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Application of the RobotStudio software package for programming assembly robots

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Abstract: *Changes in world trade in goods and services, directed towards the globalization of the market and the desire of manufacturers to meet the demands of each individual customer, imposes ever more stringent demands on existing technology systems. The application of robotic systems in assembly significantly improves the performance of this technological system, reduces the time of assembly, increases the productivity and quality of assembled products. The paper presents the application of the RobotStudio software package for programming the work of the robot for assembly. An analysis of the assembly technology of the sub-assembly of the shaft was done, which is necessary in order to get the code used by the robot in the software package.*

Keywords: *Robotic systems; robot programming; assembly; modeling;*

1. INTRODUCTION

Nowadays, the world faces an accelerated development of science and technology and is in one of the stages that we often call the stages of revolutionary change. The development of the technique and the means of production was not even. The periods of accelerated development and relative stagnation were shifted. The most famous developmental jump, known as the Industrial Revolution, took place at the end of the eighteenth and early nineteenth century. It began in 1733 with the emergence of mechanized looms for weaving. The next major invention was a steam engine (1769), followed by a boom in the development of the technique and the means of production, from which came the name industrial revolution. Historically, there are a number of inventions and scientific achievements that have markedly marked the technical development of the world in certain periods. The development of science and new technologies, suggesting qualitative changes in production and society in general [1].

One of the essential factors of the new revolution is flexible automation, the inseparable part of which is robotic systems. The idea of robots originated first in science fiction. Even today, in discussions about robotic systems and everything they bring, it is difficult to avoid vision in the field of science fiction. Of course, robots are looking much more practical today because the stage of technology development allows this. These are very complex devices that could have arisen when those branches of science were developed on which today's robotics are based: machine theory, automated control theory, computer technology, so-called methods. artificial intelligence, as well as sensor and converter technology. Robots are now seen as devices that allow for further and more flexible automation. They replace a man primarily in dangerous, monotonous and difficult jobs. Man remains jobs that require more intelligence, knowledge and creativity. Thus, robot systems contribute to the simultaneous increase of productivity and humanization of labor. The cost of product assembly significantly affects the total costs of its production and, therefore, the profit of the company. This is one of the reasons why it is necessary to make improvements and, in some cases, reengineering the process of assembly of the products of the metalworking industry. Based on the analysis carried out in the assembly sector of the 355 German companies in the machinery industry, it is pointed out that the main potentials of rationalization lie in designing the products, which are oriented towards assembly, and in the automation of assembly operations [2].

2. ANALYSIS OF THE TECHNOLOGY OF DISTRIBUTION OF THE DISTRIBUTION SHAFT

The mounting assembly consists of the pump body (position 15), the distributor shaft sub-assembly (position 25), the gaskets (positions 27 and 8), the ring (position 26), and the sub-assembly of the pad (position 24), Figure 1.

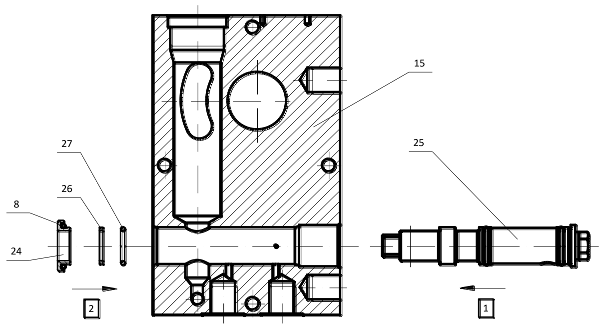

Figure 1. *Assembly Plan of distribution shaft*

The subassembly of the distribution shaft (Figure 2) consists of: a distribution shaft (position 25), a ball (position 23), two seals (position 27), springs (position 16), screw (position 18), washers (position 17), seals (position 20), and O-ring (position 31).

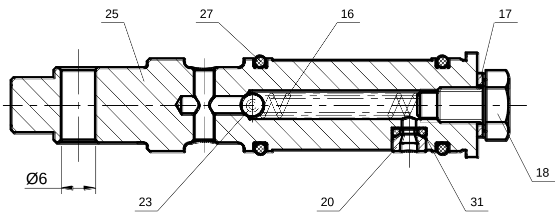

Figure 2. *Distribution axis (cross-section)*

The distribution shaft (position 25) is made of CuZn20.00 (brass), the outer cylindrical surfaces are machined with scraping and straight (quarter) milling. Holes and openings are made by drilling and depending on the class of roughness, expansion and expansion. The opening of the edges of the opening is carried out by the roller and conical feeders. The dimensions of the distribution shaft are Ø18h82,5mm. The Ø6 / Ø2,5, Ø5,2 / Ø3 and Ø3,5 holes on the distribution shaft are through which the working fluid passes. These are openings that divide the working fluid according to the corresponding openings on the body of the pump.

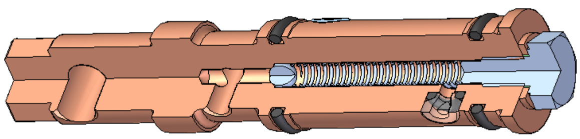

Figure 3. *3D model of distribution shaft (cross-section)*

The sub-assembly of the distribution shaft performs the key role of pump management. A handle is mounted in the opening Ø6 by means of which the control shaft is operated, i.e. the distributor shaft is rotated to the appropriate position to allow the flow of the working fluid through appropriate barriers on the distribution shaft and the body of the pump.

The pump body (position 15) is made of synthetic gray cast iron without oligo-elements (SL25). Flat surfaces are machined with milling. The holes, openings and edging of the edges are performed as with the distribution shaft. The groove is made by milling. The dimensions of the pump body are 80h30h130mm. The hole for mounting the distribution shaft is Ø16, the roughness class N6, which is extended to the Ø18 at the front, 17.5mm in length from the edge of the opening, which is 1/15 °. Between the diameters Ø16 and Ø18, a transitional cone is

made of 1.8 / 45 °. The other side of the opening is 1.8 / 15 °. There are also openings for the inlet and outlet of the working fluid.

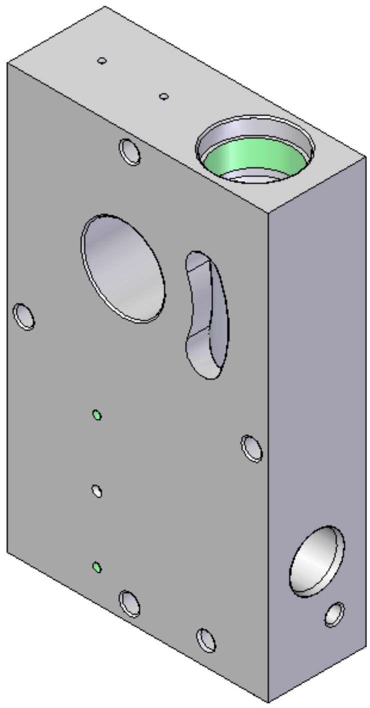

Figure 4. *3D body model of the pump*

3. STARTING AND SELECTING A ROBOT SYSTEM IN THE ROBOT STUDIO SOFTWARE PACKAGE

The simulation was made in the RobotStudio software package (hereinafter RS), version 5.15.02, of the ABB company whose robot is used. After starting the program, select Create new station, and then the Empty station project (Figure 5).

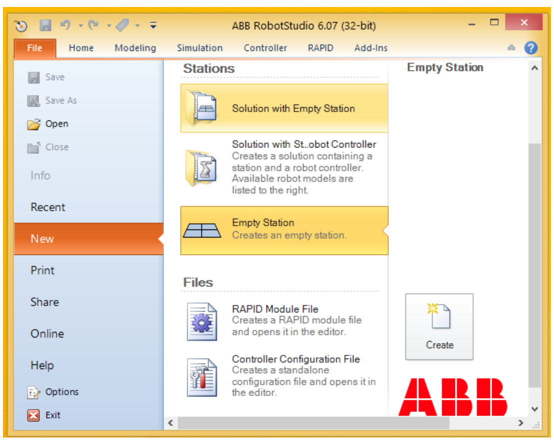

Figure 5. *Create a new empty project*

According to the task the robot needs to do, we choose the desired robot for assembly. In our case, this will be the robot IRB 140, from a series of small industrial robots. The IRB 140 has a load of 6 kilograms. It is primarily intended for work: assembly, packaging, cleaning, material handling, etc. (Figure 6).

Figure 6. *ABB robot IRB 140*

When introducing robots into the technological system of assembly, a number of technical and technological criteria should be considered. It is necessary to pay attention to the robot working space defined by the manufacturer [3] (Figure 7).

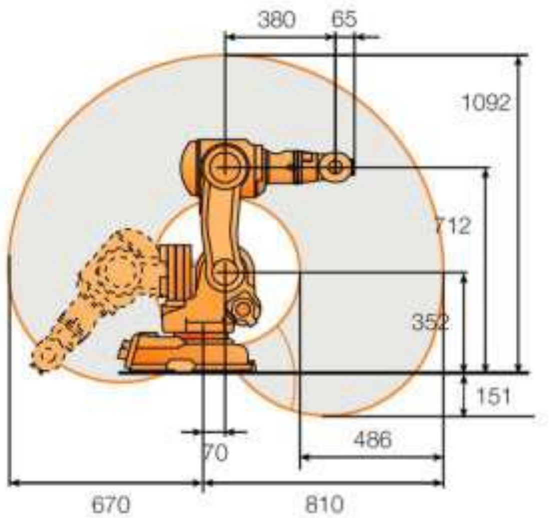

Figure 7. *Robot working space ABB IRB 140*

In order to introduce the robot model into the workspace, in the RS software package, it is necessary to use the ABB library option and select the robot IRB 140. After that, it is necessary to introduce into the program of the robot stand and the table where the assembly process takes place. In RS, we use the Import Geometry option by importing table models converted into the appropriate format (.SAT). Imported models are positioned relative to the robotic coordinate system (Figure 8, Figure 9).

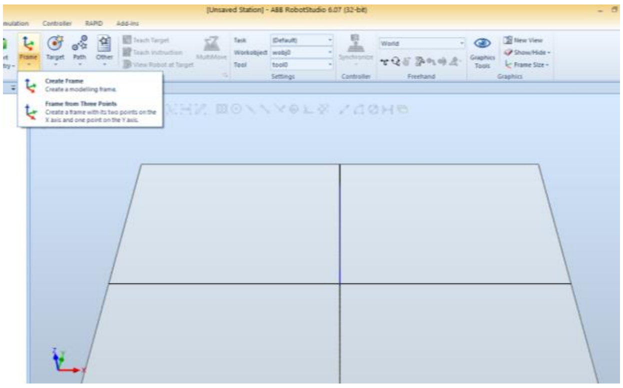

Figure 8. *Positioning of the imported geometry*

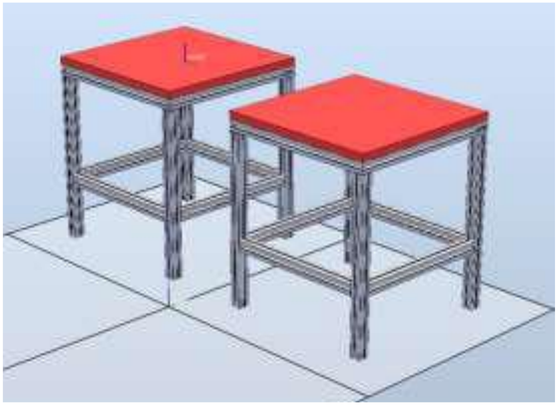

Figure 9. *Positioned tables in the workspace*

After positioning in the workspace, which is important for us to know exactly where the object is located, we place the IRB 140 robotic arm on the first working table with the Set position option. It is necessary to install the components to be installed on the second table (Figure 10).

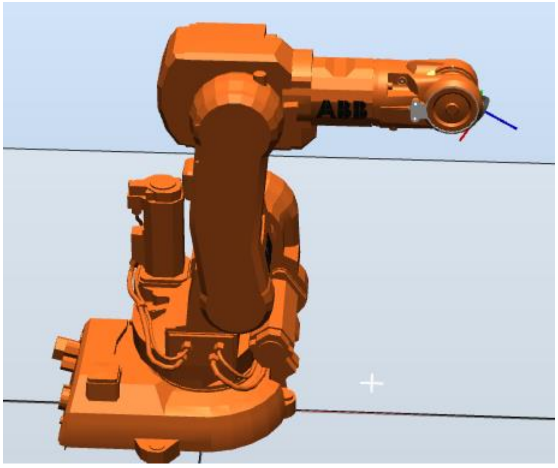

Figure 10. *Positioning the robot on the desk*

When placing robots and deciding about the position of the working model, it is necessary to take into account the maximum range of robots (the IRB140 has a maximum range of 810mm) and this robot can perform the assembly process.
The robotic arm has the ability to attach various mounting tools. It is important to pay attention to the central point of the tool (TCP; tool center point) ie. its coordinate system. At that point, the robot has a clamp where mounting tools are installed [4] (Figure 11).

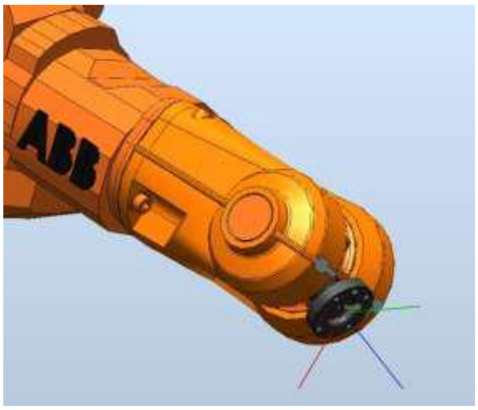

Figure 11. *Display TCP and tooltip*

4. Application of Robot Studio software package for determining the path of robots for mounting the distribution shaft

To be able to "drive" a robot at the desired installation path, we need to "learn" where these paths are. Consideration should be given to the installation technology so that the robot's paths during installation are as simple as possible. The main option of the RS to generate the path of a robotic arm is Path, AutoPath. It is located in the Home window, in RobotStudio (Figure 12)

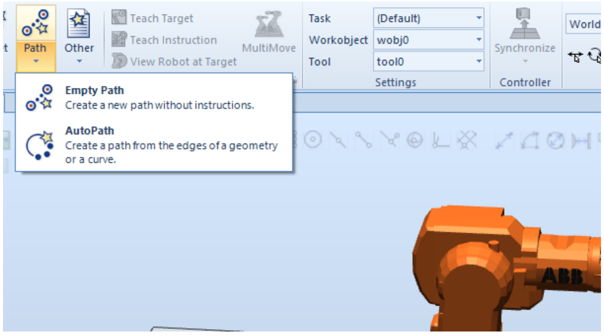

Figure 12. *AutoPath option to generate routes*

After marking all the desired paths for mounting, it is in order to set the basic orientation of the PKI mounting tool. We set this position to be in line with the central tool robot point. This was done in a way that we marked the position ie. target number 10 (Target 10), and with the Modify Target tool, Set rotation, determine the position of the mounting tool (Figure 13).

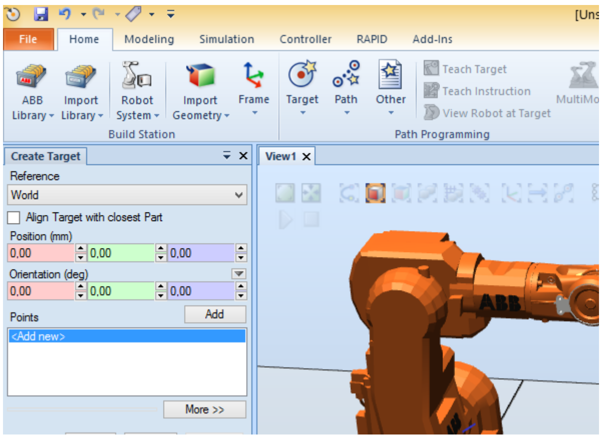

Figure 13. *Setting the basic position of the tool*

After positioning as in Figure 13, right-click the same target (target) and select the Copy Orientation option from the drop-down menu. The next step is to mark all the positions (targetes) in the dropdown menu of our work object (workobject) and right-click to open the drop-down menu and apply the same orientation to the whole set (Apply orientation). After the correct basic orientation, the necessary step is to re-mark all the positions of the mounting tool (target) and use the option to check the availability of all positions (Reachability). We see a check in Figure 14.

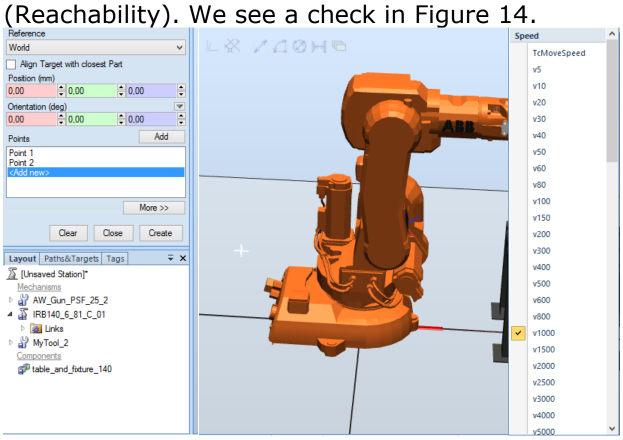

Figure 14. *Check availability of movement position*

With the availability of all robotic arm positions, we begin with the configuration of the path of the robotic arm towards the chosen path. This will be done by marking the path of the robot arm from the Path tools category, select the Auto Configuration tool (Figure 15). After choosing a robot path configuration, we can repeat the use of the Auto Configuration tool to see the simulation of robot traffic along a given path.

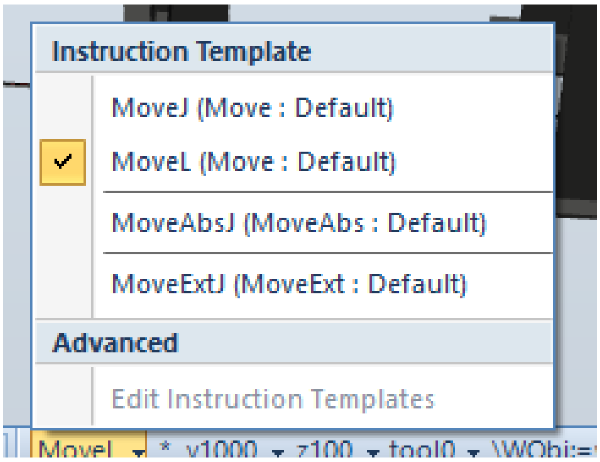

Figure 15. *Configuring the movements of a robotic arm*

The procedure is repeated for each path. Check the available movement and possible gestures in the gestures. It is possible that the robotic arm, using a linear movement, can not reach the desired position. Then the first option is to define motion as a movement of a joint (MoveJ; move joint). This is done by choosing Move; Path and using the Modify instructions to change the type of motion from the linear to the joint, (Figure 16). In the presented

Modify Instructions, it is also possible to change the speed of the movements of the robotic arm.

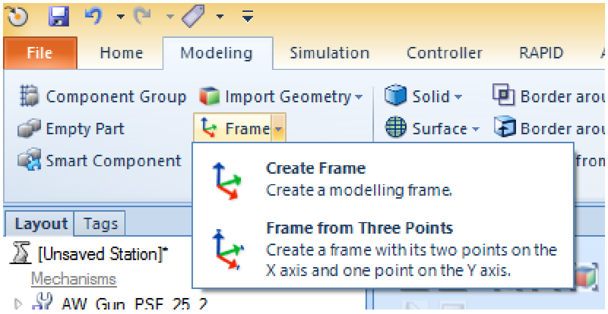

Figure 16. *Option to change instructions*

5. Simulation of the assembly process in the Robot Studio software package

After making the path, it is necessary to create a simulation of the given assembly. First, we need to choose the robotic system that we will use, in our case, this is the IRB 140. We do this in the way that under the Home part of the RS, we select the Robot System option, and set the system for our selection of the robotic arm.

The next step is synchronization with the virtual controller in RS. In the program under the part RAPID, we use the Synchronize to VC option, marking all the options, starting the synchronization (Figure 17)

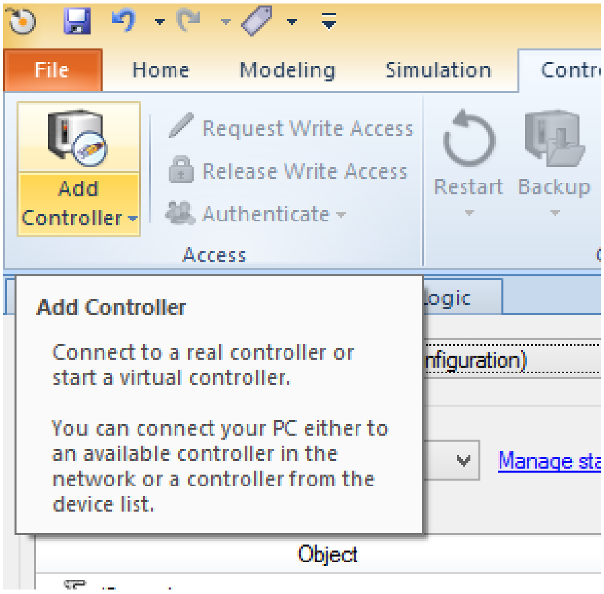

Figure 17. *Synchronization of the virtual controller*

After the synchronization has been performed, it is necessary to set the order of installation according to the set paths. This is done under the part of the RS program, called Simulation. Select the Simulation setup option. In the newly opened window, from the available Procedures for assembly, we route the routes to the main sequence of the robotic arm (Main Sequence T_ROB1). By selecting Active Tasks, by marking our previously created robotic system, it is possible to select the execution of the main sequence continuously or only one cycle (Figure 18).

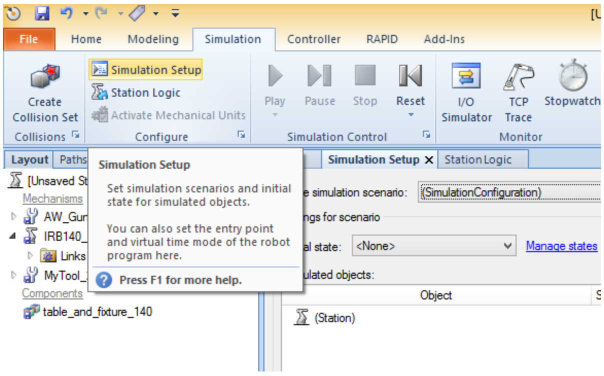

Figure 18. *The main sequence of the simulation*

After selecting the routes for executing the main sequence of the robotic arm IRB 140, it is only necessary to run the assembly simulation process, simply by commanding the Play command from the simulation part of the RS program. The robotic arm performs assembly by default, with minimal error, high precision and high speed.

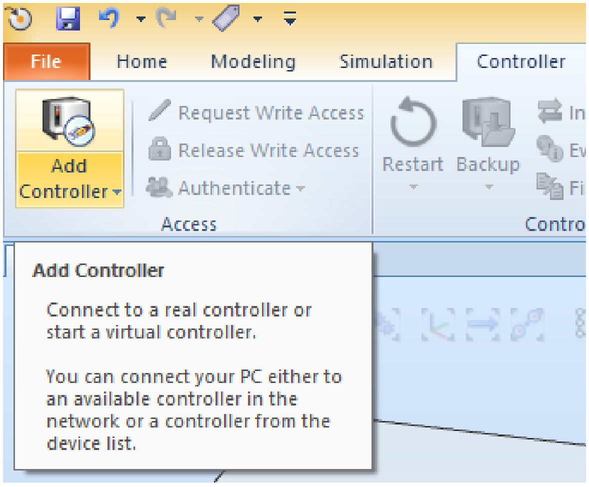

Figure 19. *Synchronization of the virtual controller*

The environment in which the assembly process takes place is shown in Figure 20.

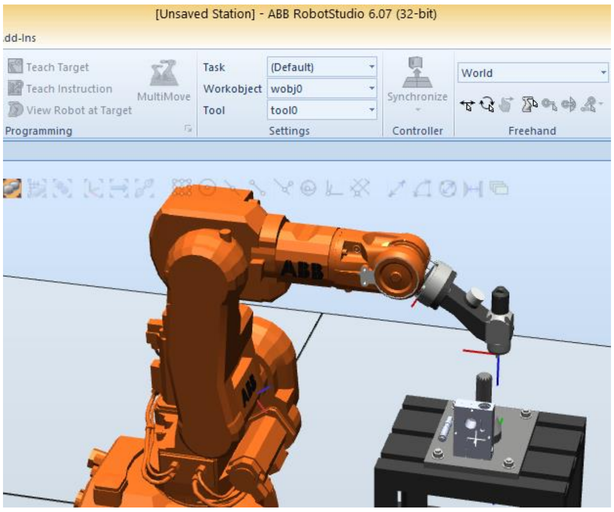

Figure 20. *The main sequence of the simulation*

6. Conclusion

Application of the robotic system in the assembly process significantly reduces the time of assembly and increases the productivity of the company. It is necessary to analyze the installation technology of the product itself so that the robot performs the assembly process in the shortest possible way and in the best possible way. Robot programming itself is very easy with graphic support in the form of images that simply describes what needs to be included in a program for simulating the robot operation, and then generates the code for managing the robot operation.

This paper discusses the process of assembling a single sub-assembly, but this robot programming process can be applied to assemble the entire manual pump. Two robots working simultaneously can be programmed.

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