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АНАЛИЗ СРАВНЕНИЯ МАТЕМАТИЧЕСКОЙ И КОМПЬЮТЕРНОЙ МОДЕЛЕЙ ПРИ ИССЛЕДОВАНИИ УСТОЙЧИВОСТИ БАШЕННЫХ КРАНОВ

В статье приведены результаты исследования устойчивости башенного крана во время эксплуатации с учетом влияния нагрузок на опоры. Приведены результаты сравнения распределения нагрузок на опоры крана, определённых в результате математического и компьютерного моделирования при повороте и подъёме стрелы.

Ключевые слова. *Исследование, башенный кран, устойчивость, распределение нагрузок, математическая модель, компьютерная модель, адекватность.*

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ANALYSIS OF THE COMPARISON OF MATHEMATICAL AND COMPUTER MODELS IN STUDYING THE STABILITY OF TOWER CRANES

The article presents the results of the tower crane stability study during the operation taking into account the influence of loads on the supports. The results of comparing the distribution of loads on the crane support determined as a result of mathematical and computer simulation during the rotation and lifting of the boom are given.

Keywords. *Research, tower crane, stability, load distribution, mathematical model, computer model, adequacy.*

Стаття надійшла 20.05.2023 р.

УДК 621.7 **doi.org/10.31498/2522-9990252023286705**

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THE DEVICE FOR ROTARY BROACHING OF BLIND POLYHEDRAL HOLES

The paper deals with the actual problem of obtaining polyhedral blind holes in a single production environment. This problem is especially relevant when performing repair work in machine-building production. The biggest problem is that obtaining multi-faceted holes using special drills as a tool is associated with large efforts that arise during the processing process. . As a result of the analysis of research on this issue, some shortcomings were identified that greatly complicate the implementation of this method for obtaining faceted holes. Namely, processing with an additional rocking motion requires special equipment, which in turn is not economically justified. A tool is proposed-a device that will allow using conventional lathes, drilling or milling machines to obtain the necessary hole profile. At the same time, the processing performance is significantly increased, and the effort is reduced. The resource of the tool increases, since during processing not the entire cutting edge is involved in the work. Recommendations on the choice of optimal processing modes for soft materials are presented. There is also a clear economic effect.

Keywords. *Polyhedral hole, force, back surface, processing, productivity, tool-fixture, rolling.*

Problem statement. Currently, the problem facing the metallurgical, machine-building or shipbuilding industry is the prompt execution of repair work, which will avoid forced downtime and economic losses. Repair work is most often associated with the restoration of expensive and difficult-to-manufacture parts, but sometimes this is not enough and new parts have to be manufactured. In this regard, the availability of the necessary equipment simplifies this process, but the repair shop does not always have a full arsenal of special equipment and tools that would solve the problem quickly and efficiently. Most often, difficulties arise with the processing of mounting holes (which are blind holes of a multifaceted shape) in products. Multifaceted turnkey holes in the heads of fasteners for mechanical engineering, shipbuilding, etc. are made according to 11, 12 and 14 accuracy standards. These holes are most expediently obtained by plastic deformation methods. But the availability of such equipment is not always economically justified in the conditions of a single production. At the moment, the production of such holes in small-scale production is carried out using a broaching tool or using electrical discharge machining. All this leads to an increase in the cost of repair work, sometimes even 5-7 times.

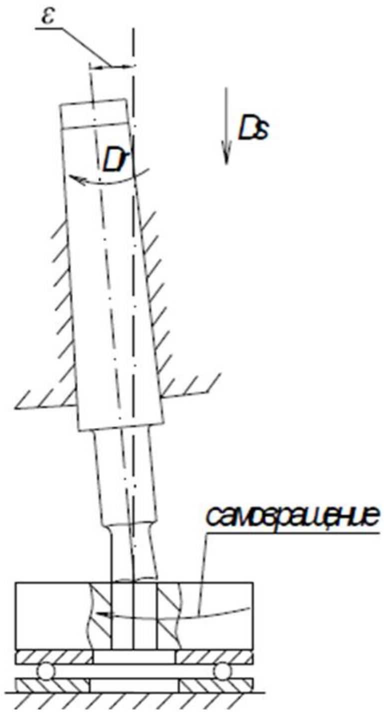
Analysis of recent research and publications. It is known that multifaceted holes can be obtained using triangular and pentagonal drills. However, this method requires the use of an additional device and considerable effort.

Also, to obtain multifaceted blind holes, firmware is used, additionally giving the tool a rocking motion.

It was shown in [1, 2] that giving the piercing a rocking motion along a circular cone with the apex of the cone in the center of the pierced hole, compared to piercing on presses, reduces the piercing force many times over. Relatively low axial forces, which make it possible to perform the operation of forming a faceted hole on metal-cutting machines of the turning, milling or drilling groups, since the piercing force is within the limits of the allowable feed mechanisms for these machines.

The kinematics of any metal-cutting machine does not provide for the possibility of oscillating movement of the tool or workpiece. Special devices that convert the rotational movement of the spindle into the rocking movement of the tool are quite complex. It is proposed to implement not an absolute, but a relative rocking motion due to the joint rotation of the tool and the workpiece with an angular mismatch between the axes of the hole and the tool (Fig. 1) [1]. Synchronization of rotation frequencies is easiest to implement by self-rotation of one of the pairs, i.e. either the firmware rotates the workpiece in the fixture (for machines of the milling and drilling groups) or the workpiece rotates the firmware in the fixture (for machines of the turning group). The design of devices for self-rotation is not complicated. For turning operations, it is even possible to implement the swing stitching method without any fixtures at all. The piercing, the shank of which has a center hole, is guided into the pre-drilled workpiece by the rotating center of the tailstock, which is offset relative to the line of machine centers, which ensures the angular mismatch between the axis of the hole and the piercing and relative rocking motion.

When implementing this process, it is mandatory to have a positive clearance angle α greater than the swing angle of the tool, a non-zero rake angle γ leads to the fact that both the cutting edge itself and its end projection will have deviations of the sides of the cutting edge from straightness. To eliminate this error, it is customary to use a tool with a zero rake angle $\gamma=0°$. An additional advantage of zero rake piercing is the high strength of the cutting wedge, as well as the ease of sharpening and resharpening of the tool.



Picture 1 – Scheme of implementation of the principle of relative rocking stitching movement due to the joint rotation of the tool and workpieces with angular mismatch of their axes

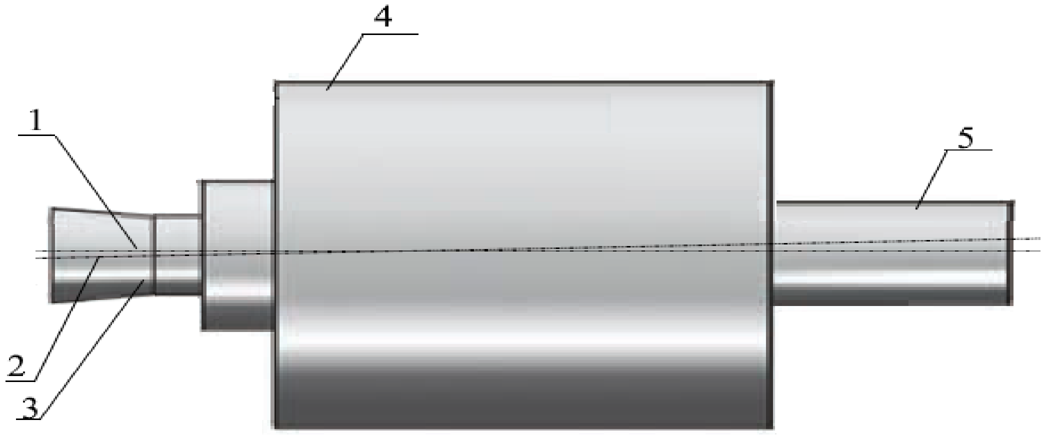
This method also makes it possible to increase processing productivity due to the concentration of operations, when a multifaceted hole is formed from a pre-drilled cylindrical hole on metal-cutting machines that form the part itself. The additional rocking movement along the cone with the tip of the cone in the center of the hole to be machined, compared to stitching on presses, can significantly reduce the processing force. Relatively small axial forces make it possible to perform the operation of forming a multifaceted hole on metal-cutting machines of a turning, milling or drilling group, since the processing force is within the limits allowed for the feed mechanisms of these machines.

However, metalworking machines do not allow for the oscillating movement of a tool or workpiece. Therefore, there is a need to use a special device that converts the rotational movement of the spindle into the rocking movement of the tool, which is difficult to implement.

Also, in scientific spaces, it is proposed to implement not absolute, but relative rocking motion due to the joint rotation of the tool and workpiece with an angular mismatch between the axes of the hole and the tool. However, this method is not universal either, since in order to implement the method of using the oscillating motion, it is necessary to take into account the kinematics of the existing machine, it is difficult to draw a clear dependence for choosing a method for minimizing the axial piercing force. . Difficulties also arise with the correct choice of rational processing modes and geometrical parameters of the tool, depending on the required hole quality parameters and the technological capabilities of the metal-cutting equipment used.

Goal (task) research.. Thus, the task was set: to make it possible with the help of self-made machines with a rotating working body (turning, milling, drilling) and, without resorting to such an expensive tool, to obtain multifaceted blind and through holes in fasteners in production.

Main text. We propose to use the existing kinematics of machine tools to design a tool that will allow the tool axis to be shifted relative to the main axis of the machine tool in the tool itself, which will significantly increase productivity, eliminate the use of additional devices, which in turn will reduce the estimated cost of repair work.

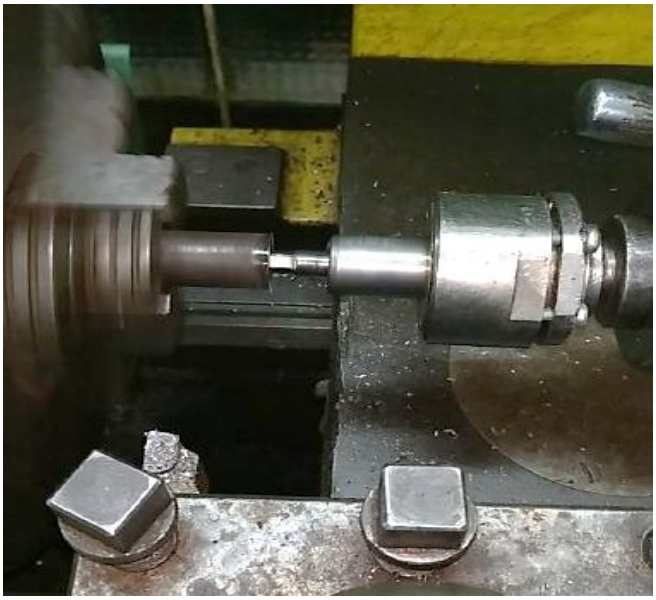


1 - tool spindle centerline, 2 - insert centerline, 3 - insert, 4 - tool spindle, 5 - tail section

Picture 2 – Tool-device for processing polyhedral holes
Author's development

The tool-device is a cylindrical body, inside of which a spindle 4 is installed (Fig. 2). During rotation, the spindle axis performs orbital movements relative to the axis of the device shank. The spindle of the device has a mounting hole for attaching the insert 3. The shank is welded to the body. Shanks are manufactured in accordance with all major tool standards; Morse taper, Weldon, flat cylinder, etc.

Insert 3 (Fig. 2) is made of hardened tool steel, the working part is a prism, the cross section of which repeats the shape of the hole to be obtained. The rear surface of the insert is made with a negative clearance angle, which reduces the effect of friction forces of the rear surface of the insert with the surface of the hole being machined. Re-filling on the front surface is possible.



Picture 3 – Processing a hole with a tool fixture on a lathe

Description of the process. A shaped multifaceted hole is machined on a lathe. The device with the insert fixed in it is installed in the trunnion of the tailstock of the machine. A cylindrical workpiece with a pre-prepared hole is installed in the lathe chuck. The workpiece is subjected to rotational motion. Insert for 3 moves along the guides of the machine until it touches the prepared hole in the workpiece. Under the action of friction forces, the insert begins to rotate together with the workpiece, in parallel with this, the tailstock pin extends to the required depth.

Insert 3 in fixture 4 is installed with a slight inclination relative to the axis of rotation of the workpiece, which causes the insert to move along an orbital trajectory.

As a result of the addition of all movements, it turns out that the cutting edge of the plate does not participate in the work all at the same time, but only part of it, which is constantly changing. Thus, we obtain a significant reduction in cutting force, which makes it possible to carry out the process of piercing faceted holes not on specialized presses, but on universal metal-cutting equipment, including CNC machines. The chips formed during the cutting process remain inside, filling the volume of a part of the preliminary hole, which is drilled slightly deeper than the piercing depth.

This process is carried out at sufficiently high spindle speeds within 1500-3000 rpm, the number of revolutions during this process does not affect the cutting speed, when the tool enters the hole, it is recommended to reduce the number of revolutions, when outputting the firmware, the revolutions must be reduced or stopped.

Optimal feed rates are between 0.03-0.06 mm/rev, depending on the material being processed. With this method, cutting forces are reduced by approximately 80% of the traditional; it is recommended to form a chamfer of 60°-90° in the inlet hole; the depth of the preliminary hole is 1.3-1.5 relative to the depth of the firmware; during processing, it is recommended to use for cooling the emulsion or oil.

CONCLUSION AND CONCLUSIONS

Thus, with the help of this tool-device, it is possible to refine with significantly reduced cutting forces, which will allow processing multifaceted holes not on specialized presses, but on universal metal-cutting equipment, including CNC machines. The chips formed during the cutting process remain inside, filling the volume of that part of the preliminary hole, which is drilled a little deeper than the required hole depth.

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Машинобудування і зварювальне виробництво

Манойлов О.В., Кудинова Е.В.

УСТРОЙСТВО ДЛЯ РОТАЦИОННОГО ДОЛБЛЕНИЯ ГЛУХИХ МНОГОГРАННЫХ ОТВЕРСТИЙ

Рассмотрена актуальная задача получения многогранных глухих отверстий в единой производственной среде. Особенно актуально при выполнении ремонтных работ в машиностроительном производстве. Самая большая проблема заключается в том, что получение многогранных отверстий с использованием в качестве инструмента специальных сверл связано с большими усилиями, возникающими в процессе обработки. Выявлено в результате анализа исследований по данному вопросу некоторые недостатки, значительно усложняющие реализацию данного метода получения многогранных отверстий. А именно, обработка с дополнительным качательным движением требует специального оборудования, что в свою очередь экономически не оправдано. Предложен инструмент-устройство, которое позволяет с помощью обычных токарных, сверлильных или фрезерных станков получить необходимый профиль отверстия. При этом производительность обработки значительно повышается, а трудоемкость снижается. Ресурс инструмента увеличивается, так как при обработке в работу вовлекается не вся режущая кромка. Представлены рекомендации по выбору оптимальных режимов обработки мягких материалов. Есть и явный экономический эффект.

Ключевые слова. *Многогранное отверстие, усилие, задняя поверхность, обработка, производительность, инструмент-приспособление, прокатка.*

Manoilov O. V., Kudinova K. V.

ПРИСТРІЙ ДЛЯ РОТАЦІЙНОГО ДОВБАННЯ ГЛУХИХ БАГАТОГРАННИХ ОТВОРІВ

Розглянуто актуальне завдання отримання багатогранних глухих отворів у єдиному виробничому середовищі. Особливо актуально під час виконання ремонтних робіт у машинобудівному виробництві. Найбільша проблема полягає в тому, що отримання багатогранних отворів з використанням інструменту спеціальних свердлів пов'язане з великими зусиллями, що виникають в процесі обробки. Виявлено в результаті аналізу досліджень з цього питання деякі недоліки, які значно ускладнюють реалізацію даного методу отримання багатогранних отворів. А саме, обробка з додатковим рухом руху вимагає спеціального обладнання, що в свою чергу економічно не виправдано. Запропоновано інструмент-пристрій, який дозволяє за допомогою звичайних токарних, свердлильних чи фрезерних верстатів отримати необхідний профіль отвору. У цьому продуктивність обробки значно підвищується, а трудомісткість знижується. Ресурс інструменту збільшується, тому що при обробці в роботу втягується не вся крайка. Наведено рекомендації щодо вибору оптимальних режимів обробки м'яких матеріалів. Є й очевидний економічний ефект.

Ключові слова. *Багатогранний отвір, зусилля, задня поверхня, обробка, продуктивність, інструмент-пристосування, прокатка.*

Стаття надійшла 16.11.2021 р.