Modular Design…A Path to Rapid Customer Response

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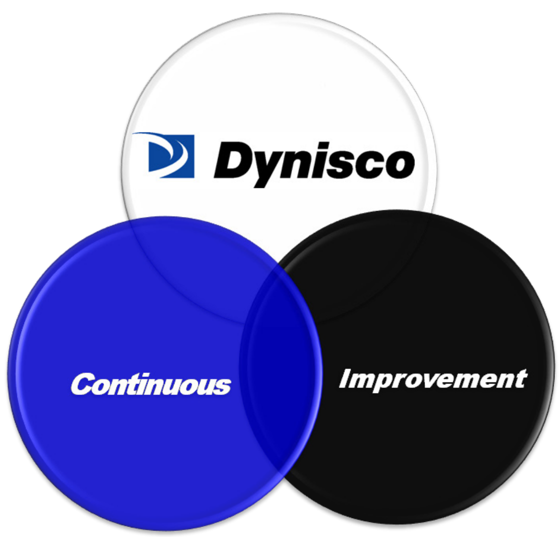

Abstract

Design for manufacture and assembly (DFMA) is an extremely powerful tool that establishes the foundation for more advanced design methodologies. Early part count reduction efforts help pave the way for forward thinking designs that incorporate common platforms, interchangeability and modularity. In addition to developing a more robust design, these methodologies generate the ability to apply lean principals such as postponement theory and kanban with minimal effort. Dynisco has applied these methodologies to their latest product release, Vertex ™ with excellent results. The following topics will be discussed to help demonstrate the activities that lead to this new and exciting product.

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Introduction

Dynisco and its subsidiary companies have been utilizing various levels of DFMA (Design for Manufacture and Assembly) since mid 2009. Like many initiatives, it began with individuals who had some familiarly with the DFMA philosophy and an understanding of the potential that DFMA could bring. Upon gaining traction, the next steps involved consultation, training and investment. One of the most significant investments was not necessarily the capital involved in purchasing the software, but the time to properly train individuals and develop the culture to utilize DFMA effectively. To date, Dynisco is still experiencing various levels of DFMA engagement, but as a whole the organization has been able to take advantage of the many benefits that DFMA can provide. The following paper will describe the efforts that were undertaken on one particular product called "Vertex ™". The paper will cover the differences in design between Vertex ™ and its predecessor, the lean principals that have been implemented as a result of the new design and finally the continued benefits that the new design is providing.

Vertex DFMA: Early Stages

For over 20 years, Dynisco has been working to develop a non filled sensor. Dynisco sensors are used in the plastics extrusion industry to accurately measure pressure and temperature. Pressure sensors come in all shapes and sizes and with various options for fill. Mercury filled units are some of the most popular types of sensors due to mercury's incompressibility quality which makes it a very good medium for measurement. Other fills such as oil and NaK, (Sodium Potassium) are also utilized in different plastic producing industries, depending on the customer's specific requirements (Figure 1).

Figure 1 - Dynisco Pressure Sensor (NaK)

As the Vertex ™ sensor was entering its early stages of design (Definition of Concept), DFMA was starting to gain traction in the Dynisco engineering community. Some initial training classes and workshops were introduced to establish the foundation for the DFMA philosophy. The workshops uncovered some eye opening opportunities for Dynisco in terms of evaluating and improving their existing and future product designs. One of the key individuals responsible for supporting the initiation of the Vertex ™ DFMA was Mr. John Czazasty, Director of Engineering for Dynisco. As the head of engineering for the Vertex ™ project, Mr. Czazasty recognized that the DFMA philosophy, not just the tool or software, could pay huge dividends in the final outcome of the design. One key element was encouraging the formation of multi function design reviews utilizing the DFMA principals of part count reduction and simplification. As the design progressed, the interactions between the groups became more and more collaborative. It was through the multiple design iterations, reviews, and adjustments that the Vertex ™ design evolved into an exciting new product. One example where DFMA was used successfully was in the development of the sensor tip assembly. Multiple iterations of the design were developed and reviewed. Unique part and part count reduction discussions drove revisions, targeting design simplification. Each design iteration of the Vertex ™ assembly was analyzed using the DFA software. The DFA index from these analyses was the metric used to help drive additional simplification as the design progressed. As a result of the DFMA exercise and multi-functional collaboration, the parts associated with the initial sensor tip were reduced from 10 to 4, (60% reduction). In addition, a 76% reduction in material costs were realized (Figure 2) by the time the prototypes were ready for pilot manufacturing.

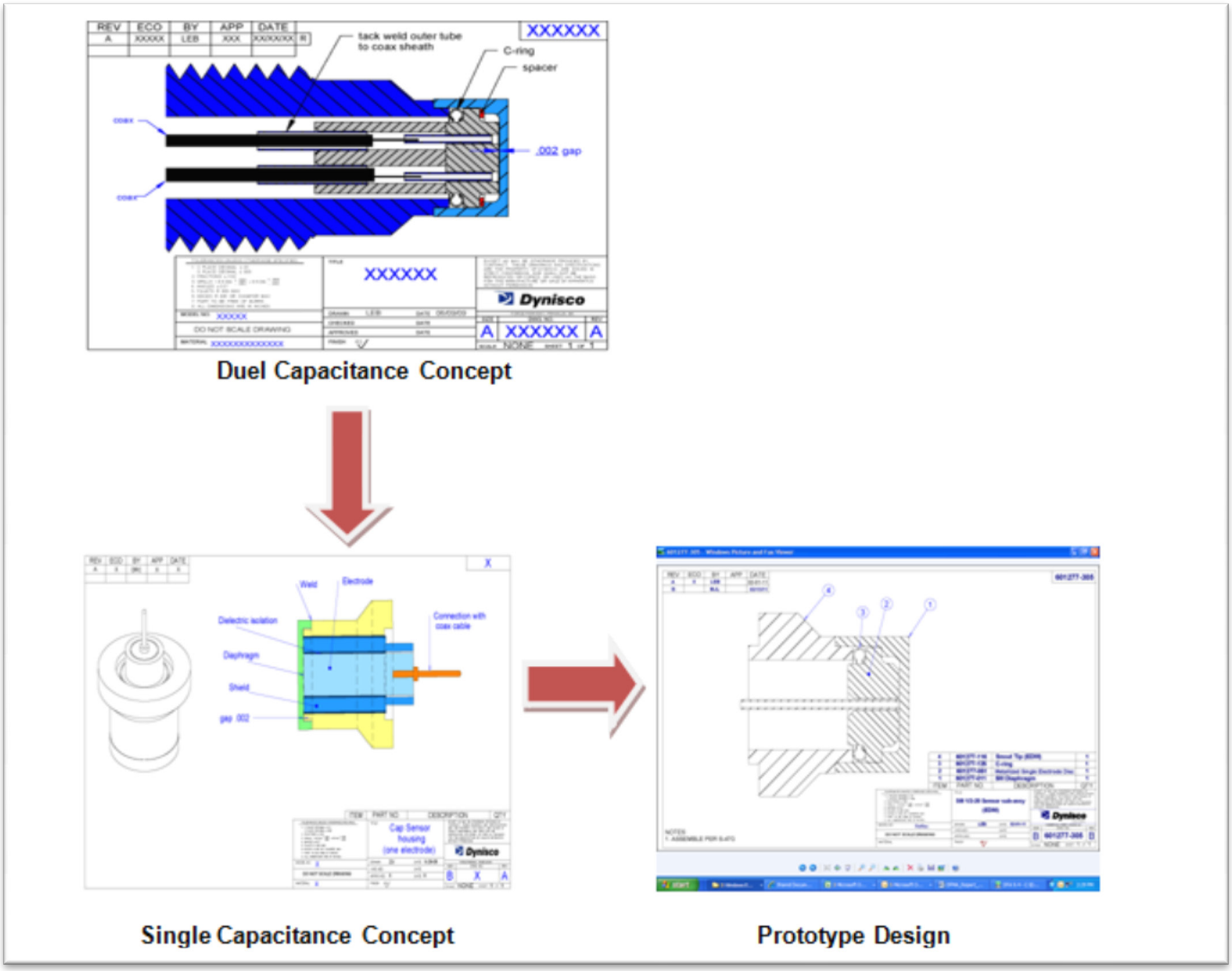


Figure 2 – Sensor Assembly Design Iteration using DFMA

Postponement Theory: Flexibility in Design

Today's manufacturers are facing elevated pressures of maintaining lower inventory levels and associated costs, while requiring more flexibility. Lower inventories with higher flexibility requirements appear to be polar opposites unless manufacturers can utilize a method to provide both attributes. In a traditional stocking model, various configurations of a product are kept in inventory at the finished goods level with the hope that an order will be placed that matches the configuration(s) that has been stocked. An important thing to remember when products are stocked at the finished goods level is that all of the value (labor and materials) have been added to the product, thus the inventory cost is at its highest value. For products that have very little variation, material and / or labor content, this model may be suitable. Alternatively, for products that have a large number of configurations and higher material and or labor content, this model can be very expensive. Higher inventory costs in addition to longer lead times are usual traits of this type of model. Figure 3 represents a traditional finished goods stocking model.

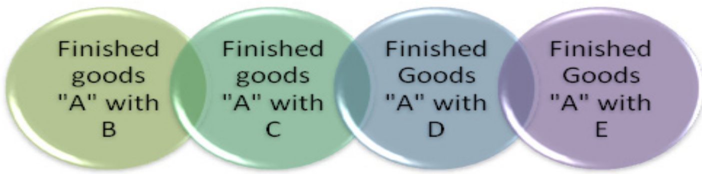


Figure 3 - Traditional Model

The type of inventory stocking profile that allows for better control of inventory is called postponement. Postponement is a method of stocking material at a lower sub assembly level, allowing for a larger number of configurations to be made at the finished goods level. It is a supply chain technique used to minimize inventory at the finished goods level and to allow for a higher level of configuration flexibility. This model differs from the finished goods model by the level at which components are stocked. For example, sub assembly “A” is stocked at a lower level instead of the finished goods level. It is still considered inventory, but less value (labor and materials) has been applied at this stage, therefore the overall inventory cost is less. As the customer order is defined, sub assembly “A” is configured with the correct component, in this case “B”. After assembly it is packaged and shipped. As additional customer orders are received, more configurations can be assembled utilizing the component that the customer desires. This model minimizes higher valued inventory at the finished goods levels and provides more flexibility as it relates to customer response. The postponement theory model is represented in Figure 4.

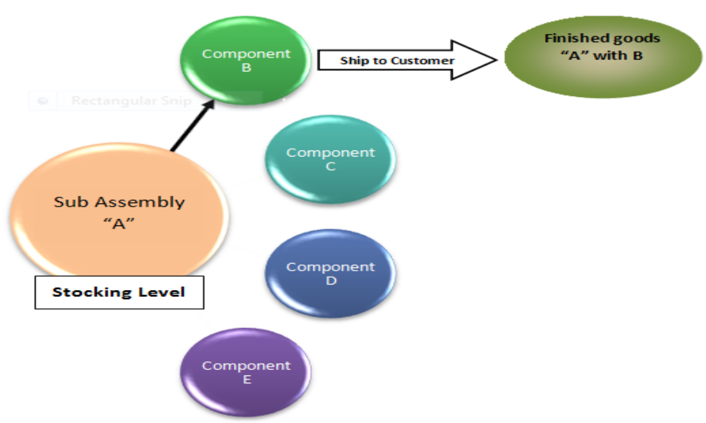


Figure 4 - Postponement Model

When dollar values are applied to the two models previously discussed, it can be demonstrated that the inventory value utilizing postponement is lower (Figure 5). Sub assembly inventory is still stocked but its value is lower because the required labor to convert the sub assembly into finished product has not been applied. Postponement supports the Lean philosophy of assembling and delivering the right products at the right time.

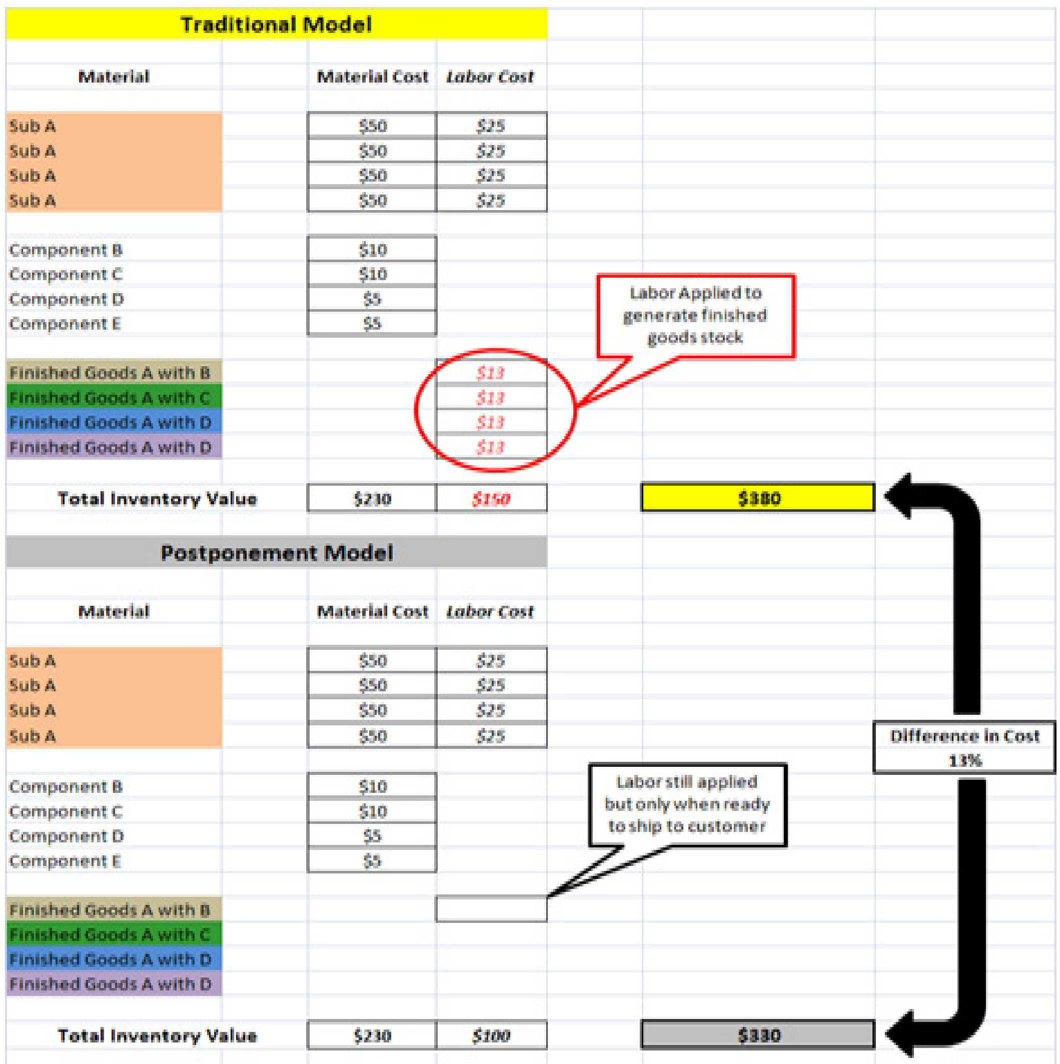


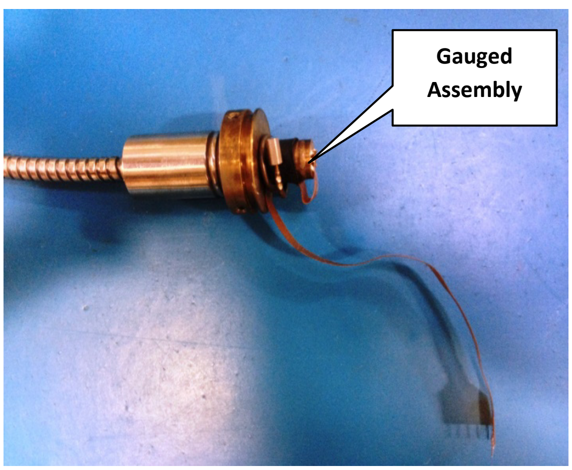
Figure 5 - Inventory Value Cost Comparison

One of the keys to achieving successful postponement strategy is ensuring that design specifications support postponement type stocking. If a product is designed with modularity in mind, the ability to stock at various sub assembly levels becomes much easier. If modularity is not a consideration in the early stages of development then postponement will not be an option in the later stages of the product life. The key to reinforce is that the **engineers and designers have a significant influence on the ability to control inventory costs and customer responsiveness before the product is launched and turned over to operations**. Dynisco's Vertex ™ product was an excellent example of this statement.

Transition to Modularity: Comparison of the Old and New Design

Although Dynisco's legacy sensor product and the Vertex ™ product have similarities, (i.e. measurement of pressure and temperature) the designs and design approach were quite different. From the onset of the project, design criteria and intent were defined not only by the customer and marketing but also by manufacturing. This early input coupled with a commitment to utilize DFMA resulted in a design that had a positive impact on manufacturing

When comparing designs, certain features look quite similar, but examining the designs more closely reveals that there are some significant differences. The main components of the legacy product consists of a gauged assembly, (Figure 6) which is then transformed into a filled assembly, (Figure 7). The gauged assembly is a critical component in the legacy design because it defines the specific pressure range that the instrument is capable of measuring. For example, if a customer requests a 5000 psi unit, then a 5M gauged assembly would be selected for the build.



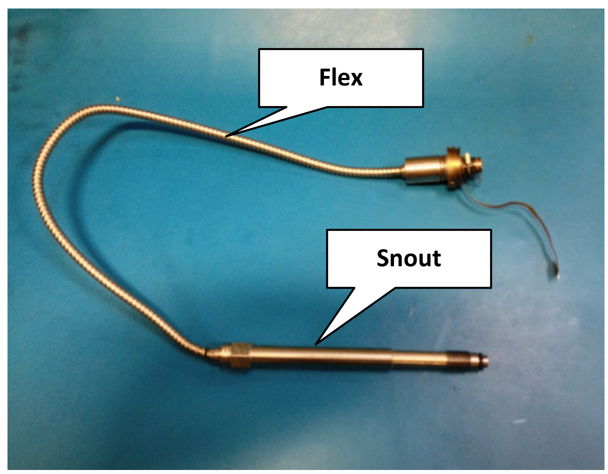


Figure 6 - Legacy sensor "Gauged Assembly"   Figure 7 - Legacy sensor "Filled Assembly"

In addition to the pressure range, the customer can select options such as snout length, flex length and the type of electronics to be utilized. There are a wide variety of pressure ranges, snouts, flexes and electronics which provide an array of choices for the customer. Alternatively, this provides a challenge to operations from an inventory standpoint. The ability to provide flexibility to the customer, while controlling inventory costs is strongly related to the level of modularity that the design is capable of providing. In the previous section, postponement was discussed as a method to control inventory while providing higher levels of responsiveness to the customer. The "Legacy" design has the ability to utilize postponement but only at the filled assembly level. The gauged assembly, (pressure range) snout, and flex all must be assembled and stored as a sub assembly with this particular design. The inventory value consists of all the material and labor required to assemble the unit up to the filled assembly level. The pressure range, snout length and flex length are all "locked in" making the electronics the only attribute that can be added at the last possible minute. Any design that supports postponement is better for a multitude of reasons but a design that allows for multiple levels of postponement is even more desirable. Dynisco's Vertex ™ sensor is an example of a design that supports multiple levels of postponement. As stated previously, customers wanting to purchase a pressure sensor will define certain attributes that are required for their plastic extrusion processes. Pressure range, snout length, flex length and electronics are the key features that make up the sensor. In order to be accepted in the market place the Vertex ™ sensor had to have the ability to offer the same level of options. The major difference between the two designs is in the way that the options can be manufactured and stocked. The main subassemblies for the Vertex ™ sensor are:

- Sensor Tip
- Transducer Assembly
- Flex Assembly
- Electronics assembly

Each of these sub assemblies can be manufactured independently and stocked at their respective levels allowing for maximum flexibility at the final assembly level (Figure 8). It should be noted that the sensor tip assembly is stocked at its own level but then must be welded on to the transducer, which is stocked at its own level.

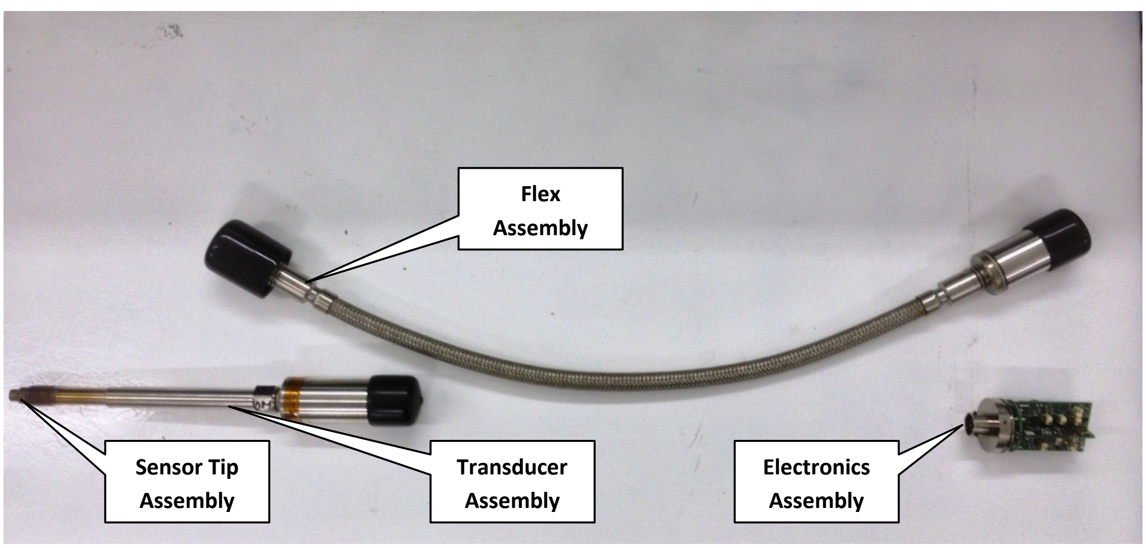


Figure 8 - Vertex ™ Sub Assembly Components

Value is added at each of the sub assembly levels allowing for multiple variations of the sub assemblies to be stocked. Multiple flex lengths (18", 30"or 72") can be assembled and stocked in pre-defined quantities which are derived from a combination of market forecasts and historical sales. The transducer and electronic assemblies follow the same methodology. Designs of this nature not only lend itself to better inventory management but also support lean replenishment efforts (Kanban) as well as faster lead times.

Manufacturing Benefits: Reaping the Rewards of a Great Design

In most Lean communities, Kanban is defined as a "signal". This signal is used to drive the replenishment of material that has been consumed during a particular manufacturing process, as a result of consumption due to a customer order. The premise to Kanban is to consume what you need and replenish what you take. When this methodology is applied correctly, inventory levels are "right sized" to the demand of the customer. The link between the customer order and the "signal" is enhanced by the level of modularity in the design. In the case of the Vertex ™ sensor, establishing Kanban levels or supermarkets was straightforward. Because of the innovation of the Vertex ™ product, historical information was not available to use as a guide for initial Kanban levels. Historical data for legacy product was used to determine the most popular pressure ranges, snout lengths, etc. Once the analysis was completed, stocking levels were defined and sub assemblies were constructed. As the orders are generated, the appropriate sub assemblies are consumed to produce a finished good. Once consumption occurs, color coded cards are utilized to schedule the work required to replenish the material and sub assembly that was used. The visual signals are a trigger to help align the work to what is truly needed, thus minimizing the waste of over production. Initially, Dynisco expected that inventory levels would be high to support the various configurations required. Currently there are 69 finished goods models for Vertex ™ representing 960 different perturbations. The entire required inventory, which is much lower than expected, to achieve these configurations is stocked in the Kanban location shown in Figure 8

Figure 8 - Vertex ™ Supermarket "Kanban" Inventory

One of the other key benefits to a modular design is faster lead times. Lead times are defined as the amount of time it takes to supply a product or service to the customer. This time is inclusive of order taking, material procurement, manufacturing processes and shipping. Initial, studies showed that the manufacturing lead time took approx 12 working days to construct a single unit. As the manufacturing process developed and the advantage of modularity became more apparent, construction from the point of postponement was reduced to 7 working days. The modularity of the design coupled with postponement helped to reduce the manufacturing lead time by approx 40%, (Figure 9). Process improvements including labor reduction efforts contributed to a portion of the lead time reduction but the most significant component was due to the ability to stock sub assemblies in supermarkets and quickly configure them.

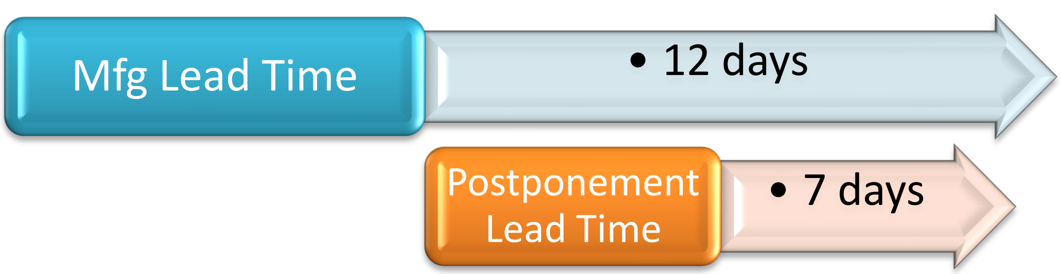


Figure 9 – Mfg Lead Time Reduction

Conclusion

Design for Manufacture and Assembly is an extremely powerful tool that helps improve designs through the use of part count reduction and minimizing the number of unique parts in a design. Reductions in labor and materials are relatively common when discussing the advantages of DFMA. When these activities are initiated during development, they can have a direct impact on the quality levels of the design as well as the overall cost associated with a design. Engineers who understand the influences that they have in the early design stages can be more effective in creating a design that is not only more manufactureable but also more profitable.

Modularity, postponement and lead time reduction are not as simple to recognize in the early stages of design, but can pay significant dividends if they are considered as part of the design activities. These dividends take the form of inventory control, inventory sizing and reduction in manufacturing lead times. The designers of Vertex ™ demonstrated the advantages of these more advanced design techniques, improving the product for manufacturing as well as the responsiveness to our customers.