A NEW FUNCTIONAL ANALYSIS APPROACH

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Abstract: This paper's aim is to propose an approach for finding the product's functions-internal, functions between components and external functions regarding the product in relation with its environment and user - from a combined perspective, that of a functional analysis completed with useful and harmful function's effects. Such a combined approach led to emphasis the harmful functions effects and further, trying to find solutions that avoid or eliminate these effects it can be obtained a better product conceptual design.

1. INTRODUCTION

The concept regarding function, functioning is widespread in many areas and there is no field that does not contain it. Even it has many utilization contexts, and a variety of meanings, from function's definition in each field it can be extracted the same feature, namely that the function seen essentially as a task, role, activity or destination. The technical function is understand as a core element of departure in designing/redesigning of new or existing products and that is because it starts from the basic idea, namely that any product has a role, a purpose, it perform functions thus satisfying the requirements/needs. In the same time, there exists also the non-technical function, which depends of the context of product's lifecycle or between users.

Conceptual design is a design activity that implies the design concept's generation and evaluation [8].

A difficult problem during conceptual design is to find the ways of support for this stage. In this idea, to support the design activity, in the paper are presented the functional analysis and TRIZ functional modeling and based on these tools a general functional analysis approach is proposed.

2. FUNCTION DEFINITION IN SYSTEMATIC AND AXIOMATIC APPROACHES

In the literature are several definitions given to the function. For example, in [6] are highlighted two concepts that are useful in the design methodology:

- function as the duty the product must be capable of fulfilling and
- function as a general connection between input and output.

A function's definition given by the [2] is: "Action of a product or one of its constituents expressed exclusively in terms of finality." In addition to this formal definition, some usage rules must respect:

- avoid passive voice;
- avoid negative form;
- the function formulation must be independent of the solutions that would achieve the function;
- the formulation should be as concise and clear as possible.

In [9] the function is defined as follows: "Designers determine the properties of every product in terms of function, safety, ergonomics, production, transport, operation, maintenance, recycling and disposal." In the same work, the term "function" is also defined like: "For the purpose of describing and solving design problems, it is useful to apply the term function to the intended input/output relationship of a system whose purpose is to perform a task…the function is an abstract formulation of the task, independent of any

solution." In systematic approach [9] stating the general function (overall function) assumes that the problem's formulation exists and then based on flows of energy, materials and signals the expression of a relationship between input and output independent of any solution is formulated.

Further, this functional requirement - general function need to be expressed in solution neutral terms and is decomposed on different hierarchical levels. A functional structure is described as "a combination of consistent and meaningful sub functions in a global function." Possible compatible solutions combination plays the main functionality.

Full structure function is performed by iterations. Thus, the idea of function(s) is central in the design process, and those involved must find the ways to respond to these functions. Knowledge of function's functionality is useful when further changes are necessary, comparisons, investigating the reasons of problems arising during the functioning. The engineering design work is always looking for different ways of obtaining functions by materializing product components. Sub functions performed by components give by integrating the product's general function.

In axiomatic design [10] the design process starts from a high abstraction level, and gradually to this level, there is a breakdown by levels and sublevels in the four areas the customer, functional, physical and process. This leads to a hierarchy of functional requirements (FRs), design parameters (DPs) and process variables (PVs) [10]. The perceived customer needs has to be translated in a „solution-neutral environment" meaning that the FRs has to be defined without thinking to something that already exists or what the solution should be. If FRs is defined for an existing design than the ways to „solve" that FRs will be different resulting different solutions, namely another better product. A functional requirement generates a design parameter, which in turn generates the next level of functional requirements. Decomposition takes place simultaneously in physical and functional domains and not entirely in a single domain.

In axiomatic design, design parameters DP are detailed as sets of sub functions and the main functionality of the system (designed object) results from the summation of the design parameters effects. Choosing a design parameter or another still generates lower level functional requirements, specific to the corresponding design parameter.

The solution chosen to achieve a function guides the function decomposition at lower levels. Defining functional requirements is very important because the evaluation process in axiomatic design is dependent on the selected functional requirements; such solutions are evaluated in terms of independence of these functional requirements.

3. FUNCTIONAL MODELING

TRIZ functional modeling is the TRIZ (Theory of Inventive Problems Solving) discipline and process for mapping systems with problems by listing all the components and all their interactions. TRIZ Function Analysis differs from other forms in that it includes all the negative, ineffective and excessive interactions in the system. Sometimes the harmful elements are the key to potential solutions [4].

Functional analysis analyses these functions and interactions between components and helps to define almost any existing problem in the analyzed system. TRIZ functional modeling is widely used in many fields. An example can be found in [5] where the functional modeling approach is used in order to recognize the products embodying physical solutions of identical function structures.

The main objective of a product existence is that it provides a useful function, the primary function. The TRIZ-based functional analysis with useful and harmful functions during product development process points out useful and harmful elements and the result

is a better understanding for the usage itself and a basis for analyze, formulate and prioritize the problems that require solving.

In [11], [12] is presented the identification process for primary basic and secondary functions and the component's analyze in order to identify the existent interactions. In [12] is presented a questionnaire regarding the links between the useful and harmful functions, offering an overview of different problems that might appear:

Regarding the useful function:

- Is this useful function required for another useful function(s)? ;
- Does this useful function cause any harmful effect(s)? ;
- Does this useful function have been introduced to eliminate a harmful effect(s)? ;
- Does this useful function require another useful function(s) in order to perform UFn-1?

Regarding the harmful function:

- Does this harmful function cause another harmful function(s)? ;
- Is this harmful function caused by another harmful function(s)? ;
- Is this harmful function caused by a useful function(s)? ;
- Does a useful function have been introduced to eliminate this harmful function(s)?

The basic elements of a functional model are functions and links. A link defines the relationship between functions. The functional modeling is represented graphically through a syntax [11] and is a graphical representation for the links between the useful and harmful functions.

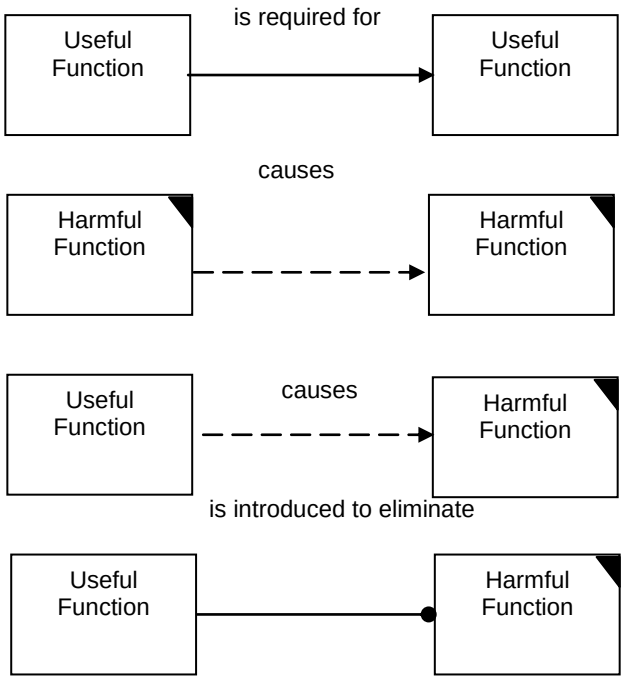

Figure 1. Syntax of functional modeling (Terniko, 1996)

This approach's idea is to reveal the contradiction by looking for functions that have both a useful and harmful outcome, find a way to improve Useful Function - Determine how the system can be changed to improve its characteristics, functionality etc. and resolve a contradiction: Useful Function should produce Useful Purpose and should not produce Harmful Function. Change the system so that the desired results are achieved while the associated undesired results disappear or diminish and find a way to counteract Harmful Function - Change the system so that an undesired factor is eliminated or reduced.

4. FUNCTIONAL ANALYSIS

To respond in a clear and accessible manner to a problem regarding the product in relation with environment from a functional point of view, it can be used the functional analysis. According to [1]: "Functional Analysis is an action which consists of searching, set in order, characterization, hierarchy and/or set a value (quantifying) for the functions". We choose functional analysis because the function definition is similar to that given in both approaches-independent of any solution - and we have to think in terms of functions and not in terms of solution.

Connected to functional analysis it has to be specified that there are many methods of AF that are more or less adapted to the analysis that we want to realize. These methods have as goal the elaboration and validation of functional specifications book, the search for solutions that correspond to the real needs and the identification of important costs.

Functional Analysis [3] is used at the beginning of a project to create (design) or improve (redesign) a product. It is indispensable to its successful completion and for that aim, we determine for a product the main functions, secondary functions and constraints functions. This functional view of a product from three “sides” is important to correct sizing of product characteristics.

The terms of service functions are normalized [1], [7] "service function is the action expected from a product (or made by him) to answer a need element of a given user.” They are responses to customer needs and are determined by an external functional analysis.

These service functions in turn are divided into:

- the subjective component functions such as aesthetics answers;
- use functions - this kind of functions translate the essential rational need component in order to meet the need;
- the main functions corresponding to services rendered product to meet user needs- are the reason why the product is made;
- constraint functions that translate the resistance or adaptation reactions to environmental factors.

There are also complementary functions that facilitate, improve, or complete the service. This type of functions does not result from the explicit request of the customer, and are not constraints. It is about offering enhancements to customers for his product.

Functional analysis is possible with clearly defined tools. Thus, we find:

- the “bête à cornes”, which can express the need of research;
- the “pieuvre” diagram, which defines the links (that is to say the service functions) between the system and its environment. This diagram helps identify the most system functions;
- the specification book, which allows to describe and list any primary, secondary and constraints functions of the studied system;
- diagrams FAST (Functional Analysis and design technique) and SADT (structured analysis and design technique), allowing the search for technological solutions [3] (fig. 1)

Functional Analysis has two possibilities to be unfolded: External Functional Analysis and Internal Functional Analysis. External Functional Analysis consists of analyzing the need, functions identification, identification of the external environment’s elements, identification of the principal functions and constraint functions, functions validity control, characterized through the assignation of criterions; levels of each criterion, flexibility class respectively the importance of the discussed function. The internal

functional analysis consists in identifying the product's internal functions – the functions accomplished by each of its components.

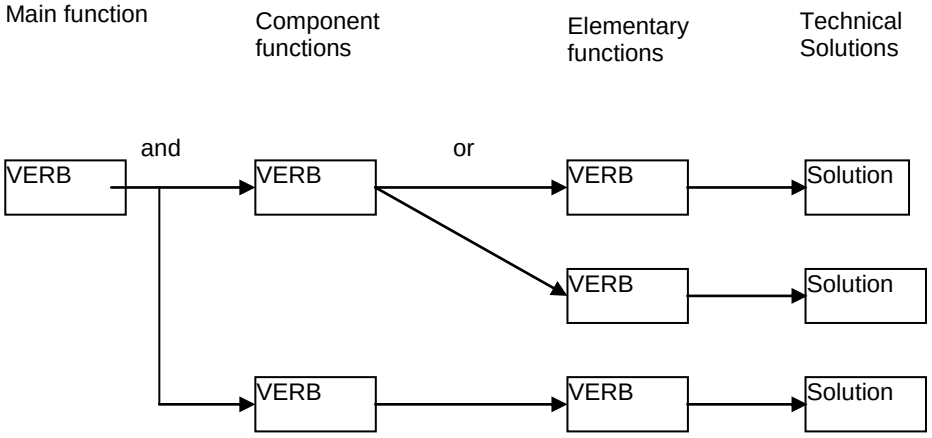

Figure 2. FAST Diagram (De La Bretesche, 2000)

5. THE PROPOSED APPROACH

The common elements between systematic design model and axiomatic design model is that deals with functions, the nature and the definition of functions and also that we have to think in terms of functions and not in terms of solution. The function is the core element that "guides" the product's design. The function decomposition is different in the two approaches, but the functions needed to satisfy the products are the same; the function itself has the same meaning in both approaches especially as the function(s) are present in all stages of development a product - or the life cycle phases. In addition, function's definition in both approaches is the same, as independent of any solution and formulated as verb. Functional analysis is also a common tool, used by these approaches. The TRIZ functional modeling can be applied there where exists a functional decomposition, but that approach emphasis the useful and harmful functions. Also, this TRIZ functional modeling can be applied in both design approaches. With respect to that we presented so far, we intent to propose a general functional approach (fig. 3) that combines the useful aspects of functional analysis and functional TRIZ modeling.

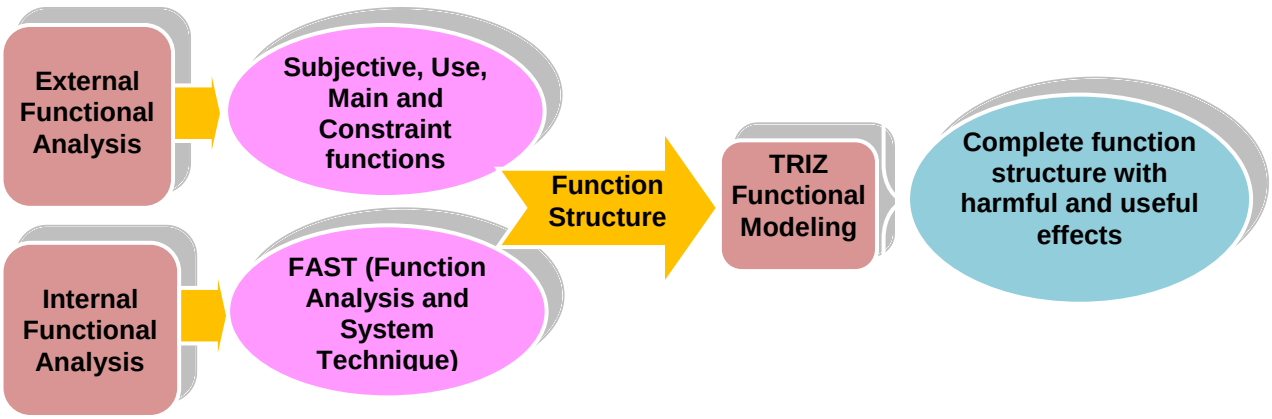

Figure 3. The Proposed Approach

A functional analysis helps to list product's internal and external functions but without emphasizing their harmful effects if they exist. We can obtain a complete function structure regarding the useful and harmful function effects if the TRIZ functional modeling is applied to those functions identified through a functional external and internal analysis.

Combining a functional analysis with a TRIZ functional analysis both for external and internal product's analysis emphasis the harmful effect that has the identified functions. Through functional analyses there are identified the interactions between the environment and product, the user and the product and between the product's components.

Next, thinking in terms of TRIZ functional modeling, for these functions there can be identified their useful and harmful effects.

6.CONCLUSIONS

The "function" concept is present in any design problem and also in design approaches. It has the same meaning both in systematic and axiomatic approaches but the way how the function structure is obtained is different.

A functional analysis helps to list product's internal and external functions but without emphasis their harmful effects if they exist. We can obtain a complete function structure regarding the useful and harmful function effects if the TRIZ functional modeling is applied to those functions identified through a functional external and internal analysis. In this way, trying to avoid and eliminate the harmful effects from the first design stage-conceptual design we think that the result will be a better product design. In our future works we will try to apply such an approach on a concrete design task.

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