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Case Study on Design

— Swimming Pool Chlorinator

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Arch Chemical Pulsar IV Commercial Pool Chlorinator
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It's difficult to remember that at one time, rotational molding was exclusively dedicated to molding large water tanks, chemical drums, or inexpensive novelty items such as decorative lawn statues. However, numerous advantages of this process have enabled designers to continually find new applications ranging from truck bumpers and kayaks to complex medical instrumentation housings. This proliferation of new applications has not only resulted from design innovations but also ongoing improvements in tooling, materials, decorating, and processing. Today, parts can be molded with very tight tolerances and complex shapes. New grades of polyethylene, nylon, polycarbonate, and PVC offer designers a wider range of materials with diverse physical properties. Excellent surface finish combined with in-mold decorating now offers designers the ability to create very attractive high-quality parts. Improvements in fixtures, CAD, and CNC machining have also made it possible for parts to be molded with exceptionally high quality. An appreciation of these advancements in rotational molding technology and the design possibilities afforded by the process can best be illustrated within the context of a case history as described in the remainder of this article.

Product Description and Project Objectives

Arch Chemicals is a leading manufacturer of pool chemicals sold under the familiar brand name of HTH as well as its Pulsar line of pool chlorinators. The company has satisfied a growing demand for its products by offering customers new and improved systems. It has also created a strong brand image by marketing products that are attractive as well as functional.

Consistent with this marketing philosophy, Arch decided to launch a new product development program targeted toward its very large commercial users. This project involved the design and development of a 200-pound capacity commercial swimming pool chlorinator, the Pulsar IV shown in figure 1. It would be sold to facilities requiring chlorine to be accurately dispensed into 500,000 to 1 million gallon capacity pools. Like all of Arch's dispensing equipment, it had to be reliable, easily maintained, and compliant with stringent NSF regulations.

The project began with a simple bread-boarded unit that was originally conceived and prototyped by Arch Chemicals. It was fabricated from 16" diameter, ¼" thick PVC sheet stock to test the basic principles of operation as summarized below:

Fig. 1.

1. The chlorinator was required to have a maximum storage capacity of 200 pounds of calcium hypochlorite briquettes.
2. The unit required a removable hopper with a hinged top cover.
3. The hopper had to be low enough for easy loading.
4. Standard components were to be mounted into the base tank.
5. The base tank was required to store a specific volume of chlorinated water.
6. A removable hopper grill was required for easy cleaning.
7. Water would be sprayed through a manifold through spray nozzles.
8. Safety precaution labels were to be prominently visible on the unit.
9. Water would be automatically shut off when the lid was opened.
10. The product had to be attractive and convey quality.
11. The unit was to be designed for easy assembly and testing.
12. Cost-effective design and ease of manufacturing were essential.
13. The product had to be corrosion resistant.

After the basic principles of operation were satisfactorily demonstrated, the design was further developed by IDS through a series of evolutionary refinements as described in the next three phases of design.

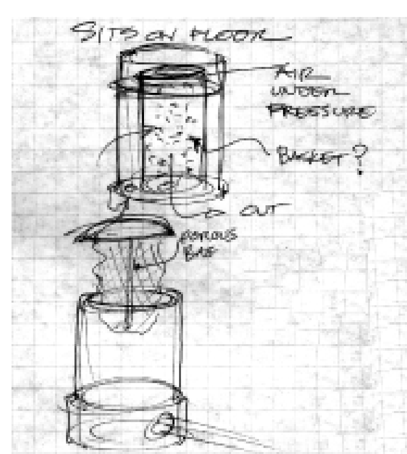

Fig. 2.

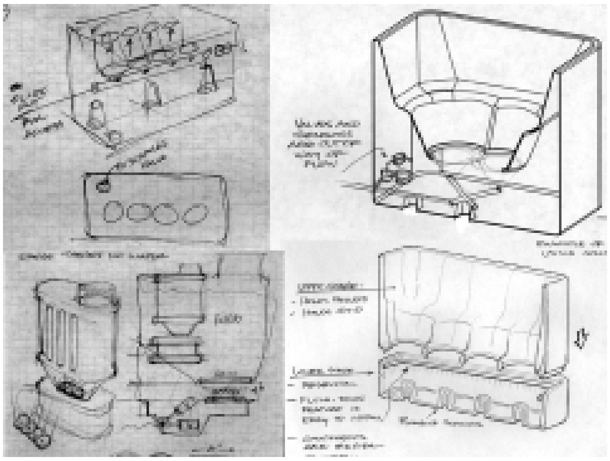

Fig. 3.

Phase 1 – Design Specifications and Concept Development

The design program began with a concise set of product specifications that were documented in a report and presented to Arch Chemicals for review. Concurrently, with this activity, numerous concepts were developed to explore a variety of design possibilities for the overall product as well as details pertaining to specific functional requirements. An emphasis on creative thinking was central to the design activities during this phase of development. The objective of this phase was to arrive at a number of possible solutions based on the prototype that could be further developed into a manufacturable product. Figure 2 shows a few of the initial concepts typical during this design phase. Continued development resulted in a two-chamber product with an upper hopper and lower tank. This two-section split appeared to solve many fundamental design requirements, and functions for each section were defined. The hopper had five essential purposes:

1. The hopper had to store up to 200 pounds of calcium hypochlorite briquettes.
2. The hopper had to be easily handled and removed for periodic cleaning.
3. A hinged lid was to be included in the hopper to isolate the chemicals.
4. A removable grid had to provide support for the briquettes while also allowing water to be sprayed into the hopper.
5. An automatic shut-off feature had to be included to stop water flow when the hopper lid was opened.

The lower tank was required to store chlorinated water as well as all the plumbing and hardware necessary to operate the device. As more details were added to the design, it became apparent each unit required features on interior as well as exterior surfaces. A double-walled construction emerged from this design activity as illustrated in figure 3. This concept provided many structural benefits, aesthetic opportunities, as well as functional advantages. A single molded piece eliminated the concerns for leaks and costs associated with assembly. The outer features of the hopper could be designed with an emphasis on aesthetics versus purely functional considerations. Exceptional strength and rigidity would be achieved with one contiguous surface. Shortly after this project milestone was reached, process selection became an important issue. Further design refinements could not take place unless a clear manufacturing direction was established. The number of plastic molding processes that would be suitable for this application was limited for the following reasons:

1. The parts were very large, consuming a total enclosed volume of 20,000 cubic inches.
2. The ideal material based on cost and performance was polyethylene. Calcium hypochlorite is extremely reactive and incompatible with many plastics as well as most metals.
3. The tank had to be leak-proof and rigid.
4. Production quantities warranted a cost-effective manufacturing method.
5. Rotational molding would provide a cost-effective method of reproducing the complex surfaces and features for each part.
6. Tolerances and quality had to be predictability consistent.
7. Tooling costs had to be easily amortized in relatively low production quantities.

Rotational molding was identified as the ideal processing method because of its benefits when compared to the requirements stated above. In addition, rotational molding was ideal for molding large complex hollow parts. The next phase of development would require an integration of product design with processing parameters. Design details would have to be optimized based on the advantages as well as limitations of rotational molding.

Phase 2- Design Refinement and Production Design Development

After Phase 1 was completed, IDS further developed the Pulsar IV within a 3D CAD layout. Initially, this assembly only included the most basic components in a simple rectan-

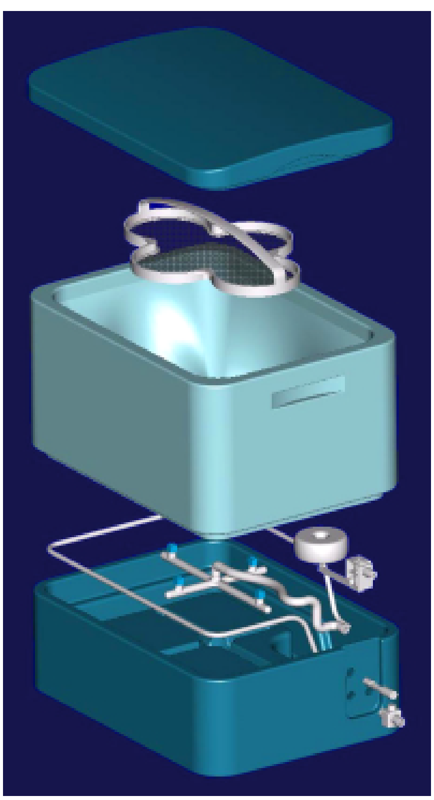

Fig. 4.

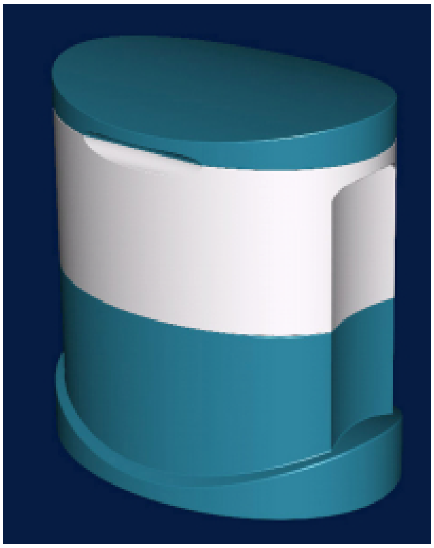

Fig. 5.

gular tank as shown in figure 4. As details became more evident within this layout, alternative shapes for the product were explored to arrive at a more aesthetically appealing design. After reviewing many concepts, an oval shape was determined to offer the best image for the Pulsar IV as shown in figure 5. The remainder of Phase 2 was dedicated to integrating functional, aesthetic, and molding parameters into the design of all parts.

This product included the design of five rotationally molded parts as well as numerous pieces of hardware, tubing, plumbing fixtures, and fasteners. Since the cost of a pre-production prototype would have been prohibitive, it was decided that this development step would be omitted. Therefore, the design had to be right the first time. There was no allowance for errors in dimensioning, structural miscalculations, or tolerances. Like any successful design project, it required a cooperative group of people and a clear list of project goals. This project included four project teams consisting of Arch Chemicals, the OEM, Integrated Design Systems Inc. — the design firm, Wheeler Boyce the toolmaker, and Gregstrom Corp., the molder. Each group shared in the design during each phase of development to minimize problems during production startup. A description of rotational molding design considerations that affected the outcome of the Pulsar IV is described below:

Double-wall construction

As previously stated, this design was based on an intrinsic characteristic of rotational molding the ability to form complex hollow parts. Rotationally molded double-walled shapes are very strong and easily formed. The only precaution that should be followed is limiting the distance between walls to a minimum of five times the wall thickness. For example, the distance between two outside .1" thick walls should be no less than .5". If walls are designed closer to each other, parts could be molded with significant voids.
The hopper, lid, and base tank were all molded with double walls. Molded features on exterior and interior surfaces satisfied many complex design requirements as shown in figure 6. In addition to providing parts that were very functional, the double-walled construction also eliminated many secondary operations since virtually all product features were molded in.

External radii

Because rotational molding has no force other than gravity acting upon the melted resin, deep narrow pockets in the mold should be avoided. As a general rule, radii should be as large as possible to optimize flow. Design details in the

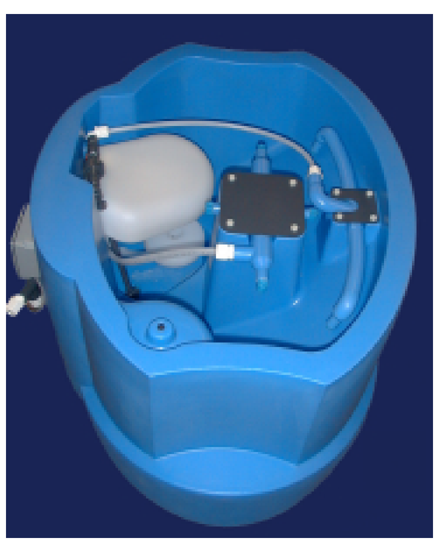

Fig. 6.

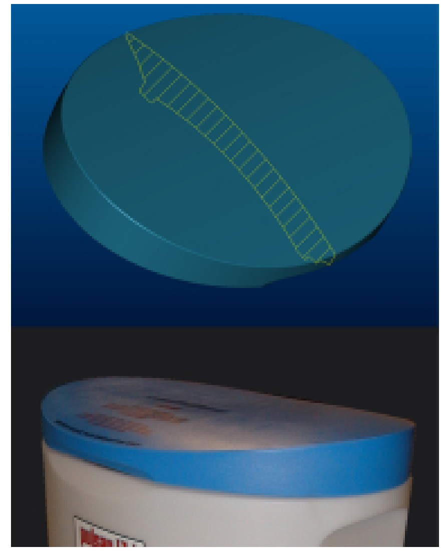

Fig. 7.

Pulsar IV required a relatively tight radius of .125" along external edges because of cosmetic reasons. Internal radii ranged between minimums of .125" to .25" where possible.

Draft

Another advantage of rotational molding is the ability to mold parts without draft along surfaces that will shrink away from the mold wall. For example, the hopper exterior walls were designed without draft since they shrank inward toward the center, pulling away from the mold. The geometric lines of the exterior were therefore preserved without the addition of draft angles that would have adversely affected appearance. However, other features, such as handle openings and the inner chamber, shrank inward around the core and draft was added for easy removal.

Domed surfaces

As a general rule, flat surfaces are difficult to rotationally mold and should be avoided if possible. Flat surfaces tend to "oil can" in a concave or convex direction, depending on processing conditions. This distortion is based on poor control of heat transfer during the cooling cycle, limitations of cast aluminum tools, and the high rate of shrinkage in polyethylene. Parts with curved surfaces are molded with more predictability and offer more struc-

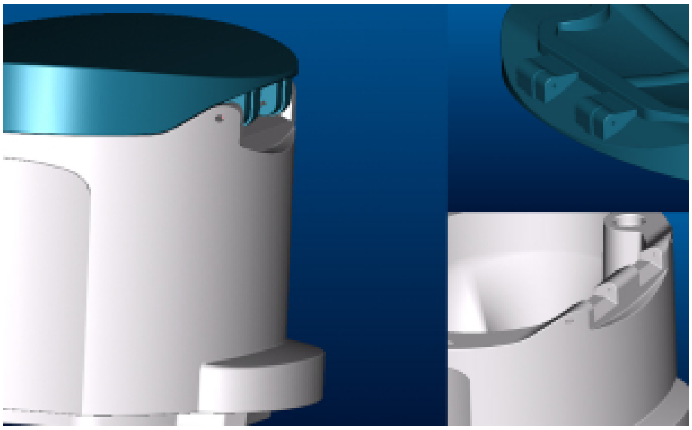

Fig. 8.

Fig. 9.

tural integrity than flat parts. The oval shape of this product combined with the domed hopper lid utilized curved surfaces to integrate form and function as shown in figure 7. During production, all parts were easily molded without any surface irregularities or "oil canning."

Molded-in hinge

A molded-in hinge was visually integrated with the design of the hopper and lid as shown in figure 8. The width and space between knuckles was based on the discussions with the molder and toolmaker. The positions of these features had to provide adequate support in the mold for the removable pin that molded the hole. In addition, the double wall around the pin had to comply with the 5:1 rule to avoid any chances of voids.

Molded-in treads

An automatic water shut-off device was designed to screw into the hopper assembly as shown in figure 9. Custom molded-in threads were designed to permit the shut-off assembly to be easily assembled and removed from the hopper. Tolerances between the machined assembly and the rotational molded hopper were discussed with Gregstrom before the design was finalized. These tolerances dictated the clearances that would be designed into the threads to insure that production parts would consistently go together. A diametric clearance of .03" was included within the 2" diameter hole that accepted the shut-off assembly. Other factors to consider for this detail included material flow characteristics and thread size.

Molded-in through holes

One of the greatest design challenges was the base tank shown in figure 10. This part supported all the electronic controls and plumbing for the chlorinator. The entire rear section of this tank was molded with a removable plate. A visit to Wheeler Boyce to review the patterns before they were completed helped resolve some of the potential tooling questions that arose. Through holes were required to be leak-proof and molded with enough accuracy to align with standard components. All interior mounting holes had to be molded blind, since water was not permitted to leak between chamber walls. A secondary tapping operation for screw threads was required since plastic machine screws were the only fasteners that would resist calcium hypochlorite without corroding. Spin welded fittings were bonded to holes that had to accept pipe fittings to eliminate post tapping operations.

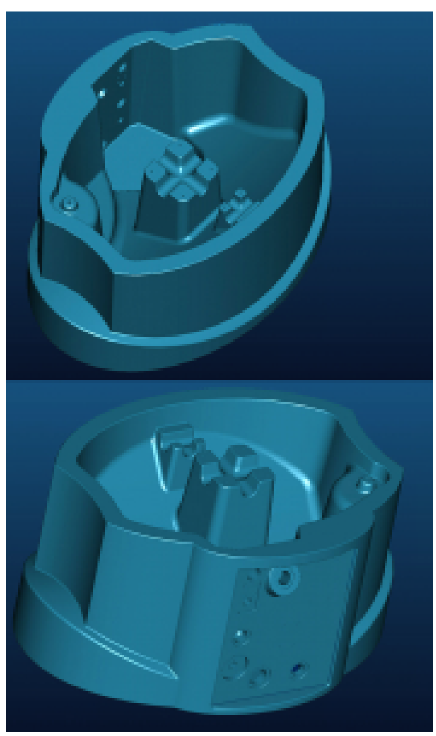

Fig. 10.

Molded-in handles and grid support

The hopper had to be designed with a great deal of structural integrity. Handles on either side were designed to follow the contours of the hopper yet be comfortable to the hand. They also had to support the weight of a fully loaded hopper. Use of a double-walled geometry resulted in a smooth handle that was comfortable and very strong. A similar technique of applying a double wall was used at the base of the hopper's inner chamber. The cloverleaf ribs shown in figure 11 supported a thin removable grid and also added to the structural integrity of the hopper.

Dimensional tolerances

One of the most important design objectives was interchangeability between all parts of any production run. In addition, special machining, elaborate fixtures, and unnecessary assembly steps could not be tolerated. These stringent guidelines required all parts to be designed and molded with tolerances that could be

Fig. 11.

reasonably achieved. Rotational molded tolerances are accumulated at four places throughout the manufacturing process:

- During pattern construction
- Casting of the aluminum mold
- Variation of resin molecular weight distribution
- Variation in processing conditions

If designs are properly created on 3D CAD programs and transferred to reputable shops for directly cutting patterns, reasonably tight tolerances can be expected. The cumulative error between part drawings and molds will be minimized. The largest tolerance range for any critical dimension within this project was no greater than +/- .1" over a distance of 30".

Minimized secondary operations

The rotationally molded parts designed within the scope of this project were optimized for the process. This means that every effort was made to minimize secondary operations such as milling, drilling, cutting, grinding, and tapping. Every effort was made to mold in features that would consolidate parts or eliminate a secondary operation. The premise was that parts with molded-in features would be stronger, cheaper, and more consistent in manufacturing. As a result of this objective molded parts only required minor secondary operations that were limited to a few tapped or drilled holes that could not be avoided.

Molded-in graphics

Safe operation of the Pulsar IV required that operating instructions were to be clearly visible during use. In addition, product identity and serial numbers had to be easily legible. The application of Mold In Graphics™ labels permanently fused this vital information to the surface of every product as shown in Fig. 12. The process offered a wide range of design freedoms and the ability to produce fine details in multiple colors. Adobe and Corel files were supplied to Mold In Graphics to be used as camera-ready artwork.

Phase 3: Vendor Liaison and Production Follow-up

After all parts were completely detailed and reviewed with the project teams, a complete set of production control drawings was created. These drawings contained information pertaining to tolerances, surface finish, material, secondary operations, and critical dimensions. Since patterns were cut directly from 3D CAD files, completely detailed

Fig. 12.

production drawings were not required. Patterns cut directly from 3D CAD files saved time and avoided any errors that could have resulted from misinterpretation. When the patterns were completed, Integrated Design Systems inspected them at Wheeler Boyce before aluminum molds were cast. Tool and part design issues were discussed, resulting in only one minor modification because the design was developed concurrently.

In addition to updating all drawings and CAD files, IDS also provided Arch Chemicals with a Power Point presentation of the product. Salesmen, distributors, and Arch Chemicals employees used this presentation to describe the benefits and specifications of the new product using full illustrations abstracted from the actual CAD file data. Production began on schedule six weeks after patterns were approved. First shots from the molds were assembled exactly as planned, and Gregstrom was in full production within one week from startup.

Conclusion

Rotational molding applications are becoming more sophisticated and challenging. As designers and other members within this manufacturing community work together, products will become more innovative. Successful designs require a team effort and cooperation between all those involved. Trade-offs between design objectives, manufacturing, and cost should be resolved throughout the design process as opposed to major revisions at the end of a project. Discussion of risk and options always provides each team member a pathway to success. Today, rotational molding is limited only by our imagination and designers who are willing to push the limits of the process.

Integrated Design Systems Inc. has been providing leading edge industrial design solutions to its clients since 1983. IDS pioneered the integration of industrial design and engineering which is the core of its design methodology. Designers at IDS have been taught to carefully listen to our clients needs, provide numerous creative solutions and select the optimum design. Our designers know how to integrate design with manufacturing for optimum results. Design details are carefully crafted for consistent manufacturing quality and cost effective parts. A few examples of products that have been designed by us are shown one this page. Our diverse background has enabled us to cross-pollinate technologies to markets ranging from swimming pools to laser scanners. Visit our web site at www.idsys.com or email us at paloian@idsys.com for additional information on an application you may have in mind.

INTEGRATED
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