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Digital manufacturing

Design, capture and re-use digital data

by Steve Krar and Arthur Gill

Today, digital manufacturing reaches all aspects of manufacturing from product design to customer service. CAD/CAM, CNC, CVD, DCA (Design and Costing Automation), EDM, FMS and SPC are a few of the technologies that use some form of digital manufacturing to design, manufacture and sell a product.

Digital operations should closely tie together plant sales, engineering, automation, supply, manufacturing, management and business systems. All of these must work together as a cohesive unit to reduce waste and save money. Time to market is critical for any manufacturer and everything that reduces product-development time, has a direct effect on how soon a product gets to the market, and how much market share a company can capture.

Above: Software from Tecnomatix Technologies, featured above, allows manufacturers to test and validate assumptions prior to manufacturing. Tecnomatix developed its eMPower line to address "how" a product has to be manufactured and provides the link betwen product design systems that address"what" has to be manufactured, and shop-floor execution systems that address "when and where" (www.tecnomatix.com)

A progression of technology
In the past, technical part prints were made, and the part was manufactured using conventional machine tools and machining processes. It was not long after NC was introduced to machine tools, that computer-aided design (CAD) started to replace drafting as a means of producing technical part prints. Eventually, this evolved into CAD/CAM where the information data on CADgenerated prints was used in CAM (computer-assisted manufacturing) to manufacture a part.

The next logical step in the manufacturing process was agile manufacturing processes and systems, supply chain integration, and collaborative product design and engineering. The introduction of rapid prototyping and manufacturing RP&M) was for the design and production
of prototype models, to reduce or eliminate manufacturing errors, and to bring products to the market faster, and at lower cost. In any manufacturing company, the combination of many technologies fits into:

- Enterprise applications such as DCA (design & costing automation), ERP (enterprise resource planning), SCM (supply chain management) and CRM (customer relationship management);
- Plant systems that meet the needs of shop floor automation; and
- Plant automation and controls that track and monitor the operation.

In the future, a new type of Internet appliance, the digital fabricator or fabber, will allow people to download the digital description of a product and have it made immediately and automatically. While fabbing of consumer products in peoples'homes is in the future, today's fabbers have become important in high-value, time-critical business applications such as:

- Salespeople can configure, visualize and price complex product variations in minutes without technical assistance;
- Automotive engineers can take months off time needed for new car designs by validating design concepts;
- Aerospace engineers can manufacture low-volume, flight-ready hardware, saving the cost and avoiding the delays of expensive tooling;
- Surgeons can model patient's bones, allowing them to practise surgery on a plastic model; and
- Digital artists can make sculptures that cannot be made any other way.

Tools of digital manufacturing
While the fabrication machine plays a central role in digital manufacturing, the entire picture involves several technologies:

1. A product knowledge model (PKM) engine programmed with a company's configuration, design and process details.
2. 3D CAD (computer-aided design) is the basic tool for creating and changing the design of a product.
3. 3D scanners that digitize the whole 3D shape of a solid object.
4. Some type of fabricating machine that makes things automatically from digital data.
5. The Internet that ties together the computers, scanners and fabrication machines to form a global-spanning communications network.

Above: The SLA 7000 series by 3D Systems allows for large part creation. Their patented stereolithography and 3D printing processes fabricate solid physical objects from digital input. (www.3dsystems.com)

Engineering without borders
The key to digital manufacturing is to get the product to the market quickly and a key place to save time is in the product developmental stage. The manufacturers, who get high quality new products to the market quickly, generally get the lion's share of the market and keep customers longer. There are numerous manufacturers that provide software programs for product development and only some of the most comprehensive ones are covered in this article.

Advanced digital manufacturing
A relatively recent technology, advanced digital manufacturing ADM), is a reliable and cost-effective method of making end-use parts for pre-production or production applications. It was developed by 3D Systems (www.3dsystems.com) and is expected to become a key technology for the customization of design and manufacturing, also called mass customization.ADM is a comprehensive technology that covers the production of a part starting at the design stage, progressing through the prototype development, and ending with the manufacturing stage.

Recent advancements in laser sintering (LS) and stereolithography (SL) technology have made advanced digital manufacturing an alternative to some conventional manufacturing methods. The aerospace industry has used LS technology to manufacture nonstructural aircraft components. Manufacturers of hearing aids have recognized the value of the LS and SL technology in the production of custom fitted in-the-ear ITE) devices. The fundamental benefits of direct ADM are: no tooling required, the ability to design for function and not for a conventional and limiting manufacturing process, significant cost savings for low production runs, and design changes that can be made quickly at a very low cost.

Above: The Stratasys FDM Titan uses high-performance engineering materials including ABS and polycarbonate to create parts with superior strength, heat resistance and chemical resistance. This system can build large, strong and durable prototypes. (www.stratasys.com)

Some of the main features of advanced digital manufacturing are:

- Designers and engineers are able to add custom features and complexity to designs;
- ADM opens up new product design possibilities that were not possible to manufacture using traditional tooling, molding and casting methods;
- The number of steps in the engineering and manufacturing phases are reduced, saving time and money, thereby reducing part and product cost, and reducing the time it takes to get a product to the market;
- The use of solid-imaging systems to speed the production of customized/specialized parts;
- The ability to manufacture a product using additive fabrication techniques will greatly change the present design and manufacturing methods; and
- The costs and lead time associated with hard tooling is eliminated and more complex designs will be easier to manufacture.

A typical ADM center may contain multiple solid-imaging technologies such as SLA (stereolithography apparatus) systems, SLS (selective laser systems), and MJM (multi-jet modeling) printer supporting advanced digital-manufacturing applications. ADM is the shifting from mass-produced off-the-shelf goods to goods specifically customized to individual customer's tastes. Thereby, offering a greater range of product choices better suited to the tastes of individual customers.

ADM hardware components
The major components of ADM systems are as follows:

1. Stereolithography apparatus systems produce highly detailed 3-dimensional (3D) parts with fine surface quality. The stereolithography process involves digital data (CAD), and a laser beam to expose and solidify layers of liquid photosensitive polymers into solid cross sections layer by layer, until the desired part is formed.
2. Selective laser sintering (SLS) systems are primarily used to produce functional parts, for use in pre-production and production applications. SLS technology is used for the direct manufacture of small lot quantities of plastic or metal parts from CAD digital data. Laser energy is used to melt and fuse, or sinter powdered material to create a solid object.
3. Multi-jet-modeling (MJM) uses hot-melt ink jet technology to build 3D models in successive layers using thermoplastic materials. Parts are created from digital data by depositing material onto a build platform — layer by layer — using an ink-jet style print head that moves back and forth, following the information from the CAD design.

CoCreate
CoCreate (www.cocreate.com) produces CAD and collaboration software to design products, share ideas and manage data. Its OneSpace Designer CAD products include:

- CAD software that works well with any imported data as well as with data created;
- The ability to allow people to interact in real time regardless of where they are located geographically; and
- The ability of handling any type of imported file.

Another important feature of the CoCreate program is OneSpace Collaboration that improves communications throughout the design process, resulting in effective design reviews and timely feedback. It allows people to reach common understanding on a product design and resolve any issues that may arise by sharing documents and designs either off line or in real time. The designs are eventually 100 percent accurate because all can view, measure, section and change designs in real time. Advantages of systems such as CoCreate are:

- It can make a company more competitive, increase productivity, and boost efficiency;
- Faster time to market with high quality products;
- The return on investment averages 60 days or less;
- Saves time and money by cutting developmental time dramatically, lowering costs and improving products;
- It is easy to learn and implement quickly; and
- Increased customer satisfaction because goods are shipped sooner.

Above: 3D carburetor parts from Z Corporation (www.zcorp.com) printed out in full colour. This helps communicate important information, including engineering data, labeling, highlighting and appearance simulation. Quick access to full colour concept models allows engineering to accurately communicate design ideas.

Tecnomatix eMPower MPM
Tecnomatix Technologies, (www.tecnomatix.com), developed the eMPower platform to help manufacturers unify their manufacturing technologies and plan their entire manufacturing process by using the Internet to tap the knowledge of their partners. Some users in the manufacturing industry mistake manufacturing process management (MPM) with product life cycle management (PLM) systems.

PLM is a computer-aided platform that supports a range of systems for the creation and management of information during the life cycle of a product. MPM software, an essential component of PLM, provides the capability and know-how for the manufacturing process. MPM is an evolution of CAPE (computer-aided production engineering) and an extension of e-manufacturing that allows manufacturers, together with their trading partners to plan, simulate and optimize precisely how a product will be built.

There are three major advantages to the MPM system:

1. Cost savings due to fewer engineers involved in the manufacturing planning for new products and more efficient designs;
2. Design input can be integrated from various sources in real time, resulting in better designs; and
3. The product cycle is becoming shorter and as a result products are getting to the market sooner.

Above: NeXtreme Automation developed Web-based software customized to help capture a company's unique design knowledge and fabrication experience. Pictured above is a 3D model of a pressure vessel and fan.

A Canadian player emerges
Tryllium Industries (http://www.tryllium.ca) of Cambridge, Ontario offers companies "design and costing automation" (DCA) for engineered products that allows them to adapt product design quickly. The objective is to identify, formalize and computerize the design rules and parameters that define all possible product variations. This complex problem requires a full set of rules for the full range of products. It defines 3D geometry and drawings, defines the assembly rules, relates the fabrication process with the type of product, and integrates bill of material data.

The main idea of NeXtreme Automation is to share product knowledge and avoid errors in understanding common with traditional methods of conveying information. This DCA platform has the ability to greatly reduce product development time from many hours to minutes while enabling non-technical people to drive engineering processes. The main purposes of NeXtreme Automation is to provide:

- A sales tool to deliver competitive advantage with 10-minute calculated quotations for engineered products.
- An engineering tool to eliminate the routine, endless work of quoting and drafting while trying to secure business.
- An administrative tool to track sales opportunities and project material plus labour requirements for outstanding quotations.
- A human resource engine that knows how a company designs, prices and builds proprietary products.
- A Web-based platform that works internally, externally and even in a customer's own office.

Engineer-to-order manufacturers can devote up to 10 percent of annual revenues designing and costing product for sale to customers. DCA technology like NeXtreme Automation eliminates the fixed cost of redundant technical work.

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