MES: Achieving Real Quality through Virtual Products

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Introduction

Product quality is one of the most important issues that face manufacturing firms. A company's reputation for quality products is difficult to establish but easily tarnished.

While the design of a product is critical to product quality, the best design, if not manufactured to the requisite specifications and process, will result in a product that lacks quality. In addition, it is not enough for today's manufacturing firms to produce most of the products correctly. Even a small number of defective products will result in a poor quality perception. In addition, the issue of quality has a halo effect for companies. The perception of poor quality for one product can easily carry over to all product lines.

Companies not only manufacture physical products. At the same time that companies build physical products, companies build virtual products. Virtual products are the data about the product and its creation that if captured and organized can provide a company and its customers with invaluable information. Virtual product information can be used to enhance quality creation, quality visibility, and prevent the valuable waste of resources, especially the time to react to quality issues.

Manufacturing Execution Systems (MES) as a part of the Product Lifecycle Management (PLM) conceptual framework is a natural collector and organizer of this virtual product information. This whitepaper will discuss the implications of this approach to product quality.

MES and PLM

Manufacturing Execution Systems (MES) are robust platforms to plan and control manufacturing resources. Specifically, MES collects data from the factory floor and uses that data to control labor, material and equipment, and the processes that use these resources to create products. MES controls product quality by matching up this data with the defined specifications that are contained within the applications that support Product Lifecycle Management (PLM).

The key to successful manufacturing is to have defined, repeatable processes that minimize the use of resources: labor, material, time, and equipment. Therefore, for each product the company produces, the goal is to create a Bill of Process (BofP) that specifies each step that goes into creating the product while minimizing resources. Considered in the context of a global manufacturing infrastructure, the impact of implementing standardized BofP is substantial.

PLM is a product-centric framework or approach that looks to "de-silo" the product information that has historically been locked away in functional silos such as design, engineering, and manufacturing, etc.. In the phase to make the rest of the products, MES, as a part of PLM, collects the information necessary to insure that the product conforms to the specifications and processes of how it should be built and uses that information about how it was built, "as-builts", to support that product in the later phases of the product's life.

PLM is concerned about the product information throughout its life. The information about how that product came into existence compared with how it should have come into existence is critical. Specifically, the resources of interest are the labor, material, time, equipment and processes that created the product and are controlled by MES.

Defining PLM

Product Lifecycle Management (PLM) is an integrated, information-driven approach comprised of people, processes/practices, and technology to all aspects of a product's life, from its design through manufacture, deployment and maintenance—culminating in the product's removal from service and final disposal. By trading product information for wasted time, energy, and material across the entire organization and into the supply chain, PLM drives the next generation of lean thinking.

Grieves, M. (2006). Product Lifecycle Management: Driving the Next Generation of Lean Thinking. New York, McGraw-Hill.

Real and Virtual Products

PLM and MES depend on the conceptual idea of real and virtual products. Before the advent of computer systems that could handle the massive amounts of information about a product, the only practical way to have information about a product was to physically possess the product itself.

If a quality inspector wanted to check the dimensions on a batch of components, then the components were physically shipped to the inspector. (In many firms, inspection of the received product at the firm's site is still the primary quality control practice.) While blueprints were available on the "as-designed" component or product, "as-built" information on each instance of the component or product that was built from that design rarely, if ever, existed.

As shown in Figure 1, the Information Mirroring Model for PLM and MES is the idea that information about the physical product is captured and maintained. All physical products have a virtual counterpart, which is the information about that product. Unlike the physical product itself, the virtual product is immediately available for inspection of the characteristics and for decision making about its suitability.

All products start out as virtual products. That is ideas and information about what the physical product should be. These virtual products are then realized in physical form through the manufacturing process. The manufacturing of products can be divided into three phases: making the first one, ramp-up, and making the rest.

"Making the first one" entailed getting a physical product that embodied the ideas of what the virtual product was required to accomplish. Ramp-up and production ("making the rest") relied on the premise that these products would be close enough to the first one so as to be functionally and physically equivalent. The accuracy of that premise varies widely even today, which is why expensive quality audit inspection processes are required of the actual products themselves.

Progressive manufacturing processes now capture data about the product as it is being manufactured so as to create not only integrated product and process traceability, but a virtual product model as the physical product is being built. As inspection processes become more technologically sophisticated and automated, the ability to create robust virtual representations of individual physical components and products becomes not only possible but necessary.

MES, with its repository of manufacturing product information, figures prominently in all three phases and is the information system that integrates this information for PLM.

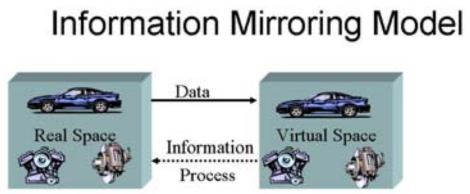

Figure 1

MES and Quality Manufacturing

Making-the-first-one

All products start out as quality products. No reputable manufacturer sets out to make a poor quality product. However, by the very nature of the design process, the first product starts out as a virtual product. The act of making that quality virtual product an actual physical product of equivalent quality is the first role of manufacturing.

Making the first product requires that material, labor, time, and equipment be utilized in a specified sequence in order to realize the design of the as-designed or virtual product. What may look trivial on the design, such as having a six inch shaft bisect the middle of a circular plate, may be of varying degrees of difficulty depending on the materials involved, the tolerances required to be considered the "middle", etc.

MES, as a repository of Bill-of-Processes (BofP), is critical at this stage. Reusing BofP's with proven quality gates and checkpoints not only insure standardization on the factory floor, but eliminates the need for trial-and-error resource waste that is necessary to produce a BofP from scratch. Consistently following the same BofP's will produce components that meet the design specifications of the virtual product.

Additionally, MES as a repository of "as-built" information has Longitudinal Product Quality information (LPQ). It does little good that a BofP will only build the first few products to the required specifications. It is important to know that the BofP will build the thousands, tens of thousands, or even a million more products that may be desired, all at the very same quality.

Examining previous product builds in the MES repository can give valuable information on the impact of wear in tool, dies, and equipment that naturally occurs. This may impact either the design or indicate the need for additional tool, die, and equipment changes necessary to maintain the virtual design for every instance of the product, not simply the first batches.

Ramp-Up

The intent in ramp-up is to reduce the amount of resources, time, energy, and material necessary to produce a unit of product. The problem is compounded in the global manufacturing environment, in that ramp-up may not occur at one physical location, but may be occurring in widely dispersed geographic locations simultaneously.

MES provides the necessary capability in order to obtain the maximum benefit from this phase. First, MES monitors the product manufacture to insure that quality is maintained as product manufacturing ramps up. While the first few product builds might meet all the requirements, as volumes build, product tolerances may start creeping toward the unacceptable. Catching that trend toward unacceptability early is invaluable.

Second, as improvements are made to the process as a result of experience, those results need to be propagated to all the manufacturing sites. Having each manufacturing site inch their own way down an experience curve is a waste of resources that can be eliminated by an MES with visibility throughout the entire global organization. The requirement in ramp-up is two-fold, reduce resources but maintain quality.

Making-the-rest

In making the rest, MES provides a number of critical functions. As discussed in a previous whitepaper[1], MES acts as the interface between PLM and ERP, so that ERP can provide its transactional functions of designating the orders to be produced and track the statuses of those orders.

In addition, MES is responsible for collecting the data on the manufacturing of the product and creating “as-builts” that can be used to maintain the product in the support phase of the product’s life. It is not enough to have a product that only meets it quality requirements at the beginning of its life. The quality of the product needs to continue throughout its entire serviceable life.

However, as discussed above, collecting and organizing this data is also invaluable for the first two product lifecycle phases, first build and ramp-up. Having a large sample of ’as-built’ records or Longitudinal Product Quality (LPQ) information is an invaluable asset of any manufacturing organization.

The recording of “as-built” information by the MES system is essentially building a virtual product based on actual results. The advantage of this virtual version of the product is that it is available anywhere and anytime far in advance of the physical product. Thus, the virtual product can be “inspected” well before the actual product can be inspected, especially if the actual product is 6 time zones and a continent away. Accordingly, decisions on the acceptability of the product can be made well before the actual product is either completed or shipped.

A New Model:

Shipping Virtual Products, Receiving Real Quality

Being able to inspect the virtual product in advance of the physical product is critical to quality manufacturing within an organization. It also has tremendous advantage when applied to the supply chain. If a manufacturer has complete control of the parts it manufactures, but receives components from suppliers that are not of the required quality, the entire product suffers.

By the time substandard components physically arrive at the loading dock, it is too late to avoid the delays and costs of dealing with the problem. The costs may simply be the cost of inspection, storing, and shipping back substandard product, which are nonetheless real and substantial costs. However, in this era of Just-in-Time manufacturing, the costs may be much more severe in that manufacturing schedules need to be rearranged, alternate components employed or remedial action taken on the substandard products so they can be utilized.

With the possibility of having access to information about the product as it is being produced, and collecting that information within an MES, customers may start requiring this capability as a part of the product requirements. Suppliers who want to differentiate their product on the basis of quality may start to offer this information.

The implication of this concept is a change in what customers are contracting to purchase from their suppliers. The old model is that customers only purchased physical products. The new model is that customers not only purchase physical products but that they are also purchasing virtual products. The virtual product is the information about the physical product.

A good deal of the product quality burden moves from the customer who, under the old model, needed to inspect and test the physical product it received in order to determine if the product met its requirements. Under the new model, the product quality burden moves to the supplier who now needs to provide the virtual product, i.e. the information about the physical product, as that product is produced.

However information and thus the virtual product is not free. There is a cost to collect and organize data about the physical product as it is being created. Some suppliers may decide that they would much rather take the risk that their physical products will conform to the customers' requirements or, as is more likely, that customers will not discover or will tolerate substandard physical products.

Using suppliers with that philosophy will result in those customers both having continuing quality problems and incurring real and substantial costs in attempting to prevent and recover from quality issues. Dealing with quality problems when the physical product shows up at the loading dock is much too late and much too expensive.

As this new model gains acceptance, customers will need to specify not only the requirements of the physical product that they are contracting for. Customers will also need to specify the requirements for the virtual product that should be transmitted to them. Suppliers will need to enable their manufacturing processes with the instrumentation and software tools to meet these requirements.

The future mantra of quality product shipments may be, "Transmit us the virtual product and we will then tell you whether or not to ship the physical product."

Conclusion

Product quality is one of the most important concerns of product manufacturers today. The lack of product quality, which can be defined as being deficient in the design and/or manufacture of product that meets the user's needs, is one of the most important factors in why products fail in the marketplace.

MES is a part of the PLM concept that deals with the realization of a physical product from a virtual design. MES is involved with the three phases of producing a product: making the first one, ramp-up, and making the rest.

In making the first product, MES is the repository of proven Bill of Processes (BofP's) that can be used to realize a physical product from a virtual design. MES also has data from previous product builds to provide a longitudinal view of how the specifications of previous products varied to understand whether the specifications of the new product are realistic over time. This Longitudinal Product Quality (LPQ) information is invaluable for understanding whether the virtual design can be realized for the each instance of the product.

During ramp-up, MES is the capture mechanism for changes to BofP as learning and experience occur during the ramp-up period. In today's global environment, MES can propagate successful changes throughout all the manufacturing facilities so that all facilities can benefit.

Once ramp-up ends and volume production occurs, the requirement is to both make the rest of the products in an identical fashion and to provide the visibility that this is indeed occurring. Collecting this "as-built" data provides a virtual product that can be used in later stages of the product lifecycle for product support, but also can be used to validate new products as the first of those begin to be built as discussed earlier.

However, these virtual products can also serve an immediate need as these products are invariably a part of the global supply chain. These virtual products are immediately available for inspection, as compared to their physical counterparts, which often must travel long distances taking hours, days, or even weeks. Using the virtual products, issues with quality can potentially be identified and addressed, long in advance of the physical product arrival at the customer.

MES is a core requirement to capture and organize the data of physical product creation. By serving as a repository of this data, which is in essence, the virtual product, real product quality can be achieved and maintained.

About Dr. Michael Grieves

Dr. Michael Grieves is a world renowned authority on Product Lifecycle Management (PLM). Dr. Grieves has written and lectured extensively on the topic and is a frequent keynote speaker on PLM. Dr. Grieves' works include the seminal work on PLM, Product Lifecycle Management: Driving the Next Generation of Lean Thinking (McGraw-Hill, 2006).

Dr. Grieves splits his time between the business world and the academic community. Dr. Grieves has over 30 years of executive experience in public and private companies. Dr. Grieves is a Co-Director of the Purdue University PLM Center of Excellence. Dr. Grieves has been the Director of Industry Research at the University of Arizona MIS Department and a Visiting Professor at Purdue University College of Technology. Dr. Grieves serves as the Chairman Emeritus of the Board of Visitors at Oakland University's School of Business Administration. Dr. Grieves co-founded the PLM Development Consortium at the University of Michigan, College of Engineering.

Dr. Grieves has a B.S.C.E. from the College of Engineering, Michigan State University, an MBA from Oakland University and a doctorate from the Weatherhead School of Management at Case Western Reserve University

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[1] See Dr. Michael Grieves, Multiplying MES Value with PLM Integration, March 2007, available at: http://www.apriso.com/Other/library2.htm