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Parts Orientation in the Case of Automatic Assembling Operation

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ABSTRACT

In this paper, parts orientation methods, during automatic assembling processes, are analyzed. Establishment of criteria that lead to a smaller influence of parts position on assembling process quality, when parts dimensions have a variation between the limits of the dimension fields, given by execution drawings, is the main purpose.
***Keywords**: automatic assembling, relative orientation, technological flux.*

1. Introduction

Any assembling process can be divided in elementary motions: assembling zone parts supplying; parts reciprocal orientation; effective assembling; assembly transfer to the next working place.

Parts reciprocal orientation, at the assembling place, is the highest difficulty phase. As consequence, a part must be placed, referred to its conjugate part, on such a way that allows an assembling process without rejects. Thus, parts reciprocal orientation must ensure assembling operation quality, no matter the effective values of dimensions, if these are between tolerance field limits.

2. Relative Orientation of Assembling Parts by Using a Split Pin

The stem on which the split pin is fit is oriented, based on its exterior cylindrical surface, by using a prism and based on its interior cylindrical surface by using a triangular section journal neck (Fig.1).

The following denominations were made:

D – Stem (3) exterior diameter;
d_b – Split pin (1) hole diameter;
d_c – Split pin exterior diameter;
d – Triangular section journal neck (4) diameter;
e – Maximum allowed displacement of stem exterior cylindrical surface referred to split pin hole axis.

As it results from Fig.1, left maximum displacement of hole right extreme point, referred to its middle position, is

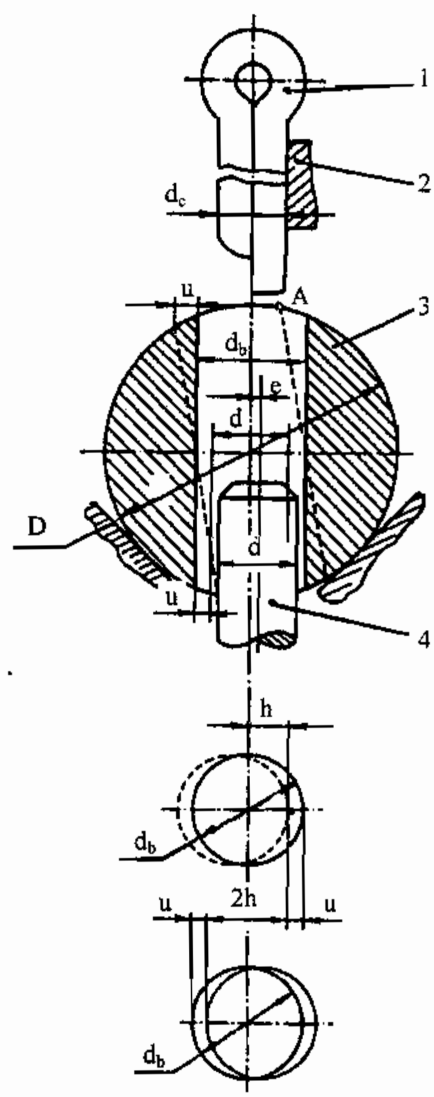

Fig.1 – Assembling Parts Relative Orientation by Using a Split Pin

$$u = \frac{d_b - d}{2} + e \quad (1)$$

Right maximum displacement of hole left extreme point can be calculate by using a similar relation. Thus, minimum dimension available to realize assembly will be:

$$\Delta = d_b - 2u \quad (2)$$

So, assembling can always be done if split pin maximum diameter satisfies relation

$$(d_c)_{max} \le d_b - 2\left(\frac{d_b - d}{2} + e\right), \quad (3)$$

which is equivalent to

$$(d_c)_{max} \le d - 2e\,. \quad (4)$$

It results that the possibility of realizing assembling without rejects is determined only by journal neck diameter, d and eccentricity, e. The distance, h, between journal neck 4 and bush, 2, surface can be found from condition imposed to bush orientation surface to include the point A:

$$h = \frac{d_b - 2u}{2} \text{ or } h = \frac{d_b}{2} - \frac{d_b - d}{2} - e\,. \quad (5)$$

Finally results

$$h = \frac{d}{2} - e\,. \quad (6)$$

Thus, assembly quality depends on same geometric constants: d and e.

3. Conditions Required by Relative Orientation when Assembling Parts with Screw Threads

In the case of mechanized flux assembling, done by using electric or pneumatic driven equipments, sometimes happens that surfaces with screw threads suffer damages (flanks breakings).

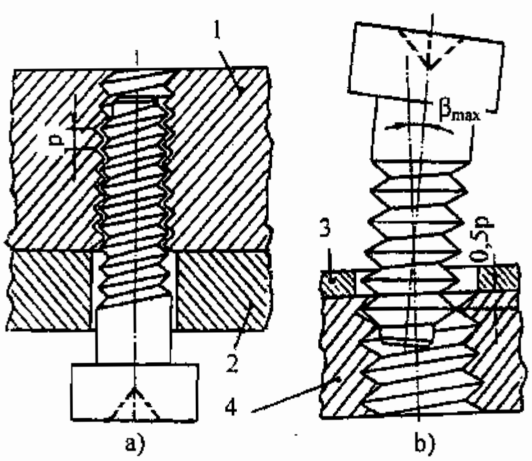

Fig.2 – Limit Situations at Parts with Screw Treads Assembling

In such a situation, the assembly must be retired from assembling technological flux, in order to extract damaged part and so, assembling technological line suffers perturbations. When automatic assembling is considered, such a situation cannot be accepted.

In Fig.2-a, a favorable case of two parts assembling, by using a screw, is presented. The part without screw thread, 2, is high enough to guide the assembly.

The situation from b – case, due to the reduced height of part 3, screw axis is too inclined and allow to the first pitch thread to incorrectly enter in the screw nut. If assembling operation is automatic, a reject will result.

To analyze the conditions on which the part with screw threads blockage appears, the following denominations were made:

d – Screw exterior diameter;

d_2 – Screw thread medium diameter;

p – Screw thread pitch;

D – Jig bush hole diameter;

t – Jig bush height;

β – Angle between screw axis and screw nut axis;

J = D – d – Clearance between screw and guiding bush.

Experimentally was made the observation that limit inclination angle $(\beta)_{max}$ to allow correct assembling, without blocking phenomenon appears, is given by relation

$$tan\beta_{max} = \frac{p}{2d_2} \cong \frac{p}{2d}, \quad (7)$$

Thus, it is accepted as favorable to obtain a correct assembling operation the relation

$$\beta \le \beta_{max} = arctan\frac{p}{2d}\,. \quad (8)$$

To satisfy this condition, in the case of automatic assembling operations, jig bushes to guide screws are necessary.

As it can be observed in Fig.3, the following relation results:

$$tan\beta = \frac{a}{h} = \frac{D - d'}{h} = \frac{D - \dfrac{d}{cos\beta}}{h}\,. \quad (9)$$

In an extreme situation we may accept that $tan\beta = tan\beta_{max}$; further results

$$\frac{p}{2d} = \frac{D - \dfrac{d}{cos\beta_{max}}}{h}\,. \quad (10)$$

If relation

$$cos\beta_{max} = \frac{1}{\sqrt{1 + tan^2\beta}} = \frac{1}{\sqrt{1 + \dfrac{p^2}{4d^2}}} \quad (11)$$

is kept in view, starting from equation (10), minimum height of jig bush not to allow blocking phenomenon appearance can be found:

$$h_{min} = \frac{d\left(D - \sqrt{d^2 + 0.25p^2}\right)}{0.5p}. \qquad (12)$$

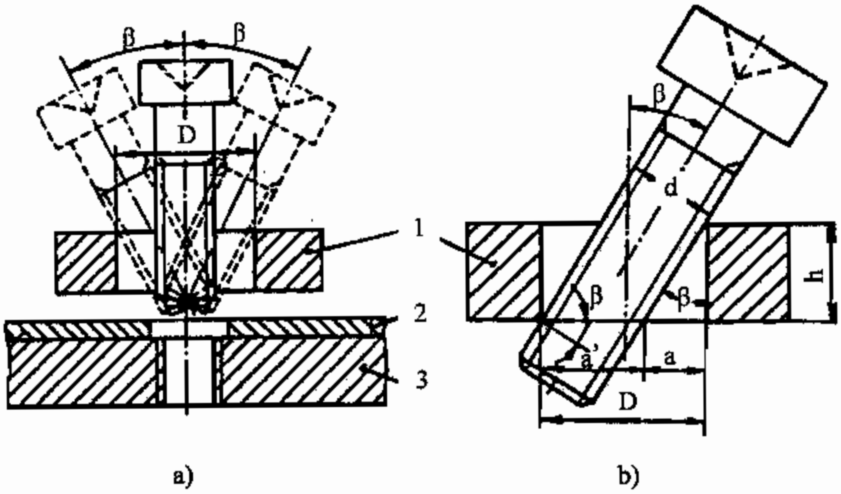

Fig.3 – Screw Guiding by using a Jig Bush

By making the substitution $D = d + J$, it follows that

$$h_{min} = \frac{d\left(d + J - \sqrt{d^2 + 0.25p^2}\right)}{0.5p} = \\ = \frac{d\left(d - d\sqrt{1 + \frac{p^2}{4d^2}}\right)}{0.5p} + \frac{d \cdot J}{0.5p}. \qquad (13)$$

Because $p/d = 0.1 \dots 0.2$, it results

$$\frac{p^2}{4d^2} \cong 0 \text{ and } \sqrt{1 + \frac{p^2}{4d^2}} \cong 1. \qquad (14)$$

Thus, first term of equation (13) can be neglected and we obtain

$$h_{min} \cong \frac{2d}{p} \cdot J. \qquad (15)$$

By considering M4 ... M10 screws, it results $J = (0.3 \dots 0.8)$ mm.

When choosing jig bush height, it is necessary to remind that it must be shorter than the screw, by minimum three pitches. After the screw has completed three rotations, jig bush (made by two segments) has to open, in order to allow complete assembling.

4. Conditions regarding Relative Orientation in the Case of Plate – Jig Bush Assembling Process

In these situations, parts orientation to assemble is done by using a journal neck with diameter steps; it guides both plates and jig bush after their interior cylindrical surfaces. As it results from Fig.4, that shows limit situation of two parts,

$$\bar{c} = \overline{Oa} - \overline{Ob}. \qquad (16)$$

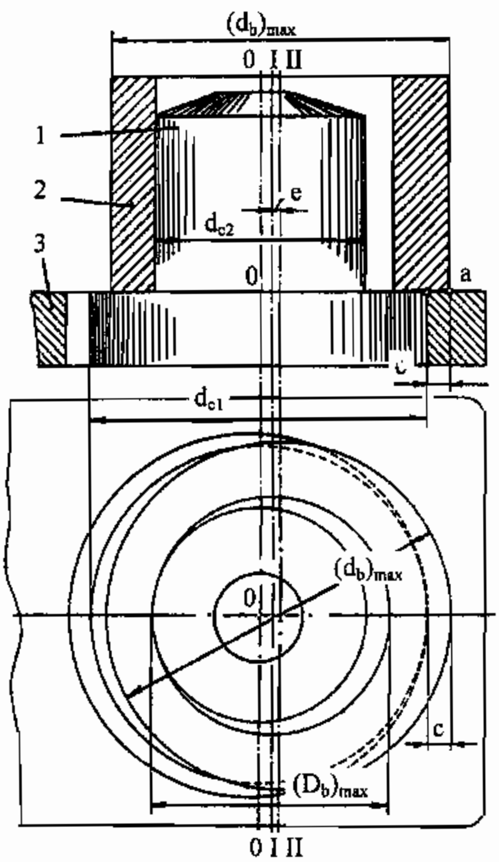

Fig.4 – Limit Situation at Plate – Jig Bush Type Parts Assembling

By expressing segments lengths in (16), we obtain

$$\overline{Oa}=\frac{d_{C2}}{2}+\left[(D_b)_{max}-d_{C2}\right]+\frac{(d_b)_{max}-(D_b)_{max}}{2}+e$$

$$=T_b+J_e+\frac{d_{C2}}{2}+e+\frac{(d_b)_{max}-(D_b)_{max}}{2},$$

$$\overline{Ob}=\frac{d_{C1}}{2}, \qquad (17)$$

the limit condition which ensures correct assembling can be expressed:

$$c=T_b+J_e+\frac{d_c}{2}+e+\frac{(d_b)_{max}-(D_b)_{max}}{2}-\frac{d_{C1}}{2}\leq 0 \qquad (18)$$

The following denominations were used:

- d_{C1}, d_{C2} – effective diameters of neck journal steps;
- $(D_b)_{max}$, $(D_b)_{min}$ – extreme interior jig bush diameter values;
- $(d_b)_{max}$, $(d_b)_{min}$ – extreme exterior jig bush diameter values;
- $(D_p)_{max}$, $(D_p)_{min}$ – extreme plate hole diameter values;
- $J_p = (D_p)_{min} - d_{C1}$ – minimum neck journal / plate clearance;
- $J_b = (D_b)_{min} - d_{C2}$ – minimum neck journal / jig bush clearence;
- $T_b = (D_b)_{max} - (D_b)_{min}$ – jig bush hole diameter maximum allowed deviation;
- e – eccentricity between hole axis and journal neck axis.

5. Conclusions

As it follows from relation (6), the probability of making a good assembly by using a split pin is determined only by journal neck, 4, diameter and by eccentricity *e* magnitude; on the same way, neither stem 3 exterior diameter value or split pin hole diameter deviation are important.

The orientation of parts having small pitch screw threads, in the case of automatic assembling processes, is more difficult to be done relative to the parts having normal pitch screw threads, because higher jig bushes are necessary. It is preferred that the part without screw thread plays jig bush role, if possible.

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Orientarea pieselor în cazul automatizării operaţiei de montaj

Rezumat

În cadrul lucrării sunt analizate unele metode de orientare a pieselor în procesul de asamblare automatizată. S-a urmărit stabilirea unor criterii care să conducă la o influenţă cât mai redusă a poziţiei pieselor asupra calităţii montajului, în condiţiile variaţiei dimensiunilor în limitele câmpurilor de toleranţe prescrise pe desenele de execuţie.

La orientation des pièces quand l'opération de montage est automatisée

Résumé

Dans ce papier certaines méthodes pour orienter les pièces pendant le processus d'assemblage sont analysées. On a poursuivi l'établissement des critères lesquels permettent une influence plus réduite que possible da la position des pièces sur la qualité du montage, quand leurs dimensions ont une variation entre les limites des champs de tolérance indiquées par les dessins d'exécution.