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RAPID INJECTION MOLDING Journal

SPRING 2005

Designing the Future

IN THIS ISSUE:

The Future: Getting it Right

It's tough to make predictions, especially about the future. — Yogi Berra

Actually, Yogi had it wrong. Making predictions is easy — we do it all the time. What's tough is being *right*. But of course, that's exactly what's expected of designers.

If you want to produce the next big thing in your industry, or simply want to stay ahead of the curve, it's important to get it right. At Protomold we work with thousands of the most creative people in a variety of fields. We leave the predicting to them, but we help them be first, because in today's markets, being right isn't enough. You have to be fast enough to get to market while your answer is still the right one. That means quickly completing the prototyping phase with all the answers you need. An increasing number of creative designers come to us, because for high-quality plastic prototypes, no one's faster than Protomold.

What's ironic is that designers make predicting the future look easy, at least from the outside. As a result, consumers have come to take "miracles" for granted. For example, my college-bound son's backpack contains all kinds of stuff that would have made James Bond jealous just a few years ago: an iPod with gigabytes of storage, a cell phone with a high resolution camera, and a PDA with wireless Internet. But beyond the innovations themselves, what's really amazing is how fast they've become ubiquitous in our everyday lives, thanks to visionary designers.

Take a look at the innovative work GE Healthcare is doing with their TruSat™ Pulse Oximeter. (Case In Point, page 3.) This is a great example of forward thinking design engineers putting their knowledge to work to improve our standard of living, cut costs, and potentially save lives.

Also in this issue is a review of a fascinating book. Today, the need for speed is becoming common knowledge, but 15 years ago, it was news. The Book Review on page 7 addresses one of the seminal works on the subject. It's an example of innovative thinkers who looked farther into the future than many of us would dare and got it right.

At Protomold, we appreciate what designers are doing, because we've done it ourselves. (See the story by Protomold founder Larry Lukis at http://www.protomold.com/company.asp) That's why we're always working, not just to speed up manufacturing and extend the range of parts we can make, but to improve support processes like our ProtoQuote® online quoting system, making it ever faster and more helpful.

We hope you enjoy the new and improved Rapid Injection Molding Journal.

Brad Cleveland
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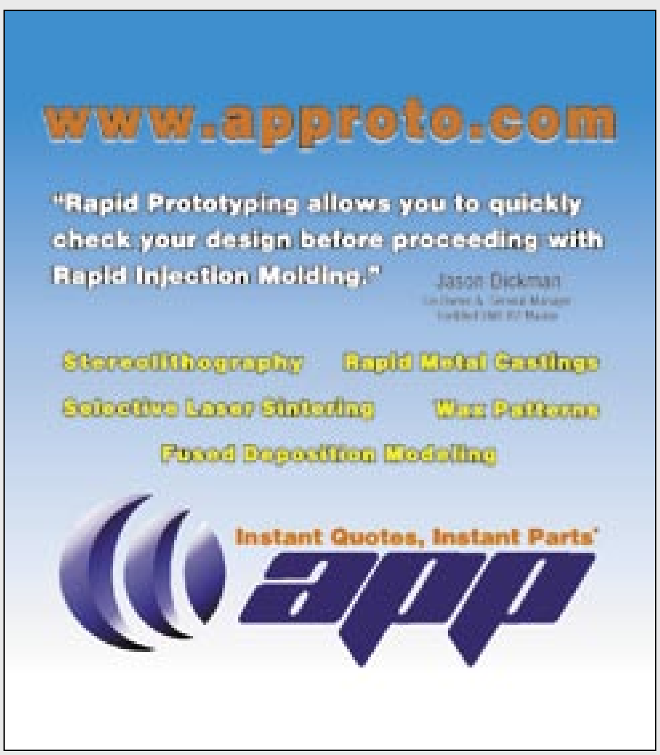


A Faster Pulse at GE Healthcare

Bringing a product to market is never easy, but when that product is a medical device, it gets more complicated

MEDICAL DEVICES MUST BE TESTED AND APPROVED IN LONG, EXHAUSTIVE PROCEDURES.

Faced with that back-end delay, manufacturers are increasingly interested in speeding up product development. That's what brought GE Healthcare to Protomold.

"We're always looking for ways to cut down the front-end time it takes to get us to the regulatory testing and approval steps," says Chris Crowley, program manager at GE Healthcare. Working on the TruSat™ pulse oximeter, a table-top device for measuring the oxygenation of body tissues, GE engineers found a way to cut that front-end time substantially.

Traditionally, prototype plastic parts had been produced by creating a stereolithographic "master" part. The master was then used to make a silicone mold, which, in turn, was used to cast urethane parts. Crowley describes the resulting parts as "realish," though not the same material, color, or feel as actual parts. "There's a definite quality difference," he says.

In the case of TruSat, however, urethane would have created other, larger testing problems. One critical function of the device's plastic "bumpers" was to keep it from sliding when a user operated the buttons. GE engineers knew from experience that urethane would not provide the grip they needed, let alone pass their flammability tests. They needed real parts, but rather than invest time and money in traditional injection molding, they turned to Protomold for real parts produced by rapid injection molding.

"We were amazed at how easy Protomold's ProtoQuote system was to use"

"We were amazed at how easy [Protomold's] ProtoQuote system was to use," says Crowley of the online quoting system's 24-hour turnaround. "Traditional quoting methods generally take anywhere from a few days to a week." After incorporating a few minor design changes suggested in the ProtoQuote, GE engineers ordered their first set of parts, which arrived within 10 days.

The combination of resin and chemical additive they had originally specified, however, did not pass their internal flammability tests. "We needed a unique material mixture that isn't regularly stocked by prototype manufacturers," Crowley says. GE purchased the material, which Protomold then used to produce a second batch of parts, which easily passed the flammability tests.

GE's third and final parts order incorporated some final design adjustments and color specifications. Because the parts were made of production-grade materials, they were ready for internal tests—chemical resistance, for example—to ensure their readiness for the rigorous certification testing to come. Crowley estimates that three rounds of prototyping using Protomold cost just \$9,000 versus an estimated \$60,000 for traditional injection molding, and cut production time by over 85 percent. "We were able to modify and finalize our design in the same amount of time it would have taken a traditional molder to create the first steel mold," he says.

GE Healthcare TruSat™

A WEEK in the Life

Hi. Professor Plastic here to answer a question I hear a lot, which is **"How can rapid injection molding be so...well...rapid?"** Good question! For an answer, let's take a brisk stroll through the rapid injection molding process.

DAY 1 It all starts on day one with an idea. This is Kevin. His idea is a hinged, latching box consisting of two identical halves. Kevin creates his 3D design and saves it in STEP format (although SolidWorks, Pro/E, Parasolid or ACIS formats would work just as well). He then goes to **www.protomold.com**, clicks on the ProtoQuote® tab, and uploads his design to Protomold's automated quoting system.

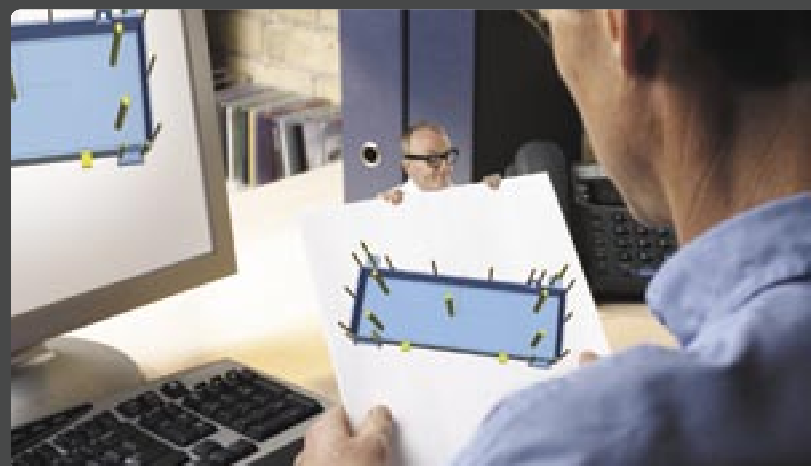
DAY 2 Kevin has just received a ProtoQuote. In this case, ProtoQuote's moldability analysis indicates a surface that needs to be drafted. Kevin goes back to his CAD program, makes the change, and resubmits the design.

DAY 5 Welcome to Protomold. It's now Day Five, and our automated processes are turning Kevin's model into toolpaths that will be sent to milling for actual construction of the mold.

DAY 6 Once milling is complete, Kevin's mold components will be polished and textured as required, ejector pins will be installed and the mold will assembled for injection molding.

# of a Part ...

DAY 3 When the revised ProtoQuote comes back, Kevin goes online and tries out various combinations of resin, surface finish, and delivery speed. Each change he makes updates his pricing. He chooses a combination of material, finish, and delivery that suits both his needs and his budget and submits an order for a mold and 100 parts, following it up with an emailed purchase order.



DAY 4 Kevin receives an order confirmation complete with gate and ejector layout. The layout shows where his finished part may have small marks where gates were removed and ejector pins pushed the part out of the mold. Kevin approves the layout and production begins.

DAY 7 Kevin's mold is mounted to a molding press, the specified resin is added to the hopper, and part production begins. Once the parts are finished, they'll go to shipping to be sent to Kevin.

DONE! And there you have it. Depending on requested lead time, part complexity, and the number of design iterations, the process could take more or less time, but Kevin's is not an unusual experience. Quality parts at a great price in less time than it would take some vendors to provide a quote, and that's why they call it "rapid."

In this issue of the Rapid Injection Molding Journal we have incorporated an excellent article originally published in the January 2005 issue of Injection Molding Magazine. We hope you find it interesting and useful.

Designing with Polycarbonate

If you need a transparent engineering plastic with high heat and impact resistance, polycarbonate is a good choice.

In this bimonthly column, Glenn Beall of Glenn Beall Plastics Ltd. (Libertyville, IL) shares his special perspective on issues important to design engineers and the molding industry.

If you handle a compact disk today you will be touching polycarbonate (PC). To date PC is the only material capable of filling the demanding requirements of that application.

In 1859 the Russian chemist Butlerov described a PC type of material. This discovery was repeated by Einhorn in the late 1800s. Fifty years passed before these discoveries were seriously pursued by General Electric in the U.S. and Farbenfabriken Bayer in Germany. Both announced pilot plant quantities in 1956. One hundred years after Butlerov's discovery, Bayer was producing commercial quantities under the trade name Makrolon. GE followed with Lexan in 1960 and Dow introduced Calibre in 1984.

There was a waiting market for this unique plastic material. Worldwide consumption reached 40 million lb/year in 1970, and 218 million lb in 1980. This rapid growth is testimonial to the material's usefulness. Today PC is second only to nylon in volume and is now the fastest-growing engineering polymer.

DESIGNING CHARACTERISTICS

Polycarbonate is an amorphous thermoplastic that combines transparency with high temperature and impact resistance. There is no other engineering plastic with this combination of properties. There are different types of PC, but a high-viscosity grade can be defined as follows.

Physical properties are around a tensile strength of 9000 psi; flexural modulus is 340,000 psi, with a heat deflection temperature of 270°F at a 264-psi loading. Strength and temperature resistance can be increased with the use of fillers and reinforcements.

Most polycarbonates have a notched Izod impact strength in the range of 12 to 17 ft-lb/in, which is retained at low temperatures. Polycarbonates are highly notch-sensitive materials. They actually have higher impact strength than indicated by the standard notched Izod impact test.

For example, a .125-inch-thick, right-angled-shaped part with an inside corner radius of .010 inch had an impact strength of 2.5 ft-lb. Increasing that radius to .020 inch resulted in an impact strength of 20.2 ft-lb. In other words, doubling the size of the radius increased the impact strength by a factor of eight. This is the reason why designers make such a fetish of radiusing the corners on PC parts.

Light transmission is 86% to 89%. This is just below acrylic at 91% to 92% and general purpose polystyrene at 88% to 91%.

Flame-retardant grades are available with a UL 94 V-0 and 5V ratings.

Polycarbonate has an excellent balance of physical properties, but it lacks the chemical resistance of semicrystalline polymers. Specifying PC requires careful attention to the chemical environment of the application.

Polycarbonate is also available alloyed with ABS, acrylic, polyetherimide, polyurethane, PBT, and PET polyesters. The base polymer and all of these alloys can be tailored for specific applications with the addition of fillers and/or fiber reinforcement.

Polycarbonate fills the gap between ABS and PPO and the higher-temperature-resistant and more costly materials such as polysulfone, polyetherimide, polyphenylene sulfide, and liquid crystal polymers. The list price for injection molding grades of PC was \$1.96/lb in 1988. Today the material costs \$1.38 to \$1.65/lb, or an average of \$.065/cu in. These prices are, however, increasing.

APPLICATIONS

GE is a major user of electrical insulating materials. The good electrical properties of PC are one of the reasons why GE originally pursued the development of this material. A favorable UL rating, plus low smoke and corrosive gas emissions, accounts for PC's use in telephones, computers, printers, copiers, other business machines, and laboratory and diagnostic equipment.

The combination of transparency, coupled with weatherability and impact strength, allows PC to be used for bulletproof windows, machine guards, lighting applications, and as window panes, especially in those instances where vandalism is a problem. Other transparent applications include greenhouse glazing, optical safety lenses, solar collectors, and automobile head and taillight lenses. A large new application just now being commercialized is side and rear car windows.

This FDA-sanctioned material has a long history in the food handling industry as processing bowls, mugs and glasses, tableware, pitchers, storage containers, baby and water cooler bottles, and in some instances as microwave cookware. Many of these applications rely on PC's transparency and temperature resistance.

The amount of PC used in the construction industry is second only to PVC. Other markets include medical products, toys, portable tools, and photographic and sporting equipment, especially in applications where low-temperature impact strength is important.

PC PART DESIGN TIPS

Wall thicknesses of .012 to more than 1 inch have been molded with PC. However, a minimum of .050 inch and a maximum of .375 inch are recommended, with .125 inch being ideal. Flow lengths of 2 inches with a .030-inch thickness and a 16-inch flow can be achieved with a .125-inch wall. With proper blending, wall thickness variations can be as much as 25%.

At thicknesses somewhere between .140 and .160 inch, PC's room temperature notched Izod impact strength declines with a change from a ductile to a brittle type of failure.

Radiusing corners improves melt flow and allows notch-sensitive PC to develop its impressive impact strength. An inside corner radius of 60% of the part's wall thickness is ideal. The absolute minimum is .020 inch.

Molding draft angles of 1/2° to 1° per side will suffice for most PC parts, but there are exceptions.

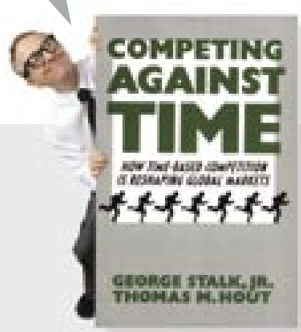
Projections of all types are molded with PC. In order to avoid sink marks and molded in stress, the thickness of projections should be limited to a maximum of 60% of the part's wall thickness.

Depressions, or holes, create weldlines. Acceptable appearance and tensile strength retention of 99% can be achieved with proper molding conditions. Glass-fiber-reinforced PC can suffer a loss of 35% to 45% of its tensile strength at weldlines. Holes require standard molding draft and corner radius considerations. Limiting the depth of holes to two to three times the thickness of the core pin eliminates pin deflection.

Tolerances on PC parts can be as small as ±.0025 inch on a .125-inch-thick, 1-inch long part. A standard, less-costly tolerance on the same part would be ±.004 inch. This amorphous material, which shrinks uniformly parallel and perpendicular to the direction of flow, is frequently specified for precision parts requiring a minimum allowable warpage.

Sounds PERFECT for a couple weeks at the beach.

Putting Time to Work

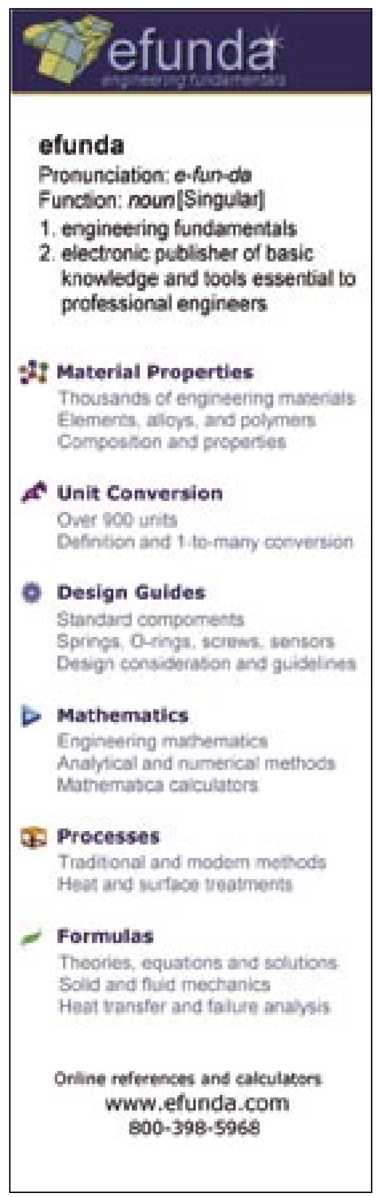


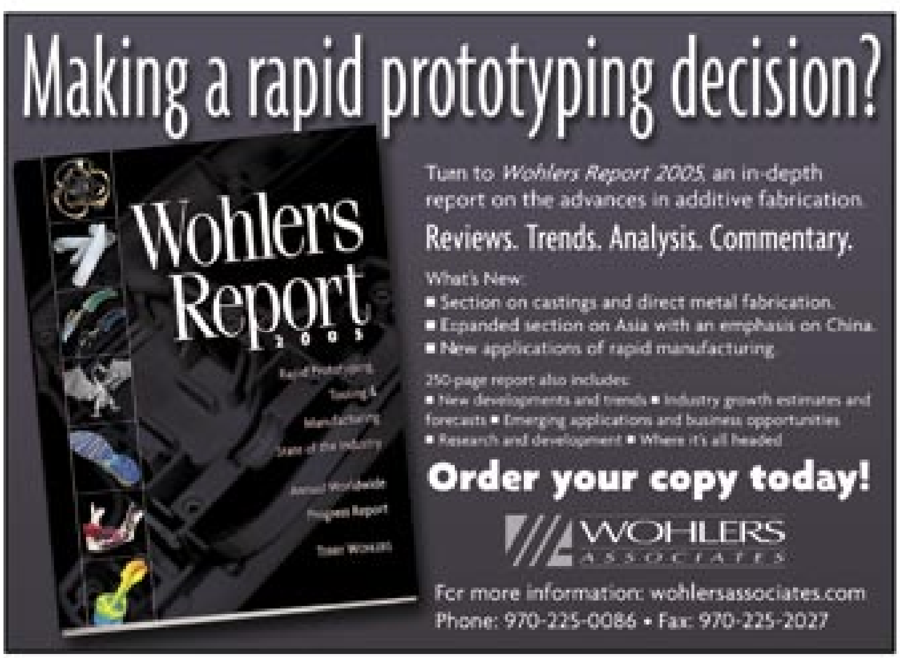
Title: Competing Against Time
How Time-based Competition is Reshaping Global Markets
Author: George Stalk, Jr. & Thomas M. Hout
Publisher: The Free Press, a Division of Macmillan, Inc. New York
ISBN: 0-7432-5341-8

Published in 1990, *Competing Against Time* is the kind of text one might find in an MBA program — full of tables and graphs — but its message is as important today as it was when it was written: "...as a strategic weapon, time is the equivalent of money, productivity, quality, and even innovation." While this revelation is less surprising today than it was 15 years ago, it is still true, and those who forget it do so at their peril.

Beyond simply equating time with other business factors, the authors address the relationships among them. For example, they graph the increase in potential profit as delivery times shorten. They list "principles" developed by a company dedicated to becoming a fast innovator, and they clearly demonstrate the potential results. In a table showing improvements in actual production flow times they show percent reductions of up to 99 percent, in one case reducing production time from 360 days to three. In what may be the simplest statement in the entire work, they list two questions that characterize time-based organizations: "What deliverables do my customers want," and "what organization and work process inside my company will most directly provide these deliverables?" Obviously, there is no single formula, but the authors clearly identify critical issues, including how work is structured, how information is created and shared, and how performance is measured.

They also address the challenges in making such sweeping changes and address the higher level issues of visualizing, implementing, and sustaining change. Finally, in what may be one of the most profound recognitions in this insightful work, they discuss ways to extend the impact of the change outward toward customers and suppliers. So, whether you read for mere historical interest or for actionable insight, this is one read that offers a significant return on investment.





What's New

AT HOME ...

To keep up with demand, we're opening a second site near our Maple Plain, MN headquarters. By the end of 2005, this new manufacturing space will expand our production capacity by about 50%. Also, in the third quarter, we'll begin exporting to Canada.

... AND ABROAD

Meanwhile, our new subsidiary, The Protomold Company Limited, will be opening a full service facility in the United Kingdom the fourth quarter of this year. This facility will initially serve customers in the UK and Germany.

BIGGER AND BETTER

Ten months ago, we announced the ability to support simple undercuts with up to two side actions per mold. We can now support four side actions per mold. Available side core dimensions and pull lengths in inches are as follows:

WIDTH	HEIGHT	PULL
8.419	2.377	1.445
3.024	2.377	1.445
3.024	1.523	1.445
3.024	1.038	1.639
3.024	0.553	1.736

As before, side actions must be at the mold parting line. Availability on a quick-turn basis will depend upon part size and complexity.

Also, we can now produce molds with deeper cuts than ever before — handy for taller ribs and similar features. If you are unsure whether we can accommodate your design, try our new Parts Tester at **www.protomold.com/parts**.

Meet the Professor

You've probably met our spokes-expert, the man with the answers, Professor Plastic. From plastics in general to rapid injection molding in particular, and from etiquette to cleaning stubborn stains, The Professor is the man in the know. The Wellspring of Wisdom, as he's suggested we address him, does answer the occasional email, so feel free to send questions to professorplastic@protomold.com. Protomold reserves the right to publish your correspondence along with the professor's response.

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