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MORPHOLOGICAL SYNTHESIS OF THE UNIVERSAL ROTARY WELDING DEVICE

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ABSTRACT

The analysis of known and proposed approach to the search for new universal rotary devices that can be used in subtractive and additive technologies is performed. It is emphasized that the use of the modular principle allows to significantly reduce the time and costs of creating universal rotating devices as part of a multifunctional smart mini-factory.

RELEVANCE OF RESEARCH

Welding is a technological process of obtaining inseparable connections of two or more parts, which is characterized by relatively low cost, high productivity and fairly high mechanization of the process. The welding process requires repeated turning of the workpiece in space. These movements of the workpiece led to the need for mechanisms capable of automatically orienting the workpiece, quickly and reliably installing it, moreover, rotating it at welding speed. It is these tasks that universal rotary welding devices (URWD) deal with. URWD are used in almost all operations of welding production, such as surfacing, assembly, welding, etc. That is why they are widely used in welding production processes, having many layouts, designs and schemes (Fig. 1-3) [14-16].

The purpose of the research is to find, using the system-morphological approach [6-8] options for the layout of the URWD, built on a modular principle, for their inclusion in the composition of a multifunctional smart mini-factory [12]. Stages of solving the problem: And - specification of the task according to the purpose of the research; II - division of the object with the image of the form of execution into morphological features: rotary block (RB), rotating block (RgB), adapter (A), base (B), and for RB and RgB with the image of movements in the X,Y coordinate system ,Z; III – compilation of a morphological model in the form of a morphological table and a morphological matrix; IV – synthesis of object variants, as a combination of alternatives of morphological features, and writing of morphological [6,8] and structural [1,5] formulas of layouts; V - selection of two or three rational options by one of the expert decision-making methods [2,3,10] for further constructive implementation taking into account the following criteria: a) minimum number of blocks; b) minimum dimensions; c) the possibility of increasing blocks. The morphological model with the image of blocks and movements is presented in Table 1 and morphological matrices: expanded (1) and collapsed (2).

Fig. 1. Universal rotary welding device [14]

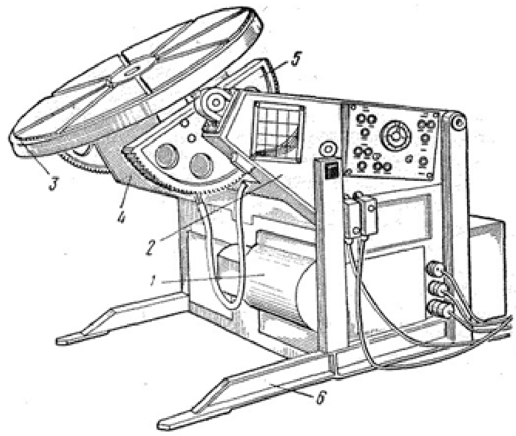

Fig. 2. Universal rotary welding device [15]

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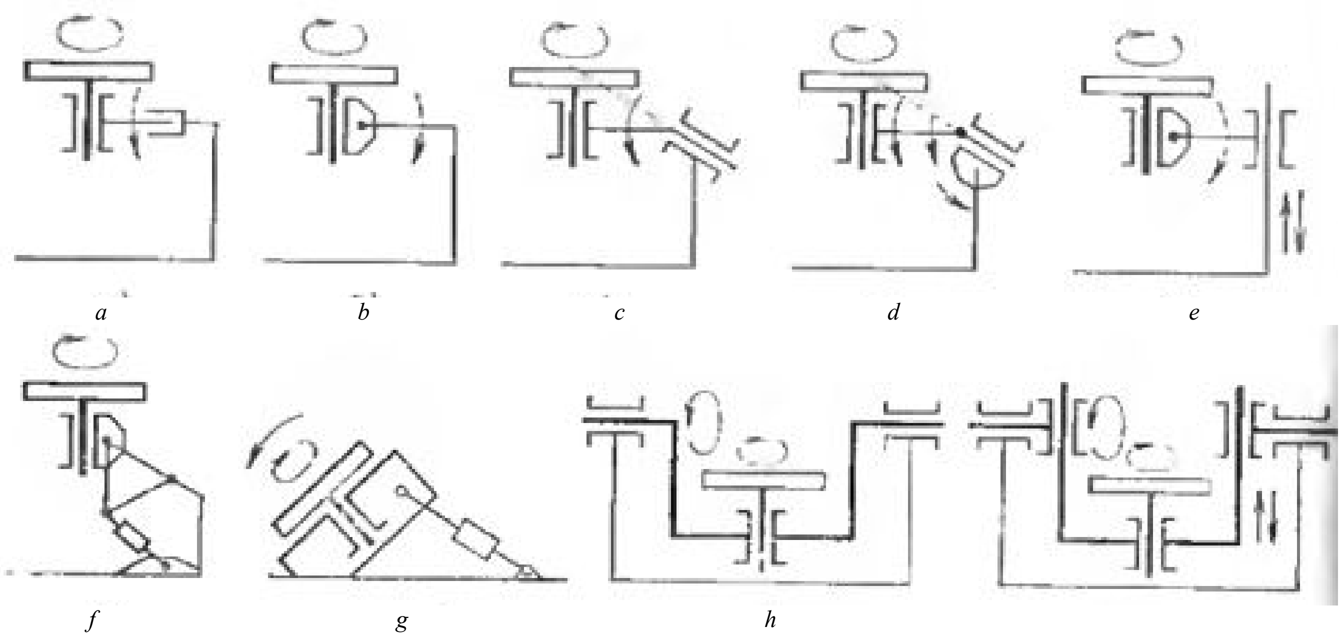

Fig. 3. Known structural schemes of manipulators-URWD [16]: a-cantilever; b-carousel; c-with full balancing relative to the tilt axis; d-carousel with vertical lift; e-carousel with radial lift; f-lever-sector; g, h-carousels with full balancing relative to the tilt axis

Table 1 *Morphological model - table URWD*

Rotary unit (RU)		Swivel unit (SU)		Fixed (immovable) parts (FP)	
1. Form	**2. Movement**	**3. Form**	**4. Movement**	**5. Adapter**	**6. Basis**
1.1	2.1 2.2 2.3 2.4	3.1 3.2	4.1 4.2 4.3 4.4	5.1 5.2 5.3 none	6.1

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Stages of solving the problem:

I - specification of the task according to the purpose of the research;

II - division of the object with the image of the form of execution into morphological features: rotary block (RB), rotating block (RgB), adapter (A), base (B), and for RB and RgB with the image of movements in the X, Y coordinate system Z;

III - compilation of a morphological model in the form of a morphological table and a morphological matrix;

IV - synthesis of object variants, as a combination of alternatives of morphological features, and writing of morphological [6, 8] and structural [1, 5] formulas of layouts;

V - selection of two or three rational options by one of the expert decision-making methods [2, 3, 10] for further constructive implementation taking into account the following criteria: a) minimum number of blocks; b) minimum dimensions; c) the possibility of increasing blocks.

The morphological model with the image of blocks and movements is presented in Table 1 and morphological matrices: expanded (1) and collapsed (2).

Morphological model - matrices URWD

Unfolded

$$M_{\kappa} = \begin{vmatrix} 1.1 & 2.1 \\ & 2.2 \\ & 2.3 \\ & 2.4 \end{vmatrix} \begin{vmatrix} 3.1 & 4.1 \\ 3.2 & 4.2 \\ & 4.3 \\ & 4.4 \end{vmatrix} \begin{vmatrix} 5.1 & 6.1 \\ 5.2 & \\ 5.3 & \\ & \end{vmatrix} \qquad (1)$$

Rolled up

$$M_{\kappa}^{1} = M_{RG} \times M_{RgB} \times M_{НЧ} \qquad (2)$$

The total number of possible and impossible options $N_k = 4 \times 2 \times 4 \times 3 = 96$. We will carry out a selective synthesis of options with the writing of morphological and coordinate structural layouts of the URWD with entry in Table 2.

Synthesized variants of URWD are presented in Fig. 4.

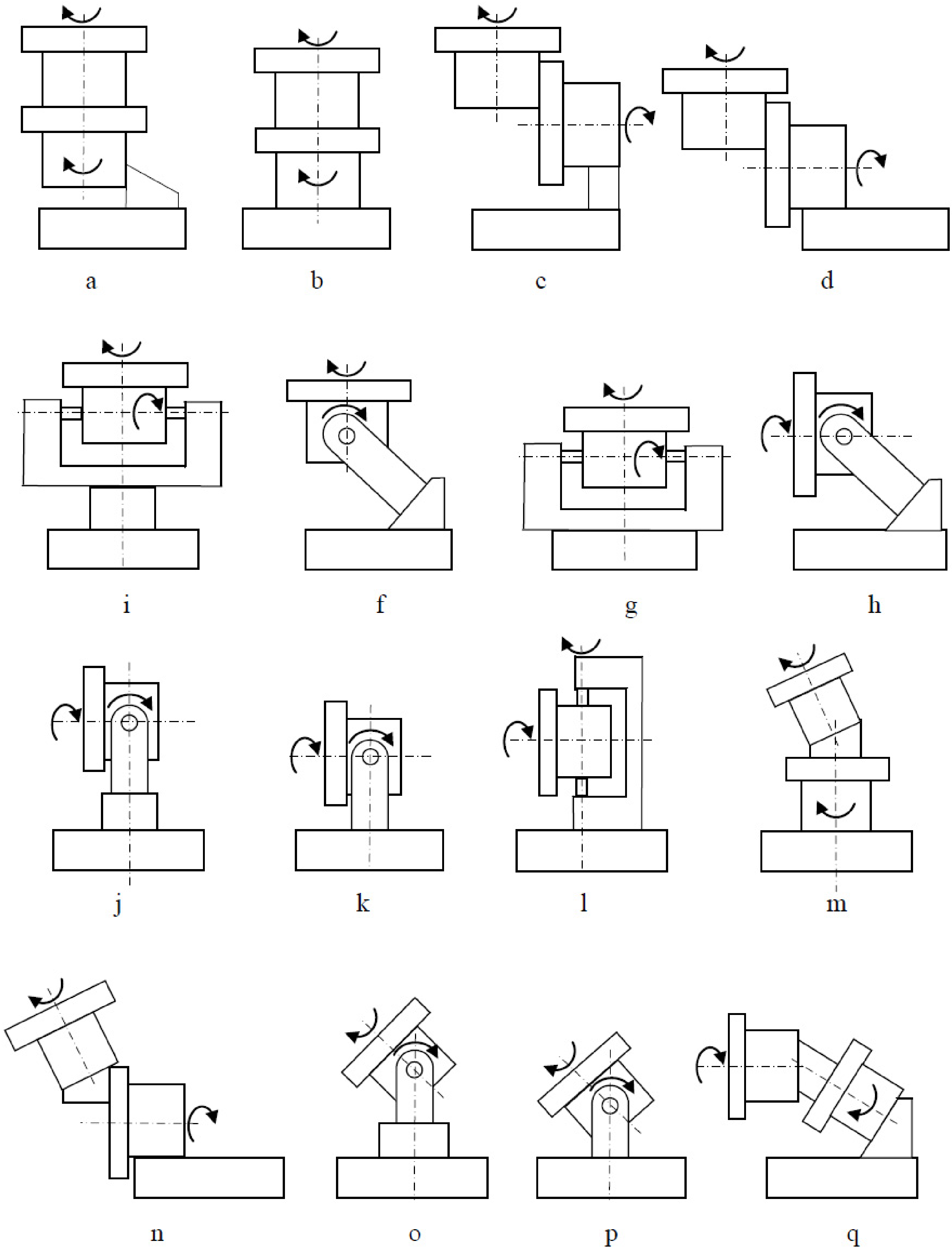

Fig. 4. Synthesized variants of URWD according to Table 2: a) X1; b) X2; c) X3; d) X4; e) X5; f) X6; g) X7; h) X8; i) X9; k) X10; l) X11; m) X12; n) X13; o) X14; p) X15; q) X16

Table 2 *Morphological formulas (tuples) and coordinate structural formulas of URWD layouts*

Option No	**Morphological formula**	**Structural formula**
1	**2**	**3**
X_1	*|1.1-2.1|∧|3.1-4.1|∧|5.1-6.1|*	$d_z e_z o$
X_2	*|1.1-2.1|∧|3.1-4.1|∧|**5.3**-6.1|*	

***Table 2** Morphological formulas (tuples) and coordinate structural formulas of URWD layouts (continued)*

Option No	Morphological formula	Structural formula
1	2	3
X_3	|*1.1*-**2.2**|∧|*3.1*-**4.2**|∧|**5.2**-*6.1*|	$d_z d_y o$
X_4	|*1.1-2.1*|∧|*3.1*-**4.2**|∧|**5.3**-*6.1*|	
X_5	|*1.1-2.1*|∧|**3.2-4.4**|∧|**5.2**-*6.1*|	$d_z e_x o$
X_6	|*1.1-2.1*|∧|**3.2-4.4**|∧|*5.1-6.1*|	
X_7	|*1.1-2.1*|∧|**3.2-4.4**|∧|**5.3**-*6.1*|	
X_8	|*1.1*-**2.4**|∧|**3.2-4.4**|∧|*5.1-6.1*|	$d_y e_x o$
X_9	|*1.1*-**2.2**|∧|**3.2-4.4**|∧|**5.2**-*6.1*|	
X_{10}	|*1.1*-**2.2**|∧|**3.2-4.4**|∧|**5.3**-*6.1*|	
X_{11}	|*1.1-2.1*|∧|**3.2-4.2**|∧|**5.3**-*6.1*|	$d_y e_z o$
X_{12}	|*1.1*-**2.3**|∧|*3.1-4.1*|∧|*5.1-6.1*|	$d_{z/y} e_z o$
X_{13}	|*1.1*-**2.3**|∧|*3.1*-**4.2**|∧|*5.1-6.1*|	$d_{z/y} e_y o$
X_{14}	|*1.1*-**2.3**|∧|**3.2-4.4**|∧|**5.2**-*6.1*|	$d_{z/y} e_x o$
X_{15}	|*1.1*-**2.3**|∧|**3.2-4.4**|∧|**5.3**-*6.1*|	
X_{16}	|*1.1*-**2.2**|∧|*3.1*-**4.3**|∧|*5.1-6.1*|	$d_y e_{z/y} o$

Note: Alternative features in variants X2 - X16, which differ from variant X1, are highlighted in bold

When writing coordinate structural formulas of layouts according to the theory of componetics according to Yu.D. Vragov [5] the matrix of auxiliary movements in the space of Z, Y, X coordinates, both for robots and manipulators, looks like this

$$\begin{matrix} dz & ez & dzy \\ dy & ey & dzx \\ dx & ex & \end{matrix} \quad (3)$$

The total number of options is $3 \times 3 \times 2 = 18$, which is much less options in morphological synthesis (96 options).

CHOOSING THE BEST OPTION

To do this, we will use the method of priority location (or pairwise comparisons) with writing a system of inequalities, building a complete graph and processing the results in the form of an adjacency table with two iterations [2].

CONCLUSIONS

1. The use of the modular principle [1, 4, 5, 9, 11] allows you to significantly reduce the time and costs of creating a URWD as part of a multifunctional smart mini-plant [13].

2. Coordinate structural formulas of layouts give only 18 different options and limit the search for new solutions in comparison with the system-morphological approach, which even with the proposed morphological model gives 5 times more options (96) and can expand the search by increasing the alternatives for the selected future.

3. Using the example of the morphological synthesis of URWD, the functions of a smart mini-factory can be expanded due to the performance of other auxiliary and technological operations during flexible automated production [9, 11], for example, automatic tool change devices.

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