PROJECT MANAGEMENT IN DESIGN STAGE

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Abstract: The design activity requires the involvement of a number of participants, with different skills using different methods, but with one common goal: design a competing product. For this, the manager must consider two aspects: the performances of process and the performances of product.
This paper presents a managing method of the design process based on the "problem-solution" indicators, on the "quality redesigned product / quality initial product" indicator and on the "quality of partial solutions indicator". The research method used in this work relies on observation of the design process made at the University of Piteşti by a design team.

1. INTRODUCTION

Quality represents the set of characteristics of an entity which confer it the ability to satisfy expressed or implied needs.
Nowadays, in the context in which the free consumer goods currency has provoked an exacerbation of competition, raised the customers' exigency concerning the quality of the commercialized products, manufacturers in different areas of activity think about making their products more and more competitive in order to conquer an important position on the market. This implies the conception of more and more diverse products, manufactured with lower costs - without affecting quality and functioning – products whose manufacturing cycles are shorter. In other words, manufacturers must produce quality products. A low quality product, which doesn't meet the customers' requirements or which does not meet their level of expectation, will determine them to orientate to the competitive products. This will bring losses for the company. Customers are becoming more and more demanding and their requirements are changing all the time. "Customer is the king" becoming the motto of today.
Carrying out the quality over the level of customer anticipations implies the necessity that the start of this step to begin with the products design activity.

2. DESIGN AND QUALITY

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. So, it is important to give a special attention to the design stage and mostly to the adopted decisions.
Among the stages of a product's life cycle, the design phase is considered a very important factor in achieving a certain quality level. The level of product quality is established by means of constructive technological solutions adopted by designer during the design stage. The subsequent stages of production and of use can either achieve the designed quality or damage it by technological errors, impairment of stuff, inappropriate control, obliquity of use or maintenance due to the fact that the specific instructions are not taken into account. Practically, at this stage, the product is endowed with value, by means

of designing, starting with the base quality characteristics whether they are explicit or implicit, identified and quantified.
During the design stage, the product exists only in the designer's imagination. After market research, the product starts to develop and becomes a project, a prototype, then the industrialization and the commercial launch take place. The customer's requirements should be attentively analyzed because the quality of a product depends mainly on a correct understanding of requirements and expectations that the market and the customers raise concerning the respective product.
Also, the quality of the product depends equally on more elements:

- the quality of need definition and the constraints evaluation;
- the effectiveness of design process;
- the effectiveness of design project management.

All these elements depend on a lot of parameters. So, the quality of needs definition depends on the customer's voice or on the reliability of the market research. This is, certainly, the most important parameter. The effectiveness of design process mostly depends on:

- defining the responsibilities for each participant;
- planning design activities;
- defining the product acceptance criteria;
- defining and introducing the verification and validation methods;
- monitoring the information's;
- monitoring the modifications.

The effectiveness of design project management depends on the following factors:

- the choice of used methods;
- the staff competence.

Taking into account all the information above, the evaluation and the assurance of the quality of product and also its design process represent a continuous concern for enterprises. For this, one should identify the evaluation criteria of quality and establish a series of indicators able to characterize it.

3. EVALUATION CRITERIA AND PERFORMANCE INDICATORS

Realizing and the follow-up of indicators constitute a paramount step in order to allow to the designers, in particular to the project leaders, to have a clear vision on the planning and the course of the design process. The indicators thus make it possible to these actors to intervene in the process to improve its performances [1].
The criteria are used as a basis to evaluate the design process.
The piloting indicators of the design process must be the control and decision tools. They must make it possible to measure a situation or a risk, to give an alarm or contrary to meaning the correct advance of the project. The choice of indicators will depend on the project objectives.
In this paper are used two categories of indicators:
- the results indicators - are indicators of various physical transformations, used for the traditional management (the costs indicators, the quality indicators, etc.); they are positioned on the laid down objective and make it possible to know if the target is reached or not;
- the process indicators - they make it possible to anticipation and to correct the course of the design process. They are necessary because the immaterial component of the design process makes more difficult the measurement of performance by a ratio between the results and the used resources. The indicators of process have the advantage of being

able to be followed and to be updated, progressively with the advance of the design process, which makes it possible to quickly react to changes.
In this paper we used as result indicator "the quality reconceived product / quality initial product indicator". As process indicators we used "the problem – solution indicator" and "the quality of partial solutions indicator".

Quality redesigned product / quality initial product indicator
This is an indicator developed based the comparing of some quality characteristics of redesigned product with the quality characteristics of initial product, figure 1.

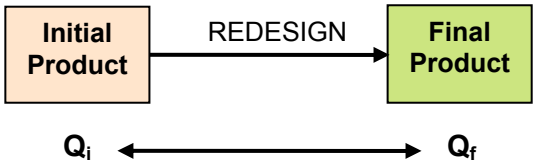

Fig. 1: Quality of initial product vs. quality of final product

This indicator is calculated as fallows:

$$I_{\frac{Q_f}{Q_i}} = \frac{\sum_{j=1}^{n} q_f}{\sum_{k=1}^{n} q_i} \quad (1)$$

where:
q_f: quality characteristics of final product;
q_i: quality characteristics of initial product;
j: variable from 1 to n (the number of quality characteristics of final product);
k: variable from 1 to n (the number of quality characteristics of initial product);

Problem - solution indicator
This indicator shows the extent to which proposed solutions answer to the design problems.

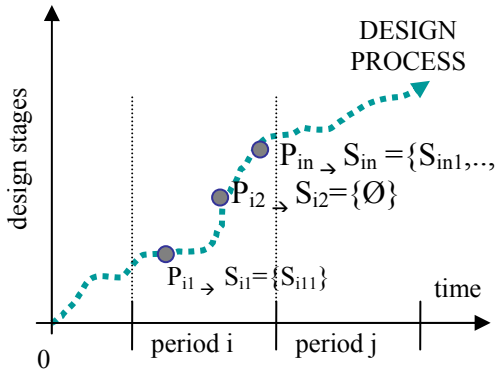

Fig. 2: Considered solutions on the period "i" to the design problems

The indicator "problem – solution" is defined as follows:

$$I_{PS_i} = \{I_i[Stage_1],...,I_i[Stage_4]\} \quad (2)$$

where:

$$I[Stage_j] = \sum_{k=1}^{n} \frac{N_{SP_k} \cdot P_{P_k}}{N_{\max}} \quad (3)$$

IPSi : value of the "problem – solution" indicator on the period "i";
I[Stagej]: value of the indicator in the stage "j" of the design process;
k :the number of problem solutions in "i" period;
NSP: note received by the solution, depending on the answer extent to the problem P;
PP: importance of the problem P;
Nmax: maximum note received by the solutions.

Quality of partial solutions indicator

This is a process indicator which shows the quality level of partial solutions developed in the considered period.

$$I_{qspi} = \frac{\sum_{j=1}^{n} N_{qspj}}{n \cdot N_{q\_\exp}} \quad (4)$$

i: the period "i" for analysis;
j: variable from 1 to n (the number of partial solutions in "i" period);
N_{qspi}: quality level of partial solution "j";
$N_{q\_exp:}$ level of expected quality;
n: number of solutions.

4. EXPERIMENTAL ENVIRONMENT

Design is a complex activity. To understand the design process, it is useful to use experimentations.

Our intention in this study is to observe the quality evolution in a design activity performed by a team of designers. Audio-based observational techniques were used in this experiment to provide useful and reach record of the design process that is then used by different researchers in different ways to study different issues.

The experiment described in this paper was undertaken in the laboratory of design of products, from the Faculty of Mechanical Engineering and Technology, from the University of Piteşti, by a team of 4 designers and a mediator.

The goal of the design experiment was to redesign a trailer pulled by a mountain bike.

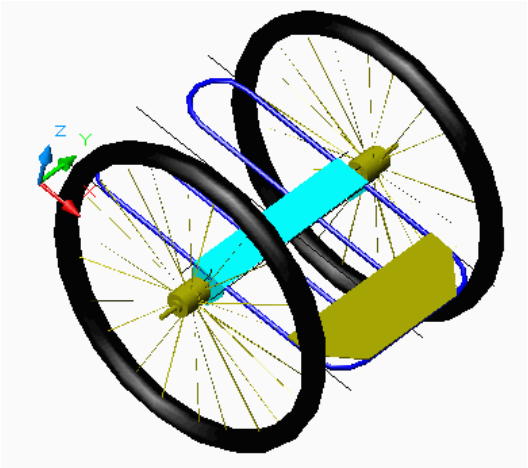

Fig. 3: The redesigned part of the trailer

The participants to this experiment have had the possibility to adapt an existed trailer, for a small bicycle, taking into account the certain economical and functional constraints:

- The cost must be minimum;
- To be adapted for any type of ground;
- To be easily collapsible;
- To be light;
- To protect the charge from the actions of external environment (rain, snow, sand, tree branches);
- To permit an easy maintenance.

In order to analyze this experiment we have used the prescriptive model proposed by Pahl and Beitz [2], [3], [4], [5]. To fulfill the analysis we have established periods of 30 minutes. At the beginning of each analyzed period one should know the problems to be treated and the level of their importance.

Thus, at the 30 minutes moment the following seven problems should be treated:

- The axle for the wheels mounting;
- Type of frame;
- Establish the frame material;
- Establish the bond system with the bicycle;
- Establish the “trailer box” shape;
- Establish the “trailer box” material;
- The distribution way of the weight on the axle.

The problems hierarchy is presented in table 1.

Table 1: Problems hierarchy

Problem	Weight [%]
P1	25%
P2	17%
P3	11%
P4	24%
P5	8%
P6	5%
P7	10%

Thus, will be studied the proposed and discussed solutions during the design experiment by the participants, in all the stages. Each solution will have a note in the whole interval [0, 3].

A note should be given for each solution specific to each problem, on the considered period, depending on the level to which this answers to the problem. In this way, there have been given the following notes:
0 - the solution doesn't answer to the requested problem;
1 – the solution answers 33% to the requested problem;
2 - the solution answers 67% to the requested problem;
3 – the solution answers 100% to the requested problem.

5. RESULTS AND DISCUSSIONS

The solutions of the treated problems will be presented in table 2. There will be presented the note for each solution and the maximum note corresponding to solutions for the same problem.

Table 2: Note received by the solution in period 2

Problem	Solution	N	N_{max}	Stage
P1	Pipe - cylindrical shape	3	3	2
	Pipe – rectangular shape	2		
P2	Bent pipe	3	3	2
	Welded pipe	1		
P3	Steel	2	2	3
	Aluminum	1		
P4	Bent bar	3	3	2
P5	Parallelepiped	2	2	2
P6	Plastic	2	2	3
	Textile	2		
P7	In two points, near wheels	3	3	2

The calculation of "problem – solution" indicator is made through the calculation of partial indicators, taking into account the maximum note obtained for the solutions of each problem. The analyzed period is the period number 2.Thus:

$I_2[Stage_1] = 0$; (5)

$$I_2[Stage_2] = \frac{3 \cdot 0,25}{3} + \frac{3 \cdot 0,17}{3} + \frac{3 \cdot 0,24}{3} + \frac{2 \cdot 0,08}{3} + \frac{3 \cdot 0,1}{3} = 0,81 \quad (6)$$

$$I_2[Stage_3] = \frac{2 \cdot 0,11 + 2 \cdot 0,05}{3} = 0,106 \quad (7)$$

$I_2[Stage_4] = 0;$ (8)

$$I_{PS_2} = \{0;\ 0,810;\ 0,106;\ 0\} \quad (9)$$

	$Stage_1$	**$Stage_2$**	**$Stage_3$**	**$Stage_4$**
I_{PS_1}	0,870	0,130	0,058	0
I_{PS_2}	0	0,810	0,106	0

I_{PS_3}	0	0,605	0,216	0,142
I_{PS_4}	0,212	0,370	0,061	0,040
…	...			
I_{PS_n}	0	0	0,086	0,914

Fig. 4: Figure 7 Centralizer with the value of the "problem – solution" indicator in the all periods

For the management of design process it is necessary that the indicator values of the analyzed periods to be centralized in the matrix form.
The matrix form offers the possibility to fulfill the further analysis. These analyses can offer information about de level to which the designers master the design problems. They can also offer information about the problems which need a high level of knowledge's or even competences from different fields.

Quality redesigned product / quality initial product indicator:

$$I_{\frac{Q_f}{Q_i}} = \frac{\sum_{j=1}^{n} q_f}{\sum_{k=1}^{n} q_i} = 1{,}68 \qquad (10)$$

This value shows that: the quality of final product is superior to quality of initial product.
In order to calculate the *quality of partial solutions indicator*, we have realized the table 3, with the partial solutions developed in period 2 and with the quality level for each partial solution.

Table 3. Centralizer with the quality level of partial solution in period 2

Problem	**Partial solution**	**Quality level of partial solution**
P1	Pipe - cylindrical shape	9
	Pipe – rectangular shape	8
P2	Bent pipe	10
	Welded pipe	7
P3	Steel	8
	Aluminum	8
P4	Bent bar	9
P5	Parallelepiped	10
P6	Plastic	8
	Textile	9
P7	In two points, near wheels	8

$$I_{qspi} = \frac{\sum_{j=1}^{n} N_{qspj}}{n \cdot N_{q\_\exp}} = \frac{9+8+10+7+8+8+9+10+8+9+8}{11*10} = 0{,}86$$

If:

$I_{qspi} \leq 0,75$ the quality level is poor;
$0,75 < I_{qspi} \leq 0,90$ the quality level is good;
$I_{qspi} > 0,90$ the quality level is very good.

In our case, the quality level is good, that mean the partial solutions are acceptable.

6. CONCLUSIONS

The leading of the design process is a delicate issue to the project managers in the present conditions.
The design activity, by its dynamic and complex features, rise up a set of problems to the person who manages it.
Because the design activity is based on problem solving, it is important to develop indicators which are to reveal the way in which the respective problems are solved, the resources needed to solve them and also the type of problems which raises difficulties.
The indicators proposed in this paper gives the project manager the possibility both to observe the evolution of the design process and to act in the way of solving certain problems in a certain time, using a minimum of resources.
We do not claim that the results of this work apply for industrial situations but it is a first step to a better understanding of quality in the design process.

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