DESIGN AND IMPLEMENTATION OF A MILLING MACHINE WITH NUMERICAL CONTROL ALONG THREE AXES

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ABSTRACT: The paper presents the constructive solution and the implementation of a milling machine with numerical control along three axes, by using linear guiding and Aluminum profiles in Bosch Automotive SRL Blaj manufacturing range, pointing out the advantages of using Aluminum profiles in the implementation of the resistance structure.

KEY WORDS: Milling machine, numerical control, three axes.

1. INTRODUCTION

The computerized numerical control of the machine tool implies the existence of a computer ("controller") that reads the instructions for the movement and control of the machine (also called G – code). The controller executes numerical interpolation of the tools position in the working context of the machine. The first controllers for machine-tools with numerical control (MYNC) were developed around the year 1950, at MIT – Laboratory for Servomechanisms.

The development of computers – especially of graphic stations – resulted in the seventies in the third generation of machines with numerical control, in which the controller was actually a microprocessor. Hence their names: CNC – Computerized Numerical Control. These are capable of executing a wide range of processing operations, and can completely memorize the execution programs. Similarly, the operator can edit/alter the program in the controller's memory. Similarly, the cost of the electronic parts is a smaller share of the total cost of the machine. The electronic part is more and more complex, and the mechanical part is more and more accurate, the price structure of the machine being reversed.

The principal three models of CNC systems used for engraving, milling, cables implementation laser cut etc., for individual production are:

a) *CNC with fixed mass* is the most frequently used model (Fig. 1) for engraving machines, laser cut, plasma sawing and milling of soft materials.

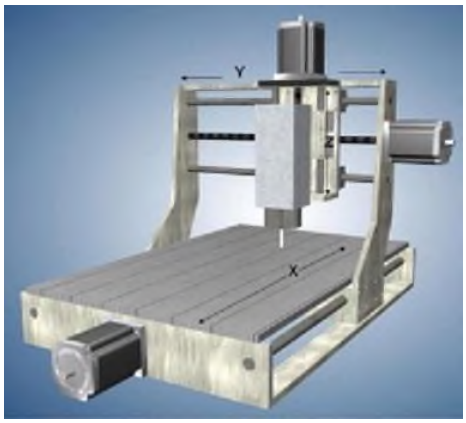


Figure 1. CNC with fixed mass

These present the following advantages compared to other models: since the mass is fixed, large and heavy materials can be milled, engraved, so that the machine functionality would not be influenced; due to the construction, no major losses are noticed along axis X; the construction is very stable and well-balanced, 2 identical motors can be used for axes X and Y, and a smaller one for axis Z, its weight being smaller.

The disadvantages of the model are: axis X should be very robustly executed, since it

supports the weights of the axes Y and Z; the use of a large sized milling machine is not recommended, the vibrations of the milling machine being felt in the entire construction; the errors of the axes are cumulative.

b) *CNC with mobile mass* is presented in Fig. 2. This model is especially used for accurate engravings, cable boring.

Figure 2. CNC with mobile mass

The principal advantage is given by the fact that the errors of X and Y axes are not cumulated, offering a very good accuracy.

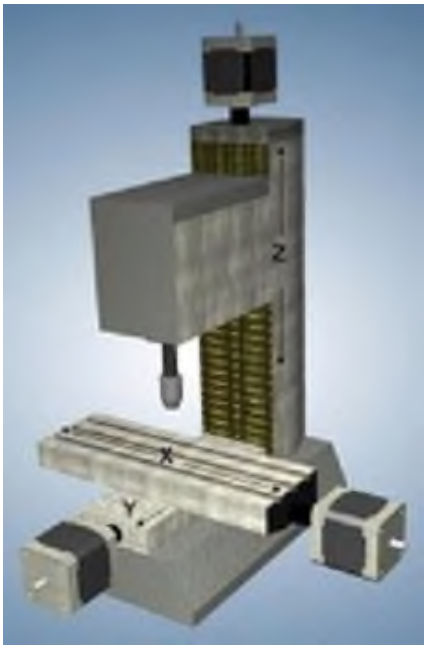


Figure 3. CNC with cross shaped mass

The disadvantages of the constructive solution are: the part increases the mass weight in motion; the size of the processed parts is limited by the construction of X axis; only half of the entire rolling surface of the X axis is used .

c) *CNC with cross shaped mass* is shown in Fig. 3 and it is used especially in accurate milling of metals.

The advantages of this model are: the most important advantage is that it allows the use of a heavier milling motor so that its vibrations would not affect the quality of the milling; accuracy superior to the fixed mass model.

Then disadvantages are: X axis is not in balance, especially at the end of the stroke; the part is in motion; for a good stability and balance; massive construction is required; work surface smaller than in the rest of the models.

2. DESIGN OF A CNC MILLING MACHINE ALONG THREE AXES WITH LINEAR GUIDANCE

Based on linear guidance with slide bed with balls and on Aluminum profiles, of Bosch Automotive SRL Blaj manufacturing range, the milling machine with numerical control along three axes (X,Y,Z) has been designed shown in Fig. 4, and with the possibility in the future of adding the forth rotation axis, in order to also implement turning processing as well.

The use of the 50x50L Aluminum profiles of Bosch Rexroth Blaj manufacturing range, compared to the welded metal construction, presents the following advantages:

- the workmanship of implementing mechanical structures by the use of typified coupling elements (elbow pieces, T headed bolts etc.) is reduced ;
- the mass of the elements in motion (vertical framework) for a good resistance module is reduced, the 50x50L Aluminum profile has specific mass 2,5 kg/m and W=8,5 cm^3;
- Aluminum profiles have a high accuracy regarding rectilinearness and planarity;
- rapid and easy fixing of rails with the help of T nuts.

Disadvantages of using the Aluminum profiles are: the high costs of profiles and coupling elements; difficult obtaining of the rigidity of profiles joints.

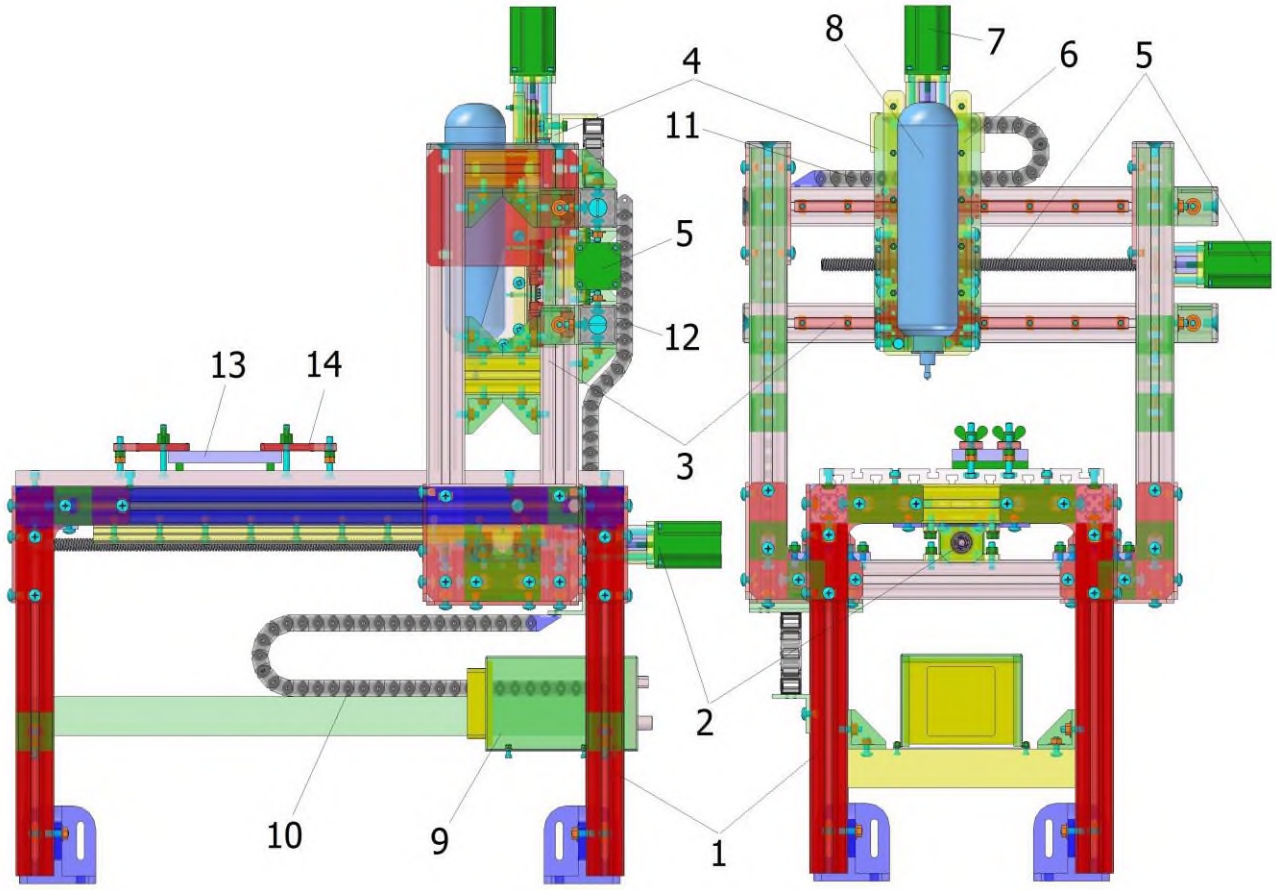


Figure 4. Construction of CNC system with linear guiding

The CNC milling machine along three axes with guiding on rails, which is presented in Fig. 4, is made up of: 1 – mass; 2 – drive group 1; 3 – vertical framework; 4 – transversal slide bed; 5 – drive group 2; 6 – vertical slide bed; 7 – drive group 3; 8 – milling motor; 9 – electric installation; 10 – cable chain axis X; 11 – cable chain axis Y; 12 – fixed vertical cable chain; 13 – piece to be processed; 14 – fixing strap for the piece .

Fig. 5 shows the construction of the vertical framework from 50x50L Aluminum profiles, made up of: 1 – distance piece; 2 – interior elbow piece; 3 – vertical side bar; 4 – double elbow piece; 5 –exterior elbow piece; 6 – upper cross-bar; 7 – 15 size rail , 440 mm long; 8 – slide bed with rolls size 25; 9 – slide bed support plate; 10 – nut support plate; 11 – anti-clearance nut Tr 16x4.

The rail is fixed to the side bar by cylindrical headed bolt and M6x25 hexagonal seat and M6 T nut the exterior elbow pieces are fixed with M8x20 spherical cylindrical bolts and M8 T bolt, and the interior elbow pieces with M8x25 T headed bolt and M8 nut collar. The slide beds are fixed to metal plates by six cylindrical headed bolts and M6x16 hexagonal seat, the support plates are fixed on the Aluminum profiles by four T headed M8x30 bolts, and Tr 16x4 nut is fixed by two M6x40 bolts.

The construction of the drive groups is shown in Fig. 6, where: 1 – 3 Nm step by step motor; 2 –M4x12 bolt; 3 – motor support; 4 – distance piece from 3/8" pipe; 5 – 4 Nm elastic Oldham coupling; 6 – M10 bearing fixing nut; 7 – 1 large bearing support; 1; 8 – Φ30 elastic ring; 9 –radial-axial bearing with balls 7200; 10 – sealing ring; 11 –Tr 16x4 bolt with l = 800 mm; 12 – radial bearing with balls 6300; 13 – end bearing support; 14 – 2 large support bearings; 15 –M8x80 bolt; 16 – Grower N8 collar; 17 – Tr 16x4 bolt with l = 450 mm; 18 –T headed M8x25 bolt; 19 –M8 nut; 20 –M8x30 bolt; 21 - Tr 16x4 bolt with l = 300 mm

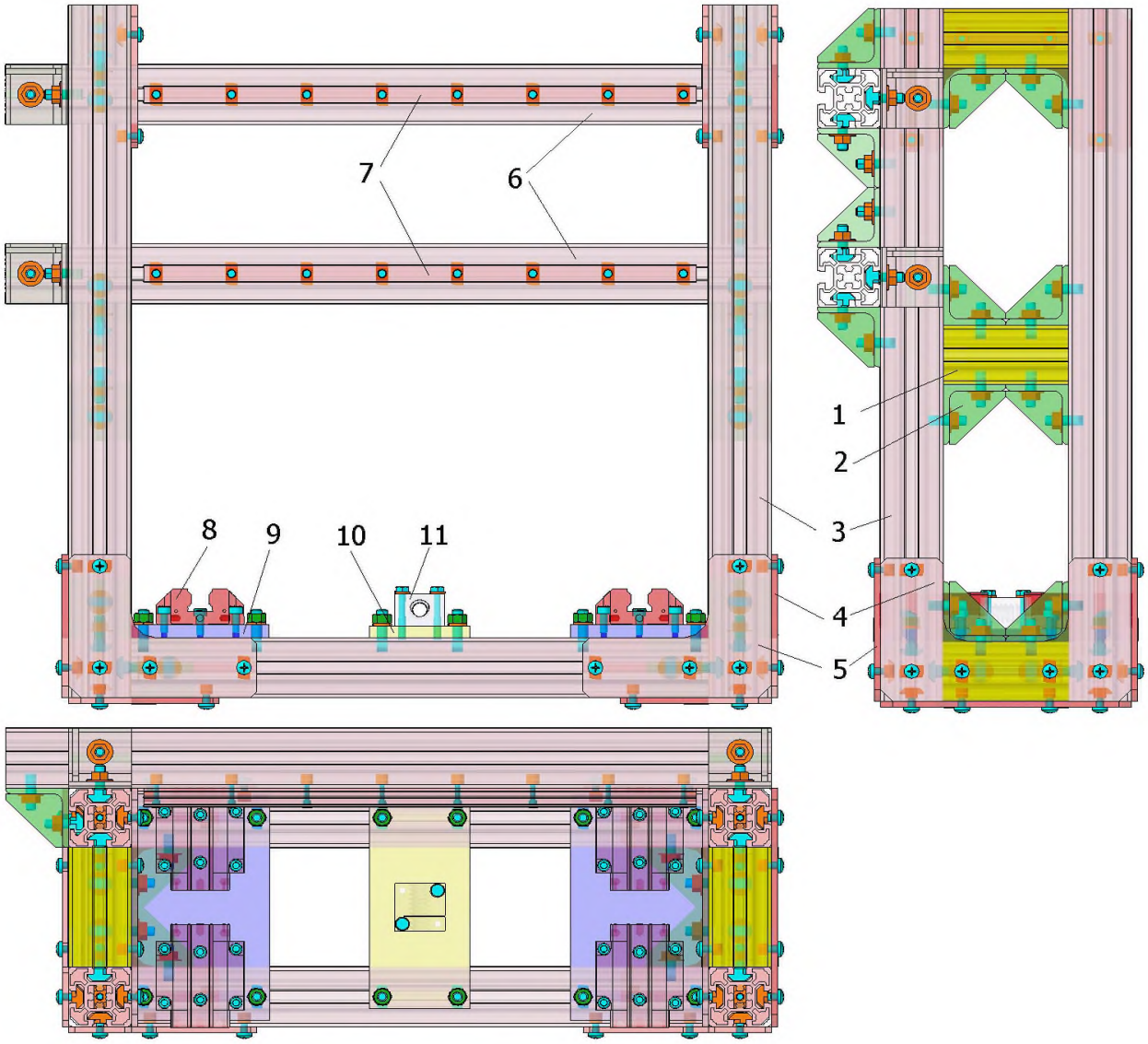


Figure 5. Vertical framework construction with 50x50L Aluminum profiles

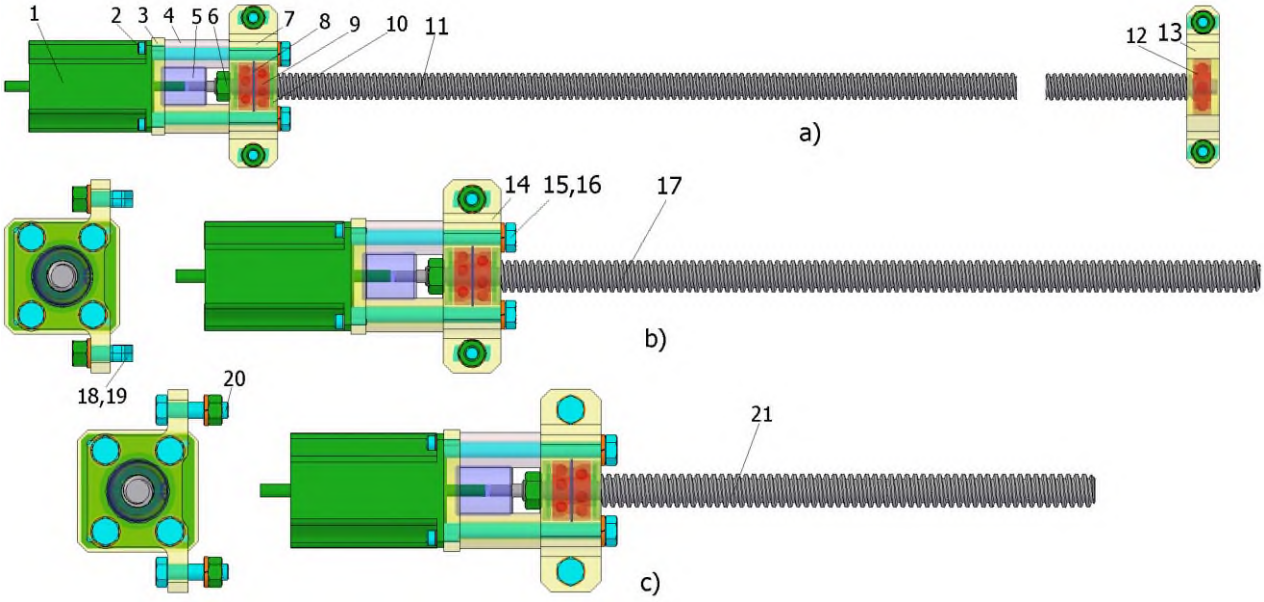


Figure 6. Construction of drive groups
a) – drive group 1; b) – drive group 2; c) – drive group 3.

Axial feed force given by the bolt-nut mechanism is taken over by the two radial-axial bearings with balls 7200 (Φ10xΦ30x9), which are mounted in O on the end of the bolt and fixed between the two sealing covers by nut M10, and its transmission to the large bearing support is done by the interior elastic ring Φ30.

The support of the large bearing 1 differs from the support of the large bearing 2 by the height to the bearing axis of 35, and 25 mm, respectively.

Fig. 7 shows the construction of the transversal slide bed, which is made up of

1 – basic plate; 2 – vertical slide bed support plate; 3 – guiding slide beds with balls, size 15, vertical; 4 – guiding slide bed with balls, size 15, horizontal; 5 – nut support plate; 6 – Tr 16x4 nut size 40x40x27; 7 – M6x40 bolt.

These are mounted by two slide beds on each horizontal rail, which improved the guiding of the vertical slide bed and increased the durability of exploitation of slide beds with balls, size 15.

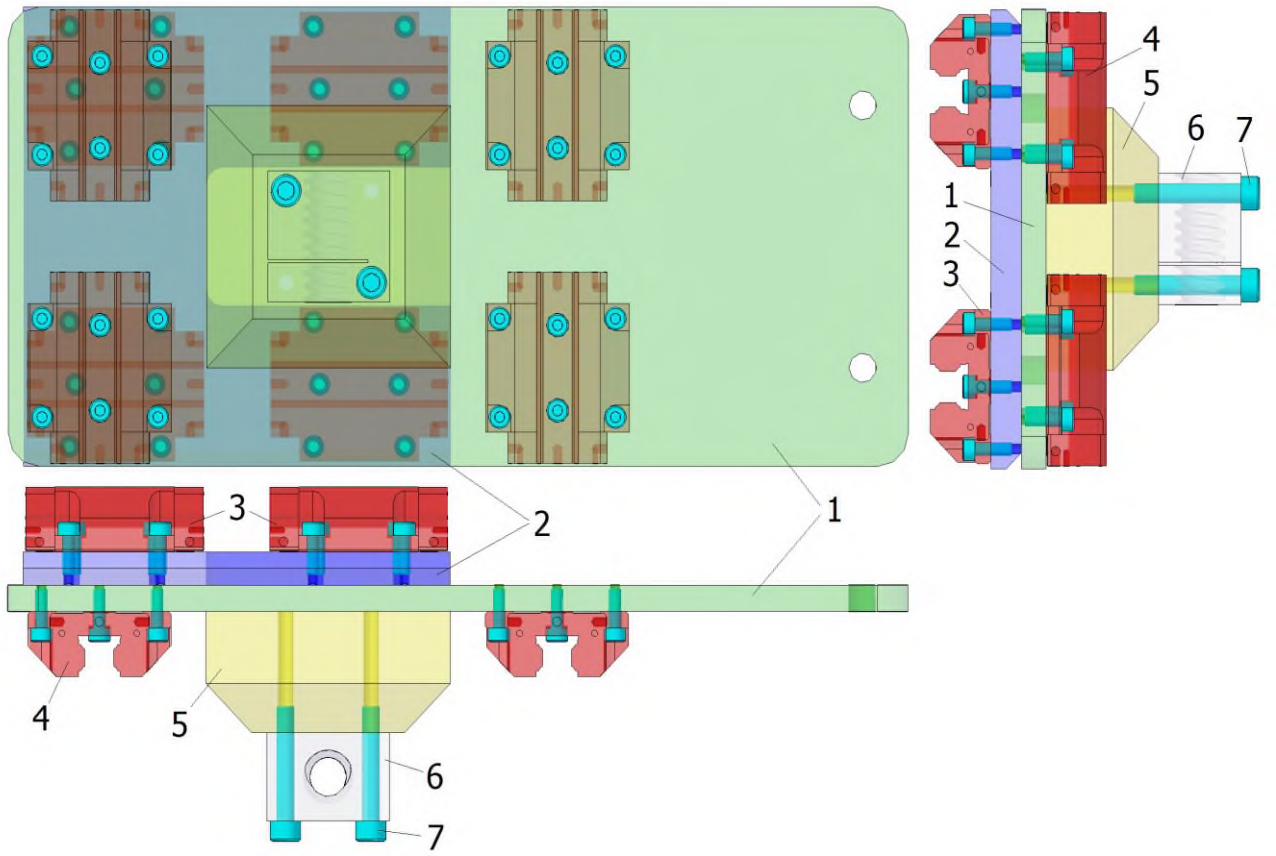


Figure 7. Construction of transversal slide bed

3. MILLING MACHINE IMPLEMENTATION WITH NUMERICAL CONTROL ALONG THREE AXES

Fig. 8 shows two stages in the implementation of the milling machine with numerical control along three axes.

Fig. 8 shows the stage at the beginning when the table and the vertical framework were assembled, and in Fig. 8.b is presented the final construction of the structure of resistance.

In Fig. 9 the improved construction of the milling machine is presented, with numerical control along three axes.

The electric control installation at the step by step motors has been changed by mounting a driver for each motor and insulating from the supply source.

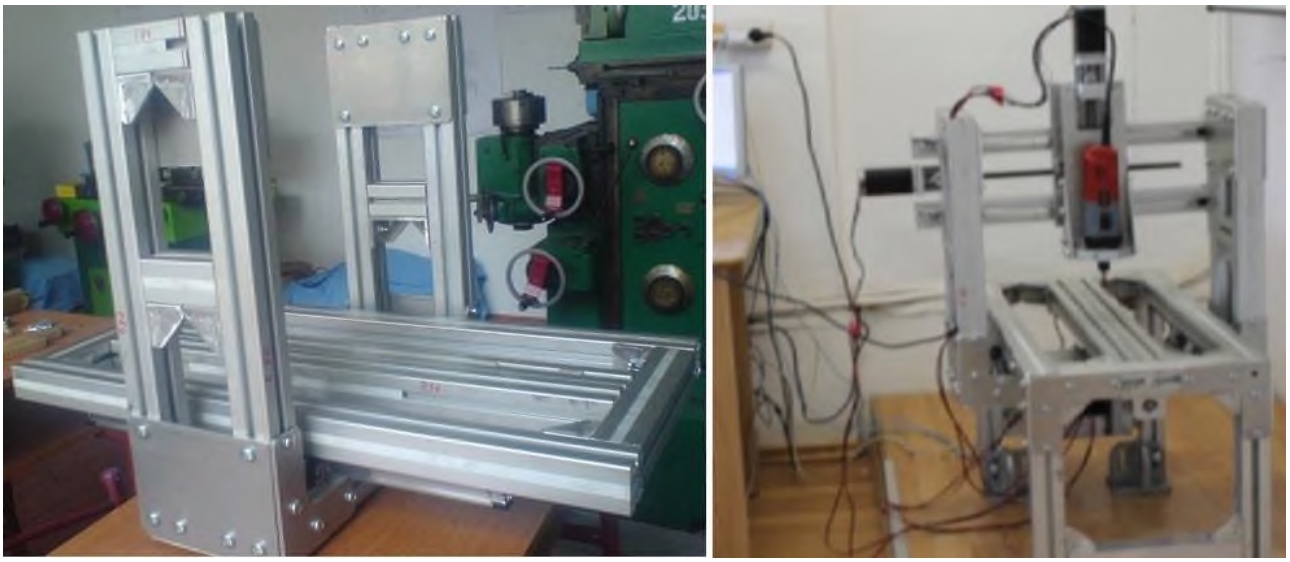


Figure 8. The way in which the milling machine with numerical control along three axes is implemented

Similarly, the supply cables for the motors and their positioning by chains for cables have been changed, and a mass with T-slots from extruded Aluminum of 375x800 mm, Φ3 and Φ6 mm tweezers cutters for 800 FNE Kress milling motor have been purchased. The new control installation of the CNC system is shown in Fig. 10.a, where each motor is coupled to the installation by four pin sleeves, and the connection to the computer is made by a 25 pin cable to the sleeve of the computer and 7 pins to the sleeve of the control installation.

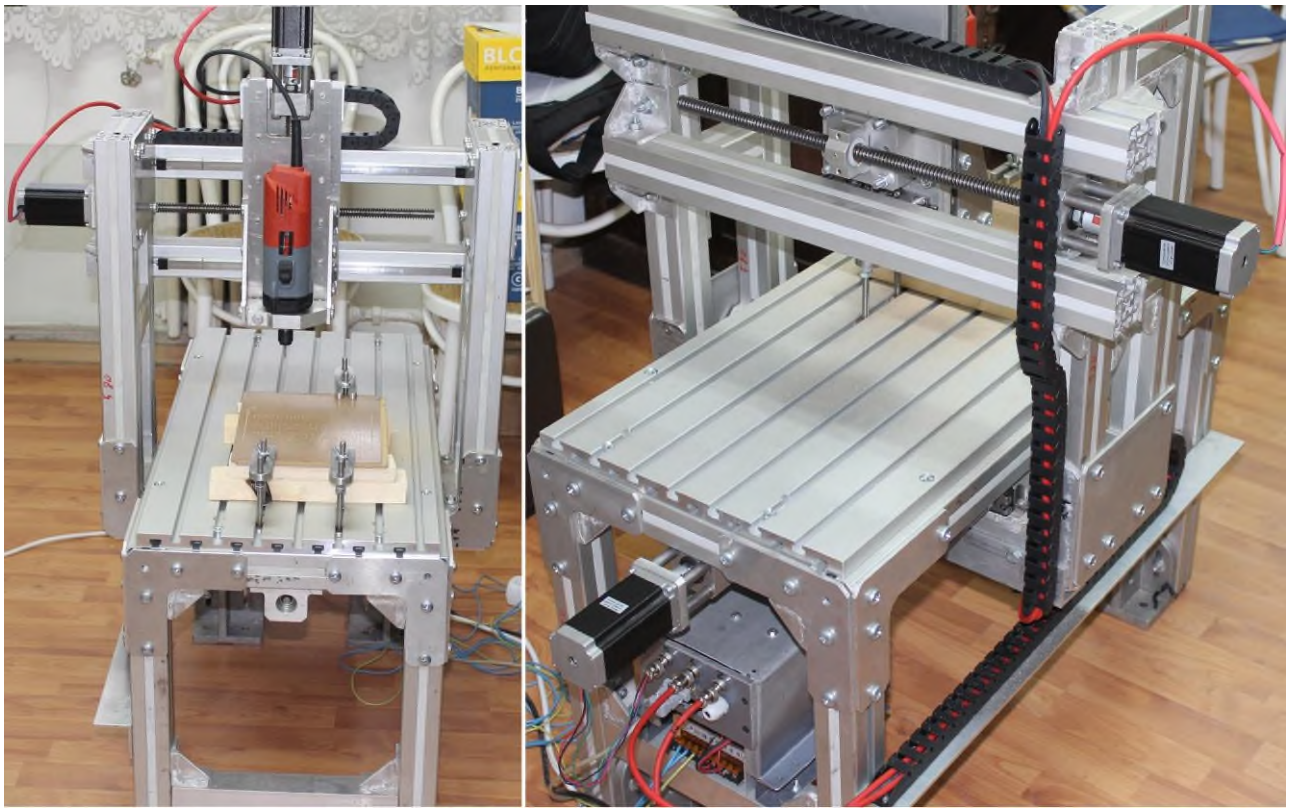
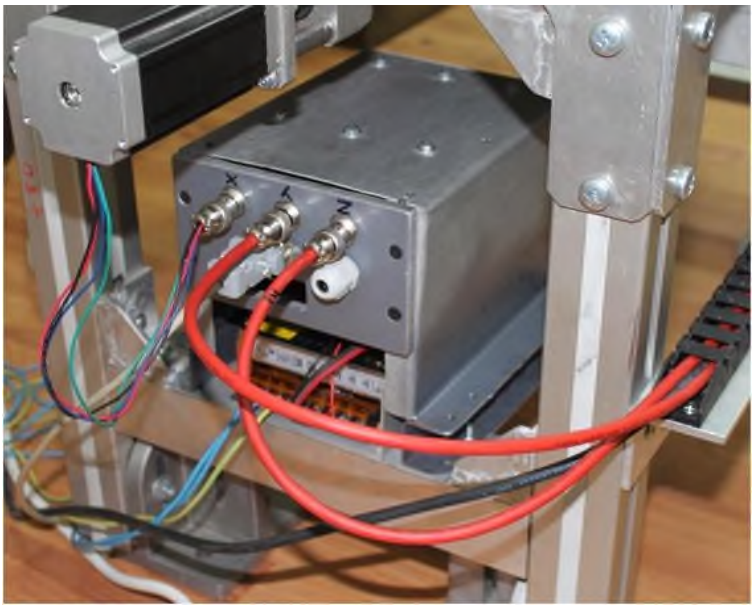


Figure 9. Improved construction of the CNC milling machine along three axes

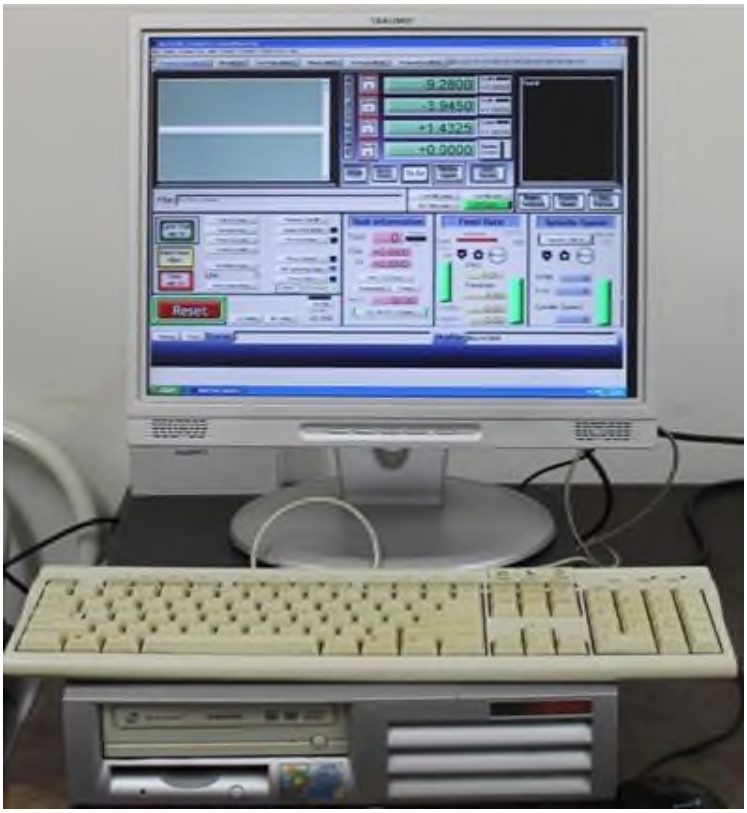
For the control of the milling machine along three axes Mach 3 soft has been used, which operates with controls written in G code, which has been installed on a computer, Fig.

10.b. Code G control is generated with soft dedicated to 3D engraving or processing operations.

Fig. 11 shows the plate that has been engraved with the help of the milling machine with numerical control and of a 3 mm diameter milling machine for engravings, having the peak angle of 30 and the radius of 0,3 mm, in 30 minutes. Being the first testing of the milling machine with numerical control along three axes, it behaved well; the adjustment of the mechanical part was also additionally, in order to achieve a good parallelism between the movement along axis Y and the mass of the machine.



a)



b)

Figure 10. Electric installation and the control computer

Figure 11. Engraved plate

4. CONCLUSION

The use of Aluminum profiles to carry out the structure of resistance of the milling machine along three axes shows the following advantages:

- the necessary time and the mass of elements in motion (vertical framework);
- Aluminum profiles are highly accurate regarding rectilinearity and planeity;
- rapid and easy fixing of rails with the help of T nuts;

Disadvantages of using Aluminum profiles are:

- high costs of profiles and their coupling elements;
- rigidity of profiles joints are obtained slowly.

By changing the electric control installation of step by step motors, mounting a driver for each motor, and insulation from the supply source, the milling machine functioning improved.

By the use of Mach 3 soft installed on the computer, which operates with G code written controls, allows the use of software dedicated to 3D engraving or processing operations.

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