Next-Generation Manufacturing processes for Composite Tooling & Trimming

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Learning Objectives

- Speed up programming of composite tooling
- Eliminate manual part setup on the machine tool
- Increase the accuracy and repeatability of part setup
- Drastically reduce or eliminate costly scrap and rework

Description

Advanced composite materials are replacing more and more metal components in a variety of industries, most notably, the aerospace industry. While there are many benefits to using composite materials, there are also inherent challenges when working with composite materials. Composite structures are often formed into complex organic shapes, and they're subject to tighter tolerancing and accuracy requirements than is a similar component made from plastic or another material. This creates the need for highly accurate, often complex mold tools and patterns to be machined. PowerMill software and PowerShape software are uniquely suited for rapidly producing high-quality composite tooling, as we'll demonstrate in this course. Another significant manufacturing challenge is machining the completed composite piece. Companies often employ the use of highly complex and expensive fixtures in attempts to accurately align and set up the part for machining while minimizing the time they have in non-productive, manual setup processes. This course will demonstrate how PowerInspect software can make possible the use of simple, inexpensive work holding while increasing accuracy and repeatability of the part setup. This tool can also be used to verify the machining operations before the part is moved from the machine, making any required rework much faster and simpler, and significantly reducing the common bottleneck at the quality department.

Speaker(s)

Jon Caliguri, Director of Sales

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Design and Software International, Inc.

Design and Software is the Autodesk Digital Manufacturing Master Reseller for North America. Founded in 1989 by Jim Caliguri, owner and journeyman patternmaker, Design and Software has the largest senior applications team in North America for the former Delcam PowerSolution Products (PowerMill, PowerShape, PowerInspect, FeatureCam, ArtCam, and now NetFabb and Fusion 360). Design and Software home office and training facility is located in Fairfield, OH, a satellite office was added in Hampton, VA earlier in 2017. DSI has the widest range of experience in the market, and offer advanced consulting and automation services for the Autodesk DMG portfolio of products as well.

Ed Hilligrass, CSO & Executive Vice President
Patrick Bollar, CTO & Founder
Diversified Machine Systems, Colorado Springs, CO.

Diversified Machine Systems (DMS), a privately-held corporation with headquarters located in Colorado Springs, Colorado, is an industry-leading designer and American manufacturer of 3 axis and 5 axis CNC routers and machining centers. We supply machines to a wide variety of manufacturing sectors including aerospace, automotive, marine, recreational vehicles, 3D sculpture, concept models, pattern making, formed plastics and woodworking among others.

The Founders

The founders of DMS are highly-talented engineers, each with over 30 years of machine tool design and CNC machining experience, which translates into a diverse product line with structural integrity, performance and features not available in any CNC machining center of this class or price range. *Meet a few of them in this video.*

Our Capabilities

The company offers a full line of standard 3 and 5 axis CNC machines, in addition to custom router and machining solutions. All engineering, structural fabrication and machine assembly takes place at our DMS facility in Colorado Springs, Colorado. DMS' capabilities include complete in-house mechanical and electrical engineering, welding and steel fabrication, a fully-equipped machine shop, a large scale CNC machining center, mechanical and electrical assembly operations, control system integration and final test processes.

Quality Assurance

The DMS Quality Assurance Program pays close attention to every detail in order to guarantee that each machine is of the highest quality and standard of reliability for any CNC router available on the market. In addition to manufacturing 3 Axis CNC routers

and 5 Axis CNC machining centers, the company provides full technical product support and a complete spare parts inventory. With our expertise and unwavering commitment to quality, DMS is able to meet the strictest tolerance standards required by our clients in the automotive, medical and composites industries. As our customers continue to develop new uses for our advanced CNC machining centers, we adapt to meet their needs.

Awards & Recognition

DMS was awarded as a <u>2014 Colorado Companies to Watch Winner</u>, named a 2015 Made in Colorado Award Winner, and ranked #101 in the <u>2014 Top 250 Private Companies in Colorado</u>, and chosen as a 2015 ACG Denver Growth Awards Nominee. DMS was also honored with the 2013 Regional Business Alliance Excellence Award given by the Colorado Springs Regional Business Alliance.]

Speed up programming of composite tooling

Autodesk PowerMill is the leading CAM solution for programming of composite layup tooling. There are many reasons that PowerMill is such an effective tool for this sort of work, among these are:

Project Mirror – Advanced composite materials are particularly common in Aerospace & motorsports applications. Both of these industries, along with the automotive and medical industry, very commonly have parts which contain components that are both left-hand and right-hand orientation, as they are largely symmetrical. Headlight molds, Airplane Wing components, etc…   PowerMill the ability to mirror complete machining projects in one operation and to maintain automatically the machining characteristics, for example to choose automatically whether climb or conventional milling should be used in each section of the toolpath. Previously, only individual toolpaths could be mirrored.

Automatic mirroring saves considerable time whenever right- and left-hand versions are needed of a part or tool. It will also be faster to program the machining of symmetrical objects since it will be possible to program one half and then mirror the toolpaths to complete the program. To ensure that the mirroring has performed as expected, the new option can be used with the ability to undertake complete verification of a project for machine-tool issues such as collisions. Comprehensive verification can be performed, including ensuring that the machine tool is capable of running the mirrored toolpaths, as well as checking for both machine-tool collisions and tooling collisions.

Dynamic Machine Control – Composite tooling commonly consists of organic shapes and complex surfaces, and can often grow very large in size to accommodate large components where weight savings are a driving factor. Because of these characteristics, and because of the popularity of dual-use milling-trimming machines, 5-axis machines are very common or necessary for this work. 5-axis machine tools introduce a level of complexity and anxiety when it comes to programming. The programmer needs to ensure that he/she does not create a collision between machine, fixture/work-holding, material, tool holder, and tool. Robust, accurate and fast 3D machine tool simulation is critical to be able to do this effectively. Programmers in most competitive systems are forced to guess and check their tool stick out, tool orientation angle, tool holder collision state, and subsequently program some or most of the part multiple times which is very inefficient. PowerMill has the ability to show in real time, the live collision state of the tool as the programmer dynamically moves around the part and drags the different axis of the machine into a position the can safely machine the part or area the user wishes to address. The programmer can drag and move the spindle away from collision area, and create better tool approach within the simulation. Because the simulation tool is driven together with Post processor, NC code will update automatically, and the machine will move accurately to the machine kinematic.

Template and Macro Automation – Many companies that manufacture composite tooling follow a similar process from job to job. The geometry of the parts themselves may vary greatly, but in PowerMill that does not mean that the programming of these tools can't be largely if not entirely automated. Composite tooling can be made from a multitude of materials, chosen based on the characteristics and properties and processes involved in the final part.

For parts cured at low temperature, where dimensional accuracy isn't of foremost importance, high-density foams, machinable tooling board, or wood models often are suitable. Tooling costs and complexity increase as the part performance requirements and the number of parts to be produced increase. High-rate production tools are generally made of robust metals that can stand up to repeated cycles and maintain good surface finish and dimensional accuracy. The molds in which high-performance composite parts are formed can be made from carbon fiber/epoxy, monolithic graphite, castable graphite, ceramics or metals, which are typically aluminum or steel. One of the most difficult to machine, and most costly, are made of high-performance steel alloys, such as Invar.

Regardless of what the material is, if the jobs are sufficiently similar, PowerMill automation can apply templates, load in commonly used tools, apply toolpaths automatically to the entire model, or defined subsets of the model to complete multiple machining operations from roughing, rest-machining, corner finishing, automatic 5-axis collision avoidance finishing paths, and much more.

Eliminate manual part setup on the machine tool

Autodesk PowerInspect Ultimate is the software solution used to accomplish what is defined in this presentation as Software Fixturing.

Free-Form Surface Location
Automated software fixturing system for multi-axis machines with advanced coordinate rotation capability. The powerful fitting algorithms can precisely align the component before exporting the alignment seamlessly to the machine tool control. This gives more consistent results than a manual set-up process, improving quality and productivity.
Benefits:
• Reduces part variation and improves quality
• Reduces process steps and set up times
• Minimizes the chances for errors
• Reduces and the need for costly fixtures
• Improves process planning by minimizing variation in setup time
• Aligns to nominal size, maximum or minimum conditions, or to a tolerance zone
• Can be used with existing NC Programs without the need to re-calculate the tool paths
• Reduced customer concessions save time and money

Reporting and Traceability
PowerInspect Ultimate creates reports of fitted and pre-fitted results, providing a record of the accuracy of the initial part setup and any changes required.
Benefits:
• Ensures that physical setups remain within acceptable limits
• Measures physical setup consistency
• Monitors performance over time
• Reviews and improves processes
• Archives provide traceability
• Monitors component quality
Autodesk PowerInspect Ultimate can be incorporated into your existing manufacturing processes and does not require changes to your proven machining programs. The operations and reports reduce the need for additional inspection operations. Archived reports on the results of each operation within the process provide valuable information for future process review

Increase the accuracy and repeatability of part setup

No manual intervention is required, this method of part setup is much more accurate and scalable
Simplifies automation of manufacturing process for lights out production, unattended machining
Optimised set-up for every part, not just the fixture
Constant set-up time for more accurate production
        planning and scheduling
Much more efficient use of highly-skilled labor and
        costly CNC Equipment

Drastically reduce or eliminate costly scrap and rework

- Identify part defects before the machining process - eliminates machining of parts that will not conform to requirements
- On-Machine Verification allows for immediate decision making on non-conforming machined parts – rework while on machine
- Reduce the bottleneck at the CMM by ensuring a conforming part every time with On-Machine Verification, and removing non-critical items from dedicated CMMs altogether
- Use in-process checks to ensure proper machining without violating critical surfaces in high value parts
- High-quality CNC machines and touch probes are often more accurate than devices used to inspect very large tools and components

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