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APPLYING FUNCTIONAL ANALYSIS AND FBS MODEL TO DESIGN A CHILD CAR SEAT

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ABSTRACT *- For the companies a challenge is to reduce the developing time for the product, to ensure the right quality, to reduce the costs and to consider the customer's requirements.*
The design stage is very important to develop a competitive product. In this stage, it is important to establish the product functions, necessary to satisfy the user's requirements. A method used to establish the relations of the product with the environment's elements is the Functional Analysis.
This method is an approach whose goal is to express the need in terms of services expected functions and, ultimately, in terms of solutions. Its aim is to reach a product to satisfy the user's requirements.
In this paper, we present an application of Functional Analysis for a product (a child car seat), in order to establish the relationships of the product, with its system. The paper is based on an experiment led at the Laboratory of Design and product Development, of the Faculty of Mechanics and Technology from the University of Pitești. The aspects that have been considered are: the relationships between functions and solutions, the fulfillment degree of the functions by the proposed structures, the development mode of solutions, etc.

KEYWORDS - Functional Analysis, design process, FBS method

INTRODUCTION

Competition in the automotive industry is increasingly higher and to resist on the market the companies have to use new equipment and methods for the analysis in the process of development and manufacturing of the products.
However, it is aimed at a better understanding of customer needs, continuous improvement of product quality and lowering costs. The high level of quality products starts since the design stage and continues in all stages of the products in question. This paper presents several methods used in design process of products, come to support the quality assurance process.

SYSTEMS TO FASTEN CHILD CAR SEATS

In the current regulations on safety rules it is mandatory to carry children up to the age of 12 using seats / systems specially adapted for children's ages H.G. no. 11/2015.
It is also mandatory to have the seats or special systems approved by specialized bodies.
Another obligation refers to equipping cars with approved (standardized) systems to fasten seats, ISOFIX.
ISOFIX is a safety system that has become an international mounting standard in fastening the child seat in a vehicle, without requiring the use of seat belts. This system was launched in 1997 by Britax-Romer in collaboration with VW.
In the event of an accident, the anti-tipping system reduces child onward movement and directs most of the forces downward. Direct connection to the vehicle chassis prevents lateral movement of the seat and improves protection in the event of a side impact. Side impact

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protection, which is mentioned in descriptions of different types of child car seats, is actually represented by a deep, tall and well-padded headrest.

EXTERNAL FUNCTIONAL ANALYSIS – CHARACTERISTICS

To select the most representative functions of the new product, to guarantee that all necessary components are listed and that no unnecessary components are requested and to understand the relationships between the components of the new product, system engineers use the Functional Analysis to design new products.
A Functional Analysis presents the functions and parts of the product, indicates the mutual relations and represents an abstract model of the new product, without material characteristics such as shape, dimension and material of the parts. Therefore, starting from a limited number of elementary (or general) functions on a high level of abstraction a function structure may be built. Functions are abstractions of what a product should do. Creativity is stimulated if one has to think about the product in an abstract way and does not 'jump to solutions', i.e. elaborate the first idea which sometimes may not the best one.

ENVIRONMENTAL ELEMENTS METHOD

The "octopus diagram" or "interactions diagram" is used for the environmental elements method based on the proceedings of the product in the elements context, "environmental factors", with which it is linked to in various situations of life. The graph of the "interactions diagram" presents the product as an oval in the center of the diagram and the environmental elements, also an oval, around the product.
The functions resulting from the relation of the product with the environmental factors are classified in two categories, as follows:

a) Main functions (MF /FP) - representing the purpose of the product's action;
b) Constraint – functions (CF/FC) - representing the actions and/or re-actions of the products towards various environmental elements, as it is present in the system and in the environment.

FUNCTION ANALYSIS SYSTEM TECHNIQUE – FAST- METHOD

The functional analysis system technique (FAST) defines, analyzes and understands product functions in a logical sequence, prioritizes them and tests their dependency (1). A chart of all functions embedded into an existing product can be drawn by applying this method to an existing product in its entirety or its component. FAST, an interrogative method helps to reduce costs by the analysis of the basic functions of products and the way they are engineered for their purpose.
FAST diagram presents graphically the technical functions of the product through which the service functions are accomplished. Start the graph by identifying a function, generally the basic function of the product which is the main reason that the product exists for the customer. From this point the other functions, dependent to the starting function, as well as the questions, are obtained horizontally and vertically. The approach chosen to achieve the basic function is described by the functions to the right of the basic function which also answer the question "How?" the functions to the left are to be produced. Whereas, the functions to the left show "why?" the functions on the right are performed. If functions occur simultaneously they are placed one above the other.
Two vertical dashed lines, called "scope lines", one to the extreme left and one to the right delimit the diagram and define the scope of the product development objective. The

functional decomposition of the general functions level to the basic functions is made between the two borders, using the above-mentioned questioning techniques.
FAST represents a synergistic way to develop, decompose and understand the functions of any product.

CHARACTERISTICS OF THE FBS METHOD

A study with the Function, Behavior, Structure, FBS, method can be done to analyze the relations between the functions and the proposed structure after determining the product functions. The interface between the functional and structural space is characterized by the FBS method. As the product passes during the design process from the functional space to the structural space (3) it can be considered that it has two faces, a functional face and a structural face.
The functions of the product (the problem), the structure of the product (the solution) and the internal behaviors of product (4), (5) are explicitly represented by the FBS method.

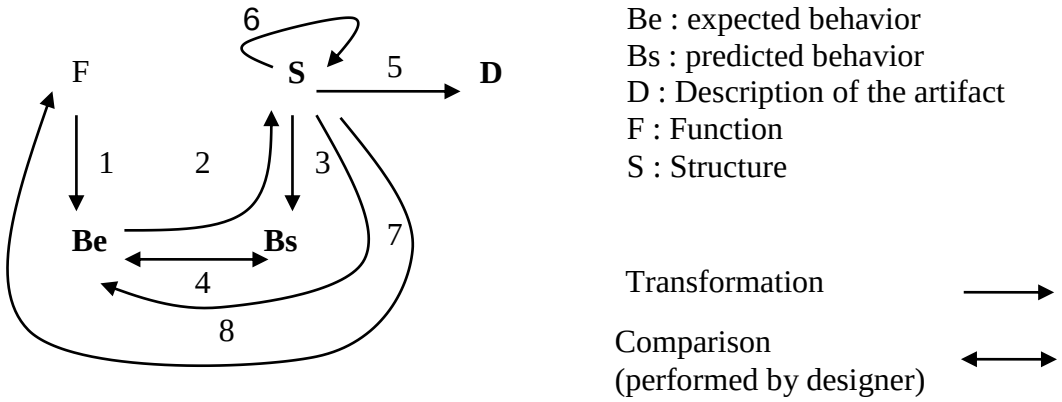

Figure 1. The FBS method

Functions: characterize, in an abstracted way, the finalities of an object (process, product or resource). The technical functions are tributary of a choice of solution whereas the functions of service are independent of any particular solution (in particular of any choice of structure).

Behavior: describes the dynamics of an object, including a set of laws and rules (model continuous) and a sequential succession of states (model discrete) which represent the evolution of a structure following an excitation (or stimulation) during a given process.

Structure: allows specifying the elements composing the artifact and the attributes of these elements. The behavioral fields F (what is waited from the structure) and S (what is noted by it) are distinct. These fields connected by comparison or transformation (simple arrows) (arrow doubles) are the variables.

EXPERIMENTAL ENVIRONMENT

In order to achieve the experiment was chosen the “child car seat” product. Because the selected product for this experiment is part of automotive products, the experiment was focused on making the analysis used in the design process for automotive industry.

This experiment has been realized by a team made up of two engineers from the "Automotive Engineering" Research Center. This team made the following phases of the experiment: determination of the product's function using the environmental elements method, the analysis of the main function using FAST method, the analysis of relations between the functions and the proposed structure using FBS method.

THE ANALYSIS OF THE EXPERIMENT

In Figure 2 are represented the environments and the functions for "child car seat" product.

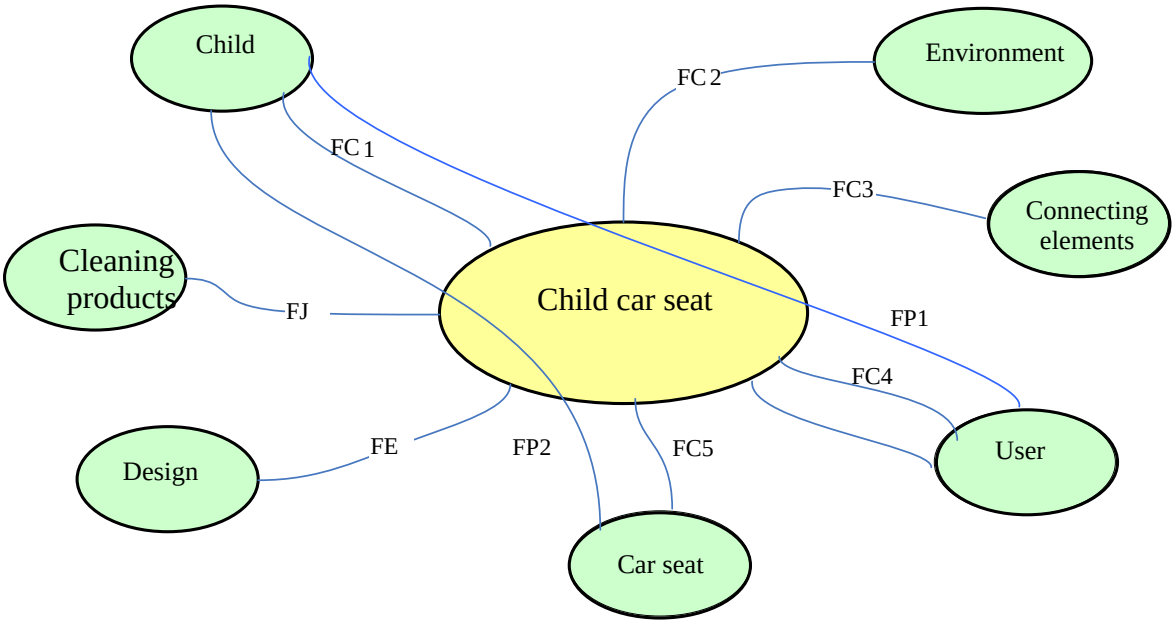

Figure 2. The environments and the functions of the product "child car seat"

In Table 1 are presented the product's principal function and the constraints.

Table 1. The product's functions

Principal functions	Constraints
FP1 – To protect the child in case of impact	FC1 –To have an ergonomic shape and comfortable for child FC2 - To resist to the environment's actions, heat, cold, the sun light FC3- To allow the attachment of the some connecting elements FC4 – To be handled by user FC5 - To not deteriorate the seat of the car FC6 – To have a nice design, nice colors for child (aesthetic) FC7 – To be washed easily FE – To not exceed an imposed price FJ - To fulfillment the standards

Applying FAST method the main function FP1 "To protect the child" has been analyzed and presented in Figure 3.

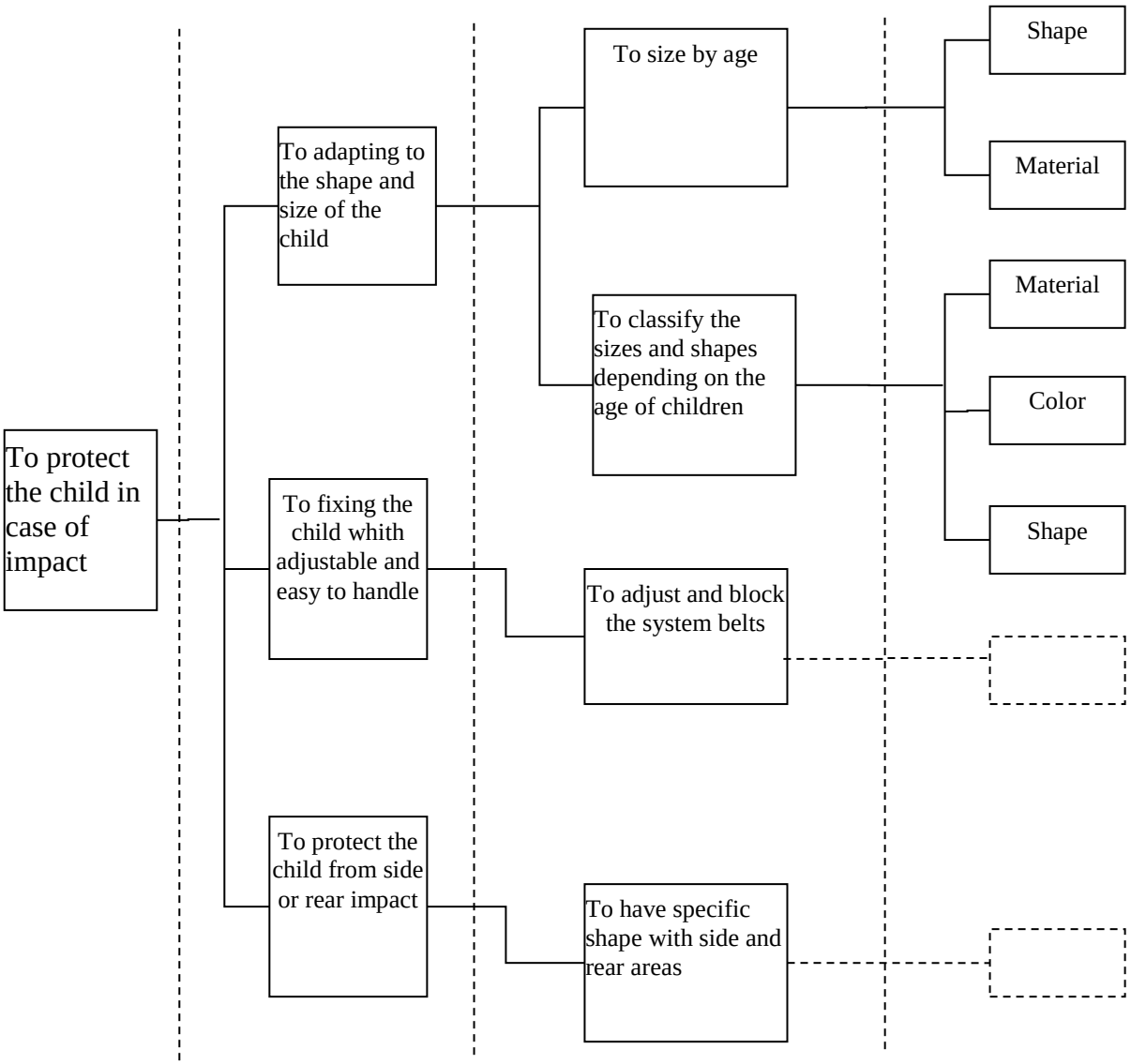

Figure 3. Example of FAST diagram for the main function FP1

ANALYSIS USING FBS METHOD

The FP_1 function claims a B_{eFP1} behavior (1). At its turn, this leads to the structure S_1 (2). This structure has its own behavior, B_{S1} (3). The team proposed for S_1 a structure that has a form able to protect the child, a material able to resist to shocks, able to sustain the child and a fixation system. The structure's behavior is compared to the expected one (4). For this function, the structure satisfies the imposed requirements.

The FC_1 function claims a B_{eFC1} behavior (1'). At its turn, this leads to the structure S_2 (2'). This structure has its own behavior, which is BS_2 (3'), figure 4. The team proposed for S_2 a material for the cover and for the arms and legs support. The structure's behavior is compared to the expected one, (4'). For FC_1 function, the structure satisfies the imposed requirements.

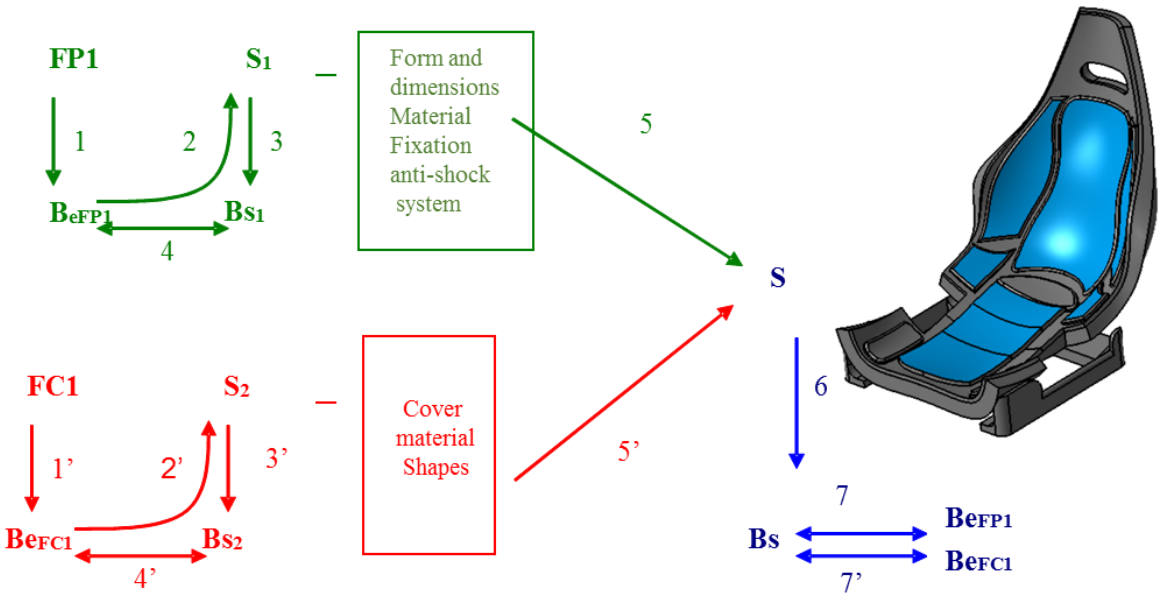

Figure 4. FBS representation of a "problem-solution"

The team proposed a new structure S, to satisfy the two requirements B_{eFP1} and B_{eFC1}. Comparing B_S with B_{eFC1} and B_{eFP1} (7 and 7'), one can notice that, in this case, the structure satisfies the requirements imposed by FP_1 and FC_1.

CONCLUSIONS

This paper presented the tools used in order to better explain the relationships that the product must have with various elements with which it interacts. By applying the FAST method, it can decompose the function of product in sub-functions leading to practical solutions (certain structures of product or properties).
With the FBS method was analyzed the solution's answer manner to the imposed requirements. The tools presented are simple, the analysis is done quickly, and input on the design process is high because the many problems are clarified in the early stage of the process, and for the participants to the design process represent a way to interact one with others in real time.

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