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ANALYSIS OF THERMAL TOOLS FOR CUTTING AND PROCESSING BLOCK STONE

***BUKAYEVA A.**
Caspian University of Technologies
and Engineering named after Sh. Yessenov
Aktau, Kazakhstan
E-mail: amina.bukaeva@yu.edu.kz
HUY-TUAN PHAM
Ho Chi Minh City University
of Technology and Education, Vietnam
***Corresponding author: amina.bukaeva@yu.edu.kz**

Abstract. The article is an in-depth analysis of the production process of facing stone from durable rocks, especially granites. He considers not only mining technology, but also the development of new thermal tools used to effectively remove rocks during the processing, grinding and extraction of block stone. Rational methods of processing and extraction of block stone and the design of thermal devices for the destruction of hard rocks during processing and extraction of block stone are described.

The methods and tools used to create such structures are discussed in detail, as well as the improved energy characteristics that make them an effective tool in production. This method helps to improve the overall productivity of the mining process by increasing the more accurate and efficient formation of cracks in rocks and, consequently, increasing the productivity of the block stone mining process. This aspect is especially important in the field of surface stone production, which requires high productivity and precision processing of the material.

In addition, the analysis and developments presented in the article can significantly improve the efficiency of the mining and processing of rocks, which will contribute to the development of the industry and improve the quality of products. As a working body, a mechanized unit of a stone-cutting machine, new designs of thermal tools with high energy characteristics have been developed and manufactured.

Keywords: rock, fuel-air thermal tool, stone-cutting machine, fuel components, performance.

Introduction. In modern industry, the stone processing process plays an important role, especially in the production of block stone from durable rocks such as granite. One of the key aspects of this process is the effective use of thermal stone cutting tools used to break down rocks and produce block stone. This study is devoted to the analysis and development of such thermal instruments in order to increase their energy characteristics and efficiency in production processes. In this introduction, an overview of the existing methods and designs of thermal instruments is given, as well as the goals and objectives of the study are formulated.

Materials and methods. The development of facing stone deposits is distinguished by a number of features that make it possible to allocate such quarries to a special group of mining enterprises. [1-3] as stated in the literature, these features are:

a) the need to maintain its main quality indicators in the process of stone production (i.e. strength, cloudiness and decorative properties);

b) the use of special methods for separating stone blocks from the quarry, their loading, transportation and lifting from the quarry;

c) the use of unique options for field discovery methods and development systems.

The first feature determines the specifics of the work of quarries for the production of block stone. It creates conditions for both funds and the organization of mining. Everything is subject to the preservation of the integrity of the stone. The experience of quarries shows that even with the correct use of cracks and micro - orientations of minerals, the outflow of large blocks from the rock mass rarely exceeds 25-30%, and the rest of the rocks are household stone, small blocks, etc.

In the organization of work in a quarry, knowledge of the anisotropy of the array structure is of great importance, which must be taken into account when choosing methods and direction of development. Anisotropy of the structure of arrays is observed in granites, which facilitates the division of the stone into certain directions.

Two methods are mainly used to obtain facing stone:

1. From the pegs of a stone block using wedges. Method-holes are drilled along the fracture line, then steel wedges are hammered into them, a strong mechanical blow is applied to them. This method is more time-consuming [4].

2. Thermal cutting of stone with fire jet. This method is distinguished by high speed, relatively low cost, high quality of work.

Let's dwell on the second method in more detail. The thermal approach to surface treatment and burying of cracked excavations in the granite massif, introduced into production, significantly increased the efficiency of work. There was an opportunity to additionally open a monolithic prepared for breaking. The groove in the monolithic blasting array is carried out using a thermal well when it is opened in four planes. The monolith prepared for breaking remains connected by an array of single vertical and horizontal planes. In addition, the horizontal plane is selected at the place of passage of the natural transverse crack. Such a technological cutting scheme contributed to the preservation of the integrity of the Stone, the yield of blocks increased to 25-40%. However, the basis of the technology remains the presence of natural horizontal cracks [5].

The main tool for digging grooved fossils in granite arrays are hand-held gasoline-air burners. With such burners, it is possible to dig grooved fossils only in the vertical direction.

The depth of the excavations is mainly 1.5-3 meters, although there are known examples of burrowing excavations at a depth of five or more meters. With manual burners, it is difficult to carry out excavations at depth, it is difficult to control them.

In accordance with the terms of reference, a laboratory sample of a machine of a new design is designed and manufactured – a stone thermal cutting unit. Technical requirements include design simplicity, serviceability, safety requirements in operation, ensuring the high performance of the new design of the machine.

According to the terms of reference, the installation for thermal cutting of stone consists of a thermal cutter, connecting pipes, a compressor, a fuel and air supply system, a transport and supply system. The power characteristics of the unit, including granite, are based on the fact that it provides a cutting speed of at least 50 mm/min.

The transport and transmission system is subject to requirements for the dimensions of the working space: the length of the horizontal displacement is not less than 4000 mm and not more than 20000 mm; the magnitude of the vertical displacement is not less than 6000 mm, the turns of the cutter in the vertical plane are not less than 180^0. For installation, an electromechanical drive is required, which provides a given speed of movement with step adjustment. The weight of the cutter should not exceed 20 kg.

Research results. As a working body, we developed improved updated designs of thermodynamic instruments (TRV-60, TRV12M). They are equipped with thermodynamic nozzles that allow you to increase the energy parameters of the burners. Industrial tests of these tools were carried out. The following technical characteristics were obtained: air consumption – 5 m^3/min, fuel consumption (gasoline/diesel fuel) – 15 l/h, nozzle diameter – 13 mm, nozzle diameter – 20 (22) mm. As a result of the test, the length of the torch torch is 25 cm, the volume processing capacity is 4000 cm^3/ min.

Also, design options for thermal cutters VR-80 were developed (fig.1) and its analogue TR-60.

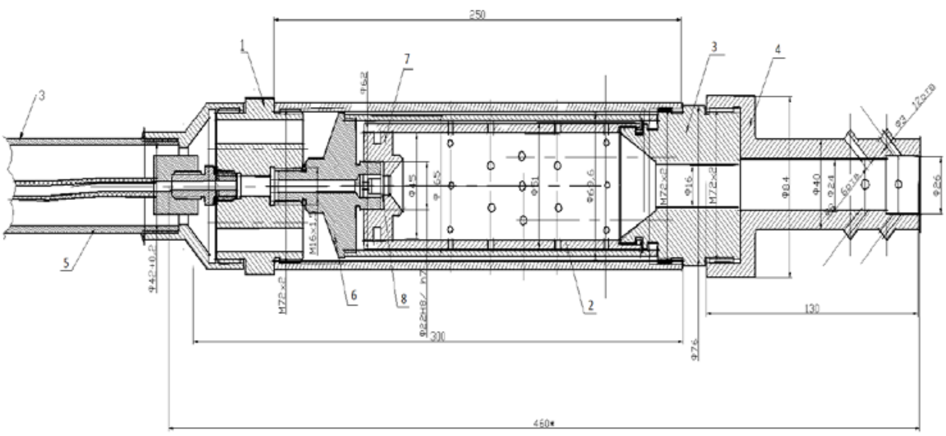

Figure 1-Thermal tool BVR80
1-distribution head, 2-combustion chamber, 3-nozzle, 4-gasdynamic nozzle, 5-extension pipe, 6-combustion chamber back cover, 7-air spinner, 8-injector

In the presented schemes, the shape and location of the injectors, the length of the combustion chamber, the size of the holes for air movement during cooling, etc. changed.

The most difficult thing in solving the problem of mechanized cutting is to obtain a stable production of cracks in sections of the granite massif with the addition of dark-colored minerals and other bedrock. The heterogeneity of the composition along the cutting line leads to an uneven production rate of holes in depth. When cutting with manual thermal tools, the situation does not make it difficult to pierce the hole, since in this case the uneven speed of movement of the tool is easily set.

It is very difficult to ensure an automatic speed control system due to the uneven movement of the working body of the stone cutting machine by laying and thermal destruction of rocks in the deposit. The actions of such solutions occurred during the creation of firing drilling machines, in which the problem of adjusting the feed speed of the thermobur depending on the speed of the face is solved, i.e.the problem of maintaining the optimal distance from the cut of the burner nozzle to the ledge. Reliable and simple transmission speed control systems have not been found [6].

We have developed an experimental stone cutting unit for digging vertical grooves. This is a cart on which all the movement drives of the working body of the machine are installed. The cart moves along the cutting line along the rail track. A bracket with a guide carriage is installed on the trolley, in which a bar with a thermoresack is attached to the hinged supports. In the same carriage, a thermorezac rotation drive is installed (Figure 2).

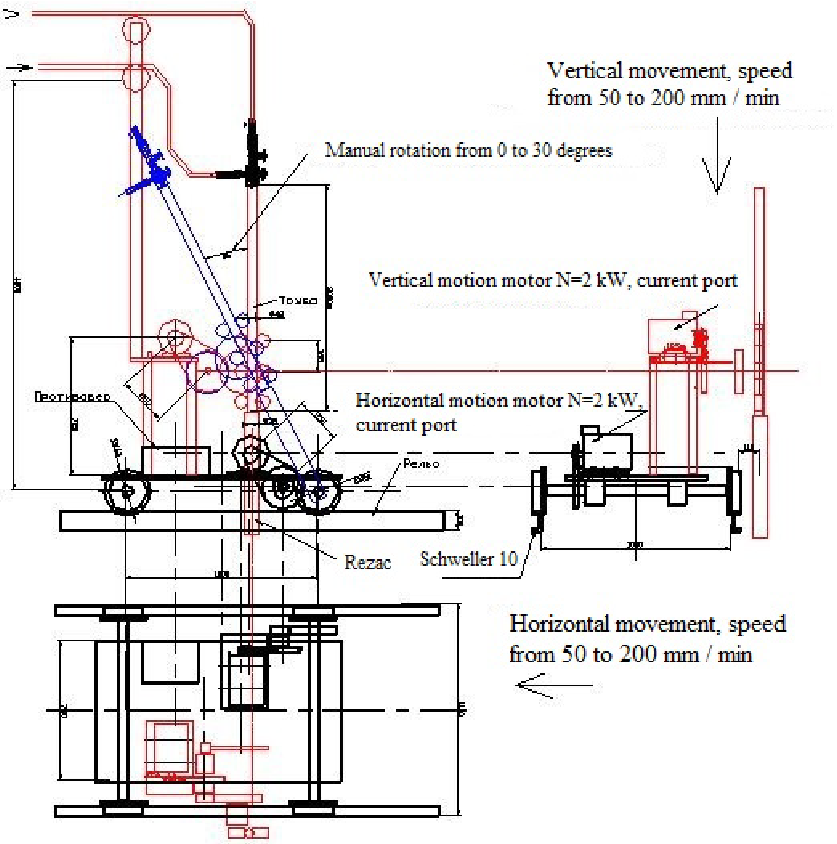

Figure 2-Structural diagram of a machine with a thermodynamic working body

So, the thermal cutter can move along the cutting line together with the cart, rotating around its axis. The speed of movement of the thermorezac along the cutting line is adjustable in the range of 0.25-1.5 cm/s. the recoil speed is constant and is 20 rpm. the rotation angle is adjustable in the range of 90-150 degrees. After each turn, the thermorezac descends to a depth of up to the size of the fossil.

The drive of movement in each direction is different. The BVR-80 thermorezac is installed as the working body of the stone cutting machine.

Technical characteristics of thermorezac BVR-80.

Fuel component costs:

- air, m^3 / min-18-20.
- gasoline, kg / h-35-40.
- burner diameter, mm-60.

Longitudinal feed of the thermocouple. The feed speed of the thermal tool is regulated by a variator. Changing the number of revolutions of the leading roller. The wiring diagram for controlling the longitudinal supply of the heat tool provides for an automatic reverse and a time-adjustable stop after each working stroke, which allows you to get a vertical wall at the end of the crack. The stop at the end of the reverse and stroke is carried out using the end switches. The wiring diagram provides for stopping and turning on the feed of a carriage with a thermal device from the control panel of the buttons.

Discussion. The use of gasoline-air burners as working bodies of mechanized thermal units is limited to a relatively low power, with an increase in which their overall dimensions, as well as the small dimensions of the torch, quickly increase (0.1...0.15 m) when using the scheme of processing the torch along the entire length of the torch - "strip source". According to this processing scheme, the gas flow of the burner is directed parallel to the surface to be treated and buried inside the rocks by 0.3. The diameter of the burner nozzle is 0.5. Compared to the contact point of the kerosene-oxygen thermal tool, the contact point with such a reactive rock is 2 or more times smaller, so the processing performance is quite low.

However, due to the ease of operation and nutrition of fuel components of gasoline-air thermosetting devices, their use as working bodies of mechanized installations is relevant. Increasing the power of gasoline-air thermosetting devices without significant development, setting their overall dimensions and increasing the flame of the burner, the dimensions of the treated surfaces of stone products (board stones, stairs, etc.) will be possible due to the intensification of combustion processes.

One of the means of intensifying the combustion of free Jets outside the nozzle cut is the combustion of incomplete combustion products of a mixture enriched with fuel by removing atmospheric air. When using heavy fuel mixtures in thermosetting devices, it is necessary to improve the way the burners are lit.

As a working body, we have developed a new design of a thermodynamic tool, the scheme of which is shown in Figure 3. In this scheme, it is recommended to alternately use two nozzles that allow you to maintain the temperature of the nozzle in such a way that it does not exceed the permissible one, which increases the service life of the latter [7].

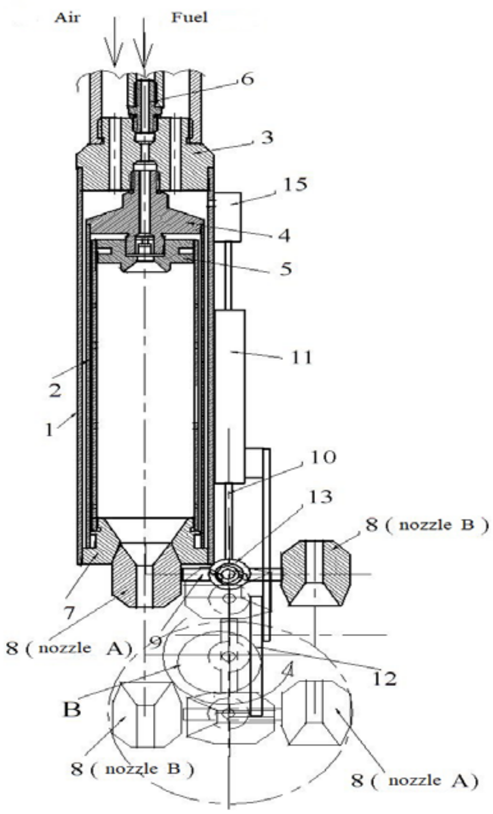

Figure 3-thermal cutter for stone cutting with two nozzles
1-thermocouple, 2-combustion chamber, 3-distribution head, 4-injector housing,
5-air drill, 6-fuel fitting, 7-nozzle housing, 8-replaceable nozzle,
9, 10, 11, 12, 13, 14 – mechanism for turning and switching nozzles

We have developed a vertical thermal cutting device design that can improve the cutting quality and performance of the stone cutting process by increasing the rigidity of the thermal cutting pipe at large cutting depths and reducing the weight load of the thermal cutting pipe to feed the roller [8-10].

The use of the presented device increases the rigidity of the thermal cutter pipe when performing the operation of cutting the stone array, especially in the downward length of the pipe. At the moment, the depth of the forward movement of the pipe is 6 M or more. The high rigidity of the pipe prevents the thermal cutter from making oscillatory movements under the influence of the gas flow, which makes it possible to create a uniform and uniform profile of stone cutting, which increases the quality of the stone array cutting process.

Also, the tension force of the cable reduces the effect of the weight force of the pipe and cutter on the feed rolls, which greatly reduces the slip of the pipe in the rollers when the pipe and cutter are raised up, especially when they are raised quickly.

The characteristics obtained are presented in Table 1.

Table 1-The main technical characteristics of the machine for cutting grooved fossils in an array of rocks with an electric drive

Name	Apparently
Cutting width not less than, mm	80
Cutting length not less than, mm	20000
Cutting depth not less than, mm	6000
Fuel type	diesel
Consumption not more, l/hour	50
Oxidizer	air
Thermocouple, length, mm	4000 - 7000
Weight not more, kg	25
Cutting speed on granite at least, mm/min	50

Conclusion. The experiments carried out found that the resulting gap is more than 7 centimeters wide, which is larger than the external dimensions of a standard thermorezac.

In this regard, a special device was developed for the machine, equipped with a powerful thermodynamic working body.

This device is designed to carry out grooved workings, ensuring uniform movement of the machine in horizontal and vertical directions.

This approach allows you to optimize the block stone mining process, improving the overall performance of the mining process, while ensuring more accurate and efficient formation of gaps in the rocks.

REFERENCES

1 Sinelnikov O. B. Extraction of natural facing stone – M.: Publishing House RASKHN, 2005. – 244 p.

2 Levkovsky G.L. and others A.S. USSR No. 1789687. The method of extraction of natural stone blocks. Publ. 23.01.1993, byul. No. 3.

3 Orlov A.M. Extraction and processing of natural stone – M.: Stroyizdat, 1977. – 349 p.

4 Povetkin V.V., Kerimzhanova M.F., Nurymov E.K., Bukaeva A.Z. Development of a prototype machine for slot workings in the extraction of granite blocks// Proceedings of the XXIII International scientific and technical conference "Mechanical engineering and technosphere of the XXI century". Donetsk: MSM, 2016. Vol. 2., pp.96-100.

5 Povetkin V.V., Askarov E.S., Povetkin A.V., Shukhanova Zh.K. Innovation patent of the Republic of Kazakhstan No. 29758. A thermal cutter for cutting stone with two nozzles. Publ. 04/15/2015, bul. No. 4.

6 Povetkin V.V., Askarov E.S., Povetkin A.V., Kerimzhanova M.F. Innovation patent of the Republic of Kazakhstan No. 30458. A device for vertical pipe feeding with a thermal cutter for cutting stone. Publ. 15.10.2015, byul. No. 10.

7 V.Povetkin, A.Bukayeva, A. Zhauyt, Ye.Nurymov, Ye. Askarov. Study of thermal stonecutting tools // Journal of Vibroengineering Procedia. – Latvia, 2016. - Vol. 8. - P. 22-27.

8 Povetkin V.V., Nurymov E.K., Bukaeva A.Z., Sermenov A.I. Improvement of the fire-blasting method of cutting rocks during the extraction of block stone from granites // Poisk Magazine, - Almaty, 2017. - №1(1). - Pp. 176-182.

9 V.Povetkin, A. Bukayeva, Y.Nurumov, A. Khandozhko. Theoretical basics of flame-jet rock destruction //Vestnik KazNRTU, Vol. 2(120), 2017. p. 109-115.

10 V.Povetkin, A.Khandozhko, A.Bukayeva, Ye.Nurymov Study of the application high velocity thermal spraying tools used in technological processes and production // News of the academy of sciences of the Republic of Kazakhstan. Series of geology and technical sciences. - Almaty, 2017. - №5. - P.190-201.

***Букаева А.З.*[1]*, Huy-Tuan Pham*[2]**

[1]Ш. Есенов атындағы Каспий технологиялар және инжиниринг университеті
Ақтау қ, Казахстан
[2]Хо Ши Мин технологиялық және білім беру университеті, Вьетнам

БЛОКТЫ ТАСТЫ КЕСУГЕ ЖӘНЕ ӨҢДЕУГЕ АРНАЛҒАН ТЕРМИЯЛЫҚ ҚҰРАЛДАРДЫ ТАЛДАУ

Аңдатпа. Мақала берік тау жыныстарынан, әсіресе граниттерден қапталған тасты өндіру процесін терең талдау болып табылады. Ол тек тау-кен технологиясын ғана емес, сонымен қатар блокты тасты өңдеу, тегістеу және алу процесінде тау жыныстарын тиімді жою үшін қолданылатын жаңа термиялық құралдардың дизайнын да қарастырады. Блокты тасты өңдеудің және өндірудің ұтымды әдістері және блокты тасты өңдеу және өндіру кезінде қатты тау жыныстарын бұзуға арналған жылу құралдарының дизайны сипатталған.

Мұндай құрылымдарды жасау үшін қолданылатын әдістер мен құралдар, сондай-ақ оларды өндірісте тиімді құралға айналдыратын жақсартылған энергия сипаттамалары егжей-тегжейлі қарастырылады. Бұл әдіс тау жыныстарындағы саңылаулардың дәлірек және тиімді қалыптасуын арттыру арқылы, тау-кен процесінің жалпы өнімділігін жақсартуға көмектеседі, сондықтан блокты тасты өндіру процесін көтеру мүмкіндіктерді береді. Бұл аспект, әсіресе, материалды өңдеудің жоғары өнімділігі мен дәлдігін қажет ететін беткі тасты өндіру саласында өте маңызды.

Сонымен қатар, мақалада ұсынылған талдау мен әзірлемелер тау жыныстарын өндіру және өңдеу процесінің тиімділігін едәуір арттыра алады, бұл саланың дамуына және өндірілетін өнімнің сапасын арттыруға ықпал етеді. Жұмыс органы, тас кесетін машинаның механикаландырылған агрегаты ретінде жоғары энергетикалық сипаттамалары бар жылу құралдарының жаңа конструкциялары дайындалып жасалды.

Кілт сөздер: тау жынысы, бензин-ауа термоқұралы, тас кескіш машина, отын компоненттері, өнімділік.

***Букаева А.З.*[1]*, Huy-Tuan Pham*[2]**

[1]Каспийский университет технологий и инжиниринга им. Ш.Есенова
г. Актау Казахстан
[2]Хо Ши Мин технологический и образовательный университет, Вьетнам

АНАЛИЗ ТЕРМИЧЕСКИХ ИНСТРУМЕНТОВ ДЛЯ РЕЗКИ И ОБРАБОТКИ БЛОЧНОГО КАМНЯ

Аннотация. Статья представляет собой углубленный анализ процесса производства облицовочного камня из прочных пород, особенно гранитов. Он рассматривает не только горнодобывающую технологию, но и разработку новых термических инструментов, используемых для эффективного удаления горных пород в процессе обработки, шлифования и извлечения блочного камня. Описаны рациональные методы обработки и добычи блочного камня и конструкция тепловых приборов для разрушения твердых пород при обработке и добыче блочного камня.

Подробно рассматриваются методы и инструменты, используемые для создания таких конструкций, а также улучшенные энергетические характеристики, которые делают их эффективным инструментом в производстве. Этот метод помогает улучшить общую производительность процесса добычи за счет увеличения более точного и эффективного образования щелей в горных породах и, следовательно, повышения производительности процесса добычи блочного камня. Этот аспект особенно важен в области производства поверхностного камня, который требует высокой производительности и точности обработки материала.

Кроме того, анализ и разработки, представленные в статье, могут существенно повысить эффективность процесса добычи и переработки горных пород, что будет способствовать развитию отрасли и повышению качества производимой продукции. В качестве рабочего органа, механизированного агрегата камнерезной машины разработаны и изготовлены новые конструкции термоинструментов с высокими энергетическими характеристиками.

Ключевые слова: горная порода, бензовоздушная термоинструмент, камнерезная машина, топливные компоненты, производительность.