PERSPECTIVES OF HEIGHTENING OF EXACTITUDE FAIR HANDLINGS OF HOLES BY THE AXIAL INSTRUMENT

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New progressive methods of the hole machining by axis cutting tool, which allowing to promote accuracy of longitudinal and transversal section of hole by management the parameters of workings processes in the cutting zone at the change of the cutting parameters is developed.

Keywords: hole, parameter, thermoelastic strains, ovality, combined axial instrument.

Development of high techniques calls growth of tolerance requirements of machining job. The problem of heightening of exactitude of a finish machining of holes development and a coredrilling which quality substantially defines reliability of operation of cars and gears is especially important. The decision of this problem in modern machine industry is carried out mainly at the expense of heightening of reliability of the equipment and at the expense of lowering of conditions of cutting. However, now redundancies of heightening of the exactitude, linked with the equipment are almost exhausted, and lowering of conditions of cutting is not always economically expedient. At the same time a considerable redundancy in heightening of exactitude of handling of holes are temperature strains of elements of technological system and, first of all, thermoelastic strains of a detail and the instrument in a cutting zone on which fraction 50 % of a total error of handling of holes are necessary almost. These strains cannot be eliminated at the expense of heightening of exactitude of the equipment and lowering of treatment schedules. Therefore now for heightening of exactitude of handling of holes it is necessary to search for new nonconventional technological and technical decisions.

For the decision of this problem authors had been conducted complex probes of working processes in a cutting zone at a finish machining of holes by the axial instrument [1-3] for the purpose of creation of new modes of the handling, allowing to ensure heightening of exactitude both cross-section, and a direct profile of a hole.

For elimination of errors of a cross-section the axial instrument with differentiated distribution of teethes on a circle with alternation of increasing and decreasing angle steps [4] was used. Such distribution of teethes allows to eliminate a facet and ovality of a cross-section. Minimum magnitude of an aberration of angle steps is defined from a ratio

$$\Delta\Theta_{\min} \geq 2\pi / z^2,$$

and maximum

$$\Delta\Theta_{\max} = \Delta\Theta_{\min}(z/2-1).$$

Values of angle steps for odd teethes of one half of cross-section of monolayer scanning it is defined by dependence

$$\Theta_k = \frac{\pi - \sum_{i=1}^{z/2} i\Delta\Theta_{\min}}{z/2} + (k+1)\cdot\Delta\Theta_{\min}/2,$$

for even teethes

$$\Theta_k = \frac{\pi + \sum_{i=1}^{z/2} i\Delta\Theta_{\min}}{z/2} - k\cdot\Delta\Theta_{\min}/2,$$

where k - cog serial number.

Differentiated decomposition of angle steps allows to eliminate a facet and ovality of a cross-section, however raises a roughness of the treated surface at the expense of the progressive circuit of cutting at which on separate teethes various magnitude of feeding is necessary. A consequence of unequal working conditions of teethes is non-uniform deterioration of teethes, to increase in a surface roughness and various temperature in a cutting zone of teethes. For elimination of these deficiencies differentiated sharpening of teethes of the axial instrument on a flank surface [5] at which everyone the pair teethes located in one diametrical plain, is executed displaced along a shaft of the instrument concerning pair teethes (fig. 1), following minimum angle step $\Theta_{\min}$, on magnitude has been offered

$$\Delta S_i^{/} = \frac{S_0}{2\pi}(\Theta_i - \Theta_{\min}),$$

where S_0 - feeding, with preservation of a shape of the teeth and the basic edges of cutting (fig.1). At such differentiated offset of teethes on each cog of monolayer scanning the identical feeding equal is necessary $S_i = S_0 / z$.

The assaying of errors of handling of a hole has displayed that one of the basic negative consequences of influence of temperature strains on exactitude of handling of a hole is distortion of its direct profile accepting the characteristic barrel-type shape which develops of the decomposition characterizing $\Delta_p = (d_{\max} - d_{ном})/2$ the maximum aberration of the actual sizes of a hole from nominal, and barrel $\Delta_б = [d_{\max} - (d_k + d_н)/2]/2$, characterizing an aberration of a direct profile from linearity, where $d_{\max}$ - the maximum value of diameter of the

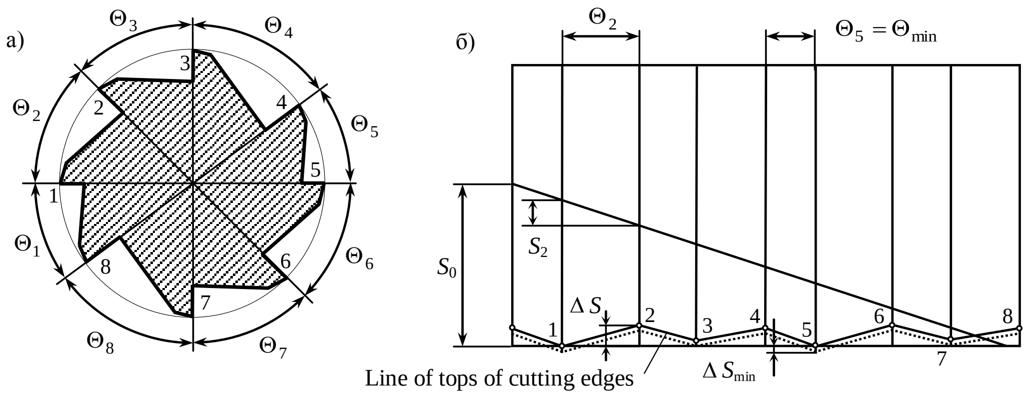

Fig. 1 - The circuit of differentiated sharpening of monolayer scanning with non-uniform distribution of teethes: a cross-section; lateral area monolayer scanning

treated hole, d_{HOM} - nominal hole size, d_{H} and d_{K} - diameter in a kickoff and the end of a hole after handling.

Probe of the physical fundamentals of working processes in a cutting zone at handling of holes has allowed to fix the most perspective technological approaches, allowing to lower this error. For elimination of these errors of a direct profile of a hole at a finish machining the coredrilling and development had been offered three new modes of handling grounded on various scientifically well-founded technical and technological decisions.

As the principal reason of distortion of a direct profile of a hole are thermoelastic strains of the instrument and a detail in a cutting zone, the basic modern technical decision, allowing to raise quality of a direct profile of a hole, temperature lowering in a cutting zone at the expense of heat evolution reduction at lowering of conditions of cutting is. Therefore for heightening of exactitude of a direct profile at development the construction of two-stage monolayer scanning (fig. 2) has been offered and the handling mode, allowing to minimise a heat evolution at the second fair step [6]. It was reached at the expense of minimisation of width of a cut off stratum at the second step which taking into account radius of a rounding off of a cutting edge was defined as

$$t_2 \geq k\rho ,$$

where k =0,5 at operation with cutting fluid, k =1 at operation without cutting fluid.

Condition of effective operation of such instrument is security of conditions of inverse cutting (cutting by an auxiliary cutting edge) at the second fair step, allowing to lower a roughness of the treated surface, and an exception of negative influence of thermal sources at the first step.

Existence of inverse cutting at the second step it is ensured with a choice of its rational geometry and it is executed under a condition

$$\varphi_2 \geq \arcsin\sqrt{\frac{k_0 k\rho z}{S}}$$

where $k_0 \geq 1{,}5$ - factor of a store for prevention of unstable cutting.

The exception of negative influence of thermal sources at the first step is reached at the expense of rational distance between steps. For reduction thermoelastic in m time in comparison with similar conditions of handling of the same hole one-dimensional monolayer scanning this distance should be equal to a strain in a cutting zone of the second step

$$l = \sqrt{\frac{240\omega h}{Sn}\ln\left(\frac{mt - k\rho(m+0{,}5)}{t - k\rho(1+0{,}5m)}\right)},$$

where h - depth of a hole.

Experimental trials of such construction of two-stage monolayer scanning at

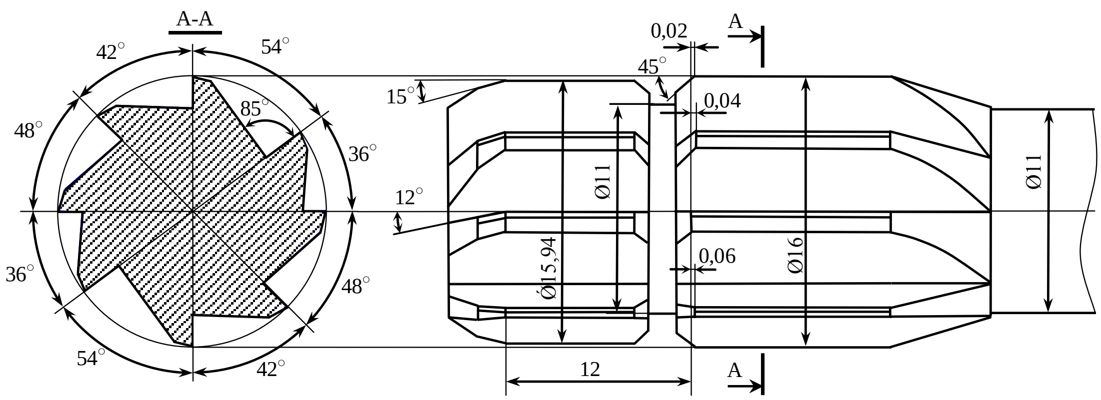

Fig. 2 - Two-stage monolayer scanning with separation of a rough tolerance and Differentiated sharpening of teeths of the second step

various toolhouse and engineering factories has displayed that in comparison with handling by single-stage monolayer scanning hole decomposition is diminished to 3,6 times, and barreling - to 3,9 times. At the expense of use of the inverse circuit of cutting at use of two-stage monolayer scanning the roughness of the treated surface was diminished to 1,8 times, and at the expense of differentiated sharpening firmness of the instrument has raised.

For working out of a mode of handling of the holes, allowing to raise exactitude of a direct profile of a hole at a coredrilling [7] known scientific position about periodic failure of an outgrowth after a flank surface of the instrument and a smooth variation of magnitude of an outgrowth has been used at change of conditions of cutting. According to a modern sample piece of a periodic cut of an outgrowth on a flank surface the number of failures of an outgrowth makes from 2000 to 14500 times a minute. Therefore intensive enough changeover of a hanging part of an outgrowth is the additional regulating technology factor, allowing to correcting exactitude in the course of machining job. The major factor of an outgrowth influencing exactitude of handling, is overhanding an outgrowth over a flank surface

Magnitude of a stratum of a material of a detail which acts in film in addition at the expense of an outgrowth, is defined by dependence

$$h = AV^{-n}S^{-m},$$

where *V* - rate of cutting, *S* - feeding, factors *A*, *n* and *m* characterise properties of a worked stock.

Elimination of decomposition of a hole in the offered mode was reached at the expense of reduction of nominal diameter of the instrument $d_{ном} = d - \Delta_p$, and lowering barrel - at the expense of change of magnitude of an outgrowth at a smooth variation of rate of cutting from $V_н = V_0\left(k(\Delta - \Delta_н)S_0^n V_0^m + 1\right)^p$ to $V = V_0$ in a kickoff of a hole and from $V = V_0$ to $V_к = V_0\left(k(\Delta - \Delta_к)S_0^n V_0^m + 1\right)^p$ in the end of a hole and the coordinated change of feeding $S_н = \dfrac{SV}{V_н}$ and $S_k = \dfrac{SV}{V_k}$. Application of this mode is calculated on handling of holes by the on-gauge axial instrument with the rates of cutting exceeding critical rates for outgrowth. It is characteristic for a coredrilling and at use of the on-gauge instrument allows to lower barreling holes to 4 times.

As a result of probe of thermal processes in a cutting zone at a finish machining of holes it has been fixed [1-3] that a principal cause of distortion of a direct profile in a hole kickoff are instrument temperature strains, and in the end of a hole - detail temperature strains in a cutting zone. It is linked by that character of development of thermoelastic strains of the instrument and a detail on depth of a hole essentially differs. This feature has been taken as a principle a mode of handling of holes by single-stage monolayer scanning [8]. As magnitude of temperature strains of a detail in the end of a hole is much less, than instrument temperature strains, depends on intensity of a heat evolution, and, hence, from parameters of conditions of cutting, the additional volume of a material in a kickoff and the hole end can be deleted at the expense of more intensive heating up and temperature deformation of the instrument. It is possible at the expense of smooth increase in feeding as approaching the end of a hole to magnitude

$$S_k = k_m k_v k_0 S_0,$$

where k_m - the factor considering influence of a mass thermal capacity of a detail, k_v - scale factor of conditions of cutting, - the factor considering decomposition Δ_k in the end of a hole. All reduced factors receive on the basis of a numerical modeling of thermal processes for each pair of materials. Therefore, in spite of the fact that this mode of handling is the most perspective, its wide application restricts necessity of additional help information.

The offered modes of handling of holes the axial instrument, grounded on control in various parameters of working processes in a cutting zone at change of conditions of cutting, have displayed efficiency and perspectivity of the similar approach in problem solving of heightening of exactitude of machining job. Therefore the further heightening of exactitude of handling of holes is anyhow linked with spreading of introducings about character of development of working processes.

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ПЕРСПЕКТИВЫ ПОВЫШЕНИЯ ТОЧНОСТИ ЧИСТОВОЙ ОБРАБОТКИ ОТВЕРСТИЙ ОСЕВЫМ ИНСТРУМЕНТОМ

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Новые прогрессивные методы исследования рабочих процессов в зоне резания при чистовой обработке отверстий осесимметричным режущим инструментом, позволяющим обеспечивать повышение точности поперечного и продольного профиля отверстия

Ключевые слова: отверстие, параметр, термоупругие деформации, овальность, комбинированный осевой инструмент.