ТОРАЙҒЫРОВ УНИВЕРСИТЕТІНІҢ
ҒЫЛЫМИ ЖУРНАЛЫ

НАУЧНЫЙ ЖУРНАЛ
ТОРАЙГЫРОВ УНИВЕРСИТЕТА

ҚАЗАҚСТАН ҒЫЛЫМЫ МЕН ТЕХНИКАСЫ

2001 ЖЫЛДАН БАСТАП ШЫҒАДЫ

НАУКА И ТЕХНИКА КАЗАХСТАНА

ИЗДАЕТСЯ С 2001 ГОДА

ISSN 2788-8770

№ 3 (2022)

ПАВЛОДАР

НАУЧНЫЙ ЖУРНАЛ
ТОРАЙГЫРОВ УНИВЕРСИТЕТ
выходит 1 раз в квартал

СВИДЕТЕЛЬСТВО
о постановке на переучет периодического печатного издания, информационного агенства и сетевого издания
№ KZ51VPY00036165

выдано
Министерством информации и общественного развития
Республики Казахстан

Тематическая направленность
Публикация научных исследований по широкому спектру проблем в области металлургии, машиностроения, транспорта, строительства, химической и нефтегазовой инженерии, производства продуктов питания

Подписной индекс – 76129

https://doi.org/10.48081/KWJR9225

Импакт-фактор РИНЦ – 0,342

IRSTI 53.19.03

https://doi.org/10.48081/XGNE2302

K. K. Abishev[1], *R. B. Mukanov[2], A. V. Mazdubay[3]
[1,2,3]Toraighyrov University, Pavlodar, Kazakhstan

STRENGTH CALCULATION OF COMBINED TOOL HEAD IN APM FEM

Assembly tool head with asymmetrically spaced hard-alloyed plates of different widths has increased durability, ensures the processing of flat-bottom holes, increases productivity, accuracy, reduces deviations of the shape and reduction of roughness of a surfaces processed. The goal is to perform a reliable calculation of the assembled tool head using ARM FEM. In this paper, two variants of the design of a prefabricated tool head with carbide plates are studied, which differ in the Compass 3D APM FEM environment. The methods of research are the finite element method (FEM), the theory of cutting and chip formation, methods of calculation and design of metal-cutting tools. Computer modeling and on the basis of the distribution of the cutting forces acting on the carbide plates established their balancing and bringing to equality of moments, uniform transformation into the processing process, reducing vibrations and vibrations, and, subsequently, changing errors and improving the accuracy and roughness of the holes. The analysis of the results of the robust calculation showed that the use of a composite tool head with carbide plates of different widths gives male otvrugye squeezes, which improves the quality, macro-and micro-deflection of the holes.

Keywords: Processing, Hole, Strength, Calculation, CAD, CAE, APM FEM.

Introduction

Sustainable development and reliable operation of mechanical engineering largely determine the energy and material intensity of the economy, labor productivity, the level of environmental safety of industrial production and, ultimately, economic security [1].

Mechanical engineering in Kazakhstan is represented by 6 main segments. The structure of the industry is still dominated by the repair and installation of machinery and equipment – 41 % of the total output. The production of vehicles, including the automotive industry, together accounts for 35 % of the total output.

The share of mechanical engineering in the total volume of industrial production has been increasing since 2008. The volume of mechanical engineering production from 2008 to 2012 increased from 301.4 to 687.2 billion tenge. In 2012, compared to 2008, the volume of production increased by 2.3 times [2].

The machine-building industry ensures the competitiveness of the economy as a whole and thereby increases the employment of the population due to the huge effect on the development of related industries. Thus, the growth of the economy of the Republic of Kazakhstan must be accompanied by faster growth of mechanical engineering that will improve the degree of mechanization in the industry and increase productivity in the sectors of the economy [3].

One of the most important elements that ensure the quality of machine parts processing and labor productivity is the cutting tool as an integral part of metal cutting equipment. The efficiency of the cutting tool has a significant impact on the economic efficiency of the production process.

One of the most pressing issues in mechanical engineering is the process of obtaining holes with increased requirements for processing accuracy, namely: size, macro-deviations and roughness.

A typical technological process for obtaining holes with the following metal-cutting tools: axial (drills, etc.), broaches, heads, cutters, etc. are used based on the operating conditions and purpose and the quality of accuracy.

Traditional drills have drawbacks: geometric and design parameters that make it difficult to remove chips and supply coolant (coolant). In addition, the transverse edge creates difficult conditions: variable rear angle and front-more than minus 50°. As a result, there is no cutting, and plastic deformation and scratching up to 80% of the cutting force during drilling.

There are many methods and ways to create favorable cutting conditions when processing holes, but the geometric parameters of the front angle are still negative, which leads to increased heat generation and wear.

To create favorable cutting conditions, the university conducts research on improving the design of tools and developing original designs [4–10].

When designing original structures of metal-cutting tools, geometric parameters and structural elements are changed, and metals with high mechanical properties are also used [11–16].

The purpose of the work is to perform a strength calculation of the assembled tool head using the FEM AWP. In this paper, two variants of the design of a prefabricated tool head with carbide plates differing in their width in the Compass 3D APM FEM environment are investigated.

Research methodology and methods

The proposed and developed metal-cutting tool is a high-precision and high-performance tool for processing holes of the cutting part, which is designed in the form of two cutters: one on the periphery, the other closer to the center.

The tool has increased rigidity without a transverse edge, where the cutting force is evenly distributed during processing, reducing the temperature and distributed load, which provides increased durability and quality of processing accuracy due to smoothing cutting elements, which reduces macro - and micro-deviations [17, 18].

Further analysis and study of the design of the tool allowed to simplify its design, and, consequently, the manufacturing technology, namely, to fix the carbide plates with screws.

This implies their replacement as a result of wear and increases the service life and service life [19–21].

During the processing process, due to the location and the same width of the plates, fluctuations and unbalance occur, which reduces the quality and accuracy.

For this purpose, the design of the tool with different widths of the plates for balancing them has been developed (figure 1).

At the Figure 1 the following parts are presented: 1 – body of combined cutting head; 2 – external hard-alloyed plate; 3 – internal hard-alloyed plate; 4 – screw; 5 – shank of combined cutting head; 6 – rotary motion of combined cutting head; 7 – axial movement of combined cutting head; L – length of combined cutting head; l_x – length of shank; l_k – length of body of combined cutting head; l_b – length of overhang of hard-alloyed plate; $b_{ï\,1}$ – width of external hard-alloyed plate; $b_{ï\,2}$ – width of internal hard-alloyed plate; $S_ï$ – thickness of hard-alloyed plate; D_r – diameter of cutting head.

The design of the tool allows you to increase the durability and accuracy of processing due to the balance and creation of favorable conditions, as well as maintainability and operating conditions.

When cutting, the cutters remove the chips according to the following scheme: the first cutter is half the diameter of the hole, the second on the periphery and cleans the surface.

Materials of the combined cutter reamer: body – steel 45 as in GOST 4543-2016, hard-alloyed plates – hard alloy T30K4 as in GOST 3882-74. The mechanical and chemical properties of steel 45 are shown in Tables 1 and 2.

The forging temperature of 1250 ° C the beginning of the end of 700 ºC.

Weldability – difficult to weld. Heating and subsequent heat treatment is required.

Cutability – in the hot-rolled state at HB 170-179 and σB = 640 MPa.

Place of publication – insensitive.

The tendency to vacation fragility – not inclined.

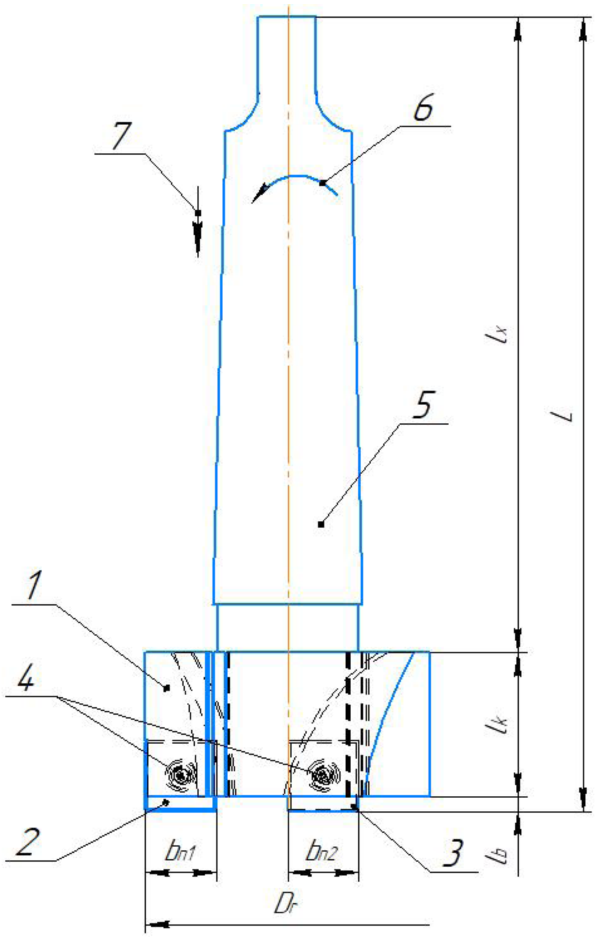

Figure 1 – Advanced design

Table 1 – Chemical composition of steel 45 according to GOST 4543-71

Carbon C,%	Manganese Mn, %	Silicon Si, %	Copper Cu, %	Chrome Cr, %, not more	Sulfur S, %	Phosphorus P, %
					not more	
0,40-0,45	0,50-0,80	0,17-0,37	0,25	0,25	0,04	0,035

Table 2 – Mechanical properties of steel 45 according to GOST 4543-71

Yield strength, σт, MPa	Ultimate strength, σB, MPa	Relative elongation, δ , %	Relative elongation, Ψ, %	Brinell hardness, HB, not more	
nevertheless				hot rolled	annealed
360	610	16	40	241	197

The mechanical and chemical properties of the T30K4 hard alloy are shown in Table 3.

Table 3 – Mechanical and chemical properties of T30K4 hard alloy

Tungsten Carbide, WC, %	Titanium Carbide, TiC, %	Tantalum Carbide, TaC, %	Cobalt, Co, %	Flexural strength σ, МПа	Hardness, HRA	Density, ρ, g /cm3	Thermal Conductivity, Вт/(м·°C)
66	30	–	4	1000	92	9,8	12,57

The equilibrium condition of torques

$$M_{kp.n.} = M_{kp.b.} \tag{1}$$

Having transformed the formula (1), the unit specific force is determined by the formula

$$P_{ud.n.} \times a \times b_n = P_{ud.b.} \times b \times b_b \tag{2}$$

whereas $P_{ud.n.}$ is single specific force of the external hard-alloyed plate;

$P_{ud.b.}$ is single specific force of the internal hard-alloyed plate;

a is distance from the axis of the combined cutter head to the axis of the hole for attaching the internal hard-alloyed plate;

b is distance from the axis of the combined cutter head to the axis of the hole for attaching the external hard-alloyed plate;

b_n is width of external hard-alloyed plate;

b_b is width of internal hard-alloyed plate;

D_r is cutter head diameter.

We suppose single specific forces of the external $P_{ud.n}$ and the internal $P_{ud.b.}$ hard-alloyed plates to be of the same modulo and with the substitute of $a = \frac{3}{4} b_n$, $b = \frac{b_b}{2}$ in the equation (2) we have that

$$\frac{3}{4} b_n \times b_n = \frac{b_b}{2} b_b \tag{3}$$

Therefore

$$b_b = \sqrt{1.5 b_n} \tag{4}$$

With this cheek, the width of the inner plates is 1.22 times larger than the intended one.

The active forces are shown on the figure 2.

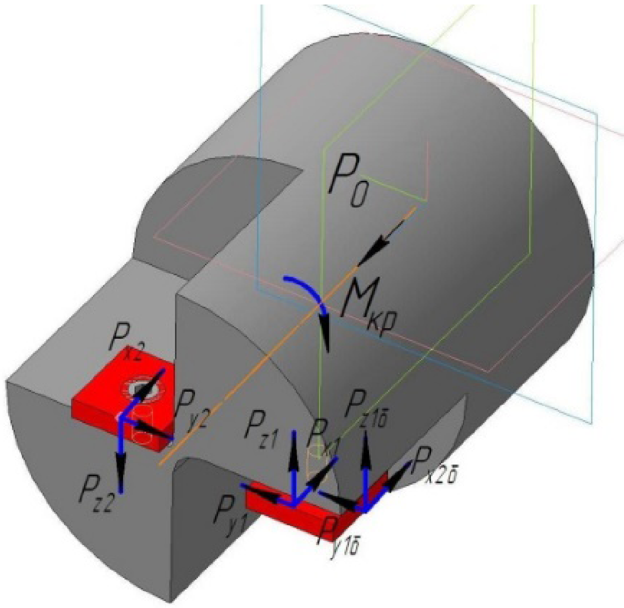

Figure 2 – Forces acting on combined cutting head

Differential equations of motion taking into account the acting forces

$$m\ddot{x}_c = -P_{y1} - P_{y1б} + P_{y2} - c_v x_c \tag{5}$$

$$m\ddot{z}_c = P_{z1} + P_{z1б} - P_{z2} - mg \tag{6}$$

whereas Cv is the conversion factor;

m is the tool weight;

x_c; z_c are the coordinates of the point C of the center of the cutting part in a fixed plane XOZ;

P_x; P_y; P_z are the axial, radial and tangential forces;

P_o; M_{kp} are the longitudinal force and torque.

Currently, the problem of combining two mutually exclusive trends in the design process is relevant: saving material, on the one hand, and ensuring the required strength characteristics of structures, on the other hand. All this can be achieved through the use of computer technology. Today, it is impossible to create high-quality, reliable and competitive equipment without a comprehensive engineering analysis of the designed objects using modern software tools and making competent design decisions based on it. Engineering analysis refers primarily to the study of the stress-strain state of models of designed structures, obtaining their dynamic characteristics and stability characteristics under constant and variable external loading conditions.

The most effective approximate method for solving this class of problems is the finite element method (FEM). FEM is implemented in such well-known and widely used software products that provide strength calculation of structural models, as ANSYS, NASTRAN, COSMOS, and some others [19–21]. These are very powerful software tools, but they are also not cheap, and they also have an English-language interface. In addition, the model editors of these packages are very complex and require extensive user training. The domestic module of finite element analysis APM FEM, which is part of the CAD/CAE System APM Compass 3D, is to some extent an alternative to these software products [22–25].

This calculation is performed using the Compass 3D software with the built-in APM FEM module.

Body material – stand 45, plate – T30K4. The hole diameter is 60 mm and the processing modes according to the calculations [22] are fixed on the body shank.

The Compass 3D computer program performs the calculation according to the following algorithm: design of 3D models; indication of the mechanical properties of materials and effective loads; rotation and automatic forms a final – element network and specifies the dimensions.

The results of this calculation are shown in figure 3.

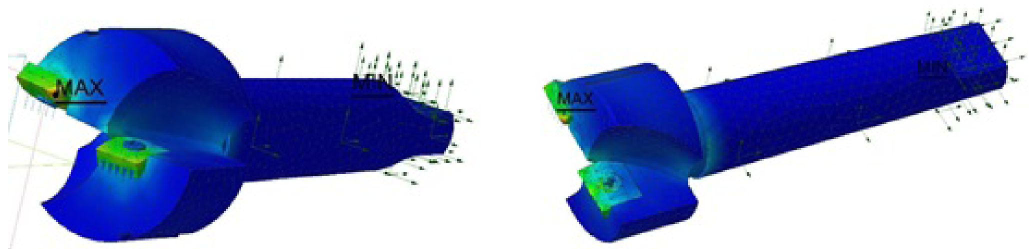

Figure 3 – Static analysis results

Results and its discussion

The analysis of the results of statistical analysis confirmed the theoretical assumptions and dependencies with the establishment of equality of forces, uniform growth, vibration reduction, and, therefore, a change in deviations and an increase in the quality and roughness of power.

When designing with the help of the 3D compass, design and geometric parameters are created, drawings are designed for the production of real samples (figure 4).

Figure 4 – Prototypes of combined cutting head

Conclusion

Thus, the calculation in the Compass 3D software in the APM FEM module confirmed that the use of the proposed tool creates small elastic squeezes, increases the quality of accuracy and the roughness of the surface of the holes.

Application of the Compass 3D software in the APM FEM in the strength analysis of the assembled cutting head with asymmetrically spaced hard-alloyed plates of different widths subject to the equilibrium of the end torques and cutting conditions allows to increase the productivity of the design, as well as to study its versatility.

Acknowledgement: Authors express their gratitude to G. Itybayeva and A. N. Baltabekova who have articles published in similar journals [22, 26], for their assistance in preparing and formatting this article.

Funding

The research was carried out within the framework of grant funding for young scientists for 2021–2023 under the project of IRN AP09058231 «Research and design of resource-saving metal-cutting tools», funded under the budget program 217 «Development of Science», subprogram 102 «Grant financing of scientific research» by the Committee of Science of the Ministry of Education and Science of the Republic of Kazakhstan.

REFERENCES

1 **Tashenov, A.** Mechanical engineering in Kazakhstan : challenges and growth prospects. // International Business Magazine Kazakhstan, 2013; 1: 26–29.

2 Development of mechanical engineering. // JSC «Kazakhstan Institute of Industry Development». – Astana, December, 2013.

3 **Mendebaev, T. M., Taskarina, A. Zh., Manezhanov, B. A., Ibragimova, Z. A., Aimukhanbet, B. A.** Problems and aspects of the development of the machine-building industry of the Republic of Kazakhstan at the present stage. // Bulletin of KazNTU. – 2012. – 1(89) : 135–137.

4 **Lobanov, D., Yanyushkin, A., Muliukhin, N., Skeeba, V.** Study of the process of tool forming made of high-strength materials. // In : IOP Conference Series : Materials Science and Engineering, 2020. – 709(4). – 044074

5 **Khodzhibergenov, D. T., Esirkepov, A., Sherov, K. T.** Rational milling of metals. // Russian Engineering Research. – 2015. – 35. – P. 43–45. – doi:10.3103/s1068798x1501013x.

6 **Dudak, N., Itybaeva, G., Kasenov, A., Mussina, Z., Taskarina, A., Abishev, K.** Multi-flute drill-broach for precision machining of holes. // Scientia Iranica. – 2019. – 26: 1415–1426. doi:10.24200/sci.2018.5623.1379.

7 **Dudak N., Taskarina A., Kasenov A., Itybaeva G., Mussina Z., Abishev K., Mukanov R.** Hole machining based on using an incisive built-up reamer. // International Journal of Precision Engineering and Manufacturing. – 2017. – 18. – P. 1425–1432.

8 **Khojibergenov, D. T., Yanyushkin, A. S., Ibragimova, Z. A., Khozhibergenova, U. D., Sherov, K. T., Absadykov B. N.** Drilling tool with negative drilling force value. // News of the Academy of Sciences of the Republic of Kazakhstan, Kazakh National Research Technical University named after K. I. Satpayev. Series of Geology and technical sciences, 2019. – 1. – P. 169–175.

9 **Dudak, N. S., Kasenov, A. Z, Musina, Z. K, Itybaeva, G. T, Taskarina, A. Z.** Processing of holes with a reamer-broach. // Life Science Journal. – 2014. – 11 . – P. 282–288 / . – doi:10.7537/marslsj1110s14.50.

10 **Dudak, N. S., Itybaeva, G. T., Musina, Z. K., Kasenov, A. Z., Taskarina, A. Z.** A new pass-through lathe cutter. // Russian Engineering Research. – 2014 . – 34 (11). – P. 705–707. doi:10.3103/S1068798X14110069.

11 **Doudkin, M., Kim, A., Kombayev, K., Azamatov, B., Azamatova, Z.** Research of cutting temperature reducing of titanium alloy grade 5 below polymorphic transformation depending on calculation of cutting modes. // International Journal of Mechanical and Production Engineering Research and Development, 2020. – 10. – P. 747–758.

12 **Divya, C., Raju, L. S., Singaravel, B.** Application of MCDM Methods for Process Parameter Optimization in Turning Process-A Review. In : Narasimham G. S. V. L., Babu A. V., Reddy S. S., Dhanasekaran R. (eds) // Recent Trends in Mechanical Engineering. Lecture Notes in Mechanical Engineering. – Springer. Singapore. 2021. – P. 199–207. – doi:10.1007/978-981-15-7557-0_18.

13 **Orlov, I. Y., Baidakova, N. V., Bochkarev, P. Y.** Optimal Sequencing at Selection of Abrasive Tools' Characteristics for Their Improvement. // Lecture Notes in Mechanical Engineering, 2020. – P. 1011–1017.

14 **Kumar, S.** Design and Analysis of Weld Bead Cutting Tool Using FEA Technique with Experimental Verification of Cutting Force. In: Pant P., Mishra S. K., Mishra P. C. (eds) // Advances in Mechanical Processing and Design. Lecture Notes in Mechanical

Engineering. – Springer, Singapore, 2021. – P. 581–592 . – doi.org/10.1007/978-981-15-7779-6_53.

15 **Kurguzov, S. A., Nalimova, M. V.** Modeling Wear of Tool's Front Surface During Turning. In: Radionov AA, Kravchenko OA, Guzeev VI, Rozhdestvenskiy YV (Eds.) Proceedings of the 5th International Conference on Industrial Engineering (ICIE 2019). Lecture Notes in Mechanical Engineering. Springer, 2021 – P. 1287–1293 doi.org/10.1007/978-3-030-22041-9_134.

16 **Akhmedov, A. B., Khodjibergenov, D. T., Khojibergenova, U. D., Ibragimova, Z. A., Absadykov, B. N.** Thermodynamic bases of metal mechanical processing by cutting method. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, 2020; 4: 110–119

17 **Dudak, N. S., Mendibaev, T. M., Itybaeva, G. T., Kasenov, A., Musina, Zh. K., Mukanov, R. B., Taskarina, A. Zh.** Pre-assembled tool head for high-performance hole turning. KZ Patent 33140, 8 Oct 2018.

18 **Mukanov, R. B., Kasenov, A., Itybaeva, G. T., Musina, Zh. K., Abishev, K., Bykov, P.O.** Face Turning of Holes. Russian Engineering Research, 2019; 39:75-78.

19 **Sherov, K. T., Sikhimbayev, M. R., Sherov, A. K., Donenbayev, B. S., Rakishev, A. K., Mazdubay, A.V., Musaev, M. M., Abeuova, A. M.** Matematical modeling of thermofrictional milling process using ANSYS WB software. Journal of Theoretical and Applied Mechanics, 2017. 47 : 24–33. doi:10.1515/jtam-2017-0008

20 **Louhichi, B., Abenhaim, G. N., Tahan, A. S.** CAD/CAE integration: updating the CAD model after a FEM analysis. International journal of advanced manufacturing technology, 2015. 76 : 391–400.

21 **Jiang Y. J.** The modeling of thread-rolling die-plates based on the «Design table» functions in CAD/CAE/CAM // Mechanical and electronics engineering III, PTS 1–5. Applied Mechanics and Materials, 2012/ – Part: 1-5. – 130–134 : 499–503.

22 **Mukanov R., Kasenov A., Itybayeva G., Musina Z., Strautmanis G.** Modeling of the cutting head for treating holes in the railway. // Procedia Computer Science, ICTE 2018. 2019. – 149 : 355–359.

23 **Kamoun, T., Guemri, K.** Modeling of the Cutting Effort. In: Kharrat M., Baccar M., Dammak F. (eds) // Advances in Mechanical Engineering, Materials and Mechanics. ICAMEM 2019. Lecture Notes in Mechanical Engineering. – Springer, 2021. – Cham : 32–37. – https://doi.org/10.1007/978-3-030-52071-7_5.

24 **Petrakova, E., Sumatokhin, V.** Development of Algorithm for Creating Parametric 3D Models, Controlled by Mathcad Calculations, to Study Parameters of Enclosed Gears Housing. / In: Radionov A. A., Kravchenko O. A., Guzeev V. I., Rozhdestvenskiy Y. V. (Eds.) // Proceedings of the 5th International Conference on Industrial Engineering (ICIE 2019). Lecture Notes in Mechanical Engineering. – Springer 2019. –P. 473–483 doi.org/10.1007/978-3-030-22041-9_51.

25 **Laporte, S., K'Nevez, J. Y., Cahuc, O., Darnis, P.** Phenomenological model for drilling operation. // N International journal of advanced manufacturing technology. – 2009. – 40: 1-11.

26 **Buss, D., Abishev, K., Baltabekova, A.** Driver`s reliability and its effect on road traffic safety. // Procedia Computer Science, ICTE 2018. – 2019. – 149: 463–466.

Материал поступил в редакцию 16.09.22.

К. К. Абишев[1], *Р. Б. Муканов[2], А. В. Маздубай[3]
[1,2,3]Торайғыров университет, Қазақстан Республикасы, Павлодар қ.
Материал баспаға түсті 16.09.22.

APM FEM-ДЕ ЖИНАҚТАЛҒАН КЕСКІШ БАСТИЕГІН БЕРІКТІККЕ ЕСЕПТЕУ

Ені әртүрлі асимметриялы орналастырылған қатты қорытпа пластиналары бар жинақталған кескіш бастиегі жоғары беріктікке ие, тегіс түбі бар тесіктерді өңдеуін қамтамасыз етеді, өнімділікті, дәлдікті арттырады, пішіннің ауытқуын азайтады және өңделетін беттердің кедір-бұдырын төмендетеді.

Жұмыстың мақсаты – APM FEM көмегімен жинақталған кескіш бастиектің беріктікке есептеуін жүргізу. Бұл жұмыста Компас 3D APM FEM бағдарламасында есептелетін қатты қорытпа пластиналары бар жинақталған кескіш бастиек құрылысының екі нұсқасы зерттеледі. Зерттеу әдістеріне шекті элементтер әдісі (ШЭӘ), кесу және жоңқа түзу теориясы, металл кескіш құралдарды есептеу және жобалау әдістері жатады.

Компьютерлік модельдеу және қатты қорытпа пластиналарына әсер ететін кесу күштерін бөлу негізінде олардың тепе-теңдігі мен моменттердің теңдігіне, өңдеу үрдісінде біркелкі түрлендіруге, діріл мен сілкіністердің төмендеуіне, соның нәтижесінде қателіктердің өзгеруіне және тесіктердің дәлдігі мен кедір-бұдырлығының жоғарылауына негізделген.

Беріктікке есептеу нәтижелерін талдау ені әртүрлі қатты қорытпа пластиналары бар жинақталған кескіш бастиекті пайдалану тесіктердің сапасын, макро- және микроауытқуларын жақсартады және олардың бұзылуын аз мөлшерде көрсетті.

Кілтті сөздер: өңдеу, тесік, беріктік, есептеу, CAD, CAE, APM FEM.

К. К. Абишев[1], *Р. Б. Муканов[2], А. В. Маздубай[3]
Торайгыров университет, Республика Казахстан, г. Павлодар,
Материал поступил в редакцию 16.09.22.

ПРОЧНОСТНОЙ РАСЧЁТ СБОРНОЙ РЕЗЦОВОЙ ГОЛОВКИ В APM FEM

Сборная резцовая головка с асимметрично расположенными твердосплавными пластинами разной ширины обладает повышенной прочностью, обеспечивает обработку отверстий с плоским дном, повышает производительность, точность, уменьшает отклонения формы и уменьшает *шероховатость обрабатываемых поверхностей. Цель состоит в том, чтобы выполнить прочностной расчёт сборной резцовой головки с использованием APM FEM. В данной работе изучаются два варианта конструкции сборной резцовой головки с твердосплавными пластинами, которые рассчитываются в среде Компас 3D APM FEM. Методами исследования являются метод конечных элементов (МКЭ), теория резания и стружкообразования, методы расчета и конструирования металлорежущего инструмента. Компьютерным моделированием и на основе распределения сил резания, действующих на твердосплавные пластины, установлено их уравновешивание и приведение к равенству моментов, равномерное преобразование в процесс обработки, уменьшение вибраций и сотрясений, и, как следствие, изменение погрешностей и повышение точности и шероховатости отверстий. Анализ результатов прочностного расчета показал, что использование сборной резцовой головки с твердосплавными пластинами разной ширины дает меньшую разбивку, что улучшает качество, макро- и микроотклонение отверстий.*

Ключевые слова: обработка, отверстие, прочность, расчёт, CAD, CAE, APM FEM.

Теруге 16.09.22 ж. жіберілді. Басуға 30.09.22 ж. қол қойылды.
Электрондық баспа
5,07 Mb RAM
Шартты баспа табағы 11,05 Таралымы 300 дана. Бағасы келісім бойынша.
Компьютерде беттеген: Е. Е. Калихан
Корректор: А. Р. Омарова, Д. А. Кожас

Тапсырыс № 3998

«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
140008, Павлодар қ., Ломов көш., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
67-36-69

e-mail: kereku@tou.edu.kz
nitk.tou.edu.kz