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GEOMETRIC PARAMETERS OF A PEAKLESS CUTTING TOOL IN THE INSTRUMENTAL COORDINATE SYSTEM

Processing of external surfaces with turning tools is the most common in the total mass of tools, and occupies a special place in the technological process of manufacturing machine parts. The issues of increasing productivity, accuracy and reliability of the processing process have always been and remain relevant and effective for metalworking.

The aim of the study is to improve the quality of processing of external cylindrical surfaces with the development of a new processing method and the design of a peakless turning through-hole cutter.

The idea of the work is to develop a new design of a lathe cutter for finishing and a new processing method.

The analysis of methods and methods of processing external cylindrical surfaces, parameters of the cut layer during cutting, geometry and designs of turning cutting tools, led to the development of a new metal-cutting tool – a peakless turning cutting tool for finishing. The new design improves cutting conditions and minimizes the impact of adverse factors accompanying the cutting process.

Thus, a pass-through peakless cutter has one cutting edge, is simpler due to the absence of an auxiliary back surface and top, has less complexity of manufacturing and sharpening, and therefore requires less operating costs.

Keywords: geometry; plane; construction; cutter; peakless; quality.

Introduction

The most expensive in terms of material consumption and energy consumption belongs to the processing of cutting materials up to 60–75 % of the complexity of manufacturing parts for all types of production – from individual to mass. The advantages of cutting include versatility and flexibility: the ability to obtain surfaces of various shapes, sizes and accuracy using a wide range of metal-cutting equipment, including CNC.

The geometric parameters of metal-cutting tools, including turning tools, significantly affect the accuracy and roughness of the outer surfaces.

One of the tasks is to create scientifically based methods and tools to improve the accuracy of processing [1–7].

Materials and methods

There are three coordinate systems defined by GOST 25761-83: instrumental (ISC), static (SSC), kinematic (KSK) [8].

ISC – designed for the manufacture of cutting tools.

SSK – is designed to determine the geometric parameters of the cutting tool when installing it on the machine.

KSK – is designed to determine the geometric parameters during its operation.

Each of the above coordinate systems ISC, SSK, KSK represents three mutually perpendicular planes oriented in a certain way in space.

By analogy with a traditional through-hole cutter, the following surfaces of the cutting part are distinguished in a peakless cutting tool (PCT): front, rear, auxiliary rear [9–13].

The intersection of the surfaces forms certain faces, for example, the intersection of the front and back forms a face, which is called the main section plane (MSP). The intersection of the front and auxiliary rear surfaces forms an auxiliary cutting edge. In accordance with this, we will select the above-mentioned surfaces for the PCT (Figure 1).

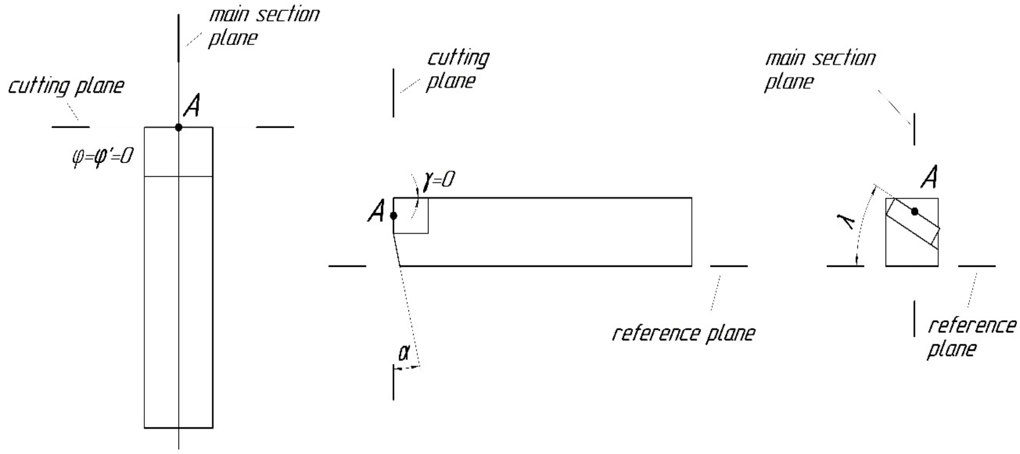

Figure 1 – Geometric parameters of the cutting part in the tool coordinate system

If the main section plane is drawn through point A of the MSP, and point A is set along the axis of rotation of the workpiece, then we will call this secant plane the main one (Figure 2). The figure shows the main section plane and the auxiliary section plane, respectively to the left and right of the main secant plane.

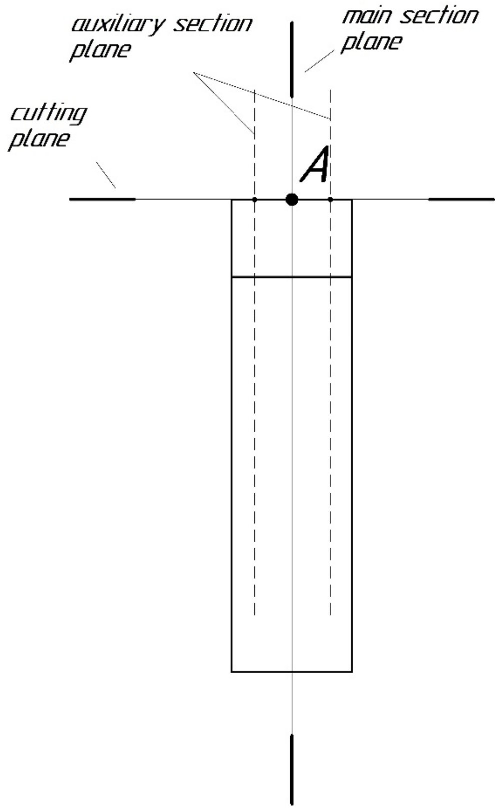

Figure 2 – Main and auxiliary secant planes

The installation of the PCT on a metal-cutting machine (MCM) is shown in Figure 3.

The PCT is installed so that the cutting edge is in a plane parallel to the axis of rotation of the workpiece. The main cutting plane must be perpendicular to the axis of rotation of the workpiece and pass through point A of the main cutting edge. In this case, the point A of the main cutting edge is set along the line of centers. The left part of the cutting edge and the right part of the cutting edge relative to the main cutting plane should be free and not participate in the cutting process. Only a part of the cutting edge is involved in the cutting process – the MSP, which is the left and right parts of the cutting edge involved in cutting adjacent to point A.

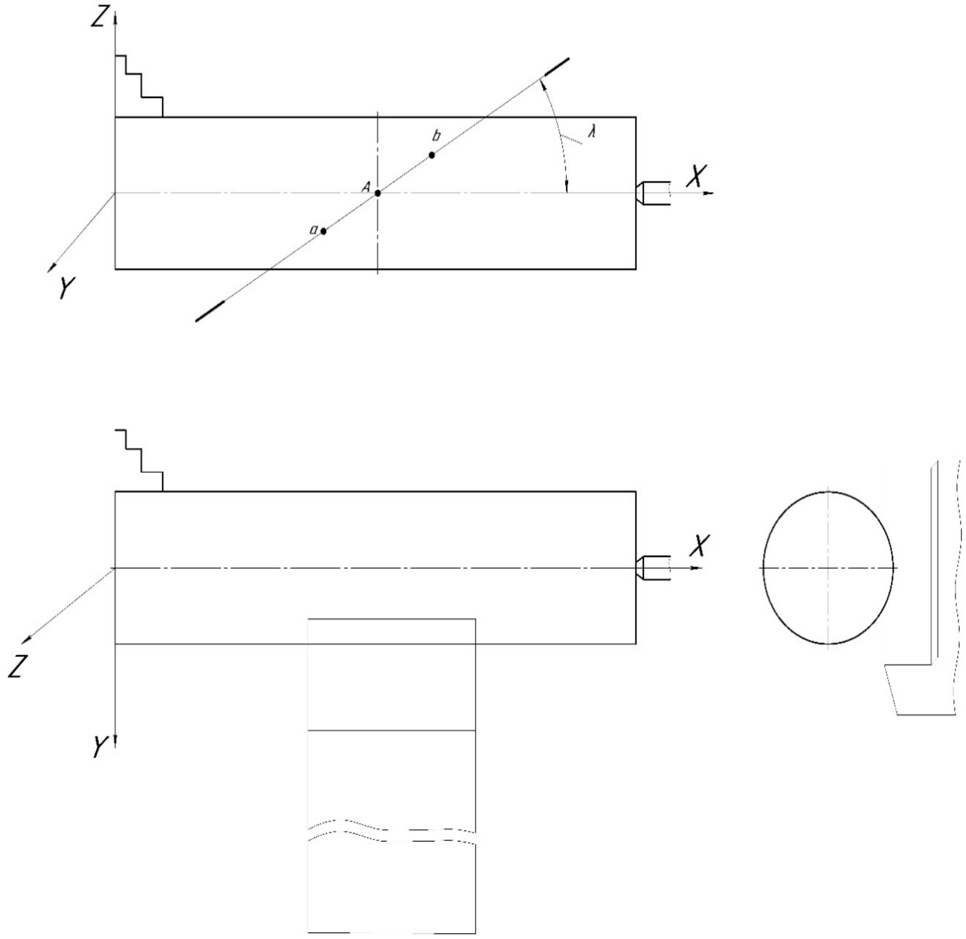

Figure 3 – Installation of a peakless cutting tool on the machine

Results and discussions

With further consideration and theoretical research, we will consider the BPR with the following geometric parameters: angle of inclination λ=30÷50°, front angle γ=0°, relief angle α= 15°.

The ISC is oriented relative to the conventionally accepted velocity vector of the main cutting movement perpendicular to the mounting plane and passing through the considered point A of the main cutting edge (Figure 4).

The SSC is oriented relative to the velocity vector of the main cutting movement passing through the considered point A of the main cutting edge and perpendicular to the mounting surface of the metal-cutting tools when it is installed on the machine.

KSK is oriented relative to the resulting cutting feed vectors and cutting speed passing through the considered point of the main cutting edge and perpendicular to the the metal-cutting tools mounting surface on the MCM.

The effective velocity vector is understood as the sum of the vectors of the feed rate and the cutting speed.

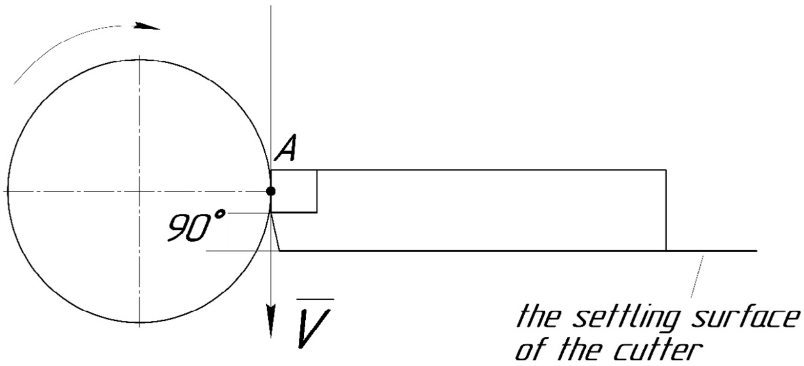

Figure 4 – The direction of the conventionally accepted velocity vector in the instrumental coordinate system

Let's consider the position of the peakless cutting tool in the instrumental coordinate system.

The tool coordinate system consists of three mutually perpendicular planes: the reference plane, the cutting plane, the main section plane (Figure 5).

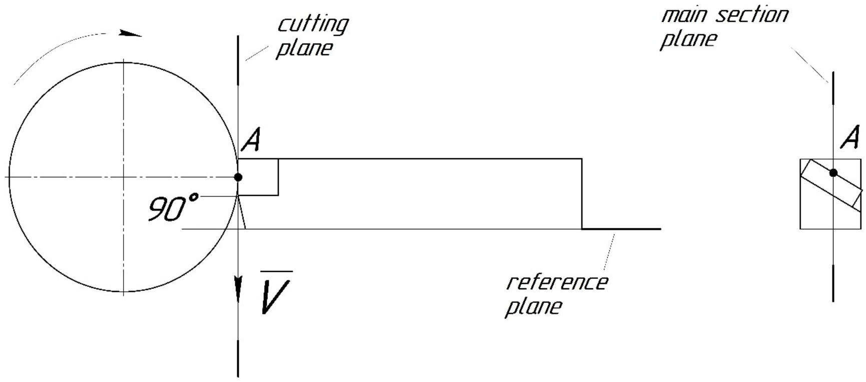

Figure 5 – Instrumental coordinate system of the BPR

In order to orient the ISC relative to the the metal-cutting tools, it is necessary to position the main tool mounting surface perpendicular to the conventionally accepted velocity vector of the main cutting movement V at the considered point (A) of its main cutting edge.

The second coordinate plane (the cutting plane) passes perpendicular to the main plane through the considered MSP point. The main secant instrumental plane is drawn through the point under consideration (.) And on the MSP and is perpendicular to the tool main plane and the cutting plane (Figure 5).

Next, we calculate the amount of displacement relative to the center line, the MSP PCT, the length of the MSP, depending on the processing diameter and cutting depth.

In Figure 6, the letters are: *ab* – MSP, where a and b are the intersection points of the MSP with the cylindrical surface being processed; *D* is the processing diameter, *R* is the radius, *t* is the cutting depth, *L* is the length of the main cutting edge, the sum of the right l_r. and left l_l, xi is the distance to an arbitrary coordinate secant plane, ±*h* is the excess or underestimation, respectively, of points (b) and (a) of the MSP above the line of centers, lx_i is the distance to the *i*–th section from (.) A in the direction of the MSP, hx_i is the excess or underestimation of the MSP for the *i*-th section above the line of centers.

Let's choose an arbitrary point (.) B on the MSP, located at a distance lx_i from (.) A along the MSP, having an excess over the line of centers hx_i, and an offset along the *X* axis from (.) A by *Xi*.

Calculate the values of the parameters lx_i, hx_i, x_i, *l*, *h*, *x* at different cutting depths. Formulas for determining the above parameters are derived based on the laws of geometry and are presented below (1-9).

$$h^2=(R^2-(R-t)^2, \quad (1)$$

$$l=h/\sin\alpha, \quad (2)$$

$$\text{We will ask } \Delta l=l/n,\ n=1,2,3,\dots\infty \quad (3)$$

$$x_1=\Delta x; \quad (4)$$

$$x_2=x_1+\Delta x; \quad (5)$$

$$\Delta x=\Delta l\cdot\cos\lambda; \quad (6)$$

$$x_i=x_{i-1}+\Delta x; \quad (7)$$

$$h_{xi}=\sqrt{l_{xi}^2-x_{xi}^2}, \text{ (see the calculation scheme);} \quad (8)$$

$$l_{xi}=h_{xi}/\sin\alpha, \text{ (see the calculation scheme)} \quad (9)$$

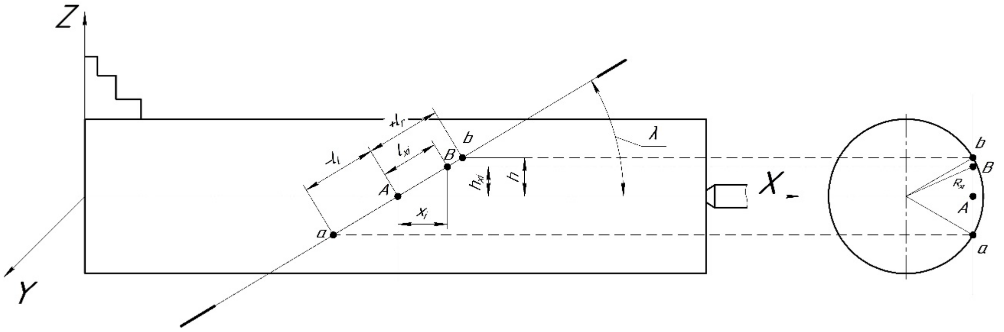

Figure 6 – Calculation scheme for determining the excess or underestimation of an arbitrary contact point of the MSP above the center line

The calculation results are shown in Table 1.

Table 1 – Results of calculations of geometric parameters h, l, hx_i, lx_i, x_i at different cutting depth and machining diameter

t	**D**	**λ**	**h**	**l**	**Δl**	**Δx**	**x_1**	**l_{x1}**	**h_{x1}**
0.1	50	30	2.23	4.47	1.49	1.29	1.29	1.49	0.74
0.2	50	30	3.16	6.31	2.10	1.82	1.82	2.10	1.05
0.3	50	30	3.86	7.72	2.57	2.23	2.23	2.57	1.29
0.4	50	30	4.45	8.91	2.97	2.57	2.57	2.97	1.48
0.5	50	30	4.97	9.95	3.32	2.87	2.87	3.32	1.66
0.6	50	30	5.44	10.89	3.63	3.14	3.14	3.63	1.81
0.7	50	30	5.87	11.75	3.92	3.39	3.39	3.92	1.96
0.8	50	30	6.27	12.55	4.18	3.62	3.62	4.18	2.09
0.9	50	30	6.64	13.30	4.43	3.83	3.83	4.43	2.22
1.0	50	30	7.00	14.00	4.67	4.04	4.04	4.67	2.33

t	**D**	**λ**	**x_2**	**l_{x2}**	**h_{x2}**	**x_3**	**l_{x3}**	**h_{x3}**
0.1	50	30	2.58	2.98	1.49	3.87	4.47	2.23
0.2	50	30	3.64	4.21	2.10	5.47	6.31	3.16
0.3	50	30	4.46	5.15	2.57	6.69	7.72	3.86
0.4	50	30	5.14	5.94	2.97	7.71	8.91	4.45
0.5	50	30	5.74	6.63	3.32	8.62	9.95	4.97
0.6	50	30	6.29	7.26	3.63	9.43	10.89	5.44
0.7	50	30	6.79	7.83	3.92	10.17	11.75	5.87
0.8	50	30	7.24	8.37	4.18	10.87	12.55	6.27
0.9	50	30	7.68	8.86	4.43	11.51	13.30	6.64
1.0	50	30	8.08	9.33	4.67	12.12	14.00	7.00

We calculate the profile of the part processing during the operation of the PCT. Consider the calculation scheme (Figure 7).

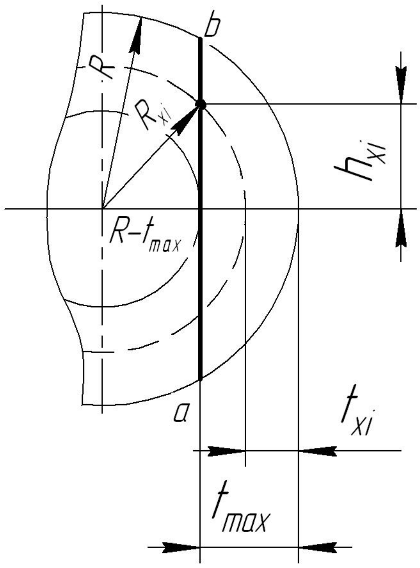

Figure 7 – Calculation scheme

Taking into account the analysis of the calculation scheme, we determine *Δh, hx_i, Rx_i, tx_i* by the following formulas:

$$\Delta h = h/n; \tag{10}$$

$$h_{x1} = \Delta h; \tag{11}$$

$$h_{xi} = h_{xi-1} + \Delta h; \tag{12}$$

$$\Delta l = l/n; \tag{13}$$

$$\Delta x = \Delta l \cdot cos\lambda; \tag{14}$$

$$x_1 = \Delta x;$$

$$x_i = x_{i-1} + \Delta x,\ i = 1, 2, 3 \ldots, n; \tag{15}$$

$$R_{xi} = \sqrt{h_{xi}^2 + (R-t)^2}, \tag{16}$$

where Rxi is the radius;

h_{xi} – height

Numerical values of the coordinates of the PCT processing profile are presented in Table 2.

Table 2 – Numerical values of the coordinates of the PCT processing profile

t	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
l	4.47	6.31	7.72	8.91	9.95	10.89	11.75	12.55	13.30	14.00
D	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
l	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
R	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
n	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
h	2.23	3.16	3.86	4.45	4.97	5.44	5.87	6.27	6.65	7.00
Δh=h/n	0.45	0.63	0.77	0.89	0.99	1.09	1.17	1.25	1.33	1.40
Δl	0.89	1.26	1.54	1.78	1.99	2.18	2.35	2.51	2.66	2.80
ΔX	0.77	1.09	1.34	1.54	1.72	1.89	2.03	2.17	2.30	2.42
R_{x1}	24.90	24.81	24.71	24.62	24.52	24.42	24.33	24.23	24.14	24.04
R_{x2}	24.92	24.83	24.75	24.66	24.58	24.50	24.41	24.33	24.25	24.16
R_{x3}	24.94	24.87	24.81	24.74	24.68	24.62	24.55	24.49	24.43	24.36
R_{x4}	24.96	24.93	24.89	24.86	24.82	24.79	24.75	24.71	24.68	24.64
R_{x5}	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
R-t	24.90	24.80	24.70	24.60	24.50	24.40	24.30	24.20	24.10	24.00
h_{x1}	0.45	0.63	0.77	0.89	0.99	1.09	1.17	1.25	1.33	1.40
h_{x2}	0.89	1.26	1.54	1.78	1.99	2.18	2.35	2.51	2.66	2.80
h_{x3}	1.34	1.89	2.32	2.67	2.98	3.27	3.52	3.76	3.99	4.20
h_{x4}	1.79	2.52	3.09	3.56	3.98	4.36	4.70	5.02	5.32	5.60
h_{x5}	2.23	3.16	3.86	4.45	4.97	5.44	5.87	6.27	6.65	7.00
t_{x1}	0.10	0.19	0.29	0.38	0.48	0.58	0.67	0.77	0.86	0.96
t_{x2}	0.08	0.17	0.25	0.34	0.42	0.50	0.59	0.67	0.75	0.84
t_{x3}	0.06	0.13	0.19	0.26	0.32	0.38	0.45	0.51	0.57	0.64
t_{x4}	0.04	0.07	0.11	0.14	0.18	0.21	0.25	0.29	0.32	0.36
t_{x5}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
X_1	0.77	1.09	1.34	1.54	1.72	1.89	2.03	2.17	2.30	2.42
X_2	1.55	2.19	2.68	3.09	3.45	3.77	4.07	4.35	4.61	4.85
X_3	2.32	3.28	4.01	4.63	5.17	5.66	6.10	6.52	6.91	7.27
X_4	3.10	4.37	5.35	6.17	6.89	7.54	8.14	8.69	9.21	9.70
X_5	3.87	5.47	6.69	7.71	8.62	9.43	10.17	10.87	11.51	12.12

Thus, the instrumental and static coordinate systems for determining the geometric parameters of the PCT and its position in them are considered.

To calculate the geometric parameters of the PCT (hx_i, ax_i, yx_i) in the ISC and SSC, dependences on D, t and λ were determined using the Excel mathematical appart.

Basic calculation schemes have been developed to determine the geometric parameters hx_1, x_i, Rx_i, lx_i depending on the auxiliary section under consideration, D, t and λ.

Conclusions

In the instrumental coordinate system, the planes of the vertex-free cutting cutter and its geometric parameters are determined, namely, the front and rear angles, the angle of inclination of the cutting edge and the angles in the plan of the main and auxiliary, which are zero. Due to this geometry of the cutter – the absence of the tip of the cutter – the cutting conditions are improved and the effects of adverse factors accompanying the cutting process are minimized and has less complexity of manufacturing and sharpening, and therefore less operating costs will be required.

Analysis of the shape of the cross-section of the cut layer and the calculated profile of the treated surface, allow us to draw the following conclusions:

- *t* (cutting depth) along the length of the MSP decreases from the maximum value to zero;
- when turning the PCT, it is possible to use a feed value less than or equal to the value of the projection of the MSP on the x axis;
- during the operation of the PCT, there will be a minimal force effect on the change in the surface layer of the treated surface, and consequently a decrease in roughness and an increase in the accuracy of the treated surface.

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АСПАПТЫҚ КООРДИНАТТАР ЖҮЙЕСІНДЕГІ ТӨБЕСІЗ ЖОНУ ӨТПЕЛІ КЕСКІШТІҢ ГЕОМЕТРИЯЛЫҚ ПАРАМЕТРЛЕРІ

Мақалада төбесіз жону өтпелі кескіштің геометриялық параметрлерін және олардың орналасуын анықтауға арналған аспаптық және статикалық координаттар жүйесі қарастырылған.

Excel математикалық картасын қолдана отырып инструменталды және статикалық координатта төбесіз жону өтпелі кескіштің (h_{xi}, α_{xi}, γ_{xi}) геометриялық параметрлерін есептеу үшін D, t және λ тәуелділіктер анықталады

Қарастырылып отырған D, t және λ қосалқы қимаға, байланысты h_{x1}, x_i, R_{xi}, lxi геометриялық параметрлерін анықтау үшін принципиальды есептеу схемалары құрастырылды.

Кесілген қабаттың көлденең қимасының пішінін және өңделген беттің есептелген профилін талдау келесі қорытынды жасауға мүмкіндік береді: негізгі кесу жиегінің ұзындығы бойымен кесу тереңдігі максималды мәннен нөлге дейін азаяды; төбесіз жону өтпелі кескішті жону кезінде x осіндегі негізгі кесу жиегінің проекциясының шамасынан аз немесе оған тең берілу мәні қолданылуы мүмкін; төбесіз жону өтпелі кескіші жұмыс істеген кезде өңделетін беттің беткі қабатының өзгеруіне ең аз күш әсер етеді, сондықтан өңделген беттің кедір-бұдырлығы төмендеуі және дәлдігі арттыруы.

Инструменталды координаттар жүйесінде төбесіз жону өтпелі кескіштің жазықтықтары және оның геометриялық параметрлері, атап айтқанда алдыңғы және артқы бұрыштар, кесу жиегінің көлбеу бұрышы және пландағы негізгі және көмекші бұрыштар анықталады, олар нөлге тең. Осындай кескіш геометрияның арқасында – кескіш шыңның болмауы – кесу процесін сүйемелдейтін кесу *жағдайлары жақсарады және қолайсыз факторлардың әсерін азайтады және шығару мен қайраудың аз еңбек сыйымдылығына ие болады, сондықтан пайдалану үшін аз шығындар қажет болады.*

Кілтті сөздер: геометрия, жазықтық, құрылымы, кескіш, төбесіз, сапа.

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ГЕОМЕТРИЧЕСКИЕ ПАРАМЕТРЫ БЕЗВЕРШИННОГО ПРОХОДНОГО РЕЗЦА В ИНСТРУМЕНТАЛЬНОЙ СИСТЕМЕ КООРДИНАТ

В статье рассмотрены инструментальная и статическая системы координат для определения геометрических параметров безвершинного проходного резца и его положение в них.

Для расчёта геометрических параметров безвершинного проходного резца (h_{xi}, α_{xi}, γ_{xi}) в инструментальной и статической системах координат определены зависимости от D, t и λ с использованием математическог аппарта Excel.

Разработаны принципиальные расчётные схемы для определения геометрических параметров h_{x1}, x_i, R_{xi}, l_{xi} в зависимости от рассматриваемого вспомогательного сечения, D, t и λ.

Анализ формы поперечного сечения срезаемого слоя и расчетного профиля обработанной поверхности, позволяют сделать следующие выводы: глубина резания по длине главной режущей кромки уменьшается с максимального значения до нуля; при точении безвершинного проходного резца возможно применение величины подачи меньше или равное величине проекции главной режущей кромки на ось х; при работе безвершинного проходного резца будет минимальное силовое воздействие на изменение поверхностного слоя обрабатываемой поверхности, а следовательно и снижение шероховатости и повышение точности обработанной поверхности.

В инструментальной системе координат определены плоскости безвершинного проходного резца и его геометрические параметры, а именно передний и задний углы, угол наклона режущей кромки и углы в плане главный и вспомогательный, которые равны нулю. Благодаря чему такой геометрии резца – отсутствия вершины резца – улучшены условия резания и сведены к минимуму воздействия неблагоприятных факторов, сопровождающих процесс резания и имеет меньшую трудоёмкость изготовления и заточки и поэтому потребуется меньше затрат на эксплуатацию.

Ключевые слова: геометрия, плоскость, конструкция, резец, безвершинный, качество.

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