COMPUTER AUTOMATION OF THREE DIMENSIONAL ART ENGRAVING ON SOLID MATERIALS

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ABSTRACT. The article presents a technology for automated production of mosaic mural, incorporating flat and three-dimensional fragments of decorative rock materials, with engraved inscriptions and images on the flat fragments.

КОМПЮТЪРНА АВТОМАТИЗАЦИЯ НА ХУДОЖЕСТВЕНОТО ОБЕМНО ГРАВИРАНЕ НА ТВЪРДИ МАТЕРИАЛИ

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РЕЗЮМЕ. В статията е предложена технология за автоматизирана изработка на мозаечно пано, съставено от плоски и обемни фрагменти от декоративни скални материали, в гравирани надписи и изображения върху плоските фрагменти.

Mosaics are wide used as decoration in modern interior for decoration of floors and curbs or as murals and pictures. The popular Florentine mosaic consists of flat fragments made from colored decorative rock materials. The process of it production is automated by the use of CNC water jets and milling machines.

The constant growth in the demand of exclusive articles needs new artistic decisions and incessant complication of the mosaic elements. The engraving of flat and 3D fragments on their surfaces broadens the opportunities of the artist-designer not only by combination of flat and volumetric elements but also by representation of images or inscriptions on them.

In order such an article to be produced is necessary the task about the creation of a new technology, which combines the two methods for the material processing to be solved:

- Engraving by milling – for obtaining the contour fragments of the mural and ornaments with different depth of the material extraction as well as for production of 3D fragments (bas-reliefs);

- Engraving by chiseling out or scraping – for representation of flat images and inscriptions.

Besides, engraving is a machine representation of an image on a hard surface by mechanical extraction of part of the material.

Generally, 5 co-ordinate machines are used for production of details with complex artistic shapes (sculptures). In this instance, the task could be solved by a 3 co-ordinate machine. The main part of the milling equipment, which is used in the decorative rock materials processing is Italian (HELIOS, INTERMAC, BRETON, BAVELLONI, CIELLE). The paper treats the production of an article consisting of contour and bas-relief fragments, flat inscriptions and images by the Russian machine GRAFIK – 3KM (NPF SAUNO). It is equipped with two changeable heads – a chiseling out and a milling, which allows operation by raster chiseling out and by the 3D milling methods. The machine general view and engineering characteristics are presented in fig. 1 and table 1.

Before the creation of the executive program by ArtCam Pro it is necessary a model of the article, which is based on the solution of a series of artistic and technological tasks, to be developed. ArtCam Pro (Delcam plc, Great Britain) is a design and technological package, allowing complex solution of tasks connected with the technological design and production preparation of the articles. It contains tools for creation and editing not only raster but vectorial graphics as well. In spite of that, in many cases it is more appropriate the images

preparation to be done in other graphical editors and then to be imported in ArtCam Pro, which could be done by the following stages:

Fig. 1

1. Image digitization – input of the image in the computer memory by scanner or digital camera with the purpose of further transformation or using as a base for new image creation. At that a raster image, which could be processed by all the programs for raster graphic (Adobe Photoshop, Corel Photo Paint) is obtained (Fig. 2). Photoshop is used further in the example as the most universal and wide spread.

Table 1

ENGINEERING CHARACTERISTICS OF THE AUTOMATED MACHINE GRAFIK – 3KM	
Overall dimensions	1860 x 1050 x 760 mm
Mass	Up to 120 kg (including the control block)
Field of operation	600 x 1200 mm
Supply voltage	~220 V/50 Hz, ~ 127 V/60 Hz
Power of the milling head	1,05 kW
Spindle rotation frequency	From 11000 to 25000 min^{-1} (the adjustment is by stages)
Positioning accuracy	0,025 mm (milling head), 0,050mm (percussive head)
Demands to the computer configuration (as a minimum)	Intel Pentium 100 MHz, 16 MB RAM, HDD 800 MB, Windows 95/98/Me/NT/2000/XP

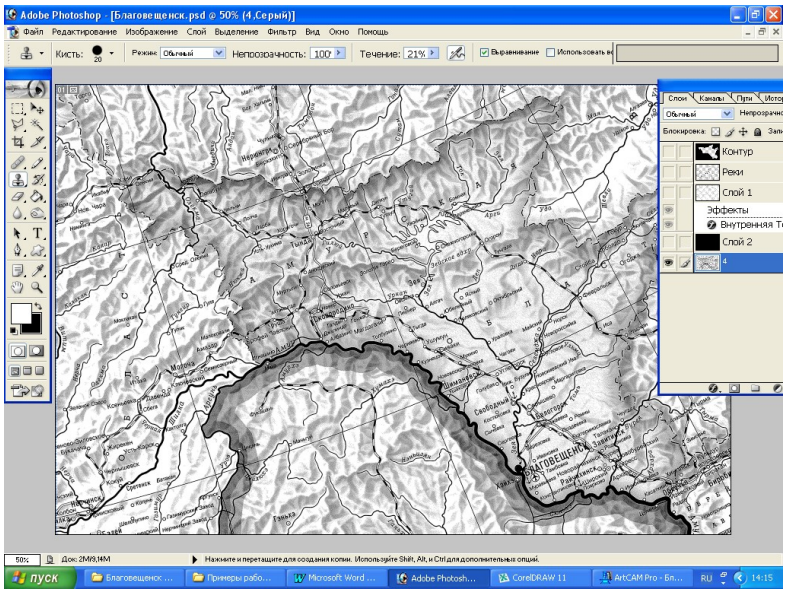
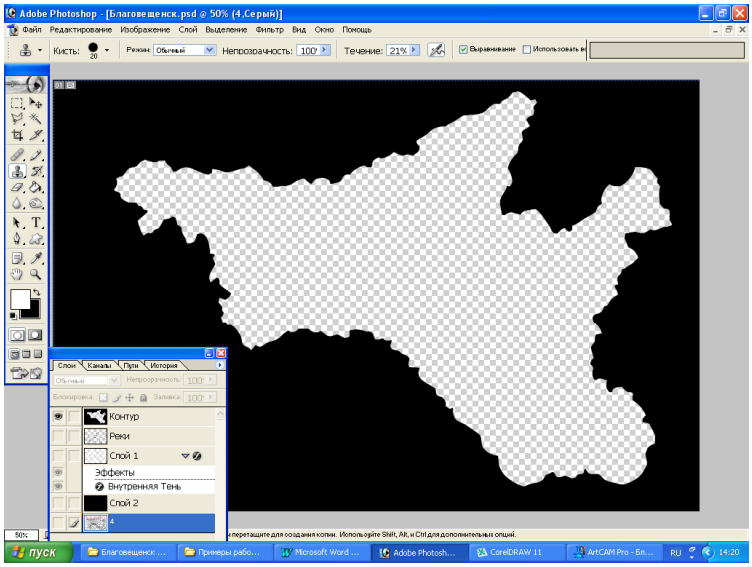


Fig.2

2. The image is broken up to fragments, which are going to be processed separately (Fig. 3). The configuration of the contour of such a fragment depends on the minimum possible diameter of the tool used. In case of necessity the contour could be corrected subsequently.



At this stage it is needed the outer appearance of the future article to be estimated and a material suitable for the production of each fragment to be chosen according with the physical and mechanical properties, aesthetic qualities and approachability.

Use of a previously prepared library of textures of decorative rock materials is recommended.

3. Inscriptions and different images, which have to be represented on the material flat surface could be created in the form of a raster (Adobe Photoshop) and further vectoring in ArtCam Pro or directly in a vectorial form (Corel Draw, ArtCam Pro). Both the variants are used in the example (Fig. 4).

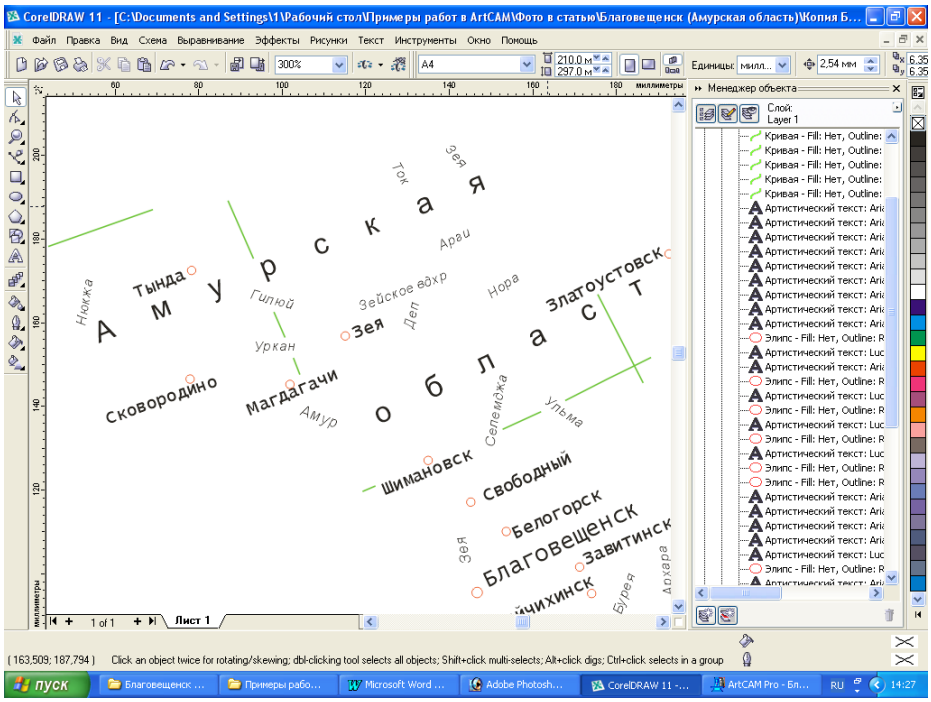


Fig. 4

4. The following methods are possible at the creation of 3D fragments: 1) modeling of the relief by the means of 3D graphics (3D Studio Max, Maya, ArtCam Pro); 2) retouching of the monochromatic undertone image (Adobe Photoshop). After that, in dependence of the undertone gradation degree the program ArtCam Pro automatically creates a relief (Fig. 5). The last method is used in the present example.

5. Import of the obtained fragments images in ArtCam Pro and design completion independence of their technological peculiarities (Fig. 6).

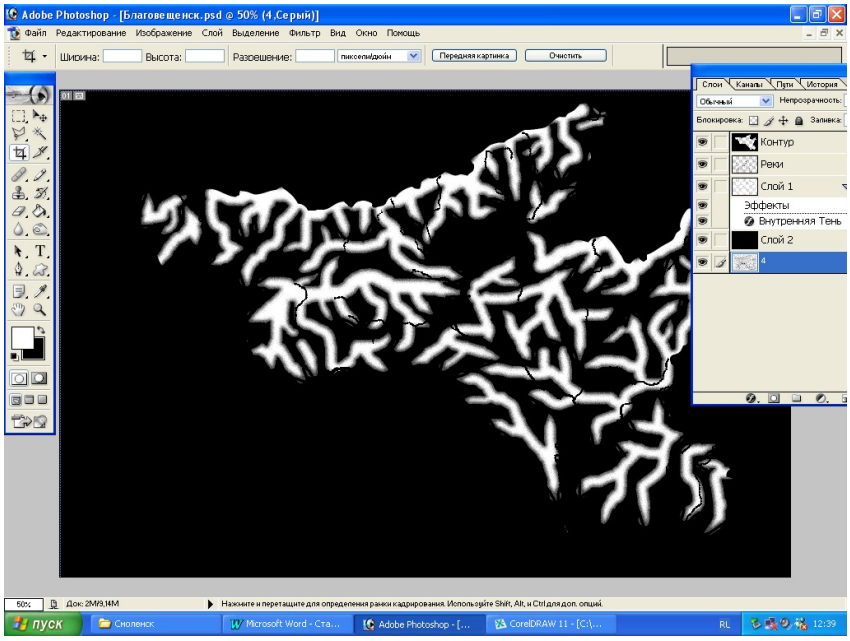


Fig. 5 - a

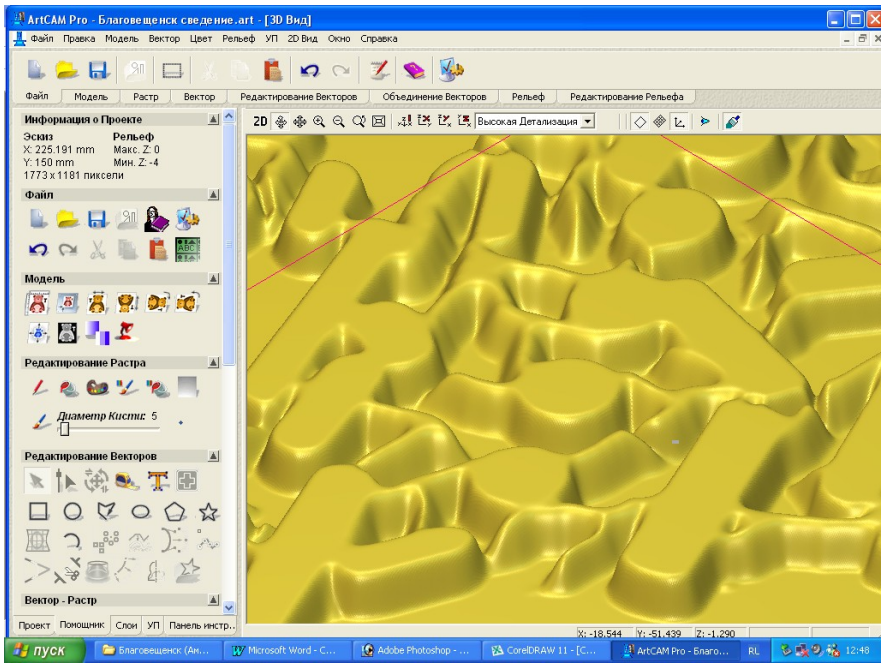


Fig. 5 - b

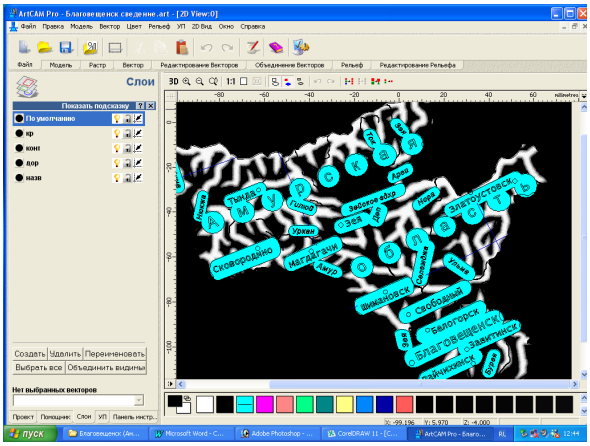


Fig. 6

ArtCam Pro is a program package for 3D modeling and mechanical processing, which automatically generates 3D models in the standard formats of graphical packages (raster - BMP, TIF, PCX, GIF, JPEG and vectorial - EPS, AI, DXF, DWG, WMF) out of flat images and realization of the by CNC machines. ArtCam Pro contains tools for complex shapes modeling and editing of saved relief. It affords an opportunity for import of previously prepared models in formats 3DS, STL, DXF, operation with layers, representation of a volumetric texture on details and use of a library with 3D elements. ArtCam Pro also contains a set of type postprocessors and a configurable postprocessor, which presents an opening for creation of executive programs for all CNC machines.

Generally, the mosaic fragment development can be realized by three stages with consecutive tool change. An executive program has to be developed for each type of processing. For that purpose the input of the following parameters is necessary:

1. Type of processing.

- Processing along the vectors – for representation of thin lines. The trajectory of the tool center passes along the lines-vectors of the picture;
- Engraving – for material extraction to a constant depth in closed contours of the picture;
- Engraving according to the middle line – usually is used for extraction of the material from a changeable depth by one tool passing;
- Processing of the relief;
- Processing the profile outside.

2. Depth of processing;
3. Shape and dimensions of the tool.
4. Operating duty.

At the rock materials processing the choice of the tools and operating duties has to be experimentally determined. In order the efficiency at the program use to be increased it is necessary the optimal parameters to be saved in a library (Fig. 7).

After that, the program generates the tool trajectory. The visualization of the processing process affords an opportunity a result, which to the highest degree approximates the one obtained on the material, to be observed on the monitor. In this way, the necessity of corrections could be fast assessed and the result could be demonstrated to the customer (Fig.8).

The choice of a postprocessor is followed by the creation of a file with an executive program for the concrete machine (Fig. 9).

The correspondence of the tool properties to those determined in the program as well as the error at the positioning of the half-finished material exerts a considerable influence on the processing accuracy. In comparison with the tools made from rapid steel and those with hard alloys the diamond tools provide higher quality of the processed surface, decrease the risk of material staining, and reduction of the noise level. It is recommended the cooling water to be delivered under pressure directly in the cutting zone (Fig. 10).

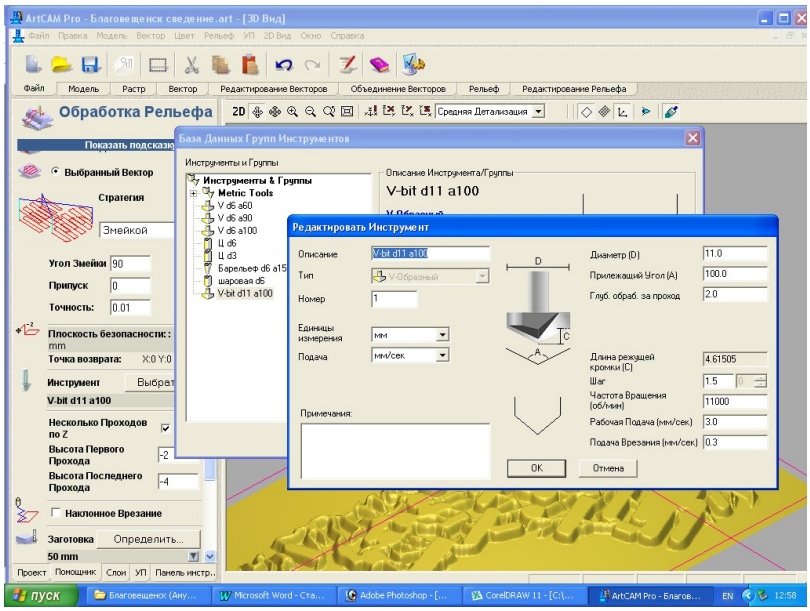
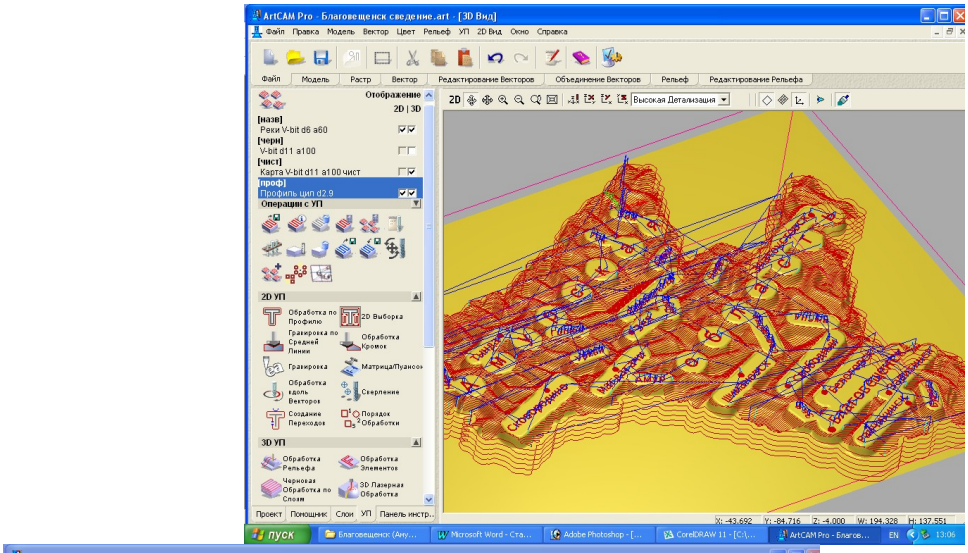


Fig. 7



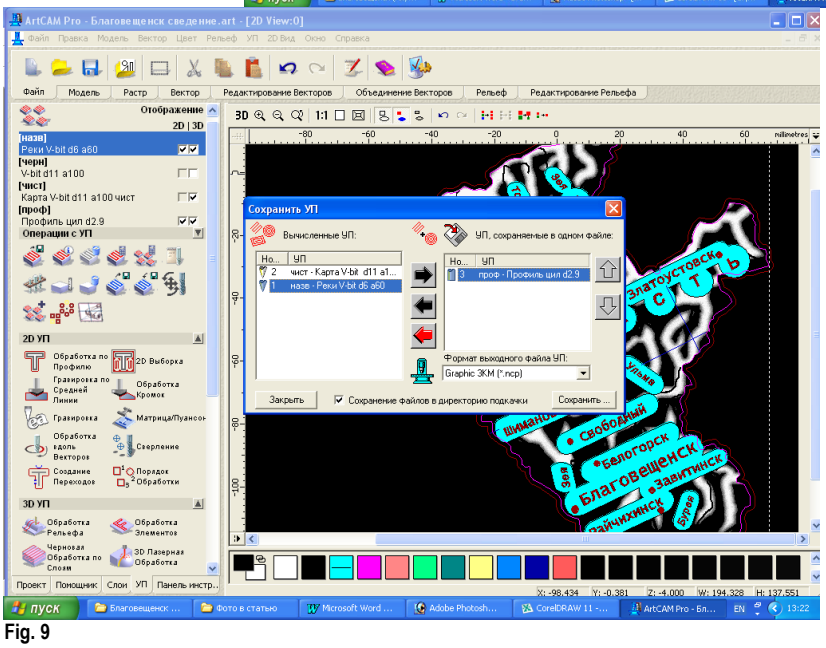


Fig. 9

Fig.10

A part of an executive program for milling of a bas-relief element by the described method and the decoded commands are presented in Table 2.

Table 2

IMF_PBL V1.0 - ARTCAM v5.5	MOVEABS Z-2000	MOVEABS X-126432 Y-14270 Z-3956
;Material:	VEL 3000	MOVEABS X-126413 Y-14448 Z-3901
; X Min:-148.730 Y Min:-129.170 Z Min:-4.000	MOVEABS Y-25654 Z-1674	MOVEABS X-126097 Y-13177 Z-4000
; X Max:76.461 Y Max:20.830 Z Max:0.000	MOVEABS Y-25279 Z-1721	MOVEABS X-126444 Y-13436
; X Size:225.191 Y Size:150.000 Z Size:4.000	MOVEABS X66995 Y-29485 Z-2000	MOVEABS X-126672 Y-13671
; Thickness:10.000	MOVEABS X66988 Y-29633	MOVEABS X-126544 Y-13867
;	MOVEABS X66458 Y-29819	MOVEABS X-126461 Y-14098
;Home Position: X 0 Y 0 Z2000	MOVEABS X65786 Y-29976	MOVEABS X-126413 Y-14818 Z-3822
;Safe Z: 2.000	MOVEABS X65500 Y-30028	MOVEABS X-126463 Y-15290 Z-3789
;	MOVEABS Y-27153	MOVEABS X-126551 Y-15784 Z-3799
SPINDLE CW RPM11000	MOVEABS Y-26528 Z-1780	MOVEABS X-126671 Y-16154 Z-3876
COOLANT ON	MOVEABS Y-26028 Z-1697	MOVEABS X-126858 Y-16518 Z-3980
PLANE XY	MOVEABS Y-24904 Z-1831	MOVEABS X-126913 Y-16607 Z-4000
FASTVEL 8000	MOVEABS Y-24404 Z-1994	MOVEABS X-127178 Y-16934
FASTABS Z2000	MOVEABS Y-24154 Z-2000	MOVEABS X-127333 Y-17078 Z-4000
FASTABS X 0 Y 0	MOVEABS X65414 Y-24145	MOVEABS Z2000 ; Retract
FASTABS X66995 Y-29486 Z2000	MOVEABS X65328 Y-24137 Z-1966	FASTABS X 0 Y 0
VEL 3000	MOVEABS X64811 Y-24133 Z-1611	MOVEABS Z2000
MOVEABS Z500	*** *** ***	COOLANT OFF
VEL 300	MOVEABS Y-13037 Z-3840	SPINDLE OFF

CMMANDS	COMMANDS MEANING
IMF_PBL V1.0 - ARTCAM v5.5	Program start.
; Thickness:10.000	Comment: Thickness of the half-finished material – 10mm.
;Home Position: X 0 Y 0 Z2000	Comment: Initial Processing co-ordinates, mm

;Safe Z: 2.000	Comment: save height of the tool lifting above the half-finished material surface, mm
SPINDLE CW RPM11000	Rotation frequency of the milling head spindle 11000 min^{-1}.
COOLANT ON	Switching the coolant on.
PLANE XY	Processing on the plane XY.
FASTVEL 8000	Velocity of the fast movement, μm/s
FASTABS X66995 Y-29486 Z2000	Fast movement (in velocity FASTVEL) to the point with co-ordinates X66995 Y -29486 Z2000 toward the half-finished material 0. The co-ordinates are presented in, μm.
VEL 3000	Feed velocity, μm/s
MOVEABS X66995 Y-29485 Z-2000	Movement (in velocity VEL) to the point with co-ordinates X66995 Y-29485 Z-2000 toward the half-finished material 0. The co-ordinates are presented in, μm.
COOLANT OFF	Switching the coolant off.
SPINDLE OFF	Switching the spindle off.

A marble mosaic mural POLITICAL AND ADMINISTRATIVE MAP OF RUSSIAN FEDERATION (1x1,5m) has been experimentally created by the suggested technology (Fig. 11). The mountain relief is presented by 3D fragments and the denominations and the legend are engraved on flat parts. The article is assembled manually. Special paints and chemical treatment of the stone surface are used for the engravings coloring and the bas-relief polishing.

Fig.11

The proposed technology for design and production of mosaic mural from engraved flat and 3D fragments affords an opportunity for:

- Expansion of the field of the artist-designer creative work;
- Reduction of the time, needed for the development of an original article, by creation of artistic elements set;
- Decrease in the work at the design and production of type articles by use of 3 co-ordinate CNC machines.

References

ArtCAM Pro. Руководство пользователя.

Казарян Ж.А. Природный камень: добыча, обработка, применение. Справочник. – М.: ЗАО "ГК ГРАНИТ", "ПЕТРАКОМПЛЕКТ", 2002. – 319 с.

Миков И.Н., Осипова Л.П. Технология и станок для растровой факсимильной гравировки минералов. Сб. научных статей Добыча, обработка и применение природного камня. – Магнитогорск: МГТУ, 2004. – с. 210…221.

Синкенкенс Дж. Руководство по обработке драгоценных и поделочных камней: пер. с англ.–М.: Мир,1998. – 423 с.

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