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Plastics in Reverse

Deconstructing plastic products can provide useful information.

By Michael Tolinski

Theoretically, reverse engineering might seem like cheating, since it often involves analyzing another company's product or material to discover its secrets. Yet in today's competitive marketplace, all information is critical, including knowledge gained from the "competitive benchmarking" of existing products.

So the concept should be defined in basic, neutral terms: "Reverse engineering is taking an existing product and going backward in the design process to learn why they did what they did, and what were the advantages and disadvantages of what they did," says Robert Browning, a consultant for McConnell Co. Inc. (Atlanta, Georgia, USA). "It is not, as many people think, just a way to 'steal' other people's ideas, but rather a way to work to improve your products and manufacturing processes."

Useful information gleaned from de-manufacturing a part might include how the part was made, what it's made from, or how it could be redesigned. For example, Browning adds, the practice of reverse engineering is taken to extremes in the automotive industry, "where they will disassemble an entire car and weigh and examine every component, down to smallest screw."

Deformulating Secrets

For plastic products, sometimes the most important information is the most basic: the composition of the part's material. Companies request deformulation of a material for three major reasons, says Dr. Fred Willard of analytical lab CAS-MI Laboratories (Ypsilanti, Michigan, USA).

The first reason is to verify a marketing claim of a competitor, such as to see if an impact modifier is indeed present in a material that is claimed to have very high impact properties. Or a company may simply be looking to discover the "trick" of another material, says Willard: "What is that special additive or ingredient that makes the product do something that theirs does not do?"

A second reason to deformulate is to check batch-to-batch variability. For example, if a customer favors one material batch over another, deformulation could reveal what's missing from the less-favored batch. The third reason is to investigate failures, such as cracked products. Deformulation would reveal if an additive or modifier had been left out.

"In most cases, our clients are interested in determining the thermoplastic's additives," says Dr. Hebi Bai, senior scientist for Chemir Analytical Services (Maryland Heights, Missouri, USA). Unfortunately, while enhancing, upgrading, and customizing resins, compounders have made deformulation more difficult because they use a greater variety of antioxidants, heat and light stabilizers, plasticizers, flame retardants, processing aids, and fillers.

Labs can sort through the additives by using chemical, thermal, or spectroscopic analysis. Their "tricks of the trade" might also be able to reveal if a resin is the virgin material that was promised in a purchase agreement, explains Willard. For example, regrind or recycled content might be indicated by analysis of the metal residue from the polymerization catalyst in the resin. Each virgin polymer producer uses a certain catalyst, which may be different from the one used in the polymer regrind. So two different residues might indicate regrind in the sample.

But not all plastics families are transparent to deformulation techniques, Willard adds. "To get a good analysis, it's very difficult to work on thermoset plastics." Without a melting point or melting behavior to analyze, only very limited information can be obtained from plastics like thermoset polyurethanes.

Bai of Chemir says that PVC and polypropylene are among the most difficult thermoplastics to deformulate. Rigid PVCs are especially difficult because they contain multiple additives used in relatively high concentrations. "I remember two rigid PVC products for window profiles that contained nine or ten components," she adds, describing one of the lab's more difficult deformulation cases. These additives included a rubber impact modifier, two waxes, two lubricants, and a tin-based heat stabilizer, plus fillers and pigments. "It was extremely challenging to separate, identify, and quantify each additive in such a complicated formulation."

On the Surface

The other basic approach for reverse engineering is to record the exact external appearance of 3-D parts, for creating new or improved designs or tooling. Here, noncontact surface-measurement tools can convert even the most flexible parts into usable electronic models, explains Giles Gaskell, director of business development of NVision, Inc., a provider of 3-D scanning systems and reverse-engineering services (Southlake, Texas, and Wixom, Michigan, USA).

"We define reverse engineering as the creation of 3-D CAD geometry based on the measurement of actual existing 3-D geometry," says Gaskell. In digitizing a part, users of 3-D scanning can learn about a product's functions or physical properties, or about how to create the same part with a different process. "I would say the vast majority of people want to create new tooling for an existing product—either because the tooling is worn out, or they want to have tools to go into a faster or cheaper-to-run machine or a different process."

For example, a company might want to use thermoforming to produce a part currently produced with rotational molding. The 3-D scanning technique could be used to determine what thermoforming tools will be needed to create different components of the part (Gaskell says this use of scanning was of interest to people at September's SPE Thermoforming Conference). Digitized 3-D data help confirm that the new part's outer 'A' surface will match what the end-user has come to expect, regardless of the process. The part's inner 'B' surface can then be re-engineered for the new process.

In a recent application, NVision helped reverse-engineer an automotive airbag trim cover to improve its design for an instrument panel. Since no accurate historical CAD data was available, a noncontact handheld scanner was used to collect over a million surface points from an existing part. This "point cloud" was used to create a CAD file and solid model, which was modified to improve part fit and function and to speed up production injection molding.

With such tools available, there's still the fear that more companies will use reverse engineering unscrupulously to copy existing product designs and engineering. But Gaskell says that in over a decade in the field, he has never encountered companies with this motive. Still, McConnell Co. consultant Robert Browning says companies should always be ready to enforce their patents against those who are blatantly infringing on them. "However, for reputable companies, reverse engineering is a method of improving their technology and the industry in general."