PARTICLE ANALYSIS TECHNIQUE

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Mr,Mudge was corporate VM Vice President, Value Planning Development Department of Joy Manufacturing Company for 24 years. His responsibilities covered the development, organization and operation of the VE activity throughout the 42 plants of Joy's worldwide operations.

He served as SAVE Vice President International, Chairman and member of the Certification Board, member of the International Affairs, Professionsl Development and Case History Committees and founder and president of the SAVE Golden Triangle Chapter, Pittsburgh.

Mr.Mudge's *Value Engineering, A Systematic Approach,* has been translated into Japanese and Russian.

ABSTRACT

Materials and their use, in most instances, both in hardware and software, often encompass a major cost element in the organizational environment. Therefore, this area of costs forms a very likely and lucrative area to start the search for waste and unnecessary costs.

The VE Systematic Approach is specifically directed at overcoming a great deal of unnecessary cost problems. However, the System- atic Approach does not readily have a technique within it that pinpoints waste as such. There are also instances when a Value Study study narrows to a single item. To find an answer to these situations, the technique described here, the **Particle Analysis Technique**, has been organized and developed.

PARTICLE ANALYSIS TECHNIQUE

"Particle Analysis is a systematic questioning of each function of each particle of raw material from which a part is made to determine its ultimate use in the part."

Starting with this definition, the Value Planning Department of Joy Manufacturing Company developed a technique to reliably accomplish the "systematic questioning" noted in the definition. One of the keys to the successful development of the technique was found in the word "function" in the definition.

After numerous trials and errors the technique to be described has evolved. The technique now uses a visual check-off approach coupled with mathematical calculations. Between these two, a visible functional analysis can be made of the item under study. This analysis evaluates each particle of the article from a "Function" standpoint and it's importance to the whole item. First, this analysis evaluates which particles of the starting material become "Waste". Second, the analysis evaluates each particle to determine if it contributes to the accomplishment of the "Basic function". If not, it must then be determined if it is "Non-Functional" or "Non-Critical".

The major benefits of this particle by particle analysis results in a visible display/recommendation of a different configuration to accomplish the Basic and necessary Secondary Functions. This visible display is strongly supported by the mathematical calculations which spell out both the volume and percentage of the starting material within each category. The combination of these two results permits the user to determine or define the least costly item configuration based on the necessary quality, production methods and usage levels.

Since the starting point of the technique is a drawing/sketch, not the physical part a second benefit is derived. The second benefit is that this approach can be applied to items that are in the "design stage" as well as those in the "Production Stage".

After determining the part to be analyzed and all of the functions that it must perform, i.e., it's Basic and Secondary functions are determined. These can be taken from the Function Definition Worksheet or defined at the start of the technique.

The first step is to overlay the part drawing with a transparent grid (preferably of 1/8" squares or smaller) or redraw all views of the part on grid paper; each square of the grid being considered as one particle of material. When this has been done, you super-impose onto the views of the part the starting raw material using the applicable "Material Manufacture's - Allowance For Machining Chart". When the raw material size has been determined, it's size and total volume is calculated and noted in the top section of the Particle Analysis Worksheet.

The second step consists of determining into which of four categories each particle of the material falls. The four categories to be considered are:

a. Waste
b. Functional
c. Non-Functional
d. Non-Critical

Each type of particle (square within the raw Material outlines) should be marked with a different symbol and/or color for the greatest clarity. When only symbols are used, the Waste/ Scrap should be shaded in solid; the Functional left clear; the Non-critical be indicated by an "O" and the Non-Functional marked with an "X". As each category of particles is marked off, the total volume of that category of material and its percentage of the starting material is calculated. These calculations are noted on the Particle Analysis Worksheet.

The third and last step of the technique is a two-part analysis of the visual display and the calculated data generated in the fourth step. This analysis is aimed at the reduction or elimination of items "a", "c" and "d" noted above. The second phase of this step is directed at possible changes in the part configuration that can be recommended based on the analysis. The major factors to be considered in this determination are different methods or processes of manufacture based on the various levels of production required.

To provide a fuller understanding of the possible applications this technique and its benefits, two examples are shown and discussed. The first, is a hardware example from a portable compressor manufacturing plant A Fan Hub Extension (Figure 1) The second, is a software example from the executive office of a international plant of a domestic company.

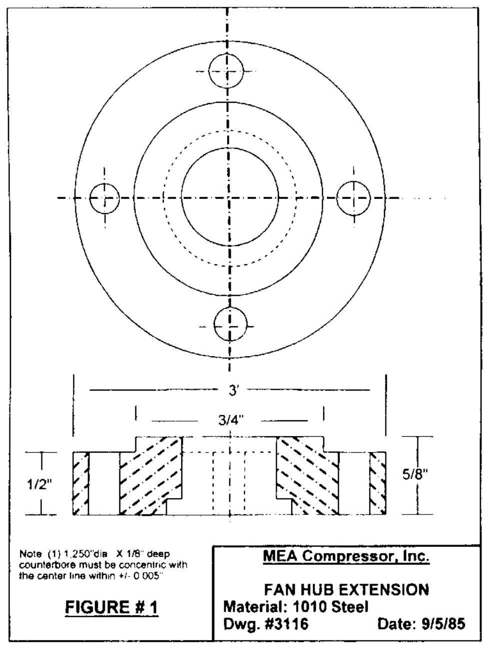

FIGURE # 1

Example # 1; FAN HUB EXTENSION
Drawing # 3116

A single part to be analyzed, not part of a subassembly, the functions had to be defined at this point. It was determined that the Fan Hub Extension's functions were:

Basic Function - Create Location
Secondary Functions - Transmit
Force, - Establish Connection

The second step was to overlay the part drawing with an 1/8" grid. Next it was necessary to with an 1/8" grid. Next it was necessary to determine the recommended starting size of material and then draw this on the transparent grid. (see FIGURE 2) It is then necessary to calculate the volume of the raw material and then complete the top of the Particle Analysis Worksheet.

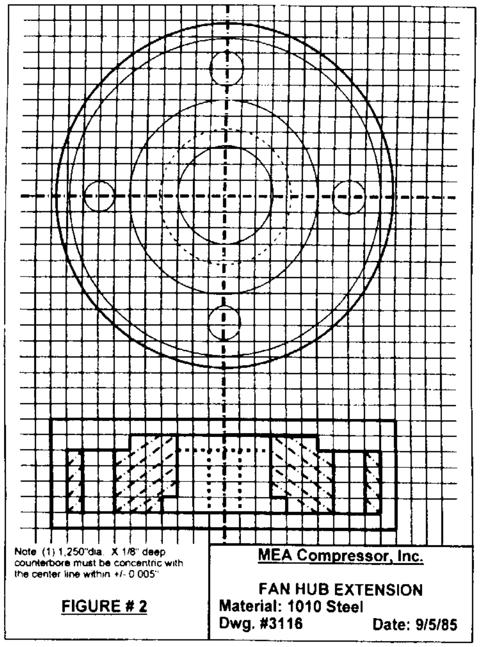

Figure 2

In this instance this Fan Hub Extension (FIGURE 2) was to be installed at the front of a gasoline engine. The engine is used to power a portable air compressor. The extension was deemed necessary to move the fan blade closer to the cooling radiator to generate a more positive air flow. After the test part was made and deemed satisfactory, it was decided to apply the Particle Analysis Technique to it. This was done to determine if the present configuration provided the best value.

The first phase of the this step is undertaken by shading in the areas of "Waste".(see FIGURE 5) In essence this is determining the particles that are going to be machined off to arrive at the final configuration. Following the shading of the Waste particles, the next action is to calculate the volume of this material and complete that Portion of the Worksheet. (see FIGURE 3)

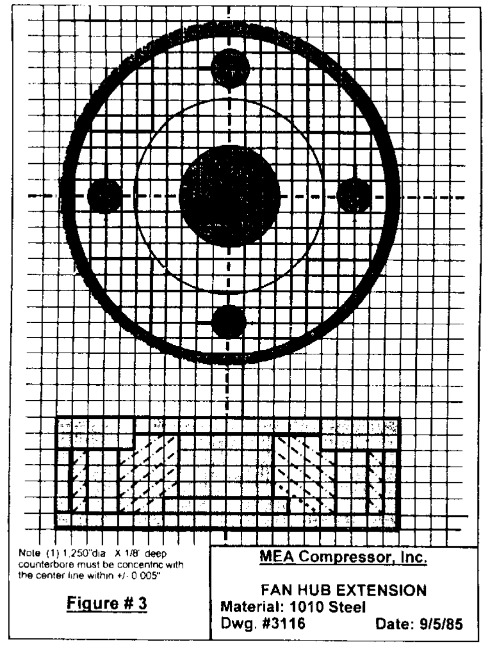

Figure 3

2. Waste Material Volume:

-Outside Dia. = (3 1/4" area - 3" area x 5/8" thk.= (8.2958 - 7.0686) x .625 = 0.7670 Cu.In.

-4 Holes = 3/8" x 1/2" thk. x 4 = 0.1104 x 0.5 x 4 = 0.2208 Cu.In.

-Center Hole = 3/4"area x 5/8"thk. x 1 = 0.4417 x0.625 x 1 = 0.2760 Cu.In.

-Top & Bottom = 3 1/4" area x 1/16"thk. x 2 = 8.2958 x 0.062 x 2 = 0.7301 Cu.In.

-Top Clearance = (3"area - 1 1/4")x1/8" thk = (7.0686 - 1.2273) x 0.125 = 0.7301Cu.In.

-Bottom=1 1/4" area x 1/4" thk.=1.2272 x 0.250 = 0.3068 Cu.In.

Total Volume: 3.3376 Cu.In. **% of Raw Material:** 49.5%

The second phase of this step outlines the areas that accomplish the Basic Function followed by marking with "X's" the Non-Functional particles of material within the present part configuration. When the marking has been done, the volume and percentage of the raw material is calculated and shown on the Particle Analysis Worksheet. (see FIGURE 4) Note that as this is done, the Functional Areas are highlighted.

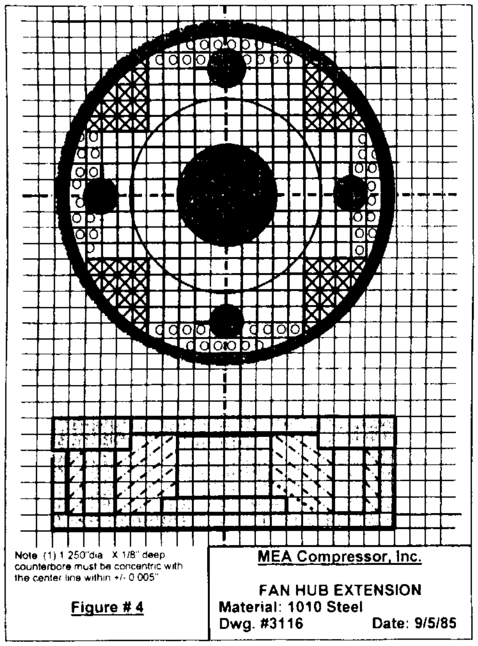

Figure 4

3. Non-Functional Material Volume:

- 3/4" Triangles in Base=3/4"triangles x 1/2" thk .x 4=1.250 x 0.3120 x 0.5 x 4 = 0/780 Cu.In.

Total Volume: 0.780 Cu.In. % of Raw Material: 11.6%

The third phase of this step marks with "O's" the Non-Cortical particles of material within the present part configuration. Following this, the volume and percentage of these area(s) is calculated and filled in the proper space on the worksheet.

4. Non-Critical Material Volume:

- 4 Ends(outside from holes) = 3/8" x 1" x 1/2" x 4=0.375 x 1 x 0.5 x 4 = 0.750 Cu.In.

Total Volume: 0.750 Cu.In. % 0f Raw Material 0.11.1 %

The Basic Function area, the Non-functional and Non-Critical areas are shown

The final step of this phase determines the total volume and percentage from the totals of the Waste, Non-Functional and Non Critical

5. Total Of Items 2,3,4:

Volume: 4.8676 Cu.In. % OF Raw Material 72.26 %

Based on the rather high individual and cumulative totals of the cubic inches and volume of the waste, Non-Functional, and Non-Critical it becomes quite evident that the fifth step of this technique is necessary. The second part of this step is started in the reverse order of the third step, i.e., an analysis of the Non-Critical Material.

In analyzing this data, the Non-Critical area falls at the end of the Functional Material. Therefore the major diameter of the raw material can be reduced to 2 3/4". Based on this fact, the starting raw material can be reduced to 3" diameter if the outer diameter does not have to be cleaned up or 3 1/8" if clean up is deemed necessary. It may be recommended that the Non-Critical areas not be eliminated for various reasons.

If 3" material can be used, a 36% reduction in raw material can be realized. If 3 1/8" material is required, a 30% reduction in raw material will result. In either case, this relates to a substantial savings in raw material and initial cost. In addition to raw material savings there will also be savings in manufacturing time, transportation and inventory costs, all of these can be done with only minor changes in the part configuration. However, this does not represent the major savings that can be realized

The second part of this step is undertaken when and if increased production or higher usage levels are anticipated. Here the analysis of the "Non-Functional Material" particles is undertaken. This analysis determines the least costly configuration based on the higher usage, methods of manufacture and necessary quality.

Based on the marked areas of Non-Functional particles, it can be readily seen that if these are eliminated, a cross-shaped configuration will remain. Considering this cross-shaped configuration and the increased usage in mind other methods of manufacture can be evaluated and recommendations made.

In this case, the remaining configuration was recommended. The estimated cost for this configuration were secured as manufactured from bar stock, as a sand casting with machining as required and as a powdered metal part with little or no machining required.

If a sand casting is used, with material left for cleanup on the required surfaces, approximately 3 1/2 cubic inches of raw material will be required. Thus the machining of the sand casting will generate approximately a 47% Waste factor. If the powdered metal process is used, all of the Waste and Non-Functional material would be eliminated, thus leaving, at most, 1.8 cubic inches of material required.

Should the cross-shaped configuration be produced as a sand casting, of powdered metal, the cost per cubic inch could be higher than for a totally machined part. However, due to the greatly reduced raw material volume required, the total cost should be lower.

The final task of this step of the technique is to determine and/or secure actual costs of the reccom- mended configuration based on anticipated annual usage, product life, tooling costs and break even points for the various processes. From this cost data, sound decisions can be made as to, if and when, a change in configuration and/or a manufacturing method should be undertaken. At the time this case history was undertaken, the following costs were secured for the Fan Hub Extension.

Fan Hub Extension Estimated Costs

	Cost/Piece	Tooling Costs	Lotsize
MANUFACTURED FROM	$7.09		50
BAR STOCK	$6.45		250
CROSS-SHAPED-			
Sand Casting	$5.22	$695.00	500
	$5.16	(Pattern & Drill Jig)	1,000
Powdered Metal	$0.43	$3850.00	5,000
	$0.42		10,000

EXAMPLE #2 - COMPANY STATIONERY

This example shows that the Particle Analysis Technique can be applied to software as well as hardware. The item is the four-color page of company stationary. The functions of this stationery are:-

Basic Function - Transmit Information
Secondary Functions - Provide Advertising, - Establish Locations

As a result of the four color company product symbols down the left side of the stationery, the left hand margin had to be established as 2 inches wide. Then to keep the contents centered on the stationery, a 2-inch right wide margin was required. Based on the width of the margins, the areas not usable at the top and bottom, the usable area to accomplish the basic function is greatly limited. The Particle Analysis Technique in FIGURE 5 (Before) shows that only 38.5% of the total area of the stationery is available to "Transmit Information.

Based on the above, the company took a serious analysis at the design of their stationery. This analysis resulted in the design of the stationery shown in FIGURE 5 (After). The new stationery has the same Basic and Secondary functions as the original. However, the Particle Analysis calculations show that the area available to accomplish the Basic Function has been increased from 38.5% to 62.6%

Although this might not seem to be to great an increase in usable area, it resulted in considerable savings. First, the increase in usable area, in most instances, allowed most letters to become one instead of two pages. Second, it was found that the margin stops on all of the typewriters were set for two inch margins based on using the stationery used for outside of the company correspondence. As a result, the stops were not reset for internal correspondence, which in turn resulted in many multi-page internal memos.

The change to the new stationery resulted in savings in stationery, postage and secretarial typing time. All of these savings resulted in helping to reduce the company's overhead costs.

In conclusion, it is signification to quote the well known statement: "**A picture is worth ten thousand words.**" The graphic pictures developed by this technique and supported by the calculations provide a very useful tool for those applying the VE Systematic Approach.

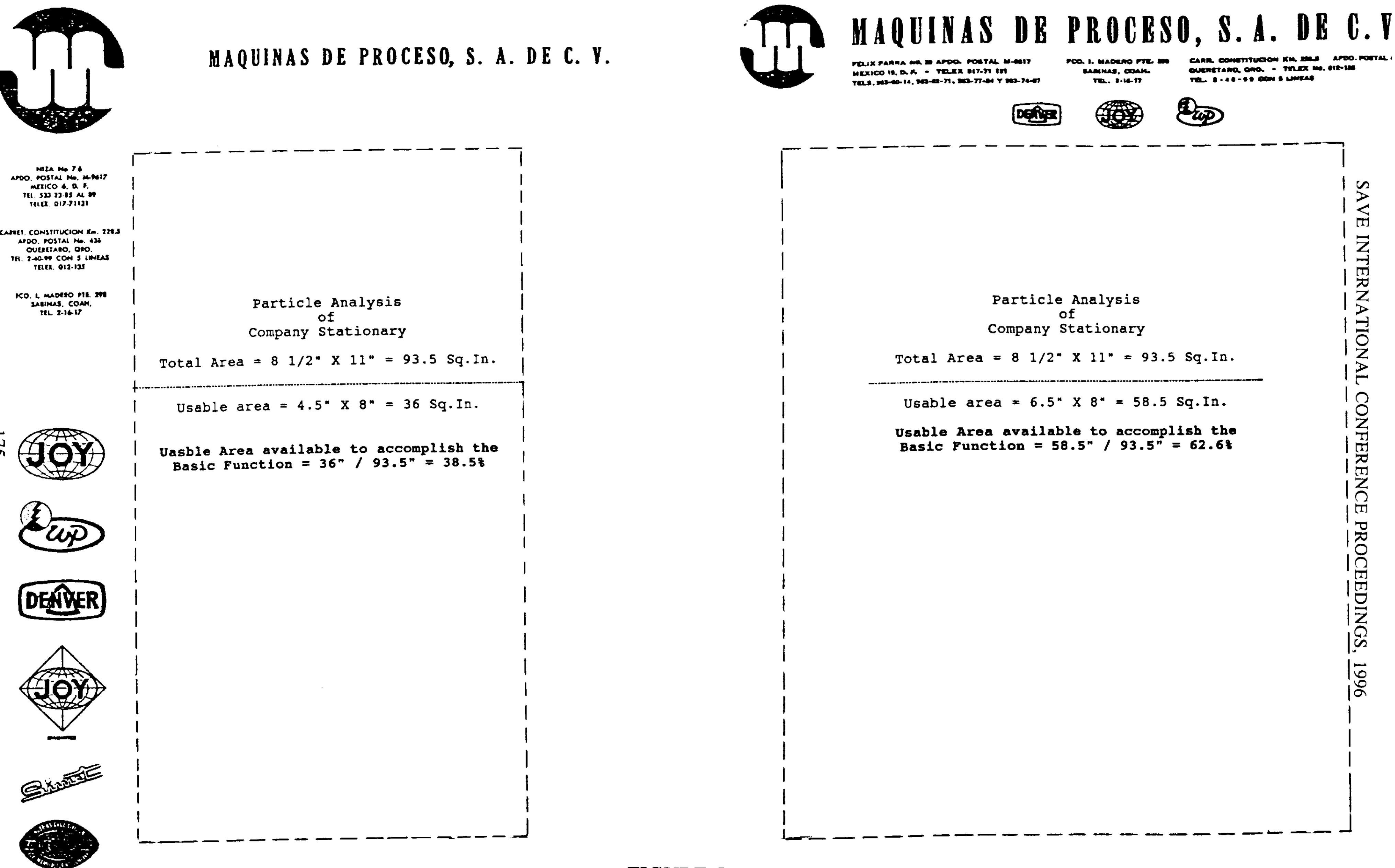

FIGURE 5

BEFORE

AFTER