

PROPOSAL FOR A DESIGN METHODOLOGY BASED ON FUNCTIONAL ANALYSIS FOR PRODUCT DEVELOPMENT

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Abstract

This research proposes a design methodology based on the identification primary and secondary functions and the detailing of subfunctions, in order to fill the gaps left by some authors concerning nomenclature and function definitions. This methodology is a five-step technique based on classical design tools and methods, resulting on an in-depth study of functional deployment starting from a basic need. Since it is a conceptual study with a philosophical approach, three hypotheses underlie this methodology: (a) the union of both functional studies allows a comprehensive and robust analysis; (b) both functional studies converge and (c) functional methods do not correlate with each other.

Keywords

Function, Functional Deployment, Design Methodology, Design Tools, Product Design

Área: Gestão do Processo de Desenvolvimento de Produtos

1. INTRODUCTION

Functional analysis is a technique that comprises the study and systematization of a function, which has its origin on customer needs. The function is the objective of the action. In the context of design methodology, the functional study allows the transcription of a customer needs in a semantic construction that, subsequently, can be decomposed into subfunctions until it reaches its most basic and simple one.

Authors such as Baxter (2011), Pahl et al (2007), Ulrich (2008), Ullman (2003), Rozenfeld (2006) and Csillag (1995) describe function and functional analysis under different points of view. However, it is consensus among the authors that this technique is used in the concept generation, which permeates the consumer need, decomposes functions and applies creativity tools until.

The method in this research aims to propose a functional study based on a necessity that represents, simultaneously, the primary and secondary functions in order to assign numerical values to each and state, from its position in the plane, the influence on the overall function and how it can be inserted into the product design. This research is guided by exploratory study based on literature sources.

The methodology described consists of an in depth-study of the functional deployment starting from a basic need, based on Csillag (1995) and Pahl et al (2007), as a way of implementing the early stages of product development. Since it is a conceptual study with a philosophical approach of classical authors on the subject, three hypotheses underlie this methodology. To validate the method, future field studies are planned.

2. DESIGN TOOLS FOR A FUNCTIONAL STUDY

It is understood by function the objective of the action, defined by a semantic construction of a verb, indicating the action on something, and a noun, the object on which it operates. This function does not relate to the means by which it is made, but with its purpose (BAXTER, 2011).

Complementing this definition, Rozenfeld (2006) states that the function describes the desired or necessary capability to make a product able to perform the goals and predetermined specifications. Therefore, the product function is the goal of operation in a prescribed manner (CSILLAG, 1995).

The product function is classified according to the hierarchy or purpose. By hierarchy means the overall function, explaining the existence of a product, the primary function, which makes

the product function and secondary function, which supports, enables or improves the basic function (BAXTER, 2011).

The classification of a function according to their purpose allows the determination of a function of use, which enables the operation of the product and the estimated function, a feature that makes the product attractive to the consumer. Furthermore, the use function must be measurable as function estimate is expressed as not measurable noun (MILES, 1989).

The functional analysis can be applied at different stages of the project, commonly found in the conceptual design process, predecessor to the study of creativity (BAXTER, 2011; PAHL et al, 2007; ULRICH, 2008; ULLMAN, 2003; ROZENFELD, 2006). Due to the ease of measurement, behavior and performance are two terms associated with a function (ULLMAN, 2003).

The functional decomposition of a product is described in different ways in the literature. According to Ullman (1997), first it is necessary to find the overall function that must be met and describe it through the black box, which are described in inflow and outflow of material, energy and signal. The second step of this technique is to describe the subfunctions involved in the system so as to control the search of solutions provide a better understanding of the problem and facilitate the correlation between the component and function. Ullman (1997) concludes the functional decomposition with the organization and refinement of subfunctions according to project requirements.

Rozenfeld et al (2006), in the same line of thinking, describes the functional modeling through the determination of a global function to structure a functional tree by means of black box and border demarcation system.

Also according Rozenfeld et al (2006), the functional modeling allows the creation of alternative structures to meet the overall function by (a) the division or combination of functions, (b) change of individual provisions, (c) change the connection type and (d) changing the system boundary.

Regarding the function modeling, Ulrich (2008) and Cross (2008) describe a five-step method in order to break a complex problem into subproblems. The first step is based on clarifying the problem to develop a general understanding, which include the mission, customer needs and product specification as inputs. After that, the problem is subdivided, known as problem decomposition, and described in black boxes. At this point, the author emphasizes that *“the goal is to describe the functional elements of the product without implying a specific technological working principle”* (ULRICH, 2008, p.103). The second step

is to search externally by interviewing user, consulting experts, searching patents and literature. Step three presents the same technique, but the search is internal, based on both individual and group knowledge. Explore systematically corresponds to step four. At this stage, the concept classification tree is broached to bring some benefits related to identification of a solution that may not appear to have merit, reflection on an appropriate allocation of resources and refinement of problem decomposition. Then, it is necessary to combine the solutions systematically, described on a concept combination table. Finally, the reflection step identifies opportunities for improvement (ULRICH, 2008; CROSS, 2008).

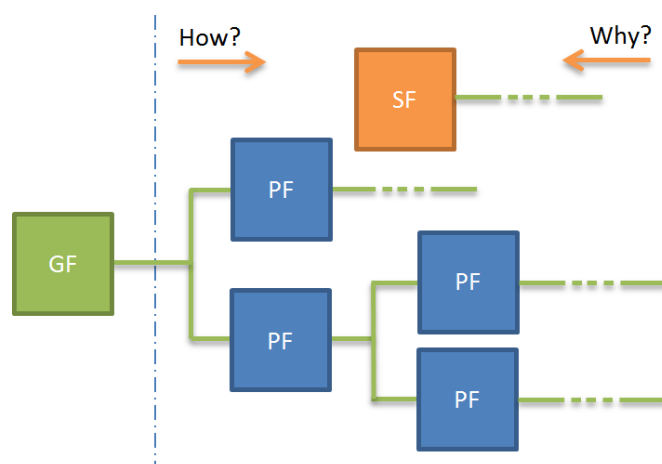
2.1 Value Analysis (VA)

By being a systematic analysis of features of a product, the value analysis requires knowledge of the functioning of the product (BAXTER, 2011).

The first step of a VA is to generate the product functions, questioning what the product "does" and not just what "is". After determining the functions, it is necessary to order them to delineate the functional tree.

The Function Analysis Systems Technique (FAST) schematically organizes the functions, emphasizing their relations and hierarchy. As the FAST diagram is executed, the team project is stimulated by questions concerning (a) the reasons about the product existence, (b) the critical path between the functions and (c) the definition of the basic function. By questions "Why" leads the users of FAST to the highest order functions (in direction to the global function), while questions "How" conduces to the lowest order function, as shown in figure 1 (BENDAOU et al, 2012).

Figure 1 – FAST diagram



Source: Authors (2013)

This tool is based on the pairwise comparison of all the functions, defining in each case which is the most important function and attributing it an appropriate weight. By the end of the comparison process, the sum of points indicates the primary functions and the sequence of the secondary functions (ROMANO et al. 2010).

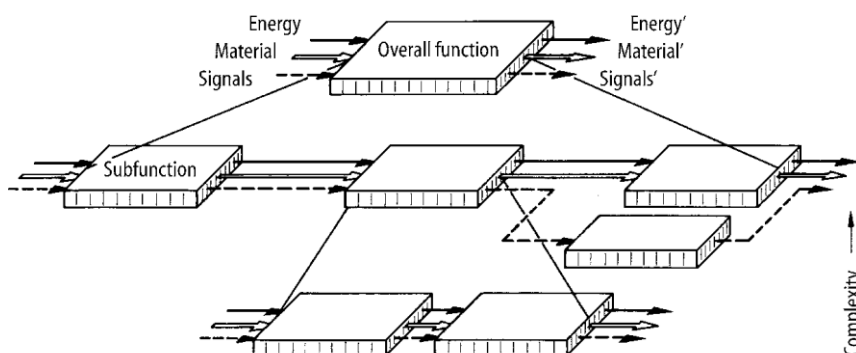
At the end of this analysis, a greater number of alternatives which generates as a consequence further elaboration of the basic concepts that modify the current performance of the product, since allowing the optimization function to the total innovation (BAXTER, 2011).

2.2 Functional Deployment by Pahl et al (2007)

Pahl et al (2007) determine the overall function as the “*overall relationship between the inputs and the outputs of a plant, machine or assembly*” (p. 169). Herein, inputs and outputs consist on material, signal and energy flow, represented by a block diagram. If the overall function is complex, it is necessary to break it down into subfunctions in order to search for simple and unambiguous solutions.

Firstly, the authors indicate that the subfunctions must be structured around a main flow. When the function structure reaches the lowest level of complexity, the next step is to detail the auxiliary flows and their subfunctions. Thus, the function deployment continues until an ultimate simple level, as described by figure 2.

Figure 2 – Function Structure



Source: PAHL et al (2007)

3. PRODUCT DESIGN METHODOLOGY BASED ON A FUNCTIONAL DEPLOYMENT

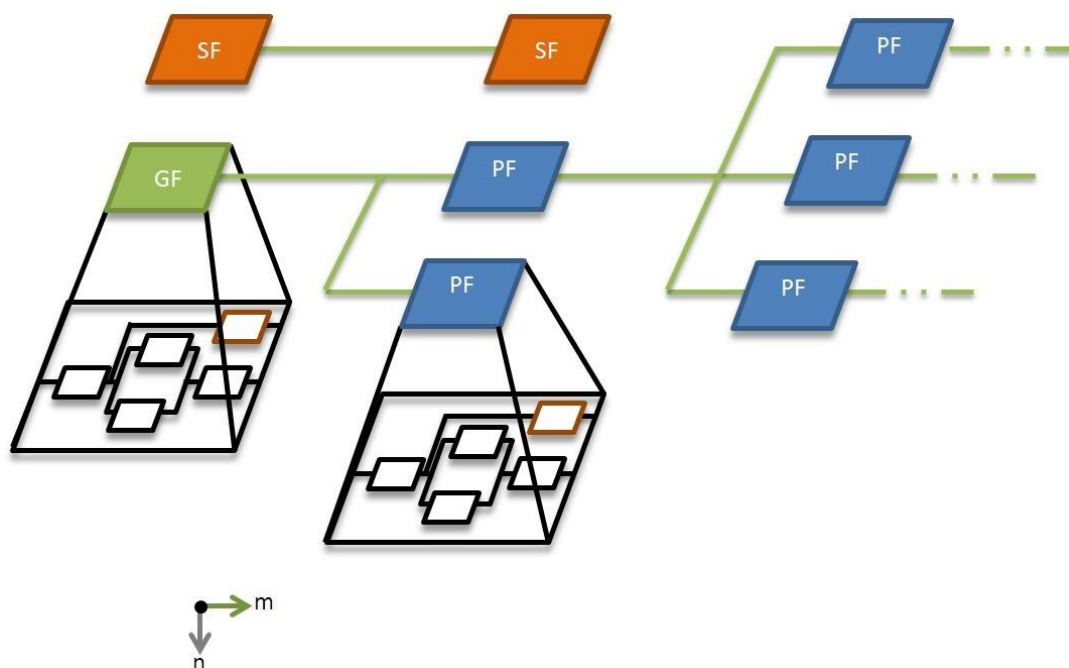
The methodology described below consists of an in depth-study of the functional deployment starting from a basic need. Note that the methodology derived from functional studies

described by Csillag (1995) and Pahl et al (2007) as a way of implementing the early stages of product development.

Since it is a conceptual study with a philosophical approach of classical authors on the subject, three hypotheses underlie this methodology: (a) the union of both functional studies allows a comprehensive and robust analysis; (b) both functional studies converge and (c) functional methods do not correlate with each other. To validate the method, future field studies are planned.

For didactic reasons, the methodology outlined in Figure 3, is divided into the following steps:

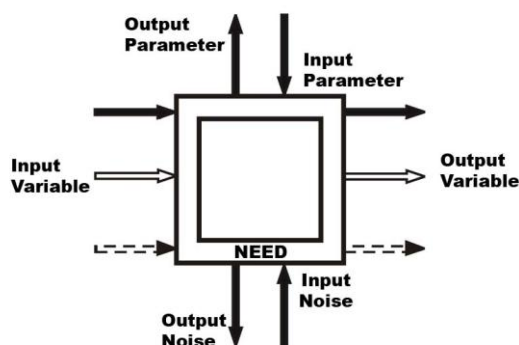
Figure 3 – Design Methodology based on a functional deployment



Source: Authors (2013)

Step 1: The basic need is described by a global function (GF), which consists of a general and desired relationship between the inputs and outputs of a product, in order to accomplish a global task. In this context, it is determined the black box, in which are considered the inputs and outputs, as shown in figure 4.

Figure 4 – Black box



Source: Authors (2013)

Step 2: The overall function is split into subfunctions, corresponding to subtasks of the overall task. Each subfunction can again be split into new subfunctions until the project requirements are met by a set of subfunctions, said the simplest possible, within the scope of the methodology, as proposed by Pahl et al (2005). The nomenclature of this step follows the standard “subfunction n.x”, where “n” is the deployment level and “x” is the subfunction index inside a “n” level.

Step 3: The overall function is split into primary functions, corresponding to how the overall function is executed. Each primary function can be split again, until the requirements of the project are described within the scope of the methodology, as proposed by the technique FAST (CSILLAG, 1995). The nomenclature of this step follows the standard “primary function m.y”, where “m” is the deployment order and “y” is the primary function index of a “m” order.

Step 4: The overall secondary function can be split into new secondary functions until the project requirements are met by a set of subfunctions, said the simplest possible, within the scope of the methodology, as proposed by the technique FAST (CSILLAG, 1995). The nomenclature of this step follows the standard “secondary function m.y”, where “m” is the deployment order and “y” is the secondary function of a “m” order.

Step 5: This step provides the interaction between the two methods. It is proposed that each function primary and secondary of a “m” order is split according to the technique described by Pahl et al (2005). Thus, projections are obtained providing information concerning all categories of function, which allows the determination functions that could previously be ignored, but with the union of methods can be evidenced.

4. CONCLUSIONS

The theoretical foundation allowed the definition for the term “function” within the context of design methodology demonstrating that there is a consensus in the formation of a function, based on the use of verb and noun. However, the authors differ on the categorization of the function purposes and hierarchical levels, indicating that the study of this topic is necessary to fill the gap left by both, the function definition and the methodology. Thus, this paper proposed that the global function must be deployed using two techniques, one described by Csillag (1995) and other by Pahl et al (2005), comparing the results in order to check convergence. This method aims at the optimization of project development, because enables wide (due to the identification of primary and secondary functions) and detailed (due to the investigation of subfunctions) approach of the global function.

5. ACKNOWLEDGEMENTS

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