THREE TYPES OF FUNCTION QUANTITY AND THE PARAMETER BASIC-POINT METHOD

Ma Qingguo
ZHEJIANG UNIVERSITY
Hangzhou, China

Prof. Ma Qingguo is the director of Soft-Science Institute of Zhejiang University, the Vice President of National Higher-Institution Society of Value Engineering, Vice President of Society of Researching VE under Chinese Mechanical Enterprise Management Association, a consultant of Society of Shanghai VE, Vice President of Society of VE of Zhejiang Mechanical Industry, and a member of SAVE. In addition, he is a member of the Specialist Group of Chinese Yangtze River Three-Gorge-Project.

ABSTRACT

This paper describes three types of Function Quantity and divided the functional measurement methods into three classes and gives a new method called Parameter Basic-Point Method (PBPM), which transforms the parameter of functional property into the function worth, the approximate lowest cost to perform this function, by using the Parameter Basic-Point Coefficient other than theoretical Value Method.

Three Types of Function Quantity and Their Measure Method

The Function Quantity can be expressed as three forms:

1) The quantity of functional property

The following quantities, such as the transmissible torque, the supportable weight, the conductible current and the maximum admitted voltage, are all the expressions of some functional properties. This kind of functional quantities is also called the functional parameter, or in brief, the parameter. All of these functional quantities have some dimensions, for instance, KG. CM, KG, V-A (Volt-Ampere) and V (Volt) etc..

In general, these quantities can be obtained by physical measuring or determined by designer. And these parameters are certainly precise. This is

why we always express the function as "a verb + a measurable noun". We note that the two functions have the same quality if the dimension of a function is the same as another.

2) The contribution degree of function

The functional contribution degree is the degree of making user close to his goal when the item which includes this function is employed (this item is also called the functional carrier). In other words, it is the numerical expression of the functional contribution to the user, or the utility of an item which includes this function. The class of these quantities has no dimension. We can obtain them by judgement, intuition, comparison, evaluation and estimation. The result of evaluating the contribution degree is always expressed as ratio, score etc.[1]

3) The lowest cost of performing function

The lowest cost to perform a function is also called the worth of this function. We can obtain them approximately by investigating, creating, comparing etc.[2] This kind of quantities is the most important expression of Function Quantity because it will indicate the direction of improvement for us.

Perhaps there is a question: why do we want to quantify the function in the two former forms? The answer is that to obtain the worth (the lowest cost) of every function is, in general, quite difficult. The methods of the third class, generally speaking , can not achieve the object of evaluating the lowest costs of all functions in a VE project. Thatis to say, we can not create so many new ways to perform all of the functions, while one of the fundamental requirement in the phase of Function Evaluation is the completeness to find out all the functions to be improved. Therefore, we need the former two kinds of methods of quantifying the functions and the methods of transforming them into the approximate lowest costs.

The Methods of Transformation

There are some methods to transform the Contribution Degree into the worth of function, such as the Method of Sharing the Total Goal Cost with each function, the Basic-Point Method[3] and the Tarmai Method[4], which determine the worth by means of the Contribution Degree (score or ratio). But there is only one method, the method of theoretical value method, to transform the parameter of functional property into the worth. The very famous example is the calculation of the worth of "transmitting torque".

Let

*t = torque (KG*CM)*
$C_{\min}$ *= the worth of the function ($)*
l = the length of the axle (CM) function carrier,

then

$$C_{\min}=k*l*t^{2/3}$$

where k is a coefficient determined by the material which the axle is made of. The formula to calculate k is

$$k=(\_/4)* \quad *p*(16/(\quad *s_t))^{2/3}$$

where

= the specific gravity of the material (KG/CM^3*)*
p *= the price of the material ($)*
s_t *=the maximum permissible shearing stress*
=3.14159

The lowest cost C_{min} can be computed by that formula if the value of the torque which the user wants to transmit is known. Of course, the calculated result is not really achievable because it does not include the manufacturing burden and the labor cost. So the goal cost (or the appropriate cost) should become slightly bigger.

Parameter Basic-point Method

The purpose of this method is to transform the parameter of property of a function into the functional worth, the approximate lowest cost.

The operating steps of this method are:

1. to determine the parameter of the function which the

user wants to achieve, and symbolize its value as P.

2. to collect the data of costs and parameters of the same functional quality. supposing that we have got

$P_1, C_{11}, C_{12}, \ldots$

$P_2, C_{21}, C_{22}, \ldots$

......

$P_m, C_{m1}, C_{m2}, \ldots$

where P_i $(i=1,2,\ldots,m)$ are the different values of parameters of the same functional quality, and $P_i < P_j$, if $i < j$. The interval (P_1, P_m) is called the parameter range that we will deal with.

C_{it} $(i=1,2,\ldots,m;\ t=1,2,\ldots)$ is the tth cost to perform the function with the parameter P_i. Furthermore, supposing that

$C_i = \min\{C_{i1}, C_{i2}, \ldots\}$

i.e. C_i is the lowest cost among the collected data to perform the function with the parameter P_i, then the data we have got can be expressed as

$C_1, C_2, \ldots, C_m$

$P_1, P_2, \ldots, P_m$

or the numerical pairs of

$(P_1,C_1), (P_2,C_2), \ldots, (P_m,C_m)$

3. to divide the data into k groups, $k<m$, the best is that $k>2$, and in general, the number of numerical pairs in a group should be bigger than 3 if there are enough data.

4. to calculate the Parameter Cost Coefficient (PCC) $_i$

$_i = C_i/P_i$ $(i=1,2,\ldots,m)$

Let

$_{bj} = \min\{_i$ in the group $j\}$

and suppose

$_{bj} = C_{bj}/P_{bj}$.

Then $_{bj}$ is called the Parameter Basic-Point Coefficient (PBPC).

5. to calculate the goal cost C_{min} (the approximate lowest cost) to perform the function with parameter P which the user needed.

1) If $k=1$, then $C_{min}=P*\ _{b1}$

The method in this case is called the Single Basic-Point Method.

2) If $k=2$, then

$$C_{min} = \frac{(C_{b2}-C_{b1})}{(P_{b2}-P_{b1})} * (P-P_{b1}) + C_{b1}$$

where the C_{bi} and P_{bi} $(i=1,2)$ are the values which structured PBPC $_{bi}$ ($_{bi}=C_{bi}/P_{bi}$). This method is called the Basic-Point Line Method.

3) If $k=3$, then $C_{min}=a+b*P+d*P^2$

where

$$a = \frac{\begin{vmatrix} C_{b1} & P_{b1} & P_{b1}^2 \\ C_{b2} & P_{b2} & P_{b2}^2 \\ C_{b3} & P_{b3} & P_{b3}^2 \end{vmatrix}}{\begin{vmatrix} 1 & P_{b1} & P_{b1}^2 \\ 1 & P_{b2} & P_{b2}^2 \\ 1 & P_{b3} & P_{b3}^2 \end{vmatrix}}$$

$$b = \frac{\begin{vmatrix} 1 & C_{b1} & P_{b1}^2 \\ 1 & C_{b2} & P_{b2}^2 \\ 1 & C_{b3} & P_{b3}^2 \end{vmatrix}}{\begin{vmatrix} 1 & P_{b1} & P_{b1}^2 \\ 1 & P_{b2} & P_{b2}^2 \\ 1 & P_{b3} & P_{b3}^2 \end{vmatrix}}$$

$$d = \frac{\begin{vmatrix} 1 & P_{b1} & C_{b1} \\ 1 & P_{b2} & C_{b2} \\ 1 & P_{b3} & C_{b3} \end{vmatrix}}{\begin{vmatrix} 1 & P_{b1} & P_{b1}^2 \\ 1 & P_{b2} & P_{b2}^2 \\ 1 & P_{b3} & P_{b3}^2 \end{vmatrix}}$$

or

$$\begin{vmatrix} a \\ b \\ c \end{vmatrix} = \begin{vmatrix} 1 & P_{b1} & P_{b1}^2 \\ 1 & P_{b2} & P_{b2}^2 \\ 1 & P_{b3} & P_{b3}^2 \end{vmatrix}^{-1} * \begin{vmatrix} C_{b1} \\ C_{b2} \\ C_{b3} \end{vmatrix}$$

This method is called the Basic-Point Quadratic Curve Method.

4. If k 4, and the scattered diagram in the P-0-C coordinate system looks like figure 1

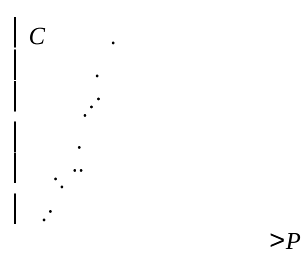

figure 1

then the equation form which will be fitted can be chosen from the following functions

$$log(C_{min})=log(a)+b*P$$
$$C_{min}=a+b*P+d*P^2$$
$$C_{min}=b*P^d$$

where the a,b,d are the coefficient of regression. We can estimate them by Ordinary Least Square (OLS).

If k 4 and the scattered diagram in the P-0-C coordinate system looks like figure 2

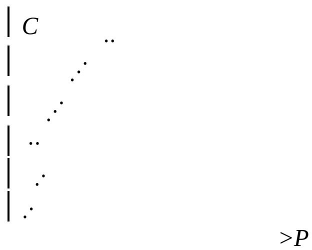

figure 2

then the equation form which will be fitted can be selected among the following functions

$$C_{min}=a+b*log(P)$$
$$P=a*[(C_{min}^2/b^2)-1]^{1/2}$$
$$C_{min}=L-a*exp(-b*P)$$

The regression equations of the last two functions are:

$$C_{min}^2 = b^2+(b^2/a^2)*P^2$$
$$log(L-C_{min})=log(a)-b*P$$

where L is known, a and b are the coefficients of regression. We can estimate them by OLS. If L is unknown, the last regression equation is

$$(C_{bi+1}-C_{bi})=Lb-b*C_{bi}$$

where $Lb=L*b$. After estimating b and Lb by OLS the L and a can be obtained by

$$L=Lb\div b$$
$$a=\sum_{i=1}^{k}\left|\frac{L-C_{bi}}{exp*P_{bi})}\right|/k$$

The method in this case is called the Basic-Point Curve Method.

References

1. Thomas R. King, *Principles of Value Analysis Engineering*, 1979

2. L. D. Miles, *Techniques of Value Analysis and Engineering*, McGra-Hill,1972

3. Ma Qingguo, The Basic Point Method for Evaluation of Functions, *Value World*, July/Aug./Sept., 1984, pp. 29-30.

4. Tarmai, *Value Analysis*, (in Japanese), 1978.