USING DFA TO ENHANCE VALUE ENGINEERING/VALUE ANALYSIS WORKSHOP OUTCOMES

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Introduction

In the automotive industry, the pressure to reduce prices is present at all levels, from the vehicle manufacturer (OEM) through to the lowest level of the supply base. Most first and second tier suppliers are faced with contractual **performance** or **productivity** clauses which require annual downward price adjustments of 3 to 5% on the products they provide to the OEM.

Faced with these pricing constraints and continuing cost pressures, the suppliers and OEM's alike have resorted to a multitude of formalized techniques designed to meet the challenge. These include GFD, TQM, VE, VA, and DFM, DFA. Some of these techniques have met with success while others have been tried briefly and dropped. At the Magna Interior Systems Seating Group, we have found the most powerful combination by a wide margin has been the melding of the disciplines of DFA and VE/VA.

This paper describes the means by which the Magna Seating Group VE/VA team has employed the Boothroyd Dewhurst DFA method to enhance the outcomes of our Value Engineering Workshops, resulting in significant savings in materials, design costs, tooling, and processing of parts and assemblies.

Value Engineering/Analysis as a Full-Time Activity

Because of the continuing requirements for maintaining downward pressures on all costs, it has been found productive to establish and maintain a small department within engineering whose only purpose is to concentrate on the broadest areas of cost reduction through the Value Engineering/Value Analysis approach. This department is made up of experts in each of the disciplines required to develop and manufacture the products of the supplier company. Personnel were selected for their demonstrated skills in the areas of product development, manufacturing, tooling, and processing as well as their overall industry experience. In many organizations, it would be difficult to take people with these skills out of the mainstream of product development for an extended period of time for this effort; however, the fact that some of the best and most experienced personnel have been assigned exclusively to this program at Magna speaks to the level of commitment required to achieve success.

Once the commitment is made, we have found that the payoffs can be several times the cost of supporting the group. Further, properly equipped with the latest computer equipment and software, and trained to use every available means to spot cost reduction targets, it is easily demonstrated that a full time VE/VA group can have a major impact on the bottom line.

At Magna Seating, we have used the DFA technique to strongly enhance our cost reduction efforts, not only in the area of metal parts, but also in the analysis of cut & sew products such as seat and armrest covers. We believe this second application of DFA is an industry first. We have developed our own formulas for each sewing operation and have verified the accuracy of the outcomes by comparing them with actual observations during visits to the various facilities. DFA is now the standard tool used to target our VE/VA efforts.

Correlating Product Design with the Manufacturing Process:

Effective design for lowest cost and fewest components can only be accomplished by a product design and engineering staff that understands the manufacturing capabilities of the plant(s) in which the assembly will be made. Unfortunately, in today's working environment, the design team is often not conversant with the processes and procedures of the manufacturing facility. Further, program time constraints frequently seem to force the design to be initiated without thought of how the final product will be made. Time for analysis is usually not scheduled into the program, and the design proceeds to a point of no return before a realization is made that tooling and processing of the parts, subassemblies and assemblies have not been considered adequately in light of plant conditions.

In order to minimize this problem, the training of product engineers and their design counterparts must include continuing exposure to the plants charged with manufacture of the products for which they have technical responsibility. Visits to plants for orientation and training should be for a minimum one week period with as much floor exposure as can be practically included. In some cases 3 to 6 month plant assignments may be considered for newer members of the product design and engineering staff.

The payoff for this type of training is the ability of the engineers and designers to visualize the manufacturing process during the preliminary design stages of new products, including direct knowledge of process layout when conducting the initial baseline DFA analysis. This procedure minimizes false starts, redesigns, issuance of Design Change Notices and the accompanying cost of tool changes later in the program.

When conducting the baseline DFA it is important to include inputs from the entire product team. Insights into potential production and assembly problems by those who live with the plant environment on a daily basis is invaluable in assuring the accuracy of the DFA outcome. Minor design changes which may vastly improve the processing of the assembly and its components can produce a major cost impact on the final product.

Purchasing, Sales, and Quality Assurance personnel will enhance the knowledge base of the team and bring independent ideas to the DFE - VE/VA process which could easily be missed by the technical staff because of their close contact with the product being considered.

Targets For Change - DFA - A Tool for Focus:

The usual way to attack a high cost part or assembly is to wait until after the design is released, tooled and in production and suddenly discover that the expected margins are not being generated. Obviously, by this time a lot of engineering and design cost is already burdening the product; often it is discovered (usually by the CEO) that "we're shipping this thing with dollar bills wrapped around it." This is usually not too good for the long term career prospects of the design or product manager. Clearly, early analysis of new designs using the DFA technique is crucial to the commercial success of each and every product. A strict regimen needs to be imposed providing for DFA analysis as soon as the first concept layouts and illustrations are sufficient to define the product in all its functions.

The early review at concept stage will reduce parts count and processing steps by highlighting possibilities for combining parts, reducing extra screws, bolts, and washers, and reduce or eliminate extra or superfluous reinforcement achieved by parts layering (common in the automotive seating industry). Major development, tooling and gauging costs are saved by the lowering of parts count, and all are familiar with the high cost associated with making changes later in the product development cycle.

A review of operations will reveal other opportunities for cost savings in the processing area. A good example is in automotive seating systems where many parts are covered with foam or fabric, or are otherwise not visible. For many years, certain customers required that all steel parts be painted or otherwise coated to prevent rust; however in the JIT environment, parts are not stored for long periods of time prior to final assembly, and, once assembled, are no longer exposed to atmospheric conditions which cause corrosion. Given these new conditions, it is no longer required that the steel parts which are covered be coated. In many cases even exposed parts which are not visible can be left without surface protection.

Wire welding is another process which often can be minimized or eliminated.

When reviewing the DFA and the preliminary design, an examination of weldments usually will expose relatively small parts (gussets, trim tabs, etc.) which could easily be made integral with the basic part to which it is welded. Very often these parts are so small that time penalties must be attached because of handling problems. If manually welded, the welder must pick up these parts using bulky gloves, place the parts in a fixture and perform the welding operation. Observation of this process in the plants has indicated that the elimination of the small parts can save 30 seconds to a minute in the assembly sequence.

Very often a change in the approach to the method of accomplishing a desired function can reduce parts count by 1/3 to 1/2. This is especially apparent in the guiding of moving parts, such as folding seats, latches, etc. Forming special guides and welding them to brackets requires extra parts sand processing to achieve a motion or function that can just as well be done by piercing a slot in the main base bracket to act as guides.

Anyone visiting a mechanisms assembly plant will observe manual lubrication of mating parts by using a brush or rag. Automation of this process can eliminate as many as three people from the assembly team and almost always results in significantly reduced material use. Equipment cost can be paid back in a very short time and exposure of personnel to a potentially hazardous environment is eliminated.

Designers and engineers are fond of creating assemblies with lots of screws, rivets and small parts. Unfortunately, these parts are difficult to handle and process, even with automated equipment. On the other hand, if caught soon enough, it is possible to find alternate constructions that will provide the same function with fewer components. At Magna we have been able to minimize the quantity of these small parts and automate the assembly of those absolutely required, using the "Suggestions for redesign" function of the DFA software to target opportunities.

Likewise, it is prudent to automate those assemblies which are prone to error for one reason or another. Parts detection equipment can be included in the automation to sense that parts such as rivets are present and properly installed. Thin washers, often omitted when manual handling is practiced, can be cartridge fed and placed. Difficult operations, such as installing press fit rollers between parts which move relative to one another, should be automated for ergonomic considerations as well as to reduce assembly time and operator error.

Multiple reorientations can make even the simplest assembly a costly proposition. Baseline DFA analysis will document the reorientations and demonstrate the time lost. Frequently a minor redesign will permit assembly of a system by stacking from one side with no orientations. Many latches, recliners and other mechanisms can benefit by reducing assembly time.

Other assists include palletized assembly fixtures and direct feed of parts from the press or rolling mill to the assembly area in a straight line operation.

Method and Approach

Before any VA or VE workshop is conducted, one or more of the engineers in the group will run a baseline DFA analysis, assisted by other available workshop team members, on the products which are to be the subject of the workshop. The Baseline analysis is reviewed by other members of the VE/VA group and revisions are made based on their inputs. If the assembly is already in production, DFA outcomes and processing assumptions are compared with actuals.

The baseline analysis is then revised, using the "Save As" utility, to preserve the original, and at least a Phase 1 analysis is done to eliminate the obviously un-needed parts and assembly process steps. At this point, nothing too radical is considered, but only those changes which the VE/VA group believe will have a good chance of acceptance by the design engineers, plant, and customer are made.

If time permits, a Phase 2 analysis is also made to determine the result of making changes which are a little more radical; that is, the parts count and processing is brought to the minimum possible while preserving the function of the assembly. In some cases there is little additional impact on cost and time, but in others, the potential is very dramatic. The example discussed in this paper is one of the latter.

During the actual VE/VA workshop, the Value Engineering team utilizes the DFA outcomes to target areas of potential product and process improvement and exposes the entire workshop group at the preliminary discussion and goal setting stage. Assembly activities with high time penalties are pointed out to the group along with suggestions for possible improvement to be made. Later, during "Brainstorming" sessions, the Phase 1 and Phase 2 reports are distributed and discussed in order to stimulate thought and increase the flow of ideas coming to the table. Timing for the introduction of the Phase 1 and Phase 2 DFA's is usually left to the discretion of the workshop leader so as to get maximum impact from the group in response to the new data being presented.

As the workshop progresses, it is a good idea to continuously update the DFA to capture the impact of new concepts as they are brought out. This practice provides an immediate estimate of the impact of the various ideas on the assembly time savings, parts count reductions and cost reduction achieved. The positive impact on workshop team members encourages a greater volume of ideas, enhancing the output of the group. There is a strong tendency for cost savings ideas to build on one another in a geometric way, and the ability to show the time/cost impact of the ideas being generated as a running total encourages active participation of even the most reluctant (shyest) participants. Having a good, updated DFA to present to management at the Executive review and close out meeting at the end of the workshop helps to ensure that the ideas brought to the table will receive top priority for study and implementation.

Example Program - Jump Seat for Extended Cab Pick-up

A truly fine example to demonstrate the power of DFA to reduce parts and operations costs was recently presented with a project to tool and build a jump-seat for use in a pick-up manufactured by a major automotive OEM (See Figure #1).

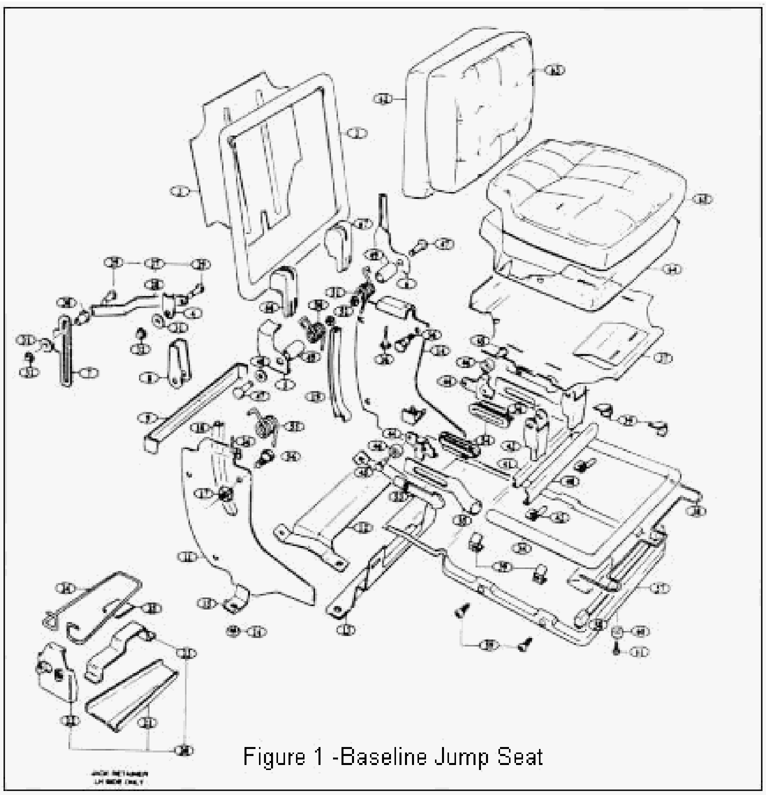
Figure 1 -Baseline Jump Seat

Drawings and sample assemblies were provided of the current version of the product, and Magna engineering was asked to design and tool a replacement for the North American market in roughly 8 months time. Options were open to tool the system as designed, or to redesign the details while maintaining features and functions. It was clear from the outset that the profitability of the project would be marginal at best if the design were not changed. The question was how to redesign quickly, maintain features and functions, and still meet timing constraints.

Baseline:

It was decided to run a DFA analysis on the part as presented and use the analysis to point out assembly problems and opportunities for change. Consequently, a baseline analysis was run, initially using an illustration drawing as reference, and later breaking down the actual assembly. The results of the DFA baseline were rather startling; the assembly consisted of 105 separate parts made of four basic materials types, formed using several different manufacturing techniques, and assembled by welding, riveting, screwing, snapping and swaging. Many of the parts were hidden from view until the assembly was actually cut apart revealing multiple layers of material, i.e., tubes inserted within tubes, multi piece plastic subassemblies, etc.

The total calculated assembly time was over 1440 seconds, not counting paint application. Six major subassemblies were made, many small tabs (less than 25 mm square) were hand welded to the basic framework to permit mounting of a plastic trim cover. MIG welding was extensive. More than four reorientations were needed just to assemble the seat base bracket. Assembly of the basic tubular framework required long insertion of a tube, then flattening a 100 mm long portion and piercing a 15mm x 45mm slot. At final assembly, several hidden or obstructed operations were encountered.

Phase 1 "Reasonable" Changes

Using the baseline analysis, a Phase 1 scenario using the "Reasonableness Criteria" was created wherein low risk changes were made to the various components, parts eliminated through combination with others, and processing and assembly simplified. The reasonableness criteria assumes that there is some good reason for some of the extra parts and makes some allowance for timing constraints imposed by the customer which may limit added design and development effort in order to meet tooling dates.

The objective of this phase was to maintain all essential functions of the seat while reducing the parts count and assembly time. Significant numbers of parts were combined or eliminated by making minor changes to a relatively few number of related parts. Most important, a large number of welding steps were eliminated, especially the welding of very small components that are difficult or impossible to handle while wearing welder's gloves. Multi-layered parts were strengthened by increasing the gage of the material slightly to provide equivalent performance.

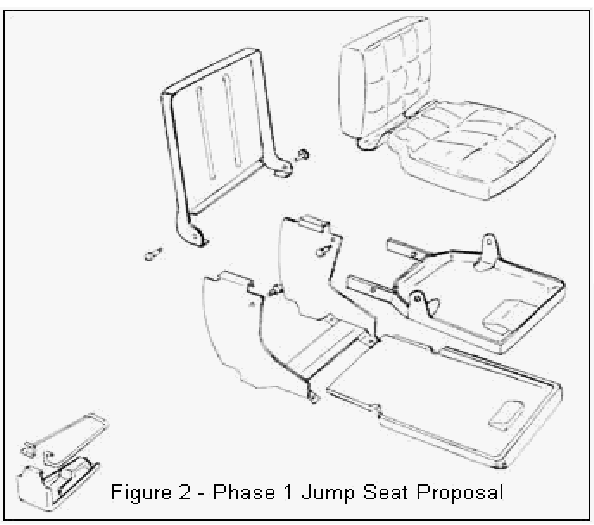
Figure 2 - Phase 1 Jump Seat Proposal

Cams and rolling components were changed to slides and guided in slots rather than formed guide ways. The resultant changes reduced part count from 105 to 19; major subassemblies were reduced to 5 and assembly time from 1445 seconds to 258 seconds. An illustration of the revised seat is shown in Figure 2.

Phase 2 "Anything Goes"

In Phase 2, the DFA is conducted using the theory that any change is possible as long as the functionality of the assembly is maintained. All the little niceties of the mechanism are considered extraneous and only the basic purpose of the system are considered. The seat must still fold up and stow in the side panels, and structural strength must be maintained, but without added reinforcement or the use of double material thickness.

Minimum parts and single axis assembly are primary. Welding is to be minimized or eliminated, and only absolutely essential screws and rivets are retained.

It is expected that the changes which are possible using this approach will be too radical or extensive to be accepted; however, by exploring the most aggressive solutions, it can be demonstrated that significant cost reductions can be achieved while keeping most product features.

Looking at the Assembly Analysis Totals, the parts count is reduced to 9, major subassemblies to 2, and assembly time to less than 100 seconds. All the tubular parts are deleted and their function combined with the seat cushion and back support stampings. The base bracket is made as one piece, omitting all welding operations. The cushion stops and guides are integrated into the stampings and plastic sliders replace the two piece rollers at the interface between the two parts. Seat belt anchors are integrated into the base bracket and separate brackets and weldnuts eliminated. The seat and back cushion are combined into a single unit with multiple parallel sew lines at the fold point used to compress the foam at the hinge point. The hinge action can be achieved using either shoulder rivets or shoulder screws which are plastic coated at the bearing point to eliminate bushings used to control squeak and rattle.

Coordination of DFA with the VE/VA Process

Outcomes of a baseline analysis are utilized to target various system components and subassemblies for cost reduction by a number of means. First, there are the obvious possibilities for the combination of parts into the components to which they are attached. Second, the analysis often makes clear that certain parts are not needed and can be eliminated without penalty to function. Not so obvious are those instances where costly handling, insertion and assembly steps and processes can be eliminated; these kinds of changes affect not only the cost of parts in the final assembly, but also tooling, gauging, fixturing and capital equipment needs which are often of no small consequence.

Worksheet Totals for the various subassemblies can be used by the VE/VA team to review the more expensive components and processes. This permits the team to focus immediately on the areas of a product which may provide the most fruitful cost reduction potential. Many times the more complex subassemblies with many processing steps and reorientations can be revised to cut their assembly times and parts count by 1/3rd or more. The Subassembly Worksheet can be used to demonstrate graphically excessively complex assembly sequences to processing engineers, or potential parts combinations to the product engineers.

If a weight analysis is also a part of the date base, the DFA software can also be utilized by the engineering staff for "what ifs" in the area of weight reduction. Material gage reductions or parts combinations can be tried and the resultant outcomes summarized by the software and shown on the Subassembly Worksheet Totals. An iterative process using this method can be a major assist in bringing system weight into the target range.

Our experience has shown that the use of the DFA software in ways outlined above have reduced the time required to conduct VE/VA workshops from the usual 3 to 4 days to 2 days. The result of the reduced workshop time has been an important factor in the willingness of our plant managers to agree to permit their people to participate, and the workshop outcomes are more agreeable to related engineering, manufacturing, purchasing and other support functions because of the enhanced documentation provided. The number and quality of the cost reduction ideas produced are much higher than those of workshops conducted without benefit of prior DFA input.

Cautions - Use Your Reality Check:

Having discussed the effectiveness of DFA as a tool which can significantly enhance the outcomes and productivity of VE/VA Workshops, it is also important to include some cautions in the way of our expectations for implementation of the ideas generated.

The reality of the business environment is that many very good ideas for cost and parts reduction will not be incorporated in the final product. Experience has shown that achievement of 25% to 30% of the changes brought out of workshops is a good result. 40% to 50% would be outstanding. In the Jump Seat example, the actual final parts count was 68 vs. The original count of 105; while this was certainly a worthwhile change, it did not approach the initial 19 parts shown to be possible in the Phase 1 analysis.

There are many reasons we can use to explain this apparent disparity, from customer resistance to change of the original concept to resistance from the designers who "own" the ideas. Time constraints for programs are frequently cited. However, the usual problem is that the DFA and VE activities were not a part of the originally scheduled work and were not brought to bear early enough to achieve maximum effect.

The obvious solution is to convince design teams and management of the benefits to be derived from early DFA and VE input in the product development process, and to continue to demonstrate the potential bottom line results from this activity.