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# The Modelling Of Basing Holes Machining Of Automatically Replaceable Cubical Units For Reconfigurable Manufacturing Systems With Low-Waste Production

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**Abstract.** Article is devoted the decision of basing holes machining accuracy problems of automatically replaceable cubical units (carriers) for reconfigurable manufacturing systems with low-waste production (RMS). Results of automatically replaceable units basing holes machining modeling on the basis of the dimensional chains analysis are presented. Influence of machining parameters processing on accuracy spacings on centers between basing apertures is shown. The mathematical model of carriers basing holes machining accuracy is offered.

## Introduction

The present stage of engineering industry development is characterized by a heading automatically replaceable machine systems and units, for solving of the nomenclature expansion, of released products, abbreviation of a time and resources on manufacture preparation problems. To overcome a complex of industrial contradictions it is necessary at the expense of theoretical researches conducting, working out of new designs. So continuation of configurations and designing machine systems, automatic transfer lines development theory is the theory of configurations of automatic machine systems of variable configuration and structure (reconfigurable manufacturing systems - RMS). Reconfigurable it is directed configuration and architecture RMS changes. Along with known solutions it was possibly to provide with application in the capacity of basing, fastening and details transportation units - automatically replaceable cubical units (carriers) [1-5].

This engineering solution improves the accuracy and performance of the parts. The most complete processing of one part is implemented in a separate working position. Implementation of low-waste production based on RMS is ensured by reducing metal consumption in machine tool systems, reducing extent of the production process, reducing the number of working positions, required areas and multiple reduce of production waste [5-14]. A heading of carriers is connected with some questions of their manufacturing accuracy maintenance.

**Formulation of the problem**

It is possible to present a design of the carrier in the form of a cube (Figure 1) where on each basil-plane is available basing holes $T_n$, $T_{(n+1)}$, $T_{(n+2)}$, $T_m$. On two non-adjacent holes, for example, $(T_n, T_{(n+2)})$ and $(T_{(n+1)}, T_m)$ there is a carrier basing on a working position, under the two non-adjacent holes and a basil-plane (Figure 2).

For raise of efficiency of the automated machining the carrier with the details installed on lateral basil-plane is resurface on a working position. Thus there is an interleaving of a complete set of basing holes and a basil with conservation of the theoretical scheme of basing [1]. Resurfacing the carrier provides change of attitude of a detail. In *XOY*-system group of holes $T_n$, $T_{(n+1)}$, $T_{(n+2)}$, $T_m$ dimensional communications define: $A_{ij}^{н}$ - not recut spacings on centers between holes $(i \neq j=1,2,3,4, m)$, $A_{ij}^{n}$ - recut spacings on centers. Each processed holes $T_{ij}$ possesses a set of parameters $A_{ij}^{н}$, $A_{ij}^{n}$, $L_{xij}$, $L_{yij}$, $B_{ij}$ (Figure 2) which define an arrangement of each hole concerning a basil of carrier *G*. The parameters influencing accuracy of a mutual bracing of holes are spacings on centers $A_{ij}^{н}$, $A_{ij}^{n}$, the set tolerance of hole - $T_{\Delta m}^{\ i}$.

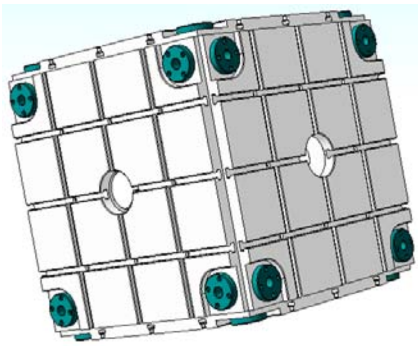

**Figure 1 - Design of the carrier**

So accuracy of hole $T_n$ machining is defined by sizes $L_n$ in *OX, OY* - directions (Figure 3). In an *OX* axis direction the arrangement of hole $T_n$ is characterized: nominal size $L_n$, size $L_{(n)\,p} = = L_n + \Delta L_n$, where $\Delta L_n$ - a deviation of size $L_n$. The data set of sizes forms a dimensional chain of hole $T_n$ machining. The closing chain link is size $L_{(n)\,p}$, increasing a deviation $\Delta L_n$, reducing - face value $L_n$.

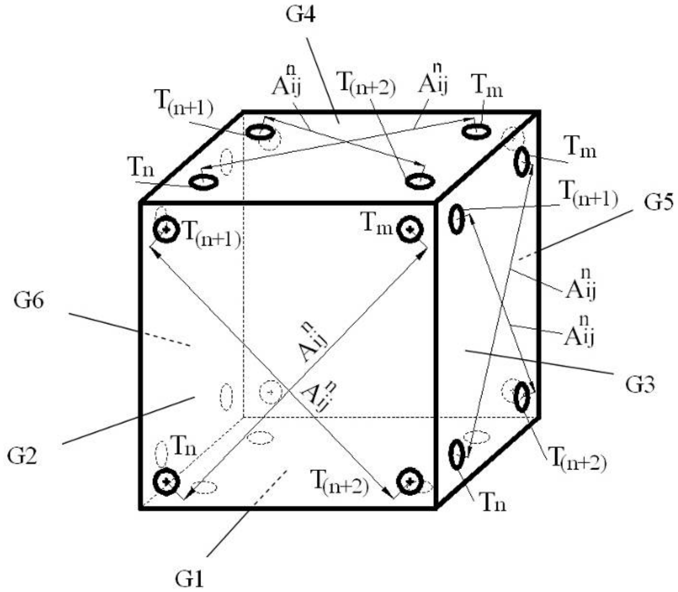


**Figure 2 -** Model of the carrier with basing holes on case lateral faces

At calculation of link $L_{(n+1)}$ accuracy for holes $T_{n+1}$ will observe a chain of sizes $B_{n\,(n+1)}$, $A_{n\,(n+1)}$, $L_n$, $L_{(n+1)}$ (Figure 4). Sizes $L_n$, $B_{n\,(n+1)}$ - have the set rating values and limits deviations $\Delta L_n$, $\Delta B_{n\,(n+1)}$. Link $A_{n\,(n+1)}$ - defined (face value is not known), is known its limiting deviation $\Delta A_{n\,(n+1)}$ .

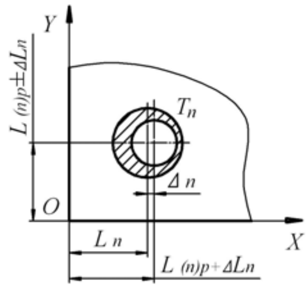


**Figure 3** - Dimensional chain

At closing link $L_{(n+1)}$ theoretical values and limiting deviations $t_{L\,(n+1)}$ are set. It is necessary to count magnitude of required link $A_{n\,(n+1)}$ face value. At calculation of link $L_{(n+2)}$ accuracy holes $T_{n+2}$ will observe a chain from sizes $B_{n\,(n+2)}$, $A_{n\,(n+2)}$, $L_n$, $L_{(n+2)}$, and also a chain which is switching on sizes $A_{n\,(n+1)}$, $A_{n\,(n+2)}$, $A_{(n+1)\,(n+2)}$. Link $A_{n\,(n+2)}$ - defined (face value is not known), is known its limiting deviation $\Delta A_{n\,(n+2)}$.

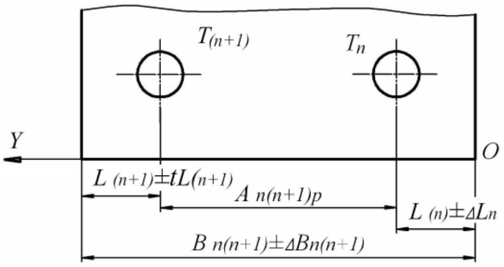


**Figure 4** - Dimensional chain hole $T_{n+1}$ machining

At closing link $L_{(n+2)}$ theoretical values and limiting deviations $t_{L\,(n+2)}$ are set. It is necessary to count magnitude of required link $A_{n\,(n+2)}$. face value. For spacing on centres size $A_{(n+1)\,(n+2)}$ it is necessary to count magnitude of face value, and to check, whether there are settlement limiting values of link $A_{(n+1)\,(n+2)}$ for its regulated values.

Accuracy of each holes machining is characterised by several closing links of dimensional chains. For hole $T_n$ it is sizes $L_n$ in *OX, OY* - directions. For hole $T_{n+1}$ it is sizes $A_{n\,(n+1)}$, $L_{(n+1)}$. For hole $T_{n+2}$ it is sizes $A_{n\,(n+2)}$, $L_{(n+2)}$, $A_{(n+1)\,(n+2)}$. Accuracy of hole $T_m$ machining is defined by accuracy of following links chains, in a *OX* - direction: $B_{n\,(n+1)}$, $A_{(n+1)\,m}$, $L_m$, $L_{(n+1)}$, in *OY* - direction: $B_{n\,(n+2)}$, $A_{(n+2)\,m}$, $L_m$, $L_{(n+2)}$. Also independent chains form the diagonal crossing sizes, in *OX, OY* - directions: $A_{n\,(n+2)}$, $A_{(n+2)\,m}$, $A_{(nm)}$; $A_{n\,(n+1)}$, $A_{(n+1)\,m}$, $A_{(nm)}$ (Figure 5).

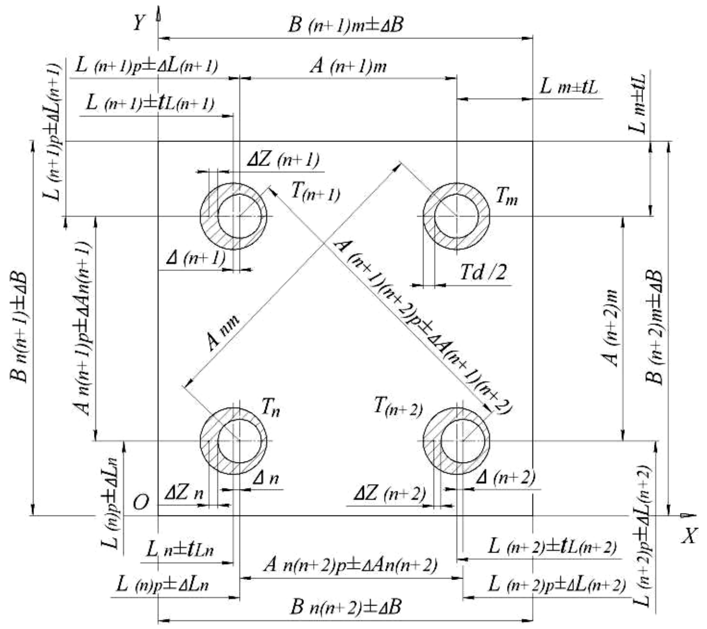


**Figure 5** - The settlement of basing holes machining dimensional chains

Thus, for maintenance of carrier basing accuracy of basing holes $T_n$, $T_{(n+1)}$, $T_{(n+2)}$, $T_m$ machining it is necessary to stand equal in limits of maximum deviations recut spacing on centres sizes $A_{(n+1)(n+2)}$, $A_{(nm)}$, that is possible if equality in tolerance limits of sizes $L_{ij}$ and spacings on centres $A_{ij}$ between basing holes is stood. For hole $T_m$ it is sizes $A_{(n+2)\,m}$, $A_{(n+1)\,m}$, $A_{(nm)}$, $L_m$.

**Method of investigation**

Let's make an auxiliary dimensional chain concerning each closing link and we will write down the additional equation defining rating value of an unknown making link. Also considering, that machining of holes begins, for example, with aperture $T_n$, sequence of holes $T_n$, $T_{(n+1)}$, $T_{(n+2)}$, $T_m$ machining accuracy calculation can look like: 1) machining of hole $T_n$, machining of hole $T_{n+1}$, machining of hole $T_m$; 2) machining of hole $T_n$, machining of hole $T_{n+2}$, machining of hole $T_m$ (Figure 5). The simplified record of dimensional chains for each alternative sequence of machining can look like: 1) $T_n$, $T_{n+1} \rightarrow T_m$; 2) $T_n$, $T_{n+2} \rightarrow T_m$. In both cases hole $T_m$ is closing. It allows, using results of calculations to define alternative of hole $T_m$ machining (a chain 1 or 2), providing the highest accuracy of its positioning concerning next holes $T_n$, $T_{(n+1)}$, $T_{(n+2)}$ in each basil $G$.

The arrangement of hole $T_m$ of relative holes $T_n$, $T_{n+2}$ is defined by rating values of closing links $A_{(n+2)\,m}$, $A_{(nm)}$ and sizes $L_{(n)}$, $L_{(n+2)}$ in $OX$, $OY$ - directions:

$$L_{(n)P}=L_{(n)}\pm(\Delta_{(n)}+tL), \quad (1)$$

$$L_{(n+2)P}=L_{(n+2)}\pm(\Delta_{(n+2)}+tL). \quad (2)$$

where $L_{(n)}$ - rating value of distance of hole $T_{(n)}$ to edge of a basil of the carrying agent, $\Delta_{(n)}$ - value of a deviation of hole $T_{(n)}$ taking into account elastic deformations of the tool and a carrier, $tL$ - a limit deviation on manufacturing of holes $T_{(n)}$ and $T_{(n+2)}$, $L_{(n+2)}$ - rating value of distance of hole $T_{(n+2)}$ to edge of a basil of the carrier, $\Delta_{(n+2)}$ - value of a deviation of hole $T_{(n+2)}$ taking into account elastic deformations of the tool and a carrier basil, $tL$ - a limit deviation on manufacturing of hole $T_{(n+2)}$.

The interconnection of sizes $A_{(n+2)m}$ and $A_{(nm)}$ is being out through a system gear ratio $\xi=\sqrt{2}$ equal-arrangement holes of settlement chain $T_n$, $T_{n+2} \rightarrow T_m$. Deviation closing links $A_{(n+2)\,m}$ and $A_{(nm)}$ are defined by relationships:

$$\Delta A_{(n+2)m} = \Delta B+(tL_{(n+2)}+\Delta_{(n+2)})+tL. \quad (3)$$

$$\Delta A_{nm} = \xi\, (\Delta B+(tL_n+\Delta_n)+tL) \quad (4)$$

Let's mark out $\Delta A_{nm}$ - a deviation of a closing size $A_{(nm)}$, $\Delta A_{(n+2)\ m}$ - a deviation of a closing link $A_{(n+2)\ m}$, $\Delta B$ - a deviation of carrier basil size $B_{ij}$, $tL$ - a maximum deviation on machining of hole $T_m$, $tL_{(n+2)}$ - a maximum deviation on machining of hole $T_{(n+2)}$, $tL_n$ - a maximum deviation on machining of $T_{(n)}$.

Let's define displacement (correction) ***e*** a design value of closing links $A_{((n+2)\ m)\ P}$ and $A_{(nm)\ P}$ concerning their face values $A_{(n+2)\ m}$ and $A_{nm}$:

$$e_{(n+2)m} = (A_{min((n+2)m)P} - A_{min((n+2)m)})+ tL+ (\Delta B+(tL_{(n+2)}+\Delta_{(n+2)}); \quad (5)$$

$$e_{(nm)} = (A_{min((nm)P} - A_{min((nm)})+ (tL(\xi)^{-1}) + (\Delta B+(tL_{(n)}+\Delta_{(n)})\xi. \quad (6)$$

Where $A_{min\ ((n+2)\ m)\ P}$ and $A_{min\ ((nm)\ P}$ - the minimum design values of links $A_{(n+2)\ m}$, $A_{nm}$; $A_{min\ ((n+2)\ m)}$ and $A_{min\ ((nm)}$ - the minimum values of links *And* $_{(n+2)\ m}$ and $A_{nm}$; $e_{\ (n+2)\ m}$ - correction of a closing link $A_{(n+2)\ m}$ design value; $e_{\ (nm)}$ - correction of a closing link design value $A_{nm}$.

Using expressions (5,6) is being out calculation of links $A_{(n+2)\ m}$ and $A_{nm}$ correction on values $e_{(n+2)\ m}$ and $e_{\ (nm)}$, taking into account deviations of links $L_{(n)}$, $L_{(n+2)}$. On design values of closing links $A_{((n+2)m)P}$ and $A_{(nm)\ P}$ accuracy of machining in *XOY* - system (Figure 5) hole $T_m$ of settlement chain $T_n$, $T_{n+2} \rightarrow T_m$ in *OX, OY* - directions is provided.

For settlement chain $T_n$, $T_{n+1} \rightarrow T_m$ the rule of hole $T_m$ of relative holes $T_n$, $T_{n+1}$ is defined by rating values of closing links $A_{(n+1)\ m}$ and $A_{(nm)}$, the rule of holes $T_n$, $T_{n+2}$ is defined by sizes $L_{\ (n)}$, $L_{\ (n+1)}$ in *OX, OY* - directions. Expressions for calculation of sizes rating values $L_{\ (n)\ P}$, $L_{\ (n+2)\ P}$ on an auxiliary dimensional chain (Figure 5) look like:

$$L_{(n)P}=L_{(n)}\pm(\Delta_{(n)}+tL), \quad (7)$$

$$L_{(n+1)P}=L_{(n+1)}\pm(\Delta_{(n+1)}+tL). \quad (8)$$

$L_{\ (n)}$ - rating value of distance of hole $T_{(n)}$ to edge of a carrier basil; $\Delta_{\ (n)}$ - value of a deviation of hole $T_{(n)}$ taking into account elastic deformations of the tool and a carrier basil; $tL$ - a maximum deviation on manufacturing of holes $T_{(n)}$ and $T_{(n+1)}$; $L_{\ (n+1)}$ - rating value of distance of hole $T_{\ (n+1)}$ to edge of a carrier basil; $\Delta_{\ (n+1)}$ - value of a deviation of hole $T_{\ (n+1)}$ taking into account elastic deformations of the tool and a carrier basil; $tL$ - a deviation on manufacturing of hole $T_{\ (n+1)}$.

Expressions (13) represent dependence of nominal sizes $L_{\ (n)}$, $L_{\ (n+1)}$ from machining parametres, the tolerances of holes in diameters $D_{\ (n)}$, $D_{\ (n+1)}$. Deviations of closing links $A_{(n+1)\ m}$, $A_{(nm)}$ are defined according to:

$$\Delta A_{(n+1)m} = \Delta B+(tL_{(n+1)}+\Delta_{(n+1)})+tL. \quad (9)$$

$$\Delta A_{nm} = \xi\, (\Delta B+(tL_n+\Delta_n)+tL). \quad (10)$$

Let's mark out $\Delta A_{nm}$ - a deviation of a closing size $A_{(nm)}$; $\Delta A_{(n+1)\ m}$ - a deviation of a closing link $A_{(n+1)\ m}$; $\Delta B$ - a deviation of size $B_{ij}$ of a carrier basil; $tL$ - a maximum deviation on machining of aperture $T_m$; $tL_{\ (n+1)}$ - a maximum deviation on machining of hole $T_{\ (n+1)}$; $tL_n$ - a maximum deviation of hole $T_{(n)}$.

Let's define displacement (correction) ***e*** a design value of closing links $A_{((n+1)\ m)\ P}$ and $A_{(nm)\ P}$ concerning their face values $A_{(n+1)\ m}$ and $A_{nm}$:

$$e_{(n+1)m} = (A_{min((n+1)m)P} - A_{min((n+1)m)})+ tL+ (\Delta B+(tL_{(n+1)}+\Delta_{(n+1)}); \quad (11)$$

$$e_{(nm)} = (A_{min((nm)P} - A_{min((nm)})+ (tL(\xi)^{-1}) + (\Delta B+(tL_{(n)}+\Delta_{(n)})\xi. \quad (12)$$

$A_{min((n+1\ m\ P}$ and $A_{min((nm)P}$ - the minimum design values of links $A_{(n+1)\ m}$ and $A_{nm}$; $A_{min\ ((n+1)\ m)}$ and $A_{min\ ((nm)}$ - the minimum values of links $A_{(n+1)\ m}$ and $A_{nm}$; $e_{(n+1)\ m}$ - correction of a design value of a closing link $A_{(n+1)\ m}$; $e_{(nm)}$ - correction of a design value of closing link $A_{nm}$.

**Modeling solutions**

Using expressions (11, 12) is being out calculation of links *And* $_{(n+2)\ m}$ and $A_{nm}$ correction on values $e_{\ (n+2)\ m}$ and $e_{\ (nm)}$, taking into account deviations of links $L_{\ (n)}$, $L_{\ (n+2)}$. Generally for machining of basing hole $T_m$ it is necessary to execute preliminary with given machining accuracy of basing holes $T_n$, $T_{n+1}$, $T_{n+2}$. Thus in calculations dimensional chains $T_n \rightarrow T_{n+1}$, $T_n$, $T_{n+1} \rightarrow T_{n+2}$ (Figure 5). For calculation of equal-arrangement holes $(T_n, T_{(n+1)}, T_{(n+2)}, \ldots T_m)$ machining accuracy following equations are gained. For rating value of size $A_{n\,(n+1)}$:

$$e_{n(n+1)}' = A_{(n(n+1))P} - (A_{max(n(n+1))} + A_{min(n(n+1))})/2; \quad (13)$$

$$e_{n(n+1)}'' = (A_{min(n(n+1))P} - A_{min(n(n+1))}) + tL_{(n+1)} + (\Delta B + \Delta L_{(n)}); \quad (14)$$

$$e_{n(n+1)}''' = (A_{min(n(n+1))P} - A_{min(n(n+1))}) + tL_{(n+1)} + (\Delta B + (tL_{(n)} + \Delta_{(n)})); \quad (15)$$

$$e_{n(n+1)}' = e_{n(n+1)}'' = e_{n(n+1)}''' \quad (16)$$

$A_{min\,(n\,(n+1))\,P}$ - the minimum design value of link $A_{n\,(n+1)}$; $A_{min\,(n\,(n+1))}$ - the minimum value of link $A_{n\,(n+1)}$; $e_{n\,(n+1)}$ - correction of a closing link design value $A_{n\,(n+1)}$; $\Delta L_{(n)}$ - a deviation at machining of hole $T_n$; $\Delta B$ - a deviation of a carrier basil size $B_{ij}$ ; $tL_{(n+1)}$ - a maximum deviation on machining of hole $T_{(n+1)}$; $tL_n$ - a maximum deviation on machining of hole $T_{(n)}$, $\Delta_{(n)}$ - a deviation on machining of hole $T_{(n)}$ taking into account elastic deformations of the tool and a carrier basil. For maintenance of given machining accuracy is necessary performance of equality (16) according to a condition for link $A_{nm}$ ($e_{nm}=0$). For rating value of size $A_{n\,(n+2)}$:

$$e_{n(n+2)}' = A_{(n(n+2))P} - (A_{max(n(n+2))} + A_{min(n(n+2))})/2; \quad (17)$$

$$e_{n(n+2)}'' = (A_{min(n(n+2))P} - A_{min(n(n+2))}) + tL_{(n+2)} + (\Delta B + \Delta L_{(n)}); \quad (18)$$

$$e_{n(n+2)}''' = (A_{min(n(n+2))P} - A_{min(n(n+2))}) + tL_{(n+2)} + (\Delta B + (tL_{(n)} + \Delta_{(n)})); \quad (19)$$

$$e_{n(n+2)}' = e_{n(n+2)}'' = e_{n(n+2)}''' \quad (20)$$

$A_{min\,(n\,(n+2))\,P}$ - the minimum design value of link $A_{n\,(n+2)}$; $A_{min\,(n\,(n+2))}$ - the minimum value of link $A_{n\,(n+2)}$; $e_{n\,(n+2)}$ - correction of a closing link design value $A_{n\,(n+2)}$; $\Delta L_{(n)}$ - a deviation at machining of hole $T_n$; $\Delta B$ - a deviation of a carrier basil size $B_{ij}$; $tL_{(n+2)}$ - a maximum deviation on machining of hole $T_{(n+2)}$; $tL_n$ - a deviation on machining of hole $T_{(n)}$; $\Delta_{(n)}$ - a deviation on machining of hole $T_{(n)}$ taking into account elastic deformations of the tool and a carrier basil. For rating value of a size $A_{(n+1)\,(n+2)}$:

$$e_{(n+1)(n+2)}' = A_{(n+1)(n+2)P} - (A_{max(n+1)(n+2)} + A_{min(n+1)(n+1)})/2; \quad (21)$$

$$e_{(n+1)(n+2)}'' = (A_{min(n+1)(n+2)P} - A_{min(n+1)(n+2)}) + tL_{(n+2)}\,(\xi)^{-1} + (\Delta B + \Delta L_{(n+1)})\xi; \quad (22)$$

$$e_{(n+1)(n+2)}''' = (A_{min(n+1)(n+2)P} - A_{min(n+1)(n+2)}) + tL_{(n+2)}\,(\xi)^{-1} + (\Delta B + (tL_{(n+1)} + \Delta_{(n+1)})\xi); \quad (23)$$

$$e_{(n+1)(n+2)}' = e_{(n+1)(n+2)}'' = e_{(n+1)(n+2)}''' . \quad (24)$$

$A_{min\,(n+1)\,(n+2))\,P}$ - the minimum design value of a link $A_{(n+1)\,(n+2)}$; $A_{min\,(n+1)\,(n+2))}$ - the minimum value of a link $A_{(n+1)\,(n+2)}$; $e_{(n+1)\,(n+2)}$ - correction of a closing link design value $A_{(n+1)\,(n+2)}$; $\Delta L_{(n+1)}$ - a deviation at machining of hole $T_{n+1}$, $\Delta B$ - a deviation of a carrier basil size $B_{ij}$; $tL_{(n+2)}$ - a maximum deviation on machining of hole $T_{(n+2)}$; $tL_{(n+1)}$ a - maximum deviation on machining of hole $T_{(n+1)}$; $\Delta_{(n+1)}$ - a deviation on machining of hole $T_{(n+1)}$ taking into account elastic deformations of the tool and a carrier basil. For rating value of a size $A_{(n+2)\,m}$:

$$e_{(n+2)m}' = A_{((n+2)m)P} - (A_{max(n+2)m} + A_{min(n+2)m})/2; \quad (25)$$

$$e_{(n+2)m}'' = (A_{min((n+2)m)P} - A_{min(n+2)m}) + tL + (\Delta B + \Delta L_{(n+2)}); \quad (26)$$

$$e_{(n+2)m}''' = (A_{min((n+2)m)P} - A_{min(n+2)m}) + tL + (\Delta B + (tL_{(n+2)} + \Delta_{(n+2)})); \quad (27)$$

$$e_{(n+2)m}' = e_{(n+2)m}'' = e_{(n+2)m}''' . \quad (28)$$

$A_{min\,((n+2)\,m)\,P}$ - the minimum design value of a link $A_{(n+2)\,m}$; $A_{min\,((n+2)\,m)}$ - the minimum value of a link $A_{(n+2)\,m}$; $e_{(n+2)\,m}$ - correction of a closing link design value $A_{(n+2)\,m}$; $\Delta L_{(n+2)}$ - a deviation at machining of hole $T_{(n+2)}$; $\Delta B$ - a deviation of a carrier basil size $B_{ij}$; $tL_{(n+2)}$ - a maximum deviation on machining of hole $T_{(n+2)}$; $tL$ - a maximum deviation on machining of hole $T_{(m)}$; $\Delta_{(n+2)}$ - a deviation on machining of hole $T_{(n+2)}$ taking into account elastic deformations of the tool and a carrier basil. For calculation of rating value of a size $A_{(n+1)\,m}$:

$$e_{(n+1)m}' = A_{((n+1)m)P} - (A_{max(n+1)m} + A_{min(n+1)m})/2; \quad (29)$$

$$_{(n+1)m}'' = (A_{min((n+1)m)P} - A_{min(n+1)m}) + tL + (\Delta B + \Delta L_{(n+1)}); \quad (30)$$

$$e_{(n+1)m}''' = (A_{min((n+1)m)P} - A_{min(n+1)m}) + tL + (\Delta B + (tL_{(n+1)} + \Delta_{(n+1)})); \quad (31)$$

$$e_{(n+1)m}' = e_{(n+1)m}'' = e_{(n+1)m}''' \quad (32)$$

$A_{min\,((n+1)\,m)\,P}$ - the minimum design value of a link $A_{(n+1)\,m}$; $A_{min\,((n+1)\,m)}$ - the minimum value of a link $A_{(n+1)\,m}$; $e_{(n+1)\,m}$ - correction of a closing link design value $A_{(n+1)\,m}$; $\Delta L_{(n+1)}$ - a deviation at machining of hole $T_{(n+1)}$, $\Delta B$ - a deviation of a carrier basil size $B_{ij}$; $tL_{(n+1)}$ - a maximum deviation on machining of hole $T_{(n+1)}$; $tL$ - a maximum deviation on machining of hole $T_{(m)}$; $\Delta_{(n+1)}$ - a deviation on machining of hole $T_{(n+1)}$ taking into account elastic deformations of the tool and a carrier basil.

Concerning closing hole $T_m$ machining can be spended out in $OX, OY$ - directions (Figure 5), according to calculations of nominal sizes of chains $T_n, T_{n+1} \rightarrow T_m$ and $T_n, T_{n+2} \rightarrow T_m$ results. Direction sampling is defined by calculations corrections $e_{(nm)}$ on each settlement chain results:

$$e_{(nm)}' = A_{(nm)P} - (A_{max(nm)} + A_{min(nm)})/2; \tag{33}$$

$$e_{(nm)}'' = (A_{min(nm)P} - A_{min(nm)}) + tL(\xi)^{-1} + (\Delta B + \Delta L_{(n)})\xi; \tag{34}$$

$$e_{(nm)}''' = (A_{min(nm)P} - A_{min(nm)}) + tL(\xi)^{-1} + (\Delta B + (tL_{(n)} + \Delta_{(n)})\xi); \tag{35}$$

$$e_{(nm)}' = e_{(nm)}'' = e_{(nm)}'' \tag{36}$$

$A_{min\ (nm)\ P}$ - the minimum design value of a link $A_{(nm)}$; $A_{min\ (nm)}$ - the minimum value of a link $A_{(nm)}$; $e_{(nm)}$ - correction of a closing link design value $A_{(nm)}$, $\Delta L_{(n)}$ - a deviation at machining of hole $T_n$, $\Delta B$ - a deviation of a carrier basil size $B_{ij}$; $tL_{(n)}$ - a maximum deviation on machining of hole $T_{(n)}$; $tL$- maximum deviation on machining of hole $T_{(m)}$; $\Delta_{(n)}$ - a deviation on machining of hole $T_{(n)}$ taking into account elastic deformations of the tool and a carrier basil.

## Conclusions

In production conditions of low-waste RMS carrier is constructive conferred a basing redundancy property under the condition of variable spatial position in the work area in order to enable the simultaneous advance of the tool to multiple parts disposed on the lateral faces of its body $G_i$. This allows:

1. Reducing metal consumption of machine tool systems and obtaining a number of technical effects that simplify the organization of the production process.
2. Reducing waste of the production concerning to traditional production forms of organization.
3. In order to enable the accuracy of spatial arrangement of parts on the RMS carrier in this study were obtained dependences of basing parameters on its manufacturing precision parameters of basing holes of its body. Thus, on carrier basing accuracy the essential agency renders mutual bracing accuracy of basing holes on each basil. Oscillations of basing holes mutual bracing accuracy are caused by alternativeness of machining concerning each carrier basil dimensional chains.
4. The carrier machining algorithmic sequence where each subsequent hole is machining taking into account a lapse of the previous hole machining and maximum deviations of spacings on centres between them is offered.
5. The machining process mathematical model, allowing to count accuracy of basing holes spacings on centres taking into account at stage of their manufacturing lapse of machining process is offered.
6. Results of modelling are confirmed by calculations of carrier basing accuracy and results of its one basil basing holes $T_n, T_{n+1}, T_{n+2}, T_m$, machining.

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