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Critical Evaluation of Individualized Progressive Lens Functions through Value Analysis

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Abstract – This paper aims to analyse the functions of the individualized progressive lens, to improve them. The determination of the functions will be based on the value analysis, which aims to eliminate unnecessary costs, which do not influence the quality and utility of the product.

Keywords: Value analysis, individualized progressive lenses, vision, presbyopia.

I. INTRODUCTION

Along with the evolution of the optical industry, new products appeared on the market, which help glasses wearers to obtain good vision at all distances. One of these products is the progressive lens, considered a small wonder of the optical world. This lens meets the visual needs of presbyopes, helping them see clearly and comfortably at almost any distance [10].

The difference between multifocal, bifocal and progressive lenses is both aesthetic and technical. The bifocal lenses have visible lines, which separate the focus area. On the surface of the progressive lenses, no lines are present, and the visual progression is made without interruptions. Progressive lenses can be customized according to the customer's lifestyle, frame and facial anatomy [10].

Based on the value analysis carried out in this paper, the functions that require improvements will be identified, to obtain a product with higher performance compared to the existing products.

II. VALUE ANALYSIS CONCEPT

Value analysis as a problem-solving system is implemented using specific techniques, knowledge and a group of learned skills. This analysis method aims to efficiently identify unnecessary costs, which do not influence the quality, utility, appearance, characteristics and life of the product [6].

Through this problem-solving system, the essential elements of the problems and the capabilities of the human brain work together to solve difficult problems. The competition for goods and services led to the emergence of the problem of ensuring the lowest possible costs of the two elements mentioned above. Thus, as a response to that request, the problem-solving system was developed, which includes specific techniques and methods by which to obtain what customers want at lower costs [6].

The identification and analysis of functions are the basic elements of value analysis. The key to success in business lies in understanding the customers perception of value, but also in identifying and prioritizing the functions of the products offered to users [7]. Therefore, by analysing the value, it is checked how the necessary function can be fulfilled in the shortest possible time, as well as with the lowest cost. This aspect marks the difference between the usual cost reduction methods and value analysis [5].

2.1. Function Analysis Principle

The main feature of value engineering is function analysis. The product functions are defined based on its constructive characteristics. Thus, the first step in determining the constructive solutions of the product consists in drawing up the function's nomenclature.

Functions analysis studies the following aspects:

- What are the necessary functions to fulfil the conditions of the beneficiaries;
- How to get better options, with lower cost, not considering the existing solutions;
- How the established functions can be performed with minimal expenses and how the products can be sold advantageously.

The starting hypothesis consists in the fact that for each function is necessary a minimum of costs and there are several possibilities to perform a function [1].

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The principle of double dimensioning of functions says that the functions of a product have two dimensions: the technical dimension expressed by a unit of measure; the economic dimension expressed by cost. Thus, the function cost is not related to a physical body, but to a certain characteristic of the product, which is measurable. The sum of the functions costs represents the total cost of the product. The principle of maximizing the ratio between use value and cost is stated as follows: maximum competitiveness is achieved when the product has the highest use value and the lowest exchange value, so it must be manufactured with low costs.

The functions costs, in most cases, are not proportional to their contribution to the general use value of the product. Thus, appears the need to establish an optimal ration between the product's functions and the necessary costs for their realization, to maximize it [1].

According to the principle of the systemic approach to the use value, the object of study is represented, first, by the product. Value analysis is only applied to utility values that meet social needs. Thus, parts of the product cannot constitute the object of study of this analysis, because the part exists as a utility only within the product, as its component element, individualized does not respond to a social need. However, there may be cases when, due to the complexity of the product, the value analysis should only be applied in stages. To comply with the principle, in the case of complex products, the analysis must start from identification of the functions of the system as a whole and then the parts and subassemblies must be grouped and studied as such. In this way, the functions of the product are realized [1].

III. FUNCTION ANALYSIS OF THE PROGRESSIVE LENS

To present the way of the analysis, the case study will be done on an individualized progressive lens. The customized varifocal lens is recommended for presbyopes, more precisely for people with distance, intermediate and near vision problems. Individualized progressive lenses bring the following benefits to wearers [2]:

- Peripherally positioned areas with reduced aberrations;
- Increasing the intermediate zone by up to 6 mm more than conventional progressive lenses;
- Comfortable view at all distances;
- Very wide visual fields;
- High clarity and detailed details;
- Very fast adaptation;
- Minimal subsequent adjustment.

In Fig. 1, the individualized progressive lens is represented, before mounting in the frame. To be used by the customer, the lens will be mounted in the frame, resulting the complete glasses, according to the image in Fig. 2.

Fig. 1. Individualized progressive lens [8]

Fig. 2. Progressive glasses [8]

In the following subchapter, the product will be presented from a technical and technological point of view.

3.1. Technical and Technological Characteristics of the Product

The technical specifications of the individualized progressive lenses are presented in the Table 1.

Table 1. Technical specifications of the varifocal lens

Technical specification	Description	Unit of measure
Lens type	Individualized progressive lens	-
Use	Correction of presbyopia	-
Length of progression	14-18	mm
Diameter	55/60 – 75/80	mm
Refraction index	1.5 – 1.78	n_e
Colour	White, coloured and photochromic	-
Treatments	Antireflection, hardening and hydrophobic	-

Fig 3. Component elements of the individualized varifocal lens [9]

In Fig 3, the components of the individualized progressive lens are represented by markings ((1) Reference area for distance vision, (2) Alignment reference marking, (3) Reference area for near vision, (4) Prism reference point, (5) Fitting point)

To obtain progressive lenses, it is necessary to go through the following stages of the technological process:

- Lens calculation based on the customer's dioptres;
- Protecting the convex part of the lens by automatically applying a protective film;
- Application of the manipulation pill by alloy fusion on the concave surface of the lens;
- Milling is done to obtain the desired concave radius;
- The polishing is done by the action of several rotating instruments with different surfaces, giving the necessary clarity to the lens;
- The micro-engravings are made with the help of the laser, thus applying the markings for assembly;
- Removal of the handling pill in two ways: by mechanical shock, for organic glass lenses or by melting, for mineral glass lenses;
- The intermediate quality control is carried out at the level of the diopters of the lenses;
- Washing the lenses in several waters, using automatic brushes;
- Automated intermediate control;
- Applying the hardening treatment is done by washing the lenses in hard washes, which does not conduct electricity;
- Then, the lenses are placed in the oven at a temperature of 80 degrees, for 40 minutes, to remove the water molecules remaining on the lens;
- Once taken out of the oven, the lenses are introduced into the hardening installation, where the following three processes are carried out: washing, baking and deposition of hardening treatment;
- The application of the anti-reflective treatment is carried out by going through the following stages: baking for 30 minutes; preparation and introduction of the sarge in the anti-reflection installation;
- Filling the micro-engraved markings with yellow ink.

The last phase of the technological process consists in carrying out the final quality control, packaging and labelling of the product. [3] [4]

3.2. Function Nomenclature. The Importance Level of the Functions

Based on the information obtained from the lens manufacturing company, in the Table 2 are presented the product functions and their level of importance.

Table 2. Individualized progressive lens functions nomenclature

Function symbol	Function description	Importance level	Importance level weight
F1	Ensures vision at all distances	9	0.164
F2	Provides protection against blue light	6	0.109
F3	Scratch resistance	5	0.090
F4	Resistance to temperature changes	4	0.073
F5	Rejects traces of dirt and grease	3	0.056
F6	Repels water	2	0.036
F7	Repels dust	1	0.018
F8	Allows mounting in all frame models	8	0.145
F9	Ensure the correctness of the assembly	10	0.182
F10	Determines the thickness and resistance of the lens	7	0.127
Total		**55**	**1.00**

Table 3. The elements that make up the total cost of a progressive lens

Cost elements	Quantity	Total cost/component (Lei)
Semi-finished HEP materials	1	100
Optimization according to the shape of the frame	1	25
Treatments	1	16.4
Special processing	1	25
Colouring	1	50
Other direct or indirect costs	1	50
Total	**266.4**	

The functions of the progressive lens were determined based on the varifocal lens components presented in subchapter 3. 1. Table 3 shows the elements that make up the manufacturing cost of the individualized progressive lens.

Analysing the product from a technical, technological and economic point of view, the ideal and real costs of the functions were calculated and presented in the Table 4.

Table 4. The ideal and real costs of the functions

Function symbol	Ideal function costs (Lei)	Ideal function costs weight	Real function costs (Lei)	Real function costs weight
F1	43.69	0.164	50	0.188
F2	29.04	0.109	25.78	0.097
F3	23.98	0.090	26.288	0.099
F4	19.45	0.073	15.468	0.058
F5	14.92	0.056	15.288	0.057
F6	9.59	0.036	12.788	0.048
F7	4.80	0.018	7.788	0.029
F8	38.63	0.145	38	0.143
F9	48.48	0.182	42.5	0.160
F10	33.82	0.127	32.5	0.122
Total	**266.40**	**1.00**	**266.40**	**1.00**

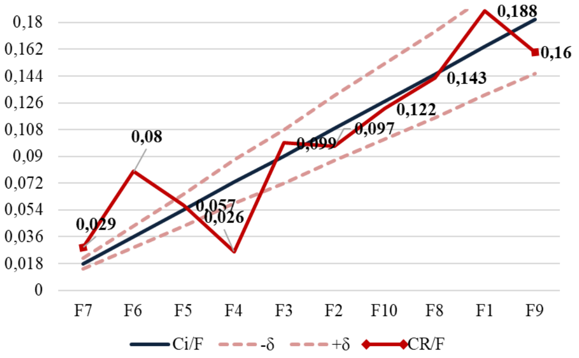

Fig 4. Correlation of importance and cost weights of individualized varifocal lens functions

Based on the information presented in table 4, the graph of the correlation of the weights is represented in the following figure.

Analysing the graph presented in Fig 4, the following oversized and undersized functions were identified:

- F5 and F8 functions present ideal cost structures;
- F1, F2, F3, F9 and F10 functions present optimal cost structures;
- F6 and F7 functions present large cost structure;
- Function F4 presents low-cost structures.

Using the information presented previously, in the following chapter, a critical analysis of the analysed product functions will be carried out.

IV. CRITICAL ANALYSIS OF INDIVIDUALIZED PROGRESSIVE LENS FUNCTIONS

To carry out the critical analysis, all the necessary information for this stage is centralized in Table 5.

Analysing the graph represented in figure 2 and the information contained in table 5, it can be observed that functions F6 and F7 are functions whose costs exceed the right of accepted deviations. They are made with high-cost structures, in relation to their weight in the value of use [2].

Table 5. Information centralizer for critical analysis

F	I	C_{IF} weight	C_{RF} weight	Δ weight	Cost structure
F7	1	0.018	0.029	-0.011	Large
F6	2	0.036	0.048	-0.012	Large
F5	3	0.056	0.057	-0.001	Ideal
F4	4	0.073	0.058	0.015	Low
F3	5	0.090	0.099	-0.009	Optimal
F2	6	0.109	0.097	0.012	Optimal
F10	7	0.127	0.122	0.005	Optimal
F8	8	0.145	0.143	0.002	Ideal
F1	9	0.164	0.188	-0.024	Optimal
F9	10	0.182	0.160	0.022	Optimal

The F4 function has a low-cost structure. In this case, it is recommended to radically improve it, since it was below the required performance level.

Functions F5 and F8 present an ideal cost structure, which means that the usage value and the production cost are in a perfect state of proportionality.

The other functions, F1, F2, F3, F9 and F10, present optimal cost structures, which means that the costs are within the limits of accepted deviations. These are considered optimal because they bring useful value to the product; they are demanded by consumers and do not present significant disproportionalities between ideal and real costs.

V. CONCLUSIONS AND FINAL REMARKS

According to the information presented in the 3rd chapter, the functional analysis was carried out on a complex product, the individualised progressive lens. It offers the wearer of presbyopic glasses an increased comfort for seeing at all distances.

After performing the critical analysis, it could be observed that it is necessary to reduce the manufacturing costs of F6 and F7 functions. Therefore, it is necessary to establish an optimal ratio between the product functions and the necessary costs for their realization. Considering the components that participate in the materialization of these functions, it is necessary to reduce the costs related to the application of the hydrophobic and antistatic treatment. Due to the disproportionality present between the real and ideal costs of the F6 and F7 functions, the second directions of improvement consist in the implementation of new technical and/or technological solutions for depositing the two treatments with a lower consumption of resources.

Functions F1, F2, F3, F9 and F10 present optimal cost structures, but not ideal ones. To eliminate the existing small disproportionalities, it is necessary to improve these functions. Thus, an increase in product quality will be obtained, but there may also be possible increases in production costs. The proposed improvement solutions are the following:

- Function F1: replacing the existing semi-finished product with one of a higher quality;
- Function F2: improving the depositing technology of anti-reflective treatment to offer greater protection against blue light;
- Function F3: improving the hardening technology, to increase the scratch resistance of the lens;
- Function F9: replacing the existing marking application technology with a more efficient one;
- Function F10: the development of a lens with a new refractive index, so that at high diopters, the lens to be even thinner.

Considering the previously mentioned information, the possibility of modernization or redesign must be considered, by replacing components and technological processes to create the individualized progressive lens. Thus, can be taken into consideration the development of a more performant individualized varifocal lens, with a longer progression length so that it can also be worn by people who have problems with accommodation.

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