

ANNOTATION

Dissertation work on the topic:
«**Development of machine parameters for mechanized cutting of slot workings when breaking block stone from strong rocks**» submitted for the degree of
Doctor of Philosophy (PhD) in the specialty
6D071200 - «Mechanical engineering»

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The relevance of research. Currently, there are a number of trends in the Republic of Kazakhstan requiring the development and modernization of industrial infrastructure. In the conditions of the transition period of Kazakhstan, from planned to a market economy, its mineral and raw materials get all-important value. In the conditions of fierce international competition, the President of the Republic of Kazakhstan Kassym-Jomart Tokayev set the task of diversification of the domestic economy.

Despite the fact that the reserves of granites in The Commonwealth countries are much higher than in foreign countries, their extraction and processing lags behind by 3-4 times compared to Italy, Belgium, the USA, and the UK.

Natural stone occupies a special place among the extensive nomenclature of building materials. Over the past 70 years, world production of natural stone has increased by almost 25 times, while over the past 20 years, the annual increase in the production and consumption of stone, on average, was 7.4%. According to forecast estimates for the coming decades, this growth will continue, and world stone mining will increase by more than 4 times. Granite is surprisingly durable, easy to process and, most importantly, incredibly beautiful, and has a huge variety of colors.

In the Kazakhstan market of a natural stone the stable tendency of growth in the consumption of this material is also traced. Since 1999, the consumption of natural stone in Kazakhstan increases on an average of 10...12 % per year. Taking into account the planned pace of the country's economic development, which implies a significant increase in GDP over 10 years, it can be expected that by 2025 the consumption of natural stone in Kazakhstan will increase by almost 2 times and amount to at least 2 million m³ per year.

However, because of a low technical level of the enterprises of the branch, caused by absence of effective means of extraction and processing of strong rocks, these natural resources are not used enough. The needs of the national economy of the Commonwealth countries in products made of natural stone are provided only by 10 ... 15 %, and needs in export requests - by 5...10 %. The development of stone processing industries is considered as one of the promising tasks, the solution of which is possible through the introduction of advanced technology and high-performance equipment.

The current GOST 23342-91 allows granite slabs to differ from each other in length by ± 2 mm, in thickness ± 3 mm. The requirements of European standards are

even tougher, the permissible deviation of only ± 2 mm. That is why Chinese granite, unlike domestic, is actively imported into the European market (especially into Germany), while the volume of supplies is growing annually by 5...7 %.

At the same time, such a rapid growth in demand for natural stone does not mean a similar pace of development of domestic stone mining and stone processing. To withstand the competition of imported manufacturers of stone products, it is necessary to introduce highly effective tools, machines and technological lines that are not inferior to their foreign counterparts into domestic industry.

The thermal tool for the processing of the rock has high resistance and reliability due to the lack of its contact with the destroyed surface, but when implementing the processing method in the form of manual thermal tools, the worker and the environment are exposed to powerful aerodynamic noise of the burner. Creation of thermal tools of increased power, while maintaining structural parameters, is an important design and technological task, and when equipping manipulating devices with these tools, it will allow you to fully mechanize manual labor, protect the worker and the environment from noise, increase productivity and work culture, and ensure work safety.

Consequently, it is necessary to create the mechanized installation for the extraction of a block stone equipped by powerful working bodies - thermal tools. To create them, it is necessary to solve a number of **problems** in the theory of destruction and in the practice of constructing mechanized thermal units, namely:

- clarifying the mechanism of destruction of rocks with various methods of orientation of gas streams and physical and mechanical properties of destroyed rocks;
- determination of rational technological parameters of processing and structural parameters of thermal tools;
- development of effective, powerful working bodies - thermal tools that implement new methods of combustion of fuel components;
- ensuring normal sanitary and hygienic working conditions for workers.

Research of parameters of process of destruction of strong rocks and development on their basis of an engineering method for calculating the parameters of thermal tools, the improvement of the technology of mechanized production and processing of block stone, as well as the development of a highly productive machine equipped with a powerful thermal instrument, are relevant problems, the solution of which will increase the efficiency of the thermal method of destruction and, as a result, improve the process of extraction of a block stone.

The work was carried out at the Kazakh National Research Technical University named after K.I. Satbayev, at the stone processing enterprise for stone processing «Crystal» JSC and «Titushin» IE (Almaty).

The goal of the work is to develop the parameters of the machine for mechanized cutting slotted workings when block stone blasting from strong rocks.

The idea of the work is to choose and substantiate the parameters of a machine for cutting slotted workings, which can increase the productivity of stone production and mechanize the process.

In connection with this goal, the following **research objectives** were

formulated:

- the analysis of modern achievements in the field of construction of machines for slotted workings in the extraction of block stone from strong rocks;
- analysis of the mechanism of destruction of rocks by fire-jet thermal instruments;
- development of kinematic and structural parameters of the manipulation device for cutting slotted workings;
- selection and justification of a fire-jet working body for cutting slotted workings;
- experimental development of the kinematic and structural parameters of the machine (manipulation device) for slotted workings;
- development of regime parameters for slotted workings by a gasoline-air fire-jet working body.

The object of the research is conducting slotted workings when chopping granite blocks.

The subject of the research is the technology for cutting slotted workings on mechanized installations.

Research methods. The results of the study are obtained on the basis of theoretical and practical provisions of the theory of wear; theories of elasticity and plasticity; theory of experimental planning and statistical data processing. The work used theoretical and experimental methods of technological support for the conduct of slotted workings with gasoline-air thermal tools using standard techniques. Experimental studies were carried out in bench conditions on operating equipment using original techniques and modern measuring equipment.

The scientific novelty of the work lies in the following:

- the condition for the destruction of the heated layer $0,063 \frac{E\alpha T_s}{1-\mu} \geq \sigma^P$ of the breed that allows to determine the linear $v_{linear}=cq_{max.total}$ and longitudinal $v_{lon}=q_{max} \frac{\sqrt{\pi}}{\sqrt{k}} c z^{-1}$ speed of destruction was found, and the volumetric productivity of destruction $W = cq_{max.total} L \frac{\sqrt{\pi}}{\sqrt{k}}$ depends on the product of three quantities: c , q_{max} , $\frac{\sqrt{\pi}}{\sqrt{k}}$ and L ;

- the theoretical substantiation of the kinematic and design parameters of an industrial sample of a machine for cutting slotted workings was performed, as a result, the vectors of angles and movements in the joints are established, equations of motion of the manipulator in matrix form are compiled, allowing to solve the problem of determining the generalized coordinates of the manipulator mechanism at a given position of the output link, and the problem of programming this manipulator in positional control;

- the creation of a machine for cutting slotted workings with a powerful thermodynamic working body, allows to increase the destructive ability of the thermal tool due to the mechanized uniform supply of the gas stream of the burner to the destruction zone, and the remote control of the working process of slotting workings will increase performance, protect the worker and the environment from

the harmful effects of burner noise;

- it has been experimentally established that the volumetric capacity of fire-jet destruction w depends on the cutting distance of the burner to the heating spot L and reaches its maximum value in the torch section where the heat flux is maximum. With an increase in the consumption of fuel components, the distance increases, and the dependence of the depth of failure h on the longitudinal velocity v_{lon} of the movement is monotonous decreasing, i.e. with an increase in the speed of movement, the depth of failure decreases.

The following main scientific provisions are made to defense:

- the theoretical model of the destruction process, that allows to find the parameters of the stress-strain state and to obtain a criterion for the destruction of the heated layer, according to which the technological parameters of the movement of the working body of the machine (burner) along the slot workings are determined;

- the theoretical substantiation of kinematic and design parameters of an industrial sample of a machine for cutting slotted workings, that allows to set the vectors of angles and movements in the joints, to compose the equations of the movement of the manipulator in the matrix form, determining the generalized coordinates of the manipulator mechanism according to the given output position, and to perform the programming of the manipulator during positional management;

- the creation of a machine for cutting slotted workings with a powerful thermodynamic working body, allows to increase the destructive ability of the thermal tool due to the mechanized uniform supply of the gas stream of the burner to the destruction zone, and the remote control of the working process of cutting slotted workings will increase productivity, protect the worker and the environment from the harmful effects of burner noise;

- volumetric productivity of the fire-jet destruction w depends on the distance of the cutter of the burner L to the heating spot and reaches its maximum value in the cross section of the torch, where the heat flux is maximum, and with an increase in the consumption of fuel components, the distance increases, and the dependence of the depth of failure h on the longitudinal velocity v_{lon} of the movement is monotonous decreasing.

The theoretical significance of the work lies in the scientific substantiation of the main parameters of the process of fire-jet destruction of rocks during the cutting slotted workings; in the development of a new design of a thermal tool that implements a new type of combustion of the fuel mixture in shock waves in the supersonic jet of the burner expiring from the Laval nozzle into the cylindrical cavity of the ejection nozzle; in the development of the parameters of a new design of a machine (manipulator) equipped with a powerful working body made in the form of a thermal tool.

The practical significance of the work lies in the following:

- according to the results of the analysis of structural and regime parameters of the burners, prototypes of thermal tools FATT (fuel-air thermal tools)-60, FATT-80A, which have passed production tests and recommended as a working body for mechanized cutting of block stone during slotting workings were developed and manufactured;

- experimental development of the design and operating modes of thermal tools for cutting slotted workings, which allows to establish rational parameters of the design of thermal tools and their regime operation parameters, was carried out;
- economical consumption of fuel components, ensuring their completeness of combustion;
- ensuring the maximum failure of the destroyed breed;
- providing the necessary width of the slotted to be cut for the free passage of the thermal tool without jamming;
- a machine for cutting slotted workings, equipped with a powerful thermodynamic working body, was tested; the horizontal drive of the machine provides a change in the speeds of movement of the fire-jet burner in the range from 0.003...0.015 m/s, while the obtained parameters of slot production varied from 0.07...0.09 m in width of the slotted and 0.07...0.09 m in depth of slot workings;
- thermal tool FATT-80A with a nozzle of 22/24 mm, which showed high reliability and easy launching in work as a result of tests, has a failure rate exceeding the existing designs of thermal cutters by 2.5-3 times, the volumetric capacity in the failure amounted to 2500 cm³/min up to 10,000 cm³/min;
- based on the results of the work, innovative patents № 29758 «Thermal cutter for cutting stone with two nozzles» dated 15.04.2015 and № 30458 «The device for a vertical supply of a pipe with a thermal cutter for cutting stone» dated 15.10.2015 were obtained.

The validity and reliability of scientific provisions, conclusions and recommendations are confirmed by:

- the analysis of a large volume of production data and empirical materials at the mining enterprises of Kazakhstan and the CIS countries on slotting workings in the extraction of granite blocks from strong rocks;
- the use of the main provisions and methods of mechanical engineering technology, theoretical mechanics, the theory of elasticity and plasticity and the theory of gas dynamics and thermoelasticity, solving problems on a computer;
- the conducting mathematical modeling and experimental laboratory studies of the technological parameters of the machine for cutting slotted workings;
- establishing the convergence of the results of theoretical and experimental studies.

Implementation of the results of the work. The results of the study were transferred for introduction into the production of stone mining and stone processing quarries and stone processing plants of «Crystal» JSC and «Titushin» IE (Kazakhstan) and used in the educational process in the training of bachelors in the specialty 5B071200 - «Mechanical Engineering» at Kazakh National Research Technical University named after K.I.Satbayev.

Approbation of the work. The main provisions of the dissertation and the results of the study were reported and discussed at the International Scientific and Practical Conference «Modern Material Science Experience, Problems and Development Prospects» (Almaty, 2015); at the XII International Correspondence Scientific and Practical Conference «Development of Science in the XXI Century» (Kharkov, 2016), at the XXIII International Scientific and Technical Conference

«Mechanical Engineering and Technosphere of the XXI Century» (Donetsk, 2016).

Publications. The main results of the dissertation work were published in 14 printed works, including 4 articles in journals recommended by the CCSON of the Ministry of Education and Science of the Republic of Kazakhstan; 1 publication in International Conferences, 7 of them - foreign; 2 articles in the Scopus database.

Structure and volume of work. The dissertation consists of the introduction, four sections and the conclusion, stated on 130 pages, contains 39 pictures, 8 tables, 115 lists of the used sources and appendices.