STUDY ABOUT VIRTUAL AND ACTUAL MANUFACTURING PROCESS WITH THE ROBOT

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Abstract: *In this paper the authors aim to identify the possibility of broadening the use of industrial robots for the processing of wood. In the robotics laboratory has attempted a stand where the robot will be able to process the wood pieces with tool attached to the robot. We try to point out the steps for application development; our target was cutting process of wooden objects. Industrial applications could be very many and diverse. The robot programming was developed for working on multiple facets of a piece type cube it used the robot simulation processing. To realize a comparative study of robot manufacturing with three axes CNC machines was used NX cam software which allowed us to simulate the same processing.*

Keywords: *robot, milling, processing, manufacturing, simulation,*

INTRODUCTION

In this paper the authors aim to identify the possibility of broadening the use of industrial robots for the processing of wood. The wood industry can be divided into four main areas: the furniture industry, the construction-related sector, the wooden materials industry, and other sectors. The jobs that robots are called on to perform in the wood industry include painting, handling, grading, and repairing of wooden parts and products. In the last years, the flat-pack furniture and construction materials industries are entering a new era of robotized, flexible manufacturing. The manufacture wood technology with flexible technology that can quickly and accurately adapt to varying surfaces and consistency of materials.

The requirements on personnel and machines are just as great in high-precision machining applications in the manufacture of large work pieces. Now we can see how an industrial robot in wood industry offers increased productivity at a lower cost.

We can offer an example polishing and buffing of wood products is an interesting application and many robots are integrated for wood products. In figure 1 we can see how a major guitar manufacturer had integrated a work cell with robot to polish and buff guitar bodies. In that application, the robot picks up the guitar body and presents it to sanding and buffing wheels [11].

Material handling of wood products is another important job that robotics accomplish for end-users. In many workshops where working with wood, in the secondary operations of wood product processing for cabinets, windows and doors manufacturing, robotics are taking pre-cut parts and assembling them or presenting them to joining machines.

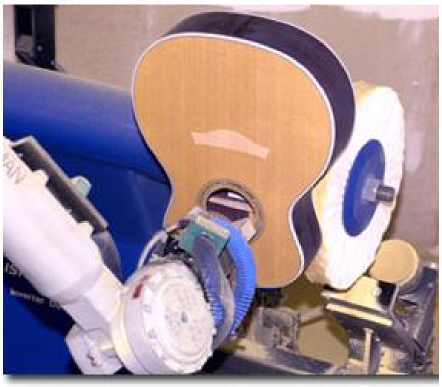


Figure 1. *Details of robotics guitar buffing* [11].

End-users ask why they should invest in robotics to help manufacture wood products when people have been performing these tasks. Most times the answer could be: tedium suffered by those in the woodworking industry is one reason that robots are used but is not only that. The robots can increase productivity, quality and efficiency of wood processing objects.

In the robotics laboratory has attempted a stand where the robot will be able to process the wood pieces with tool attached to the robot. We try to point out the steps for application development. Our target was cutting process of wooden objects. Industrial applications could be very many and diverse.

EXPERIMENTAL

The choice of the parts to be processing is very important because choosing a piece with a quite complex geometry can lead to the demonstration of all robot´s real skills. For the basic study and the work one can choose first a relatively simple part, in our case a cube, on whose sides various processing can be done. This part allows us to demonstrate the fact that the robot is not limited by its freedom degrees, but by the clamping device. This means that if we could clamp the cube on one sole corner then we could make processing on all the cube´s sides without any other movement of the device.

Next step consists of the study of the positioning and clamping device of the part. This device has to fulfill the following conditions: to be robust in order to prevent vibrations; to be universal in order to allow the clamping of a wide variety of parts; to be positioned in an optimum position (height, distance) from the robot to allow easy processing on all surfaces; to allow a simple positioning, a good screw on with a reduced number of operations; to ensure the elimination of the waste resulted in the processing operation.

The choice of the milling device, its modification and clamping to the robot form the next stage of the study within the modeling and simulation of processing with the help of the robot. The mill must be mounted on the robot so to prevent any interference or collision with the robot´s parts or with the part´s clamping device in the moment of processing and also must be rigidly clamped to ensure a quality manufacturing.

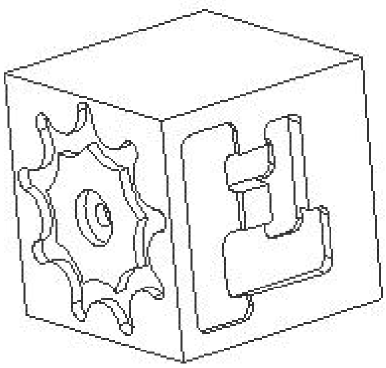
After the study of all these problems, we can start the actual simulation of the robot processing and we can make its program.

For the stand, parts as well as the splinting device the software CAD/CAM NX was used, software which offers a wide range of programs in one integrated solution, to allow the user to use the lasted technologies in terms of used tools and processing processes. NX CAM supports the latest generation of multiple function tools, including milling, drilling and turning on a 5 axis machine. NX allows a wide range of flexible processing on 5 axis machines and with tool control on various axes.

NX CAM is completely related to the other NX solutions so that the NC programmers cannot directly access technical design drawings, assemblies and tools in a processing environment. Through modeling by manufacturing´s associatively, the changes of the model are automatically conveyed into processing operations. Programmers and mechanical engineers can work with modeling parts, can create and mount devices, can develop paths and can even mould whole machines through a 3D simulation of the processing in this work environment.

For the part to be processed we will start from the simple cube type part on whose sides various types of transformations can be done. As it can be seen in figure 2, on each side of the cube the different forms from figure 2 can be milled, some simpler, some more complex. For the tridimensional parts the 3D, NX CAM software was used.

After a favorable result, more complex shapes can be tried, with complex material removal, like conic wholes, uneven surfaces, with variable radius. It is to be mentioned that now days there are specialized software which convert the course of the tool necessary for the surface processing from the design software into the robot´s specific language.



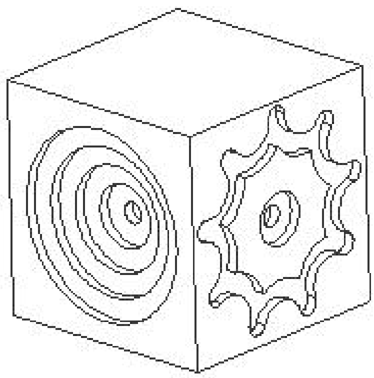


Figure2. *Cube type part with various manufacturing*

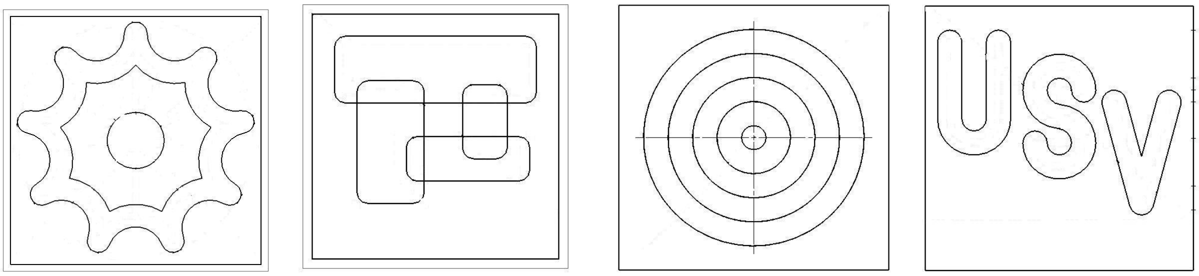


Figure 3 processing *forms to be done on the cube´s sides.*

In order to be able to compare the robot processing with classical methods of processing from today, we will use the same parallelepiped used for the presentation of the CAM software, cube which actually exists.

For the processing device we had to take into consideration the already existing stand from the robotics lab. Making a new independent stand which might be fixed on the floor could lead to an overload of the robot´s space of work and therefore to a reduction in the operation space necessary for the human factor.

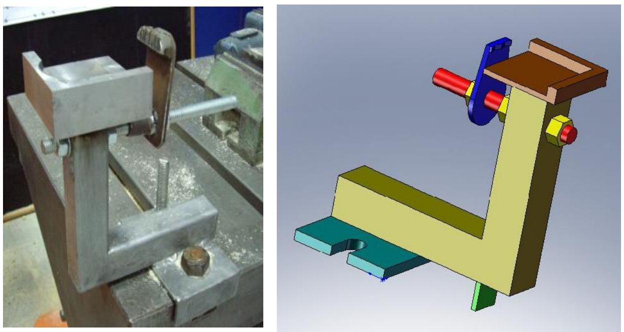


Figure 4 – *Securing device of the semi-finished attachable to the already existing stand from the robotics lab. a) real b) virtually designed in NX*

As for the choice and adaptation of the milling device to perform the task, we started from a bought hand mill, specially designed to mill wholes, slots, edges as well as wooden and plastic joints.

The specifications of this milling device make it good for the work parameters necessary for manufacturing: power 1020 Watts, tension / frequency: 230 V~50 Hz, weight: 3 Kg, revolutions: 11500-34000 rpm, mill diameter: 8 mm, adjustment: sliding rods, revolutions adjustment.

Figure 5. *Milling machine STERN ER 1020*

For this mill its modification was considered in order to be adapted and attached to the robot. After several meetings a certain shape and a clamping system were adopted, even if this meant the cancellation of certain mill elements.(figure 6).

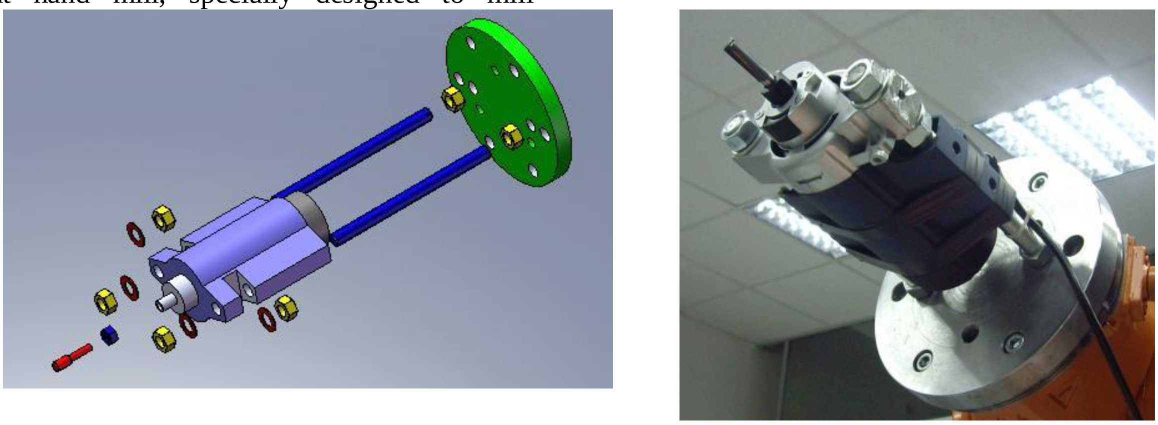


Figure 6 – *Milling device attachable to the robot Kuka KR125*

For the simulation of the robot application the special software Kuka SimPro was used, fact that allows the off line development and programming of robot applications on Kuka robots also offering the possibility to overlap production times with training times for the new processing tasks, a better solution examination and the possibility of improving robots´functioning programmes without being pressed by time. [8].

For the virtual flexible cell the robot´s specific parameters were taken into consideration and also the clamping device position and the orientation of the semifinished, meaning an external coordination system according to which the robot will be programmed. Figure 7

After programming the robot from this virtual flexible cell it was noticed that the milling device can perform any type of manufacturing, within the limit imposed by the robot. In figure 7 one can see the robot´s positioning during the processing of each proposed shape on each of the cube´s sides.

During simulation various aspects had been followed: accuracy of manufacturing, lack of interference and / or collisions between various moving parts, avoidance of impossible to reach positions from the robot, taking notes and observations in order to modify and resize some elements from the final assembly in order to improve the processing process, obtaining a program which can be directly transferred onto the robot for real manufacturing.

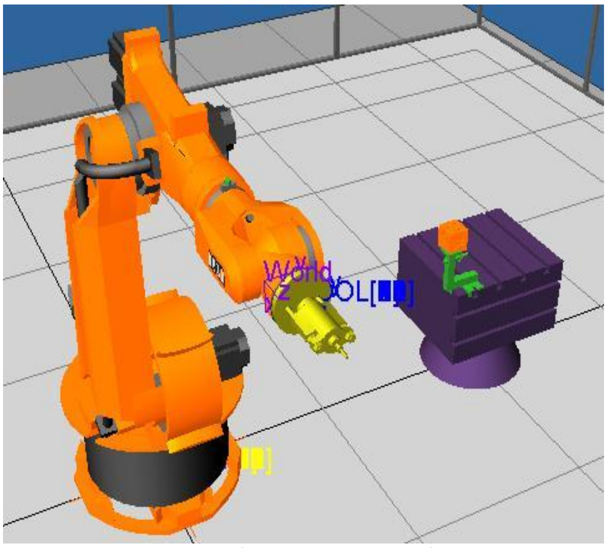


Figure 7. *Virtual flexible cell manufactured with the KukaSimPro software.*

For the simulation of a classic manufacturing, NX CAM software was used. It is to be remembered that in the simulation we will use a 3 axis numeric command machine, which means that each side of the part to be milled will be processed separately.

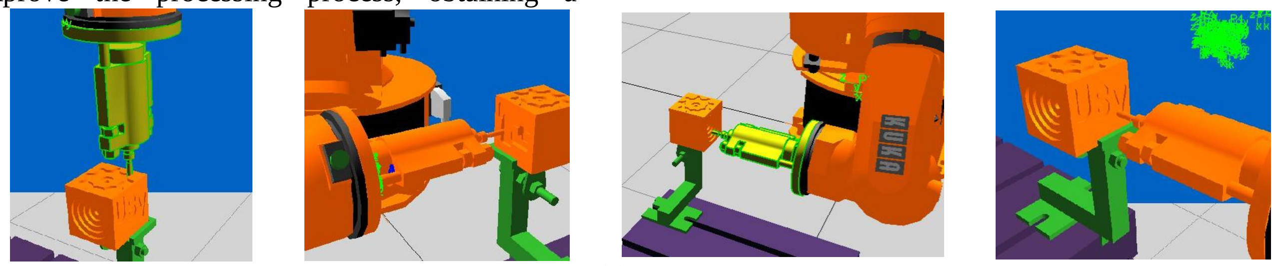


Figure 8. *Simulation of form milling on cube´s sides*

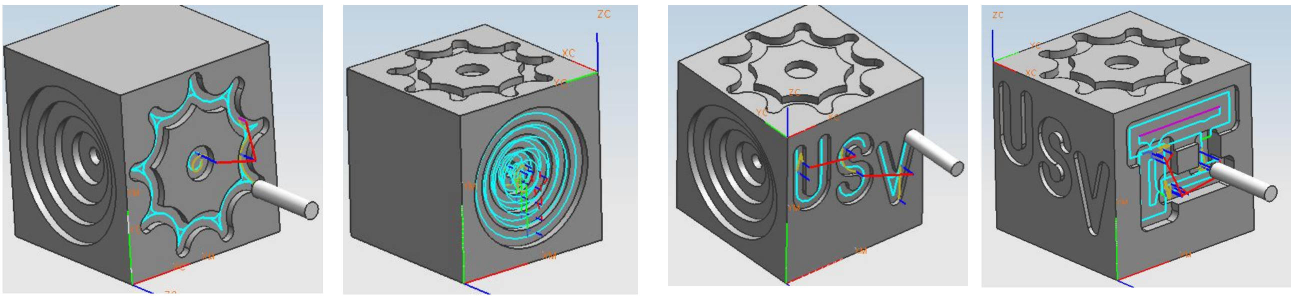


Figure 9 *Simulation of classic processing on a CNC machine with the help of NX software.*

In figure 10 one can see that the program is able to give also the time for the processing of the entire assembly, or for each manufacturing. It is also to be considered that the part must be repositioned for a new manufacturing, fact that introduces new times for each manufacturing

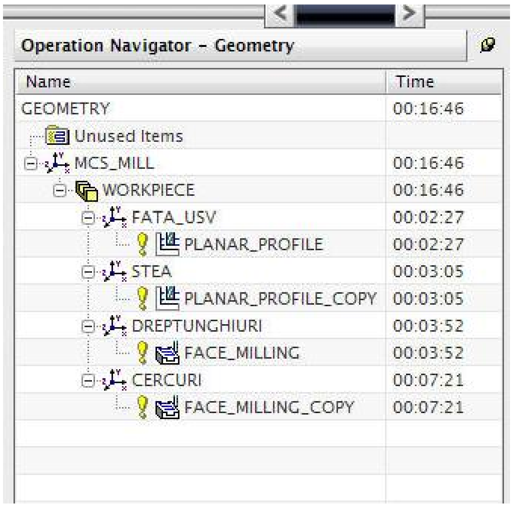


Figure 10. processing *times obtained during classic simulation with NX software.*

Below we present the programming way of the Kuka KR 125 robot. In order to program the processing of the intended shapes on the cube´s sides we followed the following steps: we used the NX software in which we traced with a dotted line the course to be followed by the tool; to obtain the coordinates of the points which give us the course described by the robot´s tool we used as starting point the point given by the intersection of the diagonals.

Therefore, an example of points to be obtained is the following:

Palpated coordinates for the center of the side are:

$$x = 16;\ y = 69{,}5;\ z = 39{,}5 \qquad [1]$$

Manufacturing is done in the positive direction of the axis X, so the table below will not show this coordinate.

Table 1.

Coordinates for U shape manufacturing

	Coordinates contrasted to the center of the side		Coordinates contrasted to base origin	
Nr. crt.	**y**	**z**	**y**	**z**
1	45	30	114.5	69.5
2	45	-2	114.5	37.5
3	35	-12	104.5	27,5
4	25	-2	94,5	37,5
5	25	30	94,5	69,5

Therefore, for the processing of the „U" shape 5 points are used, plus the points entering and exiting the material. A linear movement will be used between points 1 and 2, respectively 4 and 5 and between 3 and 5 a circular movement will be used using point 4 as intermediary.

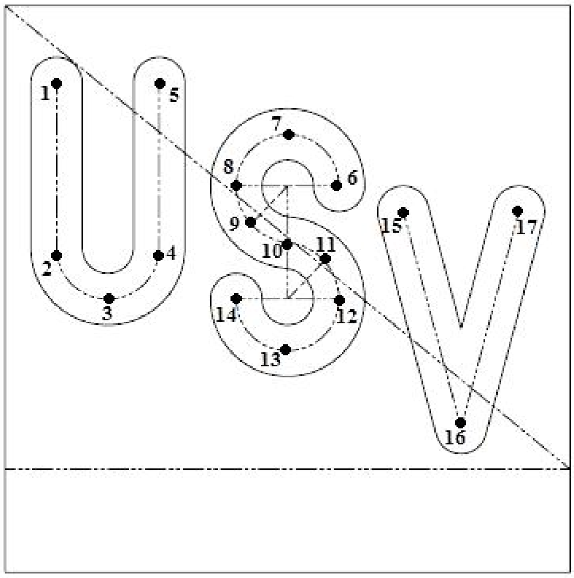


Figure 11. *Design of „USV" processing through points*

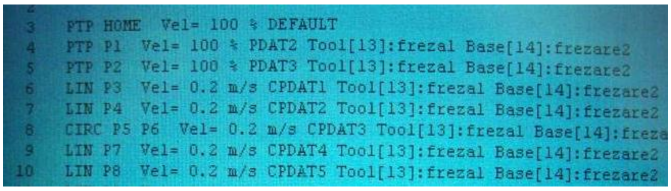
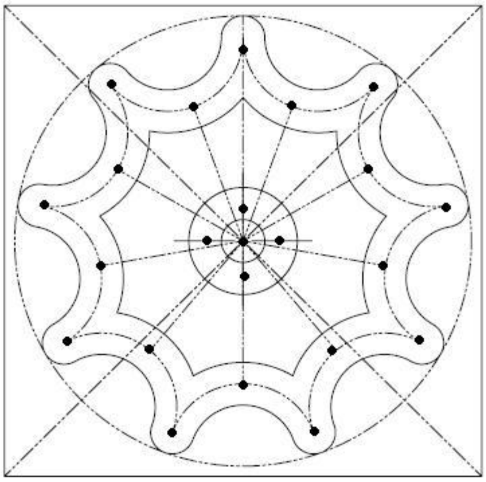


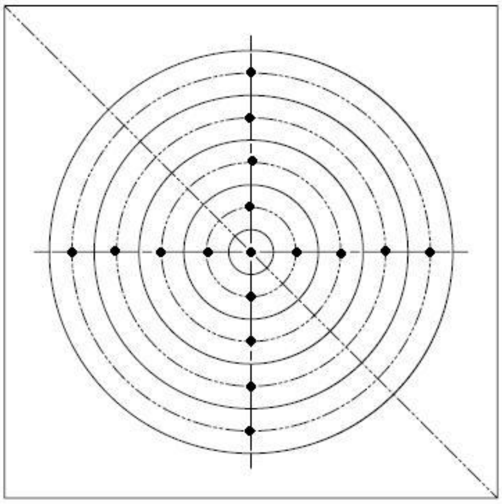
Figure 12. *Extract from „U" shape processing program.*

As we can see from picture 11 the robot starts from the position „home", in position P1, then goes traces a straight line and enters the material, performs its first linear movement, then the circular movement, followed by the second part of the „U", and at the point P7 it finishes the processing and comes out of the material.

This is the procedure which was followed for the processing on all possible sides of this cube within the robotics lab.



a)



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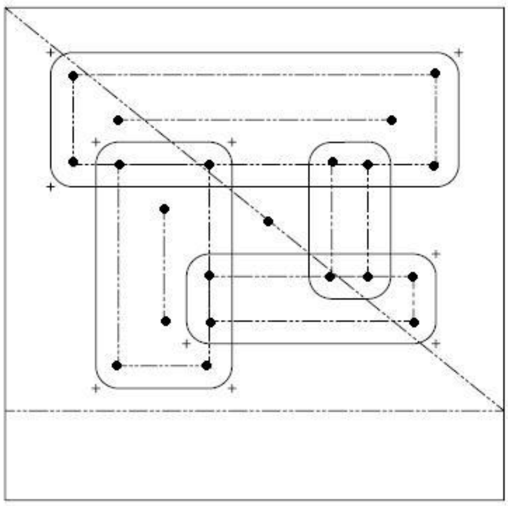
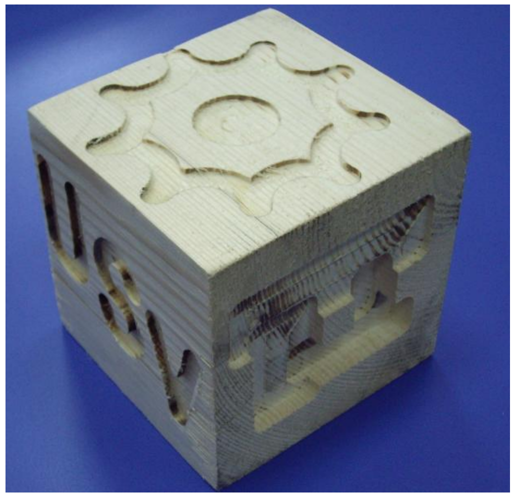


c)

Figura 13. processing of the other three sides

The figure below shows some aspects of the cube processing with the help of the Kuka KR125 robot.



a)

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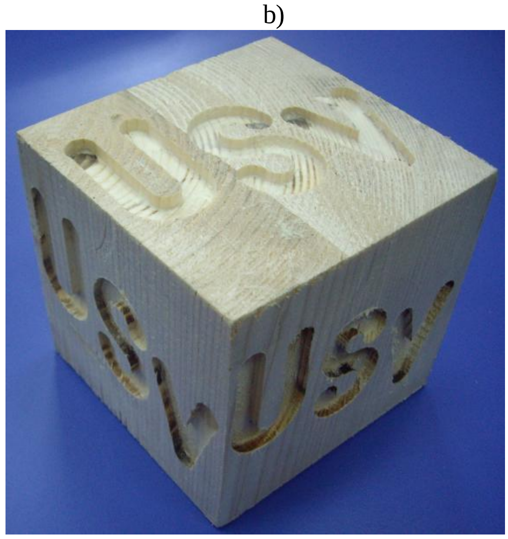

c)

Fig, 14. processing examples on cube sides

The times obtained are similar to the times obtained in the simulation with the CAM software:

- Loading a program: 32 seconds;
- Star program: 2,53 minutes;

- Rectangular program: 6, 10 minutes;
- Circle program: 5, 50 minutes;
- USV program: 2,40 minutes.

It is to remember that having only one clamping device, the times for placing the cube in the work position is eliminated fact which leads to a better processing time.

CONCLUSIONS

After the simulation with the specialized software the following have been noticed:

Table 2. Comparison between the two processing methods

Characteristic	With KUKA Kr 125	With 3 axis CNC
Work speed	Maximum (of the milling machine)	Maximum
Number of clampings	1	4
Cutting depth	3 mm	3 mm
Strength	Medium	Maximum
Wotking plan	Any plan	Works vertically

Analyzing *table 2* we can draw the following conclusions:

➢ The CNC machine is sturdier than the robot, although at the level of the processing done with the robot we are not talking about sturdiness as if the mill is properly anchored we will not get vibrations.

➢ In order to completely process the parallelepiped part the robot will do this in one clamping, because the degrees of freedom allows it. For the 3 axis processing device a new positioning for each side is necessary, fact which leads to a longer processing time.

➢ According to the type of mill, on the robot we can adopt a maximum speed of the milling device or we can mount a broach with very high milling speeds on the robot while the 3 axis machine is limited to the maximum speed imposed to the machine.

➢ The robot, because of the big number of freedom degrees can work on several plans, sidelong or on complex spatial courses, while the 3 axis processing device is limited to the vertical plan, and therefore in processing the part.

➢ If we took into consideration a 6 axis processing device then the cost price would be much higher than of a robot which has the same amount of work, so it would not be profitable.

➢ The processing device has a protected volume, so that all waste from processing is not thrown away, and the robot must be added a vacuum cleaner for the dust and for the removed material. Otherwise, it can work in special arranged rooms, where the removed material does not harm the environment.

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