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EVALUATION OF FUNCTION AND VALUE IMPROVEMENT BY RATING APPROACH

by Masayasu Tanaka

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1. Introduction

The evaluation of function,namely,determination of value is the most important theme of study for value engineering. However,the conventional evaluation of function has been conducted from the maker's stand point of view and very little has been studied from the user's.

The "value" evaluated by the maker much differs from those by the user. Therefore,we should take into consideration the more of the user-oriented value engineering rather than those for the maker-oriented. The traditional study of the value engineering has seldom touched upon the relationship between the functional block diagram or product constructional diagram.

The writer, however,considers that the systematic evaluating the function is made possible only by combining these both diagrams.

From the above mentioned point of view,this paper is discussing the evaluation of the function and value improvement of the consumer products taking a sign-pen as an example,and stating the effectiveness of the approach by applying what is defined as "Optimal Value Zone".

2. The purpose of evaluation of function by the rating approach

In general, it is considered that the purpose of evaluating function is to establish a target cost and to select the constructual elements for the study on value improvement. The writer, however, would like to paraphrase the above purpose as follows in order to clarify the cost and system effectiveness;

Measurement and analysis of balance of,

1) mutual functions.
2) cost of each element.
3) functions and costs.

Although there are several approaches for evaluating the function of consumer products in a broad sence (including use and esteem value), the rating approach is considered appropriate and is developed in this paper.

3.Outline of "sign-pen" and decision matrix

A sign-pen is the writing tool that has initially been invented in Japan. The structural elements and functions of the sign-pen produced by P company,concidered as a leading manufucturer of this product,are as follow:

The structural elements of the sign-pen

1)Ink

2)A set of pen point.......1.Pen point
                                        2.Pen ring

3)Inside elements..........1.Material to soak ink
                                        2.Solid bar

4)Body.....................1.Axis
                                        2.Tail cap
                                        3.Air hole

5)Cap

The function of the sign-pen

Use function

1)To store ink

2)To send ink into pen-point

3)To prevent evaporation of ink

4)To prevent leakage of ink

5)To protect pen point

Other function desired from the operational stand point

1)Fine appearance after writing

2)Feeling of writing

3)Uniform width of line

4)Handy size

5)Good fitting of cap and axis

6)Easy hooking on pocket

Esteem function

1)Shape and design

2)Coloring

By aligning structural elements and functions vertically and horizontally,the function matrix is prepared(Table 1).

The figures on this function matrix are based on the information obtained from 54 users'questionaeres, which is called decision matrix(Table 2),and the significance of the figures was proved by using X^2(chi-square)test.

Thus,the ratio(percentage)of importance for each unit of sub-assembly to the whole products is calculated (table 2),and applying this method,the ratio of importance for each element within the sub-assembly can be obtained.

4.Significance and calculation of value index

A value index of each constructrual element is shown by the ratio of the percentage of the functional importance to the whole products and its current cost.

$$\text{Value index(VI)} = \frac{\text{Ratio of functional importance}}{\text{Ratio of current cost}}$$

The desirable value index is to be found within the zone around the line 1. This area can be defined as "Optimal value zone". Basically, the value index higher than 1 means a good structural element, whereas value index less than 1, means a bad structural element.

Next, let's state to culculate the value index. Taking the function of "shape and design" and "coloring", for instances, their value index are calculated from,

for shape and design	33.87%x53.65%=18.17%
coloring	33.87%x46.35%=15.70%

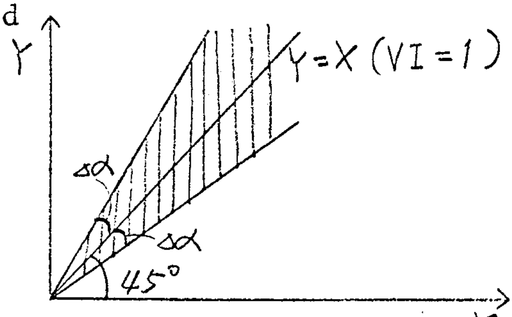
The rate of contribution of each structural element can be calculated as follows:

	shape and design	coloring
Ink	0.22%x18.10%=0.04%	2.11%x1-.70%=0.33%
A set of pen point	19.66%x18.17%=3.56%	15.22%x15.70%=2.38%
Inside elements	2.76%x18.17%=0.49%	0.46%x15.70%=0.07%
Body	39.57%x18.17%=7.19%	41.96%x15.70%=6.58%
Cap	37.75%x18.17%=6.86%	40.21%x15.70%=6.31%

5. Analysis of value index and optimal value zone

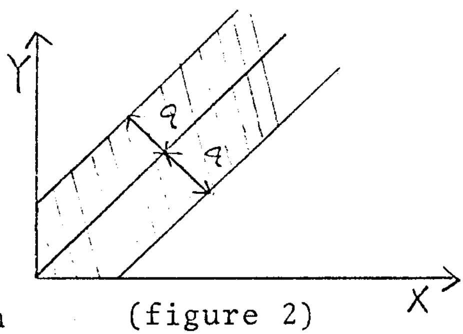
The andlysis is based on the deviation $\Delta\alpha$ $(\Delta\alpha < 1)$ from the optimal value index(VI), VI=α=1,and classified into the following three:

(1) Equi-angular deviation from the standard line VI=α=1,i.e. Y=X is shown in figure 1 and hatched. The hatched area is assumed admissible.



(figure 1)

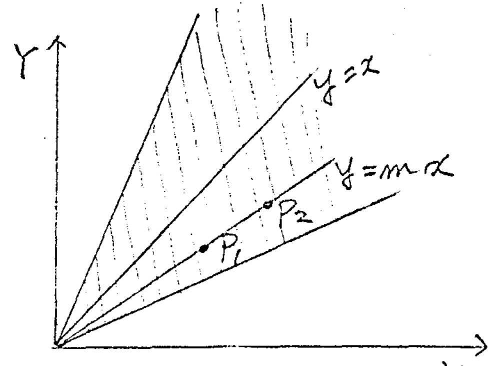
(2) Equi-distant deviation from the standard line is shown in figure 2 and hatched.



(figure 2)

However,refering to figure 3,the straight line Y=mX in the hatched zone of figure 1, may differ in its influence degree against the overall value for two points,which are on the same line,but one is at a short distance from the origin (P_1) and the other is far distant (P_2). Since the value index of P_1 is indicated by $\frac{B}{A}$ and $P_2 = \frac{B'}{A'}$ both being equal, the absolute amount of A'andB' is greater than those of

A and B. Thus,a change in the greater value against the total would give a greater inflence against the total.



(figure 3)

Therefore,application of the value index alone in the analysis of the optimal value zone may not suffice. In the same way,the linear distant deviation abovementioned in (2) does not clearly explain the true optimal value zone. Then the third alternative can be introduced.

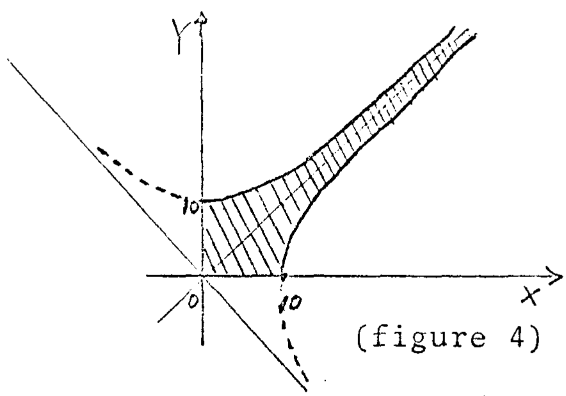
(3)Now consider a point Q(Xi,Yi) on the importance ratio and current cost ratio plane X,Y as shown in figure 4. This OQ may be considered as a sum of two vectors OP and PQ, perpendicular to and parallel with OP respectively. If the area OP X PQ = r X 1 = X is made constant regardless of the position of the point Q, the zone in which Q can exist will be represented by two curves in fügure.

This ares is shown as followss

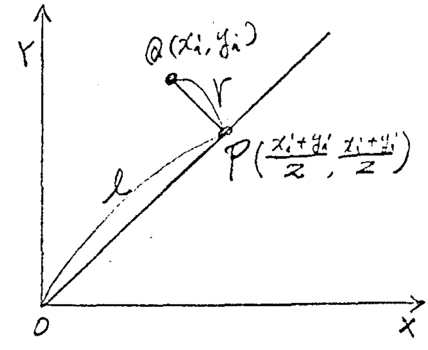
Deviation(r) $=\frac{1}{\sqrt{2}}|x_i - y_i|$ vector(1) $=\frac{1}{\sqrt{2}}|x_i + y_i|$

$\therefore$ X=rx1 $=\frac{1}{2}|x_i^2 - y_i^2|$

If X shown in this figure is 50, the equation for these two curves are; $Y = \pm\sqrt{x^2 - 100}$



(figure 4)

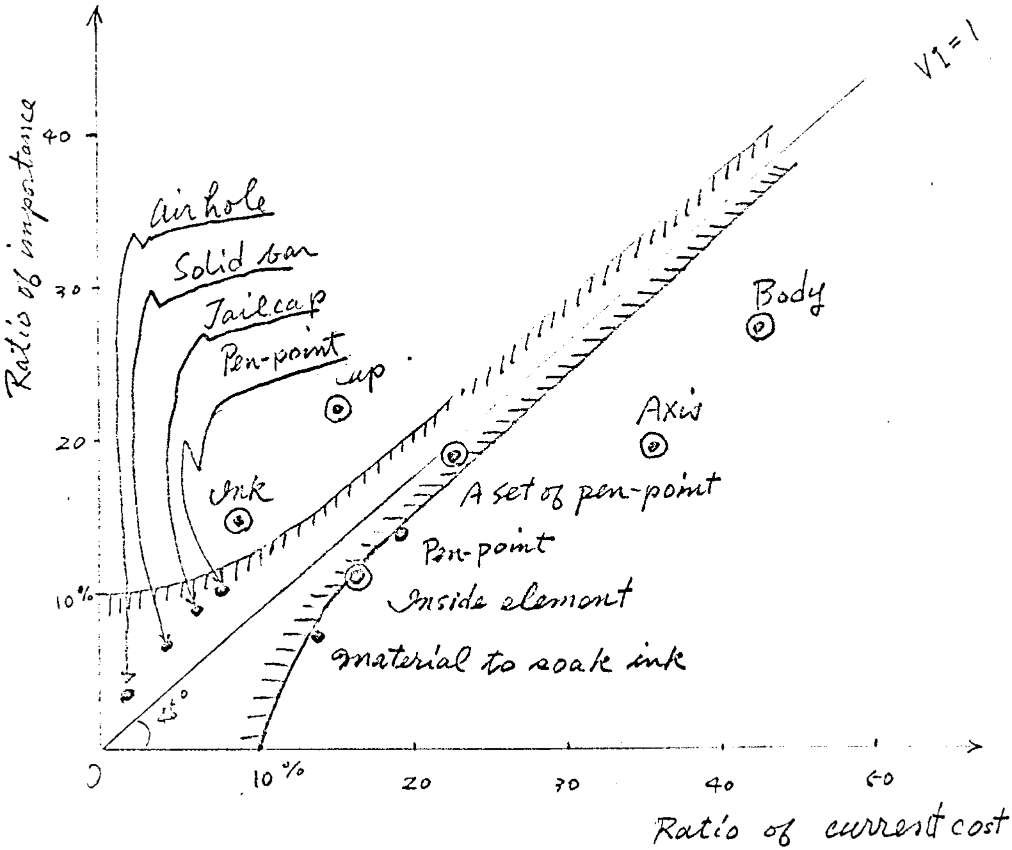


(figure 5)

The area surrounded by these two curves and X,Y,axes corresponds to the optimal value zone, freed from the ambiguous points mentioned in (1) and (2).

What can be understood from the area is that those points at relatively grater distance from the origin should be more closely studied than tose at relatively shorter distance from the origin in order to make an logical analysis on the optimal value zone. In effect, those points closer to the origin have little or no effict on the whole, although they may have greater value index.

Now, based on the aforsaid approach, the calculating value index and the analysis of a sign-pen as an example can be made as follows: The graph in drawn as X=50.



ANALYSIS OF VALUE INDEX

(table 3)

	I(%) Ratio of importance	C(%) Ratio of cost	$V_i = \frac{I}{C}$ Value index	$r = \frac{\lvert C-I \rvert}{\sqrt{2}}$ Deviation	$\ell = \frac{\lvert C+I \rvert}{\sqrt{2}}$	$X = \ell \cdot r = \frac{\lvert C^2 - I^2 \rvert}{2}$
Ink	16.06	6.93	2.32	6.46	16.26	105.04
A set of pen-point	22.68	24.91	0.91	1.58	33.66	53.18
pen-point	13.60	18.41	0.74	3.40	22.64	76.98
pen ring	9.08	6.50	1.40	1.82	11.02	20.06
Inside elements	12.90	12.85	1.00	0.04	18.21	0.73
material to soak ink	7.25	11.62	0.62	3.09	13.35	41.25
solid bar	5.65	1.23	4.59	3.13	4.87	15.24
Body	27.79	41.34	0.67	9.58	48.89	468.37
axis	15.68	36.31	0.43	14.59	36.77	536.47
tail cap	7.76	3.91	1.98	2.72	8.25	22.44
air hole	4.35	1.12	3.88	2.28	3.87	8.82
Cap	20.54	13.97	1.47	4.65	24.41	113.51

6. Research of Real Needs and Value Improvement

The aforesaid is only about the study of the functions of the present procucts and the evaluating the function of each structural element. In other words, it is just for the evaluation of the functions based on the facts obtained in the past and at the moment. However, users have all kinds of desires to the present products and expect to see them improved because they are not satisfied with the present products.

Without considering the evaluation of the functions desired by users, positive value engineering cannot be made. In this regards, we are able to state that one of the important tasks of value engineering is to aim at determining the value of functions expected to be achieved and not at the value already attained.

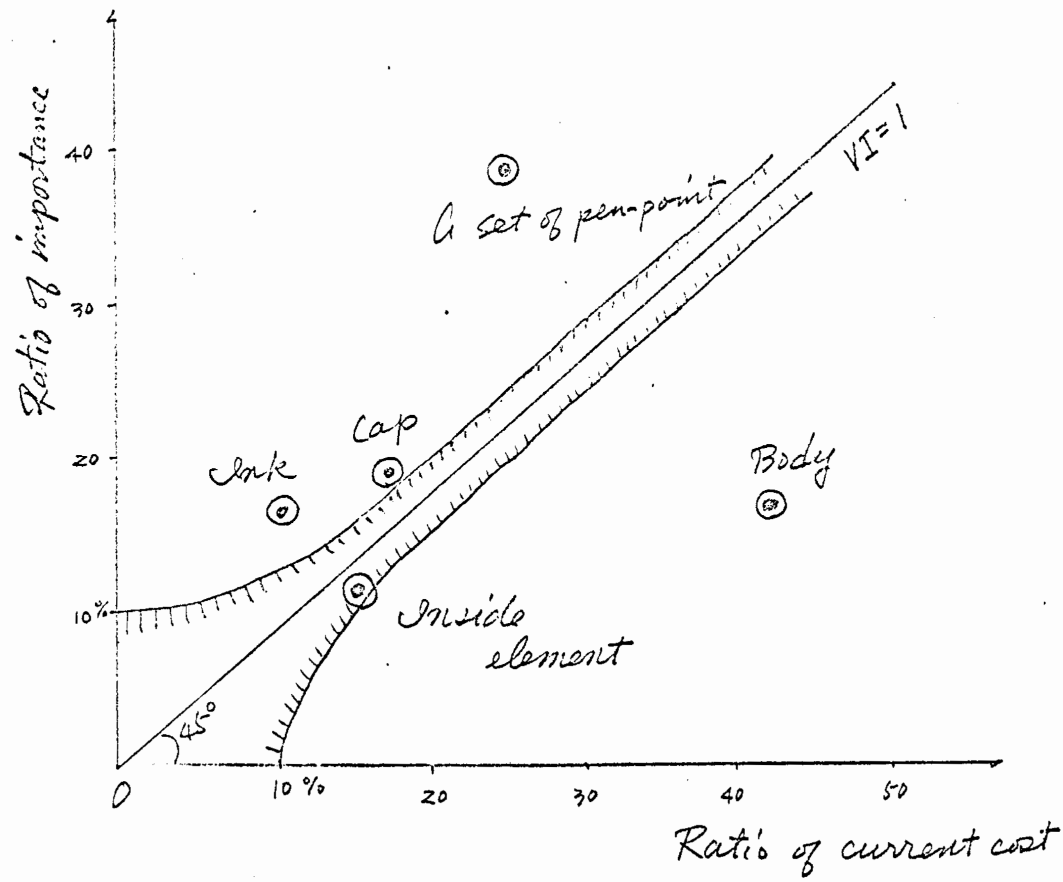
The following table 4 indicates the result of an opinionaire(the subject of the research was over 500) on a sign pen. The ratio of desirability was shown by percentage. As this may be equivalent to the ratio of importance, this can also be diagrammatized in the similar manner to the one used in preparing the previous graph. Coincidentally, both of the graphs are identical with each other and the body of a sign-pen are found in the under valued zone. This indicates that either functional improvement or cost reduction of the body is necessary and the degree of reduction is about $\frac{1}{2}$ of the current cost.

The overvalued element should be adjusted to reach an appropliate value element,and needless to say ,the under valued element should be improved and supplemented.

However, all what were mentioned heretofore about the user-oriented value engineering, is fundamental and even for such functions which users are apt to overlook(for examples, functions for safety and maintenance)makers have to study.

	I'(%) Ratio of importance	c(%) Ratio of cost	$Vi=\frac{I'}{C}$ Value index	$r=\frac{\lvert C-I'\rvert}{\sqrt{2}}$ Deviation	$l=\frac{\lvert C+I'\rvert}{\sqrt{2}}$	$X=l\times r$
Ink	16.4	6.9	2.38	6.72	16.48	110.75
A set of pen-point	37.9	24.9	1.52	9.19	44.41	408.13
Inside elements	9.3	12.9	0.72	2.55	15.70	40.04
Body	17.3	41.3	0.42	16.97	41.44	4887.02
Cap	19.1	14.0	1.36	3.61	23.41	47.04

(table 4)



Conclusion

It is assumed that the rating approach as a method of evaluating the function of the consumer products provided with both the use and esteem value will be widely adopted in futur. The rating approach enables users to check and evaluate the functions which were evaluated by the maker. This may offer a remedy for the situation in which the user oriented value engineering is apt to be neglected.

Those structural elements(or functions)which do not fall within the optimal value zone are either over or under valued,and they do not make balanced contribution to the whole system. They should be improved in their values so as to be included in the optimal value zone. The current cost of the structural elements found in the optimal value zone may well be named as target cost. The target cost indicates the marked value at which the cost reduction of the current cost is aimed. If the cost reduction of the level specified by the target cost can not be achieved, then the function has to be studied to for its improvement.

Lastly,in developing this rating approach study, the writer obtaind many valuable hints from Dr.Dumale's thesis presented at SAVE convention 1970 and 1971.

FUNCTION MATRIX (table 1)

	Use Function					Other Function						Esteem Function	
	To store ink	To send ink into pen-point	To prevent evaporation of ink	To prevent leakage of ink	To protect pen-point	Fine appearance after writing	Feeling of writing	Uniform width of line	Handy size	Good fitting of cap and axis	Easy hooking on pocket	Shape and design	Coloring
Ink													
A set of pen-point													
pen-point													
pen ring													
Inside elements													
material to soak ink													
solid bar													
Body													
axis													
tail cap													
air hole													
Cap													

(table 2)

DECISION MATRIX

	Function of Sign-pen									
	Use and Other Function (66.12%)							Esteem Function(33.87%)		
	Use functions	Fine appearance after writing	Feeling of writing	Uniform width of line	Handy size	Good fitting of cap and axis	EAsy Hooking on pocket	Shape and design	coloring	Total
	35.01	6.04	6.83	6.47	5.17	3.74	2.84	18.17	15.70	100.00 %
Ink	8.92	3.26	1.78	1.55	0.08	0.02	0.05	0.04	0.33	16.06
A set of pen-point	9.91	1.10	2.75	2.24	0.34	0.24	0.06	3.56	2.38	22.68
pen-point	6.34	0.77	1.73	1.37	0.17	0.11	0.03	1.92	1.11	13.60
pen ring	3.57	0.33	1.02	0.87	0.17	0.13	0.03	1.64	1.27	9.08
Inside elements	7.70	1.23	1.19	1.59	0.40	0.07	0.08	0.49	0.07	12.90
material to soak ink	4.27	0.68	0.65	0.82	0.27	0.04	0.06	0.38	0.04	7.25
solid bar	3.43	0.55	0.54	0.77	0.13	0.03	0.02	0.11	0.03	5.65
Body	6.09	0.32	0.89	0.88	2.95	1.59	1.18	7.19	6.58	27.79
axis	2.49	0.05	0.33	0.26	2.39	1.24	0.88	4.24	3.76	15.68
tail cap	1.25	0.06	0.12	0.09	0.46	0.31	0.26	2.57	2.60	7.76
air hole	2.35	0.21	0.44	0.53	0.10	0.04	0.04	0.38	0.22	4.35
Cap	2.35	0.09	0.18	0.16	1.35	1.77	1.43	6.86	6.31	20.54