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DETERMINATION THE CHAINS OF SIZES COMPOSED OUT OF VECTOR AND SCALAR SIZES

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Abstract— In this paper are presented some aspects on the formation and determination of dimensions chains in the component which enters both scalar sizes how and vector sizes. We studied the dimensions chains which were formed at the assembly between of a piston and a connecting rod. In this case the orientation and fixation of the piston rod is made with a centering rods on which parts are positioned horizontally. The problem is to determine the precision between the piston, rod and bolt.

Keywords— chains of sizes, scalar dimensions, tolerance, vector dimensions

I. INTRODUCTION

În industry of machinery and equipment each piece, each subassembly and assembly, each machine must be performed at certain precision and scale limits which are set by the designer. Determining the size to a piece, upper and lower limit deviations of dimensions and presentation these on the drawings of the piece is done using the chains of sizes. In the literature of specialty is shown a simple and complete definition and namely: "Through chain of sizes is defined whole the dimensions which determining the position some surfaces of a piece or more parts of a assembly, which are connected by certain relations of dependence or influence and forming a closed contour'' [1]- [2]. A classification in terms the chains of sizes formed in a plane or in space, is the following: chains of planar dimensions, in this case the dimensions of the chain are in the same plane, and the chain can be composed of non-parallel linear dimensions of the angular sizes or the mixed chains of sizes; chains of sizes spatial in this case the dimensions of the chain are in different non-parallel planes.

In this paper will analyze chains of sizes which are formed at assembly the pieces of the revolution. In this case, in the composition of chains of sizes enter both the linear and angular dimensions as well as position deviations [3] - [6]. When in structure the chain of sizes enter, besides simple scalar errors (chains of angular sizes and linear sizes) and vector errors (for example runout and front of bushings, rings, gear wheels, etc.) we are dealing with chains of sizes what have deviations of variable direction [4]. An example of this kind is shown in Fig. 1, in this case, the support frame 1 into which is placed bushing 2 has an eccentric reaming.

Chain of sizes will be given by the relation [5]:

$$x_R = R = x_1 + x_2 \qquad (1)$$

in which: $x_1, x_2\ si\ x_R$ depend on the value of tolerance field of eccentricity,, e,, as well as of the direction of eccentricity ,,θ,, respectively of a vector whose module is size of eccentricity ,, e,, and the argument is angle θ.

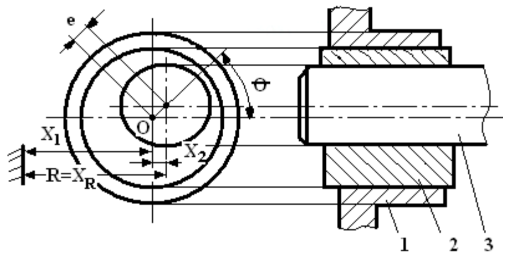

Fig. 1. Chain of sizes with variable steering deviations [5].

The primary elements of the chain of sizes are $x_1\, si\, x_2$, the latter being the given by relation:

$$x_2 = e\cos\theta \qquad (2)$$

The mean value of the element 2 will be:

$$M(x_2) = M(e\cos\theta) = M(e) \quad M(\cos\theta) = 0 \qquad (3)$$

for $\theta \in (0, \pi)$, we have:

$$M(\cos\theta) = \int_0^{\pi} \cos\theta \quad \Phi(\theta) \quad d\theta \qquad (4)$$

If we believe that we have a uniform distribution [7], $\Phi(\theta) = \dfrac{1}{\pi}$, results:

$$M(\cos\theta) = \frac{1}{\pi}\int_0^{\pi} \cos\theta \quad d\theta \qquad \text{or}$$
$$M(\cos\theta) = 0, \qquad \text{adica} \quad M(x_2) = 0 \tag{5}$$

Tolerance resulting element is given by relation:

$$T_{Rpr} = \frac{k_D}{k_R}\sqrt{\sum_{j=1}^{n\ \ 1} A_j^2 k_j^2 T_j^2} \tag{6}$$

where: k- is the scattering coefficient;

A_j- the elements of the chain of sizes;

T_j – tolerances of the elements.

In this mode are determined tolerance and the deviations of the closure element.

II. Determination Of The Chain Of Sizes At Assembly Of The Pieces Of Revolution

The case study at which you will refer to assembly pieces: the connecting rod and piston. In the scheme which will follow, the orientation and the fixation of the piston and the connecting rod is done using a centering rod, on which pieces are positioned in horizontally plane. The bevelling tapered of the rod ensures easy positioning of parts that are oriented and fixed on it.

At the displacement in outside the centering rod , forces under its own weight and the force of gravity of the piston and the connecting rod, due to the presence of the play between its supports, Fig. 2, rod will lean with angle γ and şi as a result of this, the sizes of displacement (on vertically) will be $\delta\gamma$. That size will be taken into account order to be able determine the accuracy for the scheme of orientation and fixing a the bolt in the piston's holes.

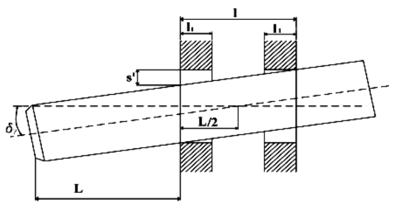

Fig. 2. The scheme centering movement of the plunger, in the case centering the piston and connecting rod.

In Fig. 3, piston and connecting rod are oriented and fixed on two cylindrical surfaces and the bolt is oriented on prisms.

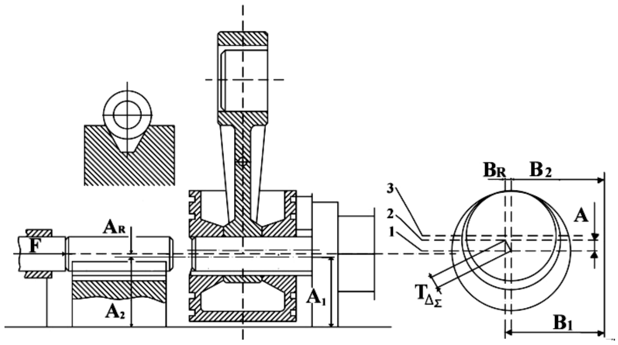

Fig. 3. Scheme at assambler with bolt and conneting rod: 1- axis piston; 2 – axis bolt; 3 - axis rod

The problem of determining the ratio of the bolt with holes in the piston and connecting rod are solved using chains of sizes A and B. In determining the closing elements of the chain of sizes and their tolerances, will write the following relations for calculation:

$$A_R = A_1 \quad A_2; \tag{7}$$

$$B_R = B_1 \quad B_2 \tag{8}$$

$$T_{A_R} = T_{A1} + T_{A2} + \delta\gamma = \frac{d' \quad d_t}{2} + \frac{T_{d'}}{2\sin\alpha} + \frac{(l/2+L)s'}{l}; \tag{9}$$

$$T_R = T_{B_1} + T_{B_2} \tag{10}$$

$$T\Delta_{\Sigma} = \sqrt{\left[(d' \quad d_t)/2 + T_{d'}/(2\sin\alpha) + (l/2+L)(s'/l)\right]^2 + (T_{B_1} + T_{B_2})^2}; \tag{11}$$

$$\Delta_{\Sigma} = \Delta_{min} + r; \tag{12}$$

In this case, the error angle $\delta\gamma$ will be:

$$\delta\gamma = (l/2+L)s'/l. \tag{13}$$

where: d' represents the diameter the bore in the piston where is fitted the bolt;

r – radius of rounding the chamfer part of the bolt;

d_t – diameter of the rod;

L – the distance between the fulcrum of the hole to the end of the piston;

l – outside distance ;

s' – the play between the rod and piston bosses;

α - semi-angle prisme;

In Fig. 4 is present a scheme of assembler of the piston and connecting rod and the elements components of chains of sizes that are formed.

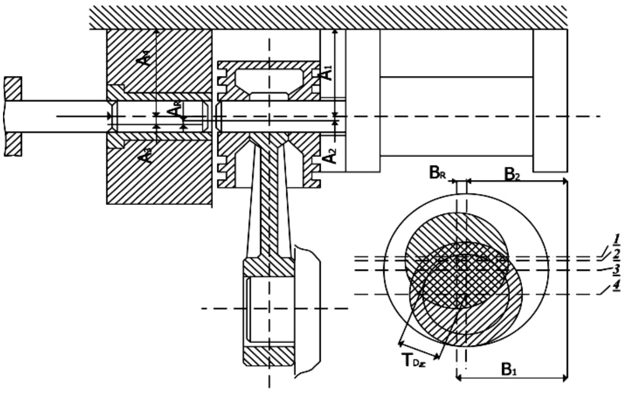

Fig.4. Scheme the guidance when fitting piston with bolt and connecting rod: 1 – axis piston; 2 – axis rod; 3- axis connecting rod; 4- axis bolt.

The problem consists in determining the the precision of the piston, connecting rod and bolt. This calculation will be determined thru the writing the relations the chains of sizes:

$$\mathbf{A_R = A_3 + A_4 \quad A_1 \quad A_2;} \tag{14}$$

$$\mathbf{B_R = B_1 \quad B_2;} \tag{15}$$

Tolerances the elements are determined by the relations

$$T_{A_R} = T_{A_1} + T_{A_2} + T_{A_3} + \delta\gamma = T_{A_1} + \left(d' \quad d''\right)/2 + + \left(d_0 \quad d''\right)/2 + T_{A_4} + \delta\gamma; \tag{16}$$

$$T_{B_R} = T_{B_1} + T_{B_2} \tag{17}$$

$$T\Delta_\Sigma = = \sqrt{\left[T_{A_1} + \left(d' \quad d''\right)/2 + \left(d_0 \quad d''\right)/2 + T_{A_4} + \delta\gamma\right]^2 + \left(T_{B_1} + T_{B_2}\right)^2}; \tag{18}$$

$$\Delta_E = \Delta_{min} + r; \tag{19}$$

In this case, the error angle $\delta\gamma$ will be:

$$\delta\gamma = \frac{(l/2 + L)s'}{l} \tag{20}$$

where:
d' is the diameter of the bore in the piston where is fitted the bolt;
r – the radius of rounding chamfers the bolt;
d_t – the diameter rod;
L- the distance from the end of the pivot to the end of the rod;
l – the distance between the ends of the pivot;
s' – the play between the rod and piston bosses;
d'' – the diameter's bolt

Tolerance $T\Delta_\Sigma$ can be a very small size, which is determined by adding his Δ_Σ, in this case impair the quality of assembly of the product quality no is longe of quality, namely in the process of the pressings bolt under action force punch is possible the deformation of the interior surfaces of the ends of the cylindrical piston, which is not permissible. Therefore guidance and fixing scheme presented can be used to automatically fitting.

In Fig. 4, the scheme of orientation and fixing a the piston with connecting rod is the same as in the previous case, with the difference that the bolt is fixed on the second guide into the bush. Base fixing and orientation is the cylindrical surface of the bushing, Base fixing and orientation is the cylindrical surface of the bushing, and the base of support is its edge. The problem of ensuring precision refers to the bore between bolt and apertures from the piston end and the connecting rod end. This precision is determined by the chain of sizes A respectively the chain of sizes B.

In this scheme, the diameter of the centering bushing hole d_{BT} it take such that the generatrix of the exterior surface of the bushing does not intersect the generatrix of the bore surface of the piston end. This condition is necessary because the bolt, at the pressing, it can move and rotate within the limits of an error, what you do not correlate the bolt and the piston.

The bushing diameter of centering is:

$$\mathbf{d_{BT} \geq d' + T\Delta_\Sigma} \tag{21}$$

The tolerance of lack of correlation is the same as for previous, but it may be greater in conditions cumulation as a result of lack bevels the bolt.

In the schemes of orientation and fixing shown in Fig.5 and Fig.6, is observed the coincidence the generators surfaces in contact of the components elements adjusted or fixed of the device assembly. In the scheme of assembly shown, the mounting of the bolt 3 in the piston 4 is achieved by means of a fixed prism 5, Fig. 5.

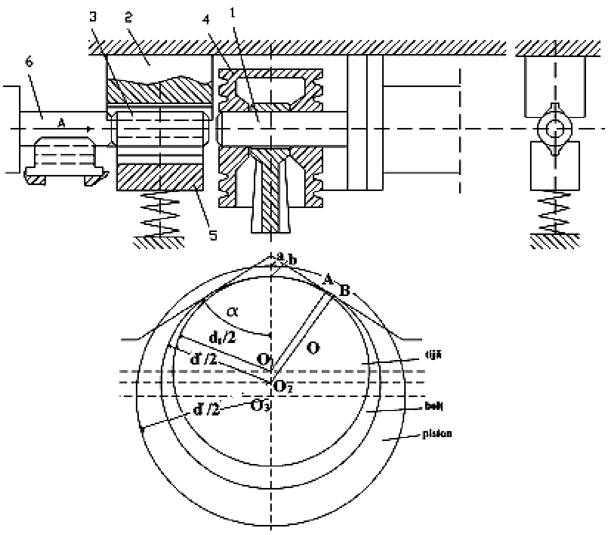

Fig.5. The mounting of the bolt in piston with help a fixed prism.

As it can be seen in figure, instead the rod of centering is using a dorn whose diameter is equal to the rod diameter. On this mandrel is mounted upper prism 2, and the two surfaces of the prism will coincide with the dorn generatrix, after which the prism position in the device shall be fixed. The size of displacement the generatrix of the piston 3 and bolt 4 is calculated, in this case, according to the equation:

$$\Delta_{ab} = \frac{d' \quad d''}{2} \quad \frac{1}{\sin\alpha} \quad 1 \tag{22}$$

The lower prism 5, which has the possibility of displacement and rotation in two directions enter in contact with the bolt 3. Under the force of a coil spring, the lower prism tighten the bolt in device. After replacing the mandrel with rod of centering, the bolt 3 installed with the punch 6 on the prisms 2 and 5, will retain the position shown in Fig. 5. And in this case, before pressing the bolt in of the ends piston holes, will ensure guaranteed game between the surfaces thereof in any section, whose size shall be determined according to the relation (22). Thus, the mounting will be done without piston deformation and without cylindrical surfaces deformation at piston ends. After installing prism 2, the end of the rod, at the repeated mounting, will retain previous position. This thing constitutes the deficiency the studied scheme of orientation and fixing.

In the case adjustable prism, Fig. 6, at every exit motion of the rod of centering 1, the prism 3 is rotating and is moving and it presses with its surfaces on the rod generators 1. For this reason, for fixing is needed of the feather 4. The inferior mobile prism 7, under the action of helical springs will push the rod in down.

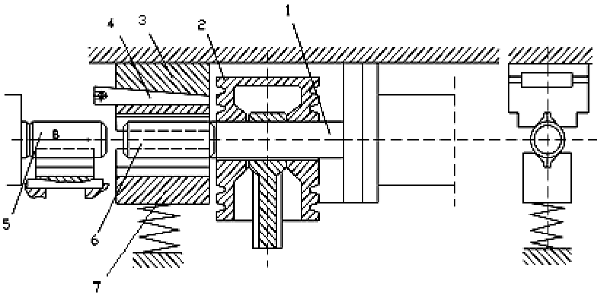

Fig. 6. The mounting of the bolt in piston with help a adjustable prism.

At moving the punch 5, that acts on the bolt 6. In his turn, the bolt 6 enters in the surfaces between prisms. The displacement upper generators piston and bolt 2 will be equal to ***ab*** (Fig.5).

III. Conclusion

The study of chains of sizes that form at the assembly of various parts of rod-piston type, helps in choosing the shortest routes and assembly and at the tolerance increasing or decreasing device dimensions of guidance and fixing. From the analysis of orientation and fixation schemes studied during assembly of the type piston - rod, we can draw the following conclusions:

1) *the contact between surfaces parts assembled it make on the shortest path by determining the shortest chain of sizes, excluding the influence of errors most elements of orientation and initial fixation; propiu center said in such cases will play the role the searcher which directs and fixes the pieces on their contact surfaces;*
2) *assembly process can be studied as a problem of surface area, whose solution has with purpose obtaining the coincidence surfaces parts that are assembled and the position their reporting.*
3) *The using the shortest path at assembly allows to increase tolerance at dimensions the device of orientation and mounting of machine of assembled, tolerance which enters the calculation of the chains of sizes;*
4) *regardless of the orientation and fixing scheme chosen, the contact surface parts is possible provided two displacement and two rotations of the piece moving in her limits no coincidence errors.*

Taking into account the the last two cases presented to mounting the bolt in the piston with help the devices with fixed prisms or mobile prisms, it may be concluded that at the automatic fitting, in cases where the the parts that touch on the cylindrical surfaces and have chamfers of very small size, will can be used as element of fastening and orientation, the fixed prism or the adjustable prism, which allows to completely exclude unwanted deformations of parts and deformations cylindrical surfaces at the ends of the piston.

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