FOUR KORDINATNYY FLOORING LAYOUT OF PORTAL COMPOSITION

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ARTICLE INFO	ABSTRACT
	The article highlights the relevance and formulates the problem of creating small-sized workbenches with computer hardware, inspecting the data generators and the design of such workbenches, and proposing options for a table-top workbench with a portal layout. The example of the preparation of a folding part shows the procedure for breaking up the ceramic program.

1. FORMULATION OF THE PROBLEM

Machine tool construction, as a key branch of mechanical engineering, plays an important role in the development of industry and national economies. In today's changing world, increasing competition, rapid changes in the technological landscape and the general transition to the digital industry present a number of complex tasks and opportunities to machine-building enterprises. The development of industry and its sectoral structure determine the state of the industrial and technological level of the country's economy, the efficiency of its production, stability, sustainability of development and economic independence of the state [5]. The modern progress of production technologies is constantly developing, requiring engineers and scientists to constantly search for new solutions and technologies to increase the efficiency and automation of production processes. This requires the creation of a modern laboratory research base in the educational process [7,9]. In the conditions of limited financing of higher education, it is advisable to manufacture small-sized desktop machines with computer control, which can be used both for the educational process and at enterprises for the production of small parts. Among the prospects for the development of mechanical engineering and, in particular, machine tool construction, the following can be noted [1,2]: 1) increase in processing productivity; 2) improving the quality of manufactured products; 3) reduction of costs and raw and energy resources; 4) reduction of the share of human physical labor; 5) facilitation of human intellectual work; 6) expansion of technological capabilities of the equipment. To achieve the above goals, it is necessary to implement the following recommendations [3]: optimize existing production facilities, automate and involve advanced digital technologies to improve work processes; accelerate the implementation of technological innovations and innovation processes; to raise the qualification level of mechanical engineering workers. At the same time, scientists and entrepreneurs should continue researching the process of developing and implementing new technologies in mechanical engineering, because the use of modern technologies is becoming a necessity, which prevents the risks of losing relevance in the market of modern industry.

2. THE MAIN TASK AND THE OBTAINED WORK RESULTS

The purpose of the work is to analyze known small-sized machines and create a new one with enhanced functionality. In the modern market of tools and equipment for small and medium production, there are many manufacturers specializing in small-sized machines. This equipment is characterized by high mobility, compactness and ease of use. On the market of small-sized CNC machines, you can find such companies as PP "ANDIS-TECHNO", CNC Machines, Raptor CNC, AST3D. The "SMART Light" CNC milling engraving machine (Fig. 1) from SmartCNC is equipped with a touch screen and an autonomous controller (can work without connecting to a PC) and is perfect for working with all types of wood and soft metals. The machine is made of aluminum profile. SBR20 support shafts and SBR20UU bearings are used as guides, which ensure high accuracy and smooth movement. A ball screw pair (BSP) is used as the Z axis drive [10].

The CNC MACHINES company is a manufacturer of the Sokil 3040 CNC 3-coordinate milling machine (Fig. 2), designed for processing 2D and 3D models, as well as

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bodies of rotation (with the 4th axis module installed). This model is characterized by high accuracy and increased processing speed, thanks to the rigid frame made of aluminum alloys. A 1.5 kW brushless motor-spindle with liquid cooling allows you to perform tasks without interruption, 24 hours a day. The machine can perform such operations as sheet material cutting, sampling, slot milling, engraving, 3D relief milling, drilling, laser engraving, rotary body milling.

Shenzhen Creality 3D Technology Co., Ltd. is a leader in the production of consumer 3D printers on the world market [11]. The latest device Creality CP-01 (Fig. 3) with interchangeable heads is designed for 3D printing, laser engraving and milling. Each module has a universal connector and is easily replaced, and in the event of a power loss, the CP-01 has protection to continue work where it left off.

Today, you can find desktop milling machines with the following layout schemes: Vertical layout (Fig. 4). In this scheme, the machine has a vertical column on which a spindle with a drill or milling cutter is located. Such machines are equipped with a movable cross table with T-shaped grooves for installation and fixation of the workpiece, vice or other device. This scheme ensures compactness, stability and processing accuracy. Vertical machines are well suited for drilling holes or milling on vertical surfaces. The working area can be limited, making it less suitable for processing large parts.

Portal arrangement (Fig. 5), where the spindle moves along the portal (frame), which supports horizontal movement along the X and Y axes. This scheme allows for a large working space and high precision processing of large parts. Machines of this type can be with a movable portal (Fig. 5) or with a movable table (Fig. 6).

Fig. 1. "SMART Light" CNC milling engraving machine

Fig. 2. "Sokol 3040" from CNC MACHINES

Fig. 3. Creality CP-01 3D printer

Fig. 4. JET JMD-X1L milling machine
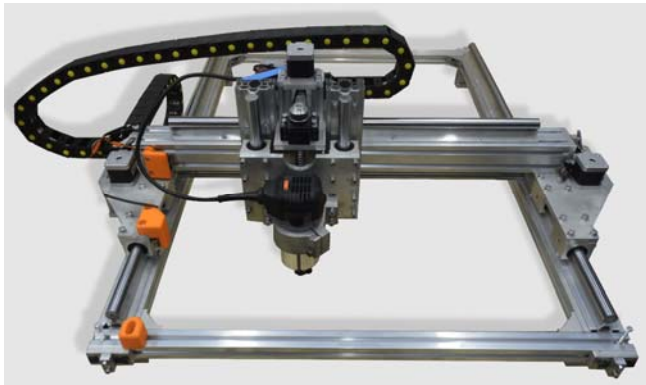
Fig. 5. CNC Router of the High-Z T-Series

In a moving gantry machine, the work tool (such as a milling cutter or other cutting tool) moves along horizontal directions on a gantry structure that supports its movement. The portal has large dimensions and allows processing large parts or large work areas. In machines with a moving table, the working tool is located on a rigid portal, and the working table, on which the processed parts are located, moves along horizontal directions. The movable table

allows for easy positioning and machining of parts, and the gantry provides stable support for the work tool.

Compact drilling and milling machines are noted for their mobility as they are easy to move around, making them ideal for small workshops or garages. They are also impressively versatile, capable of performing a variety of machining operations, including drilling, milling, cutting and other operations, yet are compact, making them ideal for confined spaces.

However, few manufacturers develop table-top milling machines that provide multi-functionality, which consists in the ability to quickly and easily replace the motor-spindle with a 3D printer print head or a laser head for sheet material cutting or engraving.

3. MACHINE DESIGN

After a thorough analysis of a significant amount of data, a patent study of similar machines and a detailed study of their design [4, 6, 8], the authors designed a desktop machine with a portal layout in various versions (Fig. 7).

The supporting frame is made of a machine-made aluminum profile of the V-slot type. This greatly simplifies and reduces the cost of the design, since such elements are standard and if any element of the frame breaks, it can be easily replaced. The machine contains two work tables. The upper one is intended for the processing of sheet material and small-sized parts, the lower one is for installing machine equipment on it (dividing head, vice) and processing larger parts. This makes it possible to process a fairly wide range of parts with a small movement of the spindle along the Z axis.

When using the lower table, several central sections of the upper table should be dismantled, and since the table consists of several profiles V-slot 20x80, then dismantling does not cause significant problems. SBR type linear guides are used as guides, which have much greater rigidity compared to ordinary round guides.
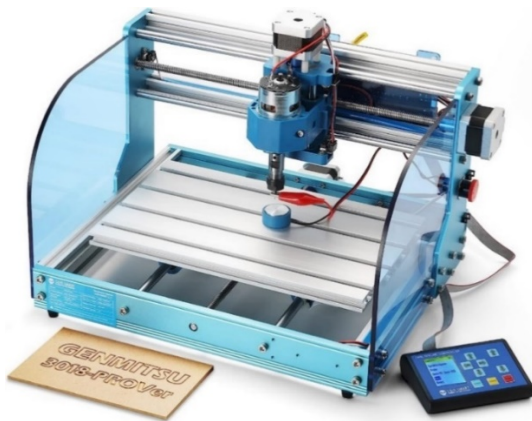
Fig. 6. SainSmart Genmitsu 3018-PROVer

Coordinate movements are carried out due to ball-screw transmissions (BSP). It should be noted that in this type of equipment, the use of a sliding screw-nut transmission is not rational, since a significant amount of chips is formed during the operation of the machine. And the sliding nut has no protection against external dirt, unlike the KGP nut. Bearings for screw pairs are manufactured by TBI MOTION (Taiwan) using radial thrust bearings manufactured by NSK. If you attach the screw directly to the stepper motor, the shaft of the KGP can move along the axis, which will not ensure accuracy. Using bearing

supports, you can significantly reduce the backlash of the entire transmission. The front support consists of two bearings and a tightening screw, and the rear support consists of one bearing that can slide in the housing. The weight of the machine after modernization is 30 kg. The working body has an increased range of movement along the axes: X – 340 mm, Y – 330 mm, Z – 65 mm. The created machine has a number of significant advantages compared to previous models.
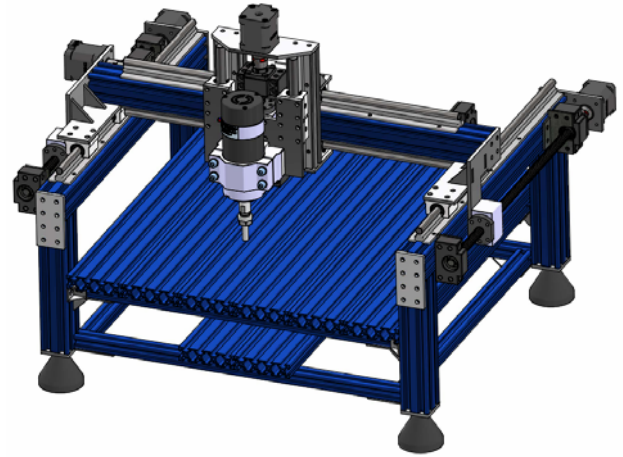
a)
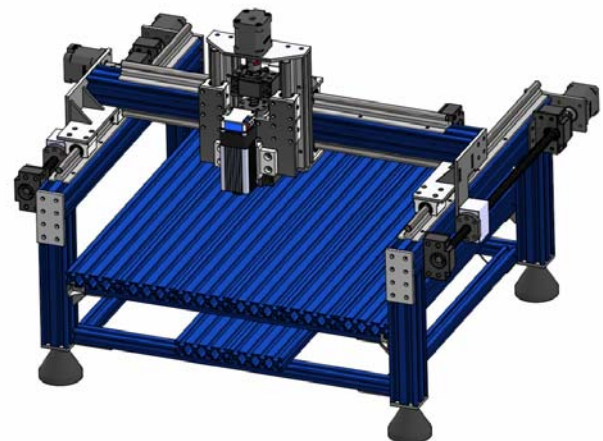
b)
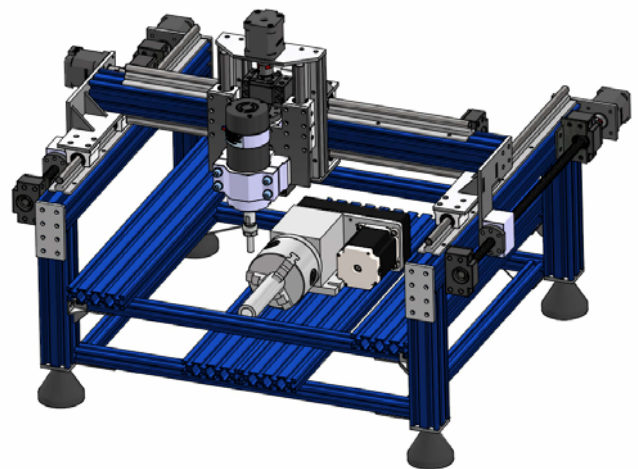
c)

Fig. 7. Variants of the created machine: a) - milling machine; b) - laser machine; c) - milling 4-coordinate machine

4. ADJUSTING THE MACHINE

Autodesk software was used to create the control program, namely Inventor 2024 and PowerMill 2024. First,

a 3D model of the part is created using Inventor 2024, which must then be loaded into PowerMill 2024 to create the control program. For example, the processing of the chess piece - the king (Fig. 8) is done.

PowerMill supports various 3D model file formats. The most common is the STEP format. The part model is loaded into the program for subsequent creation of the control program. Processing on a machine with 4 axes will take place in several stages. First, rough processing of one half of the part is performed (separation occurs along the fourth rotary axis), then the workpiece is turned 180° and the other half is processed. Finishing takes place without separating the part. Let's consider in more detail the steps for creating a control program. After loading the model file in PowerMill, it is necessary to create a workpiece (Fig. 9) and a local coordinate system in which the X axis coincides with the rotary axis A of the machine, and the Z axis coincides with the Z axis of the machine (Fig. 10).
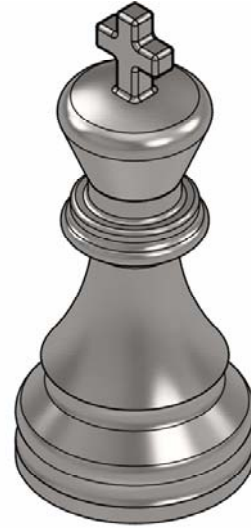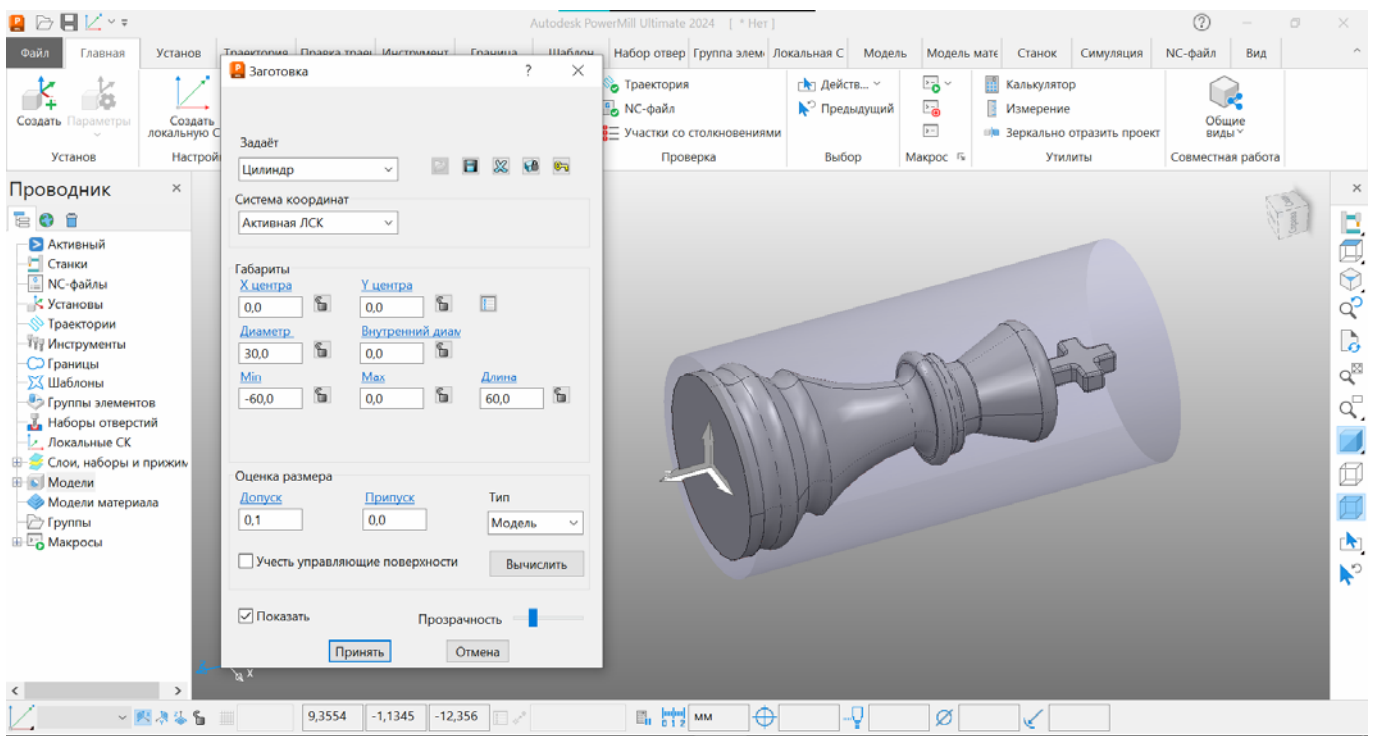

Fig. 8. Part for processing on the designed machine

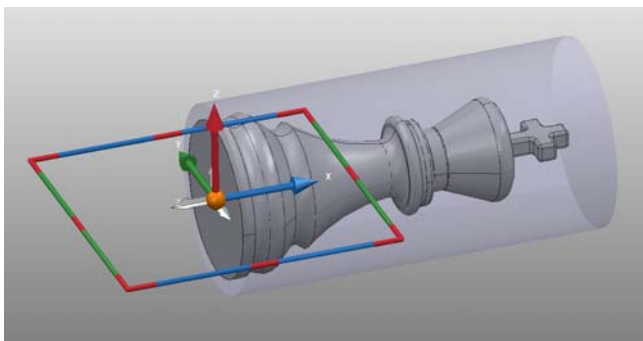

Fig. 9. Creation of a workpiece
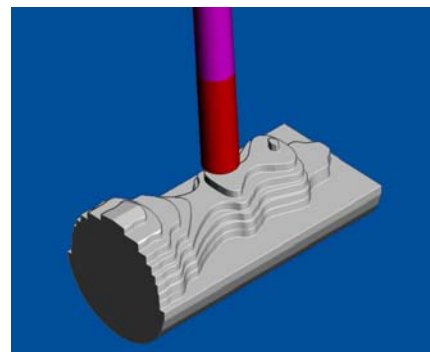

Fig. 10. Local coordinate system

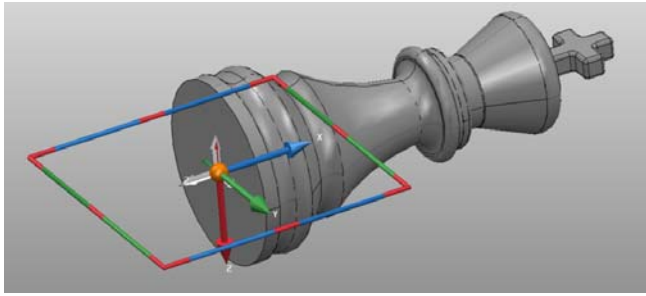*Fig. 11. The result of the first part of the rough processing*

Fig. 12. Coordinate system for rough milling of the second half of the part
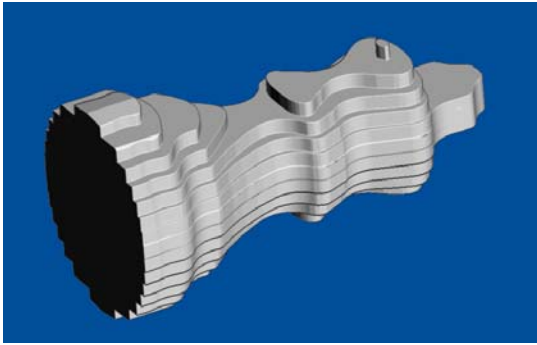

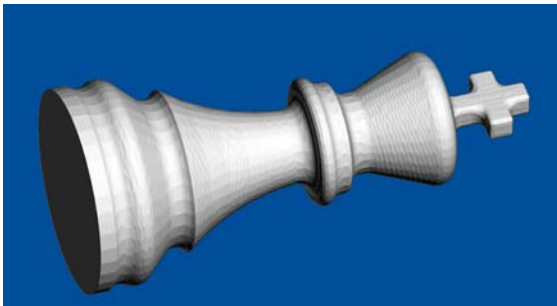*Fig. 13. Detail after rough milling*

Fig. 14. Detail after finishing milling

The next step is to create a processing path. The "3D model selection" strategy is used for rough processing. With this method of processing, milling of the main material takes place and the workpiece takes on an approximate appearance to the required one (Fig. 11). The next step is to configure the selected milling strategy. In this window, the coordinate system in which the processing is performed, the strategy of tool feeding and withdrawal, processing restrictions, tool parameters, cutting modes, and much more can be configured. After all the settings, the system generates a trajectory along which the working body will move during the processing of the part. PowerMill makes it possible to simulate the execution of the control program.

The second half of the part is processed in a similar way. For this, a copy of the previously established local coordinate system and a processing strategy are created. The coordinate system is rotated 180° around the X axis (Fig. 12), I leave all other settings unchanged.

As a result, we will get a part after rough processing on both sides (Fig. 13).

The created control programs for roughing and finishing must be saved in an NC file in which the G-code will be placed. Finishing will be carried out using a "4-axis" strategy, in which the A-axis is constantly rotating and the workpiece moves in the YZ plane. In this way, processing is performed as if in a spiral. Tool parameters, cutting modes, etc. are also adjusted for this processing method. Further, all actions are performed similarly to the above example of creating a control program for rough processing. As a result, we have a completely ready control program for processing the part. The result of the program simulation is shown in Fig. 14.

5. CONCLUSIONS

The developed universal desktop 4-coordinate machine tool with extended functionality has significant scientific and technical potential and practical value for modern mechanical engineering. It can be effectively used in the educational process and in production when manufacturing complex parts of small sizes.

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