Realizing the Value of GD&T in Model Based Definition (MBD)

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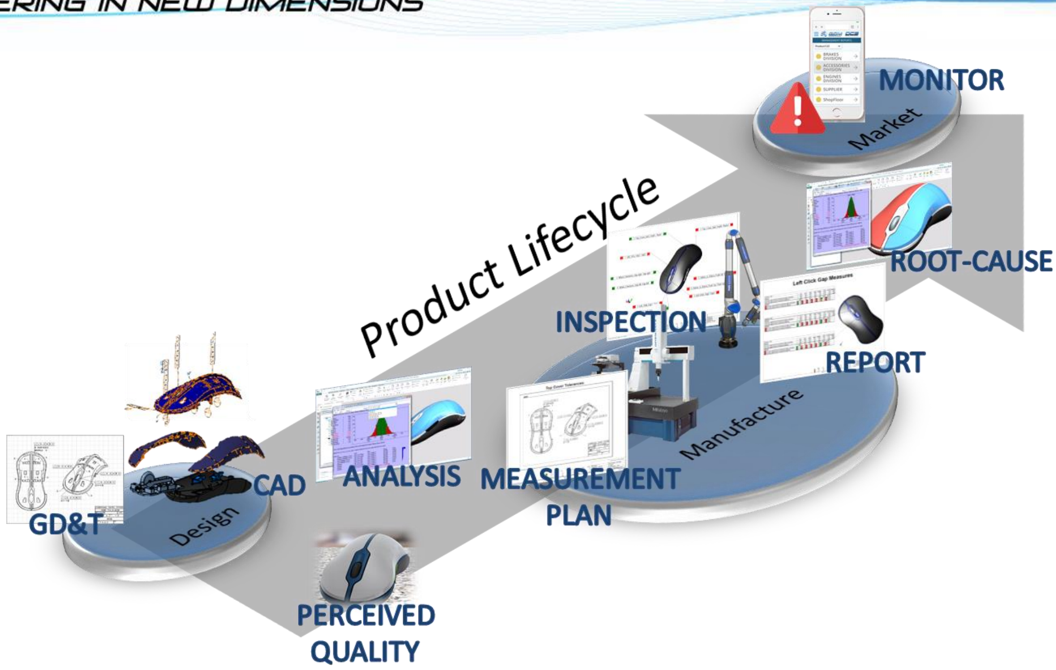
It is all too common in the industry: A part design is created and sent out for production only to hit repeated snags as questions arise about datums, locators, symbols and values. Even simple misunderstandings, such as where the Geometric Dimensioning and Tolerancing (GD&T) lines terminate, have resulted in serious delays (in some cases, of more than a month) and nonconformance issues, which resulted in wasted products.[1]

Companies that still utilize 2D drawings in their product life cycle are doing more than simply ignoring the increased productivity that comes from the streamlining of their models. They are also failing to provide their customers the best, most cost-efficient products and services that can only come from implementing a single comprehensive digital model that all stakeholders can effectively utilize. Moving away from 2D renderings (or even a hybrid approach with a 2D original and 3D model) to a completely digital design solution offers a wide range of benefits. Companies that incorporate digital GD&T with model-based definition (MBD) 3D models can create more accurate representations that speed up the design and production processes, reduce waste and improve communication and collaboration across all teams involved in the design and manufacturing process.

Getting standardized with MBD

Originally birthed in the aerospace industry because of the critical need for tight tolerances, increasing numbers of manufacturers are turning to MBD for their design requirements. MBD, also sometimes referred to as the "digital product definition," allows for the migration from 2D paper-based drawings to comprehensive 3D CAD models. The models created via MBD include all of the necessary information required to generate the part so no other files or drawings are needed. This reduces the need for an extensive collection of additional paper files or backups.

MBD is about streamlining the design and manufacturing process. It also results in parts that integrate into their target systems in a more seamless fashion, resulting in better outcomes and less waste. Importantly, MBD, which is based on the 2003 ASME Standard Y14.41-2003 Digital Product Definition Data Practices, allows designers to directly include GD&T data in the 3D CAD model.[2,3] MBD offers a broad range of benefits. It reduces the amount of manually reproduced data (as well as the errors inherent in that process) and diminishes the number of errors in a design. MBD also improves communication between designers and other stakeholders and boosts response times.[4]



A new master: The 3D model

Although GD&T and MBD have sometimes been confused, GD&T actually sits under the umbrella of MBD. GD&T, based on ASME Y14.5M-1994[5] and ISO 16792 3D,[6] is a concise language system that defines and identifies the features and attributes of a part. It forces designers to think about the functionality of a part in light of its final product.[7] Digital GD&T is the incorporation of that system in a virtual environment, such as CAD. It is an essential part of MBD and promotes its use by making the artifact more user-friendly to stakeholders who have limited understanding of the system. For example, tolerances are more clearly defined in a 3D model than on paper.[8]

Using only one 3D CAD model with all necessary data means turns the model into the master source. Since stakeholders all have access to the same model, better collaboration is possible. The MBD model eliminates redundancies throughout the design and manufacturing process and allows for the reuse of model definition data in downstream applications. MBD also improves a company's ability to inspect and report part quality across the supply chain. It helps to improve the quality of both designs and finished products, reduce the time to market and boost the communication between the various stakeholders involved in the manufacturing process, such as the designers and suppliers.

A number of large companies already utilize MBD to support corporate, design and manufacturing objectives, such as Boeing (one of MBD's early adopters), Raytheon Missile Systems Company, General Motors, and Caterpillar.[9] MBD promotes quality throughout the design and manufacturing process via standardization and limited human-driven modification. Since MBD is scalable, it can be used for everything, from model-based engineering and manufacturing to the complete product lifecycle management.[10] At its heart, digital GD&T best serves MBD by making the tolerances of the figure more understandable and universally understood.

Digital twins can avoid double work (and waste)

Many businesses, however, are still clinging to 2D drawings or a combination of 2D and 3D renderings.[11] Although 2D drawings may feel comfortable to use, they can actually cause problems throughout the design and manufacturing process. For example, any change made to a 2D drawing has to be manually applied. Unfortunately, drawings can be modified at any point along the workflow, leading to problems with the resulting manufactured part (and eventually, the entire system).

The hybrid approach is ineffective as well, as designers can make errors while manually entering 2D data into the 3D model. Additionally, any company that is still relying on 2D drawings will find that it is going the way of the dinosaurs. The hyperfast evolution of industrial technologies, such as the industrial "internet of things"[12] and edge computing, are quickly altering workflows and data usage in manufacturing. Companies that capitalize on these disruptive technologies are migrating to entirely software-based designs because they increase competitiveness (e.g., faster time to market) and improve access to clients and suppliers.

By saying goodbye to 2D drawings, businesses are saying hello to automated solutions that can boost the design and creation process. The implementation of MBD with digital GD&T naturally leads to the utilization of a key cost-saving resource: the digital twin. This is a virtual 3D rendering of a real-life product or system that offers significant benefits. It allows for the assessment of a system's capabilities throughout its life cycle and highlights potential performance issues before processes are implemented or products are manufactured. The digital twin also optimizes a range of models and simulations associated with the life cycle of a product and allows for the improvement of designs with new data.[13] By using MBD with GD&T, the digital twin will include all of the data necessary for users to be able to understand and utilize the design in one compact, easy-to-access and consistent artifact.

Digital Threads sew up loose ends

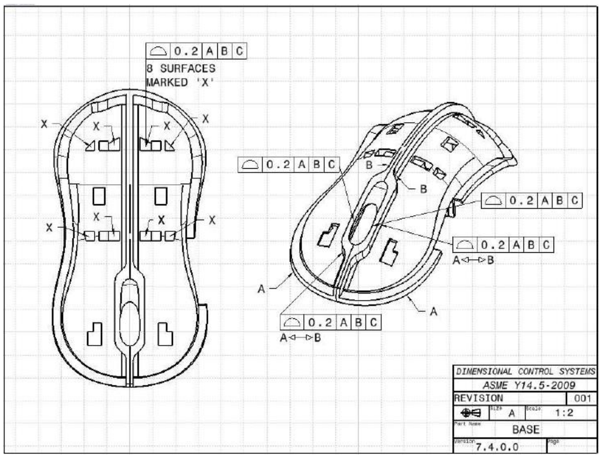
The digital twin is a virtual copy of a real-life system or part, and it requires the data nourishment provided by a digital thread. This is a communication framework that connects the disparate data sources in the manufacturing process and allows for a holistic view of a part throughout its life cycle.[14] By combining these solutions, businesses can create a living, complete 3D artifact that can be utilized in multiple places at different times. The digital twin is a large driver of promoting quality improvements.[15]

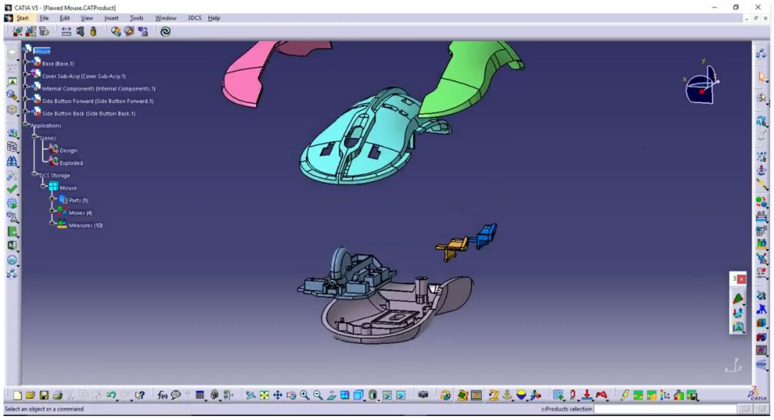
The utilization of digital twins and digital threads is long overdue. In an article in Industry Week, Conrad Leiva, vice president of product strategy and alliances of iBASEt, noted that many companies utilize a throw-it-over-the-fence approach to managing the handover of a design.[16] For example, the designer develops the initial 3D model and then hands it over to the next department involved in the process, which is Manufacturing Engineering. After this department has finished creating 2D drawings from the 3D model (wasting time and resources in the process), it then tosses it to Quality. The process continues throughout the workflow, with each department working on the design without input from the other departments. Each department involved in the workflow then silos its own data, which can result in design errors, misunderstandings and clarification delays.

This process clearly has difficulties, not only in the reduction in communication about the design but also in the wasted resources as departments wrangle with issues that could simply be resolved if one model was shared and accessible to all.

Leiva points out that the utilization of the digital twin and digital thread make the entire life cycle more effective and efficient through the improved use of data and communication (for example, the designers work with manufacturing engineers to create the original 3D model and develop the images for the process directions). The digital twin allows for the better movement of resources: Instead of bringing an expert on-site, the expert can examine the digital twin on their own remote computer. Multiple stakeholders can view the same digital twin and work from the same design. When changes are made, the entire collective of stakeholders immediately obtains an updated copy of the artifact, reducing confusion and human-created errors.

In Testing the Digital Thread in Support of Model-Based Manufacturing and Inspection, Hedberg and his colleagues noted that the digital thread allows for real-time design and analysis, automated artifact development and improved collaboration.[17] (There are, incidentally, some problems with its implementation, but some of these are related to the way companies are approaching the technology rather than issues with the technology itself.) However, even with the challenges presented, MBD designs utilizing the digital thread have superior outcomes compared with paper-based creations.





GD&T within the MBD framework promotes the usage of the digital thread because it includes the complex language of tolerancing inside the model, eliminating the need to add it in manually and increasing the ability of all stakeholders to fully comprehend and make use of the design. Digital GD&T drives the process by becoming the single source of information for the model. This not only streamlines the entire process and increases collaboration, but it also ensures that the created parts will be better integrated into their target systems.

Digital GD&T improves the functions of integrated tools. Since the computer-based model includes all the needed data for development, it no longer relies on multiple human inputs, which naturally increase error. The products can therefore be created directly by manufacturers or even via 3D printer, since the 3D design is the only artifact in the process.

Designing the future

Digital GD&T helps to drive the adoption of MBD. Its abilities to streamline the design and development process due to its comprehensive data set, reduce the need for human-inputted data and promote more collaboration through a single artifact all support reduced time to market, better designs, increased comprehension and superior collaboration. Digital twins and the reliance on digital threads enhance product and workflow development through their utilization of real-time data and ability to capture a part or process well enough to modify or improve it before problems arise.

Perhaps the most important aspects of incorporating GD&T via MBD are the efficiencies and cost savings produced. Businesses that fully embrace these data-driven technologies provide a boost for themselves in the marketplace by creating better products and designs while saving money and reducing scrap. Businesses still relying on 2D drawings will soon find that the designs on them are not worth the paper that they are printed on.

About DCS

DCS has been supporting quality management in industries including automotive, aerospace, medical device, electronics and industrial machinery for over 20 years. DCS solutions are used daily by companies like Airbus, BMW, GM, LG, Nissan, Phillips, Sony, Textron Aviation and VW. By applying DCS's 3D Model Based environment for Predictive Variation Analysis and Responsive SPC, manufacturers have reduced quality costs related to yield, scrap, rework and warranty issues. Read more at www.3dcs.com.

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