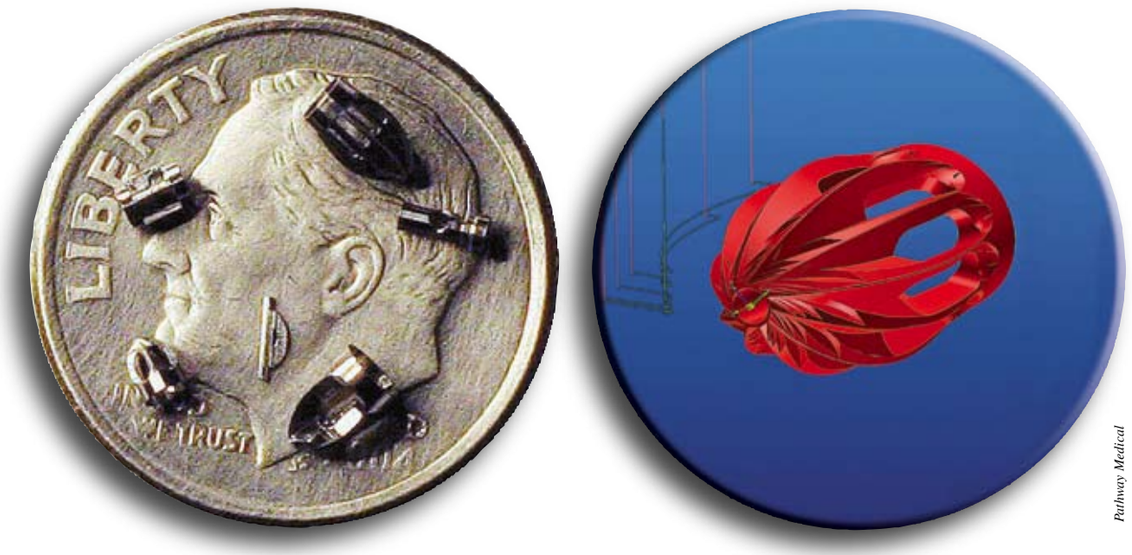
➤ BY BILL KENNEDY, CONTRIBUTING EDITOR

Partnership *by design*



Pathway Medical

The tiny size of arterial blockage-removal tools (left) made at Pathway Medical Technologies Inc. make full associativity of the CAD design (right) and the CAM program crucial for the therapeutic tool's accuracy in use.

Shops with CAD expertise can add value for customers.

Pressured by low-cost offshore competitors, machine shops are looking for ways to retain business by strengthening relationships with customers and providing value-added services. One strategy is to expand part-design capability and integrate it with the manufacturing process. Instead of simply accepting a customer's print or electronic file and cutting the part, a shop with CAD expertise can:

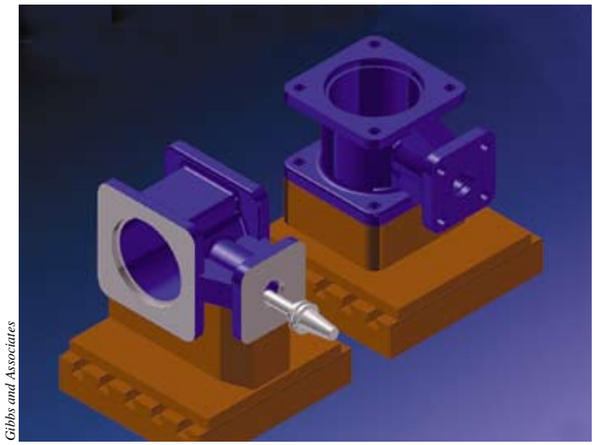
- quickly repair and modify files so the parts they're based on are easier to machine;
- fully and economically participate in part design, or at least reproduce the customer's design intentions, based on prints, files or even casual drawings;
- update designs and part programs as a product evolves; and
- provide reverse-engineering services.

"A key value-add capability is being able to take a customer's original concept and improve the manufacturability of the product," said Bob Fischer, vice president of product management and business development for CAD/CAM provider VX Corp., Palm Bay, Fla.

He described the traditional dilemma between industrial design and manufacturing: Design people often are more concerned with aesthetics than the details of particular molding or machining processes. A designer may not understand, for example, that a molded plastic part must incorporate draft angles that enable it to be ejected from a mold. "The designer leaves it in the hands of the person who has to machine the part. The old adage is 'blend to suit,' " Fischer said. Machine shops that can make rapid and accurate adjustments to accepted files will be perceived as providing better service than shops that are not as proficient in this area.

Ever-shorter lead times also increase the need for a shop to deal with design issues independently. While shops will, of course, consult with the customer on major design changes, when the issue is relatively straightforward, the shop can take care of it immediately. "Manufacturers, especially in America, no longer have the luxury of time to massage or rework," said Fischer. "You must have tools that enable you to manufacture something, even if the file you receive isn't perfect."

Fischer said a shop's CAD software should be capable of automatically closing gaps in incomplete files and preventing gouges and undercuts. And beyond repairing files or enhancing manufacturability, the systems should also permit subtle, or even dramatic, changes to part geometry, he said.



Gibbs and Associates

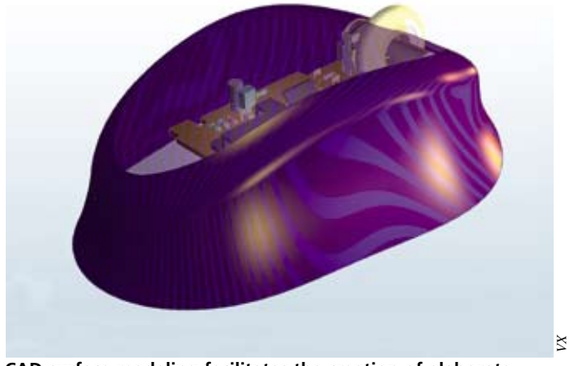
Machine simulation capabilities of CAM software can include representations of fixturing and machine components as well as the part and tool.

What is CAD?

For a job shop, the first step in boosting its part-design-related services is defining what "CAD" means for parts production. Bill Gibbs, president of GibbsCAM software provider Gibbs and Associates, Moorpark, Calif., said, "The 'CAD' we usually refer to is 'design CAD,' which makes the drawing or solid model. It doesn't machine parts—it manipulates the computer definition of them." Design CAD software's primary task is the creation of a new part, and its intended user is a design or mechanical engineer.

Depending on the parts, various CAD packages emphasize different representational methods. Wireframe is the most basic CAD technology, producing 2-D or 3-D linear models for relatively simple parts. On the other end of the complexity scale is surface modeling, which helps create the elaborate curves and contours characteristic of parts for aerospace, automotive styling and consumer product applications.

Solid models are made of separate 3-D elements combined into a unit, facilitating the construction of complex objects. In parametric modeling, elements can be altered by changing specified dimensions or ranges. Hybrid modeling systems combine various representational methods so the different features of a part can each be modeled in the best way. As an end product of the design process, solid models are becoming the preferred basis for CAM machining programs.



VX

CAD surface modeling facilitates the creation of elaborate curves and contours and can enable a shop to update complex part designs.

Unless it has only one customer who employs only one design CAD software, a shop needs general-purpose CAD/CAM software that permits it to modify and repair files from any CAD source and create toolpaths via CAM. "Modifying the part file for manufacturability and developing tooling to hold it is what we call the 'manufacturing CAD' function," Gibbs said.

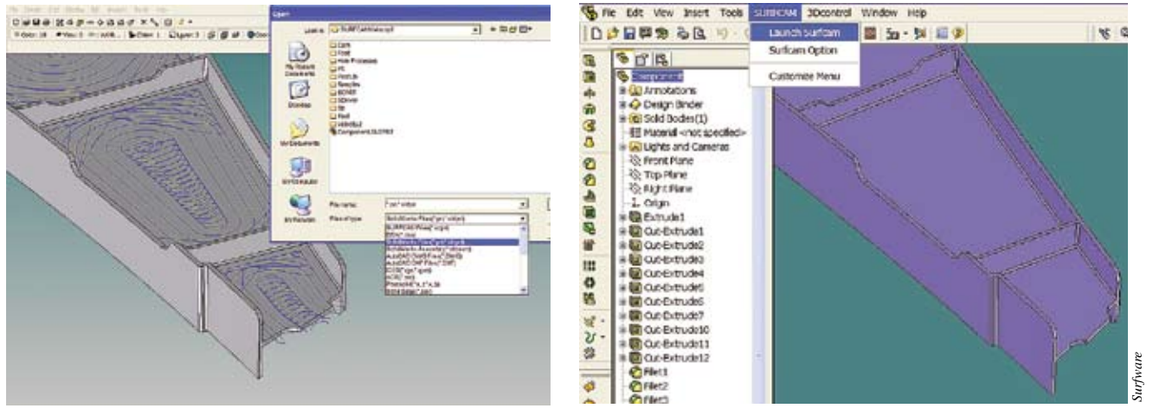
Because design CAD and manufacturing CAD both deal with solid models and 3-D views, it might be assumed they can perform the same functions. However, according to Gibbs, "all software can be evaluated based on how well it performs its primary task for its primary user. You can use a rock to drive a nail but it's not the best tool." While a design CAD package can perform part file modifications for manufacturing, "it has about 10,000 features you are never going to use," Gibbs said.

By the same reasoning, the CAD function of a general machine shop's CAD/CAM package could be used to design some parts, but without the efficiency or flexibility provided by a dedicated design package.

Doug Nemeth, outside sales representative for CNC Software Inc., Tolland, Conn., marketers of Mastercam software, said that even though Mastercam has tools to read all the different files, most users of the company's CAM software have a separate design CAD software package to create models of new parts. "I would guess that 80 percent of our users are not using Mastercam to do the full design," he said. "The people using Mastercam to do everything—design and manufacturing—are usually very small shops." Shops larger than that "are going to be using some sort of design package, then use Mastercam as a way to do the machining and a little bit of design manipulation," he said.

Associativity a Key

Glenn Coleman, vice pres-



Surfware

To carry out associativity between CAD and CAM programs, a file can be "pulled" into the CAM program via a Windows file-open command [a SolidWorks file pulled into SURFCAM featuring a TrueMill toolpath (left)] or "pushed" by using a neutral translator (right).

ident of product engineering for Surfware Inc., Westlake Village, Calif., developers of SURFCAM software, said choosing and applying separate design CAD and manufacturing CAD/CAM packages enables users to "use the best tool for whatever the job is."

For that approach to work, however, interoperability and associativity between the design CAD and manufacturing CAD/CAM packages are crucial. Increasingly, CAM suppliers are working with design CAD partners to assure that the relationship is seamless. For example, Surfware has a partnership with CAD supplier SolidWorks Corp., Concord, Mass. Said Coleman, "If someone designs a part in SolidWorks, or if they import the model from somebody else, they can generate toolpaths on that model with SURFCAM." He said SURFCAM has full associativity with the SolidWorks modeler, meaning that when changes occur in the model, the toolpath is automatically altered to reflect the changes. A key factor is that SURFCAM's solid-modeling capability is based on the same Parasolid geometric-modeling kernel that is the foundation of SolidWorks.

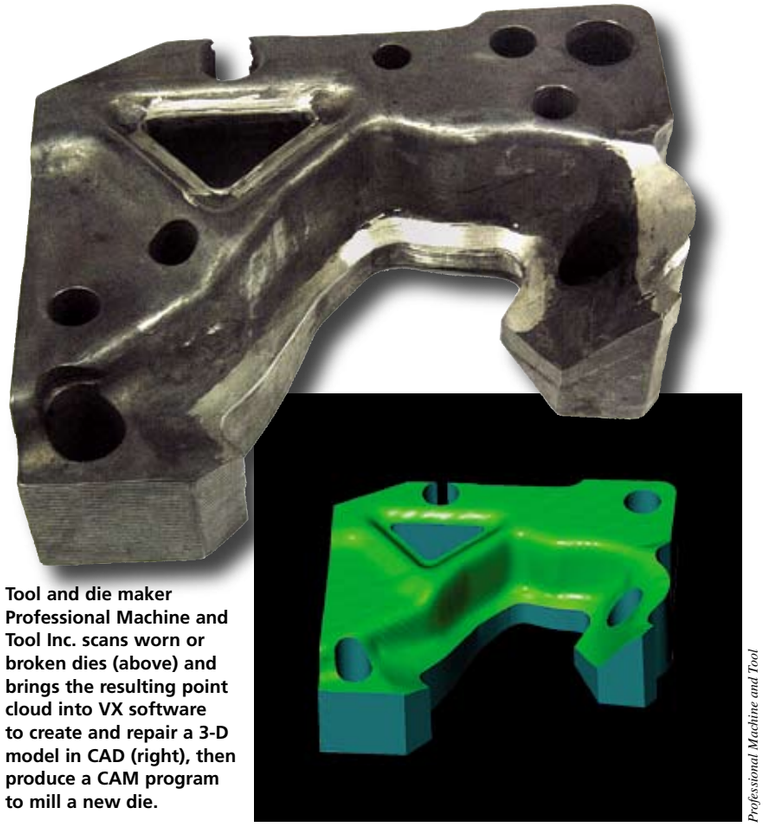
Seamless Transition

A good illustration of the benefits of seamless associativity between design and manufacturing software is the product development and manufacturing process at medical equipment producer Pathway Medical Technologies Inc., Redmond, Wash. Pathway focuses on developing treatments for peripheral arterial disease. The company currently has an equipment system in clinical trials that features a rotating, aspirating, expandable catheter designed to remove atherosclerotic debris and clots from blood vessels other than those of the heart and brain. The system's tiny, extremely precise cutters, as well as other parts, such as component housings, are subject to ongoing design changes as the product evolves.

Pathway design engineers develop the devices with physicians and also test components using bench models of different types of disease. Initial designs and ongoing engineering updates take place in SolidWorks. The parts' toolpaths are created by bringing the SolidWorks file into SURFCAM, where the full associativity shows itself.

"If the model changes, the software alerts you and asks if you want to update the model," said Matt Hefner, shop supervisor for Pathway. "Even if an engineer redraws the part, you can pull your toolpaths from the last time that you machined it and reapply them if the model is close enough to the original geometry."

Although the part model can be opened in SURFCAM, Hefner said he prefers to export it from SolidWorks through a translator. "When [the translator] brings the model up in SURFCAM, the layers menu not only gives you all the surfaces for that model and the Wireframe, it also gives you the 2-D sketch planes that show how the model was built," he said. "So any time you are doing a complex cut, the 2-D plane is already established, and you can grab that to find your cutting plane. That can save a lot of time," compared to building a machining program based solely on the more complex 3-D model.



Professional Machine and Tool

Tool and die maker Professional Machine and Tool Inc. scans worn or broken dies (above) and brings the resulting point cloud into VX software to create and repair a 3-D model in CAD (right), then produce a CAM program to mill a new die.

Hefner said the precision required for Pathway's medical parts make it critical that there be no loss of detail in the translation from the CAD model to CAM toolpath. A typical blockage-cutting component—called the distal part of a catheter—is made of precipitation-hardened 17-4 stainless steel about 0.060" in diameter and 0.080" long. "We deal with such tiny parts that if the machining is off by 0.0002", it can totally change the look of the part," he said, adding that the tolerances on the device's actual blades "are almost down to nothing."

After full associativity is achieved, Surfware's Coleman said, the critical issue "becomes how accurately and quickly something can be done. The manufacturing shop can become a bottleneck in the development process when it takes too long to machine a complex part." As an example, he cited tight part features such as very small corner radii. "The difference between a ¼" corner radius and a 1/16" corner radius can have a great impact on the cost of a part," he said. "The big problem when you get into machining tight corners is overloading the cutting tool." Avoiding overloads generally means employing machining parameters that are too slow when continued in less restricted areas.

Steve Crane, Surfware product manager, said the solution is in the methodical processes, or algorithms, the software uses to generate codes for toolpaths. Surfware offers a code-generating engine called TrueMill whose algorithms, Crane said, prevent overloading the tool and permit it to be run faster and deeper overall. The result is reduced machining time and often the elimination of processes, such as EDM, that would otherwise be required to create small details.

End to End

Instead of integrating different software systems, another approach is to use end-to-end software, which is fully associative. Changes in the model result in changes in the CAM program. With end-to-end, there are no integration or translation steps or effort needed. For example, the VX CAD/CAM package includes 3-D solid/surface hybrid modeling, parametric design and drafting capabilities, and specialized mold and die design tools with an integrated CAM package that includes 2- through 5-axis milling.

Some shops are using the end-to-end approach to expand the services they offer customers. Mike Johnson, general manager of tool and die maker Professional Machine and Tool Inc., Gallatin, Tenn., said he acquired VX software about 3 years ago and at first used it nearly exclusively for its CAM capabilities. Recently, he said, "we've gradually stepped it up, especially for reverse engineering."

Reverse engineering is a growing part of Professional Machine's die production and repair business for automotive transplant manufacturers. When the shop is asked to build a new die based on an existing one, it often finds the die has been built overseas and has poor or missing CAD data or drawings. Often, Johnson said, "somebody breaks a block [die], and they want me to perform miracles and

Is overseas overrated?

Many shops see low-cost overseas competition, specifically from Asia, as the 800-lb. gorilla in the room. They worry about their customers contracting for lower cost parts overseas. However, domestic shops still have important advantages, even if they can't compete head-to-head on price. The advantages can include machinists' skills, ability to work through problems quickly and knowledge of specialized manufacturing.

Many parts function correctly only because a machinist has applied knowledge and skill to make the part correctly. "It's because CAD models in general are not perfect," said Bill Gibbs of Gibbs and Associates. When such imperfect CAD files are sent overseas, problems can occur. The manufacturers who subcontracted the job "start getting parts back that don't work. Legally, the parts are within the definition of the CAD file. But they get bad parts or slow delivery or increased costs that are very hard to deal with 12,000 miles away in a foreign language and culture," Gibbs said.

It is possible to make a virtually perfect CAD file. Some aerospace companies, for example, invest in high-level CAD drawings that accurately define a part, but the effort drives the cost up. "Doubling or tripling your engineering cost because you can't sit down with the manufacturer is huge," Gibbs said.

The solution is close interaction between the designer of the part and the machinist who will make it. A job shop should recognize that it is "a manufacturing knowledge base," not a universal, interchangeable seller of machine time, Gibbs said. Shops develop that knowledge by specializing in classes of parts and industries. For example, a medical products provider should work with a machinist who specializes in medical parts because that machinist "has an idea as to what you are trying to achieve. He will study the part, find all the things that aren't going to machine well, then come back and discuss them with you," Gibbs said.

—B. Kennedy

get it fixed immediately." It would take an overseas supplier 1 to 3 months to repair or replace the die.

To reverse-engineer a broken die, Johnson uses a 3-D scanner to digitize the part's surface, creating a representation of the surface as a series, or "cloud," of discrete digital points. That representation is converted into a 3-D solid model in the CAD software. "We bring that into the VX and turn it into a solid, and then we've got something we can work with. The point cloud feature takes you through a series of steps to lay the surfaces, more or less defining how many of those points you want to use." Then, he said, "you can run it completely through the shop with VX, the milling and everything." The integrated software package enables him to provide quick service.

"Depending on the size of the block, sometimes we can turn them around in just a few days," he said. "Also, when a customer provides a file of a part with incomplete surfaces or other defects, the software has several methods to fix it. We can modify it however we need to and repair the surface."

When producing new dies, Johnson said, "we do a lot of complicated blocks. Essentially, we'll draw it from a concept or whatever and make a rough 2-D drawing. Then we take that and model it. The software's hybrid and parametric modeling capabilities help because there are a lot of complex parts that you just can't even draw in a 2-D form."

The following companies contributed to this report:

CNC Software Inc.
(800) 228-2877
www.mastercam.com

Gibbs and Associates
(800) 654-9399
www.gibbscam.com

Pathway Medical Technologies Inc.
(425) 497-9152
www.pathwaymedical.com

Professional Machine and Tool Inc.
(615) 452-2234
www.professionalmachine.com

Surfware Inc.
(800) 787-3927
www.surfware.com

VX Corp.
(800) 683-9222
www.vx.com

An Individualized Choice

Software selection should be based on a shop's specific needs. "Most CAM software will program your parts, but there are still tremendous differences in training curves and suitability for your specific applications and your machines," said Bill Gibbs. "Make sure that you see a demonstration of how you would program your parts on your machine. I encourage people to focus and get very selfish about what they want to see demonstrated because theirs is the only opinion they are going to have to live with."

Post-selection service is important, too. Said Mastercam's Nemeth, "CAD/CAM packages are becoming more alike. Most can do 2-D toolpaths, and decent 3-axis or even 5-axis cutting." He emphasized the value of working with a competent local reseller. "There are many packages you can buy over the Internet; although the price might be right, CAD/CAM software can typically be a pretty support-intensive thing. It's not like you are just running Microsoft Word." △

Ready to invest in CAD software?

So, you have decided it's time to buy some 2-D CAD software (finally) or to upgrade from 2-D to 3-D design software. Now, the big question is "What should I buy?" Here is a brief checklist that will help steer you in the right direction. With apologies to David Letterman, let's do a "Top Five" countdown from least to most significant.

10. **Are trained operators available?** Notice that I started my Top Five list at No. 10. This one is so insignificant that it falls off the bottom of the list. There is no such thing as a "CAD operator"; we didn't have "pencil operators," did we? Your people can be trained on a new CAD system in a few weeks, but you cannot hire new people who are as knowledgeable as your current employees.

4. **Is training and support available in your area?** See the previous item for the justification of this item.

3. **Make sure you know what your real needs are.** For example, if all you do is wire EDMing, laser cutting or plasma cutting, you may not even need 3-D capabilities.

2. **What links do I need to postprocessors?** A large percentage of machining is done on CNC machines. In most cases, design software does not directly support G-code generation, so CNC postprocessor software must be purchased. Although most design files transfer into most postprocessors, translation issues can arise (see below). Still, most major CAD packages will work directly with a specific postprocessor brand. In the best case, the connection is associative so that any changes to the CAD model will reflect through and update the G code.

1. **What are your clients and suppliers using?** There is no such thing as "perfect" translation or compatibility among different software products, so it is best to use the same product as your clients and suppliers. You will also most likely need not only the same brand, but the same version. If you translate between different software products, keep in mind that competing brands do not have the same features, nor do they handle certain functionalities the same way. The best test of a translator is to go out and then back through the same translator to see what flavoring it is adding. This will be compounded when you go out from one translator and in through another.

—Bill Fane