DFMA – Small Company, Large Impact

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Abstract

Plant Products Corporation works with a variety of different industries. One industry in particular is the meat industry, where we supply product loading and handling equipment for ready-to-eat and some raw products. In order for Planet to reach its financial goals within this industry, it has been determined that the equipment we supply must incorporate and maintain a certain minimum level of Sanitary Design. Threats of food-borne illnesses such as Listeria Monocytogenes, Salmonella and E. Coli O157:H7 has forced our industry to rethink and redefine its methods of assuring that equipment is cleanable and safe for handling ready-to-eat meat products.

The use of the Boothroyd Dewhurst DFMA software is helping us to positively impact the meat industry. Planet is setting the stage for Sanitary Design Practices. In conjunction with these design practices, our usage of DFMA is forming a way of life when designing equipment for use within this industry. I use the terms “way of life” to describe the role DFMA can play in supporting the methodology of keeping equipment designs simple and straightforward. This approach can affect the actual number of components configured within a given assembly, thus impacting the overall number of components requiring cleaning during the equipment sanitation process (machines are cleaned heavily at least once a day with very caustic solutions).

This paper has two purposes. It describes Planet’s efforts to not only understand how DFMA can help a small to medium size company save and make more money, but, it will also illustrate how an entire industry can be positively affected by the methodologies inherent to the DFMA software. The use of DFMA is helping us provide simpler, cleaner and more cost effective equipment to the meat packers of the world.

Our industry demands that suitable materials are utilized and that the equipment is designed in a sanitary fashion. DFMA, with its powerful drive to eliminate parts, helps us to support these sanitary design guidelines by reducing the number of components and bring mechanical assemblies to a bare minimum state. From a microbiological level, it means one less component to clean and one less component to inspect. This basic drive to eliminate parts is one key to sanitary design and is the key to saving and making money.

Introduction

In 1947, Planet Products Corporation was formed to design and manufacture specialty machine tools. One such product, a unique lathe, is used today to machine a pattern of grooves in steel mill rolls that form the rib patterns in concrete reinforcing bar. This successful product has become known as a deformation generator.

Planet Products has since evolved into a diversified engineering and manufacturing company, making products such as loaders for packaging processed meats, heat-sealing equipment for packaging medical devices, hydraulic motors and valves, and robot enhanced packaging systems. Planet Products also designs and builds process and packaging systems, provides product support services, and does close-tolerance machining and precision assembly. An example of a systems integration job is a computer-directed automatic line for assembling and packaging slices of four different types of luncheon meat (ready-to-eat) in a flexible film vacuum package (at the rate of 80 packages per minute).

Planet Products is the leading manufacturer of loading equipment used in the high-speed, flexible film, vacuum packaging of frankfurters and other sausage products, with installations in over 20 countries with such companies as Kraft Foods, Sara Lee, Con Agra, Smithfield, Hormel, Bob Evans, Oscar Mayer, Jimmy Dean, Kahn's, Hillshire and Bar-S Foods just to name a few. For the past 15 years, the Company has manufactured components for and carried out assembly work for Fanuc Robotics. Planet Products is the leading innovator in the design, manufacture and installation of automated lines for the cooking, assembly and packaging of a variety of complete sandwiches. Planet also supplies hydraulic motors, power supplies and drives, the critical components of laser directed guns used in light armored vehicles.

Planet's growth has accelerated in recent years as a result of its long-term commitment to process and product development and to continuous improvement. Planet was awarded the 1991 Vendor of the Year award by Fanuc Robotics (the largest Robotic manufacturer in the United States). In 1996, GM Hughes/Delco, a manufacturer of light armored vehicles, honored Planet as their best supplier. Planet is dedicated to the principles of Total Quality Management.

We currently employ approximately 80 people ranging from management & engineering to service and shop personnel. Planet is proud of its people and their contributions that have benefited the Company as well as our customers. Our vision is to be the supplier of choice for our customers by being innovative, customer focused, and efficient.

The Decision to Buy

Planet struggled with the decision to either buy a seat of DFMA software or strive to learn and apply the principles behind the software. As a small to medium size company, our initial reaction to the software was that it was geared more toward large companies that require thousands and thousands of parts to be manufactured to support their customer base. We had a hard time understanding exactly how the DFMA software could help a company like ours that makes custom equipment and one or two parts at a time. Generally speaking, a lot of what Planet has manufactured is one-off type designs, custom to the extreme. In other cases, we fabricate custom solutions adaptable to our existing equipment designs. These adaptations allow our equipment to remain flexible.

Our CEO, being exposed to the potential power of DFMA and being the driving force behind our research of the product, made the decision to send two representatives to a DFMA training course. Here we would learn about the software in more depth and we would have the opportunity to actually put the methodologies associated with the DFMA process to use. I was among the two who attended. We walked away from the training session with a newfound belief and understanding of the awesome power of the Boothroyd Dewhurst product. We could see first hand how the DFMA software helps one to dissect an assembly in great detail. Such detail that we could see how even a strip of masking tape containing a part number and work order number (hand written no doubt) was costing us money.

A determination was made. The DFMA software is not only for large companies needing to streamline the design and processing of five hundred thousand widgets, but, it has the strength to support even the smallest of companies to reduce the cost and complexity of equipment or products that containing even a few parts.

Clean Design Technology

The power of the DFMA software has allowed Planet to review and evaluate its equipment designs in such a way as to highlight overly complicated and wasteful design practices. A great number of small companies move form one project to another with the mind set that the engineering and design needs to be done as quickly as possible in order to save money and deliver their products in record time. The DFMA software has allowed us to truly think about how an assembly goes together and begs to question the existence of the majority of parts within an assembly.

Couple the power of having a software package demand simplification through the combination of hardware and the removal of fasteners, with the goal of designing clean equipment worthy of contacting food products that are ready for human consumption, and you end up with a strategy that can only be described as amazing. For years it has been stated that a sanitary design mindset must be generated when designing and

building food processing equipment. Planet believes that the DFMA software is one tool that not only supports this mindset, but it is one that can be used to actually define it!

In our industry, we understand that sanitation and cleaning crews have an enemy that is extremely small in size but very large in numbers, microbes. As designers and engineers of food processing equipment, we must find ways to support the sanitation crews. We are really after things we cannot see! One of the biggest influences designers and engineers can have on a piece of equipment being utilized in the meat industry is eliminating niches and ensuring accessibility to areas of the machine which would be hard to reach for all other practical purposes.

The goal of any food safety program should be to protect public health. Data from USDA's Food Safety and Inspection Service (FSIS) show that industry efforts to reduce Listeria Monocytogenes (L.m.) in ready-to-eat meat and poultry have contributed to significant reductions in L.m. on products. Based on data from the Centers for Disease Control and Prevention, illnesses associated with L.m. also are decreasing, which suggests that industry efforts are yielding tangible results. These are the kinds of results that are good for our customers and good for businesses.

L.m. can be harbored in areas as minute as a scratch on stainless steel or in the threads of a screw. Industry uses environmental testing widely, aggressively and voluntarily to target and destroy L.m. in areas like these. Although it may seem counter-intuitive to some, good environmental testing programs must be designed to find L.m. so that aggressive actions can be taken to remove it from the processing environment. Simple equipment design facilitates this removal process.

The meat and poultry industry currently is regulated by a number of performance standards, including "zero tolerance" for E. coli O157:H7 in raw ground beef, "zero tolerance" for any pathogenic bacteria on ready-to-eat meat and poultry products including Listeria monocytogenes and Salmonella, as well as many other performance standards.

The American Meat Institute (AMI) has formed an equipment design task force that has worked hard to define a set of 10 principles for every equipment supplier in our industry. The goal is to have companies adopt and incorporate these principles into their design routines. The principles are aimed at helping equipment suppliers produce cleaner and simpler machines. Being able to do this at a reasonable cost is one factor that can prove to be insurmountable.

The AMI Task Force 10 principles of Sanitary Design:

1. Cleanable to a Microbial Level
2. Accessible for Inspection, Maintenance, Cleaning and Sanitation
3. Made of compatible materials.
4. No Product or Liquid Collection
5. Hollow areas Hermetically Sealed
6. Sanitary Operational Performance
7. Validate Cleaning and Sanitizing Protocols
8. No Niches
9. Hygienic Compatibility with Other Plant Systems
10. Hygienic Design of Maintenance Enclosures

An engineer once said, “The difficult thing about engineering great designs is the ability to make them simple.” DFMA is helping Planet achieve this goal. We believe that DFMA and Sanitary Design go hand in hand, because, in the world of food processing equipment less is definitely better.

DFMA Evaluation

One clear example that illustrates the strengths of the DFMA software and one that provides a clear and undisputable example of how the software can benefit a small to medium size company, is a conveyor belt take-up utilized on the Planet Frankfurter Loader. The Frank Loader has a unique pocket chain incorporated into its base design that has in it a confined space for individual Franks to fit. This pocket chain delivers the Franks, some 1200 to 1400 per minute, to a loading device which groups and inserts the Franks into downstream packaging equipment. The pocket chain comes in a number if shapes and sizes depending on the configuration of Franks that are processed. Generally, the equipment is configured with two separate chains delivering product simultaneously to the packager (dual lane configuration). The drive configuration for the pocket chain is much more straightforward; drive sprockets on one end of the conveyor and spring-loaded idler assemblies (one for each lane) on the other.

For the sake of sanitary design, the original idler assembly on this machine was reconfigured at one time with a secondary set of sprockets which forced the pocket chain to drop down or dip down just prior to reaching the end of the conveyor and moving on to the convey side of the conveyor system. This dip allowed for more accessibility during the sanitation process, allowed a high temperature and high pressure spray to be applied to the back side of the chain, and also provided the quality assurance inspectors the ability to visually inspect the chain to ensure safe operating conditions.

Since this take-up is a small scale and manageable sub-assembly, it was chosen as the initial candidate to be carried through the DFMA process. Knowing there were two take-ups per machine and that additional complexity was added to the assembly, we felt our decision was a good one to help put the DFMA software to the test, reduce the number of parts on our equipment and to help save us money. It was understood that the unit had to continue to act as a continuously compensating take-up (not locked in position), it needed to support a number of existing and newly adapted sanitary design features, and it needed to achieve the goals defined by the DFMA software.

Through our evaluation we took advantage of the most critical part of the DFMA analysis, minimum part count. Through answering the detailed questions surrounding each part and each labor action within the software, specific goals were defined. The goals set by the DFMA software were simply staggering. The original take-up design consisted of a total of 44 items (including repeats) that included a total of 37 parts, labor costs equaled $20.58 dollars, and the total assembly cost totaled $1,485.81 dollars each. The staggering part is that the DFMA software actually defined the theoretical minimum number of items required for this assembly as being a whopping quantity of only 4 items. From 44 to 4, who would have imagined? For a company like ours, this equates to 40 items that do not need to be designed, purchased, acted upon, tracked, checked or evaluated. For us resources are limited. Turning one thing that is somewhat complicated into something that is simple eliminates a host of unseen complexities and cost. This is invaluable for a small to medium size company.

The DFMA software helped us to not only understand how this assembly was put together and how all steps and parts included in the assembly had an impact on the overall cost, it helped path the way for redefining the assembly to meet clear and measurable goals. At a glance, not one of our designers or engineers was able to say or would have been able to estimate that the theoretical number of items would have been as low as 4 total required items. While staring reality in the face, some suggested that the 44 items listed could probably be reduced by some healthy percentage (pulled directly from the seat of their paints) or that a good number would be in the range of about 12 to 15 parts. Not only were we unable to specify a probable minimal item quantity and reasons behind why the parts would not be needed, but any attempts we made in this effort would not have incorporated any of the actions or work required to complete the assembly.

DFMA Results

With a definitive and measurable goal in place, our next step was to put our heads together to brainstorm different designs that would allow us to reach our minimal quantity of 4 items. The original design incorporated rotating sprockets and commercial bearings, one major departure form this form of design was to envision a type of track or non-moving guide. Several other equipment designs that Planet has produced have indeed incorporated such tracks or guides as an idler or take-up. Our thinking was that

it could be a large plastic shaft or even a basic block of plastic material that had simple tracks machined into the outer surfaces. We decided that a non-moving roll or track would be the simplest and cleanest approach to guiding the pocket chain. The thought of eliminating sprockets, shafts, bearings, keys, setscrews and housing blocks tickled us to no end.

But what about the take-up functionality! The original take-up utilized springs and an adjustment feature to acquire the continuously compensating feature and allowed for some level of pressure adjustments. We needed to retain this compensating style design. We discussed ways to retain the springs yet simplify the hardware required to house and contain the spring. This proved to be feasible but we did not quite make the goal set forth for our minimal item count of 4. Another possible approach to acquiring the compensating functionality is to leverage gravity. A weighted take-up design provides such functionality and with the proper sizing of parts and materials, it can actually become a very stable design.

With so many thoughts running through our minds, we had some difficulty in limiting the number of approaches and ideas being offered. We settled on six separate conceptual approaches, some of which incorporated springs. Each concept was discussed in detail and graded for potential functionality, simplicity, sanitary design, maintainability, cost, and the ability to disassemble from the main conveyor section (disassembly from the main conveyor section allows for intense off line sanitation).

The take-up of choice was a weighted take-up design that pivots in a simple bracket welded to the main conveyor section. The wearable sections of the take-up were to be fabricated from a large round plastic material (Acetal) that incorporates the guides and tracks we discussed earlier. One of the rounds or rolls was to act as the pivot for the take-up and the other was to provide the sanitation drop down or dip described in earlier sections as well a apply the tensioning pressure. Connecting the two rolls together was a fairly large piece of stainless steel sized specifically for the appropriate weighted tension the pocket chain required. These three pieces were not only going to incorporate a simple slip in place design for the main conveyor section but these parts would have a snap fit or locking design incorporated allowing for easy assembly and disassembly from one another.

Note: Some snap fits can be construed as unsanitary. Caution must be advised when leaning toward snap fit functionality when used on a food processing equipment.

The configuration of this new take-up design has allowed Planet to simplify a section of our Frank Loader improving the sanitary design and cutting our costs by a large margin. As stated earlier, the cost of the original take-up design is $1485.81 dollars; it contained a total of 44 items and 37 parts, and had labor costs of $20.58 dollars. The new take-up design has a total cost of $217.26 dollars, contains a total of 3 items, and has a total labor cost of $0.21 dollars!

Executive Summary Comparison - DFMA

Planet Products Corporation
Product Development Group

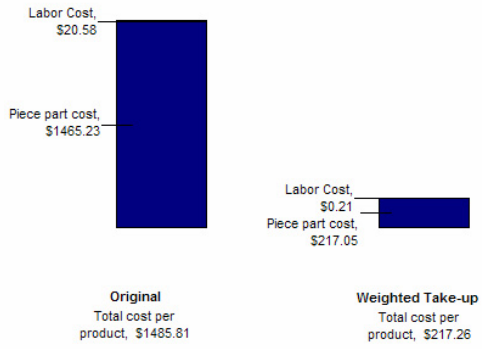
Thursday, June 05, 2003 3:43 PM
Take up operator side

R:\DFMA\Frank Loader\Take-up_20000503\Removable Take-up.dfa
Original, Weighted Take-up

	Original	Weighted Take-up
Product life volume	10	10
Number of entries (including repeats)	44	3
Number of different entries	19	3
Theoretical minimum number of items	4	3
DFA Index	1.0	70.3
Total labor time, min	20.58	0.21
Total weight, lb	** 0.00	28.00
Total labor cost, $	20.58	0.21
Tool or fixture cost per product, $	0.00	0.00
Other operation cost per product, $	0.00	0.00
Item costs (including tooling), $	1465.23	217.05
Manufacturing tooling cost per product, $	0.00	0.00
Total cost per product, $	1485.81	217.26

***Note: Item weight not given for some items. Total weight may be incomplete.*

The chart shows a breakdown of cost per product



Original
Total cost per product, $1485.81

Weighted Take-up
Total cost per product, $217.26

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With the DFMA software and this one simple step, we have been able to reduce the direct cost of this complete take-up configuration by $2,537.10 dollars or a total of 85.4%. More importantly, we reduced our take-up assembly count by 41 items or 93.2% creating a very sanitary and easy to clean device.

Summary

Some examples of sanitary design changes made to our equipment are the removal of components without the need for tools, the unique break down of conveyor frames for open access to the backside of conveyor belts & support components, and incorporating perforated guarding for inspection & wash-through capabilities. Through the use of the DFMA software, we are now looking to reduce the number of parts required to achieve these and other sanitary design approaches.

The DFMA software is assisting Planet in providing the meat industry with simple and clean equipment solutions. No words can describe the benefits we gain from having equipment designed and configured with as few parts as possible. Our challenge is to reach the goals set forth by the DFMA software and to intelligently design the components in a manner that is clean and sanitary.

Planet has just begun to scratch the surface of the vast potential the DFMA software can provide our company and our customers. The strength of the DFMA software is driving minimal part counts and the reduction of items required in an assembly. As a company, we must use this powerful tool to its full advantage and open our minds to the possibilities that come from the detailed assessment of our equipment designs.

References

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