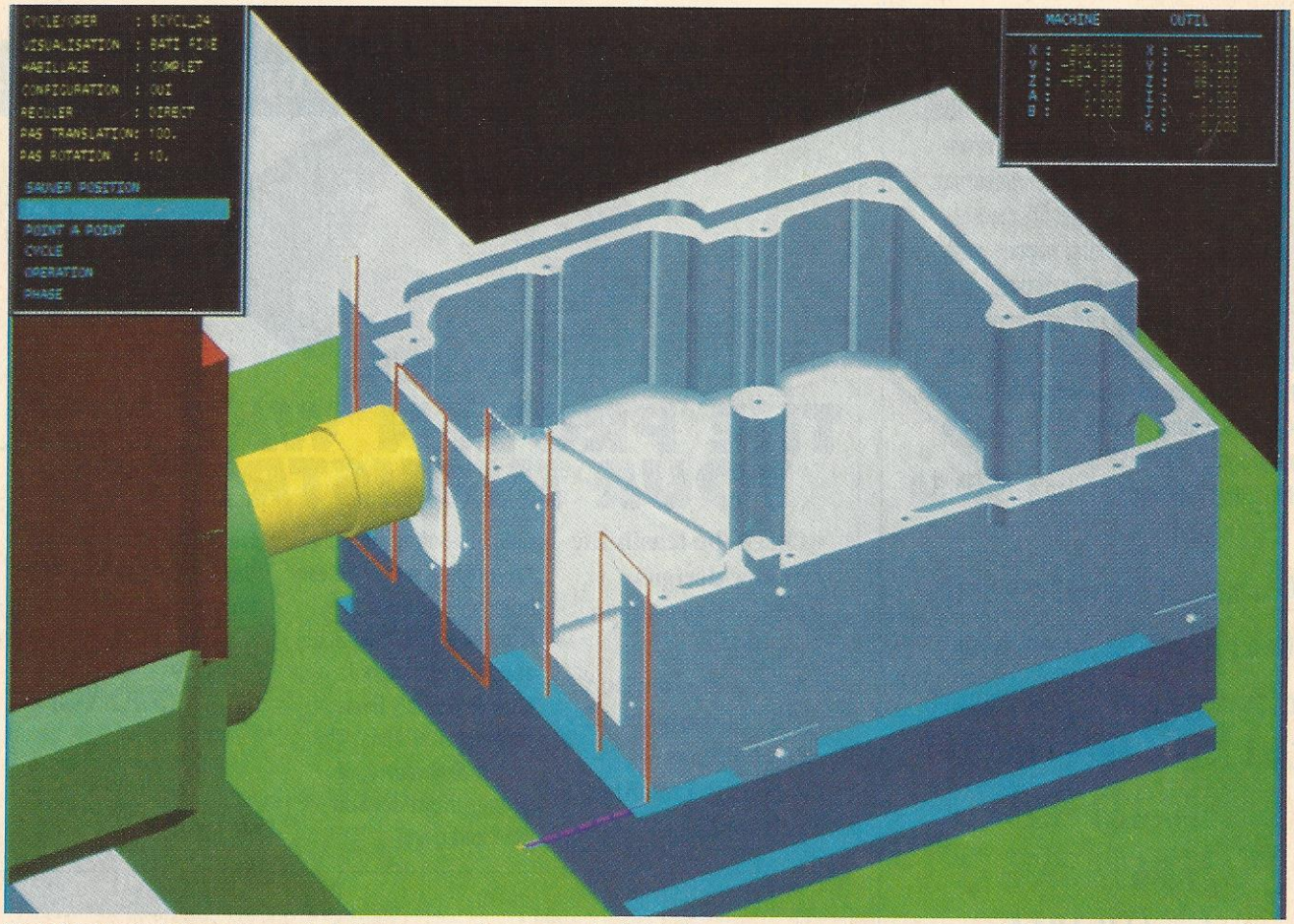
CAM codes enable small shops to compete

Computer-aided manufacturing software gives small shops the ability to create the same parts that have traditionally been the domain of large companies. Moreover, the agility and attention to detail provided by many smaller firms give them an edge.

By Michael Puttré, Associate Editor



Most of the machining operations typical of modern manufacturing can be depicted on screen using software running on desktop computers. Here, the kinematics of a machine tool (shown in yellow) are simulated using the Euclid-IS system from Matra Datavision.

THE TREND FOR many industries during the merger and acquisition fever of the 1980s was to consolidate manufacturing operations into large automated shops. The rationale was that only the largest plants could afford the hardware and software tools required to produce high-quality parts with the speed and volume necessary to remain competitive.

However, the notion that small manufacturers cannot keep up technologically with large shops has been challenged by the arrival of desktop computers and computer-aided manufacturing (CAM) programs to run on them. CAM has permitted the small manufacturer to import drawings electronically from clients, revise the models for manufacturability, lay tool paths, and drive the computer-numerical-controlled machines that cut the desired parts. Furthermore, CAM has helped small manufacturers display an agility that larger rivals might envy.

"There is no inherent disadvantage to being small," said Philip Parenti, a partner at CNC Engineering, a two-man manufacturing shop in Terryville, Conn. Parenti and his associate, Greg Laplante, produce functional prototypes of plastic parts for Fortune 500 clients in the pharmaceutical and electronics industries. The company is barely two years old and, according to Parenti, owes its very existence to the availability of inexpensive CAM systems. "Without the software we would never be able to do this," he said.

VARIETY IS THE SPICE OF BUSINESS

Many small manufacturers such as mold and die makers handle contracts for larger clients. These companies receive design data and turn out the plastic injection molds, extrusion dies, and steel-casting patterns from which parts destined for larger assemblies are created. According to John Gildea, CAD/CAM manager at Model Die and Mold Inc. in Grand Rapids, Mich., profit margins per job are low because a significant amount of engineering expense goes into each job. "We are effectively building prototypes all the time," he said. Each mold or die is generally individual and is used by a single client, he said.

Profits often are generated by keeping the NC machines producing a steady output of work, Gildea added. This requires handling jobs from a variety of clients that may represent diverse industries and requirements. Model Die, for example, creates tools for the automotive, business and consumer electronics, and toy industries. Furthermore, different clients have varying levels of fluency with computer-aided engineering. "Some of our clients are just getting into 2-D CAD, and others give us designs in 3-D surfaces," Gildea noted.

The success of a CAM installation is often not in the hands of the manufacturing engineers at all, but rather in the skill of their clients. Since small manufacturers tend to rely on contract work rather than internal product development, the quality of the design data they receive is largely beyond their control. Manufacturers can be discriminating in selecting clients, provided they have the luxury to do so. Otherwise, they must be prepared to handle data of varying quality and in different environments.

"If the caliber of the design engineer is good in the first place, then receiving data is not a problem," said CNC Engineering's Parenti. He said that his Fortune 500 clients tend to have top-notch engineering departments. CNC Engineering uses Mastercam from CNC Software Inc. in Tolland, Conn., to create manufacturing models and generate tool paths for the company's three vertical mills. About 80 percent of the design data the company receives comes in as IGES files, either on a disk or by modem. Parenti said that as long as the engineers on the front end adequately handle the IGES translation, Mastercam can read files originating from almost any CAD system. However, not all potential customers are equally fluent in translator use. As a result, CNC Engineering tends to stick with primary contractors with proven engineering departments. "We don't like to do third-party work," Parenti said, referring to lower-tier contractors.

Mark Haines, manager of computerized tools at EPW Inc. in Elkhart, Ind., agrees that the quality of an IGES translation is largely in the hands of the client sending the data. Most of EPW's clients are in the automotive industry, where the incoming files tend to come through the translation the cleanest because automotive engineers do a good job preparing IGES files. Haines indicated that it was IGES data from less-experienced clients and those with less-capable CAD systems that tend to cause the most trouble from a translation standpoint. In fact, troublesome electronic files cause about the same amount of work for EPW engineers as if the data arrived by blueprint.

Model Die's strategy is to have a number of different CAD/CAM packages in-house to handle most eventualities. The company has eight design engineers who read incoming data and prepare models for the eight manufacturing engineers who program 25 NC machines of varying ages, including a recently retrofitted 30-year-old milling machine valued at $2 million. Expensive milling machines that are serviceable can be converted to computer control, protecting a shop's sizable investment in equipment. For CAM systems, Model Die runs Euclid from Matra Datavision in Tewksbury, Mass., on Sun workstations; AutoSurf and AutoMill from Autodesk Inc. in Sausalito, Calif., and Strim 100 from Cisagraph in Paris on IBM-compatible 80486 PCs; and Acu.Carv from Olmsted Engineering Co. in Traverse City, Mich., on Prime minicomputers. "We pick software largely for the translators, and our selection gives us many distinct flavors," Model Die's Gildea said. "Among all the different programs, we can handle just about any part imaginable, from a simple washer to a Dodge truck grille with 9000 surfaces."

Variety gives the manufacturer many options about how to approach a given job. The source data determine which IGES translator Model Die will use to import the data. Matra and Cisagraph have direct translators to Catia, the 3-D CAD system from Dassault Systemes in Paris. Wireframe models of part prints are sent to the Euclid stations, where they are converted into 3-D surface

Computer-aided manufacturing software can handle many disparate functions in an integrated way that formerly required separate activities. The Camand system from Camax Systems Inc. can be used to model, render, and create five-axis tool paths for parts. Pictured here is a close-up view of an automotive taillight mold cavity composed of 260 surfaces rendered in Camand's Viewmax module. The image displays the mold cavity, parting-line surfaces, and tool paths.

models. If the designer sends a surface model, the file may be sent directly into AutoSurf for mold design. From there, the NC programmers generate tool paths using AutoMill, Strim 100, or Acu.Carv. Gildea said that as a general rule, more-sculpted parts go to Cisagraph-driven systems, and less-sculpted ones go to AutoMill, although platform schedules are the main arbiters.

Gildea cautions that flexibility does not come without effort. Since service contracts for such a heterogeneous computing environment would eat into profitability, Model Die performs all of its computer hardware maintenance in-house. The company has plenty of spare parts stockpiled, even for the Prime computers. Back in 1982, the company's tool shop was largely a manual operation. The hardware and software systems that automated it were accumulated over the years—and are still being acquired. In the future, Gildea said, he would like to concentrate more on "rocket science" systems, such as Euclid, which he says are very capable but can be difficult to learn.

Making the Leap

While some companies automated their manufacturing operations over time, others implemented CAM from the start. Arrow Pattern of Bridgeview, Ill., is an all-union shop with pattern makers who serve five-year apprenticeships. Prior to 1985, the company built all its patterns and molds by hand. However, its clients in the automotive industry, who account for almost all of the company's business, were increasingly converting over to CAD. The decision to computerize at Arrow was a matter of staying in business. "What got us moving was a $2 million project from one of the Big Three automakers," recalled John Kuchay, president of Arrow. "We knew that we would not get the contract if we did not have CNC capability."

The company made a $250,000 capital investment in CAM hardware and software, eventually selecting the Camand package from Camax Systems Inc. in Minneapolis after a three-month selection process. Camand was able to handle Arrow's requirement for four-axis machining. For hardware platforms, Arrow purchased Unix workstations from Silicon Graphics Inc. in Mountain View, Calif. Kuchay said the graphics capabilities of the Silicon Graphics machines enabled engineers to perform color shading and manipulation of 3-D models interactively. The process of acquiring CNC machines and converting the plant to their use was even more expensive. Buildings had to be modified, air conditioning systems installed, power lines routed, and computer networks erected. Over three-and-a-half years Arrow spent $6.5 million on the conversion. Additionally, Arrow had to retrain its engineers. Some of the company's union pattern makers were 25-year veterans. Ultimately, the engineers were trained, and now all of the company's CAM seats are filled by pattern makers.

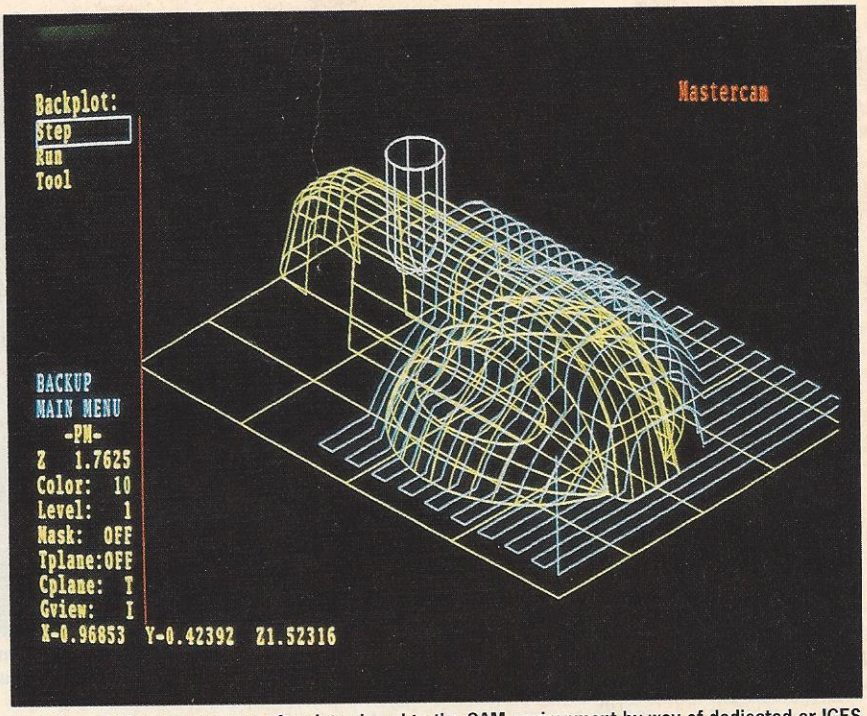
Changes in client requirements also inspired EPW to convert over to CAD/CAM. Originally a pattern shop, EPW found its foundry business dropping off during the 1980s. The company was staffed with good pattern makers but it was clear that molding was the way to go. Haines considered it imperative to follow his clients into higher-technology manufacturing techniques. "Complex shapes in the automobile industry need CAD," he said.

The company transformed its pattern business to the point where 80 percent of its current work is designing molds. In addition to constructing the mold shells, EPW builds all of the controls, hydraulics, and pneumatics associated with rim-injection molding.

Arrow and EPW had enough capital available to convert their manually operated mills over to computerized control. The partners that started CNC Engineering launched their operation with CAM right out of the gate. Both Parenti and Laplante obtained experience with computerized manufacturing working for other firms and decided to go out on their own specifically to capitalize on the possibilities that CAM offered.

The company chose to run Mastercam in the IBM-compatible PC environment due to the dominance of that platform among its clients. The engineers read incoming IGES files and program the points, arcs, and radii needed to create a mold model. Then the tool paths are generated and checked for interference and other manufacturability constraints. If problems are detected, they

are communicated electronically back to the client's design engineers for correction. Parenti said that CAM allows the two-man shop to handle jobs in 1 week that might otherwise take 10 weeks or more. The challenge is to find ways to make the process go even faster; the company has Pentium-based machines on order for that very reason. "We are the equivalent of a six-man shop," Parenti said. "Faster hardware and software multiplies our numbers without adding staff."



Data from CAD programs are often introduced to the CAM environment by way of dedicated or IGES translators. Many smaller manufacturers must contend with the vagaries of IGES quality among files originating from various customers. The wireframe image shown here is a Mastercam model from CNC Software Inc. that was received as an IGES file. Tool paths are being laid over it.

Random Precision

Some of the fallout from CAD is that manufacturers are expected to observe the same tolerances of which the designers are capable. According to Scott Lappen, CAD/CAM manager at Portage Casting in Portage, Wis., as customers get CAD systems, they expect manufacturers to follow suit. As little as four years ago, Portage Casting's customers would provide wooden models, mylar drawings, and even napkin sketches of parts for which they wanted molds. Now they send IGES files with tolerances set to tens of thousandths of an inch. "Even in situations where it really does not matter, customers hold to stringent dimensions," Lappen said. "We are also responsible for holding to them."

If dimensioning is not challenging enough, 3-D CAD systems can also be used to create intricate contoured surfaces that require multiaxis machining capability to cut. Not only do the designers have the ability to produce drawings more accurately, but they are in possession of gauges and electronic testing equipment that can determine whether the finished products measure up to the designs. Faced with more demanding customers observing tighter quality controls, Portage Casting found it necessary to achieve corresponding capabilities on the manufacturing side. The company acquired three seats of the EMS surface modeling and Maxmill CNC machining systems from Intergraph Corp. in Huntsville, Ala., running on Clipper workstations. Portage Casting also has two seats of the Cadkey CAD system from Cadkey Inc. of Manchester, Conn., running on IBM-compatible PCs. Lappen said that Cadkey is used to lay out mold designs while engineers create models in EMS that will be manufactured using Maxmill.

Using design and manufacturing software, Portage Casting can create contoured surfaces with tolerances that are sometimes tighter than the customers can use. Lappen indicated that coordinating such issues as dimensioning between the designer and manufacturer is important to avoid the gaps and inaccurately trimmed surfaces to which such inconsistencies can lead. "It used to be that some of the details depended on how the pattern maker felt on a given day," Lappen said. "Ten years ago, that was fine. Today we have to be perfect."

Ben Neff, senior CAD designer at EPW, said that current manufacturing systems can not only meet customer tolerances, they can demonstrate them as well. Electronic communication between designers and manufacturers allows them to resolve manufacturability issues interactively. The graphics capabilities of CAM systems such as Camand, married to the graphics processing of workstations such as Silicon Graphics' Indigo, permit engineers to verify tool paths and examine details that could not be verified and examined with mylar drawings and wireframe systems. "I can dynamically rotate geometries and zoom in at the same time," Neff said. "It's almost like having the real thing in my hand."

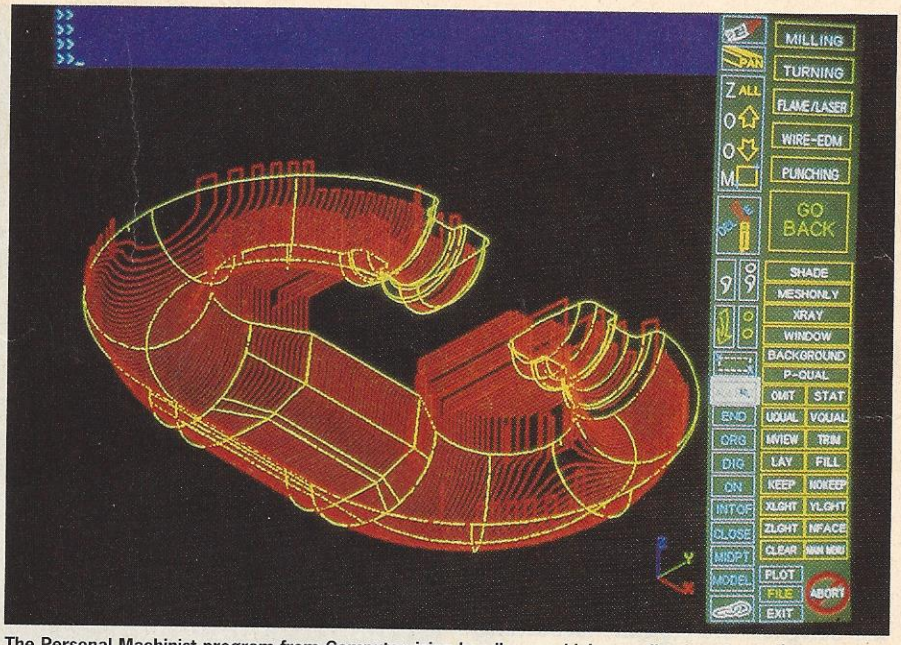
No Alternative

Smaller machine shops using desktop hardware and software are proving adept at merging design and manufacturing, two branches of mechanical engineering that were once regarded as distinct and isolated. Watkins Pattern Co. Inc. in Lakeville, Minn., is a dedicated engineering shop for Hitchcock Industries Inc. in Minneapolis. Watkins, which specializes in producing molds, fixtures, and gauges for complex aluminum and magnesium castings for the aerospace industry, is in a position to design and manufacture parts for its customers.

According to Watkins' CIM manager Daniel Handke, the types of geometries the company designs and cuts include offset serpentine turbine blades and free-form surfaces and tube passages as small as 0.187 inch in diameter. Developing tooling for these types of geometries requires a very high level of integration between design

and NC programming. Watkins achieves this integration with six Clipper workstations running EMS and Maxmill. Pattern makers create, offset, scale, and cut geometries without an intervening data translation. Handke said the engineers can develop the solid models in EMS and the tool paths in Maxmill quickly, accurately, and with fewer setups than if different departments using different systems were doing the work.

One of the benefits of having manufacturers do the actual designing is that manufacturability issues are taken into account from the outset. The castings Watkins makes are formed into complex assemblies like a jigsaw puzzle. While the parts can be created manually, as they were in the past, the ability to create 3-D surfaces for multiaxis machining allows the company to deliver the parts to the customer faster than ever before. "We communicate electronically with the design teams at the aerospace company and tackle design changes very quickly," Handke said. In a recent project, Watkins engineers actually designed a gearbox assembly from a concept sketch before the customer had completed the detailed drawings.



The Personal Machinist program from Computervision handles machining applications from 2½ to 5 axes. Pictured here is a model of a forging die used to produce links for a heavy-duty chain.

"The manual method has been trampled on," said Handke. Nearly all manufacturers that have implemented CAM systems identified the technology as an essential part of the modern working environment. Handke noted that there used to be instructions on mylars such as "pattern maker's discretion, blend to suit." Engineers would match up the templates and try to get the parts to match the best they could. That simply is not the way customers do business today. "You can't fudge things on the computer," Handke said.

The move toward CAD by high-technology companies such as those in the automotive and aerospace industries has inspired many engineering firms in general to find ways to create better designs faster and more accurately. The smaller manufacturing shops that serve these customers have felt the pressure to automate their own operations in order to stay competitive. In the minds of many manufacturers, there is simply no alternative to implementing CAM. Smaller shops may have an advantage in that they can adapt to change more readily than larger firms. "We don't have the red tape that hampers bigger companies," said CNC Engineering's Parenti. "We know what we have to do and we do it." ■

For Further Information

The following are some of the CAM programs that are available for desktop computers.

AutoMill, AutoSurf
Autodesk Inc.
2320 Marinship Way
Sausalito, CA 94965
(415) 332-2344

Camand
Camax System Inc.
7851 Metro Parkway
Minneapolis, MN 55425
(612) 854-5300

Mastercam
CNC Software Inc.
344 Merrow Road
Tolland, CT 06084
(203) 875-5006

Personal Machinist
Computervision
100 Crosby Drive
Bedford, MA 01730
(617) 275-1800

ICEM NC
Control Data
4201 Lexington Avenue North
Arden Hills, MN 55126
(612) 482-4857

Maxmill
Intergraph Corp.
One Madison Industrial Park
Huntsville, AL 35894
(205) 730-2000

Anvil 5000
Manufacturing & Consulting Services Inc.
7560 East Redfield Road
Scottsdale, AZ 85260
(602) 991-8700

Euclid-IS
Matra Datavision
Two Highwood Drive
Tewksbury, MA 01876
(508) 640-0940

Smartcam
Point Control Co.
1750 Willow Creek Circle
Box 2709
Eugene, OR 97402
(503) 344-4470