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QUALITY ESTIMATION OF STRUCTURALLY ORDERED ASSEMBLY FOR THREADED CONNECTION WELDING

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Structurally ordered assembly for threaded connection welding allowing supporting high accuracy of relative position of a product connectable components has been considered.

One of the main factors characterizing the quality of heavy loaded engineering products is an accuracy of relative position of conjugated components in static connection.

Threaded connections of drilling diamond bits are referred to such type of connections. The construction of these products (Fig. 1) consists of the body – 2 with inside metric thread, for example M68x2-6G and the nipple – 3 with outside metric thread M68x2-6g. The quality of connection is determined by the parameter of body axis coaxiality – 1 and nipple axis – 4 at the stages of orientation with metric thread of two above-mentioned components into end surface stop and fixation of relative position with welding.

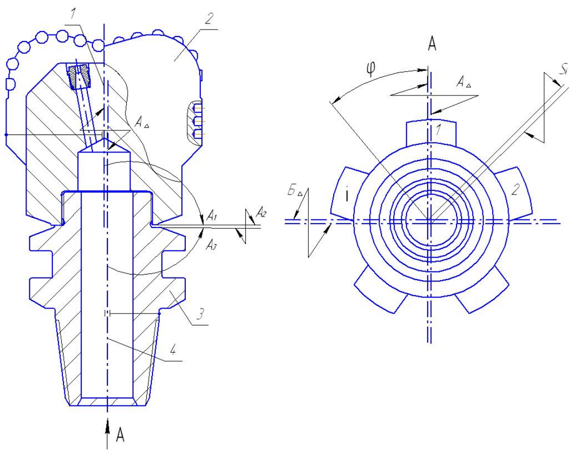

Fig. 1. *Drilling diamond bit*

Two above-mentioned stages of threaded connection assembly and welding all around the body stop with nipple should secure the accuracy of conjugated components relative position. Coaxiality is estimated by the values of radial body deviation relative to nipple which should not exceed the specified limit of 0,1 mm by the requirement of assembly drawing. Such requirements are defined at diamond bits production by significant influence of coaxiality on bit operating capacity which influences, in its turn, heading value and controllability of a bit.

Neglect of coaxiality condition of the body and nipple at welding stage could not be balanced by additional mechanical treatment of assembled elements surface using adjustment method. Therefore, in real manufacturing environment at which welding is the final assembly procedure the method of complete interchangeability is applied for achieving accuracy of master link in angular dimension chain. The analysis of practical results of bits production by the parameter of accuracy in connection elements relative position made according to the proposed diagram and technique does not secure index stability of assembly quality. Dominating influence of random factor is determined by: instability of plasto-elastic deformations in end conjugation and disorder of first tack place at welding. In this case structural parameter stability of two other tacks position made by equilateral triangle diagram does not secure the accuracy of parts position in welded connection.

To obtain coaxiality statistical estimations the statistical samples of 30 assembled diamond bits were investigated. They belong to two above mentioned assembly stages by manufacturing technique neglecting principles of order and stabilization. In some cases radial deviation before welding met the specified tolerance value, after welding it exceeded the acceptable value.

In the paper it is suggested to apply the method of structurally ordered assembly [1, 2], which is characterized by the following equation:

$$P_{as}=f(P_{op}, m),$$

where P_{as} is the parameter of assembly (coaxiality of diamond bit body with nipple A_Δ (Fig. 1), P_{op} is the parameter of operation (bit run in the well), m is the structure (at the stage of assembly for welding is the moment at torque spanner occurring at body tightening with nipple; at welding stage is the tack region).

To determine the influence of random factors on accuracy of connected parts position and statistical estimation of assembly process controllability it is necessary to calculate the controllability parameter by the realization of the random process. For this purpose let us define the change of threaded connection radial deviation at tightening and welding:

$$D(i)=D_{\text{tight}}(i)-D_{\text{weld}}(i).$$

If $D(i)$ has positive value then the process is controllable i. e. at each procedure the error of space deviation decreases. If $D(i)$ is negative then the process increases the errors. Besides qualitative characteristics it is necessary to have quantitative estimations of random process controllability. For this purpose the estimated value of mathematical expectation M_x, dispersion D_x, computed in program Matcad by the basic data of radial deviation difference $D(i)$ obtained at two stages of assembly are used. Numerical values of mathematical expectation and dispersion for two assembly techniques determined for diamond bit ∅120,6 mm are given below.

The method of complete interchangeability (used in diamond bit production):

$$M_x=-0{,}64;\ D_x=3{,}536\cdot10^{-3}.$$

The method of structurally ordered assembly (the proposed method):

$$M_x=0{,}057;\ D_x=9{,}872\cdot10^{-4}.$$

On the basis of the obtained results of comparison the conclusion is made in favor of assembly by the method of structural order.

To solve the problem of geometric relationship instability of structurally disordered assembly for welding it is necessary to enter ordering into assembly technique at retaining assembly structure. It is necessary to increase stability of ordered assembly technique at the stages including the following steps: preliminary and final assembly of threaded connection is the first stage; preliminary fixing with a help of tacks at threaded connection end and final welding all around the connection is the second stage.

The purpose of investigation is increasing assembly geometric relationship for welding of two stages each of which includes two steps. For this purpose positions of tacks are determined depending on initial conditions of achieved accuracy in relative position of threaded connection parts being in charge with accuracy of selecting the first tack position as well as determining structural optimization diagram of tacks position.

Performing the preliminary thread tightening the ends of nipple and body are deformed that causes the change of constituent link A_2 of angular dimension chain (Fig. 1). The change of this constituent link results in changing master link of dimension chain A the value of which is measured by the parameter of axis misalignment A_Δ of body axes and nipple. To determine acceptable deformations of threaded connection which result in minimal value of axes misalignment S_i the preliminary tightening is performed with torque spanner at torque fixing M_{sp}. The preliminary tightening is carried out at torque serial increase and at the end of each stage of thread tightening the radial deviation of axes S_i with i reading number by part connection perimeter is measured.

$$A_\Delta=|\max S(\varphi)|_i,$$

where i is the index denoting the measuring number of radial deviation of conjugated component axes for complete revolution of symmetric connection with selected reading sampling increment.

The torque at spanner M_{sp} at preliminary thread tightening is sequentially increased till the moment when the value of radial deviation of conjugated parts starts increasing at the next tightening stage j with respect to the previous one j–1. The end of the stage of the threaded connection preliminary assembly is expressed by the inequation

$$(\max S_i)_j>(\max S_i)_{j-1},\ \text{at}\ (M_{sp})_j>(M_{sp})_{j-1}, \qquad (*)$$

where j is the index denoting the number of tightening period characterizing threaded connection state by the moment of its preliminary assembly.

After preliminary stage of the first step the final assembly of threaded connection is carried out. This final

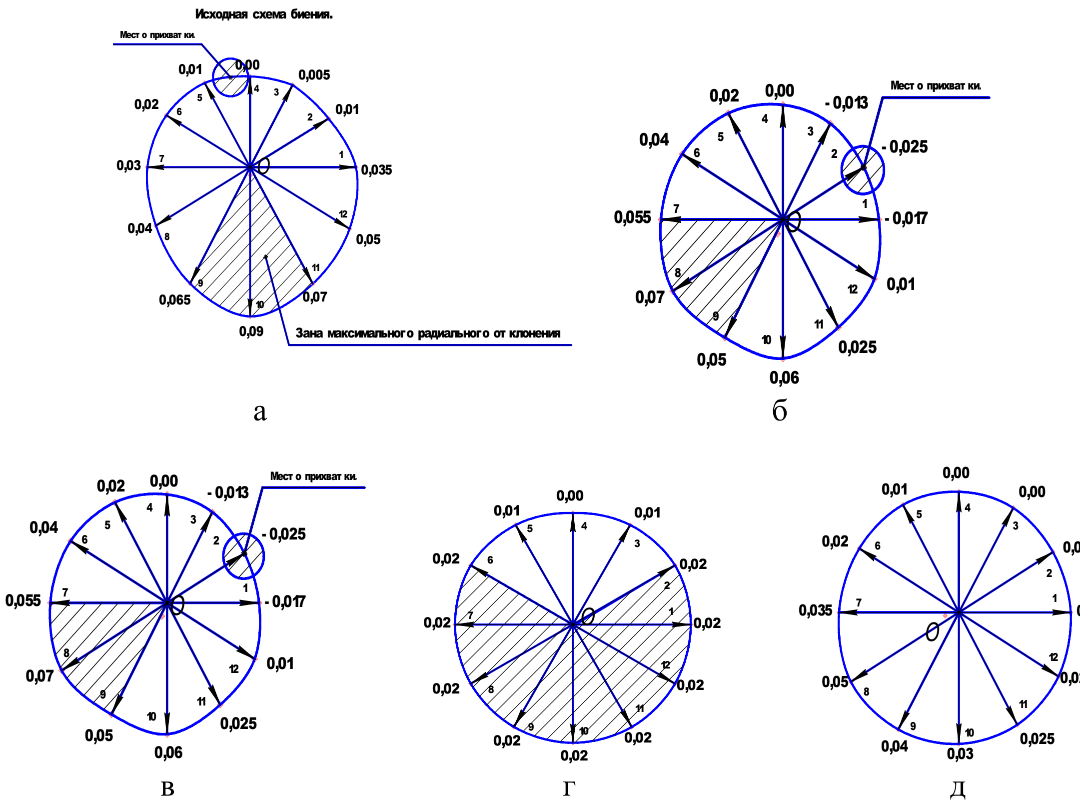

Fig. 2. *Radial deviation of connection components depending on tack position. Quality of connection: a) achieved at the final stage of the first step; b–d) achieved at preliminary stage of welding second step; e) after welding*

stage of the first step includes the procedures of attenuation and final thread tightening with an optimal torque opt$(M_{sp})_{j-1}$. The quality of threaded connection final assembly is checked by the measured value of radial deviation of conjugated components which should be minimal at finish assembled threaded connection and meet the condition (*).

Coaxiality of connected parts is determined by radial deviation indices of conjugated components by means of special measuring equipment.

The equipment consists of a plate, magnetic column and indicating gage with indicator division value 0,01 mm. There is a hole in the plate with a tool bore $\frac{H7}{e8}$, where the bit nipple is set. The body is wrapped on nipple and deviation from tool bore centre for the full connection rotation is measured with the help of magnetic column with indicator. By measuring results the section with polar angle φ in degrees having maximal value of radial deviation of elements position in the product is labeled.

At the next stage the intermediate fixing at threaded connection end is carried out realizing tacks in such way that not to increase the errors of relative position achieved at connection final assembly. For this purpose it is necessary to determine the places of tacks all around the connection and form the structure of their position which is the condition of stable increasing relative position accuracy of connected parts at welding stage.

The stage of determining tack places includes storage of labeled section with the measuring number i and/or polar angle φ the radial deviation of which has the largest value max $S(\varphi)\in i$. Then the tack of body with nipple is carried out in the place diametrally opposite to the section with maximal value of radial runout determined by the value of polar angle $\varphi+180°$. The first tack is performed by the indicated place. It results in changing relative position vector of a normal to end surfaces of connection elements supporting the increase of their relative position accuracy.

After first tack the relative position of conjugated components is measured and the place for the second tack is searched. This process is also repeated for the third tack. After performing three tacks the body welding with nipple all around the bit is carried out.

The results of changing radial deviation error of structurally ordered assembly of threaded connection for welding is presented in Fig. 2.

When performing the tacks the axis of bit body changes its position relative to nipple axis. Let us determine by the above stated diagrams of radial deviation the change of body axis position relative to nipple axis in the process of forming connection. To determine body axis position (figure centre coordinates) let us use the following dependences [3]:

$$\begin{cases} x_c = \dfrac{1}{6}\begin{bmatrix} (r_1 - r_7) + 0,866\,(r_2 + r_{12} - r_6 - r_8) + \\ +0,5\,(r_3 + r_{11} - r_5 - r_9) \end{bmatrix} \\ y_c = \dfrac{1}{6}\begin{bmatrix} (r_4 - r_{10}) + 0,866\,(r_3 + r_5 - r_9 - r_{11}) + \\ +0,5\,(r_2 + r_6 - r_8 - r_{12}) \end{bmatrix} \end{cases}.$$

The change of body axis position relative to nipple axis is shown in Fig. 3.

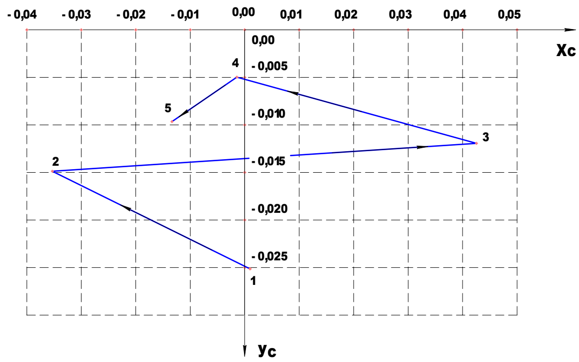

Fig. 3. *Changing body axis position relative to nipple axis. Points: 1 is the position of body axis after the final tightening, 2 is the position of body axis after the first tack, 3 is the axis position after the second tack, 4 is the position of body axis after the third tack, 5 is the position of body axis relative to the nipple axis after all around welding*

The proposed technique of structurally ordered assembly for welding bits allows supporting the required accuracy of relative position of two connected components without toughening accuracy requirements at mechanical treatment technology of product separate components.

The paper subject area is included in researches carried out within the bounds of SamSTU subject plan by the order of Federal educational agency for 2006–2009 on «Development of theoretical basis of structurally ordered assembly of heavy loaded engineering products», state registration number of the research is 01.2.006 06882.

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