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ANALYSIS OF METHODS FOR OBTAINING WIRE PRODUCTS, ADVANTAGES OF TECHNOLOGICAL PROCESSES AT RADIAL SHEAR MILLS

Abstract: *The production of wire products sets high demands in the field of assortment, quality, flexibility of technologies, efficiency and cost-effectiveness, as well as full automation of processes. This article is aimed at analyzing existing methods and identifying the most promising approach to the production of wire products among innovative highly efficient technological processes for the manufacture of rods and wire. The research is aimed at a highly specialized subject area sufficient for full coverage and disclosure of the objectives of this article. Within the framework of the article, a comparative analysis of the most effective modern technological processes for producing wire products is carried out. The authors' conclusions indicate that modern methods of producing wire products of various diameters through rolling processes (for example, on radial shear mills) often represent the most economically justified process. A significant advantage of this process is the possibility of obtaining high-quality wire products corresponding to the required dimensions, with minimal tolerances. To verify this conclusion, at this time, a radial shear mill was created on the basis of KazNRTU named after K.Satpayev, the main novelty of which is the location of the rolls. A number of practical experiments were carried out on the created radial shear mill to attract an aluminum rod of the alloy 6082 grade.*

Key words: *wire products, rod, rolling, mill, bed, deformation, radial shear, rolls.*

Introduction

The contemporary trajectory of scientific and technological advancement is inconceivable without the integration of metal products featuring diverse categories of conductive elements composed of various metals and vortices. It is imperative to underscore that domestic enterprises engaged in the production of machinery-related products lag significantly behind in terms of technological modernization, enhancement, and production expansion. Consequently, local manufacturers find themselves unable to effectively compete with their foreign counterparts, hindering their ability to secure a prominent position in the service market. This research has discerned the primary challenges and methodologies inherent in existing technological processes, thereby illuminating avenues for future development.

Literature Review

In the contemporary landscape of metal and vortex-based rod and wire production, several primary pressure treatment methods are employed, namely forging, stretching, compression, and rolling. Each of these methods plays a crucial role in shaping the final characteristics of the manufactured products. It is imperative to delve into a detailed examination of each method to discern their distinct contributions and impact on the overall production process.

The forging process is applied in the fabrication of rod and wire blanks derived from refractory metals and their challenging-to-deform alloys. This method involves subjecting the workpieces to periodic oscillatory forces utilizing a die, resulting in the comprehensive deformation of the entire surface area. Consequently, the cross-sectional dimensions of the workpiece are compressed, and the mold's configuration or the spacing between the workpieces undergo alterations in accordance with the principles governing the processing procedure. The die is strategically positioned on slides encircling the workpieces, facilitating a reversible translational motion in the radial direction. For circular machining, rotary clamping machines prove effective for smaller workpieces such as rods and wires, while radial crimping machines are employed for larger workpieces like castings composed of low-stability, hard-to-deform materials [1].

The device or drive mechanism transporting the die and moving around the workpieces is implemented in rotary-clamping machines, whereas this movement is absent in radial-clamping machines. Depending on the method of movement of the working elements, rotary compression machines are categorized as rotary, annular, and drum machines, while radial compression machines are further classified as rotary, lever, and connecting rod machines. Regarding the orientation of workpiece feed to the deformation site, both rotary-clamping and radial-clamping machines are subcategorized into horizontal and vertical configurations [2].

On the basis of scientific research at the Kazakh National Research Technical University named after K. Satpayev, a radial shear mill has been developed. This technical unit is an innovative system that integrates radial and shear motion to optimize material processing processes. The result of the creation of this mill was the improvement of technological processes in metalworking, which contributes to increased production efficiency. The machine rollers are committed to a smooth transition from the calibration section to the helical crimping segment.

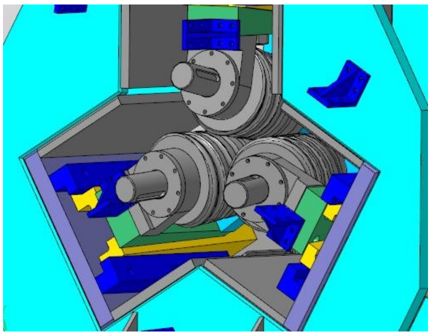

Figure 1 – Computer model of matrices with a working area

The mill itself is a matrix with an operational zone, the structure of which is characterized by sequentially arranged, the cross sections of which gradually decrease in the form of truncated cones with non-parallel bases. A notable aspect is the cruciform distribution of the great and small generators in these competitions, as well as the presence of a calibration site.

Figure 2 – The developed radial shear mill on the basis of KazNRTU named after K.Satpayev

The precision of rotation during the cold-state stretching of entire products is equivalent to that of the second category. According to experimental findings, the outer diameter of pipes processed on rotary forging machines maintains a tolerance threshold of 0.025 mm for each 6-10 mm diameter of forging.

Forging, as a rapid method of metal processing under pressure, involves the circular compression process wherein the active force is simultaneously applied from two or four opposing sides of the workpiece. In contrast to simple compression, the metal deformation transpires not under the influence of impact but rather under the substantial compression pressure exerted sequentially. Through the process of hot forging, wires adopt a coarse-grained structure. To produce flexible wire, the temperature is gradually reduced during metal processing. Rhodium sheets are prepared by sequential hot rolling using a 0.75 mm thick spatula, rendering the metal pliable enough for subsequent cold rolling. Multiple intermediate heating steps are imperative during the cold rolling phase [3].

Despite its advantages, the circular forging process is associated with several drawbacks, including low machinability, challenging working conditions marked by vibration, intense noise, substantial heat generation, a significant reliance on manual labor, a substantial material requirement, and a relatively high level of unusable material. The unfavorable stress-strain state pattern leads to surface defects such as scratches and internal flaws on the rods [4].

Stretching represents a pressure-based metal processing method where the metal, in the form of a line with a consistent cross-section, is fed into the channel of the stretching tool and subsequently stretched or elongated. The channel mirrors the shape or cross-section of the malleable metal, featuring a horizontal section that gradually contracts from the tool's point of entry to its exit. The outlet section of the channel is consistently smaller than the cross-sectional area of the stretched portion. Consequently, the stretched segment undergoes deformation as it traverses the channel, assuming the shape and dimensions of the smallest section within the channel. The length of the wire increases in direct proportion to the reduction in cross-sectional area[5].

Preceding the stretching process on a specialized machine, the stud is front-faced, allowing easy insertion with a slight protrusion from the opposite side. Subsequently, the end is engaged and stretched using a designated mechanism, applying tension force to the front end of the workpiece. This approach ensures the production of wires, rods with highly accurate transverse dimensions, and pipes with diverse cross-sections. Metal stretching treatment finds widespread application in the metallurgical, cable, and machine-building industries, encompassing the manufacturing of rod metal, wire, pipes, and other products of normal and large cross-section [6].

The stretching process accommodates steel with various chemical compositions, as well as nearly all non-ferrous metals and their alloys, including gold, silver, copper, and aluminum. Products generated through stretching exhibit a high-quality outer surface, accompanied by precise cross-sectional dimensions. When the objective is to endow a product with these specific properties, the process is referred to as calibration.

Wire steel is utilized for tension rods ranging from 16 to 100 mm in diameter and pipes with diameters between 16 and 300 mm. In instances where a workpiece with a diameter of 0.1-60 mm is being stretched, a wire made of a hard alloy based on tungsten carbide is employed. For workpieces with diameters up to 2 mm, as well as non-ferrous metals and their alloys, steel with a diameter of up to 1 mm, nichrome, tungsten, and molybdenum with a diameter of up to 0.5 mm, or a diamond conductor, and wires made of composite materials are utilized.

To minimize external friction between the drawn metal and the cord channel, a thick lubricant is applied. This reduction in stretching energy costs serves to create a smoother surface for the pulled metal, prevent channel wear, and facilitate the process at higher levels of deformation [7].

In most cases, the metal subjected to stretching is not preheated; it is introduced into the wire channel at room temperature. The deformation formed in the channel and the heat generated through external friction are managed through continuous washing of the conductor with a cooling emulsion, water, and ambient air. Under these anhydrous stretching conditions, appropriately lubricated and equipped metal attains a smooth, glossy outer surface with precise cross-sectional dimensions. Stretching on a solid conductor stands out as the most prevalent method for producing wire products, involving the deformation of metal by pulling it through the channel of the stretching tool.

The channel's cross-section gradually diminishes from the point of metal entry into the conductor to its exit plane. Consequently, the workpiece, while traversing the conductor, assumes the shape and dimensions of the minimum (calibration) section within the conductor channel. Prior to stretching, the front part of the workpiece undergoes pre-cutting. According to established protocols, the wire stretching process is typically conducted in a cold state, occasionally involving heating when processing hard-to-deform metals and alloys.

Occasionally, the stretching process employs simultaneous force on the back end of the workpiece, aimed at reducing friction during the wire-metal connection, thereby enhancing the strength of the wire channel. The evolution of the process has led to the emergence of methods such as traction on rotating or oscillating conductors, traction in a liquid friction mode, multi-fiber extraction, and traction on roller conductors.

Theoretically and practically, the rotation of a solid wire is identified as a means to reduce tension gain. However, experimental findings indicate that achieving a significant reduction in this parameter at a standard stretching rate would necessitate rotating the conductor at an ultrahigh speed. Consequently, the use of a rotating wire is infrequent and is typically reserved for ensuring even wear of the wire channel when stretching thin wires.

Vibrating wire stretching finds application in the production of thin and ultrathin wires composed of hard-to-deform metals and alloys. The application of ultrasonic vibrations in various directions, within a frequency range of 17 to 20 kHz, to the conductor serves to decrease tractive effort, enhance conductor resistance, and improve the surface quality of the wire. Vibrations of the wire tool can be horizontal, transverse, or rotational. To maximize the efficacy of vibrational stretching, it is imperative that the vibration velocity of the conductor significantly exceeds the tension velocity. A piezoelectric or magnetostrictive irradiator serves as a source of mechanical ultrasonic vibrations.

The multi-frame stretching process is employed for the repeated stretching of thin wire through sliding. Stretching is conducted at relatively low speeds, and with the repetition of the stretching cycle (4 to 8 times), the thread is simultaneously stretched, thereby increasing productivity, reducing wire tool consumption, and enhancing product quality.

The prominent drawbacks of a solid conductor become evident, particularly during extensive and moderate stretching of wire, manifesting in low productivity, stringent requirements for initial workpieces, high costs associated with preparing its outer surface, the utilization of expensive lubricants, low strength, and challenges in tool development. Notably, difficulties arise in producing profiles with intricate patterns, and the method is unsuitable for obtaining thin-walled profiles and those with a small rolling radius, as reflected in insufficient processing of the cross-section of deformable metal obtained through casting methods.

The pressing process serves as the primary method for deforming spreading and cast blanks in the production of wire-derived semi-finished products. The essence of this process lies in imparting a specific shape by compressing the metal into a cavity created by a working tool. The stress state scheme in compression (complex compression) is deemed more favorable compared to rotation. The widespread use of compression is attributed to the advantageous stress state scheme of the deformable metal – complex and uneven compression.

The selection of temperature conditions for pressing is contingent upon the deformation resistance of the metal, exerting a significant influence on both the force dynamics during the compression process and the ultimate outcome. Heating the pressed workpiece reduces the metal's deformation resistance while enhancing its plastic properties. However, elevated temperatures adversely affect tool working conditions. Consequently, a key challenge in determining temperature conditions is achieving an optimal balance between the alleviation of power conditions and the detrimental impact of high temperatures on equipment. Based on temperature conditions, the pressing process is classified into the following types: hot, isothermal, cold.

The prevalent method in pressing processes is direct compression, where the friction force of the metal between the ingot necessitates additional energy consumption as it moves within the die press. In contrast, reverse compression involves the ejection of metal in the opposite direction to the movement of the die press washer when the container is stationary. In this scenario, the ingot does not shift more than the container, leading to a reduction in the overall compression force. The size of the product in reverse compression is constrained by the dimensions of the press stamp cavity. Compression with a side outlet offers convenience during product retrieval and enables the attainment of maximum length on a vertical press [8]. The matrix is positioned directly on the sleeve of the container at a 90° angle to the press protrusion, with the cast metal outputting at right angles to the direction of the press stamp's movement. In hydrostatic compression, extrusion takes place under the influence of a liquid under high pressure, with the compressible metal isolated in a liquid layer, resulting in a significant reduction in compressive strength.

Advancements in metal pressing processes have given rise to various types of continuous pressing, including non-contact, continuous hydrostatic, rolling-pressing, and friction force-based methods such as "Linex," "disk extruder," and "Conform." Continuous pressing methods offer advantages such as automation and mechanization, increased efficiency, reduced energy consumption, and seamless integration with continuous metal casting machines.

A key advantage of pressed products lies in their ability to amalgamate multiple components, each serving different functions, into a singular pressed product. For instance, panels, designed to provide structural strength and rigidity by riveting rolled sheets and angular or T-shaped profiles, can now be efficiently produced in a single pressing revolution, eliminating the labor-intensive process of riveting and potential drawbacks associated with prefabricated structures. Pressed panels form a unified entity where sheets and T-shaped profiles are seamlessly integrated, obviating the need for assembly work to combine them. Another notable advantage is the ability to fabricate intricately shaped pressed products, a feat unattainable through other processing methods or even cutting. An illustrative example is an aluminum alloy pipe, 15 meters in length, with a diameter of approximately 90 mm, featuring through holes along its entire length (4 mm thickness), a configuration achievable only through pressing. Numerous analogous examples underscore the versatility of pressed products.

The compression process, while effective in producing wire products, presents several disadvantages, including compromised mechanical properties of the section, heterogeneity of wire products along their length, and a substantial strain load. Additionally, the equipment for pressing necessitates a significant amount of metal and occupies a substantial portion of the production area. Intensive wear of the working tool and the generation of press waste often result in reduced efficiency of the pressing process.

Rolling, particularly with a rolling diameter suitable for rods and wires, stands out as one of the most favored methods for producing wire products up to 5 mm. Challenges associated with this approach are primarily linked to the difficulty in achieving the smallest wire sizes. When considering the precise dimensions and geometry of their cross-section, available equipment may not be suitable for rolling small profiles, and an increase in the size of a clean processing bag leads to an augmented need for steel devices and additional production space. Consequently, wire production via rolling is primarily directed towards obtaining hot-rolled wire billets (wire rods) or wire products from continuous casting billets. Continuous wire mills and casting and rolling complexes have become widely employed for this purpose.

Modern mills equipped with high-speed clean processing bag blocks, where cermets are rolled on a single thread without a screen, can achieve high-precision (with a tolerance of ± 0.1 mm) wire rod rolling. Morgan blocks from the USA are widely used abroad, featuring replaceable bags with cantilever rolls positioned at an angle of 90° to each other and at an angle of 45° to the horizontal plane. These blocks, designed for manufacturing 12.7 mm wire rods, contribute to the production of high-quality wire products. Blocks with a similar design are produced by companies such as "Siemag" and «SKET» in Germany.

For rolling tension wires, the triangle-triangle calibration scheme is employed in finishing bag blocks from Kocks. These blocks consist of bags with three windings located at an angle of 120° from each other and connected by conical gears. This block design allows for the rolling of wire made from hard-to-deform steel grades with a diameter of up to 5 mm, originating from a finely dispersed rolling-type billet with an elongation coefficient ranging from 1.10 to 1.25 [9].

An intriguing technology in wire production involves tubeless rolling using the RER process, patented by the Australian company Copper Ltd. This method contributes to the standardization of rolling rolls, enhances their efficiency, reduces the number of passes, simplifies the design of wire fittings, and facilitates machine installation. The paper also explores the feasibility of using flat rolls for rolling copper wire with a diameter of 6.35 mm from corrosion-resistant steel and wire with a diameter of 8 mm.

In recent times, the method of obtaining blanks through continuous or semi-continuous casting of metal has gained widespread use. This involves the use of casting machines equipped with a graphite crystallizer, enabling the production of billets closely matching the size of the finished wire. This approach reduces the overall duration of the technological cycle. However, the cast structure of the extracted metal is unsuitable for further stretching, and the process is generally considered less productive. Hence, in global practice, the prevalent approach is the combined process of casting and rolling metal, executed in foundry and rolling complexes. This integrated method has significantly increased productivity, enhanced product quality, and reduced production costs. For the production of blanks made of aluminum and copper, rotary-type casting machines with a vertically positioned circular crystallizer are commonly utilized, followed by rolling processes according to schemes such as «hexagon-triangle – circle», «circle – oval – circle», or «sharp square – sharp square – circle». In the production of zinc and brass wire rods, casting machines with a horizontally positioned circular mold (carousel type) are employed, utilizing alternating box-shaped calibration systems. Leading companies engaged in the implementation of integrated casting and billet rolling processes abroad include Continuous Properzi (Italy), General Electric Co. (USA), and Speedem (France). The productivity of these combined processes has approached 70 t/h, with a wire rod exit speed from finishing bags of 10 m/s, and a minimum wire rod diameter ranging from 1.5 to 2.0 mm.

Cold rolling is a prevalent method in the production of rod and wire products. However, its extensive use in the production of round-section wire encounters technological challenges, primarily metal riveting during deformation, necessitating interruptions in the continuous deformation process and the implementation of heat treatment operations. Uneven deformation, more critical than in hot rolling, requires the development of a winding calibration to prevent excessive curvature of the strips and ensure proper gauge filling. In practice, combined wire production processes are often employed, incorporating various methods in conjunction with cold rolling. The choice of a technological scheme is determined by the shape and size of the profile, with an emphasis on minimizing costs and reducing technological retraining efforts. For instance, the Maschinenfabrik Gans Arnold mill in Germany facilitates cold deformation of round and reinforcing wires with a diameter of 4 to 7 mm in anhydrous and wet bags with a winding diameter of 180 mm. A single adjustable rolling speed (up to a volume of 12 m/s) ensures mill production ranging from 5 to 12.5 t/s in a hopper weighing 2.5 tons. Similar production processes have been implemented at the Cerepovets mizileumezavod for products in the range of 4 to 12 mm. LTP type lines from Impianti Industriali SpA (Italy) are currently utilized for cold rolling of wire with a diameter of 4 to 12 mm, offering the rolling of a three-chamber block at speeds up to 15 m/s. There is also information indicating the use of four-leaf caliber bags for cold rolling of circular wire [10]. Cold rolling finds application in the production of flattened strips, shaped bars, and wire, often incorporating prestressed double-frame bags and bags with a multi-frame caliber. The versatility and variety of metal products, along with their distinctive features, position them as fundamental and constructively complementary materials with widespread applications.

Conclusion

The rolling process stands out as a highly versatile, cost-effective, and quality-assuring method for manufacturing wire products. Its advantages in terms of thickness range, energy efficiency, quality outcomes, processing performance improvement, and enhanced productivity make it a preferred choice in the evolving landscape of steel profile manufacturing. Among the various methods considered for manufacturing wire products, the rolling process emerges as the most advantageous in terms of modernization and automation. In comparison with pressing and forging, rolling offers several key advantages:

1. Versatility in Thickness Range: Rolling provides the ability to obtain products across a wide thickness range, spanning from several microns to 200 mm. This expansive range enhances the versatility of steel rolling and widens its applicability.
2. Energy and Cost Efficiency: Rolling has the potential to significantly reduce energy consumption and costs. Hot rolling, in particular, involves high metal-plastic deformation during the process, leading to reduced electrical application for metal deformation. This, in turn, positively impacts the cost of finished products.
3. Quality Assurance: Cold rolling, in particular, yields products of the highest quality across various indicators, including dimensional accuracy, surface finish, and physical and mechanical properties. These advantages have contributed to the widespread adoption of cold rolling in both ferrous and non-ferrous metallurgy.
4. Improvement in Processing Performance: Hot rolling proves beneficial in enhancing the processing performance of metals and alloys. It facilitates the removal of large granules during cast production, healing of cracks, reduction or elimination of defects from casting, and transformation of the microstructure from a cast state to a deformed structure. This, in turn, improves the technological properties of the alloy.
5. Increased Productivity: The rolling process utilizes large castings and rolling equipment, leading to increased productivity. Moreover, it creates favorable conditions for elevating rolling speeds and establishing a continuous, automated rolling process.

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СЫМ ӨНІМДЕРІН АЛУ ТӘСІЛДЕРІН ТАЛДАУ, РАДИАЛДЫ-ЫҒЫСУ БІЛДЕГІНДЕГІ ТЕХНОЛОГИЯЛЫҚ ПРОЦЕСТЕРДІҢ АРТЫҚШЫЛЫҚТАРЫ

Сым өнімдерін өндіру технологияларына, яғни оның ассортиментіне, сапасына, икемділігіне, тиімділігі мен үнемділігіне, сондай-ақ процестерді толықтай автоматтандыру саласына жоғары талаптар қояды. Бұл мақала қолда бар әдістерді талдауға және шыбықтар мен сымдарды дайындаудың инновациялық тиімді технологиялық процестері арасында сым өнімдерін өндірудің перспективті тәсілін анықтауға бағытталған. Зерттеулер тар шеңберде мамандандырылған салаға бағытталған, дегенмен, осы мақаланың мақсаттарын толық жария ету үшін жеткілікті. Мақала аясында сым өнімдерін алудың ең тиімді, заманауи технологиялық процестеріне салыстырмалы талдау жүргізілді. Авторлардың тұжырымдары бойынша - илемдеу процестері арқылы әртүрлі диаметрлі сым өнімдерін өндірудің заманауи әдістері (мысалы, радиалды-ығысу білдегі) экономикалық тұрғыдан ең тиімді процестердің бірі болып саналады. Бұл процестің маңызды артықшылығы – қажетті өлшемдерге сәйкес келетін жоғары сапалы сым өнімдерін ең төмен шекті өлшемдермен алу мүмкіндігі. Осы тұжырымды қазіргі уақытта тексеру үшін, Қ. Сәтбаев атындағы ҚазҰТЗУ базасында радиалды-ығысу білдегі құрылды, және оның негізгі жаңалығы орамдардың орналасуы болып табылады. Жасалған радиалды-ығысу білдегінде 6082 маркалы алюминий қорытпасын тарту бойынша бірқатар практикалық тәжірибелер жүргізілді.

***Түйін сөздер**: сым өнімдері, шыбық, илемдеу, білдек, кереует, деформация, радиалды ығысу, роликтер.*

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АНАЛИЗ СПОСОБОВ ПОЛУЧЕНИЯ ПРОВОЛОЧНОЙ ПРОДУКЦИИ, ПРЕИМУЩЕСТВА ТЕХНОЛОГИЧЕСКИХ ПРОЦЕССОВ НА РАДИАЛЬНО-СДВИГОВЫХ СТАНАХ

Производство проволочной продукции ставит перед собой высокие требования в области ассортимента, качества, гибкости технологий, эффективности и экономичности, а также полной автоматизации процессов. Настоящая статья нацелена на анализ существующих методов и выявление наиболее перспективного подхода к производству проволочной продукции среди инновационных высокоэффективных технологических процессов изготовления прутков и проволоки. Исследования направлены на узкоспециализированную предметную область, достаточную для полного освещения и раскрытия целей настоящей статьи. В рамках статьи проведен сравнительный анализ наиболее эффективных современных технологических процессов получения проволочной продукции. Выводы авторов указывают на то, что современные методы производства проволочной продукции различных диаметров через процессы прокатки (например, на радиально-сдвиговых станах) часто представляют собой наиболее экономически обоснованный процесс. Существенным преимуществом данного процесса является возможность получения проволочной продукции высокого качества, соответствующей необходимым размерам, с минимальными допусками. Для проверки данного вывода в данное время на базе КазНИТУ им.К.Сатпаева был создан радиально-сдвиговый стан, основной новизной котороого является расположение валков. На созданном радиалльно-сдвиговом стане был проведен ряд практических экспериментов по притягиванию алюминиевого прутка марки сплава 6082.

Ключевые слова: *проволочная продукция, пруток, прокатка, стан, станина, деформация, радиально-сдвиговый, валки.*

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МСТО МЕН КЕСУДІҢ ТЕМПЕРАТУРАЛЫҚ РЕЖИМІНІҢ КЕСУ ПРОЦЕСІНІҢ ТИІМДІЛІГІНЕ ӘСЕРІ

Аңдатпа: *Мақалада МСТО (майлау-салқындату технологиялық ортасы) және температуралық кесу режимінің кесу процесінің тиімділігіне әсері қарастырылады. Мақалада оңтайлы МСТО қолдану және кесудің температуралық режимін реттеу кесу процесінің тиімділігін келесі бағыттарда арттыруға мүмкіндік беретіндігін көрсеткен эксперименттік зерттеулердің нәтижелері келтірілген:*

– Құралдың беріктігін арттыру. МСТО қолдану Кесу аймағындағы температураны төмендетуге мүмкіндік береді, бұл құралдың тозуын азайтады.

– Өңделген беттің кедір-бұдырлығын азайту. МСТО қолдану Кесу аймағындағы температураны төмендетуге мүмкіндік береді, бұл өңделетін материалдың деформациясының төмендеуіне және нәтижесінде өңделген беттің сапасының жақсаруына әкеледі.

– Кесу күштерінің төмендеуі. МСТО қолдану Кесу аймағындағы температураны төмендетуге мүмкіндік береді, бұл құрал мен өңделетін материал арасындағы үйкелістің төмендеуіне және нәтижесінде кесу күштерінің төмендеуіне әкеледі.

Нәтижелер оңтайлы МСТО қолдану және кесу температурасын реттеу кесу процесінің тиімділігін арттырудың тиімді әдістері екенін көрсетеді.

Машина бөлшектерінің беткі қабатының дәлдігін арттыру үшін МСС (майлау-салқындатқыш сұйықтықтар) және МСС түрлері; экологиялық таза МСТО-ның жаңа түрлерін жасау бойынша ұсыныстар берілген.

МСТО жаңа құрамдарын таңдаудың көп қырлы әдістемесі ұсынылды. Техника sots таңдау кезінде бөліктің материалы мен құралының химиялық құрамы, өңдеу әдістері, кесу режимдері, бөліктің беткі қабатының дәлдігі мен сапасына қойылатын талаптар ескерілетіндігіне негізделген.

Түйін сөздер: *МСТО-майлау-салқындату технологиялық ортасы, температура режимі, кесу процесінің тиімділігі, құралдың беріктігі, өңделген беттің кедір-бұдырлығы.*

Кіріспе

Кесу арқылы өңдеу кезінде беткі қабаттың қажетті сапа параметрлерін алу кейбір қиындықтар туғызады. Өйткені беттік қабат сапасының көптеген факторларының бөлшектің осындай қасиетіне әсері осы уақытта онша жақсы зерттелмеген.