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Value Analysis Method, Leverage for Cost Reduction and Technological Change in the Electrical Engineering Field

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Abstract Based on both the manufacturer's perspective (an engineering approach) and the customer's point of view (a marketing approach), the Value Analysis Method can determine both directions to reduce production cost and technological change to a product. The method allows the analysis of the possibilities to reduce manufacturing costs based on a detailed investigation of the current cost of a product. The present paper tackles the implementation of the Value Analysis Method in the manufacturing of electrical motors, with application for the flameproof motors. The authors identified four categories of flameproof motor functions: (a) strong undervalued functions, (b) strong overvalued functions, (c) slightly under / over-valued and (d) proportionately valued functions (by the manufacturer). Hence, the data on the production costs are provided by a domestic (Romanian) producer. It examines the method's potential to create solutions to increase efficiency and effectiveness of the studied motors.

Keywords Value Analysis, Cost Reduction, Technological Change, Electrical Engineering, Flameproof Motors

1. Introduction

The Value Analysis Method arose when the engineer Lawrence Delos Miles changed the product's approach: from breaking down the product into its component parts to identification of the functions that the product must meet. Hence, he replaced the question "What materials should I buy?" with "What functions need I buy?" [1]. As a result, in 1947, Lawrence Delos Miles developed a systematic method for functional analysis of the product in order to reduce the product' manufacturing cost by eliminating those costs that do not contribute to the operation/value of product. He named the method "value analysis"[1-6].

If applied, the principles of Value Analysis involve the analysis of the product from the external environment, as perceived by the user. Combining the manufacturer' (engineering issues) with the end user's point of view (marketing issues), this approach helps identify ways to reduce the product' cost [7,8]. Moreover, Value Analysis can be used as a method of assessing the quality and technical level of products, being also used in competition analysis [9,10].

A key observation is the need to distinguish between the Value Analysis and the Value Engineering since they are widely used as synonyms. The Value Analysis and the Value Engineering are not two different processes, it is one and the same method applied to two different times of the life cycle of an (industrial) product [1]. When the product is in the design phase and the purpose is to identify the best technical and economic solutions, the value engineering methodology is applied. On the other hand, when the aim is to improve an existing product, the value analysis methodology is applied [2,4,11].

In this paper, the authors evaluate the existing costs of a flameproof motor and consider whether its costs reflect the users' choices. To achieve this objective, a Value Analysis methodology to the flameproof motors is proposed. As a consequence, the authors structured it as follows. First, some illustrative applications of Value Analysis method in various areas are presented. Second, the authors describe, briefly, the proposed phases of the Value Analysis method. The phases of the functional analysis, the technical analysis, the economic analysis and the systemic analysis are summarized. Further, the Value Analysis methodology developed for two opposite flameproof electric motors is presented. The results of the study are analyzed and conclusions drawn.

2. The Applications of Value Analysis Method. A Brief Literature Review

The Value Analysis versatility is demonstrated by the variety of its applications. A brief review of the Value Analysis studies highlights the applicability of the method for both products and industrial processes: civil engineering, public services, town planning, public transport, mechanical engineering domain, pharmaceutical industry etc. Value analysis concepts can be used both in the large series products and the unique products, the simple products and the high-tech products [12]. The following examples are worth considering:

- renovation and expansion of the library at the Rhode Island School of Design. The application of Value Analysis has improved a facility function according to budget constraints (2007) [13];
- improve selection process for the construction project proposals (2007) [14];
- expansion of the Edmonton' sewer system, Canada (2009) [15];
- expansion of the Kyungboo Express Highway, the main artery between Seoul to Pusan (2010); the use of Value Analysis concepts results in a 50% project cost reduction [16];
- construction and modernization of the railways – West Rail, Hong Kong (2010) [17];
- reduce the energy costs in the Iranian industrial organizations (2010) [18];
- pricing of the electricity in Romania (2001) [19];
- the approach of the sports performance in terms of ergonomics and Value Analysis (2005) [20];
- in the pharmaceutical field, the Value Analysis concepts can be applied to achieve the following objectives: (1) to reduce the production costs by eliminating unnecessary functions of existing products (e.g. for the outer packaging box, the cardboard may be preferred to plastic packaging); (2) to identify other methods of achieving the product's functions (e.g. replacing a substance contained in a synthetic oral drug with a herbal extract less irritating to the stomach) (2008) [21];
- redesigning a jaw crusher (2009) [22];
- designing/redesigning of an organization's management system (2010) [23];
- diminish cost of the galvanization process (2012) [10].

Despite the large number of publications, the Value Analysis applications in electrical engineering are few. Ion Ioniță (2000) points out on reducing the manufacture costs of electric motors at the "Electromotor" (Timişoara, Romania), based on the Value Analysis, but in the 70s [2]. Present study aims at developing this particular domain. An adaptation of Value Analysis methodology based on the profile of the electric machines is proposed.

3. The Phases of the Value Analysis Method

In A brief relevant literature highlights different Value Analysis methodologies. Most of the time, Value Analysis phases are overlapping with those of the Value Engineering method. Even if called differently, all methodologies have the same key activities.

There are many interpretations of the Value Analysis method, the name and the number of phases varying from one author to another. For instance, L. W. Crum (1976) describes a seven-phase process of the Value Engineering: (1) the information phase (2) the speculation/creative phase, (3) the evaluation phase, (4) the planning phase, (5) the execution phase, (6) the report phase and (7) the implementation phase [1]. On the other hand, Sunil Jauhar (2012), in order to decrease cost of the galvanization process, has applied an eight-phase Value Analysis method: (1) the orientation phase (2) the information phase (3) the function phase (4) the creative phase (5) the evaluation phase (6) the presentation phase (7) the implementation phase (8) the follow up phase [10].

The present research deals with the Value Analysis in order to investigate the current production cost of a two different flameproof motors. The authors developed a four-stage methodology: (1) the functional analysis phase, (2) the technical analysis phase, (3) the economic analysis phase and (4) the systemic analysis phase. This methodology is based on Ioniță (2000) [2] and on the Romanian standard – STAS 11272/2-79 Value Analysis. The application of the method to the products [24].

3.1. The Functional Analysis Phase

The functional analysis phase implies: (1) setting up the product's functions from the end-user perspective; (2) calculating the weight value of the product's functions in the use-value of the product [1,2,8,11,23].

Value Analysis principles involve the analysis of the product from the external environment, as perceived by its user. In view of setting up the product's functions correctly, the product was considered in terms of energy exchanges with external environment [7,8].

The calculation the weight value of the product's functions is based on the determination of the level of importance. In order for the functions evaluation to reflect the reality, the authors applied the methodology for calculating the level of importance of the functions, proposed and described in [8].

3.2. The Technical Analysis Phase

Technical analysis is the correlation between product's functions with the technical parameters and the structural characteristics of the product [2,11]. This phase implies: (1) identification of the physical quantities that contribute to fulfilling each of the product's function; (2) allocation of the suitable product parts (components, subassemblies) to each of the product's functions. The characteristics (the type) of the product's parts result in variations of the physical quantities and further in variation of the functions fulfillment. In conclusion, technical analysis depends exclusively on the product structure analysis. The standard method is exposed in [1,2,22,25,26,27].

3.3. The Economic Analysis Phase

Economic analysis involves the determination of the weight cost value of each of the product's functions in the manufacturing cost of the product, corresponding to its importance to the end-user. Accuracy of the cost functions depends on how these are established: the cost of raw materials and supplies, the cost of labor and the administration costs. Authors proposed the Value Analysis to waive calculation of administration costs, by considering a one percent increase which can differ from one organization to another.

Determination of the cost functions can be done by several methods [1,2]. In this study, the authors used the method of allocation of costs on the product' functions proportional with their level of importance. This method is easy to apply and was verified empirically [2]. The method requires [2,7]:

- identification of all parts of the product;
- identification of all operations needed for product manufacturing;
- material costs of the product parts;
- costs of the operations (the labor cost);
- allocation of the parts on each product's function;
- allocation of the material costs and labor costs on each of the product's functions;
- the weight value of the product's functions in the use-value of the product (the results of the functional analysis phase).
- Determination of the cost functions implies [2,7]:
- setting the cost of (raw) materials for each part of the product;
- calculating a relative importance level for each part of the product, as sum of all importance levels of the functions for which the product part is allocated;
- calculating the cost per relative level of importance;
- calculating the material cost of each function.

The process is repeated for the labor cost of each function. The sum of material cost and labor cost for each function represents the cost of the function.

Sum of all function costs represents the manufacturing cost of the product and must be equal to the sum of all costs of the product parts and operations (labor costs) considered.

3.4. The Systemic Analysis Phase

The relationship between the cost and the level of importance for each product function is investigated within the systemic analysis phase. It aims to identify the functions whose fulfillment costs too much compared to their contribution to the end-value of the product [2,7,11]. The principle behind this phase is the proportionality between the weight value of the each function in the use-value of the product and the weight value of each function cost in the manufacturing cost of the product: a function with the weight value zero in use-value of the product must also cost zero. Proportionality analysis can be performed using the graphics method [2,7,11].

4. The Case study. Results and Discussions

The case study subjects are two flameproof motors, named M1 and M2, with the different /opposite dimensions. The two motors were designed according to the manufacturer's internal classifications:

- M1: ASA 132M-4, 7,5 kW /1500 rpm, 4/7 V, B3
- M2: ASA 225S-4, 37 kW /1500 rpm, 4/7 V, B3

Information on the constructive parts, the production costs and the labor cost of flameproof motors was provided by a domestic (Romanian) producer.

Table 1. The functional hierarchy of a flameproof electrical motor [8]

No	The function label	The description of the function	The weight value [%]
1	F21	It provides the starting torque	7.59
2	F22	It limits the starting current	7.31
3	F23	It provides the rated torque	7.01
4	F11	It provides conditions for the power supply connection	5.70
5	F12	It provides the mechanical coupling conditions	5.37
6	F32	It provides the electrical protection of the user	5.01
7	F24	It provides the established minimum efficiency (η)	5.00
8	F31	It provides the ground fault protection of the user	4.95
9	F41	It provides waterproof /dustproof options	4.71
10	F34	It provides the cooling / the extinction of any operation sparks	4.60
11	F26	It provides the maximum torque	4.30
12	F42	It provides the extreme temperature operation	3.94
13	F16	It provides the heat evacuation (to the outside)	3.90
14	F33	It provides the mechanical protection of the user	3.82
15	F13	It provides the mechanical grip of the machine	3.58
16	F25	It provides the full load power factor	3.55
17	F14	It provides the handling ways	3.24
18	F43	It provides the repair options	3.13
19	F44	It provides the identification options	2.95
20	F35	It provides the noise level limit	2.47
21	F46	It provides the warranty services	2.35
22	F15	It provides the possibilities for transportation	1.99
23	F36	It provides the possibilities for the recycling of used materials	1.92
24	F45	It provides the aesthetic characteristics	1.61
TOTAL (the use value)			100.00

4.1. The Functional Analysis Phase

Based on the methodology proposed and described by the authors in [8], 24 functions of the flameproof motor were identified, evaluated and ranked as shown in Table 1.

Given the complexity of the product, the authors considered three categories of users to evaluate the functions of the flameproof motor:

- operations engineers and technicians
- engineers – the electric machines designer
- academics (professors and researchers) specialized in electrical machines.

4.2. The Technical Analysis Phase

Based on information provided by the manufacturer of the two motors, the authors established the structure of the flameproof motor consisting of 23 parts / subassemblies – see Table 2, and 23 activities – see Table 3.

Table 2. Parts of the flameproof motor. Source: adapted domestic (Romanian) producer, March 10, 2011

The parts label	The parts (subassembly) name
R1	terminal box
R2	terminal box cover
R3	finished/trimmed frame
R4	eyebolt
R5	grounding bolt
R6	machine tag
R7	fan
R8	fan housing
R9	end shields
R10	ball bearings
R11	stator stack with slots (the stator core)
R12	stator windings (copper)
R13	conductor connections (winding terminals)
R14	insulations + impregnation
R15	thermistors, moisture resistors
R16	rotor stack with laminations (the rotor core)
R17	squirrel cage winding (aluminum)
R18	shaft
R19	coating paint
R20	motor wrapping
R21	rotor' mounting parts
R22	stator' mounting parts
R23	parts required for final mounting

Table 3. Operations of the flameproof motor. Source: adapted domestic (Romanian) producer, March 10, 2011

The operations label	The operations (labor) name
M1	mounting the terminal box
M2	fixing the terminal box cover
M3	mounting the frame
M4	fixing the eyebolt
M5	fixing the grounding bolt
M6	fixing the machine tag
M7	mounting the fan
M8	mounting the fan cover
M9	mounting the end shields
M10	attaching the bearings
M11	mounting the stator core
M12	winding and forming the coils
M13	connecting the coils and terminals
M14	insulation and impregnation procedures
M15	installing the thermistors
M16	assembling the rotor core
M17	die casting the aluminum squirrel cage
M18	mounting the shaft
M19	painting the motor
M20	Assembling the motor
M21	assembling the rotor
M22	assembling the stator
M23	motor final assembling

Based on the manufacturer's and the user's point of view, each function of the flameproof motor was defined and evaluated. In Table 4 is the allocation of the suitable product parts (components, subassemblies) to each of the product's functions.

Table 4. T he allocation of the suitable product parts to each of the product's functions

The function label	The description of the function	The flameproof parts
F11	It provides conditions for the power supply connection	terminal box (R1); terminal box (cover R2); conductor connections(R13);
F12	It provides the mechanical coupling conditions	shaft (R18); ball bearings (R10); end shields (R9);
F13	It provides the mechanical grip of the machine	finished frame (R3);
F14	It provides the handling ways	finished frame (R3); eyebolt (R4);
F15	It provides the possibilities for transportation	eyebolt (R4); motor wrapping (R20);
F16	It provides the heat	finished frame (R3);

	evacuation (to the outside)	fan (R7); end shields (R9);
F21	It provides the starting torque	stator windings(R12)1 squirrel cage (R17)2
F22	It limits the starting current	squirrel cage (R17)
F23	It provides the rated torque	stator windings(R12)[1] squirrel cage (R17)[2]
F24	It provides the established minimum efficiency (η)	stator core (R11) stator windings(R12)3; squirrel cage (R17)4;
F25	It provides the full load power factor	stator core (R11); rotor core (R16);
F26	It provides the maximum torque	stator windings(R12)[1]; squirrel cage (R17)[2];
F31	It provides the ground fault protection of the user	grounding bolt (R5); insulations + impregnation (R14);
F32	It provides the electrical protection of the user	insulations + impregnation (R14); stator windings (R12);
F33	It provides the mechanical protection of the user	finished frame (R3); fan housing (R8);
F34	It provides the cooling / the extinction of any operation sparks	terminal box (R1) terminal box cover (R2); end shields (R9);
F35	It provides the noise level limited	stator core (R11); ball bearings (R10);
F36	It provides the possibilities for recycling of used materials	stator core + stator windings + conductor connections (R11, R12, R13); rotor core + squirrel cage winding (R16, R17);
F41	It provides waterproof /dustproof options	finished frame (R3); end shields (R9); terminal box (R1); terminal box cover (R2);
F42	It provides the extreme temperature operation	thermistors + moisture resistors (R15);
F43	It provides the repair options	finished frame (R3); end shields (R9); fan housing (R8); rotor' mounting parts (R21); stator' mounting parts (R22); Parts required for final mounting (R23);
F44	It provides the identification options	finished frame (R3); coating paint (R19); machine tag (R6); motor wrapping (R20);
F45	It provides the aesthetic characteristics	finished frame (R3); end shields (R9); coating paint(R19); fan housing (R8);
F46	It provides the warranty services	insulations + impregnation (R14); ball + bearings (R10;) terminal box (R1).

1number and distribution of spires
2number of bars
3section and conductor material
4section and conductor material (cage bars)

4.3. The Economic Analysis Phase

Calculation of the functions costs requires data on the cost of the motors parts and labor. Due to privacy, Table 5 presents only the weights value of the costs in the total cost and not the actual costs of the parts and labor. These weights were calculated by the authors based on real costs existing in March 2011.

Table 5. The weight value of the cost of parts and labor in the manufacturing cost for motors M1 and M2

Labels of parts and labor	M1 [%]	M2 [%]
R1+M1	14.39	10.51
R2+M2	1.62	0.99
R3+M3	15.18	19.35
R4+M4	0.35	0.31
R5+M5	0.22	0.10
R6+M6	0.13	0.04
R7+M7	0.16	1.42
R8+M8	1.06	1.29
R9+M9	6.03	5.41
R10+M10	2.82	3.71
R11+M11	11.69	12.98
R12+M12	17.42	20.46
R13+M13	0.94	1.35
R14+M14	5.54	2.48
R15+M15	6.01	2.98
R16+M16	5.83	6.12
R17+M17	2.30	2.00
R18+M18	2.61	2.98
R19+M19	0.71	0.41
R20+M20	0.30	0.14
R21+M21	2.50	3.09
R22+M22	1.14	0.57
R23+M23	1.05	1.32
Product cost	100.00	100.00

Since the distribution of the parts and the operations/labor on functions is the same, the determination of the functions cost was achieved together and not separately, for the parts and for the labor respectively.

Table 6 illustrates the weights value of the functions cost based on the allocation of costs on the product's functions proportional with their level of importance [2,7]. Authors used *the method of allocation of costs on the product' functions proportional with their level of importance* [2]. M1 is the low power/small dimensions flameproof motor, and M2 is the high power/large dimensions flameproof motor.

Table 6. The weight value of the cost of product's functions in the manufacturing cost for motors M1 and M2

The function label	The description of the function	The weight value of cost function [%]	
		M1	M2
F11	It provides conditions for the power supply connection	6.04	4.83
F12	It provides the mechanical coupling conditions	5.48	6.19
F13	It provides the mechanical grip of the machine	2.01	2.57
F14	It provides the handling ways	2.04	2.52
F15	It provides the possibilities for transportation	0.26	0.17
F16	It provides the heat evacuation (to the outside)	3.37	5.13
F21	It provides the starting torque	5.65	6.47
F22	It limits the starting current	0.51	0.44
F23	It provides the rated torque	5.22	5.98
F24	It provides the established minimum efficiency (η)	8.24	9.28
F25	It provides the full load power factor	6.99	7.54
F26	It provides the maximum torque	3.20	3.67
F31	It provides the ground fault protection of the user	2.45	1.09
F32	It provides the electrical protection of the user	2.25	1.01
F33	It provides the mechanical protection of the user	2.62	3.32
F34	It provides the cooling / the extinction of any operation sparks	5.50	4.16
F35	It provides the noise level limited	2.91	3.38
F36	It provides the possibilities for recycling of used materials	5.43	6.04
F41	It provides waterproof /dustproof options	8.29	7.64
F42	It provides the extreme temperature operation	6.01	2.98
F43	It provides the repair options	7.65	8,41
F44	It provides the identification options	2.43	2.50
F45	It provides the aesthetic characteristics	1.77	1.92
F46	It provides the warranty services	3.65	2.75
TOTAL		100.00	100.00

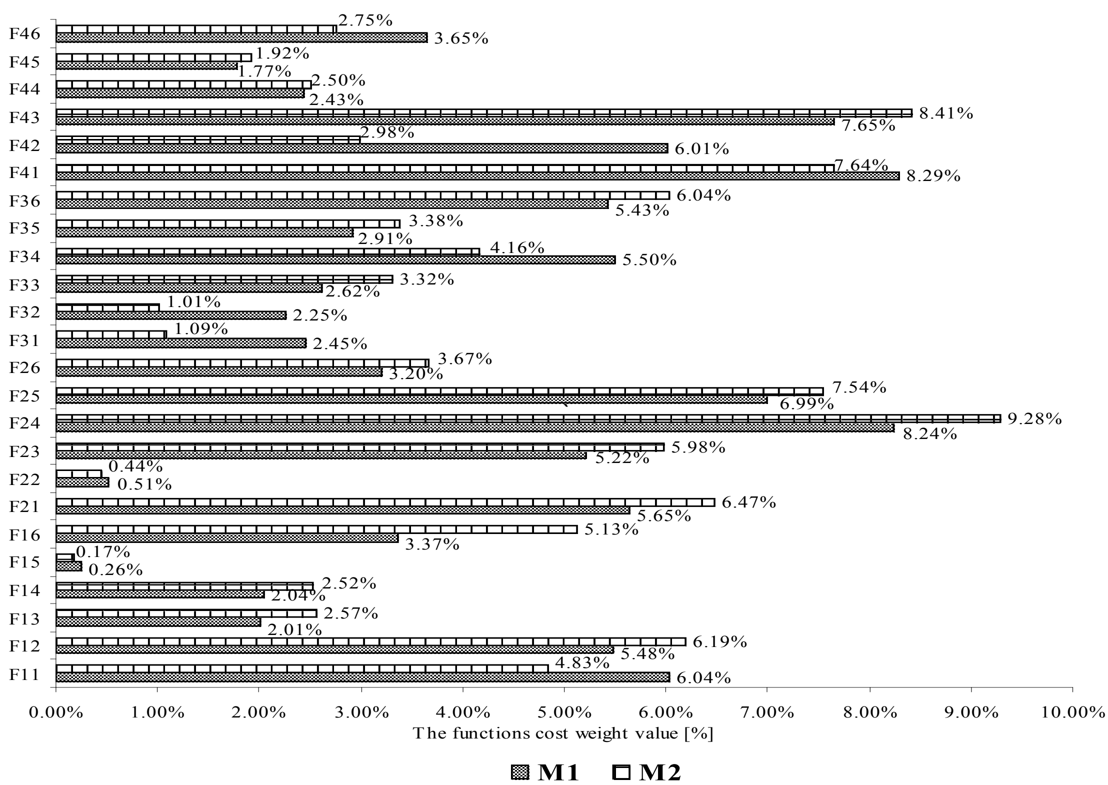

Figure 1. Comparison of costs for each function within the total cost for M1 and M2

The three most expensive functions are: F41 (*It provides waterproof /dustproof options*), F24 (*It provides the established minimum efficiency (η)*) and F43 (*It provides the repair options*). The place in the ranking of these functions varies slightly from one motor to another. For M1, the low power/small dimensions flameproof motor, the F41 function fulfillment has the highest weight value in the manufacturing cost ($Rc_{F41} = 8.29\%$). Follows the F24 function ($Rc_{F24} = 8.24\%$) and then the F43 function ($Rc_{F43} = 7.65\%$), see Table 6 and Figure 1.

On the other hand, for the M2, the high power/large dimensions flameproof motor, the most expensive function is F24 ($Rc_{F24} = 9.28\%$) followed by F43 function ($Rc_{F43} = 8.41\%$) and F41 function ($Rc_{F41} = 7.64\%$). It can be noticed that for the small dimensions motor, the cost of the function increases which constitutes the relationship between the motor and its environment (the F41 function). In the case of the large dimensions motor, the performance is achieved by the most expensive function (the F24 function).

With regard to the cheapest functions, for both motors considered, M1 and M2, F22(*It limits the starting current*) ranks before F15(*It provides the possibilities for transportation*). What varies from one motor to another is the weight value of the cost of functions: for M1, the low power/small dimensions flameproof motor, $Rc_{F22} = 0.51\%$ and $Rc_{F15} = 0.26\%$, and for M2, the high power/large dimensions flameproof motor, $Rc_{F22} = 0.44\%$ and $Rc_{F15} = 0.17\%$, see Table 6 and Figure 1.

The Systemic Analysis Phase

The application of *the principle of proportionality* for both M1 and M2 motors is illustrated graphically in Figure 2 and in Figure 3.

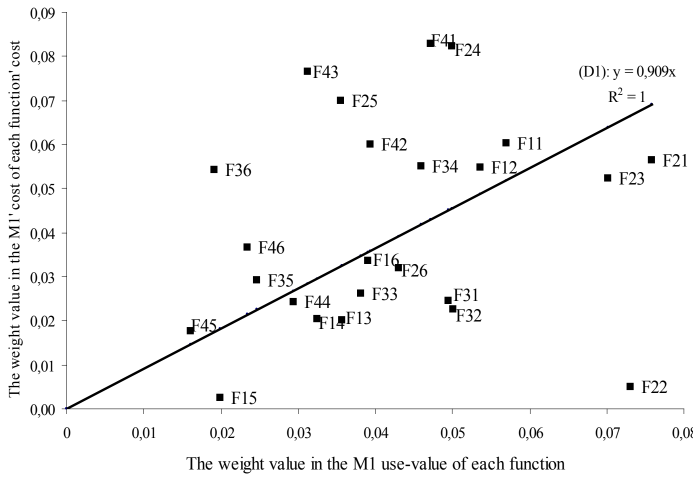

Figure 2. Graphical representation of the 24 functions considered above according to the regression line for M1

A key observation is the importance of the functions expressed as total use value for the user and, for the manufacturer, the cost of production given by the cost of the functions (materials, equipment and technologies used, construction and technological solutions too expensive as compared to other alternatives).

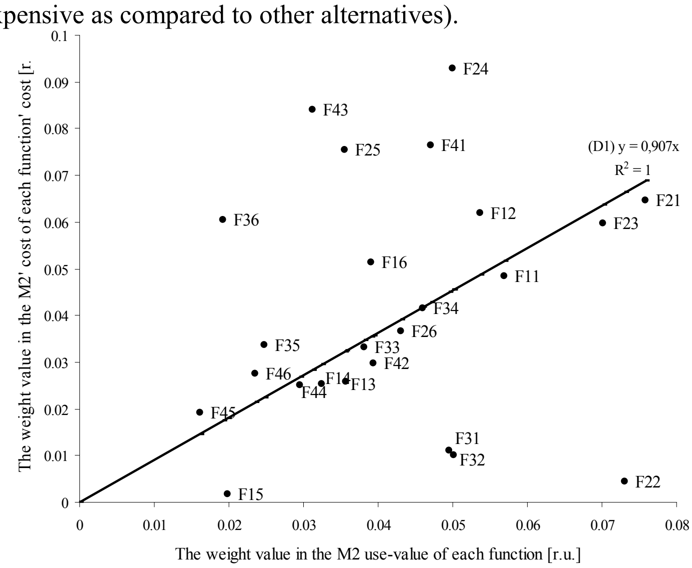

Figure 3. Graphical representation of the 24 functions considered above according to the regression line for M2

Based on the analysis of the two graphics, Figure 2 and Figure 3, the authors identified four categories of flameproof motor functions:

(a) strong undervalued functions by the manufacturer – the functions whose graphical representation is located significantly below the regression line (D1 line, see Figure 2 and Figure 3);

(b) strong overvalued functions by the manufacturer – the functions whose graphical representation is located significantly above the regression line (D1 line, see Figure 2 and Figure 3);

(c) slightly under/over-valued by the manufacturer – the functions whose graphical representation is located near the regression line (D1 line, see Figure 2 and Figure 3);

(d) proportionally valued functions by the manufacturer – the functions whose graphical representation is located on the regression line (D1 line, see Figure 2 and Figure 3).

The strong undervalued function by the manufacturer is that function that has high importance to the end-user and the low cost of fulfilling it (the low cost of the function fulfillment would suggest it is overlooked by the manufacturer). Graphically, are those functions positioned significantly below the regression line (D1).

The strong overvalued function by the manufacturer is the function that has low importance to the end-user and the high cost of fulfilling it (the high cost of the function fulfillment would suggest a higher importance for the manufacturer). Graphically, are those functions positioned significantly above the regression line (D1).

For the M1, the low power/small dimensions flameproof motor, see Figure 2, the F22, F23, F21, F32, F33, and F15 functions are strong undervalued functions by the manufacturer. It is easily observed that the most undervalued function is the F22 functions (*It limits the starting current*). In other words, the end-user assigns it a significant higher importance/value (second place in the user preferences, see Table 1) compared to the weight value of, see Table 6. In practice, the fulfillment of this function would allow an increase in cost because of the need to meet the user's requirements. The same happens to the F23 and F21 functions. These are on the first place and on the third place in the hierarchy of user importance, see Table 1, and are positioned below the regression line, but closer to it, see Figure 2.

The second category is the strong overvalued functions by the manufacturer: F24, F25, F36, F41 and F43 functions. Within this category there are more subgroups according to the importance for the end-user. For instance, the F24 function is the most expensive function and also very important for a motor. In spite of this, it is ranked only 7th in the hierarchy of user importance. This could mean that the users are not aware of the importance of the function fulfillment.

Functions proportionately valued by the manufacturers, graphically represented on the regression line (D1 line, see Figure 2) are: the F16 function (*It provides the heat evacuation*) and the F44 (*It provides the identification options*).

The remaining functions can be easily assigned to slightly under/over-valued by the manufacturer category, right near a D1 line, see Figure 2.

In the case of M2, the high power/large dimensions flameproof motor, see Figure 3, the authors identified the following:

- the F22 (*It limits the starting current*) and the F15 (*It provides the possibilities for transportation*) are the strongest undervalued functions by the manufacturer;
- among the strong overvalued functions by the manufacturer F24, F25, F36, F41 and F43 functions stand out;
- the F33, F34 and F44 are proportionately valued functions by the manufacturer; in spite of the expectations from the F44 function (*It provides the identification options*), due to its low importance to the user, the Value Analysis results show that it is well designed;
- the remaining functions are slightly under/over-valued by the manufacturer, right near a D1 line, see Figure 3.

The choice of the two very different motors (the M1, the low power/small dimensions flameproof motor and the M2, the high power/large dimensions flameproof motor) helps the authors generalize the study results. When analyzed, the results for M1 versus M2, despite some small differences, the conclusions are the same for both motors. Consequently, it could be stated that the results of Value Analysis application for the flameproof motor domain allows generalization.

Determination of the undervalued or overvalued functions by the manufacturer for the two flameproof motors emphasizes two main areas of optimization: (a) increase the overall use-value of the product or (b) reduction the product's functions cost. The first direction, increasing the overall use-value of the product, is difficult to achieve, because it highly depends on: the user's perception and preferences, the number and the type of competing products, and not least, the industrial development level. Generally, one possibility of optimization is the marketing activity aimed at increasing the product's visibility or changing the user preferences. The second direction, reduction of the cost of the product' functions can be done by changing the quantity and the type of material used, the design, technology etc.

4. Conclusions

The Value Analysis Method allows the analysis of the possibilities to reduce manufacturing costs based on detailed investigation of the current cost of a product.

The main novelty of the paper is the developing of the Value Analysis methodology for electrical machines field. The Value Analysis application for the two flameproof motors revealed four categories of a product' functions: strong undervalued functions; strong overvalued functions; slightly under / over-valued and proportionately valued functions by the manufacturer. The results could be generalized for whole flameproof motors category.

It identified two possible directions of any product optimization: increasing the overall use-value of the product and cost reduction of the product's functions. The first direction, dependent on the market perception and the users' preferences, is preferred and carried out by marketers. The second direction can be approached by engineers by changing the amount of material used, the technology, the design etc.

The value of the study consists in extending of the Value Analysis Method in the electrical engineering field. By pooling technical constraints to the requirements of users, the method offers potential for both the cost reduction of production as well as for technological changes.

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