Technological advances ensure value throughout the market

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The worldwide and U.S. manu-facturing industry is viable and growing. Production output and worker productivity continues to in-crease, and the purchase of new tech-nology — including machine tools — is experiencing a sizable growth in 2006 over 2005. Product Lifecycle Manage-ment (PLM) software purchases grew by 8.7 percent in 2005, and CIMdata projects that the purchase value of CAM software in 2006 will expand by 7 to 10 percent over 2005.

This optimistic feeling was prevalent as one walked the floor and talked to both machine tool and CAM software suppliers exhibiting at the IMTS 2006 in Chicago in September. The CAM software vendors are experiencing strong business results in 2006, with many offering new and expanded product capabilities and several discussing recent mergers or acquisitions.

However, the manufacturing business environment remains difficult, as producers continue to be faced with intense internal and external pressures. Shareholders or owners demand steadily growing revenues and profitability on a quarter-by-quarter basis, while the market expects continuous productivity improvement, greater use of advanced technology, quicker turnarounds, and a longer, useful life for products. Producers are caught in a squeeze to improve processes, lower costs, shorten lead times, and enhance quality to effectively compete in a worldwide economy.

Globalization has further increased the stress placed on manufacturers. Outsourcing, insourcing, and offshoring have become common, and producers in all areas of the world now compete aggressively to win enduser buyers, or to be an integral component in a product supply chain, or both. There is a relentless demand to make steady
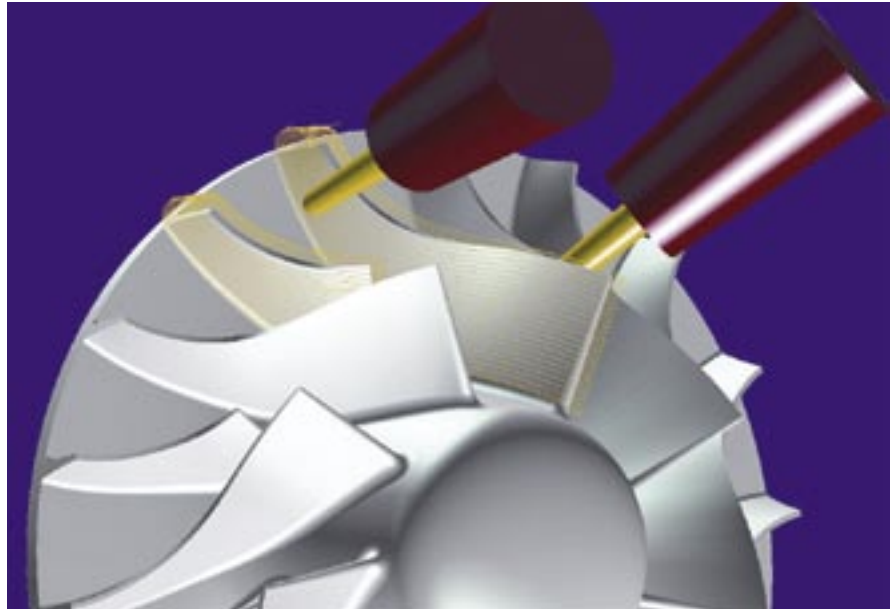
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improvements in process, people, and technology.

Producers must constantly look for ways to meet the faster, better, cheaper mantra of today's economy. Implementing new manufacturing software and other areas of advanced technology is a key strategy for firms to enhance their competitive and business position.

Let's consider the overall manufact-uring software environment in 2006, with the focus on CAM software, including an analysis of some characteristics of the market and some observations on major technology trends.

Manufacturing software

Software employed in the overall manufacturing process includes:
• PLM to manage the product data throughout the lifecycle
• CAD to define the products to be built
• Digital manufacturing to define how products are to be built
• ERP (Enterprise Resource Plan-

ning) to define when and where they are to be built and to manage production information
• CAM to control the machining operations

A PLM Environment — In the recent past, CAD/CAM and CAM software have become components of PLM and the manufacturing software market. For major manufacturers, PLM has evolved into a critical information management system, comparable in importance to ERP. CIMdata estimated the purchase value of PLM software at $18 billion in 2005. The primary PLM vendors all provide CAD and CAM as components of their broad-based PLM solution or as stand-alone offerings. PLM is a strategic business approach that applies a consistent set of business solutions to enhance a company's ability to design, produce, and service their products.

The software applications and/or technologies under the PLM umbrella include:
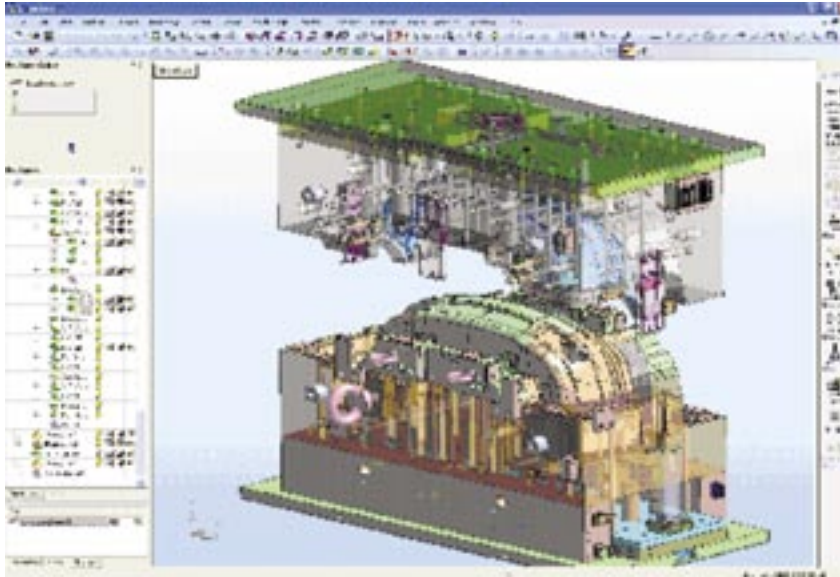
A mold design process-focused solution with CimatronE

- CAD and CAM
- Tool design and manufacture
- Digital manufacturing, including manufacturing planning, operations simulation and robotics support
- Collaboration within an operation and up and down a supply chain
- Support of workflow management, program and project management, and management of product structures, versions, revisions, configurations, and engineering changes

Solid Modeling — The use of solid models for design has become commonplace. The primary advantage is that a complete and unambiguous model is generated, thereby avoiding gaps, holes, or overlapping surfaces. Further, by establishing interoperability with a solid model, associativity can be established so that with any change to a model, tool paths can be automatically updated on a part or in related components such as molds. Design intelligence in a solid model can be transferred among software systems without getting "lost in translation."

Collaborative CAD — Collaborative CAD is a relatively new capability that permits multiple designers to work concurrently on a single product or a related set of products at multiple locations. Changes being made to a design can be reflected automatically in tools and production equipment that is being concurrently designed. It supports the industry movement to collaboration within a corporation and up and down a supply chain.

Digital Manufacturing — Digital manufacturing is a manufacturing software technology that is gaining acceptance in major automobile and aerospace firms. It establishes a digital or virtual manufacturing world as compared to a physical world by using 3-D CAD models and associated information for visualizing, modeling, and simulating manufacturing processes. The intent is to establish how to most effectively produce a part within resource constraints. Digital manufacturing establishes full automation of the manufacturing planning process.

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By creating 3-D models of factories and production systems and then evaluating multiple production scenarios in the digital environment before a product design is finalized, a production process can be optimized and potential problems can be identified before they occur on the

production floor. Typical applications that fall under the digital manufacturing umbrella include process planning, plant layout, digital mockup, discrete flow process simulation, production scheduling and line balancing, human-machine interaction simulation, worker ergonomics, work cell simulation, and robot programming. The UGS chart (right) illustrates digital manufacturing within a PLM environment.

The CAM market

CAM or NC software is an important tool for manufacturers. Its effective use can result in increased productivity, lower costs, improved product quality, and shortened lead time to market. It is becoming easier to learn and use, and more process-oriented, automated, integrated, and functional.

Some Market Characteristics — The NC software market remains highly fragmented and competitive. There could be as many as 100 vendors worldwide sharing a $1.3 billion market in 2006. By CIMdata measurements, the largest five suppliers have only 45 percent of the market, and the largest 30 vendors currently have only 90 percent of the market. This is far less than most software markets. Partly as a result of this extensive fragmentation, a "thinning of the herd" is beginning to occur as a number of suppliers have recently acquired other vendors, products, or component technologies.

As acquisitions are made, some vendors elected to merge and integrate the product lines, some transfer component technology between the products, and some decide to maintain totally independent product lines and brand names. With acquisitions, the makeup of the market continues to evolve.

Market Segmentation — The worldwide NC software vendors can be segmented in a variety of ways. For example:

• Some are PLM vendors and emphasize information management along with CAD/CAM; some are CAD/CAM providers; and some provide CAM software only and interface/integrate with third party design software.

• Some internally develop essentially their entire product; some license and assemble all components; and some internally develop strategic functions and acquire the rest.

Digital manufacturing as a component of PLM (Courtesy of UGS)

• Some develop their own modeler; some build on a modeling kernel; and some integrate with a full third-party modeler.

• Some vendors focus on specific types of products such as molds, tools, dies, furniture, sheet metal, prismatic production components, or products of complex shape; and some provide a general-purpose capability to machine a broad range of products.

• Some focus on support of specific types of machining such as three-axis milling, continuous five-axis milling, multitask machining, EDM, or Swiss turning; and some support all types of machining.

• Some vendors emphasize full process application solutions; and some offer a collection of design and machining functions.

• Some vendors emphasize data integration across a range of applications from design through manufacturing, including a single-user interface, parametrics, associativity, and transfer of full-design-intent information; and some emphasize "best in class" capabilities.

• Some software suppliers emphasize user-consulting and product support; and some do not.

Buyers of CAM software would be well served to understand the above areas of distinctions among vendors and products and the associated degree of compatibility with their own requirements as they evaluate and select NC software. Of course, there are also other buying factors to consider such as intuitiveness of the products, depth and extent of product functionality, degree of automation, level of technology being implemented, partnerships utilized, business stability, strategic direction, quality of management, knowledge of support personnel, industry reputation, and the cost of products and supporting services.

Product Line Expansion — The NC software market is relatively mature, as the earliest software dates back to the APT and Compact II programming systems introduced in the 1960s. As such, advancements have typically been evolutionary, not revolutionary. Vendors routinely expand their product line either horizontally and/or vertically through acquisition, introduction of new product lines, and/or additional application solutions, functions, and features. This process is expected to continue.

Major trends

Some major technology trends in CAM software in 2006 are as follows:

Process-Focused Software — NC programming software is evolving from the use of a combination of basic instructions to one that provides a broad or complete process solution. A process-focused approach is intended to consider and supply the full needs for a specific type of user. Examples of process-focused application solutions that are now available for design include those supporting core and cavity design, mold base design, electrode design,

progressive die design, and stamping design. Examples of process-focused solutions now available for machining include those for machining of tools, multifunctional machining of production components, support of Swiss turning for high-volume production, and five-axis machining of complex production components.

Each solution incorporates different machining strategies and parameters that are appropriate to the task and establishes default conditions tailored to the application. A process-focused approach simplifies programming, considers the full range of requirements, increases productivity, and establishes programming consistency.

Use of Best-Programming Practices — The use of best-programming practices is a companion methodology to a process-focused solution. CAM software now permits users to capture and re-use their best-machining practices. Libraries of machining strategies tailored to best practices can be established from machining rules, templates, knowledge, and the use of feature-based machining. A set of machining rules can be defined by users based on the material, part geometry, features, and operations to be performed. Or templates from actual usage can be created, captured, and catalogued. The strategies or processes can be stored and then applied to current and future machining tasks. By utilizing best practices, machining methods can be kept consistent, process variables are minimized, quality is enhanced, lead time is shortened, and programming time can be reduced substantially.

Increased Emphasis on Data Integration — Traditionally, the major PLM suppliers have emphasized data integration and the CAM-centric vendors emphasized "best-in-class" applications. Over time, this distinction has blurred as the PLM vendors introduced "best-in-class" capabilities and the CAM-centric vendors both broadened their offerings and became more integrated. Increased emphasis is now being placed on data integration by all types of vendors.

Greater use of Multitask Machines — Multitask machine tools are becoming increasingly popular because of their ability to fully machine a wide variety of parts entirely within their working space without human intervention. These machine tools are

also becoming increasingly complex in terms of being multifunctional, multi-spindle, multiturret, and multi-axis. Material is machined in multiple stages and stock is transferred from spindle to spindle without handling. Effective CAM software is required to provide individual control of each turret, together with turret synchronization, accurate cycle time calculation, and graphical simulation of machine tool motion.

Significant improvement is being made in software for machine simulation, tool path verification, and rendering. Realistic simulation of the entire machining process encompassing the machine tool, holders, machine components, cutting tools, and stock can be made to provide the user with a complete picture of a machining operation.

Greater Use of Feature Technology — In feature-based machining (FBM), a part is viewed as a group of interrelated manufacturing features such as pockets, holes, slots, bosses, and user-defined features. A feature also describes how to produce the shape and specific machining operations are applied to each feature. The programming process becomes more automatic since one does not have to create or manage each machining operation. FBM has been most commonly applied to hole making and machining of prismatic parts in production machining, but it is now being applied to cutting of parts of complex shape.

Automatic feature recognition software as a companion technology is becoming more common in both production machining and moldmaking. It can be used to examine a model, determine which features exist, convert design features into manufacturing features, and extract the features for subsequent processing. The software automatically recognizes features on an imported solid, including faces, splines, all types of holes, bosses, and

closed and open pockets. Most feature recognition software is now applied to prismatic components, but software to support five-axis operations has become available.

Direct Machining of Solid Models — Since most part design is now accomplished with solids-based software, direct solids-based machining is now commonplace in production machining and its usage is increasing in moldmaking. Most software now supports machining on a tessellated solid or surface model and solid and surface machining can be intermixed on a hybrid model.

High-Speed Cutting Becoming Commonplace — Most mold and die operations now employ high-speed machine tools. The software to support this technology must provide for fast and efficient transfer of data, smooth tool movement that minimizes any sudden change in direction, a constant chip load to maximize the life of the cutter, and support of those machine tool features necessary to produce gouge-free, high-surface finish parts.

Machining is sometimes done on actual surfaces as opposed to tessellated surfaces to obtain a higher quality output. Quality problems sometimes occur with high-speed machining, as the material can overheat, cracks can develop, and the material can move. Nevertheless, the use of high-speed cutting has become mandatory for moldmakers and all NC software vendors providing products to this industry must effectively support this technology. High-speed machining typically results in increased performance, accuracy, repeatability, and less hand work to achieve the required surface finish.

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Five-Axis Machining — The use of five-axis machining is growing as the price of the tools is being reduced and the software programming becomes easier to employ. Its usage is now becoming commonplace in moldmaking as well as in aerospace operations. Performing operations on either 3 +2 or continuous five-axis machines that have heretofore been done with three-axis NC machines can result in a number of advantages including an elimination of manual positioning, fewer setups and tool changes, a reduction in in-process inventory, use of smaller and shorter tools, improved surface finishes, and avoidance of EDM that eliminates the

need for electrodes. Machine time is reduced and product quality is usually better because workpieces do not have to be moved from machine to machine for multiple operations.

To ease the programming effort, some vendors have generated standard application solutions that include default conditions and pre-packaged machining parameters and strategies for specific types of complex components in which five-axis machining is typically

discrepancies between the target part and the machined part are shown. By comparing an in-process model with the designed part the rest material can be displayed. Rendering software provides for photo realistic images of a machined part. The verification and simulation software is also becoming more highly integrated with the tool path generation software and some vendors perform simulation within the CAM module.

In summary, the manufacturing and
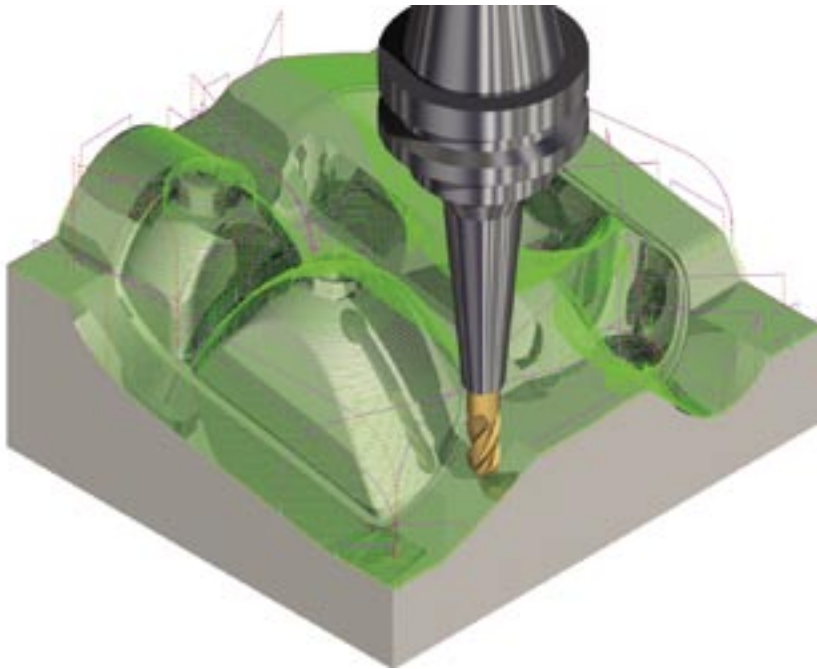
High-speed cutting with Delcam PowerMILL

employed. These include standard processes for machining components such as turbine blades, impellers, blisks, tire molds, tubes, and pipes. By so doing, best practices can be captured, consistency can be obtained, quality improved, and NC programming time reduced.

Emergence of More Realistic Simulation — Significant improvement is being made in software for machine simulation, tool path verification, and rendering. Realistic simulation of the entire machining process encompassing the machine tool, holders, machine components, cutting tools, and stock can be made to provide the user with a complete picture of a machining operation. Kinematics and other characteristics of a machine tool can be considered. Simulation of a tool path is provided to verify its accuracy. Collisions, gouges, undercuts, and any

CAM software world should be an exciting time for users and vendors alike. The technology continues to advance, the software is more intuitive, process-oriented, functional, and automated, users are receiving greater value for their investments, and through its use producers can better compete in a highly competitive, but growing worldwide marketplace and also improve their financial performance.

Alan Christman is chairman of CIMdata, a leading and independent worldwide strategic consultancy "dedicated to maximizing an enterprise's ability to design and deliver innovative products and services through the application of PLM solutions." CIMdata works with both industrial organizations and suppliers of technologies and services seeking competitive advantage in the global economy. **CIMdata Inc., www.rsleads.com/611tp-158**