Pros and Cons of CAD

Computer-aided design is far from perfect, but still pretty great, these experts say. By Jean Thilmany, Associate Editor

Computer-aided design software: love it or hate it? Mechanical engineers in equal measure love it, rave about it, or grudgingly put up with it. Judging by a very informal poll conducted by this staff writer (who asked approximately 25 engineers how they felt about CAD), we find that mechanical engineers have mixed feelings about the software that drives much of their working day.

"No one has any doubts CAD does help the bottom line," said Bernhard Bettig, a professor of mechanical engineering at Michigan Technological University in Houghton. "No one really hates it. It's just that there are a lot of issues in terms of ease of use that could be better. But mostly people just accept it the way it is. They work with what they have."

Bettig's comments got us thinking. What exactly is there to love and what's to hate about everyday design software? And what would experts—those who teach CAD and work with it every day—like to see done better? Mechanical Engineering asked three prominent CAD users what they perceive as the software's drawbacks and what they couldn't live without. Along the way, the three also discussed CAD's history and talked about the future of CAD design.

Gordon Lewis, as principal at DaTuM 3D, a product-development company in Watertown, Mass., speaks as an everyday, high-end CAD user. The company brings customers' ideas for products to fruition, analyzes and prototypes them, and proceeds through branding and market positioning. Lewis has worked as a designer for 44 years, beginning on a drawing board and now calling up CAD on his laptop. His company runs the SolidWorks and Pro/Engineer CAD systems and maintains seats of Euclid from Dassault Systèmes in Paris.

William Durfee is a professor of mechanical engineering and director of the design education department at the University of Minnesota in Minneapolis. He addresses the issues that students and novice designers run into when working with CAD for the first time. He has taught CAD to college students since 1985. The department maintains Pro/Engineer and many students use SolidWorks as a second system.

Bettig has taught CAD to college engineering students for the past six years. His academic research focuses on ways to create faster and better designs than possible with today's CAD systems. He is particularly interested in ways to give designers immediate feedback on how design decisions would affect the part's performance or manufacture.

Is This for Real?

No question, today's CAD systems have room for improvement, Bettig said. Still, they're simpler to use now than at any time since their inception about 50 years ago. But that ease of use can be a double-edge sword. All three experts cited as CAD's main drawback the tendency for newbie or less experienced engineers to create designs that can't be made, although they look perfectly manufacturable on screen.

Here's an example of how a new student might get in such a pickle. All CAD packages include a function that lets users mate two parts to create a simple assembly, Durfee said.

"They snuggle right up against each other. The holes line up, but it's a fiction," he said. "In real life, they'd need to be welded, or adhesively bonded, or fastened with some type of fastener. It's easy to forget that on the screen."

The design would need to account for that fastener. And perhaps it couldn't.

Many beginning designers make common mistakes, like forgetting the fastener because they have no experience in manufacturing. They don't take into account a part's ability to be manufactured, and they're not exactly sure what to take into account.

"But you even see it with professional designs," Durfee acknowledged.

Both Lewis and Durfee put this down to the CAD software's ease of use.

"The CAD tools are getting so much simpler to use. We even see kids in high school using them," Lewis said. "But because of that, some people don't understand they're creating something that can't be built."
DaTuM 3D offers the full range of product development—from idea to branding—so sometimes customers show up with a hastily drawn-up CAD design they'd like to bring into reality.

"We have customers come in here and say, 'My brother's grandson did this design for me; can you guys make it?'" Lewis said. "We have to say, 'Sorry. It can't be built.' I've seen some very poor designs done, but because they're done on CAD people don't understand they can't be manufactured."

John Walker, who founded Autodesk in 1982, can't speak to present-day CAD. He retired from Autodesk 12 years ago, an eternity in software morph time. He does say, however, that engineers have complained for generations about recent graduates who know how to make all kinds of calculations, but have little grasp of how they work for real-world products.

"But then that's why one pays a newly minted engineer less than an experienced one, isn't it?" he said via e-mail from his laboratory in Switzerland. "You learn product design by doing it and building things, not by calculation. CAD is simply another form of calculation and needs to be grounded in real-world experience and experimentation."

The Great Equalizer

Flip the coin and CAD's ease of use is also its most positive feature. According to Bettig, "The software can make a bad engineer as good as a good engineer in many respects. If you have all the checks in place, you're less likely to make a bad part than you were before."

That's good news for students and beginning engineers. But it's even better news for more experienced and naturally talented designers. The same systems that give their less-experienced colleagues a leg up give veteran engineers a bedrock technology to support their advanced designs, Durfee said.

To hear him tell it, the best engineers know how to work with their CAD systems in an intricate back-and-forth dance. Because they're always aware of how a design will be made and assembled, they're much less likely than new engineers to come up with a part or product that faces trouble on the manufacturing side.

"As they create a design, they run a movie in their head about how it could be made," Durfee said.

Experienced designs begin with a base feature—say, a rectangle. If they make a CAD cut in one end, they think, okay, that's a lathing operation.

"They're really thinking about the manufacturing of it as they go along, which requires design skills," Durfee said. "A CAD system mimics the manufacturing process quite nicely, but if you don't know anything about manufacturing, you'll design something that can't be assembled or that costs a gazillion dollars to make."

And then there are the designs themselves. Today's technologies allow for a variety of shapes and swirls, a definite point in CAD's favor. Gone are the square, serviceable designs that were prevalent before digital design took off, Lewis said.

"In the early days, everybody tried to use CAD tools like they'd used their drawing boards, and they couldn't do it because CAD had such restrictions," Lewis said. "Twenty years ago, you saw designs that were very boxy because of the limitation of the tools. Today, we see flowing shapes, and contours and blended angles. Stylish products are more the norm today."

Durfee agrees, but thinks that novice designers surrounded by those stylish products overreach before they truly know how to work with their software. Or, frustrated because they can't make such shapes, they fall into a pattern.
of creating and reusing the patterns that are easiest to carry out in their CAD systems. They get into a rut. They don't care to work outside their comfort zone by exploring software features that might rev up their designs.

But it doesn't help that CAD packages still lack features to easily make the intuitive, complex shapes so pervasive in modern products. "It's much easier with CAD to create a part with square features and rectangles and straight lines and round things because those buttons are right there, and you can whip up a rectangle with round things on it in 20 seconds," Durfee said.

More challenging is the double-curved surface, he added. Consider the mouse, which is much harder to draw digitally than its shape implies.

"CAD has evolved so it's easier to make a double-curved surface than five years ago, but it'll be a while before it'll be truly easy to do," Durfee said.

That's why quite often, even in a current design project, engineers will sculpt the design in clay, scan it with a digitizer, bring it back into the CAD package, then change it into a solid model and refine that, he said.

Durfee and Bettig said that skilled designers aren't cranking out as many great designs as they could be, another drawback to today's modeling software.

One of Durfee's biggest criticisms of CAD systems is that digital design is slower than sketching. And that inhibits the brainstorming process. Imagine if every time you wanted to update your grocery list or, while driving, suddenly had a brilliant idea for a novel, you had to go home, turn on the computer, call up a word processing program, write a note, and print it out. That tedious procedure would stop you from ever getting that idea down.

It's the same way with design. "You fire up the CAD application and three minutes later you're making a rectangle. Twenty minutes later, you're coming up with your first idea," Durfee said. "A good designer could come up with 100 fledgling ideas in that time."

For that reason, most engineering companies should still rely on brainstorming sessions complete with markers and plenty of paper, Durfee said. Engineers can go on to develop the ideas in CAD later.

Bettig said he would like to see CAD systems that let engineers brainstorm. In addition to being slow to capture a flurry of ideas, today's systems aren't equipped to let engineers play with a design. Engineers start with a basic design. They can change parameters as they draw, but can't change complete concepts midstream or cut and paste ideas between designs. "You end up making a different CAD model for each concept," Bettig said.

Save the Records

Durfee pointed out that CAD brings a benefit in design documentation. An engineer fresh from a brainstorming session may have 100 ideas. That's a lot of paper. Most designers would cram it into a folder. But turn the ideas into CAD files, and they're automatically archived and documented, he said. "Once you've created something in a CAD package, you've committed it to a paper trail," he said.

Most CAD packages include features that track design changes so engineers working collaboratively can see what's been changed, where, when, and, increasingly, why (by way of a feature called design rationale). This gives everyone on the team a way to follow the design process.

"That's huge in things like medical design, where you have to track the process from day one," Durfee said. "The average engineer isn't that excited about documentation, so it's nice to have a system that does it for him."

Bettig takes issue with the CAD systems today that don't let engineers include design rationale.

Lewis praises rules that can now be included in CAD systems. Those rules automatically create certain aspects of a design—like a hole—in a company-prescribed manner, to standardize them.

"That drives standardization without limiting creativity," Lewis said. "If you make it easy for somebody to make that hole, it becomes a no-brainer, and they can turn their efforts to the creative part of the design process."

Durfee cites CAD's easy integration with analysis packages like FEA or CFD as another pro on the CAD pro and con balance sheet. Even if the coupling is clunky or the analysis is fairly elementary, the capability to analyze designs instantly is huge, he said.

Oh, and we haven't even touched interoperability. Next month's article will address that large and wriggling can of worms.

Drawbacks aside, Durfee, Bettig, and Lewis agreed that it's an exciting time for CAD.

Lewis added that, whenever he's frustrated by the limitations of the software, he remembers his early days in industry—quite different from how he works now.

"I can make and cost out anything you want to build, all on my laptop," he said. "It's really Buck Rogers."