Rotational Molding: Lowers Cost and Improves Customer Appeal

by Michael Paloian, Integrated Design Systems

How many times are companies faced with the challenge of enhancing appearance, lowering part cost, and improving performance with a minimal investment in tooling? The answer is always! This is especially true today, when product life cycles are much shorter and companies are trying to capture market share with new products quickly and profitably. Profits are dependent upon sales volume, return on investment, and manufacturing cost, which are all affected by product design. Design will ultimately dictate how the product looks, functions, and costs, having a direct impact on sales and profits. This correlation is best explained using a case study describing how design objectives can be achieved using rotational molding as the process of choice. The case study will examine the development of a rotationally molded stand used to support a pool chlorinator. Although this is a relatively simple part, the results clearly demonstrate the benefits of rotational molding when parts are properly designed.

Less than a year ago Arch Chemicals, a world leader in swimming pool chlorinators and chemicals, planned to improve one of its products, a chlorinator stand. Arch's extensive product line is marketed to commercial and residential markets as integrated systems, which accurately meter calcium hypochlorite into swimming pools. Its creative marketing group is continually developing new products to satisfy its customers within a growing industry. These products include dispensing systems as well as a comprehensive line of auxiliary equipment, providing added versatility to the core product line. This chlorinator stand positions the chlorinator at a convenient height, providing ease of use for the operator during replacement of cal-hypo cartridges.

The stand was originally designed by Arch for the Qwikload 1 chlorinator as shown in figure 1. Due to its initial limited production volume, it was constructed of PVC tubing as shown in figure 2. Although the design was simple and functional, it had many limitations. Some of these limitations are listed below:

Figure 1

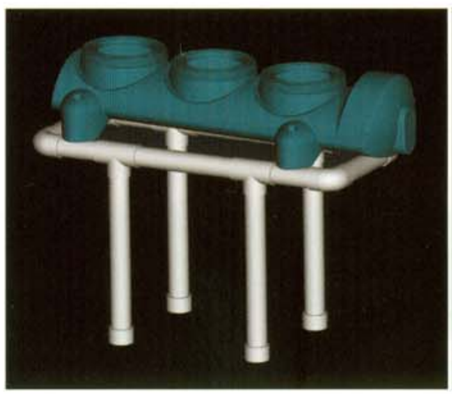

Figure 2

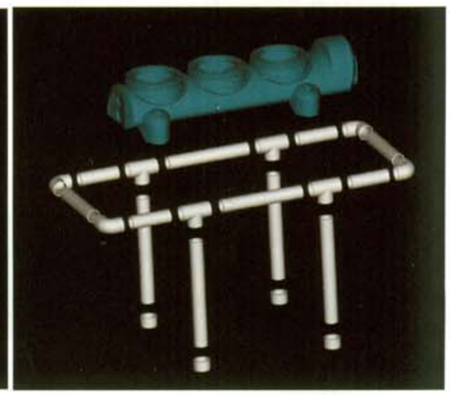

Figure 3

- Labor intensive to manufacture
- Difficult to manufacture consistently
- Complex
- No aesthetic appeal
- Difficult to package
- Limited to a specific pool chlorinator
- Legs could not be adjusted in height for irregular floor surfaces

Conventional rigid PVC tubing was cut to length and solvent bonded to numerous standard pipefittings as shown in figure 3. Despite these limitations, sales for the stand increased because of its benefits. In addition to increased demand, Arch introduced another pool chlorinator, the Pulsar 1, shown in figure 4, which also required a stand. These factors, combined with the limitations of the existing design, induced management to consider redesigning

Figure 4

the stand. Integrated Design Systems, Inc., located in Great Neck, NY, the industrial design firm that developed the Qwikload 1 and Pulsar 1, was asked to design a new stand that would provide it with a superior product. The new product was to be designed based on the following general criteria:

- Low capital investment in tooling
- Eliminate assembly
- Minimize and simplify packaging
- Improve appearance
- Support both the Qwikload 1 and Pulsar 1 pool chlorinators
- Provide improved stability
- Provide easy adjustments in each leg for irregular floors
- Reduce manufacturing cost
- Be easily assembled in the field
- Be very rigid and structurally superior to the current design
- Reduce part count
- Be corrosion resistant
- Improve passage of tubes and piping to chlorinator

Process Selection

During the initial stages of concept development, numerous ideas were proposed to satisfy these requirements. Concepts were developed through sketches exploring various methods of adjusting legs, minimizing the number of parts, and means for supporting both products. Since the specific material and manufacturing process was integral to the design, a selection had to be made in the early stages of development.

Figure 5

For example, concepts based on a metallic structure were immediately eliminated due to their inherent limited corrosion resistance. Variations based on the current method of fabrication proved to be too costly and complex. Part designs based on injection molding or structural foam molding required an unacceptably high capital investment for the relatively low production volumes. Higher capital investment and design limitations of blow molding eliminated this process as a viable option. Requirements for UV stability and high tooling costs for reaction injection molded polyurethane eliminated this material as a possibility. Designs associated with plastic extrusion would have been too complex and labor intensive during assembly. Therefore, rotational molding became an ideal option for solving most design requirements. The challenge that lay ahead was to develop an optimum design that would benefit from the advantages of rotational molding. The following section will describe the design process, which led to a solution satisfying the entire list of design criteria previously cited.

Early Concept Development

Since the stand was to support two very dissimilar products, the first step in development involved a comparison of how each would be mounted. CAD files for each product were superimposed to define a common surface to which each would be mounted as shown in figure 5. Later, mounting points and a basic footprint area were defined to establish minimal size and shape for the support platform. The next phase of design was dedicated to concepts focused on leg designs and their interface with the support platform. The challenge was to design legs that would be stable, adjustable, and inexpensive. Provisions for clearance to allow plumbing fixtures to be attached to the chlorinator were also required. Although initial concepts shown in figures 6 and 7 solved many problems, each had significant drawbacks. Figure 8 shows a pair of rotationally molded legs that would be cut to size in the field. This would have been complicated for the end user. Alternative concepts restricted pipe routing as shown in figure 9 while others were overly complicated and too bulky. Eventually, continued

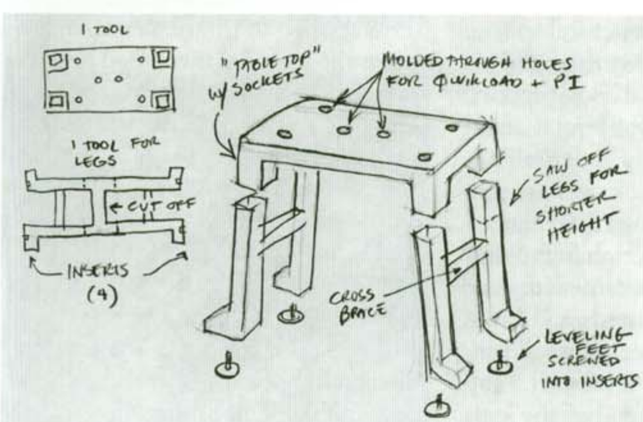

Figure 6

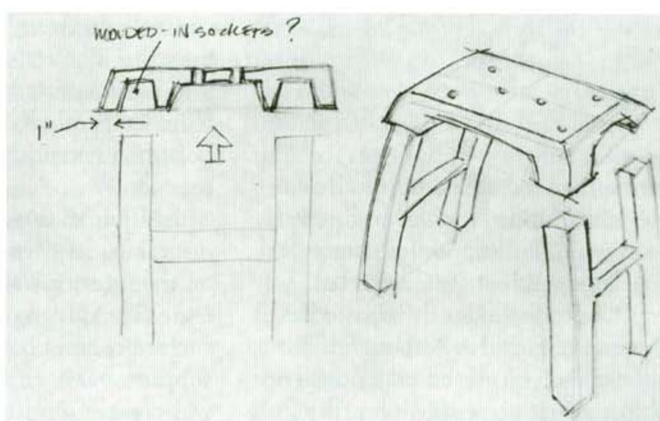

Figure 7

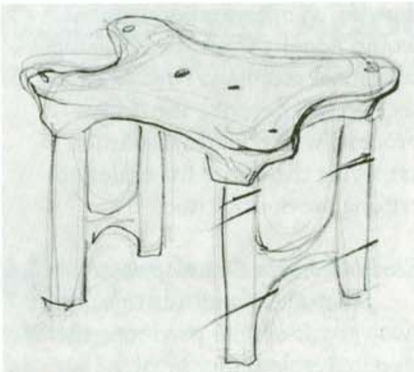

Figure 8

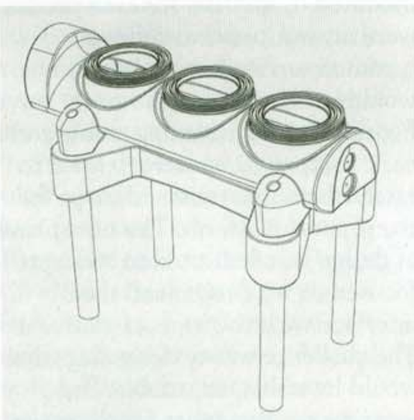

Figure 9

Figure 10

refinement led to a simple and elegant solution, which was limited to one molded support platform and four independent PVC legs that could be independently adjusted as shown in figure 10. Although this concept solved all the major design objectives, it presented a few design and processing challenges:

- Designing the interface between the legs and the platform to be structurally adequate
- Minimizing draft to provide good surface to surface contact between the legs and the platform
- Developing a simple and reliable locking technique to secure the legs
- Minimizing the mass in the area where the legs engaged with the platform
- Forming the required features to support the tubes
- Maintaining tight tolerances and perpendicularity

If these challenges could be resolved, the aesthetics and specific design details could be completed for the product.

Design Refinement

The most critical feature of the stand was in the area between the leg and the platform. The joint at this intersection had to be rigid and straight. If the feature were incorrectly designed, the legs would flex joint excessively, resulting in an unstable stand. Structural integrity was achieved by molding a double wall in each leg support as shown in figure 11. The inner wall was to provide a continuous surface area of contact for each leg, while the outer wall contributed to the overall structural integrity of the assembly. Molding this feature into the stand optimized the benefits of rotational molding by limiting parts within a multifunctional component. Reduction of parts simplified assembly, inventory control and overall structural integrity. Two set screws threaded into brass inserts at each leg support would securely lock the legs at any position preventing any undesirable rotation.

Although the design was highly desirable, concerns pertaining to draft on the interior wall became a major issue. The design required good surface contact between the leg support and each PVC tube. If a gap was created at either end of the leg support because of draft, the legs

Figure 11

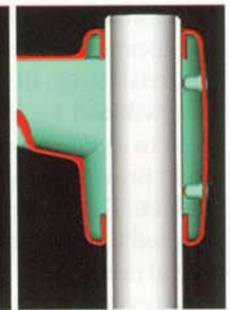

Figure 12

would become unstable. Alternatively, if draft was not added to the part, it would be very difficult to mold. It was at this time that Formed Plastics, located in Carle Place NY, was called to review the design and molding parameters. Formed Plastics was selected by Arch as the intended molder for this application. After its engineers reviewed the cross section and design intent, they suggested modifying the proposed cross section to that shown in figure 12. Formed Plastics determined that the part could be molded without draft for 2" on either end without any problems. This design compromise provided an excellent solution to the draft and molding dilemma. The suggested modification provided adequate surface area of more than 2" on either end of the opening for support with no gaps on either end.

Another challenge to address was potential bridging between mold walls. Since rotational molding involves the melting, flowing and cooling of polyethylene powder within a closed vessel at atmospheric pressures, it has some limitations. One of these is bridging. Bridging is a term applied to rotational molding when the material is trapped between two mold surfaces that are too close. The result is a partial fill within the area, resulting in a void or surface defect. The general rule for rotationally molded parts is to maintain a minimum 5:1 ratio between two opposing mold surfaces to avoid bridging. This sometimes presents problems for designers since the resulting forms can tend to be very chunky. This limitation was resolved by contouring each attach-

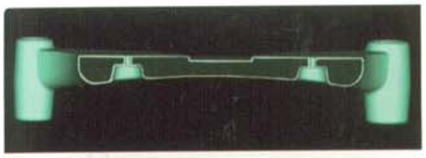

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

ment point with a barrel shape. The contoured shape included generous radii leading into the feature, visually relating the leg supports to the overall design while providing adequate area for material to flow without bridging.

Maintaining proper tolerances was the next technical issue to address. Tolerance concerns included flatness, hole-to-hole dimensions, and perpendicularity between the leg supports and the stand support platform. These issues were also reviewed with Formed Plastics. Its engineers discussed tolerance limitations and methods of controlling dimensions using specially designed shrink fixtures to insure that tolerances between holes complied with design requirements. These fixtures were designed to accept parts immediately after molding. The fixtures had to be designed to accept the oversized parts which shrank to their final state as they cooled to room temperature. The fixture limited the shrinkage of holes and other critical features during this cooling cycle. Machined blocks in each corner insured perpendicularity between the leg supports and the top deck. Flatness was maintained by restricting the mounting surface to the fixture during cooling. Kiss-off features in the double walled surface also contributed to overall structural rigidity and flatness as shown in figure 13.

Production

The parts were molded in a quality cast aluminum mold built by Norstar Aluminum Molds, Inc. in Cedarburg, WI as shown in figure 14. Molded inserts were manually loaded and held in place with bolts placed through the mold as shown in figures 15 and 16. The interior of the mold was Teflon coated for easy part removal as shown in figure 17. Molded parts were placed in the shrinkage fixtures to control dimensions, perpendicularity and flatness after removal from the mold as shown in figures 18 and 19.

Figure 18

Figure 19

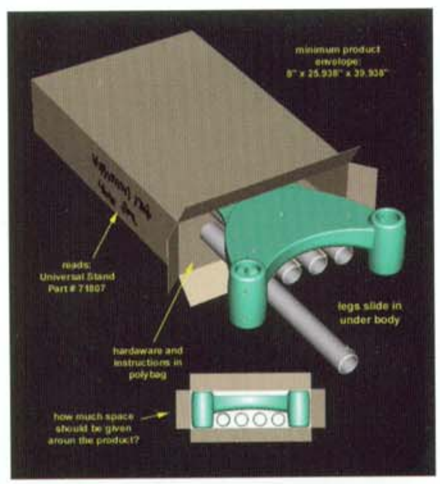

Figure 20

Conclusion

The resulting design successfully transformed a purely functional stand into a quality product satisfying all the desired objectives. Low cost tooling associated with rotational molding satisfied the requirements of minimal capital investment. Quality was attained with excellent mold design and craftsmanship. Details along parting lines as well as surface finish were crisp and clean. In addition, the new design eliminated the high costs of assembly inherent in the previous design since the product was shipped as a "knock down" assembly. Packaging costs and shipping were dramatically reduced due to the compact size of the shipping container as shown in figure 20. Costs associated with breakage during shipping of the previous product were eliminated. The overall appearance was drastically improved and visually associated to both products as shown in figure 21. Structural integrity of the new design was a significant improvement compared to the previous tubular construction, due to the fewer number of joints, and overall construction. Unlike the tubular design, each leg could now be adjusted to accommodate any floor irregularity as well as position the chlorinator at any desired height. Production quality was improved since parts were molded with much more consistency than the previously labor intensive assemblies. Lastly, manufacturing costs were greatly reduced by molding parts in low cost tools with improved quality and efficiencies.

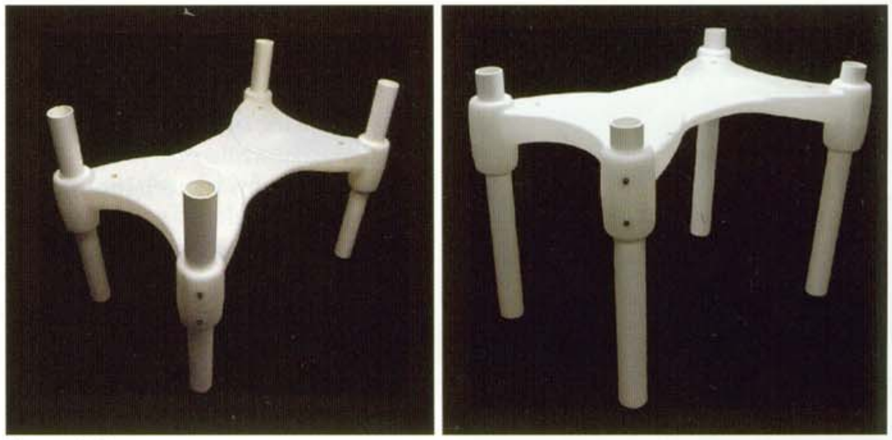

Figure 21

Use of UV stabilized polyethylene for the main structure and standard rigid PVC pipes for the legs provided Arch with a quality product ideally suited for the harsh chemical and environmental conditions for which it was designed. Ease of assembly in the field, combined with its versatility made this a very successful product for Arch and its customers.