# APPLICATIONS OF VALUE ANALYSIS WITHIN BEARING INDUSTRY

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**Abstract.** The method of value analysis aims at achieving the functions of the product requested by the user so that there should be proportionality between the usefulness of every function and the consumption of means necessary for its achievement. The article herein synthetically submits a case study upon applying the method of value analysis to products from bearing industry, as well as the results obtained following the analysis.

**Keywords:** value analysis, conic roller bearing, bearing manufacturing

## 1. Introduction

Value analysis stands for an organized method, displaying economic character, whose target is letting subsist within a product no more than is necessary, to the purpose of allowing the product to fulfil through its functions the desired level of the user's necessity. Milles [1] defined the method of value analysis as a procedure designed for identifying the useless costs.

Whatsoever the life stage the product finds itself within (maturity or conception – design), the method equally analyses the economic aspects and the technical aspects of the product undergoing the study. From the economic standpoint, the method aims at identifying the relation between the function costs and their achievement level, under the aspect of their compliance with the specifications imposed by the design. From the technical standpoint, within the analysis, there is targeted that within the product there only exist the functions required by the client – user; and the material carriers of these functions should be able to ensure their realization to the required level, through the intermediary of the measurable technical parameters.

The value of a product or of a service is perceived from different outlooks by the user-client and by the manufacturer. In general terms, the user perceives the value of a product as an amount of money (the exchange value) that he is willing to pay off in order to enter into the possession of the product in demand and in order to make good use of its characteristics. The producer will pursue the economic value of the product expressed through the overall necessary expenses for obtaining the finite product.

The method of value analysis, through its specific approach [2] aims at achieving the functions of the product required by the user so that there should be proportionality between the usefulness (expressed through achieved performances) of each function and the consumption of necessary means for achieving it. Consequently, within value analysis, the expression form of the product value is the one in which the usefulness is corroborated with the cost, in order to obtain that particular utility (the utilization value). Moreover, the activities developed within the analysis mainly aim at maximizing the ratio between usefulness – cost, for every function. Taking into consideration that the amount of the functions pertains to and effects on the studied product, there ensues that the value analysis approach sets out to obtain the maximal value of the product.

Into this general context there likewise fits the subject dealt with by the paper herein. The case study achieved by the author during the year 2008, upon products in the bearing industry mainly aimed at determining the product value and at identifying the main directions of action for enhancing these values.

## 2. Case study upon the application of the value analysis method within the bearing industry

Orienting the value analysis study towards products within the bearing industry was based on information resulted because of:

- Investigating the demand for rolling contact bearings on the worldwide market and throughout

Romania. The results of the studies show that the demand for this category of industrial products marks up an increasing rise. In Table 1 there is presented the assessment of the evolution, to medium term, of the bearing sector in Romania, both from the standpoint of the quantity of manufactured and sold products, and from the standpoint of the investment necessary within this industry [3].

- Analysing the production of the company wherein there was carried out the research, from the standpoint of the structure, of the quality and of the earning capacity.

The activity profile of the company wherein there was carried through the study consists in producing and marketing several types of industrial products: pump carcasses, gearbox yokes – destined for auto industry; linear guides for machine tools; cages and rings for different types of bearings (bearings of precision used in the air-space industrial and auto sector) and bearings of great dimensions.

Justifying the orientation of the value analysis study upon the group of great dimension bearings mainly resides in the fact that in order to manufacture these products there are being consumed large quantities of rough materials, that the duration of the manufacturing cycle takes too long a time (measured in weeks), and therefore the manufacturing cost for such a product is considerably higher than in the case of a standard dimensioned bearing. Under these circumstances, there has been called for identifying the paths either leading to reducing the manufacturing cost or leading to coming up with solutions (technical, technological) for raising the product utilization value.

In order to attain the targets – determining the product value and identifying the main directions of action for enhancing this value – there was aimed at:

- ✓ determining the product utilization value;
- ✓ determining the production cost for the product functions;
- ✓ systemic analysis of the product functions;

The case study submitted herein is based on the methodology for applying the value utilization according to STAS 11272 /1/2-79. The stages: I – „*Preparing measures*", V – „*Approving the optimal solution*", VI „*Application achievement and control*", with the afferent phases are not be retrieved in detail as there was deemed that their in-depth study is only necessary when carried through by team purposely designated by the organization wherein the product undergoing analysis is being manufactured.

### 2.1. Stages and phases undergone in the framework of the value analysis study

*Stage II „Analysis upon social necessity", Phase 1 „Collection"*. The activity of information-documentation in the framework of this stage aims at culling the general data, technical and economic, upon the product undergoing analysis. The purpose of this stage consists in identifying the analysed object under the aspect of the social necessity, of the modality employed for carrying it through (the technology resorted to) and in enhancing the cost elements afferent to the product manufacturing. Following the analysis of the available information and considering the indications as to the data culling method, the following aspects were identified:

- the product having undergone study pertains to the group of conic roller radial – axial bearings, which are great dimension bearings (diameters of bore ranging between 320 mm and 1600 mm), responding thereby the diverse demands manifested worldwide. The types of bearings manufactured within the company fit within the specified dimensions: cylindrical roller bearing, conic roller bearing and oscillating barrel type roller bearing;
- the principal field of utilization of the bearings under study: turbines for wind installations;
- the demand for bearings of this type, on the company level, which has kept on even, both from the standpoint of the frequency and from the standpoint of the number of pieces manufactured [3].
- from the manufacturing standpoint, the bearings of this type (figure 1) have a single internal ring with two ball races and two external rings. The two roll strings face each other. The bearing allows the separate set-up of the external ring and of the assembly made up by internal ring – roller cage. For the adjustment of the bushing, the bearing is provided with an internal (intermediate) distance ring. Although the conic roller bearings are being executed within a variegated range of dimension series, the greatest part being standard dimensioned, the product under study belongs to the category characterized by non-standard set-up dimensions;
- several data have been culled with respect

to the cost structure of the product, taking into considerations the stage that the product goes through: conception, design or serial execution.

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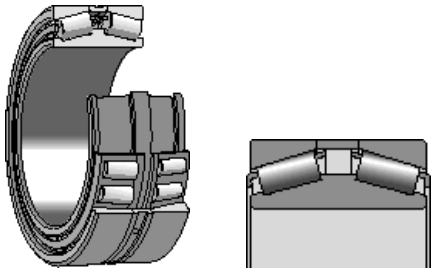

Figure 1. Conic roller radial – axial bearing

*Stage II „Analysis of social necessity", Phase 2 „Determining the function list and the limits for their technical dimensions"*. For the best possible accuracy in determining the product functions, they were split up in their component parts and there were defined, for each component part, the functions they perform within the assembly. Considering the considerations submitted in paper [3], as regards the manner of defining the functions for the rolling contact bearing in general, for the particular case of this product, due to the constructive particularities brought along by the requirements it has to comply with, beside the general and specific functions defined for the rolling contact bearing (in general), there add up the following particular functions:

a) *It allows the (periodical) adjustment of the bearing*. The material carriers for this function are the intermediate ring and the external rings. The adjustment of the play within the bearing is done through setting up the external rings depending on the position of the internal ring.

b) *It allows lubrication*. The holes practised within the intermediate ring enable both the initial lubrication, and the maintaining lubrication.

c) *It is maintainable*. This function pertains to the category of the particular functions according to the classification carried through [3]. The existence of this function is brought along by the fact the for high dimension rolling contact bearings (the diameter of bore greater than 300 mm), the cost of remedying the flawed component parts is lower than the acquisition price of a new rolling contact bearing.

Following the analysis of the demands for the product and of the requirements it has to comply with, there was put forth the list of functions submitted in Table 1.

The technical dimensions of the functions have to be expressed through easily measurable technical parameters. They are determined (such as the variation limits they should range within) during the design phase of the product. Due to the fact that the product under study is serially executed, the values for assessing the technical parameters have already come into being.

*Stage II „Analysis upon social necessity"; Phase 3 „Determining the importance level of the functions"*. Determining the importance level of the functions compels to arranging, placing into hierarchies, determining the relative positions and the importance of each function depending on the product utilization value.

To determine the relative importance of the functions, there was carried out an opinion poll among the specialists, upon a sampling of 25 persons. The enquired persons were mechanical engineers, university teaching staff in the engineering field. The working tool employed to this purpose was the survey. Following the analysis of the answers there could be noted the following:

✓ Several persons were not enough acquainted with the existence of the function „E" – enabling set-up;

✓ There was advanced a new function (specific function): „It conveys precision" (comparatively to the glide friction bearings). As a follow-up of this proposal, the function E „enabling set-up" turned into „Conveying precision during set-up". The technical dimensions of the function were expressed through the quality of the surface of the rolling trace of the external ring, as well through the quality of the internal ring, whereon the shaft is set up (parameter Ra);

The functional analysis (considering the recommendations in the specialized literature [2, 4, 5]), enhanced the following:

- the (relative) utilization value of the product, expressed through the sum of the marks granted by the specialists to the product functions, is 36.
- the majority of the enquired persons considered that the function B: „Takes over radial-axial functions", displays the highest importance, with a utilization value percentage amounting to 17.536%. It is followed by the functions: A, C, E, F, H, I, D
- the auxiliary functions display the same level of importance as the principal functions to whose achievement they bring their contribution. This way, the level of importance displayed by the

function J is 3.76 (= level of importance of the function H); the level of importance displayed by the function K is 4.64 (= level of importance of the function E) and the level of importance displayed by the function G is 5.24 (= level of importance of the function C).

*Stage III „Analysing and assessing the existing situation", Phase 1 „Technical dimensioning of the functions"*. This phase imposes determining the characteristics of the material product, which procedure is of interest for the final client, and likewise in determining their characteristics. These characteristics are criteria for assessing the utilization values of the functions. Table 1 presents the function list of the product, as well as their technical dimensions, according to the explicit requirements expressed by the end user, as well as in guise of outcome of the technical solution that the function is carried through.

Table 1 List of functions and technical dimensions of the functions for the conic roller radial – axial bearing

| SYMBOL OF THE FUNCTION | NAME OF THE FUNCTION | CLASSIFICATION | TECHNICAL DIMENSION |
|---|---|---|---|
| | | | NAME OF THE PARAMETER |
| A | It supports the shaft | F.O. (principal) | Diameter of bore, d |
| B | It takes over radial-axial forces (it participates in the force discharging chain) | F.O. (principal) | Dynamic basic charge, C<br>Static basic charge, $C_o$ |
| C | It provides the diminution of the friction coefficient | F.O. (principal) | Roll big diameter, D<br>Roll small diameter, d<br>Height<br>Generator inclination<br>Roll number on a string |
| D | It enables determined working turns | F.O. (principal) | Limit rotative speed |
| E | It provides precision during the set-up | F.O. (principal) | Diameter of bore, d<br>Width of rolling contact bearing, T<br>External diameter, D |
| F | It allows the (periodical) adjustment of the play within the bearing | F.O. (principal) | Width of ring |
| $G_C$ | It allows lubrication | F.O. (auxiliary) | Quantity of lubricant |
| H | It displays durability | F.O. (principal) | Running duration ensured by the rolling contact bearing |
| I | It is reliable | F.O. (principal) | Operation probability according to determined specifications, R(t) <= 1 sau<br>Medium lifecycle |
| $J_{H, I}$ | It is maintainable | F.O. (auxiliary) | Average maintenance time /repair $T_{rep}$ |
| $K_E$ | It is inter-changeable | F.O. (auxiliary) | Diameter of bore, d<br>Width of rolling contact bearing ,T |

*Stage III „Analysing and assessing the existing situation", Phase 2 „Function economic dimensioning"*. The economic dimensioning of the functions is based on the information upon the product cost structure. The cost structure is being determined according to the stage wherein the product is: conception, design, project, prototype or serial execution. Due to the fact the product under execution is serially executed, the economic dimensioning is based on accountancy information upon the manufacturing costs (costs with the materials, with the manoeuvre, and with the overhead expenses) of the rolling contact bearing components [3]. In table 2 there is forwarded the final situation of the activity distributing the costs incurred with the materials, the manoeuvre, the overhead expenses upon the product functions and the determination of the function weight in the

overall product cost, considering the recommended methodology [4, 5, 6]. The weight of the auxiliary functions within the product utilization value is determined on the level of the conditioned objective functions.

Table 2 Cost centralization (materials + manoeuvre + overhead expenses) distributed on product functions

| Nr. Crt. | Reference Name | Total (lei) | Product functions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F | H | I |
| 1 | Internal ring | 1637 | 210,582 | 182,521 | 150,773 | 155,537 | 238,644 | - | 597,286 | 101,657 |
| 2 | External ring (2 units) | 1502 | - | 182,553 | 66,389 | 113,116 | 289,522 | - | 748,745 | 101,675 |
| 3 | Distance external ring | 541 | - | - | - | - | 104,319 | 275,646 | - | 161,035 |
| 4 | Rolls (78 units) | 887,64 | - | 118,063 | 200,512 | 89,516 | 144,404 | - | 269,372 | 65,757 |
| 5 | Cage | 391 | - | - | 119,393 | - | 105,722 | - | 85,671 | 80,203 |
| 6 | Assembling | 63 | - | - | - | - | 12,6 | 6,3 | 25,2 | 18,9 |
| | Total | 5021,64 | 210,582 | 483,137 | 537,067 | 358,169 | 895,211 | 281,946 | 1726,274 | 529,227 |
| | Weight in overall cost (%) | 100 | 4,19 | 9,62 | 10,69 | 7,13 | 17,82 | 5,61 | 34,37 | 10,53 |

*Stage III „Analysing and assessing the existing situation", Phase 3 „Systemic analysis of the functions".* Analysing the correlations between the cost and the level of importance may be achieved through comparing their weights within the utilization value and within the overall cost of the product. The analysis enhances the most expensive functions and the functions that cost too much compared to their contribution in achieving the utilization value of the product. The tool resorted to is the method of linear regression [4, 7, 8]. This way, determining the likely disproportional ratios between the function costs and their weight in the product utilization value is carried our through determining the regression line, which represents the medium proportionality. In Table 3 there are centralized the data necessary for the systemic analysis.

Table 3 Data necessary for the systemic analysis

| Function | $x_i$ (%) | $y_i$ (%) | $Y_i=a*x_i$ |
|---|---|---|---|
| A | 15.21 | 4.19 | 13.90 |
| B | 17.54 | 9.62 | 16.04 |
| C | 14.54 | 10.69 | 13.30 |
| D | 8.88 | 7.13 | 8.12 |
| E | 12.87 | 17.82 | 11.77 |
| F | 10.77 | 5.61 | 9.84 |
| H | 10.43 | 34.37 | 9.54 |
| I | 9.77 | 10.53 | 8.93 |

$x_i$: weight of functions in the product utilization value (i .=1..,8)

$y_i$: weight of functions in the manufacturing cost;

a: coefficient of deviation from proportionality (relation 1)

$Y_i=a*x_i$: series of adjusted data of $y_i$

$$a = \frac{\sum x_i y_i}{\sum x_i^2} = 0.91449 \quad (1)$$

The graph in figure 2 plots the correlation between the utilization value and the costs.

The analysis of the graph in figure 2 conveys the following:

- so that a medium proportionality should be possible, the line has to deviate to the least from the real points (the coordinates of the product function);
- the functions H and E present disproportions between their contribution to achieving the product utilization value and its weight within the cost;
- the functions A, B and F are situated below the regression line, which proves that their weight in the utilization value is greater comparatively to the their weight in the production cost;
- the functions C, D, G are situated close to the regression lines, which expresses a satisfying ratio utilization / production cost and subsequent researches will not focus upon them

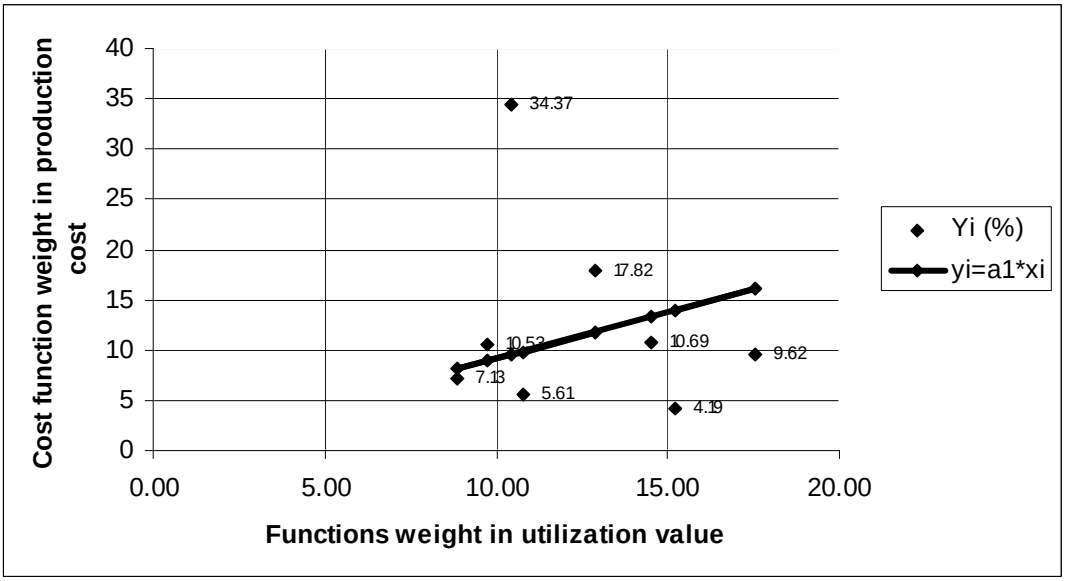


Figure 2. Correlation between the utilization value and cost function

*Stage III „Analysing and assessing the existing situation", Phase 4 „Determining the directions of research"*. In order to improve the relation between the utilization value and the product cost there is called for identifying and applying technical or managerial solutions that should allow:

- the best possible cost reduction, especially for the functions H and E. The reduction of the costs should not however be done to the detriment of the product utilization value;
- raising the product utilization value on the grounds of the functions H and E;
- eliminating useless costs.

## 4. Conclusions

The article herein presents part of a case study upon the application of the value analysis methodology for products within bearing industry. As a follow-up of the results obtained, we dare say the method of value analysis may prove a particularly useful tool in the design activity and the approach for reducing the product costs to find the solutions that should materialize the requirements on an adequate level both from the technical and from the economic standpoint.

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