Die Design and Validation Software

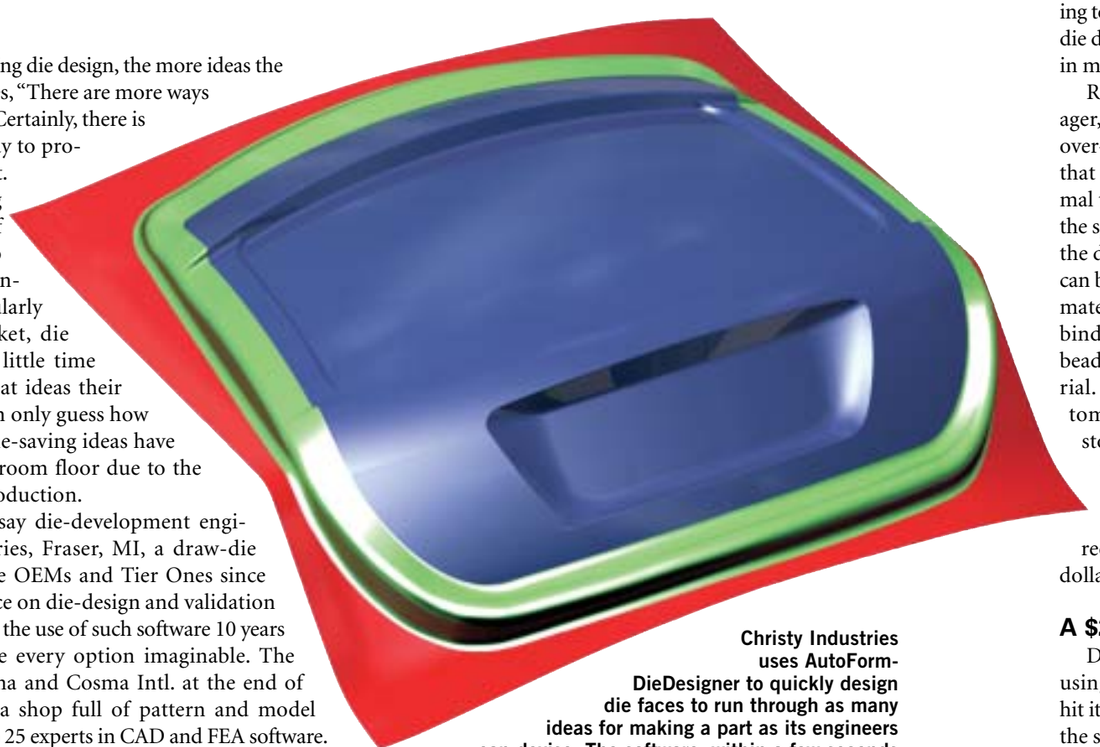
Seeing is Believing

Supplying draw-die-development services to major automotive OEMs and Tier One suppliers, Christy Industries relies on simulation software, enhancing its die-design and tryout brawn with brains.

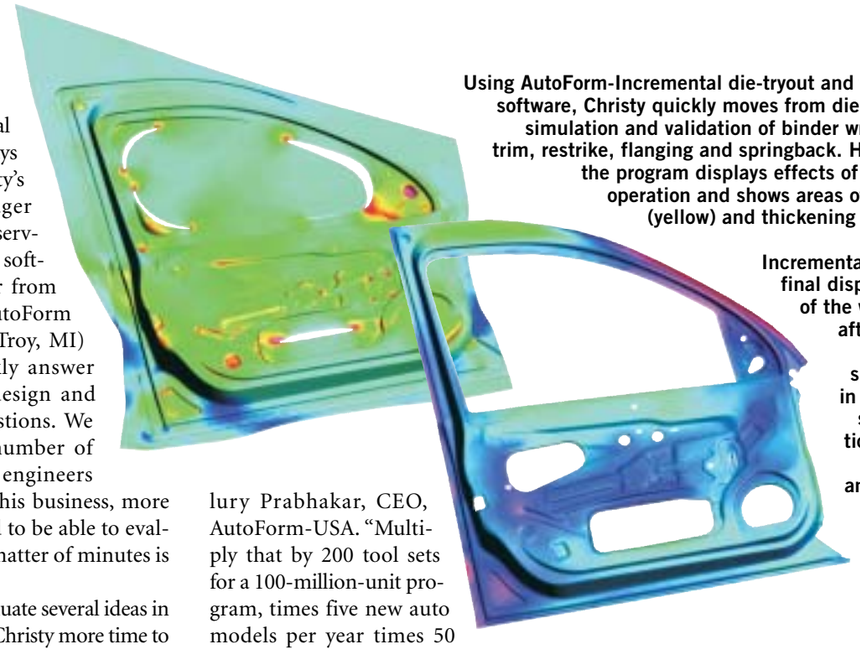
BY BRAD F. KUVIN, EDITOR

In the business of stamping die design, the more ideas the better. As the saying goes, "There are more ways than one to skin a cat." Certainly, there is always more than one way to produce a stamped metal part. But—and this is a big "but"—as the window of time from part concept to required first-part off continues to shrink, particularly in the automotive market, die designers have precious little time to evaluate all of the great ideas their engineers present. We can only guess how many great cost- and time-saving ideas have been left on the cutting-room floor due to the need to rush dies into production.

Well, rush no more, say die-development engineers at Christy Industries, Fraser, MI, a draw-die developer for automotive OEMs and Tier Ones since 1958. Its increased reliance on die-design and validation software, since pioneering the use of such software 10 years ago, allows it to evaluate every option imaginable. The firm, purchased by Magna and Cosma Intl. at the end of 2003, has evolved from a shop full of pattern and model makers to one staffed with 25 experts in CAD and FEA software. Many of the newly trained designers grew up in the toolmaking trade. All they did was trade in one tool—their skilled craftsmanship using their hands—for another tool—computer modeling.



Christy Industries uses AutoForm-DieDesigner to quickly design die faces to run through as many ideas for making a part as its engineers can devise. The software, within a few seconds of receiving part data, calculates the addendum (in red) and displays the formed part (blue) and binder (green).



Using AutoForm-Incremental die-tryout and validation software, Christy quickly moves from die design to simulation and validation of binder wrap, draw, trim, restrike, flanging and springback. Here (left), the program displays effects of a restrike operation and shows areas of thinning (yellow) and thickening (blue). To the right, Incremental displays final displacement of the workpiece after springback—springback in the opposite directions shows as green and purple.

"During the initial die-concept stage," says Boris Shulkin, Christy's engineering manager for design and FEA services, "our die-design software (Die-Designer from software vendor AutoForm Engineering USA, Troy, MI) allows us to quickly answer fundamental die design and process-layout questions. We can evaluate any number of opinions that our engineers may have. And in this business, more ideas are better, and to be able to evaluate each idea in a matter of minutes is invaluable."

The ability to evaluate several ideas in less than a day gives Christy more time to fine-tune the design concept selected. This development time, says Shulkin, combined with the power of AutoForm-DieDesigner, often has Christy presenting to its customers aggressive optimized die designs that yield millions of dollars in material savings.

Ritch Judkins, Christy general manager, explains: "Die designers typically over-engineer their dies to help ensure that they'll run in the press with minimal tryout headaches. Today, thanks to the speed, accuracy and transparency of the design and simulation software, we can be much more aggressive in tackling material utilization, designing shallow binders and eliminating unnecessary beads, all of the things that waste material. We often redesign dies for customers and shave several inches of stock per coil, savings which more than pay for new draw dies. Over the life of a four- or five-year program, optimized and redesigned dies can save millions of dollars on material for just one part."

A $25-Billion Market

Die design, tryout and validation using software rather than hardware hit its stride at the end of the 1990s, and the savings it can deliver may be just in their infancy, with so much more to come.

"The typical vehicle program averages $500,000 per tool set," figures Valury Prabhakar, CEO, AutoForm-USA. "Multiply that by 200 tool sets for a 100-million-unit program, times five new auto models per year times 50 different brands, and you wind up with a $25-billion market for automotive dies per year. The potential savings by optimizing die designs and then reducing or even eliminating tryout on a press will make a huge impact."

Judkins and his engineering team at Christy "saw the light" way back in 1995 when die-design and simulation software first began infiltrating the business. That was about the same time that the firm hired Shulkin, a mathematician by training. Marrying Shulkin's expertise in, and affinity for, finite-element software with Judkins' years of hands-on die-engineering expertise created a powerful team. Together, the pair researched and evaluated every design software package it could get its hands on. They refined the programs they bought, and worked with the software developers to help drive product growth to ensure the development of program features specific to the needs of die designers.

"We've seen software developers committed to becoming educated in the unique requirements and characteristics of metalforming, and they are much better equipped today to meet our needs," says Judkins. "Our philosophy always has been to not stick with one software product, but instead to always keep looking, keep trying new products. We're not loyal for the sake of being loyal. We purchased AutoForm software in 2001 and since then it has proven to be a very productive tool for us."

The key to moving from part concept to final validated die, says Shulkin, is using the right software tool for each task along the way. "AutoForm-Die-Designer is the perfect tool to quickly and conceptually explore all of our engineering ideas before we get to CAD," Shulkin says. "It allows us to think out of the box, and use forethought rather than hindsight. Then we go to CAD for the finessing of the design, the little nuances."

Out-of-the-Box Thinking

"One day in development analysis on the computer can save weeks in on-the-press die tryout and refinement," stresses Shulkin. As an example of an unorthodox solution to a problem that could have caused enormous headaches on the press, he describes a draw-die design for an existing production part where he put part on binder in areas where "we never would have done so without the benefit of the software analysis. We would have expected such a design to cause binder-wrap problems, but instead we were able to achieve a controlled binder wrap where during the stroke the die moved sheetmetal into areas on the blank where we would need it later in the stroke. This ultimately improved the part, minimized

strains, reduced scrap rates and decreased blank size. Only the draw die was replaced."

In another case, simulation of initial die designs for a high-strength-steel frame rail predicted splits and wrinkles next to each other on the part. Running through design iterations in design software and then simulations in Incremental, Christy developed a solution that included building upper pads in the tool to preform some areas of the part.

Predicting and/or preventing springback is another dividend of using die-design and validation software, one that has paid off on many recent projects for stamping new materials such as dual-phase steels. One recent program had Christy designing tooling for 25 parts, 24 of which were of dual-phase steels.

"The software," says Judkins, "helps us avoid costly mistakes with new materials, so that we help our customers move more quickly and cost-effectively into those programs. You can't use traditional thinking with these steels—the springback characteristics, for example, are completely different, and you really can't restrike them. This means we have to accomplish more, if not all of the forming, with the first hit, leading to very complex tools that the software assists in developing."

One key to working with new materials is equalizing stresses and strains to avoid severe springback problems. AutoForm-DieDesigner shines here. "Its color-contour representation of overall depth of draw when designing a blankholder," says Shulkin, "provides immediate feedback so that I can identify areas where we might experience severe springback. I can go quickly into the program and balance draw depth to avoid inconsistent stresses and strains—do more upfront design enhancement to avoid having to engineer out springback later on."

"We told the customer that this part (left, a front rail of dual-phase steel) would split in the press, based on the model we created in the design software and simulation we ran in Incremental, but it asked us to make a tryout die (right) and sure enough, it splits," says Christy general manager Ritch Judkins (wearing the red shirt). Christy's die-tryout shop measures 35,000 sq. ft. and houses 12 presses.

Creating an addendum geometry follows blankholder design, and Shulkin uses AutoForm-DieDesigner to interactively manipulate profile parameters such as punch radius, wall angle and die radius to fine-tune the addendum shape. In this way, he optimizes tool-to-sheet contact during forming.

Other tasks designers accomplish with DieDesigner include determination of optimum tip angle, evaluation and development of flanges, and evaluation of trim angles. Christy runs the latest version of the software, version 3.2 introduced last July 2003, which in addition to being more robust and stable, says Shulkin, added a feature called Develop Trim. Through automatic determination of trim angle, shear angle and scrap diameter, this feature develops the complete trimming process of a part.

Boris Shulkin, engineering manager for design and FEA services at Christy, says, "The integration of the packages (AutoForm-DieDesigner and Incremental in this case) is huge. I can import product data into DieDesigner, run an analysis and within 20 min. start the simulation, with no recognizable breaks, no interruption. Any communication between the two programs is transparent."

Validation Through Simulation

Pecking away at die-tryout time and reducing the number of iterations before a tweaked-out die actually makes it into production seems to be a time-honored tradition. But with the well-documented and dramatic shrinking of the new-model introduction cycle (most automotive OEMs, offers AutoForm's Prabhakar as an example, now strive for an 18-month development cycle from concept to production, vs. 35 months in 2000) comes escalated pressure on metalformers to quicken the die-development process. Key to success here is seamless integration of simulation software and die-design software, as well as accurate predictability of die performance in a press.

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Prabhakar says that AutoForm-Incremental can produce accurate tryout results in as little as 5 min.; larger jobs, such as a whole body side, might take three hours to run. The program begins by automatically meshing the initial blank once the user specifies blank size and any features such as those evident with tailored blanks. Optimal blank size also can be calculated. Tool geometries can be developed or imported from CAD, and the user can define process parameters such as material properties and thickness, binder tonnages, tool velocities and bead-setting forces. Once the simulation job begins, the program computes binder wrap, allowing the user to check for wrinkles as the binder closes. It then simulates drawing (for single- or double-action presses), restrike and flange forming, contour trimming and hole cutting, edge flanging and cam operations, and springback displacement. Engineers can view a simulation while it's still processing, enabling them to catch a potential problem before the whole job runs, go in and make changes and restart the simulation.

"We find the use of color contours in how AutoForm-Incremental displays problem areas a big benefit," says Judkins. "The map of deformation, for example, is simple and logical—splits appear in red, risks of cracks in yellow, wrinkle zones in violet, risk of wrinkles in blue, thinning in orange and safe zones in green. Every step of the way the software prompts you for information that you, as a die designer, expect to be asked about a job. And it uses metalforming terms to do so, again communicating as any other engineer would.

"The software predicts, very accurately, material formability," continues Judkins. "We're extremely confident that if the material splits and wrinkles in our simulation, you had better pay attention to it because it will split and wrinkle in the press, too."

All of this adds up to that often-used but often difficult-to-explain function of software called user friendliness. "For us, this engineer-like interface significantly shortens the development cycle as we move back and forth from AutoForm-DieDesigner to Incremental," says Judkins. **MF**