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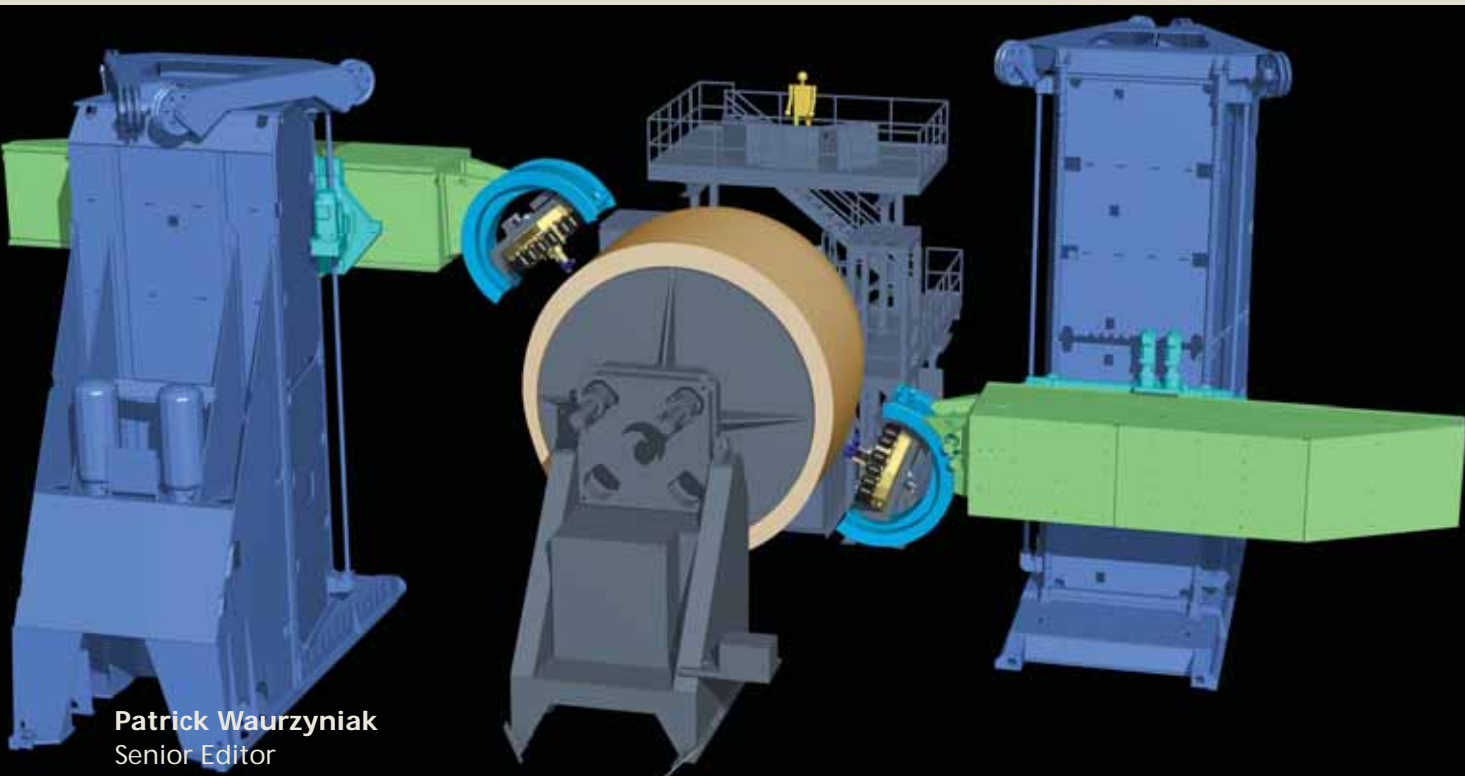
## Visualizing Manufacturing

Drilling is Only  
the Beginning

The Tricky Business  
of Fluid Selection

# *Visualizing* Manufacturing

*Advanced 3-D simulations offers manufacturers  
a more realistic view of the factory*



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**The new Vericut Composite Simulation software simulates an automated fiber placement process on a Boeing 787 fuselage built with equipment from aerospace supplier Electroimpact.**

**W**ith competitive pressures greater than ever, manufacturers need to cut costs and compress product-development time-to-market cycles as much as possible. New advanced 3-D simulation tools can help manufacturers wring out costs and speed development by using much more advanced 3-D visualizations, ranging from systems displaying highly realistic views of NC cutting toolpaths to full machine simulation, and to enterprise-level digital manufacturing/PLM systems.

Simulation software takes on many forms, including packages offering 3-D animations of the NC toolpath processes, full machine-level simulation with collision-checking capabilities used with complex machine tools, and factory-floor planning and validation tools that help manufacturers prove out metalcutting processes prior to actually cutting metal or finalizing factory layouts. The current crop of simulation software aims to offer a level of realism that was unattainable in recent years.

**Complex NC toolpath and machine simulations** pose significant, computationally intensive hurdles for manufacturers, requiring very efficient simulation software and higher-performance computers. With its Vericut NC toolpath simulation software, CGTech Corp. (Irvine, CA) helps machine tool users accurately simulate cutting-tool



**New Jack human modeling in Siemens PLM Software's Tecnomatix 9 adds realism to simulations.**

motions prior to cutting metal. In its latest Vericut Version 7.0 update, CGTech has re-written and improved the software's main motion-processing loop, according to Bill Hasenjaeger, CGTech product manager, which helps speed up simulation performance by approximately 15-20% over the previous version.

The Vericut software, which runs on both Windows and Unix-based systems, offers not only NC and full-

machine simulation but also NC toolpath verification and optimization capabilities. "We took a look at Vericut's main motion-processing loop, to see how we could improve it to achieve some things our customers were asking us to do," Hasenjaeger says. "We did a huge amount of work, essentially storing much more information as we're processing the NC programs, storing more information about the individual motions, so the user can look at a piece of the NC path, see what's happening, and replay it in more detail."

Compared to CAD/CAM systems, NC simulation and verification tasks put a lot more strain on computer systems, requiring fast processors and large memory capacities to perform as well as needed, Hasenjaeger adds. "CAD/CAM systems are honestly not that computationally intensive," he says. "They have some graphics, and you do some toolpath computation or some CAD modeling computation, but they're little flurries of activity based on the user poking some buttons, with lots of inactive time. The software reacts at human speed, more or less.

"With Vericut, because we throw an NC program at it, which it has to process continuously for a long time, it's intensively computing for an extended period, while it's simulating the program," Hasenjaeger states. "We're similar to FEA in that we have this large computational set, which is the NC program for us, and we're having to read this and do literally dozens of solid-modeling operations per second. Vericut has a very purpose-built computation engine for doing that. So that's sort of one side of the computer nightmare. The other side of it is, we are an animation program. At the same time we're doing this intensive computation, we're animating its results, so not only are we computationally intensive, we're graphically intensive."

**Simulating with Vericut** usually requires a higher-performance Windows-based PC equipped with a lot of memory, he notes. Vericut is offered in 32-bit and 64-bit Windows, the latter able to access even higher amounts of RAM. "The 64-bit Windows has a really big upper limit—it's just computer science, but 16 terabytes is the addressable limit for a 64-bit word. The hardware doesn't support that yet, but the operating system would, if the hardware could. What we're seeing is our high-end users are running 12 or 16 GB of physical memory. And that's about the limits of conventional hardware these days.

"When you're simulating an NC toolpath or NC programs, you're really hitting the three major subsystems on a computer—you're hitting the computation limits, the graphics limits, and memory limits," Hasenjaeger observes. "You're maxing everything out when you're running simulation—not just Vericut—but in general that task hits everything. That's why I often say 'We're hardware's

worst nightmare.' We spend a lot of time focusing on that, because the truth is Vericut and any simulation package is never, ever, fast enough. And so performance is just a huge part of our day-to-day concerns when we're doing anything in software."

**Composites simulation** is an example of a compute-intensive application. CGTech now offers its Vericut Composite Programming (VCP) and Vericut Composite Simulation (VCS) software packages, which Hasenjaeger says were developed after Boeing Co. (Chicago) asked the company to create a system to use with CNC automated fiber placement (AFP) machines deployed at large aerospace suppliers. These suppliers include Electroimpact Inc. (Mukilteo, WA), which is building equipment to create the large composite airframe pieces for Boeing's new 787 Dreamliner aircraft. Robust computers are needed to run the VCS software in many aerospace applications, he adds. "If we're simulating a wing spar layup that is 60' [18.3-m] long, we're trying to detect very small features, because they're machining very thin quarter-inch [6-mm] strips of material on this long piece, and having to resolve down to a really small size.

The Vericut composite programming and simulation is the first machine-independent software package for AFP machines, notes Hasenjaeger. "What really prompted this was Boeing and the 787. The process technology for what they wanted to do didn't exist," he adds. "Boeing was extremely interested in somebody developing software that was machine-independent."

CGTech initially started working with Boeing in 2004. The company recently has demonstrated its VCP and VCS applications, and aerospace builders are now using the software to craft early-production composite workpieces. "It's moved along and ultimately culminated in an order for a production version of the Electroimpact machine, with our software supporting the machine," he says. "That machine went to the former Boeing Wichita, which is now Spirit AeroSystems. They're building section 41 of the 787, the front fuselage section, which is the biggest piece of the airplane, the most complicated fuselage section, which includes the cockpit."

**Digital manufacturing**, a subset of enterprise-wide PLM systems used by mostly larger manufacturing companies, also has made strides in offering realism in simulations that are employed in planning and proving out equipment used on the factory floor. Recent advances by PLM software developer Dassault Systèmes' (Paris) Delmia Automation (Auburn Hills, MI) unit offer improved digital validation and commissioning of PLCs used in factory-floor machines.

"This technology, which we have put into full production at companies like General Motors, has created tremendous value for GM and other manufacturers,"

notes Peter Schmitt, Dassault Systèmes vice president. "This development is the partnership we have with Rockwell, Omron, Mitsubishi, Schneider Electric, pretty much all the traditional PLC manufacturers.

"If you launch a new vehicle, you typically need a new piece or a modified piece of equipment to do that, and that's often mostly outsourced to one of the hardware manufacturers. What is happening is they design it mechanically, and then they set up that equipment physically in their location, test, and optimize the PLC code which is running that equipment. After that is done, they tear down the equipment, transport it to the OEM, rebuild it, revalidate it, and re-optimize under the given conditions there. It's very time-consuming, there are always delays, and delays are the last thing you need when you face the tremendous pressure of getting a line and the PLC software up to production rate."

With Delmia Automation's solutions, manufacturers can compress the time required for digital simulation, validation, and commissioning of new or redesigned factories, he adds. "Typically what we see is companies launching equipment in a sub-optimal way, because they don't have enough time to properly test it out, properly drive the production execution speed, and in some cases, they haven't even tested out all the kinks that the system might have," Schmitt says. "If you run into an issue in production, there's no defined recovery, how you get the system back up online, and you have to get the line manufacturer back in to help you sort that out. There is a lot of potential for error, for delays, and it all results in a tremendous amount of cost."

**Digital validation and commissioning** allows manufacturers to greatly increase efficiencies while cutting costs dramatically, he adds. "When we help create the mechanical kinematic structure of that piece of equipment, we can utilize that code to validate it against the PLC program," Schmitt says. "So instead of plugging your PLC into the machine, you're connecting it to your computer, and you can see the behavior of that equipment against your actual PLC code. Therefore, you can predict productivities, and you can validate all possible states the equipment can take. You can develop strategies on how you recover from emergency situations, such as a lack of air pressure or power. You can ensure that, for each of those scenarios, you have a recovery plan. You know how to get the machine, the line, back up to a nominal behavior, to regular operation without causing any damages to the equipment or to the workpieces, or even more important, to humans who are working along that line."

The Delmia simulations can include actions by humans and machines on a factory floor, using 3-D simulations in Delmia Assembly Human, Schmitt notes. "We simulate

everything that moves in an automated line," Schmitt adds. "All the actors, all the sensors, all the robots—everything is simulated, and we are optimizing the orchestration of all those devices. It's absolutely accurate; we know exactly the cycle times, and the behavior of each of the components. And that is true not only for electronic components, it's also true for pneumatic and hydraulic components."

**Realism in simulation has improved** at many levels in manufacturing in recent years. From factory-floor layouts to NC and machine-level simulations, software solutions from Siemens PLM Software (Plano, TX) offer highly realistic 3-D simulations that show detailed processes in assembly, robotics, and in machine cutting motion.

"Simulation is one of the key cornerstones of digital manufacturing," notes Stefan Linner, vice president, digital manufacturing, Siemens PLM Software (Plano, TX), a unit of Siemens Automation & Drives (Nuremberg, Germany). "We are offering different solutions to different industries that cover specific workflows, like Body-in-White planning, or planning processes of part manufacturing, or assembly planning. In each of these solutions, we have a simulation component to validate and optimize these concepts. The simulation validates things upfront, before you go to the shop floor, and gives you the ability to simulate and optimize processes."

**Improved human simulations** will be available after Siemens PLM introduces its updated Tecnomatix 9 software, which will include a new Task Simulation Builder. The update, scheduled to be introduced this month, builds on the Tecnomatix Jack human-modeling applications for the factory.

"We have a new human model in terms of the look, which has a smooth skin model, so it really looks like a real human," Linner adds. "This is important, because the acceptance you get from the simulation is much better if people feel that the human on the screen looks like a real human. You can scientifically do the same analysis with a human that looks like a robot, and people don't believe that the ergonomic analysis can be true. If you look at a very complex assembly situation, where you have very little room

and you really need to find out if the fingers can get in there or not, it's important to have a geometry that really resembles a human, where it's not too simplified."

Since Siemens acquired UGS in 2007, Siemens PLM Software has been working on several elements of its Archimedes Project, which includes virtual commissioning and Hi-Fi machining, the latter an effort involving tighter integration of CAM software with Siemens' Sinumerik CNC controls (see "Enter the Virtual World," in the October 2007 issue of *Manufacturing Engineering*.)

"Virtual commissioning is a bigger thing—it's not just connecting a controller to a 3-D environment and having them run together," Linner explains. "We created a completely new generation of robotic simulation that we call Process Simulate Robotics, which allows for very smooth workflow during the virtual commissioning. Now, it's actually one step in the process of planning and simulating your automated robot line."

Siemens also is creating tighter integration between CAM and CNCs, including simulation of its Sinumerik CNC using the control's Virtual Numeric Control Kernel (VNCK). "We've had some progress with developing optimized post-processing, optimizing output from the CAM system to take advantage of the advanced functions on the Siemens Sinumerik controllers," says Vynce Paradise, NX CAM product manager, Siemens PLM Software, "to an extent that we would not have done before. What we've also done in the case of the VNCK is that we can take software from the real software controller and we can embed that inside NX as an option.

"Our aim is to improve the overall machining process by being able to take advantage of the advanced functions of the controller," he adds. "A better connection between CAM and controller is really the over-arching theme. The simulation is a piece of that, but the main element is being able to achieve higher performance, perhaps a higher-quality finish on the part, by optimizing the output from the CAM system to take advantage of the functions of the controller." ■