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A Dynisco Case Study: From DFMA Implementation Plan to Results#

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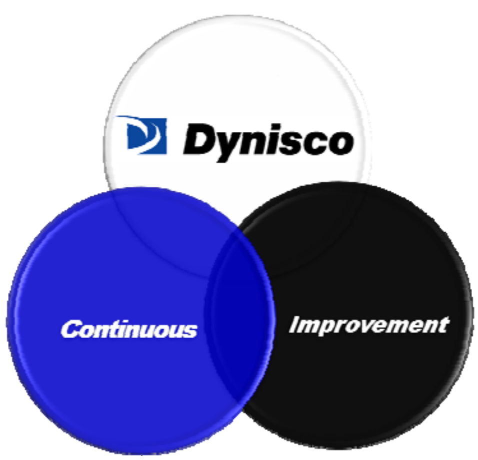


Introduction

At the 2012 International Forum on Design for Manufacture and Assembly (DFMA), Dynisco Instruments (Roper Industries) had the opportunity to present a few topics that explained their DFMA implementation plan and how it tied to other company initiatives. The roadmap included executive support, training plans, and cultural change in order to establish a solid DFMA support structure. A second paper described application of DFMA techniques at the appropriate time in the design process. It's been well documented at Boothroyd Dewhurst's (BDI) past twenty-seven Forums that application of DFMA early in the design process yields the best results. The third paper tied together all the new business initiatives to demonstrate the positive impact to Engineering, Supply Chain, and Operations. These new initiatives included: Lean, Total Cost of Ownership (TCO), DFMA, and creation of a new Value Analysis/Value Engineering (VAVE) Group.

The following is a review of a product redesign from one of Dynisco's four business units, Viatran. This redesign project utilized all aspects of Dynisco's DFMA, Lean, and TCO initiatives. A key application with BDI's Design for Assembly (DFA) software is competitive benchmarking. This project evaluated existing Viatran product assemblies and competitor offerings that were analyzed with the DFA software. Additionally, Dynisco's VAVE group provided "should cost" analyses for all major machined components from each assembly with BDI's Design for Manufacture (DFM) software. The competitive benchmarking process was performed to glean important design and cost information for the redesign process.

The essence of BDI's DFMA methodology, especially with regard to their DFA software, is part count reduction. Dynisco, like many other companies who are BDI customers, has tried to instill the mantra of part count reduction to develop products that are efficiently assembled and cost effective. Kevin Dailida of Dynisco wrote in his 2012 DFMA Forum paper, "DFMA must be integrated into the product development process," at the proper time, which is early in the design process "to evaluate the design from a form, fit, function, and cost perspective" to maximize assembly efficiency and achieve cost targets for the product. Reviewing this redesign project will demonstrate the positive results from early DFMA application and highlights Dynisco's revised product development process with DFMA, TCO, Lean, and Benchmarking steps fully integrated.

The Hammer Union Product

Viatran, one of Dynisco's four business units, is a global leader providing pressure and level sensors designed for accurate and repeatable measurement for all pressure ranges and most temperatures in applications such as oil and gas services, steel productions, food and medical equipment, injection molding, die casting and chemical production. Their products are widely recognized for withstanding the most aggressive and harsh environments.

A signature product in the Viatran portfolio is the Hammer Union (HU) Pressure Transmitter 510. Viatran Model 510 pressure transmitters are designed for use with a Hammer Union fitting (Figure 1502) for use in oil well cementing, fracturing and acidizing.   They have been designed to be accurate yet rugged instruments ideally suited to the harsh oil field environment. Among the salient features of the HU fitting:

1. Model 510 forms the male sub of the Hammer Wing Union. It features an essentially flush face pressure sensor so mud and cement mixture cannot accumulate and interfere with the measurement.
2. Three-lug nuts and self locking ACME threads provide fast make-up and break-out regardless of the position or space constraints and without special tools. The pressure fitting features a replaceable primary lip type seal ring in the female sub which protects the secondary metal to metal seal from abrasion and corrosion while minimizing flow turbulence.
3. All parts of the HU wing fitting of the same figure number, size and rating are interchangeable. This makes it easy to install Model 510 transmitters in any HU fitting.

Figure 1 – Viatran Hammer Union Model 510 shown left. On the right, a hammer union unit installed.

Competitive Benchmarking Process

The Viatran engineering group teamed with Dynisco's corporate VAVE group and began a redesign effort to further improve the Hammer Union 510 feature set. The first step was to perform a competitive benchmarking analysis on Dynisco/Viatran Hammer Union Pressure Transmitters as well as competitor units. Four Dynisco/Viatran units and seven separate competitor units were disassembled piece by piece in order to create a bill of material for each assembly using the DFA software. Each part and assembly process was meticulously counted, including solder joints, wires, and potting operations in addition to major mechanical parts and printed circuit boards within each unit. Major mechanical components were modeled in 3D CAD to recreate the assemblies and look at the amount of raw material used for the base part and the adapter which houses the electrical connector for each unit. The base part and adapter were then analyzed with BDI's DFM software to determine the cost to machine each part. The benefit from these DFM cost analyses combined with creating the 3D CAD models is to better understand the amount of raw material used, the work piece size or "billet," the manufacturing processes used to machine the parts, and of course the final cost and weight of the part. Also, the actual geometry of the base part and adapter provides insight to how each unit is assembled. This is evident in the resulting DFA Index calculated by the DFA software on each unit that enabled us to compare assembly efficiencies of our products versus our competitors.

Figures 2 and 3 show the type of data collected and calculated for each assembly. Examples of the attributes collected are DFA Index, Total Part Count, estimated Assembly Time, and Total Cost per assembled unit. Data collected for the base parts and adapters include the weight of the raw material used, the weight of the finished part, part cost, and welding processes used if applicable. Photos were taken during the disassembly process of each unit. PowerPoint summaries were created for each unit that included DFMA data and photos. This led to an off-site review of the competitive benchmarking process that involved many stakeholders at Viatran. Included in the review were personnel from engineering, product management, operations, sales, and executive staff. The group was able to review each assembly, pass parts around, and assess strengths and weaknesses in each design. The competitive benchmarking review session was a new step in the Viatran design process that allowed a progressive dialogue to occur to help determine the best design path for the model 510.

Viatran/Dynisco Hammer Union Models					
Description	**Units**	**Dynisco/Viatran #1**	**Dynisco/Viatran #2**	**Dynisco/Viatran #3**	**Dynisco/Viatran #4**
DFA Index	%	6.9	7.0	7.2	6.3
DFA Part Count (Parts & Processes)	#	137	151	134	65
Component Count	#	85	102	62	33
Theoretical Minimum Part Count	#	22	23	21	15
Theoretical Assembly Time	Min.	16	21	17	60
Total Cost		Baseline	1%	21%	72%
Base Part					
Cost	$	Baseline	-46%	-5%	43%
Billet Size	in.	3.75" dia x 2.19" lg	3.75" dia x 1.25" lg	3.00" dia x 2.50" lg	3.00" dia x 1.25" lg
Billet Weight	lbs.	7.4	4.4	5.7	4.0
Finished Weight	lbs.	3.9	2.0	3.4	2.0
Adapter					
Cost	$	Baseline	-3%	55%	-34%
Billet Size	in.	3.25" dia x 2.25" lg	3.25" dia x 2" lg	3.00" dia x 2.50" lg	2.5" dia. x 2.25" lg. tube
Billet Weight	lbs.	5.4	4.7	4.9	4.7
Finished Weight	lbs.	1.3	1.1	1.8	1.1
Weld		NA	EB	NA	EB

Figure 2 – Benchmark results for Dynisco/Viatran Hammer Union products. Unit #1 serves as the baseline all other units are compared with.

Joel Neri, Engineering Manager at Viatran, summarized the benchmarking process, "This allowed us to do a detailed study of all the parts and processes that were used to manufacture the competitor products as well as our own existing products. By ranking these attributes, we could use this information to avoid previously unknown pitfalls and to guide our new designs as well as improve our existing products."

Competitor Hammer Union Models								
Description	**Units**	**Competitor #1**	**Competitor #2**	**Competitor #3**	**Competitor #4**	**Competitor #5**	**Competitor #6**	**Competitor #7**
DFA Index	%	4.5	3.6	8.3	3.1	9.1	6.1	7.3
DFA Part Count (Parts & Processes)	#	83	184	118	91	101	105	114
Component Count	#	39	106	63	58	66	59	62
Theoretical Minimum Part Count	#	17	27	25	15	31	20	23
Theoretical Assembly Time	Min.	20	41	18	27	21	18	18
Total Cost		-6%	18%	4%	-15%	-1%	-22%	-5%
Base Part								
Cost	$	-53%	-31%	-62%	-81%	-77%	-79%	-38%
Billet Size	in.	3.75" dia x 1.5" lg	3.75" dia x 2" lg	3.75" dia x 5.50" lg	3.75" dia x 1.25" lg	3.75" dia x 1.50" lg	3.75" dia. x 3.31" lg.	3.75" dia x 1.38" lg
Billet Weight	lbs.	5.3	6.2	17.6	4.4	5.3	10.3	5.7
Finished Weight	lbs.	3.2	3.5	7.9	2.6	3.3	5.0	3.0
Adapter								
Cost	$	27%	19%	-53%	13%	1%	-49%	7%
Billet Size	in.	3.50" dia x 2.38" lg	3.25" dia x 3.38" lg	3.00" dia x 2.50" lg. .31" thick wall tube	3.38" dia x 1.62" lg	2.5" dia x 5" lg, .38" thick wall tube	2.75" dia. x 2.75" lg.	2.62" dia x 1.38" lg,
Billet Weight	lbs.	6.4	7.9	2.7	4.1	3.5	4.6	2.7
Finished Weight	lbs.	2.2	1.8	1	1.5	1.8	1.9	1.0
Weld		NA	NA	NA	TIG	EB	NA	TIG

Figure 3 – Benchmark results for Competitor Hammer Union products

Engineering Toolbox

The competitive benchmarking process generated plenty of ideas for product redesign. The redesign focused on creating a unique feature set for the model 510 hammer union while applying DFMA principles to reduce part count of the assembly. Reducing part count in product assemblies consistently provides positive improvements in reliability, quality and delivery, and makes products cost effective and easier to assemble. From the benchmarking results, the team set the following targets for the project:

- Improve access and protection for the electrical connector
- Improve the ability to clean the adapter in order to help reduce corrosion of the connector
- Eliminate the adapter-to-base part fasteners
- Compatibility to the Weco® fitting and customer electrical connector
- Reparability
- Improve cost effectiveness and improve the assembly process

To start the redesigns, 3D CAD models of four initial concepts were created. Each assembly was reviewed with operations to determine any possible issues that could occur during assembly. The VAVE Group provided the DFA analysis of each concept assembly and DFM cost analyses on the main mechanical parts. This was quickly completed by adjusting the DFA and DFM files created during the benchmarking process. Reuse of the existing DFMA files is another positive outcome of the benchmarking process and speeds up the design process. The DFMA analysis for each concept assembly confirmed we weren't on the right path for achieving our targets and the reviews with operations found potential assembly concerns.

Based on these results from the first round of concepts, the design team developed a second iteration of concept hammer union designs. The same steps were followed as the DFMA process was again applied to the second round designs. Through collaboration from the same stakeholders who participated in the benchmarking review session, the design path was chosen for the new Viatran hammer union model 511. The next step was to optimize this design and determine if it would fully meet all of the project targets.

Rapid prototypes (see Figure-4) of the 3D CAD models were procured to allow the team to get a feel for what the new mechanical parts would look like and walk through the assembly processes. In parallel, Engineering developed Finite Element Analysis (FEA) models from the 3D CAD models to simulate stresses and deformations in the hammer union from normal operating pressures and sledgehammer impacts to the adapter. The worker in the field will tighten the Weco® nut down onto the hammer union pressure transmitters with sledgehammer strikes. Occasionally the sledgehammer swing will strike the hammer union unit on the adapter top (see Figure-1). Baseline FEA analyses were run on the existing design, which was followed by FEA runs on the new design (see Figure-4). Similar to comparing the existing benchmarked design versus the new design with DFMA analyses, we were able to ensure the new design would meet, if not exceed, performance and design criteria of the existing design through FEA analysis as well. The application of these engineering tools was necessary because, as Neri states, “Using DFMA with 3D modeling and FEA really allow the design and development to progress more quickly before ever ‘cutting metal.’ This definitely saves a few expensive steps in the process.”

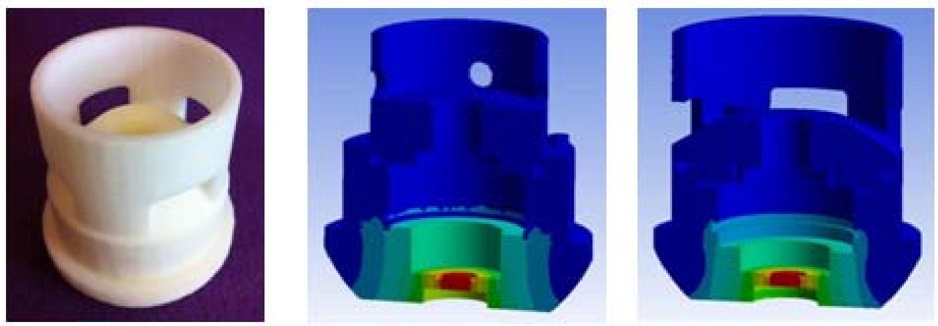


Figure 4 – Shown left, a stereolithography rapid prototype part. Middle and right pictures show FEA results for deformation from pressure, existing design vs. new design.

<u>Results</u>

As we’ve stressed throughout this summary, driving part count reduction using BDI’s DFMA methodology yields positive results in product design. It is proven. Diving down one more level in this philosophy, the next question is what kind of “part type” should be the focus of the part count reduction effort? The answer is fasteners and connectors. BDI’s DFA software requires the user to assign the “part type” for each and every part of the bill of material being analyzed. This is done through the questions on minimum part criteria in the DFA software, where the user assigns that a part theoretically must be separate because of either its material type, movement within the assembly, or that the part must be separate to allow assembly. However, a part is automatically considered a candidate for elimination if it is a fastener or connector. Traditional examples of fasteners are screws, nuts, and washers, but a solder joint can be considered a fastener as well. An example of a connector can be a sheet metal bracket that mounts to one part while housing an electrical USB port. Taking the concept further, a wire that connects two electrical contacts can be considered a connector and is therefore considered a candidate for elimination. It was this philosophy that the Viatran and VAVE teams used as they evaluated the hammer union model 510 design and developed the model 511.

The Viatran model 510 uses six screws to assemble the adapter to the bottom base part. Each of these screws uses a tear-drop, anti-rotation washer as the working environment of the hammer union is under heavy vibration. Each tear-drop washer is secured with a small retaining ring. That's a total of eighteen fasteners used to assembly two parts together. John Biagioni, Vice President/General Manager of Viatran, has a favorite saying when it comes to identifying waste in the business, and that is "eliminate the need." The engineering teams used this thinking in the redesign of the adapter, the top half of the hammer union. They eliminated the eighteen fasteners by designing the model 511 adapter so that the part itself screws into the base part. The perception from the field is that the six mounting screws are a weakness in the design. FEA results showed that the screw will not fail under typical impact loading in the field and the adapter will deform first, but again, eliminating the screws will eliminate that perception all together. See Figure-5 below:

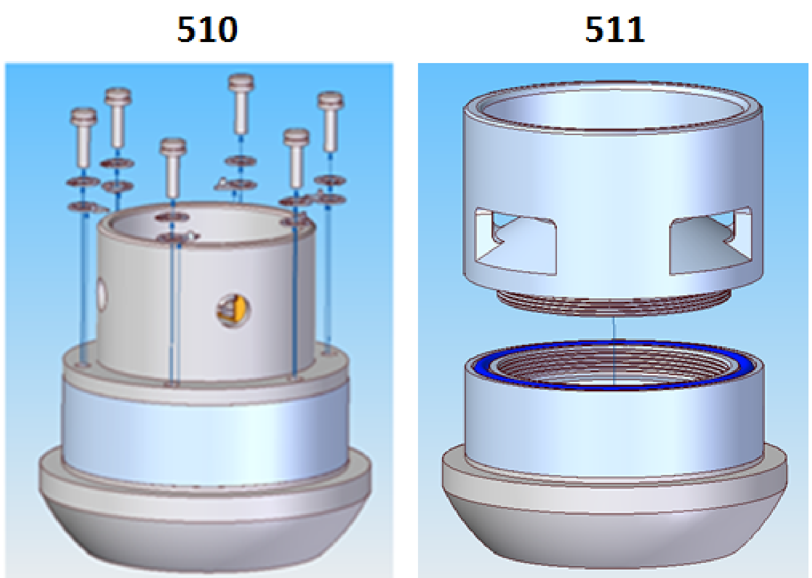


Figure 5 – "Eliminating the need" of eighteen fasteners on the model 510 vs. the new model 511 in the assembly of the adapter to base part.

The new feature set within the adapter part itself is designed to eliminate or improve two additional failure modes the hammer union 510 sees. The sledgehammer swings previously mentioned can sometimes clip the very top of the six-pin electrical connector. With the connector's protective bayonet cap installed, the cap actually protrudes above the adapter wall. This impact usually results in a catastrophic failure of the connector. Additionally, due to the elements in the environment, the electrical connector housing is prone to corrosion leading to signal failure.

To address the impact failure, the adapter wall was extended to fully protect the connector even with the bayonet cap installed. The 511 adapter wall protecting the electrical connector also increased in thickness when compared to the 510 adapter. The internal diameter of the adapter was also increased. This provides increased access to the connector as many workers in the field are wearing protective gloves making it difficult to unscrew the bayonet cap. The increase to the height ('X' dimension) and the internal diameter ('Y' dimension) are shown below in Figure-6.

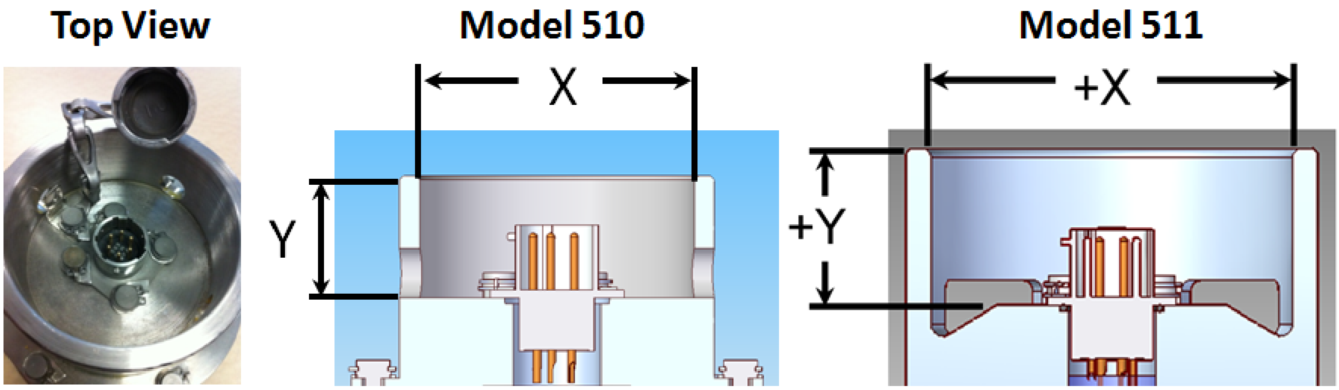


Figure 6 – On the left, existing model 510 showing electrical connector and protective bayonet cap. Middle and right, cross-section view comparing model 510 vs. model 511, X and Y dimensions.

To address the debris collecting in the top of the adapter, the new model 511 adapter has four large window openings and a sloped surface around the connector which provide an easier path to flush out debris. The new 511 adapter's larger internal diameter, increased height for connector protection, thicker wall, larger egress windows, and sloped connector surface are all features in the part that are accomplished without machining one "chip" of 304 stainless steel. How did we accomplish this? "Design for manufacture" completely describes the new adapter for the hammer union model 511. The VAVE group investigated different materials and manufacturing processes during the competitive benchmarking process. Based on the design requirements and final geometry, the part was an ideal candidate for the investment cast process. By casting the part to "near-net shape," all of the features previously mentioned in the adapter are as-cast features that eliminate time consuming and costly machining processes. For example, during the benchmarking process, we determined that the raw material work piece used to machine the 510 adapter is a billet of 304 stainless steel that weighs 4.7 lbs. After machining, the 510 adapter as a finished part ready for assembly weighs 1.1 lbs. That's 3.6 lbs of 304 stainless steel that was wasted. 76% of the 4.7 lb billet is machined away. By switching to the investment cast process, the casting blank weighs 2.9 lbs and after machining the finished 511 adapter weighs 2.0 lbs. Solid reductions in both the amount of material purchased and processing time resulted from designing with manufacturing processes in mind (see Figure-7).

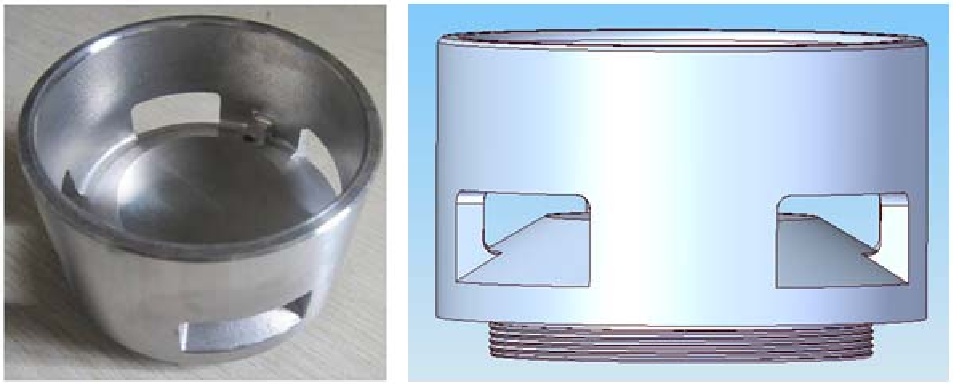
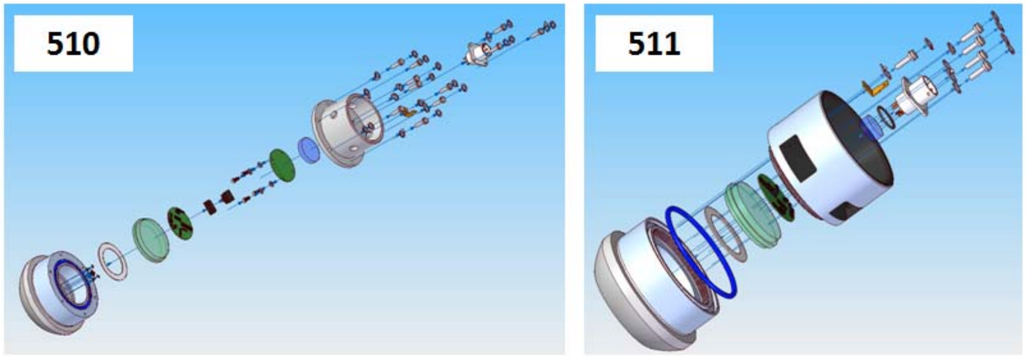


Figure 7 – On the left is a picture of the investment cast blank for the 511 adapter. On the right, a rendering of the finished part.

The positive results from Viatran's hammer union project are best shown through a summary of the DFMA metrics for the entire assembly. The DFA index is a measure of assembly efficiency calculated by BDI's DFA software. The baseline index for the model 510 assembly was 7.0, while the index for the model 511 assembly improved to 9.6. The total part count decreased from 102 for the model 510 to 66 for the model 511. The majority of this review focused on the mechanical design effort. Not to be out done was the work by Viatran's electrical engineering team. On the electrical side, the group merged two printed circuit boards from the model 510 into only a single board for the model 511 and eliminated solder joints and a snap fit electrical connecter that was wired and soldered in the assembly cell. Eliminating the second circuit board eliminated 4 screws and 4 washers used to mount the board. Good examples of targeting those "candidates for elimination," fasteners and connectors. Overall, a total of 36 fasteners were eliminated from the model 510 by moving to the model 511 design while a projected 25% reduction in assembly time is expected (see Figure-8).



	510	511
DFA Index	7.0	**9.6**
Part Count	102	**66**
Fasteners	82	**46**
PCBD	2	**1**
Assembly Time	**25% reduction**	

Figure 8 – Summary of DFMA metrics comparing 510 and 511 assemblies.

DFMA Metrics in the Product Development Process

As stated in Kevin Dailida's 2012 DFMA Forum paper, Dynisco's previous version of its Product Development Process (PDP) had DFMA processes only at Stage 4. This is essentially the validation stage, when the design is locked in and there is little opportunity for iterations or designing out costs that late in the design process if required. Over the course of the past few years changes have been discussed to properly integrate DFMA within the PDP and Figure-10 shows the revisions based on these discussions.

To fully accept a change of this extent, Dynisco had both internal and external contributions to revise the PDP. Back in late 2011, Dynisco worked with Dr. Mike Shipulski who conducted a workshop tailored specifically for Dynisco on Shipulski's Systematic DFMA Deployment program on product design with DFMA. Shipulski's program involves the creation of Pareto charts to help identify where the costs and part counts are within existing and newly designed products. A simple and powerful method that can be applied across almost any area of the business, Dynisco has adopted using three types of Pareto charts within their PDP process. "The Big Three," as Matt Miles, DFMA and Value Engineering Manager at Dynisco, refers to them, are Pareto charts identifying "Cost by Subassembly," "Part Count by Subassembly," and "Part Count by Part Type." Creating the third Pareto chart mentioned, "Part Count by

Part Type," can be performed individually, but can also be a highly effective group exercise. This exercise challenges engineers to define the "part type" of each part in a product's bill of material. Creating the part type Pareto chart even prepares the bill of material to be imported into the DFA software. It could be considered an essential step to take before beginning the DFA process because, as Miles states, "you will know your product inside and out by preparing these three Pareto charts."

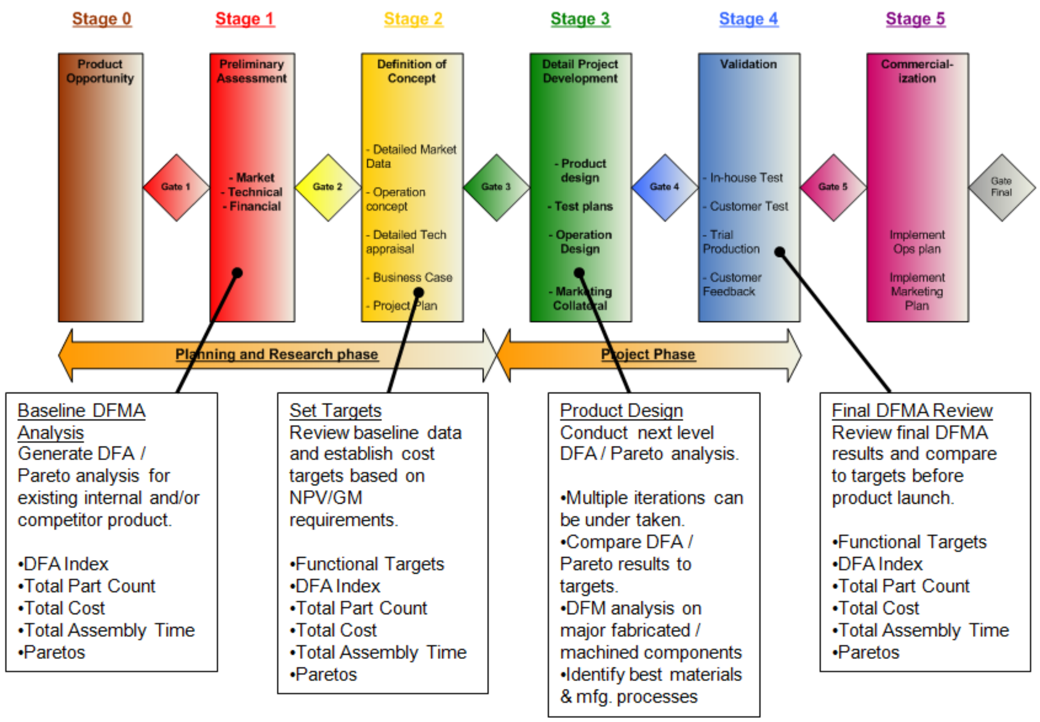


Figure 10 – DFMA Metrics in the revised product development process for Dynisco. Revisions include adding competitive benchmarking (stage 1), establishing product/project targets (stage 2), designing to meet targets (stage 3), and validating project targets were met (stage 4).

Additionally, Dynisco recently attended Goldense Group, Inc.'s (GGI) 15th R&D Product Development Metrics Summit. The purpose of this three day summit is to understand current and best practices, as well as the projected future of R&D and Product Development Metrics. The summit includes a workshop on day three where attendees develop a Product Development Metrics Portfolio. This portfolio of metrics will be suitable to pass the necessary metrics to the CEO that are needed by the corporation and measure the performance of projects. Founder and CEO of GGI, Brad Goldense, stated during the summit, "By developing a set of metrics that measure product development, a company creates a set of corporate assets to build upon." Dynisco followed this thought by including DFMA metrics into their PDP such as DFA Index, Total Part Count, and Assembly Time, to name a few examples.

The hammer union project followed this new process verbatim. The new process is; performing DFMA baselines on existing products and competitive benchmarking, setting targets for the project, designing to the set targets, and, lastly, validating that they've hit their targets through the DFMA metrics. The results from the project are further validation of practicing DFMA "sooner rather than later" in the product development process. From Joel Neri of Viatran regarding DFMA, "This should be done at the beginning of any new product design or refresh program. This allows engineering to "design out" a lot of the part costs and avoid major manufacturing issues. This essentially gives the design team a one or two step jump in the development process."

Total Cost of Ownership

The design of the model 511 hammer union was heavily influenced by the DFMA, Lean, and VAVE initiatives Dynisco/Viatran have implemented and embraced. There are similarities in all of these programs as Chris Tsai, DFMA Implementation Service Manager at BDI states, "Though they have different techniques and practices, DFMA, Lean, and VAVE have the same fundamental objectives … they're all focused on providing value to the customer in the lowest cost way without sacrificing system performance or delivery." An ideal complement to these programs is the TCO initiative that has been implemented simultaneously at Dynisco with DFMA, Lean, and VAVE. Dynisco's TCO effort has been led by Biagioni, formerly Dynisco's Vice President of Supply Chain & Operations.

The Dynisco TCO model still starts with the piece part cost procured from within the supply chain. The second level of TCO is referred to as the "Total Landed Cost" (TLC). TLC includes *where* the piece part is purchased because it factors in freight, insurance, and duties as well as potential fuel surcharges in shipping from supplier to the business. The third and final level completes the "Total Cost of Ownership" as additional overhead and risk factors are added to the calculation. Biagioni presented a thorough description of his TCO approach at the 2012 DFMA Forum.

How was TCO applied within the hammer union project? An example for review is a hammer union piece part that was procured from a supplier in China. First the part had to be shipped from Shanghai to Dynisco headquarters in Franklin, Massachusetts because the part is electron-beam welded to a mating part and the original welding supplier was based in Massachusetts. A change occurred in the supply chain; the original welding supplier had capacity limits and the part was moved to an alternate welding supplier. The value stream was never adjusted, therefore the part continued to be shipped from Shanghai to Dynisco and then over to Viatran in Wheatfield, NY, near Buffalo. After inspection at Viatran, the part was put in sets with its mating part and shipped to the second welding supplier in Syracuse, NY. Post weld, the two-piece weldment was then shipped to yet another supplier back near Buffalo for a clean-up machining cut. Finally, the part reached its destination at Viatran for assembly.

This example is an exhaustive and expensive value stream based on the TCO analysis that was completed on only these two parts within the assembly. The TCO results showed that this value stream adds an additional $22 per hammer union unit in overhead expenses. To correct an example like this, Dynisco/Viatran will rely on their philosophy of regional manufacturing and distribution. In its simplest form means, build where you sell the product. Biagioni adds, "Regional manufacturing and distribution is the quickest way to fulfill demand while minimizing risk."

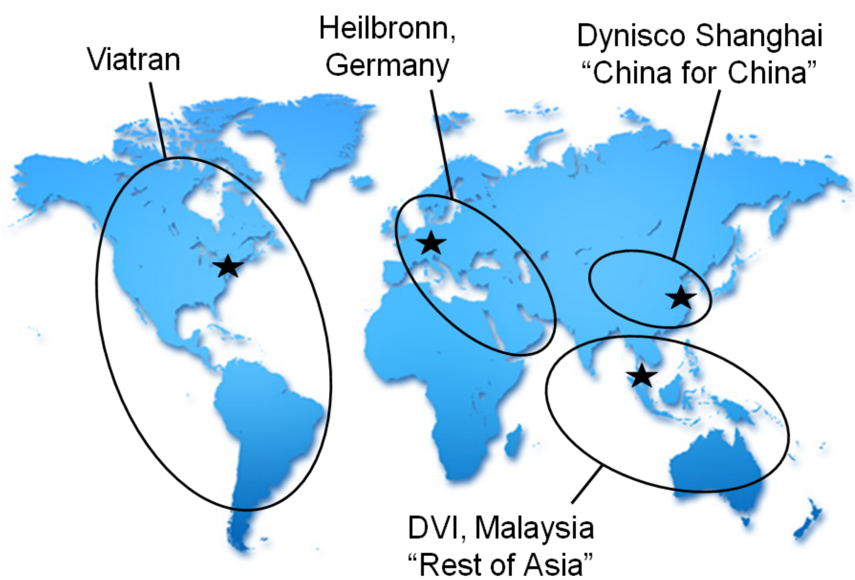


Figure 9 – Regional manufacturing and distribution example from Dynisco. Products can be manufactured at Dynisco sites and distributed to customers within the region.

Moving forward, Dynisco's DFMA and TCO efforts will assist the supply chain in procuring cost effective parts and subassemblies. TCO still begins with the cost of the piece part. This is where the DFM software will help Dynisco engineers understand the part costs at any point in the design process. Dynisco's VAVE group runs the "should cost" analyses in DFM on concept and existing parts for the supply chain based on the methodology Miles presented on at the 2010 DFMA Forum. This method is a six step process that ensures that all assumptions are accounted for in building the most accurate DFM cost model possible. "DFMA and TCO go hand in hand," says Biagioni. He adds, "Both DFMA and TCO have been institutionalized into our stage gate process contained within our product development cycle."

Summary

Over the past few years, Dynisco set out to change their approach to design through initiatives such as DFMA, TCO, and Lean. The results of the hammer union model 511 project display the positive results from applying DFMA, TCO, Lean, and Benchmarking practices all within our revised product development process. We are hopeful that the results from projects such as the model 511 help create the "sense of want" in our engineering groups to use DFMA. The goal still remains for Dynisco and that is to build the "DFMA mindset," that design drive costs. However, by focusing on part count reduction, products can be designed cost effectively.

As Biagioni summarizes, "There are (4) businesses within Dynisco, and as the leader of Viatran I can tell you we are 100% bought in. We have, and will continue to set aggressive part count and assembly time reductions targets. We incorporate postponement into our designs to enable the quickest response to the greatest variation in demand. We make sure that the design that we come up with utilizes as many COTS (Commercial Off-The-Shelf) components as possible and can be made anywhere in the world because we have right toleranced it."

In the spirit of continuous improvement, Dynisco will persist at looking for areas of the business to improve upon the strong foundation it has established with DFMA, TCO, and Lean. Consider the benchmarking process, Brad Goldense stated at his summit, "benchmarking should be ongoing, not on a product or project basis. Ongoing benchmarking will increase the velocity of design." While we are currently practicing benchmarking on a per project basis, we have discussed expanded its role to a continuous practice. Additionally, we'll continue to look for ways to expand our DFMA use. "DFMA, as I mentioned before, has become part of Dynisco's DNA. We have also championed different DFMA efforts across the ES&C group (Roper Industries) and have offered our services beyond the ES&C Group with the support of our management," says Biagioni. Dynisco's DFMA and VAVE Groups led by Biagioni and Miles have performed DFMA analyses for other ES&C businesses and have advised other companies within the DFMA community on DFMA and TCO best practices. It's important to continually challenge ourselves as Neri states, "The DFMA process works very well. However, it makes sense to constantly challenge it with experience and common sense. This will help "fine tune" the process around our product type and manufacturing strengths."

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11. Weco® is a registered trademark of FMC Technologies.