VALUE ANALYSIS - THE KEY TO QUALITY INITIATIVES

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ABSTRACT

This paper presents a technique for Value Analyzing manufacturing processes and integrating the Quality Initiatives: TQM, Continuous Quality Improvement (Kaizen), Mistake Proofing (Poka Yoke), and Design/Process Failure Mode Effects Analysis (DFMEA and PFMEA respectively). The initial Value Study cross-fertilizes the Quality Initiatives and the Process FAST becomes a living document which functionally defines the manufacturing steps and provides structure to the Quality Studies.

Introduction

In today's manufacturing environment, we are constantly being besieged with "New" Quality Initiatives. The general thrust of these systems appears to be the improvement of the quality at the least cost appropriate to satisfy the customers needs.
Value Analysts cannot disagree with these goals. As stated above, they match closely the stated goals that we espouse. It stands to reason then that we must learn to incorporate these aims in our studies and support them. It is through the feedback communication of the results of all the efforts directed toward reducing costs or improving the quality that we become more competitive and "World Class".

A review of the various systems reveals a number of commonalities with which those of us already exposed to Value Analysis (VA) are familiar. We see the use of team efforts to solve problems, the use of various brainstorming techniques, the evaluation of ideas, and the presentation and implementation of selected ideas. The one thing that appears to be most commonly overlooked in the quality directed techniques is a structure (like the Job Plan) and a means to focus the energies of the team and zero in on a particular area (FAST DIAGRAMMING).

THE GENESIS

ICI EXPLOSIVES has for years served commer-cial mining interests supplying the needs for explosives and detonators (both electric and non-electric). The Aerospace business has traditionally developed detonators and explosive actuators for Governmental Interests and produced robbery deterrent bill packs for the Banking Industry. All of these devices have followed the Mil-Standard and Mil-Specification systems for Quality. In the late 1980's, ICI Aerospace & Automotive Products was formed to serve the Automotive requirements for Air Bag initiators.

The Automotive Production brought with it change to the old views of Quality. The American Automotive market, in an effort to change its image, was embracing new quality techniques as rapidly as they were introduced. In turn they were requiring their suppliers to do the same to retain their supplier certification. The new systems introduced additional documentation on design, quality and, above all else, on the process. The value of these changes was recognized in the other businesses and the need to view Quality as a single entity encouraged the cross-fertilization of the reforms in the older businesses.

The Process Flow

Basic to the manufacture of electric detonators, ignitors, actuators, and initiators is a hermetically sealed subassembly commonly known as a Glass-to-Metal Seal (GTMS). See figure #1 below.

This subassembly, when combined with a super fine wire welded across the conducting portions (housing and electrode) of the device, functions in the finished product as a heating element to ignite a sensitive powder which may in turn initiate delay columns or detonating compounds. Millions of these subassemblies are produced annually to support final production. As with any production process, there are inprocess losses due to the process capabilities, handling, lost parts, scrap and a multitude of other causes. A three to four percent loss is common in this operation and it is therefore used in estimating the initial product costs.

Let us assume a problem and then work through the steps of this technique to understand its logic.

During a new product production start-up, the quality data begins to show increasing GTMS losses. A Pareto analysis (part of the new quality procedures) is performed and will quickly reveal that a majority of the parts are failing in the final inspection step before additional processing and cost were added. Now let us assume that the failure mode was a plating adhesion failure. The parts in question are prenickle plated, assembled, fired to form the seal, ground to flatten the surface, deburred, dipped in tallow to remove water, degreased, and finally plated to specification. These are fairly common steps on a number of devices. So, why the change? Product Engineering immediately responds by instituting more rigorous inspections, higher destructive test quantities,replacing the plating baths, replacing the anodes, and testing the base metal for impurities. With the losses and higher Quality Cost the actual product cost of the subassembly can increase by 50 to 60 percent over the estimated standard costs. After considerable effort, we might determine that the cause of the failure is due to incomplete cleaning of the parts between the grinding and deburring steps. A new ultrasonic cleaner could be purchased and installed (increasing the capital investment). Now assume that these product losses declined only to resurface during a production ramp-up to increased volumes and during this episode the true cause was found to be insufficient controls on the flow of water and detergent in the deburring process. Problem solved? So where does VA/VE come into play.

VA can now be employed in an attempt to contain a loss of revenue on a potentially long-running product. The first FAST diagram might produce a result similar to the one below. The design is set. The customer will allow no further design changes in this year. The goal then must be to analyze the process since the design could not at this point be attacked.

These are obviously the functions of the part, but the costs are contained in those previously described processes which do not directly deal with the critical path functions. They are found in the all-the-time or esthetics functions.

Serendipity

Was the scope too limited? No! The functions being served by the process are there on the original FAST diagram as design objectives or all the time functions. What is the basic function? "Resist Breakage". The housing and electrode are ground flat to support the bridge wire and prevent breakage. It is the bridge wire that is outside of the scope. So the team reasoned," why not begin a FAST with "Resist Breakage" as the higher order function and describe the process steps in terms of the functions which they perform." This thinking lead to the type of diagram below, one that focuses on the process steps and the functions we are attempting to perform by the process, as well as the functions being performed as a result of the process being chosen which may or may not be desirable.

In the problem above, the recommendations from functional analysis could result in a cost for the product less than the original standard cost with the side benefits of reduction in Quality Costs, an improved product, a recognition of environmental control requirements and reduced scrap.

Briefly, the ideas could be to produce an already flush GTMS, to bevel the housing to reduce the grinding time and eliminate the burr. Either of these two ideas effectively prune the entire process branch.

Note that, if the surface is made flat to begin with, all functions following will essentially disappear.

So basically what was discovered was that processes do not necessarily follow the critical path of functions, but we all knew that didn't we. That's why we were taught that the FAST diagram is not a flow diagram. However, by looking at the process in a functional manner, providing the costing with the FAST procedures (showing Labor, Materials, Capital and Quality costs), when the study is completed, we have a document that can be effectively used initially reduce the cost of manufacture and one that can be used to further refine the processes and to focus the later quality initiatives.

Since discovering that we could focus on the process rather than the part, we have noted that most processes do not follow the direct path of functions and that most are related to design objectives or all-the-time functions. Using this new technique, we have found that the processes on products which have been running for some time are many times a patchwork of fixes to problems which no longer exist but still remain to generate costs. It is also important to note again what was mentioned above as the "pruning effect". This has repeated in process after process. The interesting aspect of this technique is the unusual applications where it has been now applied, i.e., maintenance (determining the areas needing preventive maintenance on equipment) and the impact on quality programs.

As one of our goals, we plan to perform a Value Study of the product and the process prior to the production start-up. Thus, we may gain the maximum effect by reducing the up front set-up costs, product costs and provide the type of documentation necessary for PFMEA's and the later continuous quality improvement studies. At least now, we have a tool which may be used to improve current processes when the design of the product has already been set.

The second part of this paper demonstrates recent refinements or how and where this information can be used in two programs by the quality function and how the Process FAST comes full circle as a living document of the process.

The Quality Tools

Two quality tools which have proven highly effective in the systematic elimination of product nonconformances and related costs are Process Failure Mode and Effect Analysis (PFMEA) and Mistake-Proofing. Both of these techniques require a detailed knowledge of the manufacturing process and its related controls. As a result, a process functional analysis, complete with nonconformance and cost-related information, can provide an exceptional basis for maximizing the benefits of these techniques. Using the information generatedearlier in this paper, we can now easily develop a PFMEA and use this information to prioritize and drive efforts aimed at Mistake-Proofing.

Process Flow

The first step in the creation of a PFMEA is to develop a Process Flow diagram. This can be a lengthy time consuming task, but by using the hypothetical process FAST developed earlier for our GTMS, we see that the process flow is already defined as follows:

1) Remove Material
2) Remove Burr
3) Remove Material
4) Dissolve Material
5) Tumble Grind
6) Prevent Corrosion
7) Remove Water

Failure Mode Identification

Once the process flow has been established, a list of potential failure modes (nonconformances) must be generated for each process step. Once again, this is easily achieved by a review of the FAST diagram of our process. For instance, according to the stated problem, as a result of our desire to remove material, a burr has developed. This is clearly undesirable as evidenced by our later efforts aimed at removal of this burr. Hence, "Burr on GTMS" is a clear potential failure mode related to material removal. By incorporating inspections and related processing into our FAST all potential failures mode should become evident.

Severity, Occurrence, Detection

Once they are identified, we must then attempt to quantify the severity (degree of impact to end-product functionality), occurrence (how often does the failure mode occur) and detection (how effective are the controls) for each individual failure mode.

Severity is generally determined by an understanding of the product and the intended use. Typically the severity is expressed in terms of its impact on the customer. The greater the effect on the customer, the higher the severity rating.

An occurrence rating is supported by in-process, final inspection, or field failure data. The greater the frequency of each failure mode, the higher the occurrence rating.

Detection is based on an assessment of the merits of the controls in place which would detect or prevent the failure mode in question. For example, controls which function on a continuous basis are of greater merit than those which merely sample the process.

Each of these ratings (Occurrence, Severity, Detection) are based on a scale from 1 to 10, with 1 being the optimal and 10 representing a worst-case condition.

Risk Priority

Having evaluated the severity, occurrence, and detection for each potential failure mode, we must then multiply these three numbers together. The product is the Risk Priority Number (RPN) associated with that failure mode. By ranking all RPN's from the largest to the smallest, we now have a prioritization of where our greatest risks lie relative to nonconforming product, customer dissatisfaction, internal and external failure cost, etc. This prioritization is essential to effectively addressing nonconformance and cost savings.

Assuming that a burr is not desirable to our customer and the frequency data suggests that burrs are present in every lot, the Process Failure Mode Effect Analysis would look like the following: RPN for any failure mode, a reduction in either the occurrence or detection rating must occur. Severity can in no way be minimized by any action on the producer part. Only a change on the part of the customer or end user can reduce this component of the RPN an event which is both impractical and unlikely. Now VA offers us another means of directly reducing the RPN without an increase to the manufacturing costs.

Traditionally, RPN's have been reduced by adding additional methods of inspection thus lowering the detection rating. Unfortunately, these additional inspections are only partially effective and may increase the total costs of manufacturing. True, the probability of detecting a given failure mode may increase by instituting additional 100% inspections or even SPC, but these methods aloane do not provide complete confidence relative to

Process Step or Function	Failure Mode	OC	Cause of Failure	Effect of Failure	SV	Current Controls	D t	RPN
Remove Material	Burr	10	Metal soft	Not desired by Customer	10	Inspt 1st Cont. Sample	5	50 0

Figure 4

By comparing this issue with all other potential failure modes for this process, we can determine where our resources are best spent. The following example clearly suggests that there is no better place to spend our efforts than in reducing the risks associated with the burrs.

Potential Failure Mode	RPN
Burr	500
Chip in Glas	120
Bent Pin	90
Contamination	40

Having determined that we should reduce the risks associated with burrs, we must determine the best method for accomplishing this goal. In this
every part produced.

What is needed is the application of mistake-proofing devices to either preclude the manufacture of failure mode (a reduction in the frequency of occurrence!) or inspect each and every part produced in an automated and mistake-proof fashion (an increase in the probability of detection to 100%!).

What is Mistake-Proofing

Before defining mistake-proofing, we must first define mistake.

> Mistake: The fabrication or assembly of a product outside the established limits of our customer's requirement.

> Mistake-Proofing: The use of techniques or devices that prevent mistakes or prevent the movement of product with mistakes to the next step of the process.

The subtle difference between "mistake" and similar terms such as "failure mode" or nonconformance is crucial. By recognizing the physical and attentive limitations of humans regarding the manufacture and inspection of product, we begin to understand that any lasting and meaningful solution must eliminate the opportunity for human error. That is to say, the opportunity for making mistakes.

The most common forms of mistake-proofing devices are contact and non-contact sensors. These devices detect the presence of mistakes themselves, on an automated 100% basis. Once having detected the mistake, our process must provide feedback to mutilate or sort the nonconformance. It must also provide feed-back to the worker so that immediate corrective action can be instituted.

In our GTMS example, the current controls (first piece inspection and on-going sample inspection have yielded good results, but occasionally a burr is observed in subsequent operations. The fallibility of human inspection clearly suggests that some product with burrs may reach our customer. In order to mistake-proof this operation, an effective, automated 100% inspection must be enacted. This may be as simple as an inexpensive optic sensor or as complex as a vision system.

The application of mistake-proof manufacture has several benefits. Most importantly, it providesfor effective inspection, thus insuring customer satisfaction. Secondly, it may eliminate the need for time-consuming human efforts at inspection. Finally, by providing a more timely feedback to the operator and establishing and eliminating true root cause, we will drive the occurrence of nonconformances down while driving our yield and productivity up. At some future point in time, the PFMEA should look like the following:

Process Step or Function	Failure Mode	OC	Cause of Failure	Effect of Failure	SV	Current Controls	D t	RPN
Remove Material	Burr	1	Metal soft	Not desired by Customer	10	Inspt 1st Cont. Sample Vision System	1	10

Figure 5

And coming full circle, once the root cause is eliminated the revised FAST is pared down to represent the current process for future analysis. The result is higher quality and enhanced cost-effectiveness.

Results

Completely outside of scope in previous FAST diagrams was a higher order process function "Seal Housing" and on the other end "Plate Header". The changes above can eliminate the processing between those steps by providing a functional "flush seal". The RPN becomes effectively "0". Additional Mistake-proofing steps added to the later processing in the form of vision systems at the welding operation, will identify and reject any nonconformances.

This discussion centered around VA and its contribution to two of the Quality Initiatives, however it is as easily applied to TQM, and Continuous Quality Improvement. The lesson is, that as a team we can accomplish greater things than we can as individuals or individual functions. We must find ways to interact together and maximize our resources.