Countering the Reappearance of Old-School Views on Product Design

Abstract : In the early 1980's a product design methodology called Design for Assembly, which focused on the amount of assembly labor required to build a product, began to gain popularity. Since that time, the Design for Assembly methodology has been adopted with much success by more than 850 corporations. However, in the past ten years there has been a significant resurgence in a very old and outdated design philosophy that promotes product cost reduction through the focus on the cost of parts within the product. This paper describes why a focus on assembly labor reduction delivers larger cost savings and superior products when compared to products designed with a focus on part cost reduction. Evidence is presented that indicates there is a resurgence in this outdated design method and a product design case study is shown that illustrates what happens to a product when designers focus on the cost of parts during redesign. An alternative redesign that uses Design for Assembly principles to reduce assembly labor through the use of multifunctional parts is also presented and the cost reductions that result are discussed. Finally, conclusions are drawn regarding each of the two design methodologies.

Although the exact percentages can vary, sometimes pretty substantially, the overall cost breakdown of a typical manufactured product appears much like the one shown in Fig. 1 where the overwhelming majority of the total product cost is tied up in the cost of the parts. Overhead is a still significant, but much smaller proportion of the total product cost. The cost of assembly labor usually makes up the smallest proportion of the cost of a product.

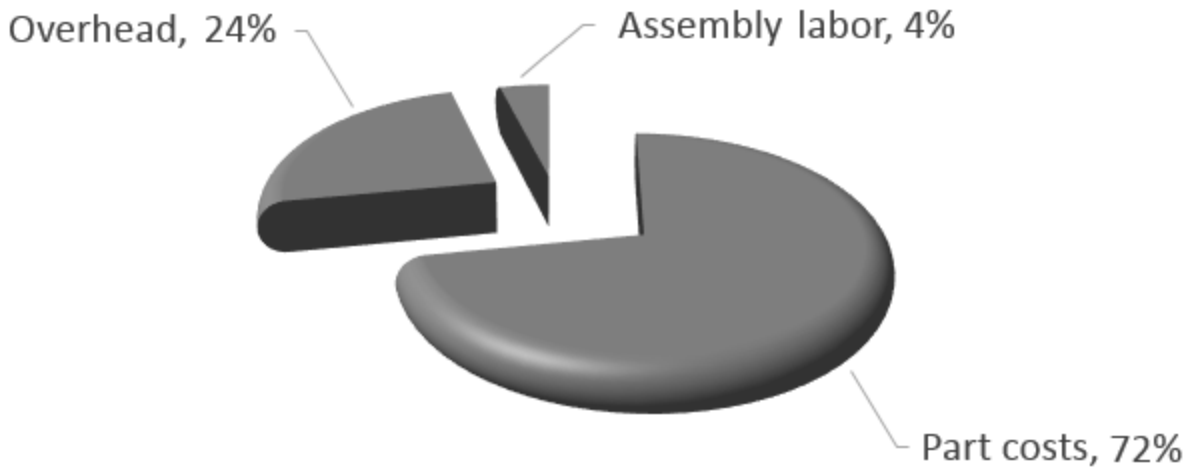

Figure 1 Cost breakdown of a typical manufactured product

In the early 1950s, a design philosophy began to take hold where designers that were interested in creation of cost effective product designs began to really focus on the cost of the parts, perhaps because the part manufacturing costs make up such a large proportion of the total cost of a product. At that time, Design for Producibility guidelines started to become much more common, and these guidelines

almost always focused on methods to design individual parts so their cost is reduced. This sort of approach would invariably simplify parts but create a much more complex product structure through an increase in the number of parts required within the product. One such Design for Producibility guideline is shown in Fig. 2, where it is recommended that designers break complex parts up into a series of simple shapes and then join them together during final assembly.

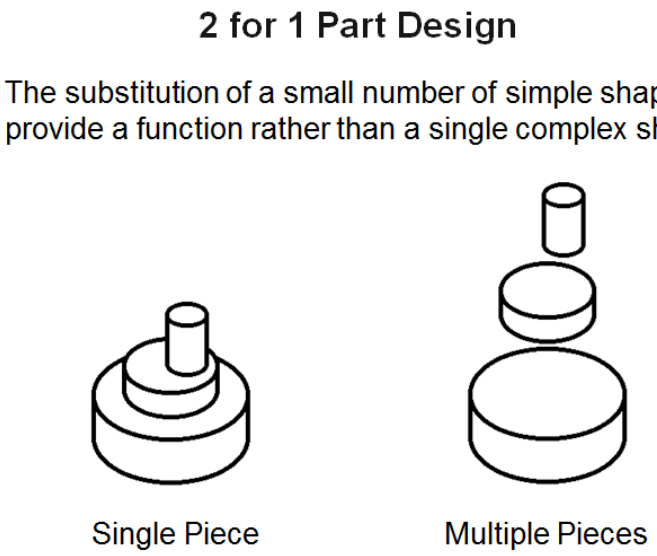

Figure 2 Incorrect Design for Producibility guideline published by General Electric in 1960.

Based on the typical breakdown of costs for a manufactured product shown in Fig. 1, this sort of approach might seem to make some sense because it's the parts themselves that make up the majority of the total product cost and the cost of assembly labor is often small. However, there has been over thirty years of experience now that shows it's much more cost effective to produce the design that uses the single more complex part rather than the series of simple shapes all joined together.

Perhaps what is less understood is that the majority of the cost reduction that results from using the more complex shape does not come from a reduction in the assembly cost. Usually, the largest cost reduction actually comes from a reduction in the part manufacturing costs. This is because it is often less expensive to use modern manufacturing processes to make the single more complex part rather than to make the larger number of simple parts. However, the most easily recognizable characteristic that distinguishes between the two designs shown in Fig. 2 is the amount of assembly labor required. Dr. Geoffrey Boothroyd used this realization to develop the Design for Assembly methodology, which uses assembly labor reduction as a guide to help designers produce more cost effective products.

In order to illustrate what happens during redesign when the focus is placed on the assembly labor, consider a thought experiment where the three part product shown on the right side of Fig. 2 is redesigned to reduce the amount of assembly labor as much as possible. That goal would tend to lead the redesign towards the less expensive single-part design shown on the left, where no assembly labor is

required. The focus on assembly labor reduction guides the redesign so that a larger number of simple single function parts are combined into a smaller number of more complex, multi-functional parts. The redesign that results delivers a double cost reduction because the parts themselves are less expensive to manufacture and the cost of assembly labor is also reduced.

In order to illustrate what happens during redesign when the focus is placed on the cost of the parts, consider a second thought experiment where the single part product shown on the left side of Fig. 2 is redesigned to minimize the part costs. That goal could very easily lead the designer to break up the complicated multifunctional part into a series of simple shapes so that the more expensive design shown on the right is produced. Experience has shown that this is exactly what happens when designers focus on part cost reduction, especially when designers have little accurate feedback on part manufacturing costs during design. Experience has also shown that the same problems occur when an automated CAD costing system is used because evaluation of each design alternative requires a series of new CAD models to be manually created, which can be very time consuming.

In the past ten years, the author of the present paper has noticed an increase in interest in design methods that focus on cost reduction of individual parts within a product. Evidence that there is a resurgence in this old and outdated design philosophy includes:

- New consulting companies have opened, many of which also sell part costing software. When these companies sell their software, they promote a design methodology that focuses on the cost of individual parts and they justify the approach with statements like “The largest spend is on the parts, so that’s where you want to focus.”
- University-level coursework is currently being taught based on this outdated design philosophy and university professors have stated that their curriculums will be modernized with this approach. Class projects focus on part costing and cost reduction that is centered on individual parts. For example, the professor might take apart a bicycle in front of the class and ask for cost reduction ideas, one part at a time.
- Newer users of DFMA commonly focus on part costing as an up-front product design tool instead of focusing on Design for Assembly to simplify product structures. For example, the author of the present paper recently spoke with an overseas manufacturer of sewing machines and they were fairly close minded about Design for Assembly. All of their assembly work is done in China at a very low hourly labor rate so the cost of assembly is insignificant to them. As a result, they want to focus on the parts because that is where their cost is.
- Newer projects that Boothroyd Dewhurst’s customers concentrate on commonly focus on reduction of part costs, even when the projects are called “Design for Assembly projects.”

This reappearance of the outdated design method that focuses on the cost of the parts is likely due to a lack of knowledge and understanding about what Design for Assembly actually does. In the 1990s, Design for Assembly knowledge was somewhat common, but over time the engineers and designers with that knowledge have moved on or retired and the education of the younger replacements has become fragmented.

As an example of a recent product redesign project, consider the original design of a rear lamp assembly as shown in Fig. 3. This product mounts to the rear of a piece of heavy equipment and it is made from 37 individual parts. There is a lamp bracket that is made from a mounting block welded to a cantilevered mounting plate. There are four rubber isolation mounts that are secured to the lamp bracket with nuts and washers. A lamp guard is then mounted to the other end of the four rubber isolation mounts with nuts and washers. The lamp and pivot bracket are then mounted inside the lamp guard with a screw and washer. Many of the parts are made from one quarter in. thick mild steel and the total weight of this assembly is just about 18 pounds. This design has been in production for more than 20 years.

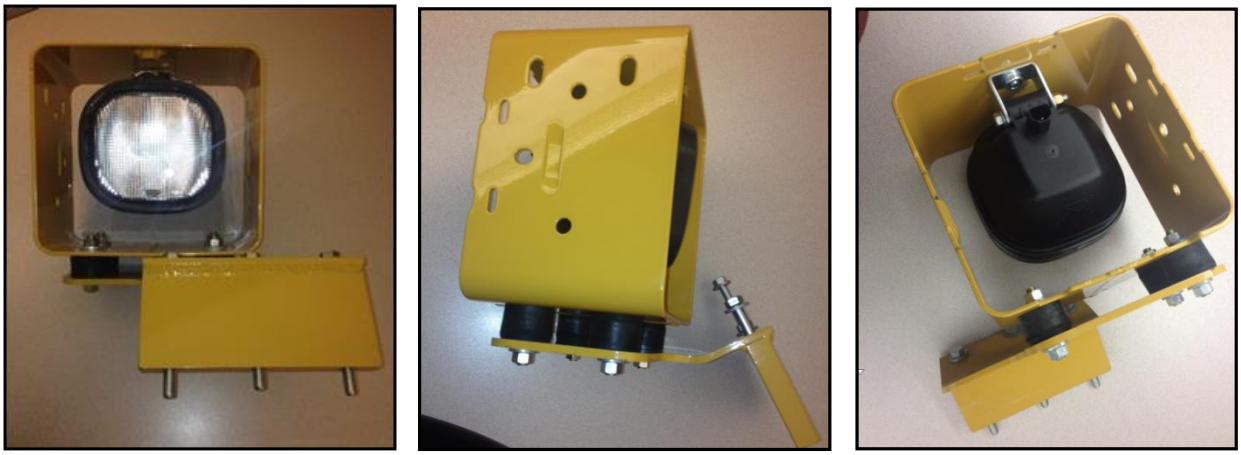

Figure 3 Rear lamp assembly - original design.

The DFA software was used to estimate that it takes 13 minutes to assemble this original design, including the time for all of the welding and weld dressing required. The DFM Concurrent Costing software was also used to estimate the manufacturing cost for all of the individual parts within this design. The total cost to manufacture, assemble, and install this design of the lamp assembly was estimated to be 88 dollars. Feedback received from the company that produces this design indicates that that estimate is within 10 percent of the price they pay for the product, so the estimate of total cost for the original design is reasonable.

The company identified this original design as a possibility for cost reduction and redesigned this product in order to reduce its cost. The cost reduced redesign that resulted, is shown in Fig. 4.

Figure 4 Rear lamp assembly - cost reduced redesign.

In order to generate this cost reduced redesign, the lamp guard and the rubber isolation mounts for the lamp have all been removed from the product. The lamp bracket used in this design is now one eighth of an in. mild steel instead of the thicker material used in the previous design. Each of the parts in this cost reduced redesign still serve only a single function, and the functionality of the lamp bracket in the design is certainly debatable. The DFMA software was used to estimate that this redesigned lamp assembly costs 42 dollars to manufacture, assemble, and install on the equipment. Feedback received from the manufacturer indicates that estimate is within 10 percent of what the company pays for this design of the lamp assembly, so that estimate is also reasonable.

Clearly, the design philosophy this company has taken with the redesign of this lamp assembly focuses on the cost of the parts. In order to satisfy their cost reduction goals, the company has removed the functionality of the lamp guard and the rubber lamp mounts. The remaining parts have been cheapened through a reduction in their thickness and their strength. This case study is quite unusual and was included in the present paper because normally, functionality cannot be removed from a product design in order to reduce its cost. Normally, the functionality required in a product is fixed by the final customer's expectations or by the functionality of similarly classed products from competitors. However, it is very common for design teams or cost reduction teams to cheapen parts within a product through strategies like reducing their thickness and strength, changing to less expensive but less effective materials, and sacrificing aspects of the product's performance to gain a cost reduction. Each of these approaches to cost reduction comes about by focusing on the cost of the parts and each results in product designs that the end customer will view as compromised and of lower overall quality.

The original design of the lamp assembly is located on the vehicle, just above the transmission cover casting as shown in Fig. 5. That is the optimal location for the lamp because it is unlikely to suffer an impact significant enough to cause damage and it can provide light where it is needed on the rear of the equipment. This situation presents an opportunity to use Design for Assembly principles to reduce cost through the integration of the lamp mounting bracket and lamp guard into the transmission cover casting. This DFA redesign changes the simple, single function, transmission cover into the multifunctional part shown in Fig. 6.

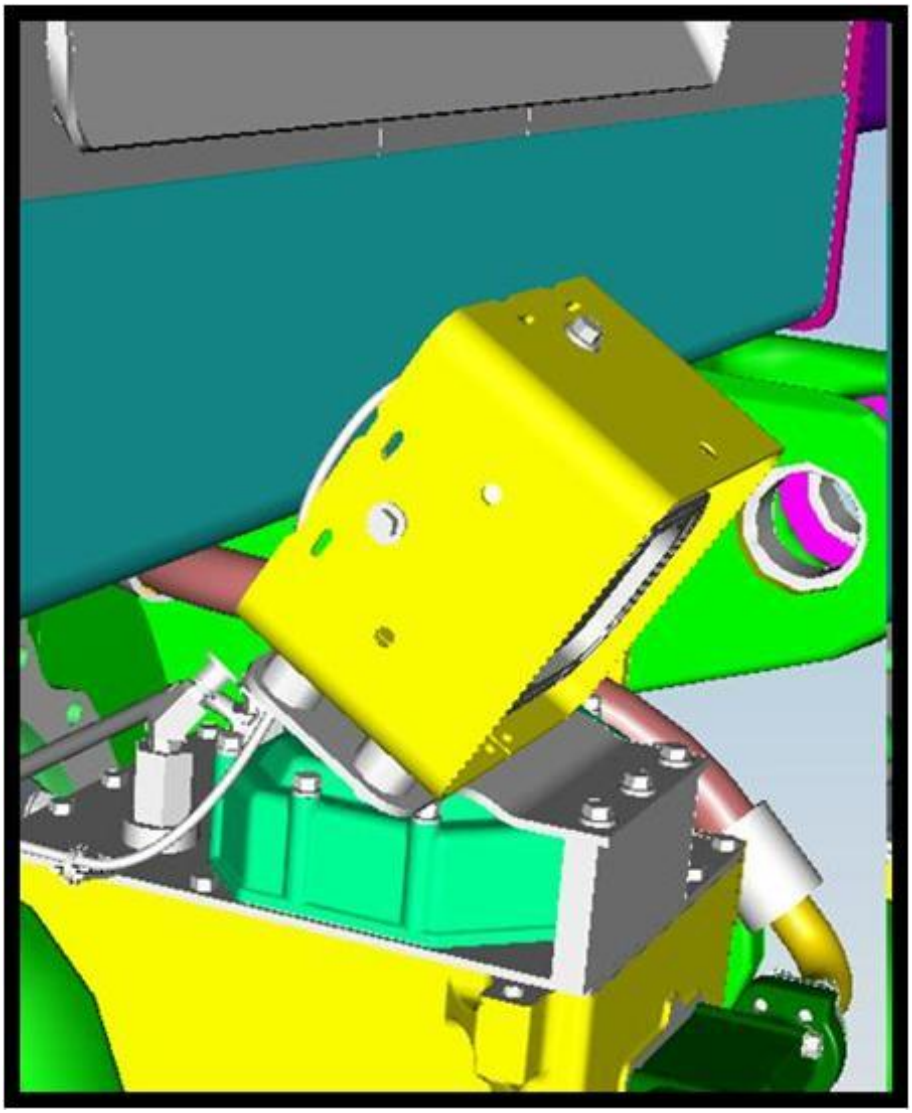

Figure 5 Location of rear lamp assembly original design on vehicle.

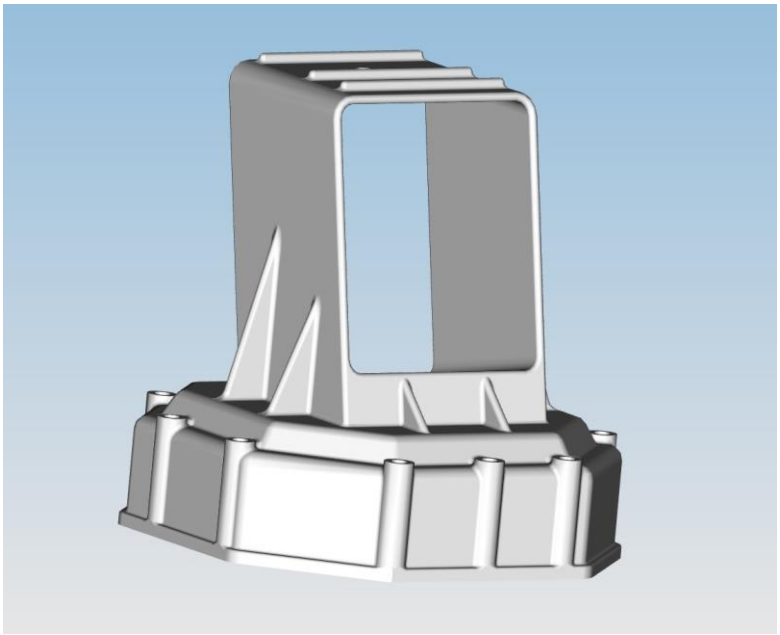

Figure 6 DFA redesign of lamp assembly.

In order to determine the portion of the cost for the multifunctional part this is attributed to the lamp assembly, the cost of the original single function transmission cover was estimated and then subtracted from the cost estimate for the redesigned cover that includes the integral lamp guard. This results in a cost estimate of 48 dollars for the DFA redesign of the lamp assembly and includes the amortized cost of the pattern and core box required to make the aluminum sand casting. The cost estimate for the DFA redesign also includes a cost of just over 4 dollars for the rubber isolation mount and associated hardware to mount the lamp inside the lamp guard.

Discussion of case study results

In this case study, the design method that focused on the cost of the parts resulted in the cost reduced redesign of the lamp assembly and a 52.3 percent cost reduction. However, that cost reduction was generated at the expense of the functionality and usefulness that the end customer pays for when they buy the lamp assembly. This illustrates the largest problem associated with such a design philosophy because it really leaves the design team with few options to satisfy cost reduction goals other than to sacrifice the very things that the customer wants to buy, such as the functionality, durability, and performance of the final product. If this design method was applied to redesign the remainder of the vehicle, it is very likely that the end customer would find less value in the vehicle and make their purchase from a competitor instead.

The Design for Assembly design method that focused on assembly labor reduction resulted in a very similar 45.5 percent cost reduction yet it sacrificed none of the original design's functionality. In fact, a knowledgeable customer is likely to view the DFA redesign as an improvement in the product rather than a cost reduction because the DFA redesign is likely to handle vibration better than the original and will tend to be more reliable during use due to the robust lamp guard integrated into the casting. However, the DFA redesign in this case does cost 6 dollars, or 14.3 percent, more than the cost reduced

redesign. More than two thirds of that cost difference can be attributed to the cost of over 4 dollars to rubber mount the lamp, a feature that was removed from the cost reduced redesign in order to save money.

Upon presentation of this DFA redesign to the company, the designer said that he would never take this approach with the design because the redesigned transmission cover casting would cost too much to produce and would require a core during manufacture. These statements from the designer really demonstrate this resurgence that is occurring right now in the old and outdated design philosophy that focuses on the cost of the parts in a product, even to the point that the functionality and usefulness that the customer buys is removed in order to save money. While it is true that the multifunctional casting used in the DFA redesign costs more to produce than the original transmission cover casting, the multifunctional casting also eliminates the need for a separate lamp bracket and lamp guard. When all of this is considered, the DFA redesign is quite cost competitive especially if the functionality and usefulness of the design are taken into account.

The designer at this company also indicated that it would be much more cost effective to add a guard and a rubber isolation mount to the cost reduced redesign. This option was investigated and the DFMA software was used to determine that this design would cost just over 60 dollars to manufacture, assemble, and install. This means that the least expensive option that incorporates all of the original design's functionality is the DFA redesign which utilizes the multifunctional transmission cover/lamp guard casting to minimize the amount of assembly labor required.

It should be noted that this feedback we received from the designer did occur before the designer saw the cost estimates for each design alternative. After the cost estimates were disclosed, the managers at the company thought it was well worth the extra 6 dollars to provide the customer with a guard and a rubber mounted lamp.

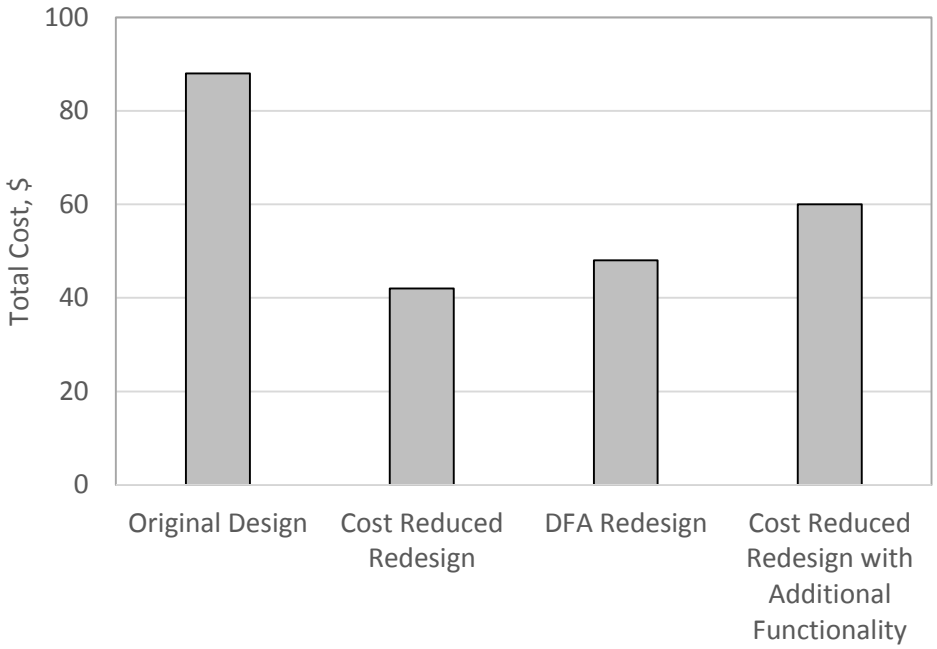

Figure 7 Total cost to manufacture, assemble and install each design alternative.

Conclusions

The methodology adopted during product redesign and cost reduction efforts will largely determine the type of product design that results. The old and outdated redesign methodology that focuses on the cost of the parts means that product designs will be composed primarily of single function parts that are all joined together. Cost reduction goals will be met through the use of approaches such as the elimination of functionality or features from the product, the reduction of strength through a reduction in the factor of safety in part designs, and a reduction in the usefulness and durability of the final product. All of these approaches present the end customer with a compromised design. For that reason, the redesign methodology that focuses on the cost of the parts is not sustainable because when it is carried out on a large proportion of a product, the customer will leave and buy a competitor's product instead.

The Design for Assembly redesign methodology that focuses on assembly labor reduction means that product designs will be composed of a smaller number of multifunctional parts. Cost reduction goals will be met through the simplification of the product structure and that results in products that the customer doesn't view as cost reduced. This is because, in most cases, the products that are redesigned with this methodology not only generate cost reductions but they also generate improvements in performance, durability, and reliability. There has been thirty years of experience that proves Design for Assembly is a superior method to generate cost reductions without sacrifices to the product that the customer really wants to purchase.