

FUNCTIONAL STRUCTURE GENERATION WITHIN MULTI-STRUCTURED MATRIX FORMS

Mirko Karakašić, Žiga Zadnik, Milan Kljajin, Jože Duhovnik

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This paper aims at showing the possibility of improving the initial phase of design process using the matrix function multi-structured form of products and their requests. The developed matrix model is a tool which by using a mathematical model interconnects functions and technical systems that solve them. This is one of the main differences with regard to morphological matrix. By mutual linking of matrices the matrix structure is generated in which the whole functional structure of a product is stored. For the sake of uniformity the functions are described by parameters defined from physical laws. In this way the complete knowledge about a product is registered in matrices enabling the generation of the variant and new products. The model is implemented into a prototype computer Web application with the central relational data base. A higher quality, faster and cheaper management of the design process is thus made possible.

Keywords: *conceptual design, design process, functional matrix, functional modelling, functionality matrix, matrix structure*

Generiranje funkcijske strukture unutar više-strukturnih matričnih oblika

Izvorni znanstveni članak

Cilj ovoga rada je prikazati mogućnost poboljšanja inicijalne faze konstrukcijskog procesa korištenjem više-strukturnog oblika matrice funkcije proizvoda i njihovih zahtjeva. Razvijeni matrični model je alat koji korištenjem matematičkog modela dovodi u međusobne odnose funkcije i tehničke sustave koji ih rješavaju. To je jedna od bitnih razlika u odnosu na morfološku matricu. Međusobnim povezivanjem matrica generira se matrična struktura u kojoj je pohranjena cjelokupna funkcijska struktura proizvoda. Kako bi se postigla jednoznačnost, funkcije su opisane parametrima određenim iz fizikalnih zakona. Ovako je u matricama popisano cjelokupno znanje o proizvodu koje omogućuje generiranje varijantnih i novih proizvoda. Model je implementiran u prototipnu računalnu Web aplikaciju s centralnom relacijskom bazom podataka. Na ovakav način omogućeno je kvalitetnije, brže i jeftinije vođenje konstrukcijskog procesa.

Ključne riječi: *koncipiranje, konstrukcijski proces, funkcijska matrica, modeliranje pomoću funkcija, matrica funkcionalnosti, matrična struktura*

1 Introduction

Uvod

In a design process products can be described by the requests of users, the requirements of design, functional structures, sketches and technical drawings [1]. The complexity, one of the main problems of conceptual design [2], is included into the modelling and representation of a design solution. To represent a design solution in its conceptual phase, *the representation of function* and *the representation of form* are of particular importance.

The meaning of function can be explained in different ways [3]. According to [4] a function can be defined as the conversion of energy, material and information from the input into the output state. By a decomposition procedure the overall function of a product can be decomposed to partial functions necessary for the performance of the main function. The authors in [4] use "black box" in order to decompose the overall function to partial functions. A product description by a function generates the product functional structure. The functional structure can be represented in different ways. One of the ways is by graphs. This method is called graph grammar [5, 6]. Chakrabarti and Blessing [7] identify three ways of the function representation: verb-noun representation, input-output flow transformations and input-output state transformations. Žavbi [8] describes functions by the chaining of physical laws.

To achieve standardization when modelling by functions a standard dictionary called the basics of functions is needed. The dictionary compiles a list of functions of 130 electro-mechanical devices. The works [10] generate the product conceptual variants by using design generated functions, Design repository, based on the

previously mentioned method. In [11] the rules are defined on how to list the product functions. These rules are applied in defining the functions listed in the matrix model presented in the present paper. The starting point for defining these rules was found in the rules developed by Duhovnik [12]. The rules given in [11] do not refer to electromechanical devices only [9] but to all types of products.

A design process sets out to connect functions with physical principles and the structure that should enable the realization of the desired function. The interaction of function and form is based on functional requirements and requests, defined descriptively and graphically. Descriptive requests are defined by function. Graphical requests are defined as a conceptual model or a known technical system.

To interconnect functions and technical systems numerous tools are used, among other things matrix methods like morphological matrix [13] design matrix [14] and the house of quality [15]. The matrix that would enable a transparent design process should be defined based on a precisely defined mathematical model and unambiguous rules, not on the intuition of a designer only. A drawback of a morphological matrix is that with a small number of rows and columns it offers a great number of solutions which are often wrong. The developed model of the second structural form of the function matrix of products and their requests, presented in this paper, aims at correcting the drawbacks of the morphological matrix in the following fields: mathematically conceived model correlating functions and known technical systems (functionalities), function description by means of parameters, sub-matrix characteristic and the possibility of organizing the matrix rows and columns. The rows and columns of a matrix can be enlarged to infinity and there are no limits to the matrix expansion. By correlating this model with the model of the first structural form of the function matrix of products and

TECHNICAL SYSTEM	FUNCTION	DESCRIPTION	PARAMETERS	WINNING PARAMETERS	FUNCTIONALITY													
					TS1						TSe							
					PARTIAL						PARTIAL							
					M	M	S	A	B	M	M	S	A	B				
WP _{TS1} M1	MI _{TS1} BB1	MI _{TS1} BBj	SI _{TS1} BBj	Sk _{TS1} BBj	AI _{TS1} BBj	Ak _{TS1} BBj	BI _{TS1} BBj	Bk _{TS1} BBj	WP _{TSe} M1	MI _{TSe} BB1	MI _{TSe} BBj	SI _{TSe} BBj	Sk _{TSe} BBj	AI _{TSe} BBj	Ak _{TSe} BBj	BI _{TSe} BBj	Bk _{TSe} BBj	
PARTIAL	M	MI _{TS1}	PM _{TS1} M1	WP _{TS1} M1	+													
	M	MI _{TS1} BB1	PM _{TS1} BB1M1	WP _{TS1} BB1M1	+	+												
		MI _{TS1} BBj	PM _{TS1} BBjM1	WP _{TS1} BBjM1	+	+												
	S	SI _{TS1} BBj	PS _{TS1} BBjS1	WP _{TS1} BBjS1			+											
		Sk _{TS1} BBj	PS _{TS1} BBjSk	WP _{TS1} BBjSk				+										
	A	AI _{TS1} BBj	PA _{TS1} BBjA1	WP _{TS1} BBjA1					+		+							
		Ak _{TS1} BBj	PA _{TS1} BBjAk	WP _{TS1} BBjAk							+							
	B	BI _{TS1} BBj	PB _{TS1} BBjB1	WP _{TS1} BBjB1						+								+
Bk _{TS1} BBj		PB _{TS1} BBjBk	WP _{TS1} BBjBk															
M	MI _{TSe}	PM _{TSe} M1	WP _{TSe} M1															
PARTIAL	M	MI _{TSe} BB1	PM _{TSe} BB1M1	WP _{TSe} BB1M1							+							
		MI _{TSe} BBj	PM _{TSe} BBjM1	WP _{TSe} BBjM1								+						
	S	SI _{TSe} BBj	PS _{TSe} BBjS1	WP _{TSe} BBjS1									+					
		Sk _{TSe} BBj	PS _{TSe} BBjSk	WP _{TSe} BBjSk										+				
	A	AI _{TSe} BBj	PA _{TSe} BBjA1	WP _{TSe} BBjA1											+			
		Ak _{TSe} BBj	PA _{TSe} BBjAk	WP _{TSe} BBjAk												+		
	B	BI _{TSe} BBj	PB _{TSe} BBjB1	WP _{TSe} BBjB1														+
		Bk _{TSe} BBj	PB _{TSe} BBjBk	WP _{TSe} BBjBk														

Figure 1 Model of the second structural form of the function matrix of products and their requests
Slika 1. Model drugog strukturnog oblika matrice funkcije proizvoda i njihovih zahtjeva

their requests [11, 16, 17], the matrix structure of products is generated. The matrix structure stores the complete functional structure of products, the description of functions by parameters as well as the links between functions and functionalities that solve them. By using the developed matrix models the knowledge about existing products, stored in the matrix, can serve as a basis for a quicker, better quality development of completely new products.

The matrix models have been implemented in a prototype computer system with a central relational data base. The idea is to thus lower the costs during the design process, shorten the duration of the process and improve the management of the process itself.

2 Methods
Metode

2.1 The second structural form of product function matrix and its requests

Drugi strukturni oblik matrice funkcije proizvoda i njihovih zahtjeva

The second structural form of the product function matrix and its requests is at the levels that are above the last level of the product matrix structure. The last matrix level consists of the first structural forms of the function matrices

of products and their requests [11, 16]. The first structural form matrices get connected into new matrices that form the second structural form of the function matrix of products and their requests. By correlating matrices the matrix structure is obtained. The matrix structure model will be explained in detail in the text that follows.

Products at different levels form a system. The way the system is generated is shown in [11]. Higher levels of the listed system consist of other structural forms of the function matrices of products and their requests. The functionalities in the second structural form matrices consist of the matrices from the matrix structure lower levels of the indexed system. In the representation of the model of the second structural form of the function matrix of products and their requests (Fig. 1), the names of technical systems are represented by general symbols. The symbol TSe is the name of one of the technical systems from the lower level of the matrix structure, where e=1,...,f in addition to forming part of the name, also represents the number of the technical systems that some of the matrices consist of.

The main, supplementary, auxiliary and binding functions of the structural elements that constitute the functionalities of the matrices at the lower level of matrix structure become partial functions in the function matrices of products and their requests of the second structural form. The partial functions are grouped into four types of functions within each of the technical systems they belong

to [11].

The names of functions in the illustration of the second structural form model (Fig. 1) are generalized. The TSe technical system's name of the main function is presented by the symbol $M1_{TSe}$. The index TSe denotes the technical system a particular main function belongs to.

The names of partial functions for the TSe technical system are represented by the following symbols: partial main functions: $M1_{TSeBB1}, M1_{TSeBB2}, \dots, M1_{TSeBBj}$; partial supplementary functions: $S1_{TSeBB1}, \dots, Sk_{TSeBB1}, \dots, S1_{TSeBBj}, \dots, Sk_{TSeBBj}$; partial auxiliary functions: $A1_{TSeBB1}, \dots, Ak_{TSeBB1}, \dots, A1_{TSeBBj}, \dots, Ak_{TSeBBj}$; partial binding functions: $B1_{TSeBB1}, \dots, Bk_{TSeBB1}, \dots, B1_{TSeBBj}, \dots, Bk_{TSeBBj}$. The meanings of particular indices are explained in [18].

The parameters by which each function is described are listed in the matrix. Thus every technical system has its main function which is described by the partial main functions at the lower matrix level. All the parameters of the main partial functions at the matrix structure lower level describe the technical system's main function. The winning parameters of these functions are the winning parameters of the technical system's main function. In this way the more complex main functions at the matrix structure higher levels are unambiguously determined by the parameters of the main functions at the matrix structure lower levels. So the link is made between the higher level main functions and the lower level partial main functions. By their parameters the lower level functions thus determine the more complex main functions at higher levels of the functional and matrix structure.

2.1.1

Correlation of functions and technical systems within matrix

Povezivanje funkcija i tehničkih sustava unutar matrice

Within every column that forms a technical system there are two columns called: *M* and *partial* (Fig. 1). The *M* column for the technical system denoted TSe contains a set of all winning parameters of the main function M1 belonging to the technical system of the same name. The following is valid for the TSe technical system:

$$WP_{TSeM1} = \{WP_{TSeBB1M1}, WP_{TSeBB2M1}, \dots, WP_{TSeBBjM1}\}, \quad (1)$$

$e = 1, \dots, f; j = 1, \dots, m.$

where is:

WP_{TSeM1} – a set of all winning parameters of the main function M1, of the *e*-th technical system Tse,

$WP_{TSeBBjM1}$ – a set of winning parameters of the main function M1, of the *j*-th structural element BB*j*, of the *e*-th technical system TSe.

Then every set WP_{TSeM1} is a subset PM_{TSeM1} as it contains only those parameters from PM_{TSeM1} which are the winning parameters. The following can be written:

$$WP_{TSeM1} \subset PM_{TSeM1}, \quad (2)$$

$$PM_{TSeM1} = \{PM_{TSeBB1M1}, PM_{TSeBB2M1}, \dots, PM_{TSeBBjM1}\}, \quad (3)$$

$e = 1, \dots, f; j = 1, \dots, m.$

$$PM_{TSeBBjM1} = \{P_{TSeBBjM11}, P_{TSeBBjM12}, \dots, P_{TSeBBjM1i}\}, \quad (4)$$

$i = 1, \dots, n,$

where is:

PM_{TSeM1} – a set of all parameters of the main function M1, of the *e*-th technical system Tse,

$PM_{TSeBBjM1}$ – a set of all parameters of the main function M1, of the *j*-th structural element BB*j*, of the *e*-th technical system Tse,

$P_{TSeBBjM1i}$ – the *i*-th parameter of the main function M1, of the *j*-th structural element BB*j*, of the *e*-th technical system TSe.

The column denoted *partial* contains the partial main, supplementary, auxiliary and binding functions for every technical system (Fig. 1). The text that follows presents the way the partial supplementary functions are interconnected by means of winning parameters. The analogy applies to the partial auxiliary, binding and main functions [18]. For the partial supplementary function *Sk* of the structural element BB*j* of the technical system TSe the following is valid:

$$WP_{TSeBBjSk} \subset PS_{TSeBBjSk}, \quad (5)$$

$$PS_{TSeBBjSk} = \{P_{TSeBBjSk1}, P_{TSeBBjSk2}, \dots, P_{TSeBBjSk i}\}, \quad (6)$$

$i = 1, \dots, n; k = 1, \dots, p; j = 1, \dots, m; e = 1, \dots, f,$

where is:

$WP_{TSeBBjSk}$ – a set of winning parameters of the *k*-th supplementary function *Sk*, of the *j*-th structural element BB*j*, of the *e*-th technical system Tse,

$PS_{TSeBBjSk}$ – a set of parameters of the *k*-th supplementary function *Sk*, of the *j*-th structural element BB*j*, of the *e*-th technical system Tse,

$P_{TSeBBjSk i}$ – the *i*-th parameter of the *k*-th supplementary function *Sk*, of the *j*-th structural element BB*j*, of the *e*-th technical system Tse.

The set of winning parameters $WP_{TSeBBjSk}$ of the supplementary function *Sk* is a subset of the set of parameters $PS_{TSeBBjSk}$ of the supplementary function *Sk* of the same name because it is formed of only those parameters that are selected from $PS_{TSeBBjSk}$ as the winning parameters in $WP_{TSeBBjSk}$. For every supplementary function within the technical system TSe and individual structural element BB*j*, the values for *p* and *i* need not be the same. Thus every structural element can have a different number of supplementary functions that it solves. A supplementary function within every particular structural element can have a different number of parameters that describe it.

The connections between functions and technical systems within the function matrix of products and their requests are represented by the binding links placed in the matrix fields. If the connection between the function and the technical system is not realized, the matrix fields are empty. The binding links are of two types, interconnected in two ways [11, 16]. For the interconnection between the partial main, supplementary, auxiliary and binding functions to be realized for every technical system, the winning parameters of each particular function are to be equal to the winning parameters of the functions that describe the technical systems. These technical systems (functionalities) are stored in the relational data base of the computer application. The link is established by a binding link that makes the interconnection within the matrix possible. The binding link can be on the matrix main diagonal and off the diagonal, correlating technical systems by means of the mutual partial binding functions. The connection between the main function and the technical system that solves it is

made by the binding link of the same name. The winning parameters of the main function consist of the winning parameters of all the partial main functions that describe the main function of the technical system [18].

Connection towards other matrices at the same level and towards the matrices at other levels is established by the binding links which are on the main diagonal of the matrices only. This is where the interconnection is made between the technical systems that are within other function matrices of products and their requests of the second structural form. These binding links are transferred from the lower level matrix structure matrices to the higher level matrices [18].

The second structural form matrix of products and their requests is square and not completely diagonal due to the fields within which are established the binding links that are off the main diagonal. The matrix is composed of sub-matrices. The functions and the technical systems that solve them are correlated within the sub-matrices. The sub-matrices are positioned along the matrix main diagonal.

2.2 Product matrix structure building model

Model gradnje matrice strukture proizvoda

Matrix structure is composed of the first and the second structural forms of the function matrices of products and their requests. The matrices are organized by levels and interconnected by binding links for linking towards matrices at the same level and towards matrices at other levels [11, 16].

Matrix structure for a listed product is generated from the product detailed functional structure [18]. The detailed functional structure is a starting point for the generation of the product matrix structure. Besides, the detailed functional structure is the input into the first and the second structural form of the function matrix of products and their requests. The first and the second structural forms are generated from the input lists of solutions [18].

The total number of matrix structure levels corresponds by analogy to the total number of levels of the product's detailed functional structure. Matrix structure is built from bottom to top, the same as the detailed functional structure of the product.

Figure 2 shows the product's matrix structure building model by both structural forms of function matrices of products and their requests. The model represents the building up of the system starting from the *assembly* level. The analogy is also valid for the system started to be built from the level *object* or *device* [18]. In that case total number of levels of a detailed functional or matrix structure would be greater.

Each function matrix of products and their requests at any level within the matrix structure has its name. The matrix name is analogous to the name of the input list of solutions, used to supply the matrix with the functions and technical systems that solve them. As the name of the matrix represents the listed technical system analogous to the name of the input list of solutions in a detailed functional structure, beside the name the matrix is also described by the name of the main function of the listed technical system as well as by the number of the level the matrix is at in the matrix structure of the listed product (Fig. 2).

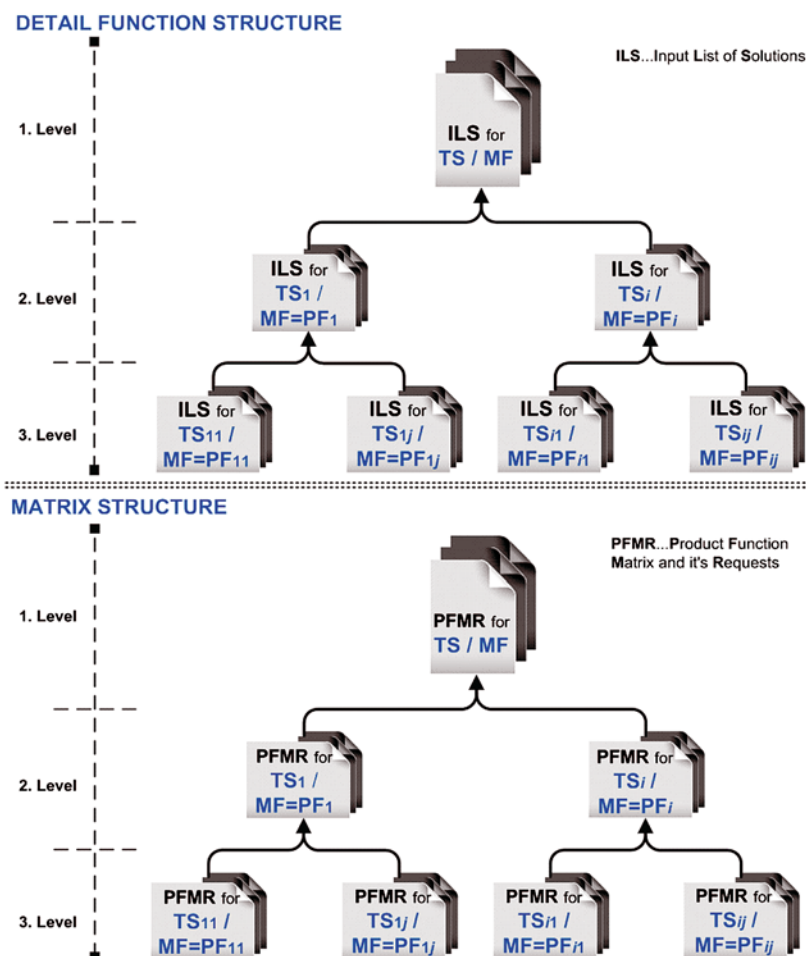


Figure 2 Product matrix structure building model
Slika 2. Model gradnje matrice strukture proizvoda

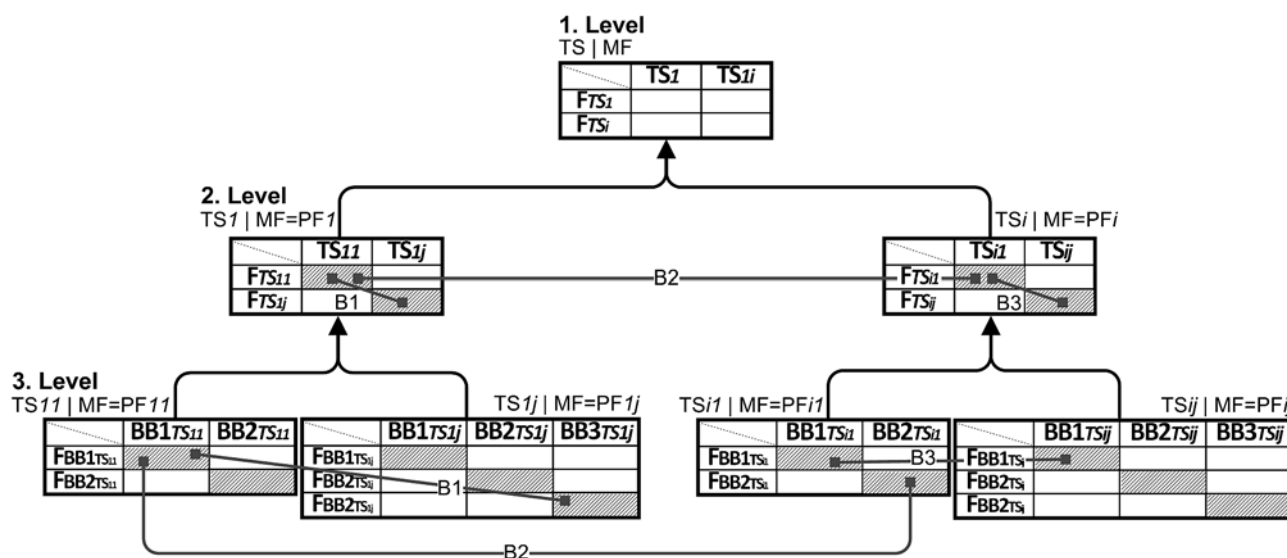


Figure 3 Interconnection of function matrices of products and their requests into the matrix structure
Slika 3. Povezivanje matrica funkcije proizvoda i njihovih zahtjeva u matičnu strukturu

2.2.1

General example of modelling the system assembly matrix structure

Opći primjer modela gradnje matične strukture sustava sklop

In (Fig. 3) a general scheme of the listed product matrix structure is illustrated. The product is structured starting with the level *assembly* and it forms a system which has three levels in a detailed functional structure (Fig. 2). Therefore the matrix structure too, deriving from detailed functional structure, has three levels.

At the matrix structure third level are the first structural forms of the function matrices of products and their requests. The listed functions in these matrices are solved by the simplest technical systems (structural elements). As the listed product is structured starting with the level *assembly* structural elements are composed of *element* and *part* [11, 18]. At the matrix structure first and second level are the other structural forms of the function matrices of products and their requests.

Within the matrix fields can be seen the links (binding links) between functions and technical systems that solve them and the links between technical systems within one matrix and technical systems within other matrices [11, 16]. By the binding links toward other matrices at the same level and toward matrices at other levels the matrix structure is generated of the product that is being listed.

Interconnection between matrices at the same level and matrices at different levels of the product matrix structure is shown by the binding links B1, B2 and B3. The binding links for connection toward other matrices at the same level and toward matrices at other levels are on the main diagonal of the matrices only.

3

Results and discussion

Rezultati i diskusija

In order to illustrate the application of the described theoretical bases of the developed models in practice, a computer Web application was developed. The application is of modular structure and contains several modules. The

matrix model and the product matrix structure building model are implemented in one of the modules. In the relational data base several products are listed by functions. To demonstrate the model application the Suction unit was selected as a product (Fig. 9). This paper along with the papers [11, 16, 17] gives a detailed account of the whole functional structure of the suction unit stored in the matrix structure. Due to the product complexity only some matrices are represented in the paper.

3.1

The Suction unit matrix structure

Matična struktura Usisne jedinice

The matrices shown in Figures 4, 5 and 6 have been generated by means of a computer Web application in which simple technical systems (structural elements) are functionally described. The access to the matrix and its structuring is made possible by means of a developed Web interface.

The Suction unit consists of three levels of matrix structure (Fig. 8). The text that follows shows two matrices from the second level named Turbo-blower and Casing. The Turbo-blower matrix (Fig. 4) consists of two matrices of the first structural form from the third level of the matrix structure: Blower and Diffuser. These two matrices are the more complex technical systems which by their functions solve the main function of the Turbo-blower matrix. By the binding functions at the third level the Blower and Diffuser matrices are interconnected into a mutual Turbo-blower matrix thus forming two sub-matrices of this matrix.

By its physical form the Casing matrix (Fig. 5) takes the second structural form of the function matrix of products and their requests at the second level of the matrix structure. At the third level of the matrix structure this matrix has the first structural form. The reason for this is in the fact that at the third level of the matrix structure this matrix consists of the structural elements listed from the data base so that it is in fact the matrix of the first structural form. Its structural elements are connected with the first structural form matrices by binding functions and then through these binding functions they are also linked toward the matrices at the second level of the matrix structure. Therefore the computer application automatically raises the Casing

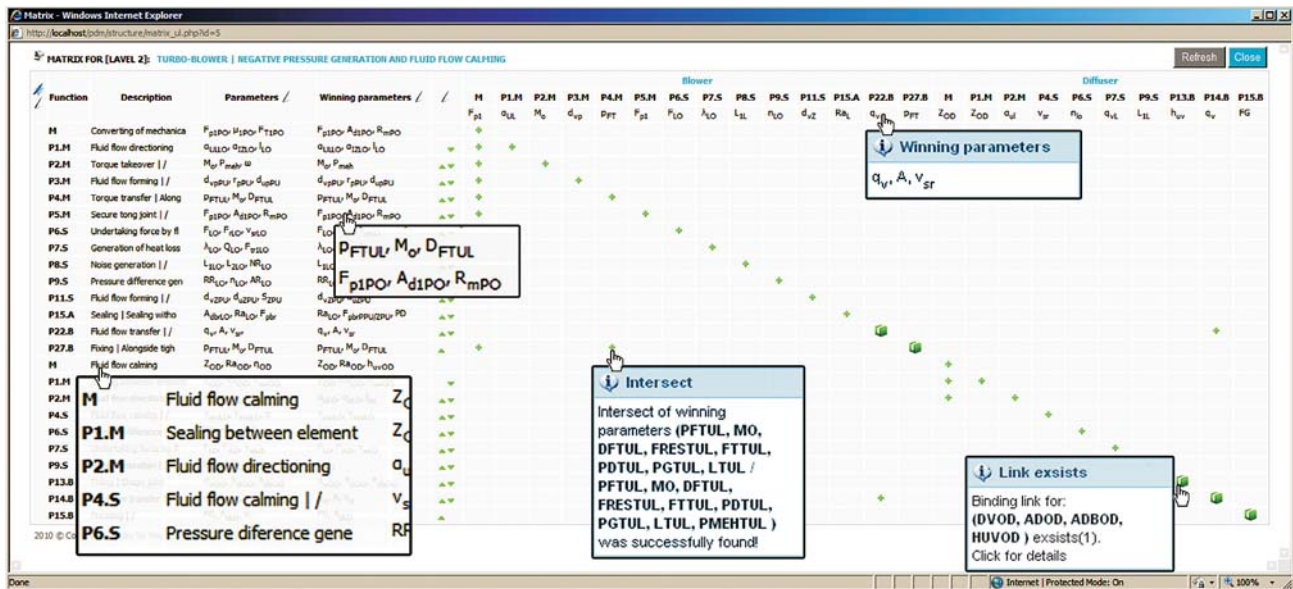


Figure 4 The Turbo-blower matrix
Slika 4. Matrica Turbo-puhalo

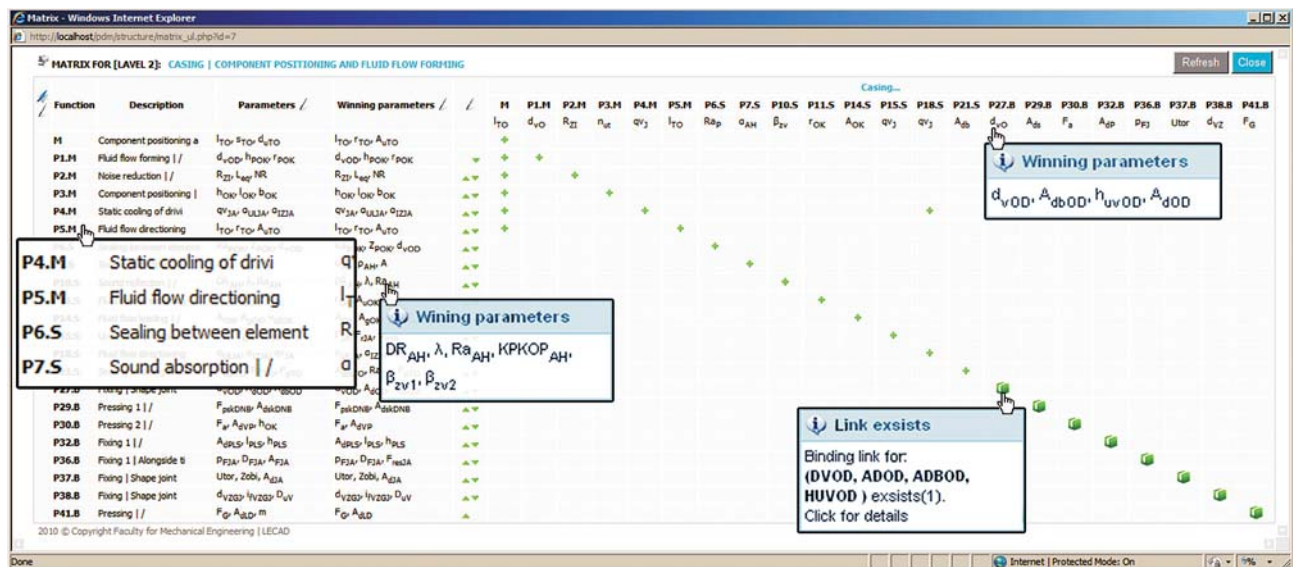


Figure 5 The Casing matrix
Slika 5. Matrica Kučište

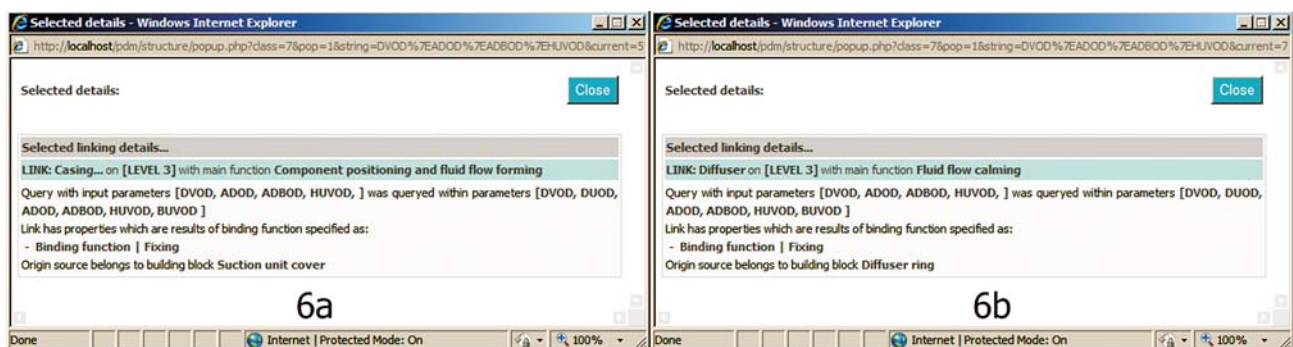


Figure 6 a – Binding link between the Turbo-blower matrix and the Fixing function of the Casing matrix; b – binding link between the Casing matrix and the Fixing function of the Turbo-blower matrix
Slika 6. a – Poveznica matrice Turbo-puhalo s matricom Kučište funkcijom Fiksiranje; b – Poveznica matrice Kučište s matricom Turbo-puhalo funkcijom Fiksiranje

matrix from the third into second level of the matrix structure and by its form and properties transforms it into the matrix of the second structural form. That is why the Casing matrix has only one sub-matrix of the same name.

The Turbo-blower matrix is linked with the Casing matrix by two binding functions. These binding functions are both located within the Diffuser sub-matrix. The names of these functions are *Fixing* and *Pressing* (Fig. 4). By

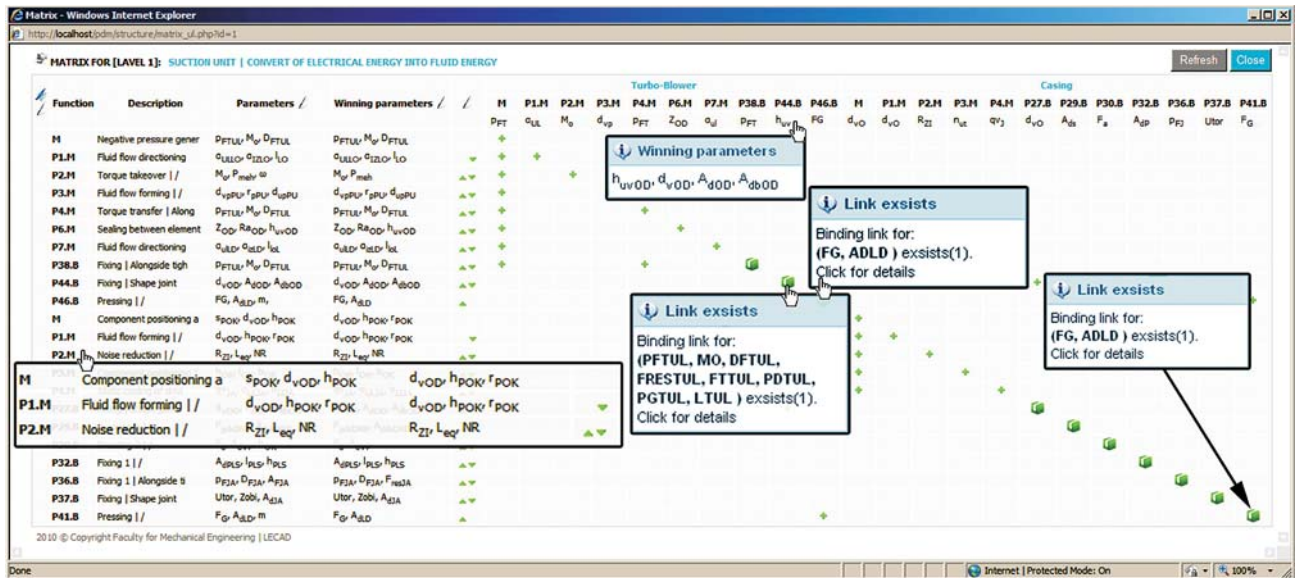


Figure 7. Part of the Suction unit matrix
Slika 7. Dio matrice Usisna jedinica

opening the binding link *Fixing* within the sub-matrix Diffuser the link leads into the matrix Casing, its binding function *Fixing*. In the matrix Casing this function is solved by the building element Suction unit cover (Fig. 6a). By analogy, by opening the binding link *Fixing* within the matrix Casing (Fig. 5) the link leads into the matrix Turbo-blower to the binding function *Fixing*. This function is solved by the building element Diffuser ring (Fig. 6b). The same analogy applies for the binding link *Pressing*.

The matrices that form the Suction unit matrix at the first level are the matrices from the matrix structure second level. These matrices form sub-matrices within the matrix, illustrated in Fig. 7. The two matrices from the matrix structure second level, Turbo-blower and Casing, can be observed in the matrix. Each sub-matrix in the Suction unit matrix is at the same time the functionality that solves a particular function listed in the matrix.

Fig. 8 illustrates the overall matrix structure of the suction unit in the way it is generated by the computer application. The matrices coloured blue represent the part of the matrix structure outlined in this work. At its level every matrix has its main function (MF) solved by two partial

functions (PF). The partial functions from a higher level of matrix structure become main functions of the matrices at a lower level of the matrix structure. The procedure is repeated up to the last level of the matrix structure. The partial functions from the last level are solved by the building elements listed in the data base.

3.2 Product design structure Oblikovna struktura proizvoda

Fig. 9 illustrates the design (physical) structure of the suction unit. The structure is generated from the previously designed matrix structure of the suction unit (Fig. 8). From the hierarchy tree the correlation between the matrices and sub-matrices can be observed quite in accordance with the previously generated matrix structure.

The paper [11] outlines the criteria on how to define a product. When a product design structure is represented the structure is defined according to the second criterion. The design structure of the suction unit illustrated by the

Matrix structure of Suction unit

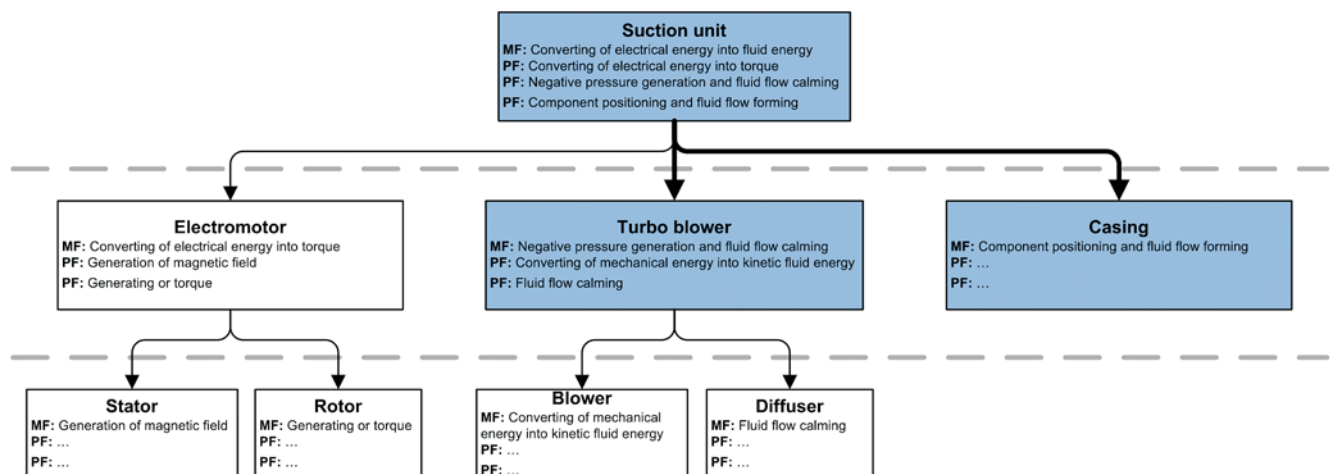


Figure 8 Illustration of the Suction unit matrix structure
Slika 8. Prikaz matricne strukture Usisna jedinica

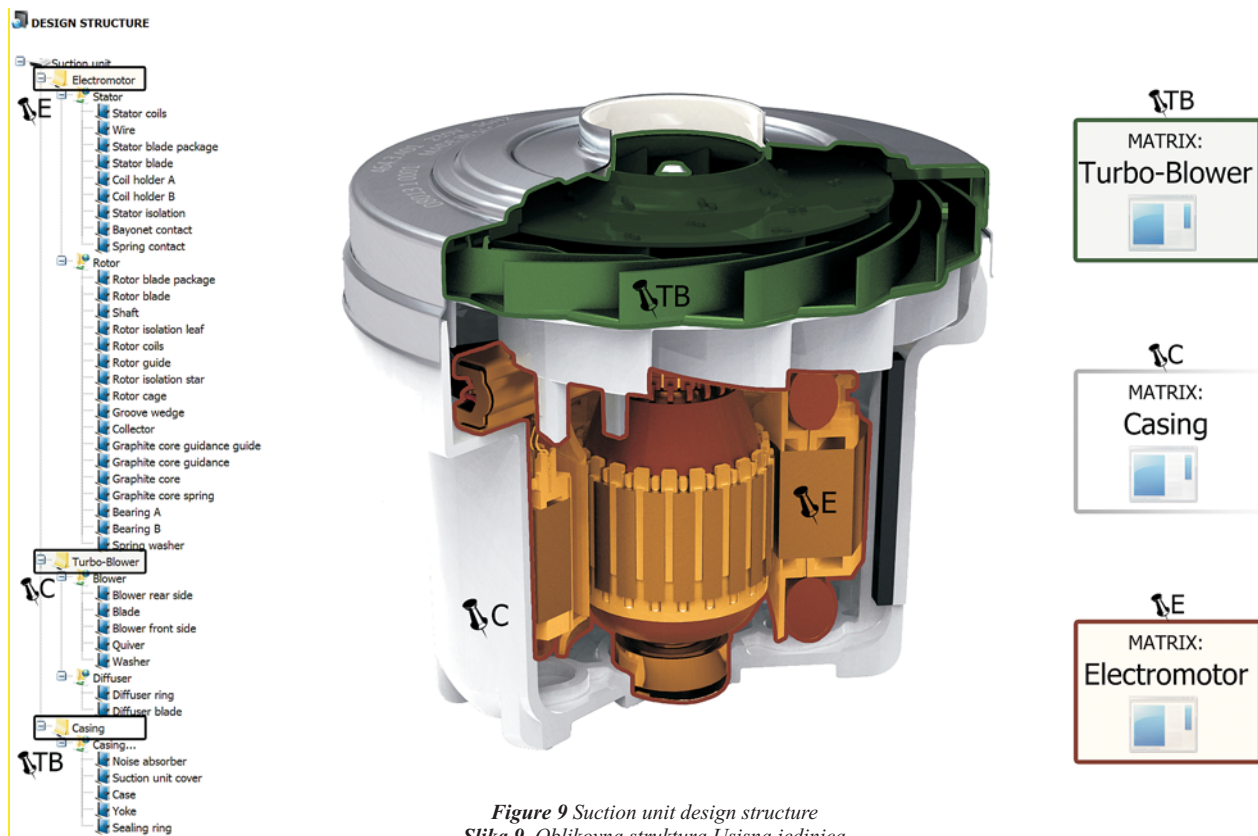


Figure 9 Suction unit design structure
Slika 9. Oblikovna struktura Usisna jedinica

hierarchy tree is generated according to this criterion. Therefore in the design structure the matrix structure matrices form the technical systems of different complexities. According to the second criterion of the product definition set of criteria the technical systems can be structured into eight levels [11]. This means that, by analogy, the matrix structure matrices can also be structured into eight levels.

4 Conclusions Zaključci

A design process is a transformation process in which input information is transformed into design solutions represented by technical systems. Functional requests presented descriptively by means of functions form the starting point of a design process. The design process is aimed at linking functional models with existing technical systems and at thus generating new products. In order to achieve this goal the overall knowledge about functions and existing products must be obtained. The knowledge must be stored and thus used for development of new products.

The work outlines the second structural form model of function matrix of products and their requests. The starting point for the model development was the morphological matrix. The development of this matrix model made it possible to constitute a link between functions and technical systems (functionalities) based on the mathematical model, not on the intuition of a designer. By a Web application the matrix was automated, enabling quick changes of data stored in it.

The matrix has no limits as regards its expansion by all rows and columns. The existing data can be updated in the matrix at all times. The matrix model is then implemented into a developed computer Web application. The

application is accessed through the Internet menu so as to enable a distributed development of the product. This product along with the model of the first structural form of the function matrix of products and their requests, outlined in works [11, 16, 17], makes the matrix structure generation of products possible.

The complete functional structure of products is stored in the matrix structure by means of the first and the second structural form of the function matrix of products and their requests. The functions listed in matrices are defined according to the rules outlined in [11]. To achieve the unambiguousness of functions all the functions are described by parameters composed of physical constants and basic and derived physical magnitudes. Physical laws form a basis from which the parameters are defined. The parameters can be observed in matrices. Thus the knowledge about functional structure of the product and its functionality represented by technical systems of different complexity is stored in the matrix.

Matrix structure is generated by binding functions and a set of winning parameters the functions are unambiguously listed by. The linking is denoted by the binding links which fill up the matrix fields. The binding links contain the data about the parameters and the winning parameters which describe the function and provide interconnection between functions and functionalities. The generated matrix structure forms the basis for the creation of the product design (physical) structure.

The future research will be aimed at developing a central computer system that will provide complete and integral management of a design process from the conceptual phase up to the production of the final product. The development of such a system would also serve as a basis for development of a computer system whose aim would be the management of all the data referring to the complete service life of a product.

These matrix models make the higher quality, faster and shorter management of a design process possible as well as lower costs and smaller errors within the process itself.

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Authors' addresses

Adrese autora

Mirko Karakašić, PhD ME

J. J. Strossmayer University of Osijek
Mechanical Engineering Faculty
Trg I. B. Mažuranić 2
HR-35000 Slavonski Brod
Croatia
mirko.karakasic@sfsb.hr

Žiga Zadnik, BSc ME

University of Ljubljana
Faculty of Mechanical Engineering
Aškerčeva 6
SI-1000 Ljubljana
Slovenia
ziga.zadnik@fs.uni-lj.si

Milan Kljajin, full time professor

J. J. Strossmayer University of Osijek
Mechanical Engineering Faculty
Trg I. B. Mažuranić 2
HR-35000 Slavonski Brod
Croatia
mkljajin@sfsb.hr

Jože Duhovnik, full time professor

University of Ljubljana
Faculty of Mechanical Engineering
Aškerčeva 6
SI-1000 Ljubljana
Slovenia
joze.duhovnik@fs.uni-lj.si