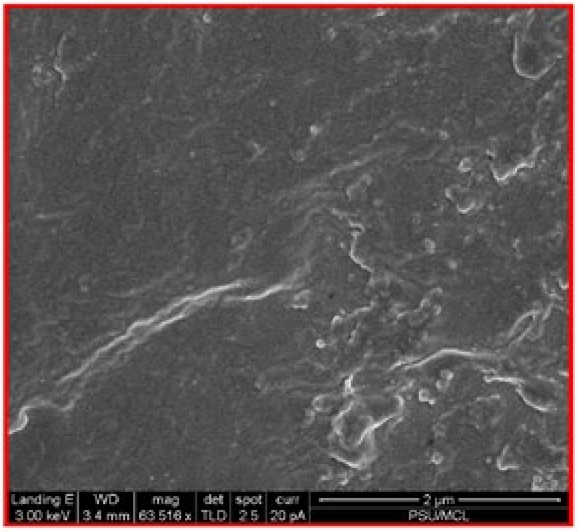
Old Process Made New?

Rotomolding is an old process for creating hollow parts via biaxial rotation of a tool that is simultaneously heated then cooled. Interestingly, for almost 100 years, it was used with many different materials but not plastics. The first documented use, circa 1855 in Great Britain, produced metal artillery shells and, later, other hollow vessels. In 1905, an American used the method to create hollow wax objects. Five years along, it was used to produce hollow chocolate eggs, a process still employed by the confectionary industry. In the 1920s, plaster of Paris was rotomolded to form hollow decorative objects. However, it wasn't until the early 1950s that polymers began being rotomolded, first to produce doll heads and later other plastic toys. Today, rotomolding is used to form a broad and ever-growing range of parts, including kayaks, bins, coolers, drums, barrels, trash cans, shipping containers, tanks, playground equipment and balls, outdoor furniture, garden planters, water-filtration systems, pallets, utility carts, stretchers, oxygen masks, medical supply cases, floats and buoys, pool liners, dental chairs, plastic cones and road signs, manhole covers, mobility devices, agricultural equipment, and fuel tanks and ducting.

It's one of the few thermoplastic processes (other than blow molding) that produces hollow, 3D parts in one piece but, unlike blow molding, it can do this without parting lines, pinch-off seams, or weldlines. That eliminates secondary joining operations, which can create weak spots and/or aesthetic blemishes in finished parts. Because forming pressures are extremely low, residual stresses in parts also are quite low. Low forming pressures means investments in tooling and equipment can be quite modest versus other thermoplastic forming processes. For example, most tools are made from soft metals, and the process has comparatively low energy usage, making it cost effective for development programs and short production runs. Material waste is also low, since there are no sprues or flash to trim. It can produce a good A-surface that is textured or smooth, colored, and that includes logos and/or lettering. The process tends to create parts with consistent wall thicknesses. Using drop-box technology, it also can make double-wall constructions without secondary operations, e.g. sandwiches of costly colored exterior polymer with natural-color interiors using the same polymer, or two different polymers such as a tough exterior resin with a more chemical-resistant liner as with fuel tanks, or even a foaming agent to increase stiffness at lower weight. One interesting process feature is that it produces slightly thicker corners, which are higher in strength, reducing the chance of premature failure in what in other processes would be high-stress areas of the part. From a design standpoint, rotomolding is flexible enough to create parts with molded-in threads, handles, inserts, ribs, and flat surfaces with 0° draft angles. These parts can be large or small—the latter molded in single- or multi-cavity tools or on rotating platens with multiple molds and stations. Parts can be reinforced with fiberglass or foam-filled. Unlike other molding processes, with rotomolding it's not only feasible but cost effective to create huge parts—as large as 22,000 gallons/83,279 liters.

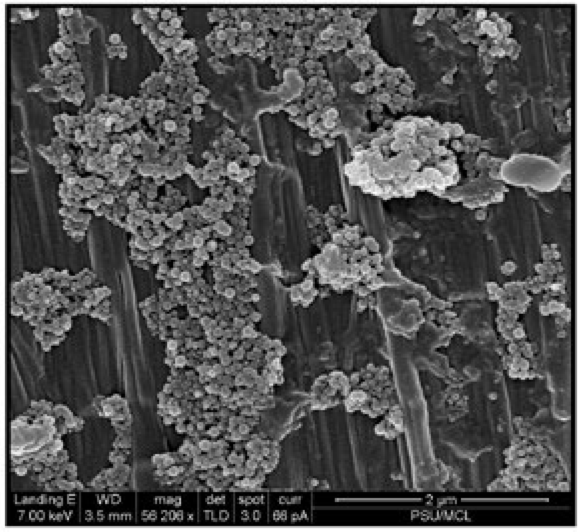
However, like any process, rotational molding has its challenges. These include long cycle times—from 30 minutes to three-plus hours—low levels of automation (and, therefore, higher labor costs), low repeatability and reproducibility (R&R) with part quality affected by operator skill, ambient temperature/humidity, powder quality, and many other issues, and the need to refurbish or replace those soft tools after roughly 3,000 molding cycles. While forming pressures are low, molding temperatures can be high and long, which limits material choices. Resins require both excellent flow to properly fill molds with minimal voids as well as high thermal stability and oxidation resistance to withstand those long molding cycles. Still another issue is the need to grind—in some cases to cryogenically grind—most materials into fine powders, increasing cost. At present, most rotomolded parts are olefins—especially those in the polyethylene (PE) family with lesser amounts of polypropylene (PP). Other polymers sometimes employed include polycarbonate (PC), polyamide 6, 11, and 12 (PA6, PA11, PA12), styrenics including acrylonitrile butadiene styrene (ABS), polymethyl methacrylate (PMMA), polyoxymethylene (POM), and polyvinyl chloride (PVC). Thermoset epoxy and silicone also are rotomolded.

In recent years, process improvements have focused on two areas. One is mold pressurization, which helps produce parts with fewer voids in less time, but increases the risk of explosion of the pressurized part. The second is monitoring air temperature inside the mold, which helps take the guesswork out of when to remove molds from ovens and when to remove parts from molds. These changes have helped reduce cycle times and make part quality better but have not been universally implemented.



Ripple Pressure-Cooled Rotomolding:

Internal cooling causes the molecular structure to solidify quicker, resulting in fewer crystals. These structures are more ductile.



Traditional Rotomolding:

No internal cooling allows more time for the crystals to re-form. These structures are more brittle.

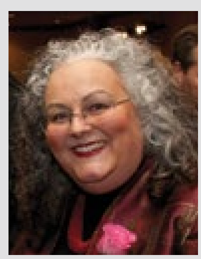
Another interesting aspect of the process is that because parts cool much faster, crystallization rates can be significantly lower, increasing impact strength, albeit at a slight loss of chemical resistance and environmental stress cracking. Above are scanning electron micrographs of two samples of medium-density polyethylene cut from rotomolded parts. The right sample was cooled the traditional way (outside the part only) while the left sample was cooled both inside and outside. Courtesy of Ripple Engineering

apply either a vacuum or introduce inert gas during the heating cycle to reduce oxidation risks. Further, the team has added the ability to control a drop-box inside the mold to produce multi-material parts. The system's oven can reportedly heat tools to 650˚F/343˚C in order to process higher performance engineering thermoplastics. Also beneficial, the active vent can be retrofitted to existing tools and existing tools can be mounted to Ripple's new machines once the active vent is installed. In fact, the company reports that it has started both materials- and mold-testing programs for customers wishing to see what pressure-cooled rotomolding can do for their current cycle times and part properties. The engineering team also is exploring gas versus electric oven heating with a goal of quadrupling machine heating capacity, making the system practical for customers without higher-voltage electrical service access.

Combined, these technologies are said to make part quality more consistent regardless of operator experience, shift, or weather. "With the new technology and real-time process monitoring, if something goes out of variance, you can adjust it on the fly, not wait until the end of the shift to check and find out you've made bad parts all day and have to throw away a truckload of product," notes Ismert. "With the process savings and far better quality, payback is much faster too."

What's the company's long-term plan? "Our mission is to be a catalyst to double the size of the global rotomolding industry over the next 30 years by exposing what happens during the molding process so people can take better advantage of it," explains Ismert. "First, we'll show people exactly what's happening inside their tool during the molding process, and then we'll teach them how to control it to make perfect parts every time. Second, we'll greatly expand the range of resins that can be rotomolded, which will open up a host of new applications." To that end, he says Ripple currently works with 10 compounders plus a third-party test lab, which does all the company's materials-characterization studies.

ABOUT THE AUTHOR



Peggy Malnati has more than 30 years' experience writing about the global plsatics and composites industries. She has organized technical conferences for SPI, SPE and SAE international, edited the 1994 book, "Structural Analysis of Thermoplastic Components" from McGraw-Hill, spent 15 years as board member and communications chair for the SPE Automotive Division, and has been a contributing writer covering automotive and composites beats for various trade publications, including Plastics Engineering. She also provides communications services for plastics-and composites-industry clients globally via her own Detroit-area firm. Contact her at peggy@malnatiandassociates.com.