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USING THE FBS MODEL FOR THE ANALYSIS OF THE CORRELATION "PROBLEM – SOLUTION" IN THE DESIGN PROCESS

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Abstract: The product's competitiveness on the market depends by the efficiency of developed process during the product's life-cycle. Among the stages of a product's life cycle, the design phase is considered a very important factor achieving a certain quality level. In this stage, the designers must solve a lot of problems (related to the necessary functions) to find solutions acceptable (necessary to build the awaited structure). In this paper, we present a study carried out on a design experiment, using an analysis based on the FBS model (Function, Behavior, and Structure).

1. INTRODUCTION

The AFNOR standard defines the product design as being "the creative activity which, starting from the expressed needs and from the existing knowledge, leads to the definition of a product which can satisfy these needs and which may be carried out from the industrial point of view." The design is the key factor of the product development process. The costs, at this stage, have represented only 5% from the total cost, but the design activities are able to induce the costs up to 75% from the total cost. This is therefore, the logical stage, at which to invest more time and effort into getting the design right first time. "The decisions made during the design process have a great effect on the cost of a product but cost very little" [1], [2].

During the design process must be treated more serious problems. Any design problem requires at least one solution. In general, one can find functional, structural and behavior problems. A functional problem requires functional solutions which, in their turn, can generate the structural problems. A structural problem requires structural solutions which can generate problems relating to the structure behavior proposed as solution.

2. CHARACTERISTICS OF THE FBS MODEL

The model Function, Behavior, Structure (FBS) allows an explicit representation of the functions of the product (the problem), of the structure of the product (the solution) and of the internal behaviors of product [3].

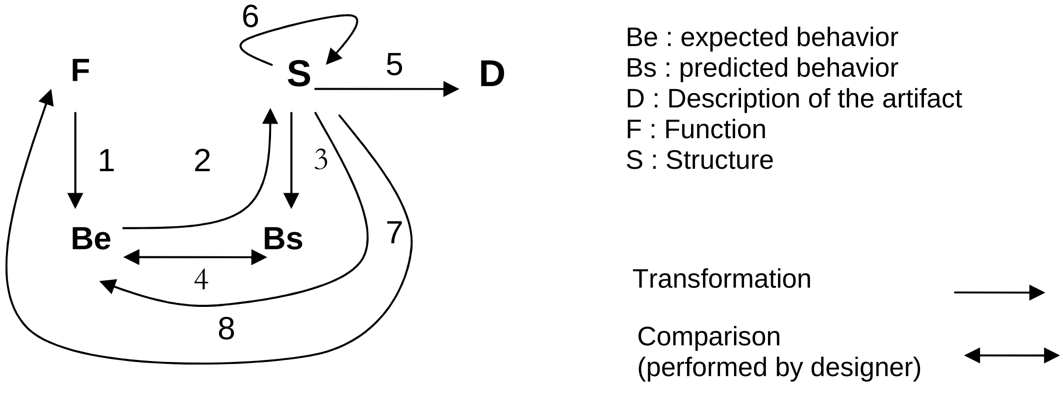

Fig. 1. ***The FBS model***

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

Behavior: it describes the dynamics of an object. It can include a whole of laws and rules (model continuous) as well as a sequential succession of states (model discrete) representing the evolution of a structure following an excitation (or stimulation) during a given process.

Structure: it makes it possible to specify the elements which make the artifact and the attributes of these elements. The behavioral fields F and S are distinct. The behavior F indicates what is waited from the structure and the behavior S what is noted by it. These fields are the variables and are connected by comparison or transformation (simple arrows) (arrow doubles).

3. UTILIZATION OF THE FBS MODEL IN THE DESIGN EXPERIMENT ANALYSIS

The design experiments are carried out to simulate a real process. The simulation of design process is a means used by the research laboratories with the aim of obtaining information regarding their behavior and the variation of their parameters.

3.1. Experimental environment

The design experiment which has been analysed in this paper was made at the University of Pitesti, Faculty of Mechanical Engineering, Department of Technology and Management, in the laboratory of integrated design, by a team made up of seven designers, one expert and the project manager. The aim of the experiment was to design a quick gripping system of the pieces on the table of a machine-tool.

The experiment needed more meetings and during all these the designers worked synchronically on a physical faceplate. The methods and the devices they used were specific to the design, as follows: computer software, calculus models, transmission devices, information processing and registry, data base, drawings, standards. During the first design experiment meeting, the proposed theme was discussed, each participant was given a role and the functional analysis of the product took place. On the basis of this analysis, there were issued theories concerning the possible technical solutions of the product. These solutions were compared to similar solutions existing on market.

During the other meetings, we passed to the embodiment design. Yet, during the entire design process, the product did not have a linear ascending evolution and it developed in an iterative way. This phenomenon resulted from a series of factors: design errors, aims change, improvements, dependences between the design tasks, the necessity to explore the existing solutions at a certain moment.

Not always the identified functions were the real ones; the proposed structure behavior differed from the functional one and the proposed structure did not satisfy all the requirements (costs, maintenance).

For the best understanding of the problems that might appear during the design there has been proposed to analyze the design process with the FBS model.

3.2 Observing the design experiment

The observation of the design experiments represents an efficient method of “entering” the real work space [4]. The observation has to be done carefully, without influencing the participants' behavior. Each meeting concerning the studied design experiment has been filmed for further analyses, figure 2. The information has been filtered and stored on different supports.

Fig. 2. ***Experimental environment***

3.3. Findings

After the observing stage, one should pass to the data analysis. When using the FBS model analysis it is necessary to know the functions which should be fulfilled by the product, their level of importance and the outer constraints. As a rule, one structure should satisfy at least three main functions and one constraint.

Analysing the design experiment there were identified more conjugated functions:

- F: to gripe the piece;
- FC: not to deteriorate the piece while gripping it.

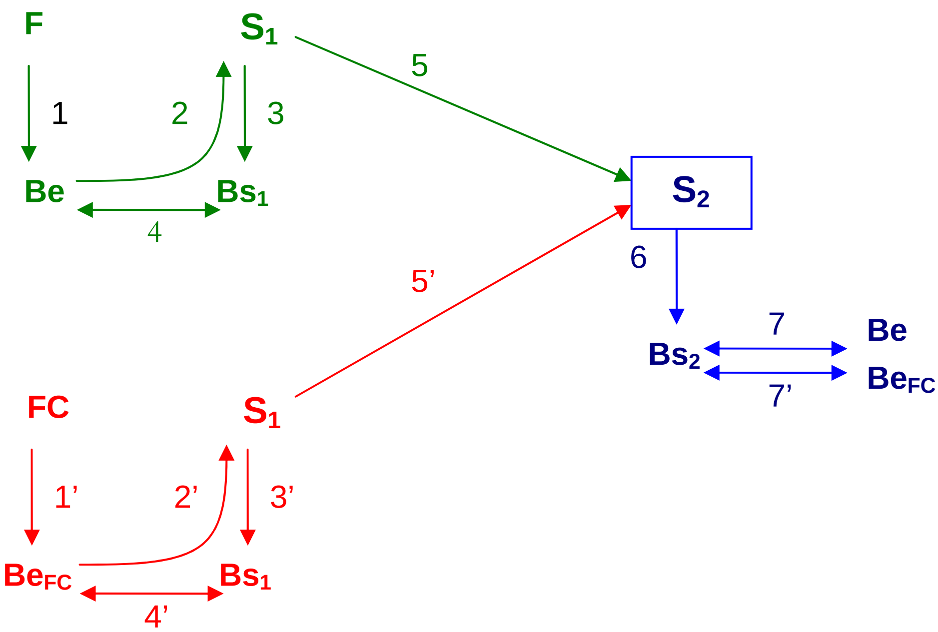

Fig. 3. ***FBS representation of a "problem-solution"*** **F(FC)→S_1(S_2)**

The F function claims a B_e behavior (1). At its turn, this leads to the structure S_1 (2). This structure has its own behavior, B_{S1} (3). The structure's behavior is compared to the expected one (4). For this function, the structure satisfies the imposed requirements.

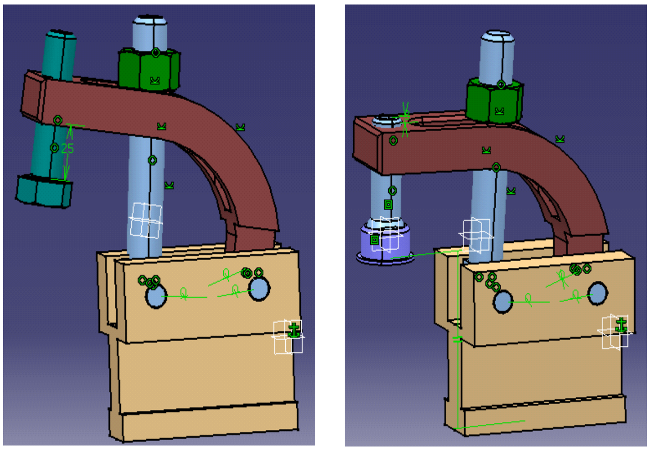

Fig. 4. ***Change of a design solution***

The FC function claims a B_{eFC} behavior (1'). At its turn, this leads to the structure S_1 (2'). This structure has its own behavior, which is B_{S1} (3'), figure 3 and 4. The structure's behavior is compared to the expected one, (4').For this constraint, the structure does not satisfy the requirements, B_{S1} does not correspond to B_{eFC}. This thing makes it appear an iteration at the structure level, S_1 performing up to S_2 (5 and 5'). In its turn, S_2 has its own behavior, which is B_{S2} (6). Comparing B_{S2} with B_{eFC} (7 and 7'), one can notice that, in this case, the structure satisfies the requirements imposed by F and FC.

4. CONCLUSIONS

This paper presents an analysis method of the "problem – solution" coupling using the FBS model. The used method was been the observation and analysis of the design experiments. Through this method was been identified the design problems, by the designers during the design process and the proposed solutions for their fulfillment.

Using the FBS model was been analyzed the solution's responding manner to the imposed requirements and was been identified a lot of iterations. This iterations show changes: in the structure because that behavior isn't adequate; on the functions because theirs nomenclature wasn't established correctly or mixed changes required by necessity of improvement for some partial solutions.

Therefore, the analysis of design processes using the FBS model presents a series of advantages: a simple manner to problems identification and correspondingly solutions, the identification of design difficulties and iterations origins and also the follow up possibility of the knowledge's construction mode.

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