Functional Cost Analysis

A functional cost analysis is a method that can be applied to examine the component costs of a product in relation to the value as perceived by the customer. The outcome of the analysis is to improve the value of the product while maintaining costs and/or reduce the costs of the product without reducing value.

Project activities in which a functional cost analysis is useful:

- Identifying product needs and requirements
- Conceptual through to detail design
- Pre-production
- Post-design product improvement

Other tools that are useful in conjunction with a functional cost analysis:

- Competitive Analysis
- Requirements Management
- Kano Model Analysis
- Brainstorming
- Prioritization Matrices
- Evaluation Matrices
- Quality Function Deployment
- Configuration Management

Introduction

The functional cost analysis is a value engineering method that aims to increase the difference between the *cost* and the *value* of a product. The cost is the amount that is incurred in the production and delivery of the product. This expense can include the price of parts, labour, overhead (e.g., building, power), packaging, shipping, and advertising, among others. What the product is worth in the eyes of the customer is considered the value. When completing a functional cost analysis, remembering this definition of value is extremely important. The design team may not perceive a certain product feature to be valuable, however if it is important to the customer, then that feature must be regarded as valuable.

Value Engineering versus Value Analysis

Value engineering can be applied to new designs, extensive redesigns or in an evaluation of a competitor’s product. Ideally, the application of value engineering should begin at the conceptual design stage and continue through the design process as part of the design to cost effort. Value analysis is generally considered an abbreviated form of value engineering that is primarily concerned with product cost improvement. In other words, value analysis' primary focus is not on enhancing the value of a product and therefore lends itself well to exercises in reducing high cost items, especially those that provide little value.

Who should contribute to the functional cost analysis?

The functional cost analysis is yet another tool that is best executed with a team approach since it is unlikely that a single individual would be intimately familiar with all of the parts and functions of a product as well as the value customers place on these functions. Moreover, this cross-functional approach leads to a swifter and more accurate assessment than could be achieved by a lone designer.

In addition to the design team, representatives from marketing, purchasing, costing and production should be invited to participate – in short, anyone who can provide detailed cost information or provide insight into the value customers place on individual functions. If the design team has access to the customer, including them in the exercise can be valuable; however if the analysis will be conducted on a competitive product, be cautious about inviting the customer to the table.

Application of a Functional Cost Analysis

There are many approaches and formats for creating a functional cost analysis. Attachment A provides an example of one form that can be used. In the attached form, components are listed vertically and a number of functions are listed horizontally. The result is a matrix format that allows a component or sub-assembly to contribute to more than one function or multiple functions to be attributed to a single component. *Engineering Design Methods* by Nigel Cross provides other examples of approaches and formats that can be used.

Step 1: Create a list of components

The first step in a functional cost analysis is to list the component parts of the product. If a tangible product exists (e.g., existing product, competitor's product, prototype), it may be beneficial to dismantle the product to support this exercise. If a tangible product does not exist, exploded diagrams can be used. Parts lists and engineering drawings can also be used but may be of lesser value because they do not offer the same ease of visualization.

For each component, indicate the purpose of function. In some cases, it may be difficult to attribute a function to a single component therefore grouping a number of components as a sub-assembly may aid the process. When assigning functions, consider whether they are:

- Primary functions- for example, a kettle **heats water**;

- Secondary functions that support the basic function- for example, the kettle housing **contains water** or the handle **facilitates pouring water**; or
- Other functions which are neither primary nor secondary functions. These other functions may be determined to be unnecessary, or they may be functions that have been added to solve problems with the product or introduce redundancy in order to increase reliability – for example, an opening flap over the spout **to aid filling**.

Step 2: Determine the cost of each component

The determination of product costs is often oversimplified and therefore inaccurate, even for relatively simple products. This explains why many companies employ specialists in cost estimating. It is not sufficient to merely determine the cost of the individual components and estimate the labour involved. A number of other factors must be considered and included. Some of these factors are:

- Cost of parts including the purchase price as well as any associated shipping costs.
- Cost of consumables that are used in the fabrication of the product (e.g., glue, cleaners, finishes)
- Labour costs for assembly as well as for any modification or finishing to parts
- Equipment or tooling costs
- Handling and inventory control
- Packaging and shipping costs

Make sure to consider even what appears to be an insignificant item. A few screws may not seem like much, but consider a product that uses a half dozen screws of which a thousand units are manufactured every day; over the course of a year, over 1.5 million screws will be used.

Equipment or tooling costs are items that may require some calculation since there is not a one-to-one ratio between the unit of equipment and unit of product. Therefore, it may be necessary to calculate equipment costs based on projected volumes. Depreciation of equipment may also need to be taken into consideration. If the equipment is used for more than one product line or component, the equipment costs are further subdivided.

Very detailed cost calculations may also include indirect or overhead costs. These involve facility costs (e.g., heat, hydro, taxes), non-direct labour (e.g., finance, human resources, marketing), or any other cost that cannot be directly tied to a product. There are a number of different methods by which companies apply overhead costs to products. One method is to add an overhead percentage to direct labour costs while another is to divide the overhead costs amongst all products. In a functional cost analysis, it is easiest to assume that all components equally share the overhead costs and therefore leave these figures out of the calculations.

Note: if there are multiples of a component in a product (e.g., screws), make sure to multiply all costs accordingly.

Cost Calculations

Once the costs have been determined for each component or sub-assembly in relation to the function(s) they support, the total cost of the component or sub-assembly is determined. The total product cost is calculated by summing the totals for all components. This total is then used to calculate the percentage of the total cost that each part represents. For example, if a component costs $0.27 and the total cost of the product is $4.90, the component represents 5.5% of the total cost.

The cost of each function can be calculated by adding all of the costs attributed to a specific function. As with the component costs, the percentage of the total cost that each function represents is calculated. If desirable, the cost sequence can be determined where the functions are numbered, with (1) representing the most costly function. This sequence may be useful when comparing cost of functions to their value.

Step 3: Determine the value of each component

This step is one of the most difficult in the functional value analysis because much of it is subjective and it requires an estimate of the value as perceived by the customer.

When determining the value of the components and subassemblies, it is important to consider the value of aspects other than those that contribute to function or performance. For example, the brass plating of sink taps does not contribute to performance but do provide prestige or aesthetic benefit that can be labelled *esteem value*. Automobiles provide an example of exchange or market value. Two vehicles may provide the same performance and functionality, but a customer may attribute more value to one over the other if there are perceived differences in *market value*. Other values that can be considered are those associated with materials, serviceability, and place of manufacture.

One method to determine value in terms of currency is to compare the costs and characteristics of similar products. For example, if two televisions are identical in every aspect except one has picture-in-picture, the difference in cost of the two televisions may represent the value of the picture-in-picture functionality to the customer.

Although it is preferable to quantify the values of components, it is often difficult for developmental products or when legacy products do not exist. In these situations, a relative comparison can be made where components are assigned a high, medium or low value. Prioritization matrices can help make these comparisons.

Step 4: Consider the value of functions

Before looking at ways of reducing the cost of the product or increasing its value, the value of the current functions should be examined. If a certain function is not perceived to be valuable to the customer and the function is determined not to be necessary for reasons such as performance or reliability, then perhaps that function should be simplified or eliminated. Having added functionality in a product that is not perceived valuable by the customer can actually hurt the sale of the product. For example, if a television with an antenna is priced the same as one without, a customer may believe that the first television is inferior as the antenna is provided at the expense of the quality of the other components.

Step 5: Generate alternatives that lead to reduced costs and/or increased value

Once the existing product has been assessed, the next step is to find design or component alternatives that serve to reduce costs without risking value or increase value without adding cost. The most ideal situation is to find alternatives that reduce costs while adding value.

Brainstorming and Kano analysis are methods that can be employed to generate alternatives. Checklists such as the following can also be used to stimulate ideas.

<u>Cost Reducing Ideas</u>

Reduction	• Reduce the number of components • Combine components • Reduce specifications (e.g., material strength requirements) • Reduce or change packaging
Elimination	• Eliminate redundant or unnecessary components
Simplification	• Simpler design • Simpler shapes • Simpler assembly process or sequence • Relaxed tolerances or dimensions
Modification	• Less expensive materials • More efficient manufacturing • Less expensive finishes • Use alternative transportation methods

Standardization

- Use standardized or bought-out rather than specialized components
- Standardized dimensions
- Duplicated components

<u>Value Enhancing Ideas</u>

Utility

- Increase capacity, power, accuracy, flexibility

Human Factors

- Increase ease of use, intuitiveness

Reliability & Maintainability

- Limited or no maintenance
- Reduce susceptibility to environmental conditions
- Reduce risk and severity of malfunction
- Increased lifetime

Safety

- Risk free operation
- Protection from injury

Environment

- Little or no undesirable by-products (e.g., chemical, noise, heat)
- Recyclability or reusability

Aesthetics

- Enhanced appearance
- Improved visual and tactile finish

Step 6: Evaluate alternatives

Not all alternatives suggested to improve costs or increase value will be feasible or compatible therefore a careful evaluation should be made before any implementations are made. Evaluation matrices or quality function deployment may be helpful in considering the alternatives.

If the functional cost analysis results in changes to the product design, be sure to manage these changes carefully and update all necessary documentation including specifications.

References

Cross, Nigel, *Engineering Design Methods*, John Wiley & Sons Ltd., United Kingdom, 1989. ISBN 0-471-92215-3 pp. 123-142

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Pahl, G. and Beitz, W., *Engineering Design: A Systematic Approach*, The Design Council, London, 1988. ISBN 0-85072-239-X pp. 285-287

Singh, Karambir, *Mechanical Design Principles: Applications, Techniques and Guidelines for Manufacture*, Nantel Publications, Melbourne, Australia, 1996. ISBN 0-646-25797-8 pp. 368

Attachment A

Functional Cost Analysis Form*

Product: Kettle ______________________________ Completed by: ________________________________

Date Completed: ____________________________ Revision No.: __________________________________

Component/Assembly	Support Functions									Cost of Component	
	Provides Heat	Holds water	Protects user	Transfers power	Notifies of boiling water	Provides mounting				Total	% of Total Cost
Heating Element	2.30									2.30	29%
Housing		1.50	.75			.30				2.55	32%
Power cord				1.65						1.65	21%
Whistle					1.45					1.45	18%
Cost of Function	2.30	1.50	.75	1.65	1.45	.30				**7.95**	**100%**
% of Total Cost	30%	19%	9%	21%	18%	4%					
Cost Sequence	1	3	5	2	4	6					
Value of Function	H	H	M	M	L	L					

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* based on p. 132 of *Engineering Design Methods* by Nigel Cross (1989).