THE ECONOMIC DIMENSIONING OF PRODUCT FUNCTIONS WITHIN VALUE ANALYSIS STUDIES

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Abstract: The paper herein presents the problem of economic dimensioning of product functions in the general context of the methodology for achieving value analysis studies. Synthetically, it is referring to the possibilities (methods) for determining the costs on product functions, as shown in the literature. The paper presents, also, a part of a case study where was applied one of those methods, in order to determine tapered roller bearing cost functions.

1. INTRODUCTION

Achieving the studies of value analysis entails a series of systematic actions oriented towards determining the product usage value (as sum of functions with partial usage values) and of the cost afferent to obtaining the respective value.
The part within the cost of the product under study, afferent to the function, constitutes its economic dimension. The action through whose intermediary the function costs are determined stands for economic dimensioning.
The issue of the function economic dimensioning within the value analysis studies has been receiving various solutions. The literature [2, 3, 6] submits the following methods for determining the costs on functions:
-comparison with other known costs, used to the purpose of achieving the same functions by other products;
-comparison with other known costs, of similar functions;
-comparison with the estimative costs for achieving the functions through the simplest technical solutions;
-comparison with the competitors' selling cost for products achieving the same functions etc.
These methods display the disadvantage of a low degree of rigorousness; however they allow accomplishing the economic dimensioning activity in a short while.
The methodology for applying value analysis elaborated by the French Association for Value Analysis (AFAV), recommends that, in calculating the function cost, not to include the expenses that are not influenced by the value analysis action. This way, the estimated cost will include fixed expenses: depreciation, the cost for arranging a directly productive working place; and variable expenses: rough materials, materials, acquired sub-assemblies, direct manual work. The estimated cost, in this case, will express the sum of these expenses, denominated functional cost, which will be distributed, in this constituency, on the product functions.
In this context, determining the cost on functions supposes identifying the guide marks participating in achieving the function and estimating in percentage and in absolute value every one's contribution [3].
In the case of the guide marks contributing to materializing several product functions, one of the methods for distributing the costs on functions, verified in practice, [3] supposes the following stages:
- emphasizing the costs with the materials (rough materials, components) and their distribution on the functions in whose achievement they participate, in direct proportion with the level of importance of the functions;

- emphasizing the costs with direct manual work and the indirect costs (overhead and manufacturing expenses) and their distribution on the functions, on the basis of a technical analysis for every real processing operation (study of VA in the case of the redesigned products) or design (study of VA in the case of new products). The purpose of this analysis is to distribute the costs only upon those functions to whose materialization there contributed the operations from the technological sheet of the guide mark.

2. THEORETICAL SUBSTANTIATION OF THE ISSUE OF FUNCTION ECONOMIC DIMENSIONING

The specialized literature [1, 2, 3] specifies that a guide mark or an operation may contribute to achieving one or several functions. If the guide mark/operation participates in achieving a single function, then the cost (C_i) of the guide mark/operation will be transferred on the function. If the guide mark/operation participates in achieving several functions, the economic dimensioning algorithm should determine how much of its costs are incumbent on a function and how much on another.

This approach requires a logical reasoning, the analysis of the build-up and functioning principles of the product under study, of the characteristics of the guide mark materials and the analysis of the manufacturing (processing) of the product.

If we denominate [1]:

- a_{ij} – indicator that reflects the connection between guide mark (operation) – function and that is determined through logical reasoning. If a_{ij} = 1, the guide mark R_i determines the function F_j. If a_{ij} = 0, the guide mark R_i does not determine the function F_j.
- k_{ij} – the quota of guide mark participation in the function cost. It is determined as fraction from the whole, which represents the contribution of the guide mark to the function cost, so that

$$\sum_i k_{ij} = 1 \tag{1}$$

Then there may be calculated

- cost of the function to whose achievement the guide mark participates:

$$C_{ij} = a_{ij} * k_{ij} * C_i \tag{2}$$

where: C_i – production cost (material, energetic, human resources) of the guide mark.

- C_{Fj} - total cost of the function, as sum of the function costs to whose achievement, the guide mark participates

$$C_{Fj} = \sum_i C_{ij} \tag{3}$$

- p_j – function weight in the total cost of the product (economic dimensioning of the function)

$$p_j = \frac{C_{Fj}}{\sum C_i} \tag{4}$$

3. ECONOMIC DIMENSIONING OF THE TAPERED ROLLER BEARING

In the study case realized for determining the usage value of the industrial product: *radial – axial bearing with tapered rolls* [4], the economic dimensioning of the functions was achieved resorting to the method of distributing the costs with the materials in direct proportion with the level of importance of the function; and of the costs with the manual

work and overhead & manufacturing, on the basis of the technical analysis of each and every operation.

The economic information necessary for the economic dimensioning, in the study case, aimed at:

- cost structure of the product – which is determined as function of its stage: design, project, prototype or series execution;
- specific consumption of materials and their costs;
- costs of manual work and overhead & manufacturing expenses, on components / operation;
- costs referring to typeset, standardized or acquired components, replacement materials, technological procedures etc.;
- costs for SDV-s, package, waste etc.

Due to the fact that the studied product is executed in series, the economic dimensioning was based on information from the accountancy as regards the manufacturing costs (costs with the materials, with the manual work and overhead & manufacturing expenses) (table 1) of the bearing components [4].

Cost structure of the product

Table 1

No.	Denomination component	Expenses with materials (RON)	Manufacture and machine expenses (RON)	Overhead & manufacturing expenses (RON)	Total overhead & manufacturing expenses (RON)	Total manufacturing cost (RON)
1.	Inner ring	777,45	709,872	149,678	859,55	1637
2.	External ring (2 pieces)	619,3	745,365	137,335	882,7	1502
3.	Spacing ring exterior	127,8	363,734	49,466	413,2	541
4.	Roller (78 units)	498,42	308,059	81,161	389,22	887,64
5.	Cage	-	-	35,750	35,750	391
6.	Assembling	-	57,24	5,76	63	63
7.	Total					5021,64

Previously, in the first part of the study [4, 5], the following functions of the product under study were defined (table 2):

Functions of the radial-axial bearing with tapered rolls

Table 2

SYMBOL OF THE FUNCTION	NAME OF THE FUNCTION	CLASSIFICATION
A	It supports the shaft	F.O. (principal)
B	It takes over radial-axial forces (it participates in the force discharging chain)	F.O. (principal)
C	It provides the diminution of the friction coefficient	F.O. (principal)
D	It enables determined working turns	F.O. (principal)
E	It provides precision during the set-up	F.O. (principal)
F	It allows the (periodical) adjustment of the play within the bearing	F.O. (principal)

SYMBOL OF THE FUNCTION	NAME OF THE FUNCTION	CLASSIFICATION
G_C	It allows lubrication	F.O. (auxiliary)
H	It displays durability	F.O. (principal)
I	It is reliable	F.O. (principal)
$J_{H, I}$	It is maintainable	F.O. (auxiliary)
K_E	It is inter-changeable	F.O. (auxiliary)

3.1 Repartition of the material expenses on the product functions

As a consequence of having determined the relation guide marks – functions [4] and following the economic dimensioning algorithm presented above, the distribution of the costs with the materials was achieved on the functions of the product under study.

We exemplify the modality of distributing the expenses with the materials, on the functions, for the guide mark „Internal ring".

The internal ring of the bearing participates in achieving the following functions (there were solely considered the main functions): A, B, D, E, H, I.

The sum of the levels of importance for the functions in whose materialization the guide mark participates is: $\sum_{i=1}^{8} n_i = 26,92$

The cost of the materials for this guide mark is C_{m1} = 777,45 lei.

The expenses for materials / level of importance are: $\frac{C_{m1}}{\sum_i n_i} = 28,88\, lei / level$

The distribution of the expenses for materials on every function was achieved in direct proportion with the level of importance of the functions [4].

A = 5,48 * 28,88 = 158,262 lei
B = 6,32 * 28,88 = 182,521 lei
D = 3,2 * 28,88 = 92,416 lei
E = 4,64 * 28,88 = 134,003 lei
H= 3,76 * 28,88 = 108,588 lei
I = 3,52 * 28,88 = 101,657 lei

The distribution of the expenses with the materials on the functions was achieved the same way for all components of the product. In table 3, the situation on the level of the product is shown.

Centralization of the costs with the materials on the main functions of the product

Table 3

No.	Denomination guide mark	Total (lei)	Functions of product							
			A	B	C	D	E	F	H	I
1	Inner ring	777,45	158,262	182,521	-	92,416	134,003	-	108,588	101,657
2	External ring (2 pieces)	619,3	-	182,553	-	92,432	134,026	-	108,607	101,675
3	Distance external ring	127,8	-	-	-	-	-	67,0076	-	60,790
4	Rolls (78 pieces)	498,42	-	118,063	97,888	59,779	86,679	-	70,24	65,757
5	Cage	391	-	-	119,393	-	105,722	-	85,671	80,203
	Total costs of materials	2413,97	158,262	483,137	217,281	244,627	460,43	67,0076	373,106	410,082

3.2 Distribution of the manual work expenses, cumulated with the share in the overhead & manufacturing, on the functions of the product

The distribution of the expenses with the manual work and the overhead & manufacturing on functions, for every guide mark of the product, was achieved through logical reasoning and considering the designed manufacturing technology.

We exemplify the distribution modality for the guide mark „Roll". Following the technical analysis, the following ensued:

- The operation *rectification* participates in achieving the functions: C, D, E. For the cost distribution on the three functions, their order of importance was first determined, in relation to the operation, as shown in table 4 :

Determining the level of importance

Table 4

Functions	C	D	E
C	1	0	0
D	1	1	1
E	1	0	1
Suma	3	1	2
Level of importance	0,5	0,17	0,33

- The operation *thermal treatment* exclusively participates in achieving the function H, consequently the entire cost will be transferred to the function;
- The operation *washing* exclusively participates in achieving the function C, consequently the entire cost will be transferred to the function;
- The operation *control* exclusively participates in achieving the function H, consequently the entire cost will be transferred to the function.

The manual work and the overhead manufacturing (C_{manr4}) for „Roll" sum up 389,22 lei. This value was distributed on the operations who contributed to achieving the guide mark in direct proportion with the level of importance (table 5):

Distribution C_{manr4} on the operations through whose intermediary „Roll" is achieved

Table 5

No.	Operations	Value of manual work and overhead & manufacturing(lei)	Functions it participates in			
			C	D	E	H
1	Rectification	174,926	87,463	29,737	57,725	
2	Thermal treatment	195,387				195,387
3	Washing	15,161	15,161			
4	Control	3,745				3,745
	Total	389,22	102,624	29,737	57,725	199,132

In table 6, there is submitted in a centralized manner, the distribution of the costs with the manual work cumulated with the share from the overhead & manufacturing, on the functions of the product: „radial – axial bearing with tapered rolls".

Centralization of the costs with the manual work and with the overhead manufacturing on the main functions of the product

Table 6

No.	Denomination guide mark	Total (lei)	Product functions							
			A	B	C	D	E	F	H	I
1	Internal ring	859,55	52,320	-	150,773	63,116	104,641	-	488,698	-
2	External ring (2 units)	882,7	-	-	66,381	20,684	155,496	-	640,138	-

3	Distance external ring	413,2	-	-	-	-	104,319	208,639	-	100,241
4	Rolls (78 units)	389,22	-	-	102,624	29,737	57,725	-	199,132	-
5	Cage	63	-	-	-	-	12,6	6,3	25,2	18,9
	Total manual work and overhead & manufacturing costs	2607,67	52,320	-	319,778	113,537	434,781	214,939	1353,168	119,141

Following the distribution on functions of the costs with the materials and of the costs with the manual work and with the overhead & manufacturing for each guide mark, the situation shown in table 7 was obtained.

Centralization of the costs (materials + manual work + overhead & manufacturing) distributed on the product functions

Table 7

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

4. CONCLUSIONS

The studies of value analysis entail achieving the economic dimensioning of the product functions. This activity is based on the data existing in the respective economic agent's accountancy, as regards the level of the production costs for every sub-assembly or component. The economic dimensioning of the product functions is the activity wherein there must be determined the relation existing between the level of the technical dimensions and the level of the costs for the physical components of the product, so that we might eventually compare the usage value of the functions with their cost.

Bibliography

1.Condurache, Gh., Managementul valorii produsului, Gh.Asachi Publishing House, Iaşi, 1989;
2.Crum, L.W., Ingineria valorii, Technical Publishing House, Bucharest, 1976
3.Ioniţă, I., Ingineria valorii, Economic Publishing House, ISBN 973-590-399-7, Bucharest, 2000;
4.Limbăşan, G., Studii de analiza valorii în industria de rulmenţi, Report no. 2 for elaborating the doctoral thesis, Braşov, September 2008;
5.Tureac, I., Limbăşan, G., Considerations upon the possibilities of applying the value analysis method in manufacturing rolling contact bearings, RECENT Magazine, vol. 10 (2009), No. 3 (27), ISSN 1582 – 0246;
6.Tureac, I., s.a. Ingineria valorii, Publishing House of Transilvania University, ISBN 973-947-44-6, Braşov, 2002.