THEORY OF COMPONENTS ORIENTATION IN ASSEMBLY

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Abstract

In this paper is explained the theory of components orientation in assembly. This paper explains known principles of the components orientation. The article explains the principle of new component orientation expressed by overall runway effortlessly of assembly which is the author's original solution.

Key words

design for assembly, theory, orientation

Introduction

Unfortunately components from the production intended for assembly are yet supplied for assembly in disordered and disoriented state. For these reasons the thesis about components orientation mainly deals with automatic orientation (2, 3, 4).

The first theoretical thesis focused on the development of shape classifiers and on sample solution of automatic orientation relevant shape groups (1, 5). This thesis has been more cataloging of success solutions. Example of the classification is shown in the Fig. 1.

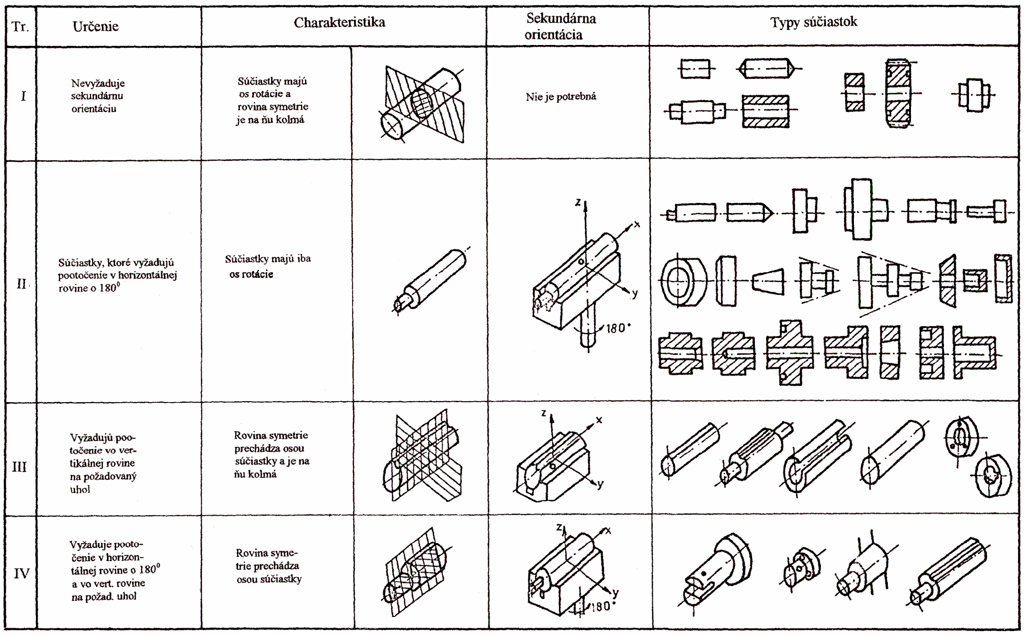


Fig. 1 *Example of shape classifier and sample automatic solution for orientation of the shape groups (8)*

In some of these thesis component sorting attempts according to the degree of their symmetrical been published. Orientation (9) has crucial importance to performance and to assembly cost and relates mainly with the shape but with dimensions of assembled parts too. Professor Boothroyd dealing with the problem of components orientation and with process systematization as first (10).

Boothoyd theory

Boothroyd has focused to the orientation of thin cylindrical components only. He found that they exists two types of symmetry respectively asymmetry – so-called „α symmetry"and „β symmetry"(asymmetry) (Fig. 2). This value is considered as a criterion of complexity of assembly. Later he quantify the „α and β symmetry" by necessary angle in degrees (Fig. 3), (10).

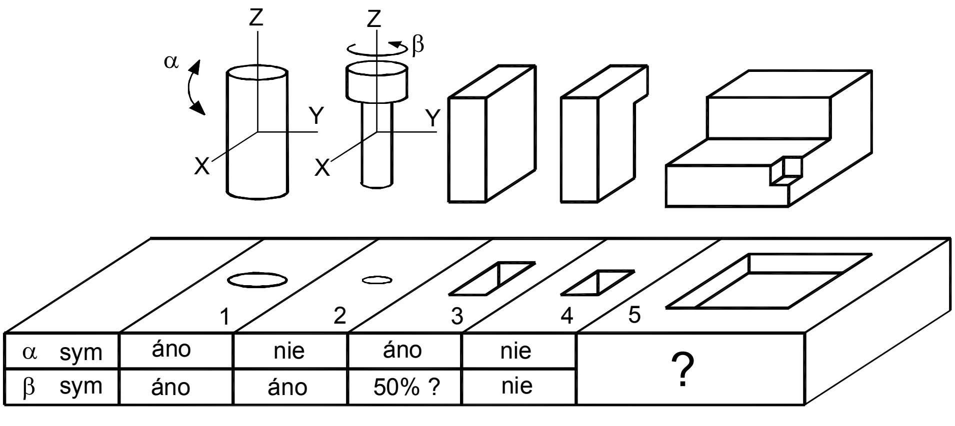
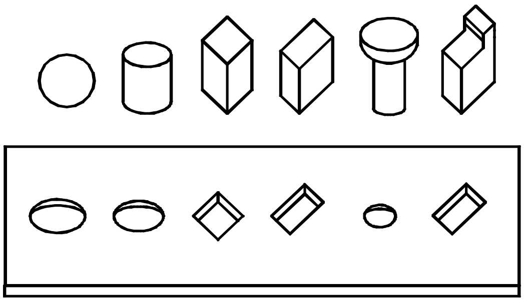


Fig. 2 *Boothroyd orientation theory (5)*

Alpha symmetry - symmetry with respect to a plane perpendicular to the longitudinal axis components
Beta symmetry – symmetry with respect to axis rotation around the longitudinal axis parts.

The cylinder in the (Fig. 2) is "α and β symmetrical" and can be nested into the hole upper or lower side. When the orientation of cylindrical parts from one side of recessed it is already „α asymmetrical“ and can be nested into the hole only one side. Other shown components are considered similarly, where the last oriented components the author can not reconsider. Boothroyd noted in his thesis, it is only the beginning of this theory because it does not solve problems with component, which are not axially symmetric, but they are entirely general shape.



α	0	180	180	90	360	360
β	0	0	90	180	0	360

Fig. 3 *Component as an object of assembly.*
Boothroyd orientation theory (5)

Boothroyd change the orientation before evaluation so that its longitudinal axis in the direction of the axis „z“ (Fig.2). This component rotated about "gamma" symmetry whose value is not evaluated.

According to facts obtained by previous author, Valentovič solved the problem of orientation of components, which are not symmetric, and that was how the theory of orientation of components with any shapes was created.

Ergonomics at the manual assembly station

Valentovič (11, 12) found out, that three different symmetries are needed to be distinguished in case of every (thin and thick) shape as the reason of three dimensional spaces. Each symmetry can be measured by the number of rotations, fraction of one rotation, respectively. He created the theory applicable for various shapes of components. This theory can be explained on thin components (obr. 4 a). Figure shows, that orientation of circle into the hole is not necessary, the circle can be simply put in the hole.

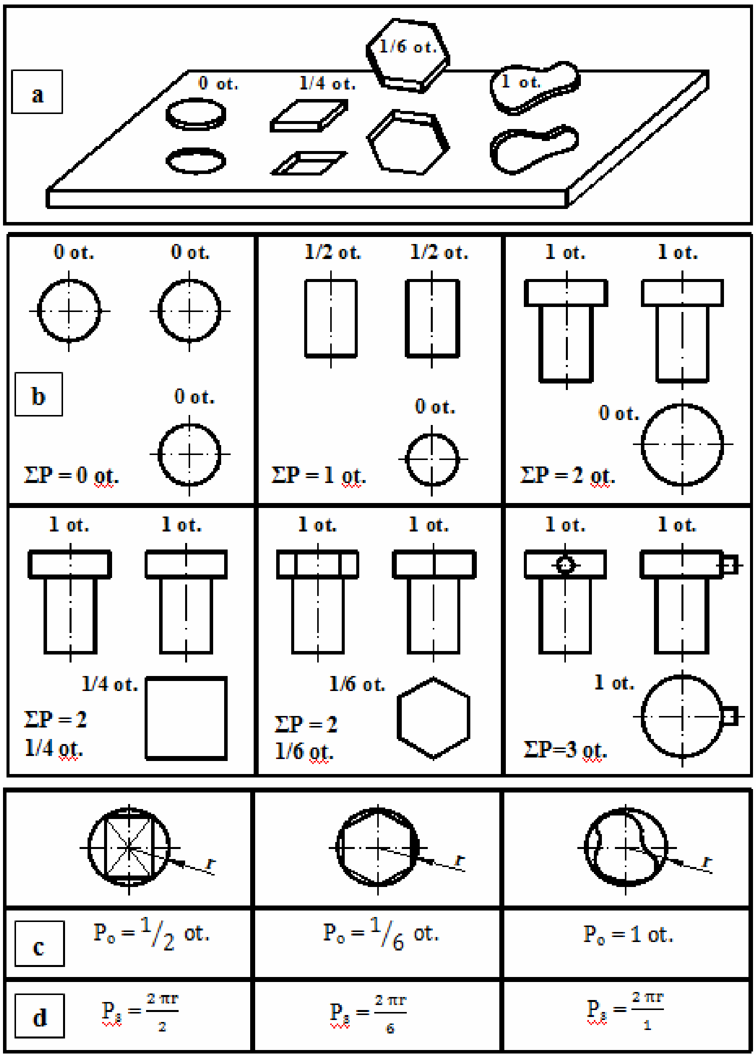


Fig. 4 *Complexity of orientation and assembly*

a – Plain orientation measured in rotations,
b – Space orientation measured in rotations (Po),
c, d – Orientation complexity (Po) and trajectory complexity(Ps).

When there is necessity to insert square into square hole, only one quarter of rotation is needed. In case of hexagon, when we need to place this shape into the hexagonal hole, only one sixth of rotation is necessary.

This principle was applied to all of three views and, subsequently, there was concluded, that: when we have to evaluate complexity of orientation, we have to make this operation three times- in front view, side view and top view of component.

Orientation of sphere in three views does not require any rotation, which means, that orientation complexity is zero.

As we can see in the fig. 4b, during orientation of cylinder, we need one half of rotation in top view, one half of rotation in side view and no rotation in ground plan. By the same principle, every next shape can be explained. Orientation of the most complex shape in the figure can be described as follows: one rotation is needed in front view, and also in side and top view. This theory is applicable to components with any dimensions, but still the dimensions of components should be considered. As a result, we suggest not to calculate the complexity on rotations (Po), but to calculate it owing to circular trajectories that have to be performed. This is why the dimensions of components take place, because rotation of large component requires longer trajectory in comparison with smaller component.

From this follows, that orientation elaborateness (Po), will be the sum of the indicative trajectories circumscribed front view, side view and top view as shown (Fig. 4c), by Valentovič this means that elaborateness of the rectangle is 1/2 turn. I recommend, that this elaborateness meant a half circle (Fig. 4 d), i.e. it is a trajectory of half circumscribe. It is also similarly for other shapes. In this way one number i.e. Sum of these trajectories determines elaborateness of orientation this part. Fig. 4d is shown, how deliberate during elaborateness investigation not only orientation but also handling part dimensions (trajectory elaborateness orientation - Ps).

Elaborateness of assembly calculation

In Fig. 5 is shown practical example of this theory, which lies in the fact, that we put prism into chuck, then drive the screw from the top and pin (stick) plug from side. When we sum and calculate elaborateness all of orientation, so this elaborateness will be consist in the fact, that we investigative elaborateness of all orientation movements (all of movements from view of orientation), which take place during assembly.

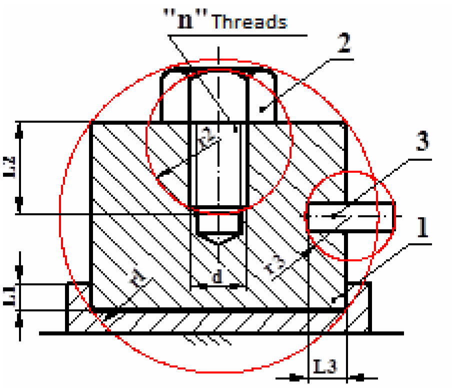


***Fig. 5** Mounting complexity*

1 – Prism,

2 – Screw,

3 – Pin.

The first is the fixing of a prism (Fig. 5 Pos. 1), which we need to orientate about ¼ turn before inserting into the chuck. When the screw is just above the hole and we have to orientate it (Fig. 5 Pos.2) then we calculate the orientation as it has been already mentioned (2 1 / 6 turn). Then we must whole future product to rotate about 90 degrees, so we can assemble the pin from a top and again we recalculate the orientation necessary for the pin orientation (1st turn, Fig. Pos. 3).

From the above calculation procedure of orientation one can easily derive:

Track complexity Ps:

- prism: $\left(\frac{1}{4}2\pi r_1 + \frac{1}{4}2\pi r_1 + \frac{1}{4}2\pi r_1\right)$,
- screw: $\left(2\pi r_2 + 2\pi r_2 + \frac{1}{6}2\pi r_2\right)$,
- pin: $\left(\frac{1}{2}2\pi r_3 + \frac{1}{2}2\pi r_3 + 0\right)$.

Mounting complexity Pm:

- prism: L1 (insertion into the chuck),
- screw: L2 + πdn (screwing, respectively displacement and rotation),
- Rotation of the pin hole into the upright position: $\frac{1}{4}2\pi r_1$ pin: L3.

Total track mounting complexity PCS

PCS = Ps + Pm [m].

Conclusion

From the above mentioned it follows that the orientation is a strange and typical phenomenon in the mounting and its meaning is up to 50% of the complexity, which must be done in the mounting. The reason is that up to now the components have been delivered for mounting in no oriented position. In a designing we need not to sum the partial complexities, it is enough to minimize that variables which increase the overall complexity.

The rules:

1. If the track complexity is less labor intensive, then product design is better.
2. Reduce the appropriate shape and dimensions of the overall track labour intensive assembly.

During production the components are correctly oriented, but often are freely falling into storages, where they reorient. This we consider to be the mainly problem of assembly.

"The best orientation is no orientation."

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