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FOOTWEAR NEWS VOL. 62 NO. 28 WWW.FOOTWEARNEWS.COM $10.00

COLOR MY WORLD

TECHNOLOGY : Monochromatic 3-D prototyping is already a critical design tool, but now companies can produce color models of insoles that paint an even better picture of the final product. **<< By Denise Power**

Product prototypes — so critical to the footwear design process — just took on a colorful new dimension.

Canton, Mass.-based Reebok is one of the latest of a growing number of companies to adopt technology that makes 3-D molds of product parts in color, reflecting a designer's vision more accurately than ever before. Until recently, most prototype-making machines could create only monochromatic versions using 3-D printing, a process that uses plaster or other materials to produce a life-sized, what-you-see-is-what-you-get sample of an item.

Now, with the addition of color into the process, "people are excited," said Paul Bates, director of advanced process engineering at Reebok. "It's a whole other measurement when color comes into play. It affects people far more than I expected. They are more emotional about it." Toby Ringdahl, CAD manager for global footwear product development at Stratham, N.H.-based Timberland, which uses the same technology as Reebok, agreed, noting that a prototype with color is "far more engaging than monochrome."

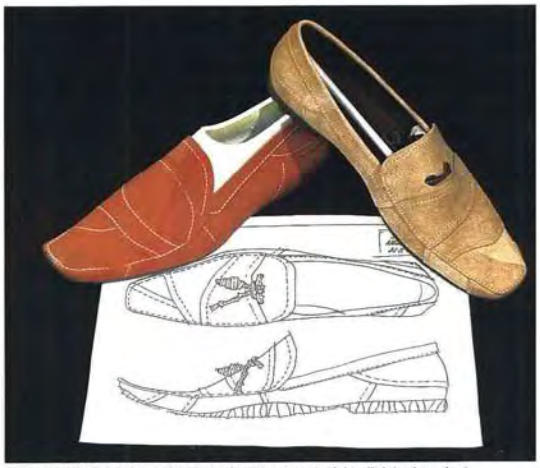
Timberland's Discovery Point and prototype.

Essential Tools

A 3-D product prototype is an essential communication tool around which design, development, sales and marketing people can rally before finalizing a style. New ideas may begin as a sketch and be converted to 3-D models on a computer, but until a concept takes physical form, it can be hard to grasp. This can hamper decision making, or worse yet, lead to expensive mistakes further into the production cycle.

The 3-D printing process is one of several manufacturing steps that fall into the larger family of rapid prototyping. "Rapid prototyping is a way to create a three-dimensional part in a quick manner," said Frances Bryant, a research assistant at the Virtual Reality & Rapid Prototyping Lab at the University of Missouri-Rolla. "Instead of setting up fixtures [and] tools in a factory to create a model, everything is done with a computer program and a machine that can make a part on demand in a relatively short time."

Generally, footwear companies use 3-D printing to produce shoe components that are molded or require tooling, such as outsoles. The process can also be used to create an entire shoe model, including uppers, but most vendors focus on the highly complex soles.



Timberland's Capiz from sketch to plaster upper model to finished product.

There are a number of technology providers on the market. Reebok uses 3-D printing technology from Z Corporation, based in Burlington, Mass. Another major U.S. player is Stratasys, based in Minneapolis, which distributes rapid prototyping technology from Israel-based Objet Geometries. [See "Model Materials" for more.]

In each case, CAD software renders a design and the data is fed into the printing

>> Model Materials: The range of compounds available for model-making is fast becoming high-tech.

Materials used in model-making have expanded beyond basic plaster into a range of polymers allowing 3-D prototyping to produce ever-more-realistic replicas.

It's giving footwear artisans using rapid prototyping fresh options that make for models that not only look like the real thing, but feel like it as well.

A flexible, rubber-like photopolymer was recently introduced by RedEye RPM, a division of rapid prototyping company Stratasys, based in Minneapolis. Stratasys is the U.S. distributor for the new material, called FullCure Tango, developed by Israeli company Objet Geometries.

Various materials are used for on-demand production of 3-D models, explained Frances Bryant, a research assistant at the Virtual Reality & Rapid Prototyping Lab at the University of Missouri-Rolla. "There are rapid prototyping machines that use metal, plastics, even ice," he said.

Stratasys' FullCure Tango material is said to be soft, highly elastic and well-suited for products that have pliable components, such as shoes, toys and tires. The material is available in either black or gray.

While the flexible new photopolymer may not be as durable as other materials engineered for rapid prototyping, it produces fine design detail and sharp edges, said Terry Wohlers, who has checked out boot sole samples made of the FullCure Tango material. Wohlers, who is not affiliated with Stratasys or Objet Geometries, is president of Wohlers Associates, Fort Collins, Colo., and the author of an annual report on the rapid prototyping industry. **<< D.P.**

machine. In two-and-a-half hours, the machine produces a true-to-life, full-color plaster prototype that can be examined by everyone involved in the decision-making process. It looks quite similar to the final product. [See "The Process" for details.]

The cost is also attractive — less than $50 for each 3-D prototype manufactured, Ringdahl said. When compared with traditional hand-crafted samples, which take two weeks to make and cost $1,500 apiece, models made with 3-D printing deliver dramatic improvements in cost and efficiency.

But with all that, "the key word is 'time,'" said Reebok's Bates.

Because 3-D prototypes can be made in hours rather than weeks, they allow for the luxury of tweaking designs. Where manual model-making might permit two iterations of a prototype before going to commercialization, the speedy 3-D printing process allows for four or more versions to be made, Bates said. "We are allowed to focus on the finer details of a design and get everything right, versus looking at an overall concept and getting it 'close enough,'" he said.

Bright Solution

The refinement of color-rendering technology in 3-D printing is a recent development. "Now, [color has] moved away from 'gimmick' to 'usable feature'" in 3-D printing, said Todd Grimm, president of T.A. Grimm & Associates, an Edgewood, Ky.-based rapid prototyping consulting company.

"Until last year, the colors were very muddied," Grimm said. "They weren't very vibrant at all. 'Fire engine red' would come out 'red' but it wasn't 'fire engine.'"

"[The colors] bled like crazy," added Reebok's Bates.

In fact, there used to be more cons than pros to the process. Grimm said that results from the first color models had "a yucky, negative emotional appeal" so strong that a prototype would not be circulated widely for fear of turning people off from the overall design concept.

But now it's becoming a crucial tool for the industry. Ringdahl said 3-D printing of prototypes played a key role in the development of Timberland's Smart Comfort line for men, its Agile IQ outdoor performance collection and its Comforia shoes, contoured specifically for women's feet.

Reebok sneaker and prototype.

"Rapid prototyping really helped us develop that Comforia platform by letting us experiment with molded tuckplates as prototypes before we even open[ed] the mold," Ringdahl said. Three-dimensional printing was used to create the footbeds as plaster models. "Although it's not flexible, we can put [the model] against a woman's foot and check to see if it feels [right] and [that] there's not too much arch support."

While these prototypes are almost-perfect facsimiles of real outsoles in terms of looks, most do not duplicate the flexibility of an actual sole. That's why, for the Miön water shoe, Timberland outsourced production of flexible 3-D prototypes to Harvest Technologies in Belton, Texas. Going forward, however, Timberland is considering bringing flexible prototyping in-house. "Maybe in the next year or two, we'll look at that," Ringdahl said.

Breaking the Mold

Another noteworthy development in the 3-D prototyping field broke this past spring at Loughborough University in Leicestershire, England. There, researchers in the university's Rapid Manufacturing Research Group, together with London firm Prior 2, took rapid prototyping to the next level: rapid manufacturing. Instead of just producing a prototype, the team used laser sintering technology to create actual end product. The result was the first fully functional soccer shoe produced without the need for either molds or tooling.

"If I were in the footwear business, I would want to be aware of this, and I would want to look at [whether] there is an opportunity for me. Is this something that will impact my business?" said Terry Wohlers, president of Fort Collins, Colo.-based Wohlers Associates Inc.

He acknowledged that the technology will likely have little impact on the mainstream for quite some time, but that companies that make product for Olympic, professional and collegiate athletes might take note.

Custom footwear has been around for ages, he added, but not every single component of a shoe, such as the outsole, is tailor-made. "Longer term, this could usher in the opportunity for truly customized footwear — from the sole up," Grimm said.

>> The Process: A step-by-step look at 3-D printing.

Considering that traditional printed images are typically flat, the idea of 3-D modeling may seem paradoxical. However, it's actually a fairly simple task.

Offering a disclaimer that it may sound like "crazy talk," Reebok International's Paul Bates, director of advanced process engineering, took a shot at explaining how a design goes from concept to tangible model.

A designer's idea is first committed to paper as a sketch. That two-dimensional rendering is then transformed into a 3-D model using CAD software. Reebok uses software from UGS, Plano, Texas. The computer image simulates height, width and depth.

"So how do you feed that to a printer, right?" said Bates. "The way they do that is they take that [3-D computer image] and they slice it." Picture a mandolin, that kitchen device that slices an onion in one pass [in extremely thin slices]," he said. "The software actually does the same thing to the 3-D model — it slices it about a million times, across one axis, so it becomes a stack of little, thin cross-sections."

Each cross-section is so thin that it almost appears to be two-dimensional. One cross-section is printed onto a fine layer of powder – 4/100ths of an inch thick, about the thickness of a piece of paper, he said. The powder hit by the inkjet becomes solid, while the rest of the powder remains loose. Another fine layer of powder is spread on top, and a second sliced section is printed on that layer. One by one, each printed portion fuses to the one below. The process continues for about two hours until all the layers come together as a three-dimensional object made of fused powder that has become solid plaster. When the process is complete, the loose unused powder is brushed away from the finished prototype and reused for production of the next one. << **D.P.**