Pressure Forming with Molded-in Color

Formed Dimensions: Pressure Forming with Molded-in Color

This white paper is based on a speech that Profile Plastics gave at the 2001 Spartech Technical Conference. We're sharing this content now in recognition of the recent retirement of Eric Lattanner, Spartech's business development manager, who received a Lifetime Achievement Award during the SPE Thermoforming Division's October 2023 conference in Cleveland, Ohio. Profile Plastics salutes Eric for his service, especially his support of Royalite® sheets for pressure-formed parts with molded-in color.

Getting Started with Pressure Forming

Nearly 50 years ago, Profile Plastics pressure-formed its first part on a used 5' x 10' unit from Brown Machinery, which is now known as BMG Solutions. This "true" pressure-forming machine was built in 1972 and designed originally to vacuum-form bass fishing boats. According to Brown folklore, only six of these massive machines with bayonet locks were ever built.

Because these units featured a hydraulic squeeze for die cutting, they were well-suited for pressure forming long before this thermoforming method became popular. The market for plastic pressure forming grew slowly at first, but it accounted for approximately half of Profile Plastics' business by the time we gave our 2001 speech. Yet that involved overcoming a major obstacle: tooling.

Tooling and Other Considerations

With our Brown machine, molds needed to leave their wooden 2x4 legs, adopt a negative instead of a positive design, and become vessels capable of withstanding 50 to 80 pounds of pressure per square inch (psi). Mold construction was easy, but these changes increased tooling costs by as much as $5,000. That undercut the economic justification for using pressure forming in the first place.

Profile also needed to address challenges with part attachment, color, texture, and function. Typically, pressure- formed parts require some method of attachment. If they don't have consistent dimensions, however, parts mating and fastening are challenging. All of the points of attachment, including the secondary ones, need to work reliably. The pressure formed parts need to look good as well.

Pressure Formed Part Colors and Textures

Unlike injection molding, the tooling for pressure forming readily supports undercuts. That's an important advantage for attachment, but color and texture are also key considerations. Pre-colored plastic sheets were available during pressure forming's early days, and it had been a standard practice to share color chips with vacuum forming customers. But pressure-forming customers wanted more.

Some wanted sheets in custom colors that matched their company's brand. Others wanted to color-match different parts, including non-plastic components. Textures were also important. At first, customers preferred heavy textures that could hide any imperfections in the tool. Finer textures were possible but required parts painting. As tool-making techniques improved, molds with finer features became possible.

Run-to-Run Color Matching and Royalite® Sheets

Run-to-run color matching was critical, and top covers from a first run need to match the back covers from the next run. That's also true of injection molding, but plastic pressure forming has different design considerations, including depth of draw. Plus, the gauge for adjoining parts is often different. Heavier gauges require a longer heat soak, and that increases the potential for sheet discoloration.

Painting can cover up imperfections, but it adds costs and extends project timelines. For molded-in color, Royalite® sheets proved to be very resistant to color shifts, especially compared to competitor offerings. Today, the Royalite® brand is owned by Spartech, the company from which Eric Lattanner recently retired.

Pressure Forming's Second Decade

As pressure forming entered the 1980s, OEMs who made expensive equipment wanted to replace their sheet metal parts with lighter weight, less expensive plastic ones. Typically, the part volumes were 50 to 250 per series. Pressure forming provided a cosmetic and functional alternative that was both quick and cost-effective.

The business environment could be challenging. Sometimes, OEMs who faced potential plant closures, relocations, or outsourcing would present us with urgent projects for half-finished equipment. Many of these jobs were unprofitable and required upfront engineering and overtime that we couldn't recapture. Profile learned from these experiences, which were the exception rather than the rule.

Fitting, Fastening, and Color Matching

For OEMs, pressure forming's formed-in undercuts were attractive because they solved fit and function challenges. Generally, designers specified looser-fitting parts since pressure forming used lower-cost tooling. Yet this created the cosmetic challenge of hiding the witness lines from a mold's moving sections. Fortunately, painting could cover witness lines with just a little sanding and filling.

Eventually, however, the way that parts came together became an issue. They needed to match each other in appearance and also fasten together in a way that was cosmetically pleasing. Hand-trimming highly visible parts was challenging, so Profile Plastics purchased a 5-axis Thermwood electric router in 1979. To say that this technology was still in its early stages was, in retrospect, an understatement.

Early Automatic Trimming: Pros and Cons

Profile's 5-axis Thermwood electric router could trim features that were difficult or impossible to hand fixture. This 1970s-era machine could also trim very large parts that were difficult to trim by hand. Yet setting up jobs and programming parts was difficult. Plus, the repeatability was poor. Therefore, the electric router needed continuous adjustments and tweaking.

Although this machine was like an extension of an expert craftsman and a programmer, it didn't meet our expectations for decreased production times and reduced skilled labor inputs. Too often, the finished parts neither looked good nor fit well together. Fortunately, we had enough customers with the right type of applications to support this form of automatic trimming, despite its challenges.

Molded-In Color vs. Parts Painting

During the early days of pressure forming, most pressure formers didn't have especially high expectations for sheet materials. However, Midwestern thermoformers didn't want to paint parts. Painting isn't a clean process, and it poses problems with odors and exposure to carcinogens. The prep work is dusty, dust removal requires air handling, and HVAC energy costs can be significant because of our winters.

Midwestern thermoformers also preferred pre-colored parts because of the influence of the automotive industry. To reduce costs, the automotive supply chain wanted material suppliers to develop colored sheets for parts that would be ready right out of the mold. That would eliminate or reduce the need for parts painting, but it would also require close collaboration with material suppliers.

Building a Business Around Royalite Custom Color Matched Sheets

To avoid parts parting, Profile Plastics developed a strong relationship with Royalite, an Indiana-based division of Uniroyal that was later acquired by Spartech. Royalite's color-matching technique supported the production of custom-colored sheets in lower volumes – and with predictable costs and lead times. Although these lead times were still relatively long, most of Profile's customers preferred molded-in color.

Without Royalite sheets, painting would have remained the primary way to produce pressure-formed parts with color. Yet painting's higher costs would have limited the growth of the pressure-forming industry. The freight costs associated with outside painters and the time that painting adds to manufacturing are problematic, especially among customers who want to accelerate time-to-market.

Material Costs and Manual Trimming

When Profile Plastics addressed the Spartech Technical Conference back in 2001, the cost of thermoplastic sheeting was three times greater than the cost of the materials used in injection molding. More significantly, pressure forming was working to overcome its higher reject rates because of the lower-tech molds that were used at the time. To make parts functional, secondary trimming was required.

Unfortunately, the variations in hand trimming were too great to meet customer requirements. Therefore, Profile pursued quality by culling unacceptable parts. Yet we also labored with inefficient designs that were based on injection molding and used stands-offs and bosses instead of through holes or undercuts for attachment. Our employees had to learn new skills, including precision bonding, to support this.

Part Measurements and Reject Rates

Measuring close-tolerance parts was another challenge. For example, a part with 45 minutes of CNC trimming needed 2.5 hours to measure all of its critical dimensions. Every time this job was set up, it required time-consuming adjustments before production could begin. Meanwhile, our reject rates ranged from 10 to 25%. Some sheets were sent back to Royalite, but at least they could be recycled into feedstock.

The cost of part rejects is an area of disagreement between thermoformers that prefer painting to molded-in colors. Painted parts aren't easily recycled into non-virgin feedstock, but they can be sent through the paint shop again, which reduces the load on landfills. At Profile, substantial equipment investments have enabled us to optimize our high-volume pressure forming with molded-in colors.

From Low-Volume to High-Volume Pressure Forming

Back in 2001, Profile's reject rates ranged from less than 1% to as high as 4%, depending on the part. As we explained in our speech to Spartech, this reduced our need for painting and cut our direct labor costs from 20% to 12%. It also strengthened our relationship with Royalite. Now that Profile could consistently produce tens of thousands of parts per year, we could pursue higher-volume applications.

Originally, Profile had asked Royalite for low volumes of custom-colored sheets with close color matching. This enabled us to break into many low-volume applications, but now we needed less expensive sheets so we could keep jobs as volumes grew and injection molding became more appealing. Yet sheet prices weren't the only obstacle to high-volume pressure forming.

Tooling for Automation

For high-volume pressure forming, Profile needed tooling that supported automation. By using machine control to reliably cycle a mold's moving sections, we could run our rotary equipment 24/7 – and without rejects. We also needed faster ways to program and trim a job's first parts, and CNC machines and fixtures that could position and trim subsequent parts quickly and reliably.

In addition, Profile needed to work closely with designers to eliminate the bonded-on features that some designs required. Through progress in all of these areas, the costs of pressure-formed parts would continue to fall and we could produce higher volumes economically. Profile Plastics has made tremendous strides since our Spartech speech of 2001, which also addressed what was then our next thermoforming frontier.

PROFILE PLASTICS℠

Twin Sheet Thermoforming Arrives

Twin sheet thermoforming wasn't new when the twenty-first century began, but Profile Plastics was mainly a vacuum former and pressure former at the time. Today, it's a service that we offer for great-performing hollow and lightweight plastic parts. The process, which uses a clamshell technique of molding two sheets in one frame, was used originally to produce boats and then pallets and shipping containers.

The rise of twin sheet thermoforming dates back to the 1980s, when GE Plastics pioneered a technique called large part blow molding, or engineered blow molding to stimulate demand for its materials. Designers and molders liked what they heard, but they didn't like how the parts looked. Excessive die lines required painting, and hand trimming was difficult. Plus, blow molding machines were expensive. In addition, GE targeted applications for its highly engineered resins, which were more expensive.

Engineered Blow Molding vs. Twin Sheet Thermoforming

During the 1990s, engineered blow molding developed a specialized but significant market. With the exception of polyethylene parts, however, blowing molding doesn't have a cost advantage over twin sheet forming, which is also capable of specialized applications. For example, when Exxon's Greg Wilson addressed the Spartech Technical Conference in 2000, he envisioned a market opportunity for twin-sheet thermoforming fuel tanks that were better than blow-molded ones.

Today, twin-sheet thermoforming has lower tooling costs than blow molding and advantages that include faster turnaround and lower part costs than rotational molding can achieve. Highly detailed cosmetic parts are readily achievable, and twin-sheet forming makes it possible to obtain more difficult draw ratios than other plastics manufacturing methods can achieve. To learn more about Profile Plastics' capabilities and how we can help you succeed with your next project, contact us.

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