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FUNCTIONAL-COST ANALYSIS OF «DSC» SYSTEM OF MOTOR VEHICLES «BMW»

In Ukraine for the implementation of the International System of Quality ISO 9000 it is necessary that the producer uses the methods of the project solutions analysis. Both input and output data must be subject to such analysis. The enterprises which create or develop quality products must apply either standard technologies of functional-cost analysis or use their own technologies. Functional-cost analysis is aimed at provision of needed consumer properties of the object with minimal possible resources expenses at all stages of production process.

The paper considers functional-cost analysis of «DSC» system of the motor vehicles «BMW». Functional model of «DSC» system of motor vehicles «BMW» and classification of functions of its functional model is developed.

Classification of functions of the functional model of the system «DSC» of the motor vehicle «BMW» is presented. Utility factor of «DSC» system of the motor vehicle «BMW» is determined by constructing the priorities matrix according to the known calculation technique.

Aggregated expenses criterion during the design of the engineering or production systems takes into consideration expenses at all the stages of the system life cycle, for the assessment of which matrix of expenses of «DSC» system of the motor vehicles «BMW» is constructed, the expenses coefficient is determined from this matrix.

Utility diagram of «DSC» system functions of the motor vehicle «BMW», diagram of functions ranking relatively functional-cost diagram of the system, diagram of the system functions expenses, diagram of system functions ranking relatively expense ratio, diagram of the values of functional cost of the system functions index, diagram of system functions ranking relatively functional cost index have been constructed.

According to the constructed diagrams functions of «DSC» system of the motor vehicle «BMW» are determined, which have positive functional-cost index and the highest rating among the considered functions. Operations or functions which have the highest functional-cost index and rank are those operations, improvement of which leads to further development of the system or achieving the objective of the analysis.

Key words: *«DSC» system, functional-cost analysis, functional model, classification of functions, utility coefficient, priorities matrix, expenses ratio, diagram of functions utility, diagram of functions rating, functional-cost diagram, diagram of functions expenses.*

Introduction

For rational and substantiated decision-making it is expedient to use functional-cost analysis, which combines various methods of aggregated analysis of the systems, creative search, optimization and solutions selection [1].

The basis of functional-cost analysis is the analysis of functional perfection, ways of improving the system by means of comparison the utility of separate functions and expenses for its realization.

Objective of functional-cost analysis – provide necessary utility of the system by minimal possible total cost.

Thus, decision in case of carrying out functional analysis is taken on the base of two criteria – utility and cost [2, 3].

In Ukraine for the implementation of the International System of Quality ISO 9000 it is necessary that the producer should use methods of projects solutions analysis. Such analysis must be performed over both input data of the project and output ones. That is why, the enterprises, creating or developing quality products obligatory use either standard technologies of the analysis or perform functional-cost analysis or use their own technologies.

Thus, functional-cost analysis is aimed at provision of necessary consumer qualities of the object with minimal possible expenses of the resources at all stages of the production process [4].

Problem setting

In the optimization of the engineering projects, aimed at the enhancement of the production efficiency main role is allocated to the analysis of the decisions taken. Analysis as the method of investigation, enables to detect available contradictions and discrepancies in the developments, objects, systems and methods, determine cause-effect relationship, providing the needed information.

Among the known methods of analysis (engineering, technical-economic, economic, ecological) functional-cost analysis occupies special place, it is recommended to be used in the process of new products and technologies design, up-grading of the equipment and manufacturing of new products, reconstruction of the industrial objects, reduction of the production cost, etc.

The essence of the functional-cost analysis method is practical decomposition of the object (construction, technology, management of production processes) into the components for the determination of their role and value in general system, assessment of their functions and reduction of all unnecessary costs.

Experience of using functional-cost analysis in automobile building industry shows [4]:

– on basic elements (functions) of the system, which represent 20 % of their total amount, falls 85 % of the total cost of the system, that is why, the study of the above-mentioned elements must be the matter of priority ;

– errors of the final calculation in the process of functional-cost analysis must by an order less than the volume of cost reduction.

Analysis of the recent studies and publications

Two persons almost simultaneously pioneered the development of the functional-cost analysis method , they were: employee of the company «General Electric» – engineer L D. Miles [5] and Yuriy Mykhailovych Sobolev – engineer-designer of Perm telephone plant [6]. They are considered to be the founders of functional-cost analysis. Special attention to this type of analysis in the system of the methods, aimed at improvement of products quality and efficiency of production was paid in the studies of Soviet economists.

In Ukraine functional-cost analysis is considered as the component of the science, studying the methods of the activation of creative thinking. The most outstanding domestic specialists who made great contribution to the development of functional-cost analysis are: M. Ivanov [2], N. Veselovska [3], Z. Lytvyn [4], I. Tsygylyk [7], I. Prokopenko [8], V. Zelinskyi [9], I. Tverdokhlib [10] and others.

Objective of the research

Objective of functional-cost analysis is minimization of the object expenses at the stages of design, production, operation, saving or enhancement of their functions usage and increasing the utility of the object for the consumers.

Hence, **the objective of research** is development of functional-cost analysis of «DSC» system of the motor vehicles «BMW» for determination of the system components functions which are to be improved.

Main part

System «DSC» (Driving Stability Control) – performs the control of the dynamics of the motor vehicle motion in the transversal and longitudinal directions, influencing its braking mechanism and engine operation [11]. System «DSC» is connected with such systems:

– antiblocking system («ABS»);
– electronic system of braking forces distribution («EBV»);
– curved road brake control («CBC»);
– automatic system of stability control («ASC»);
– dynamic traction control («DTC») system;

– system of engine braking moment regulation («MSR») system;

– dynamic brake control («DBC») system.

Construction links of the «DSC» system with the blocks of the motor vehicle when fully equipped are shown in Fig. 1. «DSC» unit comprises electronic control block with the sensor of the longitudinal acceleration and hydraulic block.

«ABS» system prevents wheels blocking during braking. It provides shorter car braking distance and stable motion of the motor vehicle. «ABS» system regulates braking pressure at all the wheels, so that each wheel slides relatively the pads in optimal mode, maximum braking effort and keeping the car from sideways skidding is performed.

System «EBV» is a component part of the system «ABS». System «EBV» controls the distribution of braking forces between front and rear wheels, irrespective of the loading of the motor vehicle optimal braking distance is achieved at high stability of the motor vehicle. To avoid braking in certain situations that causes the blocking of the rear wheels, «EBV» system constantly controls rear wheels slippage, depending on the front wheels.

System «CBC» is the supplement to the system «ABS», it improves the stability in the process of braking while cornering. Maximum accuracy of the motion path is provided, as during cornering even slight braking changes loading on the axles on the left/right, so that it can lead to the reduction of the motor vehicle stability. If necessary, «CBC» system at light braking, creates stabilizing moment, if the regulation range of «ABS» system is not sufficient.

System «ASC» prevents wheels slip during acceleration, stability is maintained during the increase of the traction power. If one of the wheels of the drive axle is on the surface with good adhesion and the other on the slippery surface, then the wheel, which starts slipping, brakes. System «ASC» can «interfere» in the control of the engine, changing the ignition timing, amount of the injected fuel or the position of the throttle valve, intake valves lift.

System «DTC» together with «DSC» system is intended for the optimization of the traction power of engine during driving to the road sections with bad surfaces. Function of the system «DTC» corresponds to the designation of the system «DSC», but the strategy of traffic management changes, as the engine traction power increases.

System «DTC» is involved by means of switching off «DSC» system. System «DTC» as a result of the impact on braking mechanisms realizes the function of the differential blocking. System «DTC» increases the torque on the wheels, which are in more favorable conditions of adhesion with road surface (higher friction coefficient).

System «MSR» during downshift or after sharp loading change, prevents blocking of the driving wheels. As a result, driving wheels keep in coasting mode the motor vehicle from the side skid. By means of the angular speed of the wheels sensor, «MSR» system «recognizes» driving wheels, being blocked, and at the very beginning of the process, adds the gas and decreases braking torque of the engine.

System «DBC» helps the driver in the mode of emergency braking. Due to this system automatic increase of pressure occurs in the braking system, if the impact on the brake pad turns out to be insufficient. Minimal brake distance is provided in the situation of the emergency braking during braking by means of «ABS» system of all four wheels.

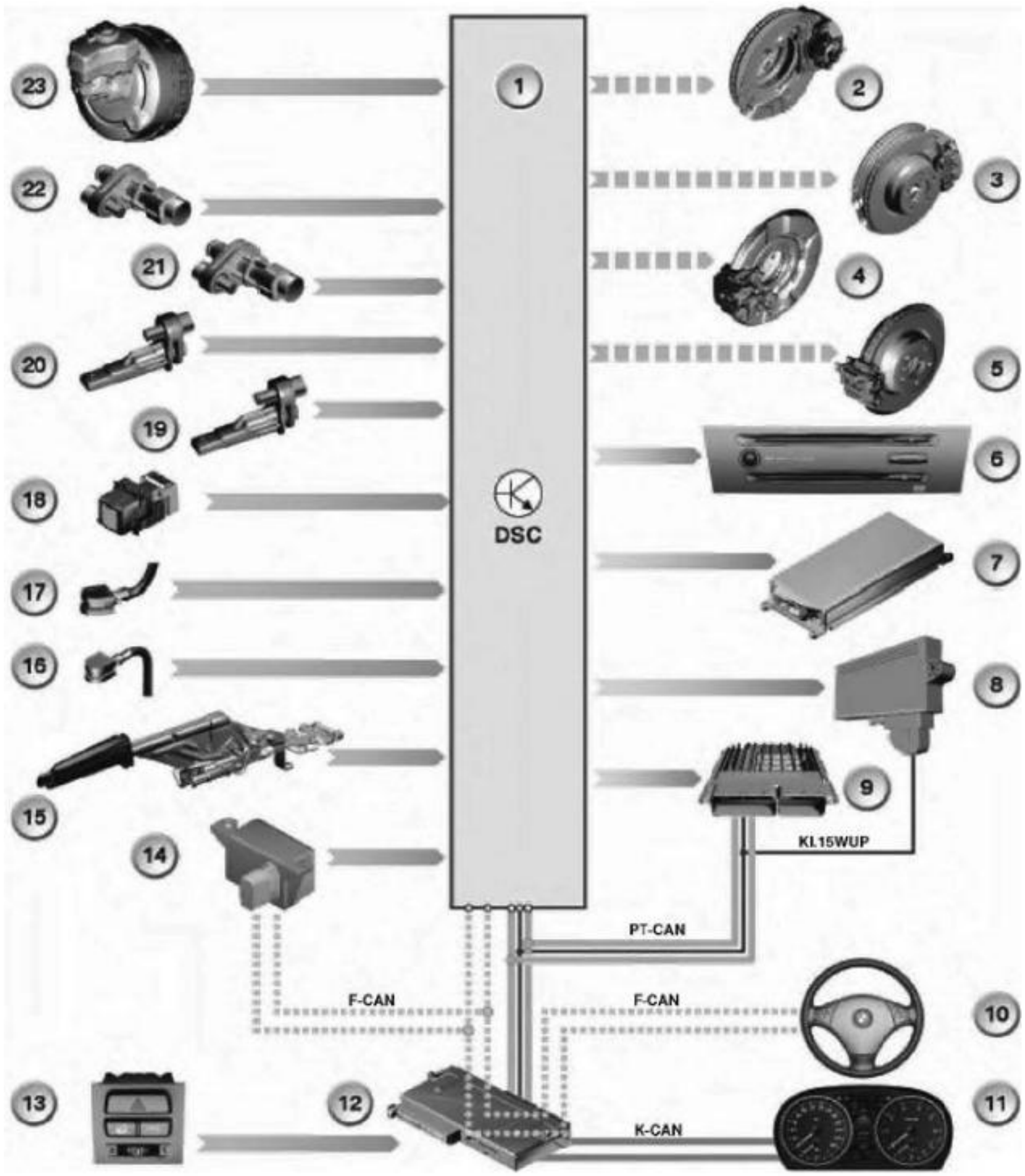

Fig. 1. Model of «DSC» system of motor vehicles «BMW» connections:
1 – unit of «DSC» system; 2 – right front braking mechanism; 3 – left front braking mechanism;
4 – right rear braking mechanism; 5 – left rear braking mechanism; 6 – navigation system «CCC»;
7 – control system «TCU»; 8 – car access system «CAS»; 9 – electronic control unit of the integrated engine management system «DME» / «DDE»; 10 – switching center of «SLZ» system;
11 – dashboard; 12 – electronic unit of «JBE» system control; 13 – key «DTC»; 14 – active steering sensor;
15 – terminal switch of parking brake indicator; 16 – brake pad wear sensor of right rear wheel; 17 – brake pad wear sensor of left front wheel; 18 – brake light switch; 19 – right rear wheel speed sensor; 20 – left rear wheel speed sensor;
21 – right front wheel speed sensor; 22 – left front wheel speed sensor; 23 – brake fluid level sensor

Additional functions are realized if the motor vehicle is equipped with the system «DSC» of «Mk60E5» type:

– readiness of the braking system for operation in emergency case (sharp release of the gas pedal) due to untimely supply of brake pads to the disks by means of pressure increaseрізке;

– drying of the brakes by increasing pressure in the braking system according to the information from the rain sensor or position of the wiper switch;

– compensation of the brake system efficiency drop at their heating by pressure increase in the braking system, set by the driver;

– smooth stop of the motor vehicle;

– assistance at movement from a place;

– compensation of the motor vehicle torques relatively vertical axle by means of active steering.

Study of «DSC» system of «BMW» motor vehicles at functional-cost analysis is based on the functional approach, when the system is considered as the set of functions performed by it. Further, the search of better principle of these functions realization is performed. Functional-cost analysis is carried out on the base of functional model [3, 4, 10].

Functional model is graphic or mathematic representation of the arranged totality of the system functions and connections among them. Graphic representation of the functional model can be given in the form of the graph (functions tree) or technological chain. Functional model of «DSC» system of motor vehicles «BMW» is shown in Fig. 2.

Construction of the functional model is only initial stages of functional -cost analysis, final goal of it is establishing analytical links between separate factors, influencing the course of the process and final indices of the system operation [12].

After the construction of functional model functions classification is performed.

Function is an external manifestation of the object properties, stipulated by certain actions, regarding the transformation of the input impacts into the output results. Function may be of the dynamic character, that is, be directed on performing of certain work and static.

Structurization and analysis of functional model provide the allocation of the main function, which defines the aim, designation of the system and basic functions, without which main function cannot be performed. As well as allocation of the auxiliary and redundant (harmful) functions.

Classification of the system functions is carried out according to two criteria – character and properties of the functions. Classification of the functions of the functional model of «DSC» system of the motor vehicle «BMW» is presented in Table 1.

External function is realized either by the system or its element in the process of the interaction with the environment (supersystem).

Internal function is the result of the interactions in the system.

Main function – it is the external function, which reflects the aim and designation of the system.

Useful functions are the functions which meet the requirements of the humans, regarding their utility.

Redundant functions are not obligatory functions but their realization improves the quality of system operation.

Neutral functions – are the functions which do not perform functional loading but provide the place for location of the object in certain place and certain time.

Harmful functions are the functions, which can be simultaneously useful, but have the obligatory element of harmful action.

The next step of functional-cost analysis is determination of the utility coefficients of each function. Utility coefficient was determined by means of construction the matrix of priorities (Table 2) according to the known calculation technique [13 – 15].

For the construction of the priorities matrix the coefficients of the advantage k_{ij}, of the i^{th} row (a_i) in comparison with the element of the j^{th} column is written on the cross section of the row and column (a_j).

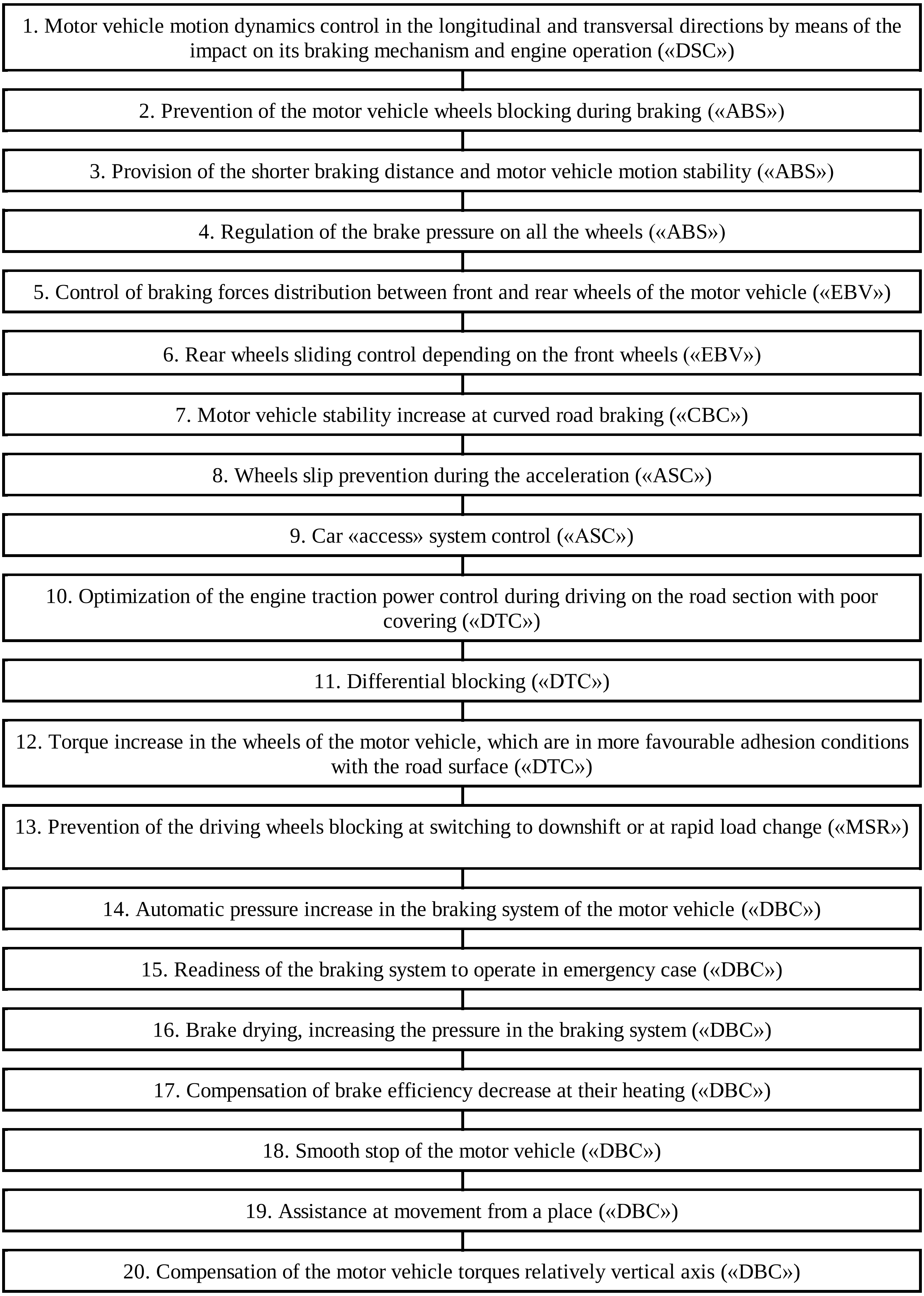

Fig. 2. Functional model of «DSC» system of motor vehicles «BMW»

Table 1

Classification of functions of the functional model of «DSC» system in the motor vehicle «BMW»

№ of the function	Name of the function	Character of the function	Features of the function
1	Motor vehicle motion dynamics control in the longitudinal and transversal directions by means of the impact on its braking mechanism and engine operation («DSC»)	External main	Useful
2	Prevention of the motor vehicle wheels blocking during braking («ABS»)	Internal basic	Useful
3	Provision of the shorter braking distance and motor vehicle motion stability («ABS»)	Internal basic	Useful
4	Regulation of the brake pressure on all the wheels («ABS»)	Internal auxiliary	Useful
5	Control of braking forces distribution between front and rear wheels of the motor vehicle («EBV»)	Internal auxiliary	Useful
6	Rear wheels sliding control depending on the front wheels («EBV»)	Internal auxiliary	Redundant
7	Motor vehicle stability increase at curved road braking («CBC»)	Internal basic	Useful
8	Wheels slip prevention during the acceleration («ASC»)	Internal auxiliary	Redundant
9	Car «access» system control («ASC»)	Internal auxiliary	Redundant
10	Optimization of the engine traction power control during driving on the road section with poor covering («DTC»)	Internal auxiliary	Useful
11	Differential blocking («DTC»)	Internal auxiliary	Neutral
12	Torque increase in the wheels of the motor vehicle, which are in more favorable adhesion conditions with the road surface («DTC»)	Internal auxiliary	Neutral
13	Prevention of the driving wheels blocking at switching to downshift or at rapid load change («MSR»)	Internal auxiliary	Neutral
14	Automatic pressure increase in the braking system of the motor vehicle («DBC»)	Internal auxiliary	Redundant
15	Readiness of the braking system to operate in emergency case («DBC»)	Internal auxiliary	Redundant
16	Brake drying, increasing the pressure in the braking system («DBC»)	Internal auxiliary	Redundant
17	Compensation of brake efficiency decrease at their heating («DBC»)	Internal auxiliary	Redundant
18	Smooth stop of the motor vehicle («DBC»)	Internal auxiliary	Harmful
19	Assistance at movement from a place («DBC»)	Internal auxiliary	Harmful
20	Compensation of the motor vehicle torques relatively vertical axis («DBC»)	Internal auxiliary	Redundant

Table 2

Matrix of «DSC» system priorities of the motor vehicle «BMW»

№ of the function	Number of the function / Advantage coefficients																				Sum of the advantages coefficients	Absolute priority	Utility factor	Rank of the function
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	29.5	585	0.07971	1
2	0.5	1	1.5	1.5	1.5	1.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	27.5	528	0.07195	3
3	0.5	0.5	1	1.5	1.5	1.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	26.5	501	0.06827	4
4	0.5	0.5	0.5	1	0.5	1.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	24.5	450	0.06133	6
5	0.5	0.5	0.5	1.5	1	1.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	25.5	475	0.06473	5
6	0.5	0.5	0.5	0.5	0.5	1	0.5	1	1.5	0.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	21	372	0.05067	9
7	0.5	1.5	1.5	1.5	1.5	1.5	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	28.5	556	0.07576	2
8	0.5	0.5	0.5	0.5	0.5	1	0.5	1	1.5	0.5	0.5	0.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	19	332	0.04522	12
9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	17.5	303	0.04130	13
10	0.5	0.5	0.5	0.5	0.5	1.5	0.5	1.5	1.5	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	23.5	426	0.05806	7
11	0.5	0.5	0.5	0.5	0.5	1.5	0.5	1.5	1.5	0.5	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	22.5	403	0.05492	8
12	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.5	1.5	0.5	0.5	1	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	19.5	341	0.04641	11
13	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.5	1.5	0.5	0.5	1.5	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	20.5	361	0.04914	10
14	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1.5	1	1	1.5	1.5	1.5	15.5	272	0.03705	14
15	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1.5	1	1.5	1.5	1.5	15	264	0.03596	16
16	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	1	1	1.5	1.5	1.5	14.5	257	0.03500	17
17	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1.5	1.5	1.5	15	265	0.03603	15
18	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1.5	0.5	11.5	216	0.02945	19
19	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	10.5	205	0.02796	20
20	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.5	1.5	1	12.5	228	0.03109	18
Sum																							1	-

Advantage coefficients may have values:

– 1.5 – if the function in the i^{th} row has greater advantage, that the function in j^{th} column ($k_{ij} = 1,5 \rightarrow a_i \succ a_j$);

– 1 – at the same significance of the functions ($k_{ij} = 1 \rightarrow a_i \approx a_j$);

–0.5 – if the function in the i^{th} row has less advantage than the function in the j^{th} column ($k_{ij} = 0,5 \rightarrow a_j \succ a_i$).

Further parameter P_i is found (absolute priority). Parameter P_i is defined as the sum of products of each element of the i^{th} row by the elements of the vector-column Σk_{ij}, i. e. [2, 13]:

$$P_1 = k_{11}\sum k_1 + k_{21}\sum k_2 + ... + k_{1j}\sum k_i + ... + k_{1n}\sum k_n;$$
$$P_2 = k_{21}\sum k_1 + k_{22}\sum k_2 + ... + k_{2j}\sum k_i + ... + k_{2n}\sum k_n;$$
$$\dots \quad (1)$$
$$P_i = k_{i1}\sum k_1 + k_{i2}\sum k_2 + ... + k_{ij}\sum k_i + ... + k_{in}\sum k_n;$$
$$\dots$$
$$P_n = k_{n1}\sum k_1 + k_{n2}\sum k_2 + ... + k_{nj}\sum k_i + ... + k_{nn}\sum k_n.$$

Then utility factor λ of each function is found [1, 15]:

$$\lambda_i = P_i / \Sigma P_i \text{ if } \Sigma\lambda_i = 1. \quad (2)$$

Rank of the function is determined, depending on the value of the utility factor λ. The greater is the utility factor, the higher is the rank of the function.

Having performed the above –mentioned calculations utility diagrams (Fig. 3) and raking (Fig. 4) of the functions of the system «DSC» of the motor vehicles «BMW» relatively utility factor will be constructed.

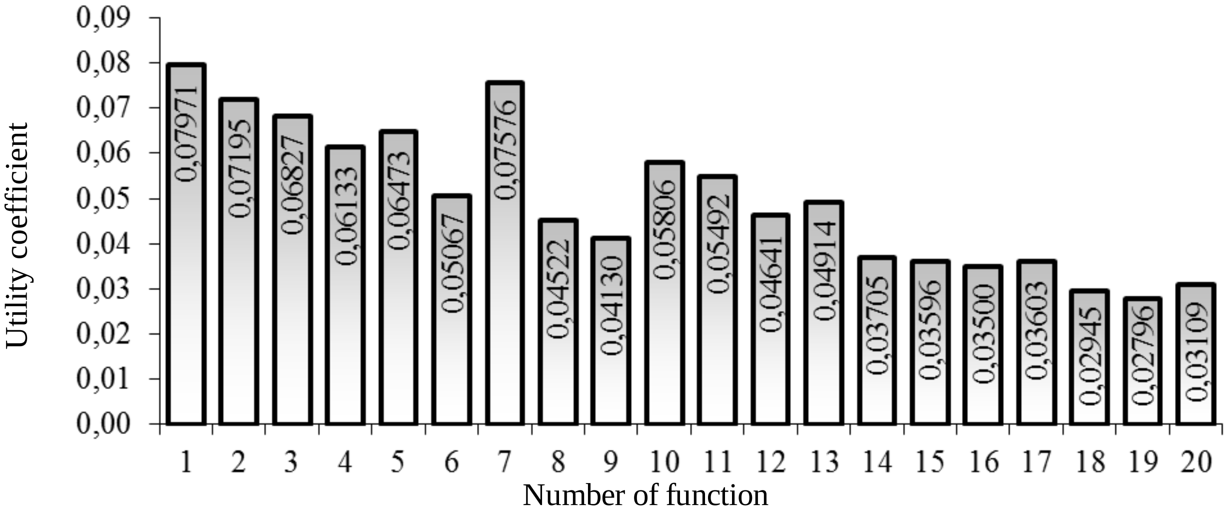

Fig. 3. Utility diagram of the functions of system «DSC» of the motor vehicles «BMW»

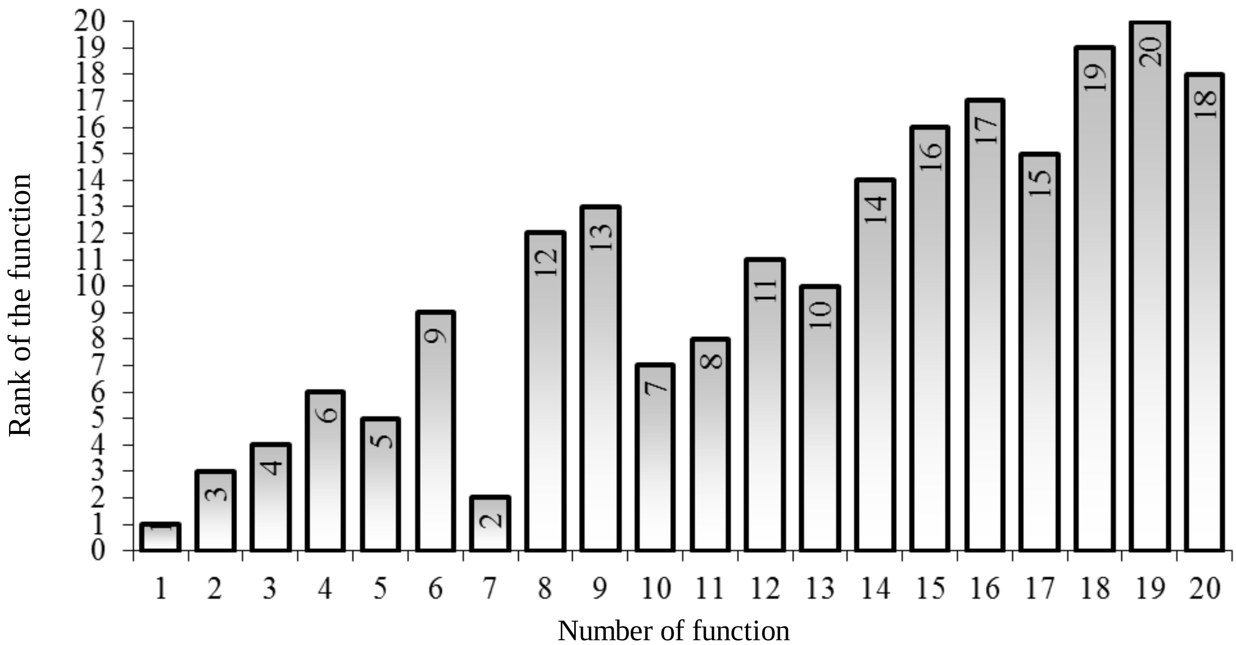

Fig. 4. Ranking diagram of the functions of the system «DSC» of the motor vehicles «BMW» relatively utility factor

Expenses in the process of functional cost analysis act as the payment for the utility. Generalized criterion of the expenses in the process of design of technical or production systems takes into account the expenses at all the stages of the system life cycle, for the assessment of which matrix of expenses is constructed (Table 3), expense ratio is determined by means of this matrix.

At this stage the method of expert assessments, comparison with the «ideal model» are widely used, also the significance level of each function and expenses on it. For this purpose cost factor per function is used, it is calculated by means of comparison of the share of the parameter (function) in the costs to its utility factory.

Cost factor is determined by the following formula [2, 3]:

$$K_i = \varepsilon_i / \lambda_i \text{ if } \Sigma\lambda_i = 1, \Sigma\varepsilon_i = 1, \quad (3)$$

where ε – is the share of the function in the costs.

Table 3

Matrix of function costs of the system «DSC» of the motor vehicles «BMW»

№ of the function	Name of the function	Share of the function in the costs	Utility factor	Cost factor	Rank of the function
1	Motor vehicle motion dynamics control in the longitudinal and transversal directions by means of the impact on its braking mechanism and engine operation («DSC»)	0.121	0.07971	1.518	7
2	Prevention of the motor vehicle wheels blocking during braking («ABS»)	0.005	0.07195	0.069	16
3	Provision of the shorter braking distance and motor vehicle motion stability («ABS»)	0.002	0.06827	0.029	19
4	Regulation of the brake pressure on all the wheels («ABS»)	0.061	0.06133	0.995	9
5	Control of braking forces distribution between front and rear wheels of the motor vehicle («EBV»)	0.061	0.06473	0.942	10
6	Rear wheels sliding control depending on the front wheels («EBV»)	0.052	0.05067	1.026	8
7	Motor vehicle stability increase at curved road braking («CBC»)	0.003	0.07576	0.040	18
8	Wheels slip prevention during the acceleration («ASC»)	0.102	0.04522	2.256	4
9	Car «access» system control («ASC»)	0.011	0.04130	0.266	13
10	Optimization of the engine traction power control during driving on the road section with poor covering («DTC»)	0.015	0.05806	0.258	14
11	Differential blocking («DTC»)	0.101	0.05492	1.839	6
12	Torque increase in the wheels of the motor vehicle, which are in more favorable adhesion conditions with the road surface («DTC»)	0.101	0.04641	2.176	5
13	Prevention of the driving wheels blocking at switching to downshift or at rapid load change («MSR»)	0.011	0.04914	0.224	15
14	Automatic pressure increase in the braking system of the motor vehicle («DBC»)	0.002	0.03705	0.054	17
15	Readiness of the braking system to operate in emergency case («DBC»)	0.001	0.03596	0.028	20
16	Brake drying, increasing the pressure in the braking system («DBC»)	0.111	0.03500	3.171	3
17	Compensation of brake efficiency decrease at their heating («DBC»)	0.019	0.03603	0.527	11
18	Smooth stop of the motor vehicle («DBC»)	0.101	0.02945	3.430	2
19	Assistance at movement from a place («DBC»)	0.009	0.02796	0.322	12
20	Compensation of the motor vehicle torques relatively vertical axis («DBC»)	0.111	0.03109	3.570	1
Sum		1	1	-	-

Share of the function in costs is determined by the formula [2, 3, 14]:

$$\varepsilon_i = \frac{B_i}{\sum_{i=1}^{n} B_i}, \tag{4}$$

where B_i – is the cost of each function; $\sum_{i=1}^{n} B_i$ – is the sum of the costs of all functions of the system.

In theory and practice of functional-cost analysis such criteria are used for the assessment of the cost factor per function [1, 3]:

– cost factor equals «1» or is close to «1» – ration between costs and function is justified;

– cost factor is less than «1» – ratio is favorable;

– cost factor is greater than «1» – measures should be taken to reduce the costs for obtaining function.

Specific procedure of functional-cost analysis is the construction of functional-cost diagrams, which are graphic representation of the ratio between the utility of the functions and costs for their implementation. Construction of functional cost diagrams is performed to reveal the discrepancies of the costs relatively the utility of the function. Functional-cost diagram is constructed for the group of functions, having common peak. In the first guardant utility and significance of the function is shown, in the second-cost per function (Fig. 5).

Having carried out the above-mentioned calculations costs diagram (Fig. 6) and ranking diagram (Fig. 7) of the functions of «DSC» systems of the motor vehicle «BMW» will be constructed relatively the cost factor.

The next stage of functional-cost analysis is determination of functional cost index [2, 13]:

$$\Pi_{\Phi B i} = \lambda_i - K_i. \quad (5)$$

Functional-cost analysis shows to what degree cost part of the operation or function is greater than the useful function. Values of the functional cost indices of the system «DSC» of the motor vehicle «BMW» relatively the cost factor are presented in Table 4.

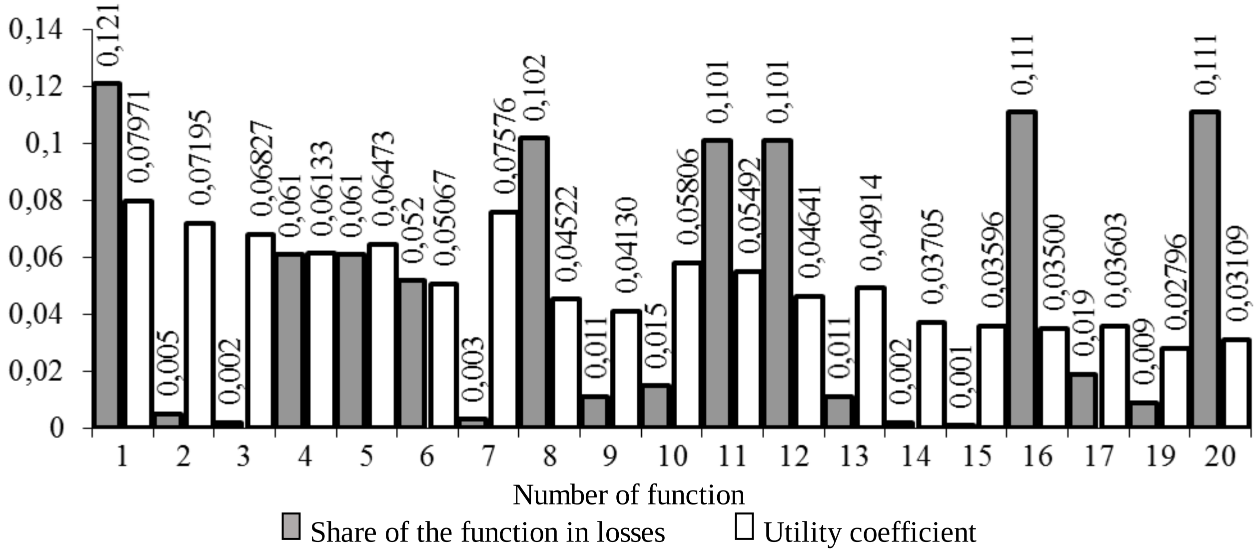

Fig. 5. Functional-cost diagram of the system «DSC» of the motor vehicle «BMW»

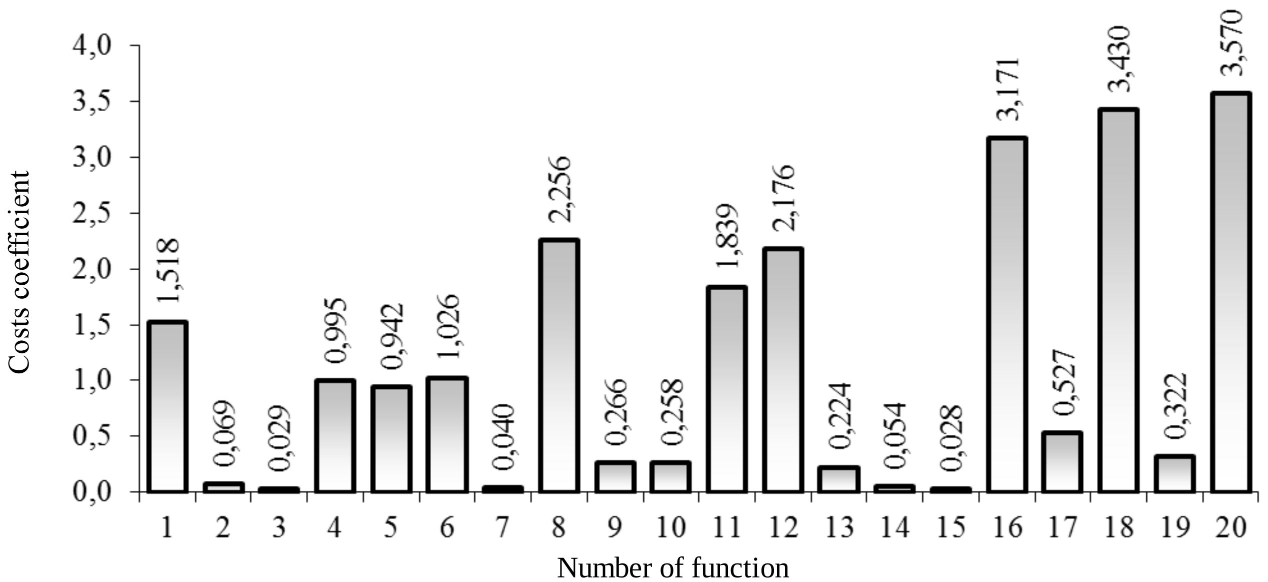

Fig. 6. Diagram of cost functions of the system «DSC» of the motor vehicle «BMW»

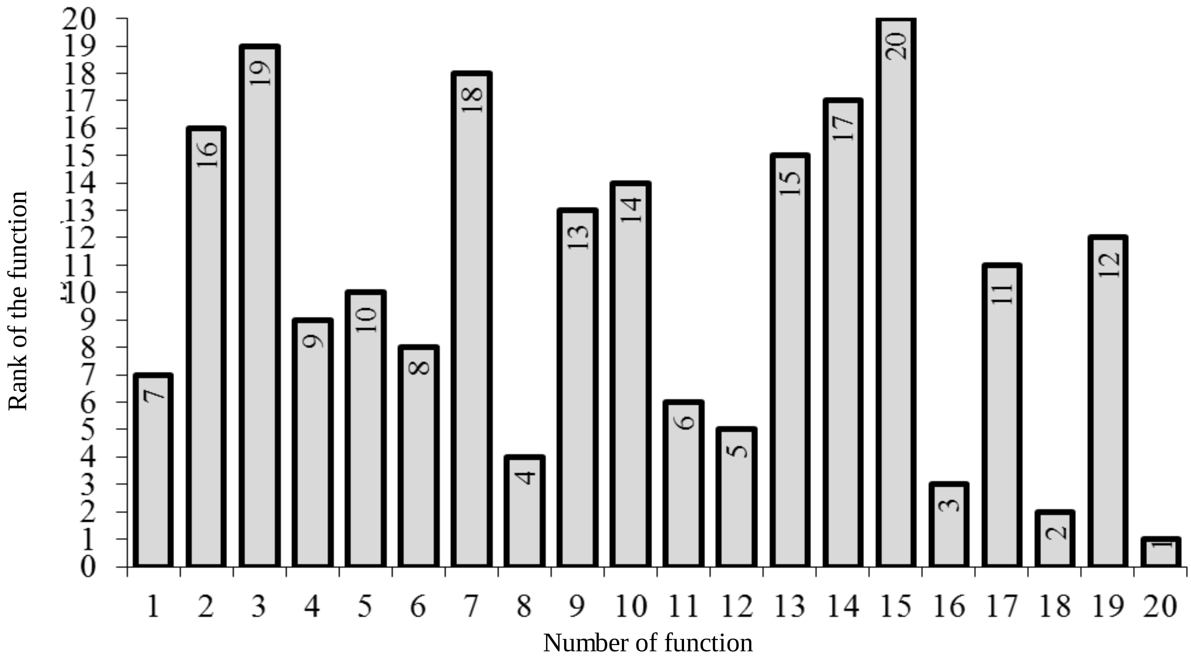

Fig. 7. Diagram of functions ranking of the system «DSC» of the motor vehicle «BMW» relatively cost factor

From economic point of view it is expedient to develop functions with positive functional-cost index.

Having performed the above-mentioned calculations, the diagrams of the values of functional-cost indices (Fig. 8) and ranking (Fig. 9) of the functions will be constructed of the system «DSC» of the motor vehicle «BMW» relatively functional cost index.

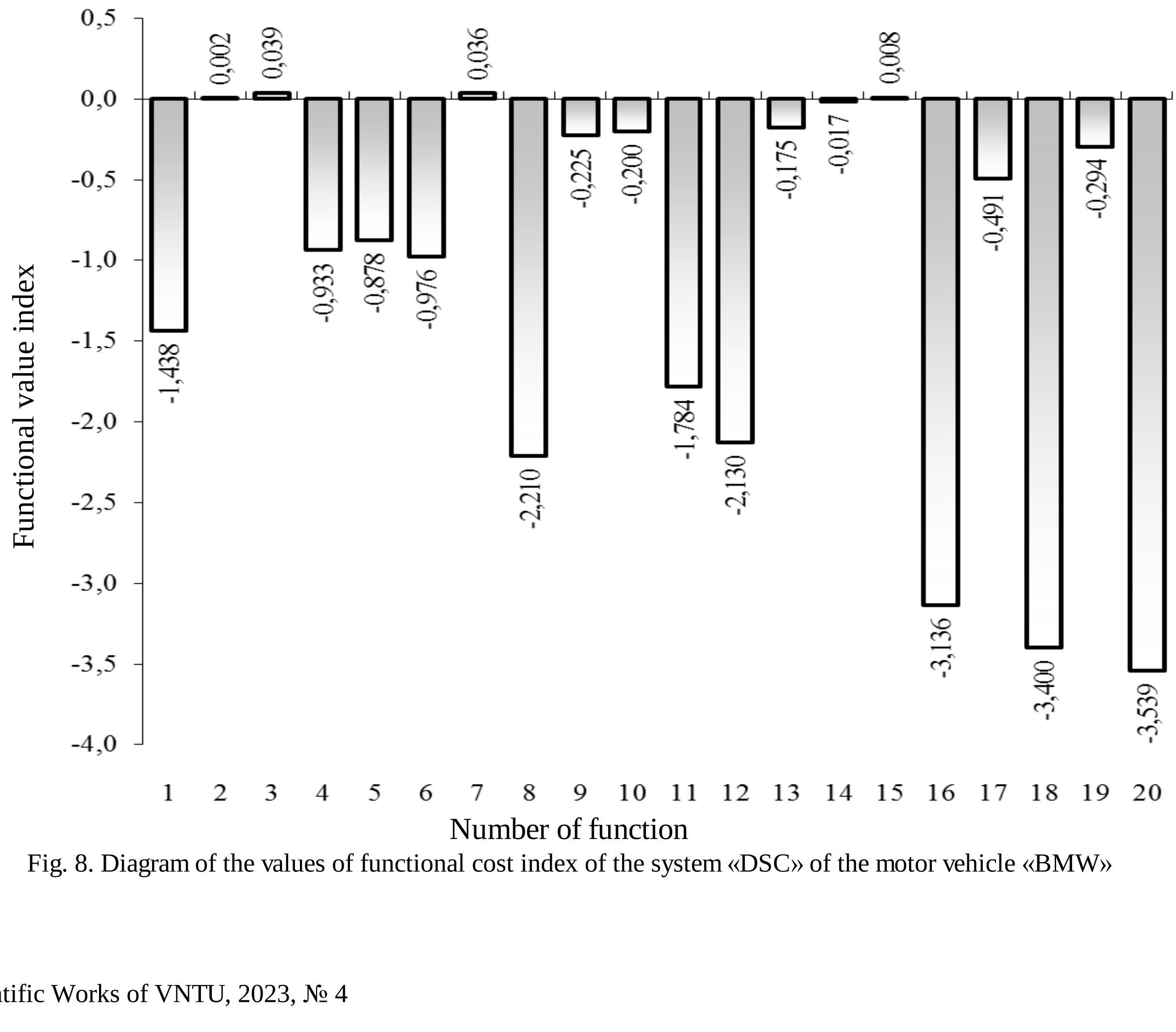

Fig. 8. Diagram of the values of functional cost index of the system «DSC» of the motor vehicle «BMW»

Table 4

Values of the functional-cost indices of the functions of the system «DSC» of the motor vehicle «BMW»

№ of the function	Name of the function	Functional-cost index	Rank of the function
1	Motor vehicle motion dynamics control in the longitudinal and transversal directions by means of the impact on its braking mechanism and engine operation («DSC»)	-1.438	14
2	Prevention of the motor vehicle wheels blocking during braking («ABS»)	0.002	4
3	Provision of the shorter braking distance and motor vehicle motion stability («ABS»)	0.039	1
4	Regulation of the brake pressure on all the wheels («ABS»)	-0.933	12
5	Control of braking forces distribution between front and rear wheels of the motor vehicle («EBV»)	-0.878	11
6	Rear wheels sliding control depending on the front wheels («EBV»)	-0.976	13
7	Motor vehicle stability increase at curved road braking («CBC»)	0.036	2
8	Wheels slip prevention during the acceleration («ASC»)	-2.210	17
9	Car «access» system control («ASC»)	-0.225	8
10	Optimization of the engine traction power control during driving on the road section with poor covering («DTC»)	-0.200	7
11	Differential blocking («DTC»)	-1.784	15
12	Torque increase in the wheels of the motor vehicle, which are in more favourable adhesion conditions with the road surface («DTC»)	-2.130	16
13	Prevention of the driving wheels blocking at switching to downshift or at rapid load change («MSR»)	-0.175	6
14	Automatic pressure increase in the braking system of the motor vehicle («DBC»)	-0.017	5
15	Readiness of the braking system to operate in emergency case («DBC»)	0.008	3
16	Brake drying, increasing the pressure in the braking system («DBC»)	-3.136	18
17	Compensation of brake efficiency decrease at their heating («DBC»)	-0.491	10
18	Smooth stop of the motor vehicle («DBC»)	-3.400	19
19	Assistance at movement from a place («DBC»)	-0.294	9
20	Compensation of the motor vehicle torques relatively vertical axis («DBC»)	-3.539	20

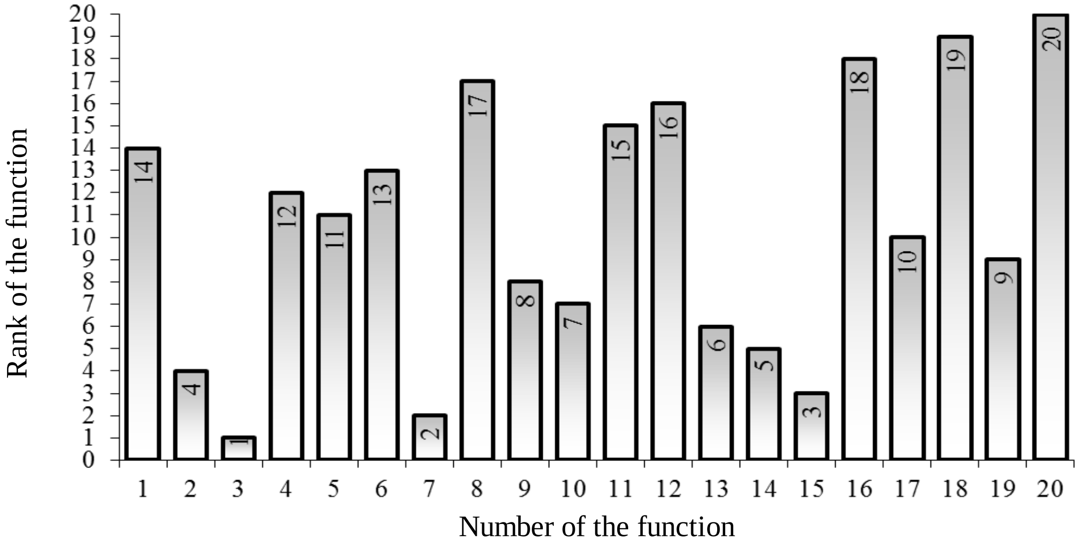

Fig. 9. Diagram of functions of the system «DSC» ranking of the motor vehicle «BMW» relatively functional cost index

According to the diagrams functions (Fig. 8 and 9) having positive functional-cost index and the highest rating of the considered functions, are determined. Operations or functions, having the greatest index and rank are the operations, improvement of which leads to further development of the system or achievement of the objective of the analysis.

Conclusion

1. Functional-cost analysis of the system «DSC» of the motor vehicle «BMW», carried out showed that the highest rank and the greatest functional cost index has function №1 «Motion dynamics control of the motor vehicle in the longitudinal and transversal directions by means of the impact on its braking mechanism and engine operation» the base of this is put main task of the developed technical system.

2. By the results of the calculation of functional-cost indices of the system «DSC» of the motor vehicles «BMW» the conclusion can be made that function №3 «Provision of the shorter brake distance and stability of the motor vehicle motion» and №7 «Increase of the stability of the motor vehicle at braking in the process of turn passage» are the functions, the improvement of which lead to further development of the system.

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