

EXPERIENCE OF DIMENSION STONE EXTRACTION BY QUARRY CUTTING MACHINE IN POKOSTOVSKY DEPOSIT, UKRAINE

Vasyl Mamray, Valentyn Korobiichuk, Volodymyr Shlapak

Zhytomyr State Technological University, 10005 Zhytomyr; mamrayv@ukr.net

ABSTRACT. Modern technology for the extraction of dimension stone in Ukraine involves mining operations with high bench up to 6 m. The separation of a monolith from the massif is carried out mainly by diamond-wire cutting. This technology involves the throwing of the monolith onto a pillow of crushed stone, which causes additional losses and use of special equipment for the dumping of monoliths. Today, diamond-wire cutting machines are replaced by disk saw cutting machines. That is why in this paper the working parameters and technological methods of disk saw cutting machines operations are considered. The analysis of dimension stone extraction technologies has been made showing that the disk saw extraction technology of hard natural stone makes it possible to reduce natural stone waste by 30–40 %. This technology increases the productivity of natural stone blocks extraction up to 1.12 times due to the increased productivity of cutting planes; reduces the cost of blocks extraction by using cheaper diamond disk saws in comparison with diamond wire; improves productivity by reducing time for natural stone blocks sorting and shaping.

Keywords: extraction, dimension stone, technological methods

ОПИТЪТ ПРИ ДОБИВ НА ОБЛИЦОВЪЧНИ КАМЪНИ ЧРЕЗ КАМЕНОРЕЗНИ МАШИНИ В НАХОДИЩЕ "ПОКОСТОВСКИ", УКРАЙНА

Васил Мамрей, Валентин Коробийчук, Володимир Шлапак

Житомирски държавен технологичен университет, 10005 Житомир

РЕЗЮМЕ. Съвременната технология за добиване на облицовъчен камък в Украйна включва добивни работи със стъпала до 6 m. Разделянето на монолитни блокове от масива се извършва главно чрез рязане с диамантено въже. Тази технология включва хвърляне на монолитния блок върху възглавница от натрошен камък, което води до допълнителни загуби и използване на специално оборудване за хвърляне на монолитните блокове. Днес, режещите машини с диамантени въжета са заменени от дисково фрезни каменорезни машини. Ето защо в тази статия са разгледани работните параметри и технологичните методи за работа на циркулярни каменорезни машини. Направен е анализ на технологиите за добив на облицовъчни камъни, който показва, че технологията за добив на твърд естествен камък с циркуляр позволява намаляване на загубите на естествен камък с 30-40%. Тази технология увеличава производителността при добив на блокове от естествен камък до 1,12 пъти поради повишената производителност на режещите повърхнини; намаляване на разходите за добив на блокове чрез използване на по-евтини диамантени циркуляри в сравнение с диамантеното въже; подобряване на производителността чрез намаляване на времето за сортиране и оформяне на блоковете от естествен камък.

Ключови думи: добив, облицовъчен камък, технологични методи

Introduction

The stone industry around the world records significant volumes of stone production (about 35 million tons per year). China is currently occupying the leading position, followed by Italy, Turkey, India, Brazil, Spain and Greece. Ukraine holds the seventh place in the world by the number of granite quarries. Together with other building materials, the extraction of natural stone has a significant impact on the environment. The extraction of raw materials from the earth's surface leads to a change in the landscape, vegetation and fauna, and the relief of the territory. For these reasons, quantitative assessment and management of the relevant environmental impacts is becoming more and more important. Thus, the European Commission, with the support of experts from both academia and industry, is currently implementing a revision of the EU criteria for the environmental label of hard coverings (which include building materials from cement, concrete,

ceramic and clay materials, and also natural and engineering stones), (EU-European Commission, 2010).

The output of blocks after the extraction of natural stone is 25-40% of the rock mass. The main factor that influences the output of natural stone blocks (Sobolevskiy et al., 2016) is natural and man-made fracturing. The second factor is the direction of extraction in relation to the direction of cracks. Quantitative operational losses in the extraction of decorative stone blocks are insignificant, usually up to 10%, and qualitative losses (colour change, development of microcracks) of stone reach considerable volumes. At the beginning of the last century, the extraction of natural stone used a blasting method, which led to significant losses of raw materials, both qualitative and quantitative. In some dimension stone deposits the explosive mining technology reduced the output of blocks to 50%. In recent years, the diamond wire cutting technology has become widespread in granite quarries (Levytskyi, Sobolevskiy, Korobiichuk, 2018; Korobiichuk et al., 2016; Ozcelik, Yilmazkaya, 2011; Yurdakul, Hürriyet, 2012; Ersoy, Atıcı, 2004; Yurdakul, 2015).

The use of mechanical cutting methods has led to reduction of technological losses of natural stone. That is why, the improvement of the mechanical technology of extraction is a substantial scientific and applied problem. Until now, disk saws were used for the extraction of soft rocks - tuffs, limestone and so on. In China, disk machines for the extraction of hard and medium-hard rocks have been developed and manufactured. The technology of natural stone extraction by using disk machines has become widespread in Chinese granite deposits. It should be noted that most of the Chinese granite deposits have rocks with higher porosity and less compressive strength than Ukrainian ones. Due to the difference in physical and mechanical properties of the rocks, it is necessary to adapt this technology to Ukrainian deposits.

The main exposition

The main technology for natural stone extraction for Ukrainian granite deposits involves the use of diamond wire cutting machines and drilling rigs. Extraction is carried out according to a two-stage separation system of natural stone blocks (Fig. 1).

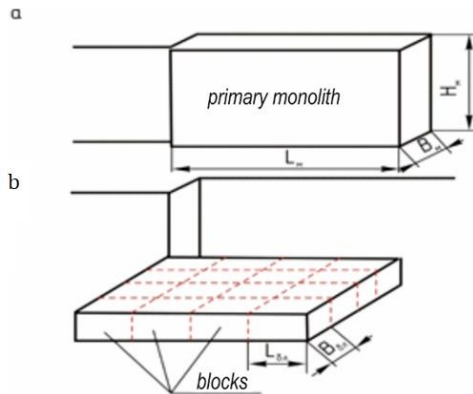


Fig. 1. Two-stage system of separation with fallen down of the primary monolith: a – separation of the primary monolith; b – separation of fallen down primary monolith into blocks

To join together the ends of the diamond wire, two opposite holes are drilled so that they converge at one point (Fig. 2). In this case, drilling can occur in a horizontal and a vertical plane when cutting in a vertical plane or two wells in a horizontal plane when cutting in a horizontal plane.

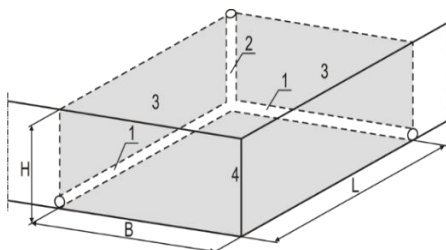


Fig. 2. Scheme of drilling converged holes: L – length of the monolith; B – width of monolith; H – monolith height; 1 – horizontal hole; 2 – vertical hole; 3 – vertical cutting plane; 4 – horizontal cutting plane

In the primary monolith, firstly the horizontal plane is cut and then the vertical one (Fig. 3, a). Secondly, the vertical side of the monolith with the largest area is cut, and in the last

turn the vertical side with the smallest area. After that, the monolith is thrown onto a pillow of crushed stone. At a height of a monolith from 5 to 6 m, there are losses of natural stone during falling of the monolith due to the decomposition of the monolith into smaller pieces.

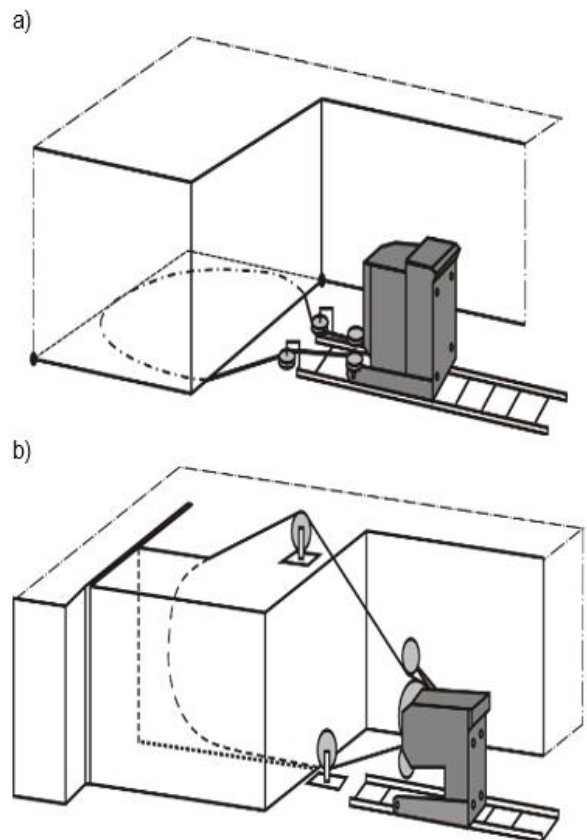


Fig. 3. Scheme of cutting by diamond wire machine: a – horizontal cutting, b – vertical cutting

The use of disk saws involves mining operations with height of the bench of about 1.2 m. The most optimal (minimum) parameters of the monolith for the estimation of technology is a monolith with a length of 10 - 16.0 m and a width of 3 m at its height of 1.2 m. The volume of such a monolith is 36-57.6 m³.

The technology for separating monoliths includes the following operations:

- 1) formation of two vertical separating planes (droplet knife) 1.2 m deep along the front of the work - 15.0 m at a distance of 3 m apart with using a saw cutting machine with a disk Ø 2.6 m, followed by cutting with a saw with a diameter of 3.5 m;
- 2) drilling of vertical holes Ø 32.0-50.0 mm along the edge points (corner) of the monolith by a perforator for cutting sharp corners;
- 3) insertion of a diamond wire into a slit along the perimeter of the base of the monolith for cutting the sole;
- 4) wedges hammering in the formed plane, so that the monolith does not catch the diamond wire;
- 5) formation of a horizontal plane in the base of the monolith using the diamond wire cutting machine (cutting the base);
- 5) formation of vertical holes Ø 32.0 mm with a distance between the centres of holes 15.0-20.0 cm to the width of the monolith along the line of planned cutting by a drilling machine.

6) direct separation of the monolith to blocks by means of metal wedges or a hydromachine.



Fig. 4. Implementation of the technology of cutting by disk saw machine at Pokostovsky granite deposit (Ukraine)

The technology of extraction of natural stone blocks by using the disk saw machine in China involves the drilling of horizontal holes for separating the blocks. The application of the bore-wedges technology to create a horizontal plane at Pokostovsky deposit has caused significant loss of natural stone and has complicated the technology for separating the monolith from the massif. Therefore, for the formation of a horizontal plane, a diamond wire has been used (Fig. 5).

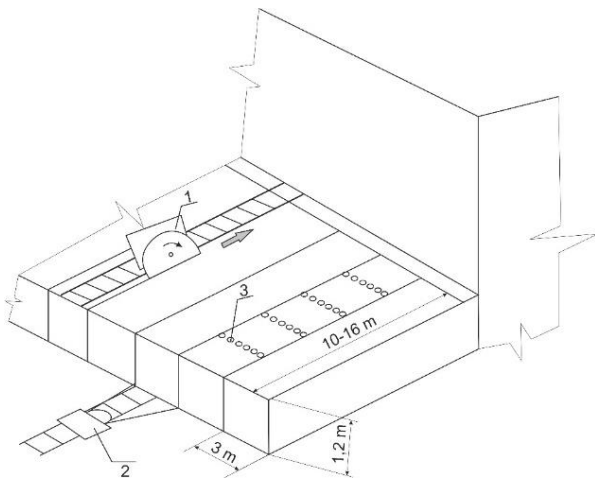


Fig. 5. Scheme of the natural stone block extraction using a disk saw machine: 1 – disk saw machine; 2 – diamond wire machine; 3 – holes

By using a disk saw machine in cracked massif the bottom plane of the monolith is separated by a bore-wedge method. The disk saw machines require a liquid for cooling the diamond saw in a quantity of 140 l/min. It complicates the work of the disk machine when opening a quarry. During this period, there is no debit of natural water in the quarry.

For a disk saw machine, an important factor is the length of the front of the work. The longer the cutting length of the disk saw, the higher the performance of the disk saw machine is. When the front of the work increases from 5 to 60 m, the productivity increases up to 2.8 times (Fig. 6).

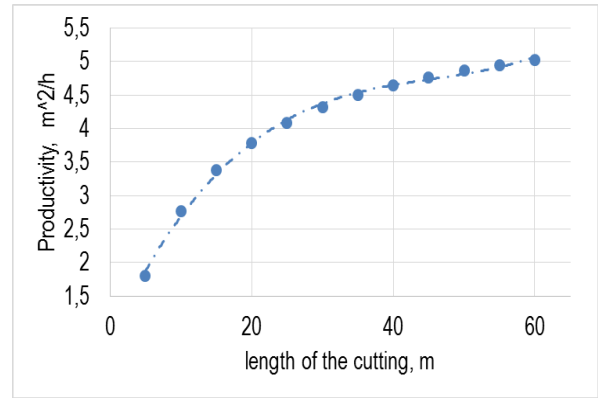


Fig. 6. Dependence of the productivity of the disk saw machine at Pokostovsky deposit on the length of the cutting

Under this technology, the loss of natural stone when cutting the base of monolith with a diamond wire technology is less than 10 times due to the absence of drilling operations (boreholes for wire laying). The absence of drilling works increases the productivity of the diamond wire by 27% compared to the existing technology (Fig. 7).

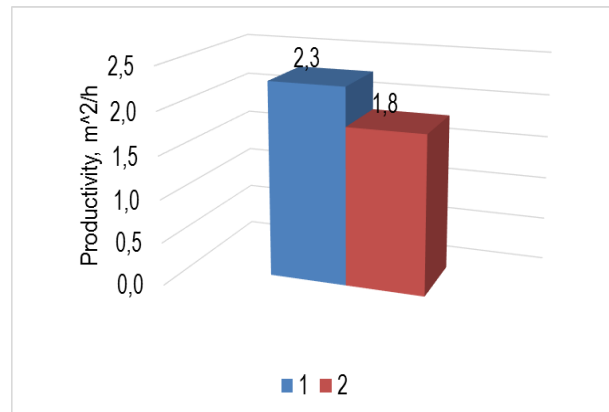


Fig. 7. Productivity of a diamond wire machine at Pokostovsky deposit 1 – technology of natural stone extraction by disk saw machine; 2 – technology of natural stone extraction by diamond wire machine

In general, the disk saw extraction technology (when working on one disk machine) has a higher productivity 12% compared to the existing technology (Fig. 8).

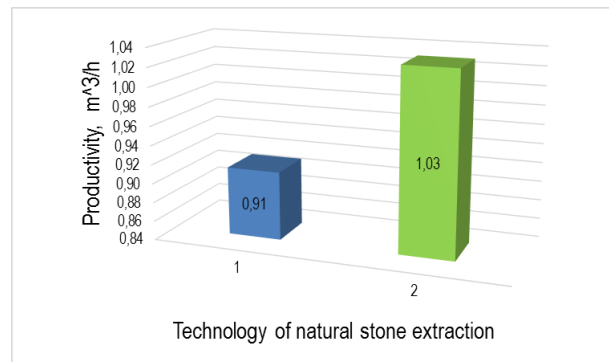


Fig. 8. Productivity of blocks extraction at Pokostovsky deposit 1 – technology of natural stone extraction by diamond wire machine; 2 – technology of natural stone extraction by disk saw machine.

The disk saw technology has quantitative losses of granite of 35% less than with existing technology. This is due to the lack of drilling operations for the diamond wire laying (Fig. 9).

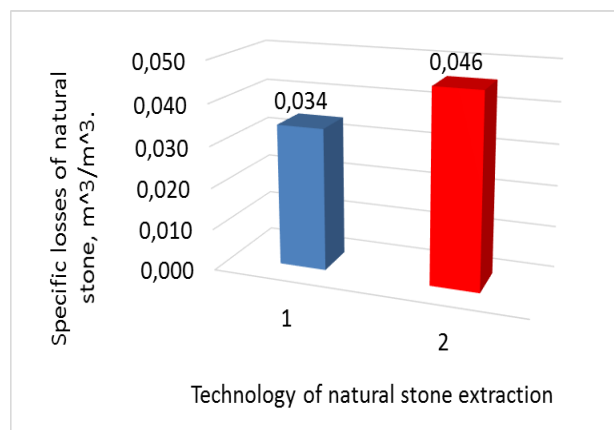


Fig. 9. Specific losses of natural stone at Pokostovsky deposit: 1 – technology of natural stone extraction by diamond wire machine; 2 – technology of natural stone extraction by disk saw machine

However, for the effective extraction by disk saw machine, a large area of extraction is required. This extraction technology limits the height of the blocks to 1.2 m. Also, when using disc saw machines it is difficult to take into account the fracture of the massif and inclusions of natural defects. Cracks can reduce the output of blocks from the massif.

Conclusion

The natural stone extraction technology by using disk saw machines requires a large area of the bench surface. Therefore, the application of this technology in small quarries with height of the bench of 6 m is complicated. This technology limits the height of blocks of natural stone to 1.2 m. However, this technology of extraction has a high productivity and allows the production of blocks with flat surfaces. The natural stone extraction technology with disk saw machines

has higher productivity and lower specific losses of natural stone than the diamond wire technology.

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