Methodology for design of automatic orienting systems in bowl feeders

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Abstract: **The objective of this paper is to introduce methods for design of automatic orienting systems of parts in bowl feeders. The performances of discernible stable positions of details are classified. Interaction forces and details recognition methods are classified and possibilities of combining are given. Simple orienting devices are chosen from working catalogue. The index number of every device was created in order to simplify work with catalogue. The example of application of above methods is shown.**

Keywords: **automation, design, automation orienting, supplying vibration containers and methodology.**

I. Introduction

One of the main goals in automating of discrete manufactory is design of effective and reliable automatic orienting systems [1,2]. To solve the above mentioned problem is complex task, which depends on number of factors as characteristics of details, designer experience, manufacture, technological processes, type of equipment, productivity, coast, etc.

In order to aid the design process number of methods is used [3,4,5,6]. Well known methods have some weaknesses, which make their application difficult. In most of then the choice of orienting system is based on classification of details according to detail characteristics. Despite discernible stable positions are with high priority in the design of automatic orientation systems. Besides this for some details included in classification decisions are not given. In those methods not all the ways of detail recognition and the interaction forces are observed. Which leads to limited solutions (often the solution is only one), in consequence of that it is difficult to reach optimal decision.

The aim of this paper is to describe methods for design of systems for automatic orientation of details in bowl feeders. In this methodology disadvantages of the known methodologies are eliminated.

II. Description of methodology

Algorithm of application of the methodology is shown on fig.1.

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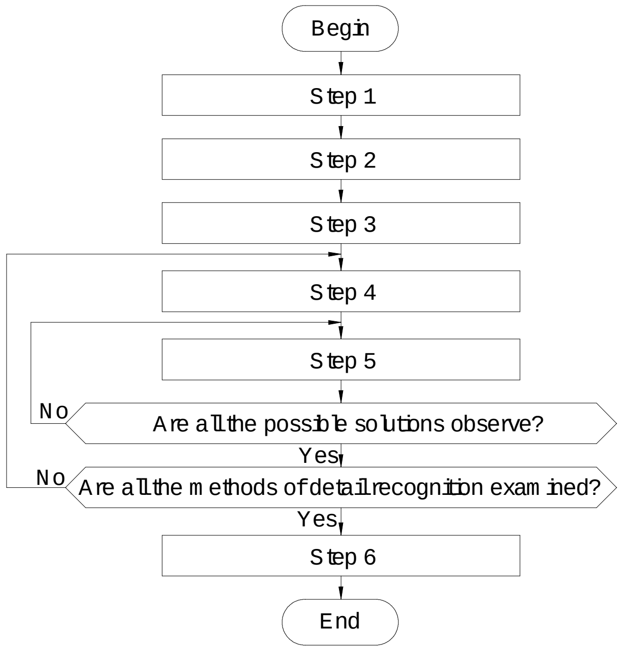


Fig.1. Algorithm of methodology

Step 1. Different discernible stable positions of objects (parts, assemblies) should be determined. Mathematical probability of stable positions of objects is determined empirically.

Step 2. The physical properties of the details are determined: material, color, transparency, weight, roughness, reflection capability, coefficient of friction, adhesion towards vibrating containers, relative magnetic permeability, relative permittivity, conductivity, etc.

Step 3. The differences between characteristics of discernible stable positions of details (vertical projection onto surfaces of orientation, physical properties, etc.). Moving direction of the details should be taken into account. Comparison between different projections and ignoring of them is unallowable, since this will cause unacceptable errors. Most frequently used parameters are shown bellow:

01 – size; 01/1 – height; 01/2 – width; 01/3 – length;

02 – outlines; 02/1 – contour; 02/2 – concentric circular contour, orthogonal to direction of moving; 02/3 - concentric eccentric contour, orthogonal to direction of moving;

03 – internal contour; 03/1 - contour; 03/2 - concentric circular hole, orthogonal to direction of moving; 03/3 - eccentric circular hole, orthogonal to direction of moving;

04 – outer cone surfaces; 04/1 – $D>>H$; 04/2 – $D<H$, $D\approx H$;

05 – guiding surfaces; 05/1 – grooves; 05/2 – ribs; 05/3 – cotters, pins, etc.

06 – chamfers; 06/1 – extruded surfaces; 06/2 - revolved surfaces;

07 – stepped surfaces; 07/1 - L>a (L>R); 07/2 - L<a (L<R);

08 – Obviously shifting of the center of mass; 08/1 – orthogonal to direction of moving; 08/2 – parallel to direction of moving; 08/3 – in height;

09 – color;

10 – coefficient of friction and etc.

The results of analyzes are summarized in the Table 1. Number of discernible stable positions is marked by n.

TABLE I

N	1	2	…	j	…	n
1	-	P_{12}	…	P_{1j}	…	P_{1n}
2	P_{21}	-	…	P_{2j}	…	P_{2n}
…	…	…	…	…	…	…
i	P_{i1}	P_{i2}	…	P_{ij}	…	P_{in}
...	…	…	…	…	…	…
n	P_{n1}	P_{n2}	…	P_{nj}	…	-

Step 4. Analyzes of the results from *Step 3* should be done as well as determination of the simple orienting devices, using working catalogue, which is no shown in this paper. The choice of the devices is based on method for recognition and characteristic of discernible stable position.

The choice of recognition method should be done according to *Step 2* and Table II. Recognition methods and interaction forces, used in the methodology and possible ways of method combining are shown in Table II.

Recognition method is defined as a way to distinguish characteristics of discernible stable positions of details. Various methods are: MM – mechanical; ME – electrical; MEM – electromagnetic; MP – pneumatic; MH – hydraulic; MG – gravitational; MO – optical; MT – television.

The interaction forces are: FG - gravitational; FI – force of inertia: centrifugal force; FF – friction force; FP - pneumatic force: FP1 – air drag, FP2 – aerodynamic drag, FP3 - blast pressure; FE – electric force: FE1- effect of capacitor, FE2- dielectric placed in non-uniform electrical field; FEM – magnetic force: FEM1 - electromagnetic force, FEM2 – diamagnetic and paramagnetic placed in non-uniform magnetic field; FM – mechanical force and FEL – elastic force.

TABLE II

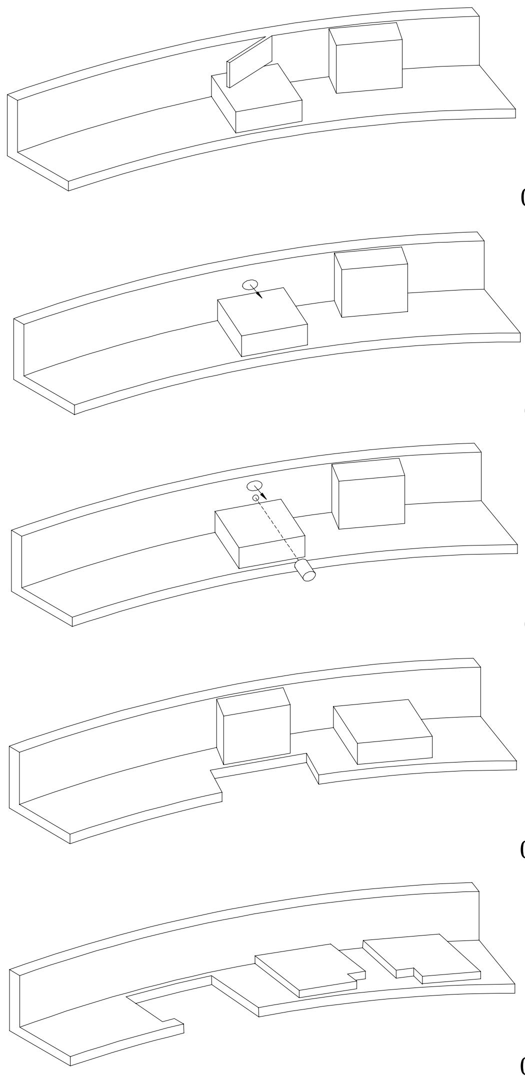
	MM	ME	MEM	MP	MH	MG	MO	MT
FG	●	●	●			●		
FI	●			●		●		
FF	●		●					
FP1	●	●	●	●		●	●	●
FP2	●	●	●	●		●	●	●
FP3	●	●	●	●		●	●	●
FE1		●				●	●	●
FE2		●				●	●	●
FEM1	●	●	●	●		●	●	●
FEM2			●					
FM	●	●	●	●	●	●	●	●
FEL	●							

Step 5. Making systems using simple orienting devices. Compatibility between simple orientation devices should be taken into account. Compatibility is defined as possible way for simultaneous work of devices in common system. Combining of simple orientation devices which used different recognition methods is unacceptable, because is too expensive.

Interactive procedures for determining of multitude of possibilities for automatic orienting systems are included in this algorithm. Varying of possible recognition methods can approach different solutions.

Step 6. The optimal system for automatic orientation should be chosen. Evaluation of different solutions is done according to project.

A small passage of the working catalogue containing the simple orienting devices is shown on fig. 2.



01/1/MM

01/1/MP

01/1/MO

01/2/MM

02/1/MM

Fig. 2. Catalogue with simple orienting devices

III. Application of the Methodology

To illustrate how methodology of design of automatic orienting system in bowl feeders is applied in practice we shall consider the design of orientation system of prismatic part - type “Body” (shown on fig. 3).

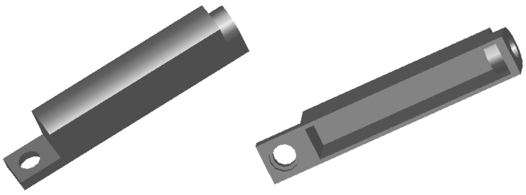
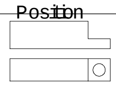
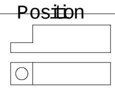
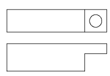
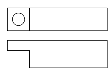
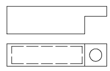
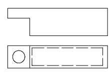
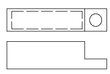
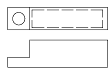


Fig. 3. Prismatic part type “Body”

Step 1. In table 3 are shown discernible stable positions of parts and empirical determined probabilities with which the various orientations of parts would occur after initial orientation.

TABLE III

N	Position	Probability	N	Position	Probability
1		9,4%	5		10,4%
2		14,6%	6		13,4%
3		14,5%	7		9,9%
4		16,4%	8		10,9%

Step 2. The main characteristics relative to the orientation process are shown in Table IV.

TABLE IV

Material	PE
Color	Cyan
Transparency	<5% (λ=500nm)
Weight	0,5g
Roughness	R_Z=40
Reflection capability	≈15% (λ=500nm)
Coefficient of friction	0,2
Relative magnetic permeability	≈1
Relative permittivity	2,2
Conductance	0

Step 3. Discernible stable positions in relation to basic orientating surface were compared. The result of the analyses is shown on Table V.

TABLE V

N	1	2	3	4	5	6	7	8
1	-	01/2	07/2	01/2	07/2 03/1 08/2	01/2 08/2	07/2 08/2	01/2 08/2
2	01/1	-	01/1	02/1	01/1 08/2	02/1 08/2	01/1 08/2	02/1 08/2
3	07/2 03/1	01/2	-	01/2	07/2 03/1 08/2	01/2 08/2	07/2 08/2	01/2 08/2
4	01/1	02/1	01/1	-	01/1 08/2	02/1 08/2	01/1 08/2	02/1 08/2
5	07/2 03/1 08/2	01/2 08/2	07/2 08/2	01/2 08/2	-	01/2	07/2	01/2
6	01/1 08/2	02/1 08/2	01/1 08/2	02/1 08/2	01/1	-	01/1	02/1
7	07/2 03/1 08/2	01/2 08/2	07/2 08/2	01/2 08/2	07/2 08/2	01/2	-	01/2
8	01/1 08/2	02/1 08/2	01/1 08/2	02/1 08/2	01/1	02/1	01/1	-

Step 4. The weight of the part is small. Material characteristics are: paramagnetic; relative permittivity is with small value; reflection capability is low; material is transparent for IR rays. Suitable recognition methods are: mechanical; electrical; pneumatic; optical (in visible light spectrum). Gravity method can be used in suitable conditions. The interaction forces are as follows: Gravity force; centrifugal force; pressure of fluid; capacitor effect; dielectric placed in non-uniform electrical field; mechanical force.

Simple orienting devices and recognition method are show in Table VI.

TABLE VI

Char.	Description	Method
02/1 (2,4,6,8)	Outlines – Contour	MM, MP, MO
07/2 (1,3,5,7)	Stepped surfaces - L<a	MM, MO
01/1	Size - Height	MM, MP, ME, MO
01/2	Size - Width	MM, MP, ME, MO
03/1	Internal contour - Contour	MM, MP, MO
08/1	Obviously shifting of the center of mass - Orthogonal to direction of moving	MM

Step 5. In this example are developed five different versions of automatic orienting systems, which consist of simple orienting devices shown in Table VII.

TABLE VII

N	5	7	5	6	8
1 (07/2)	-	-	-	-	-
3 (07/2)	-	-	-	-	-

5 (07/2)	MM	-	MO	-	-
7 (07/2)	-	MM	-	-	-
2 (02/1)	-	-	-	MM	-
4 (02/1)	-	-	-	MM	MM
6 (02/1)	-	-	-	-	-
8 (02/1)	-	-	-	MM	-
2, 4, 6, 8 (01/2)	-	-	-	-	-
1, 3, 5, 7 (01/1)	-	-	-	MM	-
1, 5 (03/1)	-	-	-	-	MM
1,2,3,4 (08/1)	-	-	-	-	-
5,6,7,8 (08/1)	-	-	-	-	-

Theoretically total number of solutions is 20, but in practice most of them are ignored due to higher costs, lower reliability, high complexity, etc.

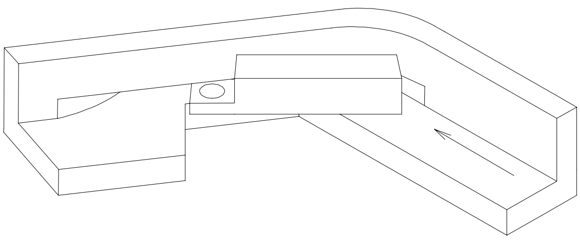


Fig. 4. Version one

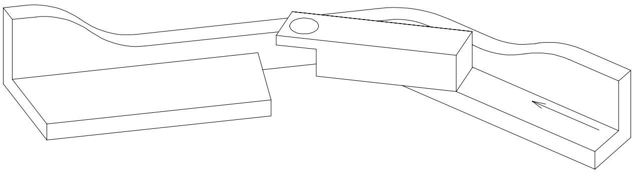


Fig. 5. Version two

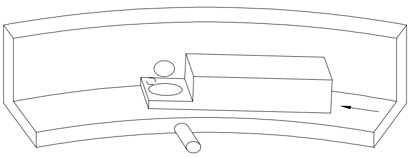


Fig. 6. Version three

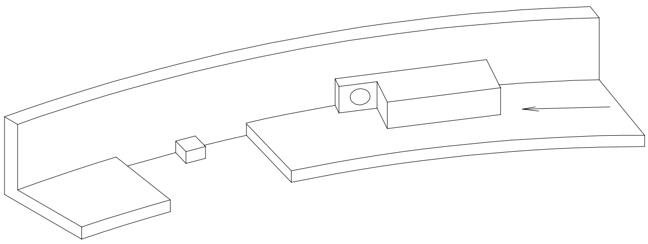


Fig. 7. Version four

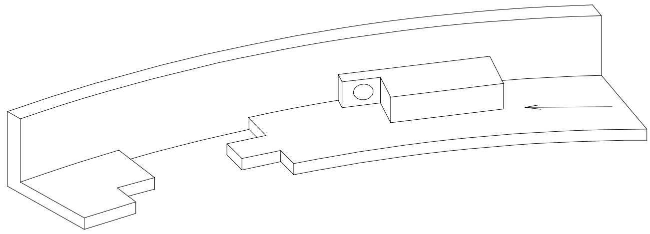


Fig. 8. Version five

IV. Conclusion

A methodology of design of automatic orienting systems in bowl feeders was described in this paper. The methodology is interactive and is based on combining of different simple orienting devices, performing common function. The choice of the devices is based on different discernible stable positions of the parts.

For determining of multitude of possibilities is used the method of "morphological box" and all the possible solutions are found out.

The discernible stable positions of parts are classified.

The interaction forces and recognition methods are classified.

Catalogue of simple orienting devices was made (a small passage of the catalogue is show in this paper). This catalogue can be updated. The index number of every device was created in order to simplify work with catalogue.

The example of design of orientation system of prismatic part - type "Body" is shown to illustrate application of the methodology in real conditions. After the analyses five versions were chosen out of twenty possible solutions.

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