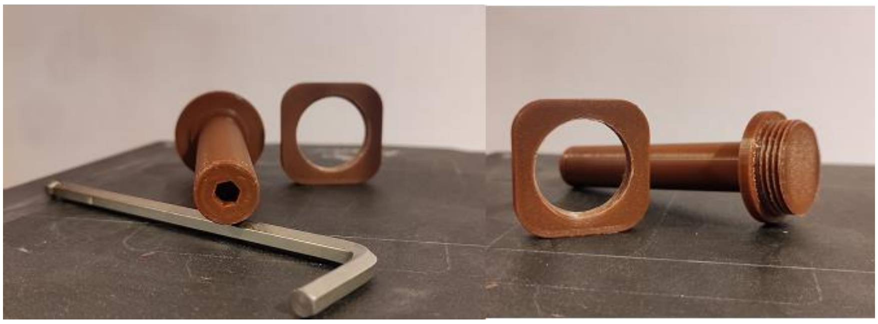

Fig. 8. Shaft and Nut

Making the drum on which the filament roller is mounted:

Fig. 9. Drum

After printing all the component parts, the final assembly was made and its functionality was tested.

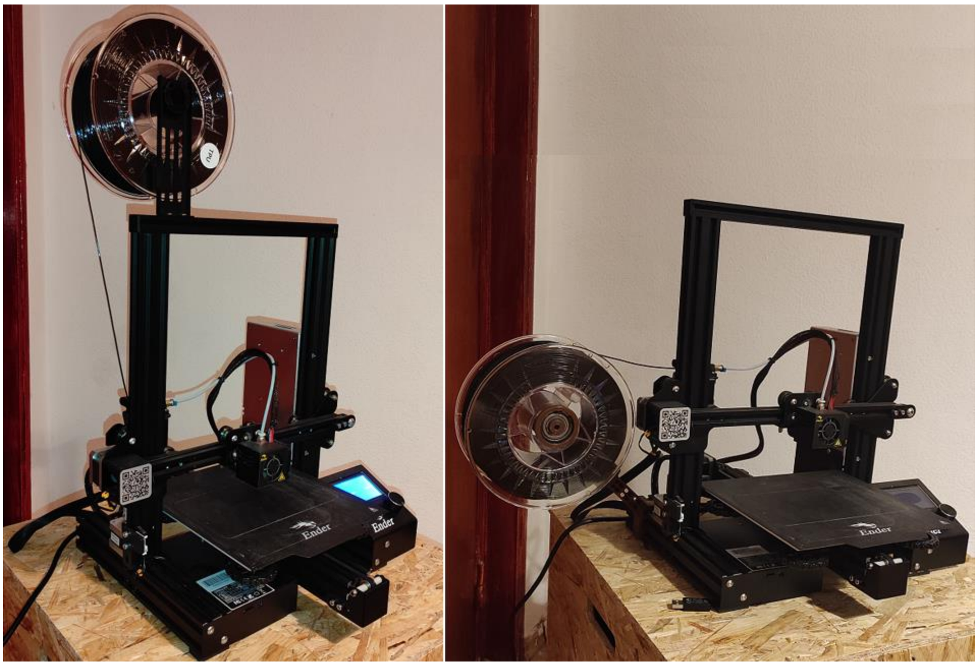

Fig. 10. Standard Holder and New One

5. Conclusions

After one year of use, the filament holder works very well without any deficiencies that affect printing. The only impediment found over time would be that the base holder has twisted which causes the axis of the filament roller to be slightly tilted in the YZ plane of the printer. This aspect can be solved by making the filament holder from a more rigid and durable material such as PETG. Also, when the printer is not in use, the filament roll can be stored separately so that the filament holder is no longer kept under pressure all the time.

Another improvement that I want to make for this printer is a two-roll filament holder that would make it easier to print in two colors on this printer designed by the manufacturer to use a single roll of filament. With such a holder the filament exchange would be done much faster so that the part does not cool during the exchange and the new material adheres much better on the surface of the part. It also reduces the risk of the printer being inadvertently misaligned when changing the filament roll, the main risk being mechanical movement on one of the axes and loss of reference which would lead to resume printing.

6. References

[1]. SU, A. and AL'AREF, S.J. (2018), *History of 3D printing. In: 3D Printing Applications in Cardiovascular Medicine*, Academic Press.

[2]. JIMÉNEZ, M., et al (2019), “Additive manufacturing technologies: an overview about 3D printing methods and future prospects”, Complexity, 8-13.

[3]. Palermo, E. (2013), Live Science, [Online] Available at: https://www.livescience.com/39810-fused-deposition-modeling.html [Accessed 03 4 2022].

[4]. Polak, R., Sedlacek, F. and Raz, K. (2017), “Determination of FDM printer settings with regard to geometrical accuracy”, In Proceedings of the 28th DAAAM International Symposium, 562.

[5]. Evans, J. (2022), 3D Beginers, [Online] Available at: https://www.3dbeginners.com/what-is-fdm-3d-printing/ [Accessed 03 04 2022].

[6]. Behzadnasab, M. and Yousefi, A.A. (2016), “Effects of 3D printer nozzle head temperature on the physical and mechanical properties of PLA based product”, In 12th International Seminar on Polymer Science and Technology, 2.

[7]. Hiemenz, J. (2011), “3D Printing with FDM: How it Works”, Stratasys Inc, 1,2-5.

[8]. Anon., n.d., Wikipedia, [Online] Available at: https://en.wikipedia.org/wiki/Creality [Accessed 05 04 2022].

[9]. Anon., n.d., 3D in the Box, [Online] Available at:https://www.3dinbox.ro/cumpara/creality-3d-ender-3-pro-1013 [Accessed 12 03 2022].

[10]. EKINCI, A., et al (2021), “Mechanical and hydrolytic properties of thin polylactic acid films by fused filament fabrication”, Journal of the Mechanical Behavior of Biomedical Materials, 1.

[11]. Ilyas, R.A., Sapuan, S.M., Kadier, A., Kalil et al (2020), “Properties and characterization of PLA, PHA, and other types of biopolymer composites”, In Advanced Processing, Properties and Applications of Starch and other Bio-based Polymers, 115-116.

OFFLINE PROGRAMMING OF WELDING ROBOTS

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SUMMARY: Programming robots to perform welding processes is challenging in terms of the requirements for the availability of robotic cells to perform initial tests. In this context, a time and material saving solution is offered by offline programming of robots. The paper presents the possibility of offline programming of welding robots, in particular the programming of a Fanuc robot type ArcMate 100iC, by means of the software solution called "Roboguide". The necessary programming steps will be presented in order to realize the necessary path for circular corner welding of pipe-to-plate components using the "Roboguide" software.

KEYWORDS: welding, industrial robot, programming, offline programming

1. Introduction

1.1. Welding Robots

The expansion of mechanisation and automation of manufacturing processes is one of the most important aspects of the development of manufacturing forces both globally and especially nationally. In the particular case of welding processes, the expansion of mechanisation and automation is the most pressing task facing machine-building companies in the near future.

In the field of robotic welding there are various options for automation and mechanisation of the process. Depending on the proposed application to be realised, there is a multitude of manufacturers offering robotic solutions. These include Fanuc, Kuka and ABB Robotic.

1.1.1. Fanuc

The FANUC ARC MATE 100iBE robot is a robot in modular construction with 6 axes of motion, designed for very high precision. The FANUC ARC MATE 100IBE robot is compatible with all brands of welding equipment and can be programmed point-to-point. It weighs 238 kg. It operates at temperatures between 0°C and 45°C and can withstand a maximum load of 6 kg.

1.1.2. Kuka

The KR 70 R2100 has a streamlined, 6-axis design with greater flexibility; and with a single click you can adjust the movement of the robots to various processes, ease of installation even in compact cells as it has multiple installation modes (floor, angle, wall, ceiling). It has the largest operating range in its class, is suitable for various applications and can be tailored to specific requirements, and presents a low investment for a wide variety of tasks.

1.1.3. ABB Robotics

The IRB 2400 comprises a complete family of application-optimized robots that maximize the efficiency of arc welding, processing and tendering applications. The IRB 2400 is a dedicated high performance robot for process applications where the required accuracies are very demanding. All models offer reverse fit capability. The compact design of the IRB 2400 ensures ease of installation. Robust construction and use of minimal parts contribute to high reliability and long maintenance intervals.

Fig.1. FANUC ARC Mate 100IBE robot (left) and KUKA KR 70 R2100 robot (right)

Fig.2. IRB 2400 Robot

1.2. Offline robot programming possibilities

1.2.1. Roboguide

ROBOGUIDE is a software developed by FANUC to perform most of the operations that can be done on a real robot, but in a virtual environment this offers increased flexibility and overall speed of work as well as a much more efficient possibility to organize activities.

1.2.2. KUKA.Sim

KUKA.Sim is a software developed by KUKA. It creates an identical image of the production process afterwards. The 3D simulation covers the entire planning process: from process design, to visualisation of material flows and bottlenecks, to PLC code. The data is 100% consistent, which means that the virtual and real controllers work with exactly the same data. In this way, KUKA.Sim creates the basis for virtual commissioning, so that new production lines can already be tested and optimised in advance.

1.2.3. Robot Studio

Robot Studio is built on the ABB Virtual Controller, an exact copy of the real software that runs robots in production. This allows very realistic simulations to be carried out using real robot programs and configuration files identical to those used on the shop floor. RobotStudio comes with a complete package of features and add-ons that enable seamless offline simulation, reducing risk, speeding up start-ups, shortening changeovers and ultimately increasing productivity.

2. Offline programming of Fanuc robots

2.1. Roboguide Software

In the ROBOGUIDE program the following types of activities can be done:
- Programming any Fanuc robot model;
- Programming several robots simultaneously;
- Virtual creation of the entire robot cell;
- Import external 3D models as well as existing ones into your own database;
Modelling primitives (cubes, cylinders, etc.) to create secondary models (supports, panels, etc.) ;
- Create additional robot axes;
- Simulation of robot trajectories and operations and of equipment controlled by the robot;
- Automatic creation of trajectories;
- Record simulations to video files.

2.2. Equipment used

2.2.1. 3D model of the components to be joined

The welded sample (Fig. 4) consists of an 8 mm thick plate with dimensions of 400x400 mm and a 10 mm thick square profile with dimensions of 220x220 mm. Both components are made of material S355 JR.

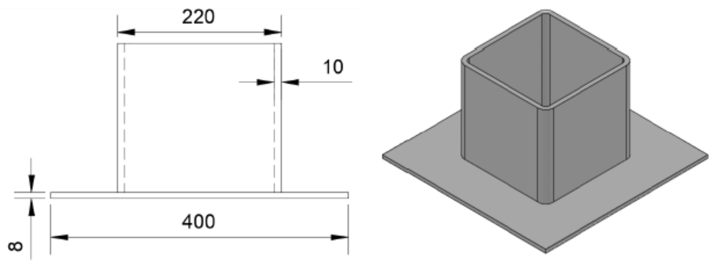

Fig. 3. 3D model of the welded sample

2.2.2. 3D model of the welding robot

The robot used is the FANUC ARC MATE 100iBE, also found in the robotic welding laboratory of the Quality Engineering and Industrial Technologies department.

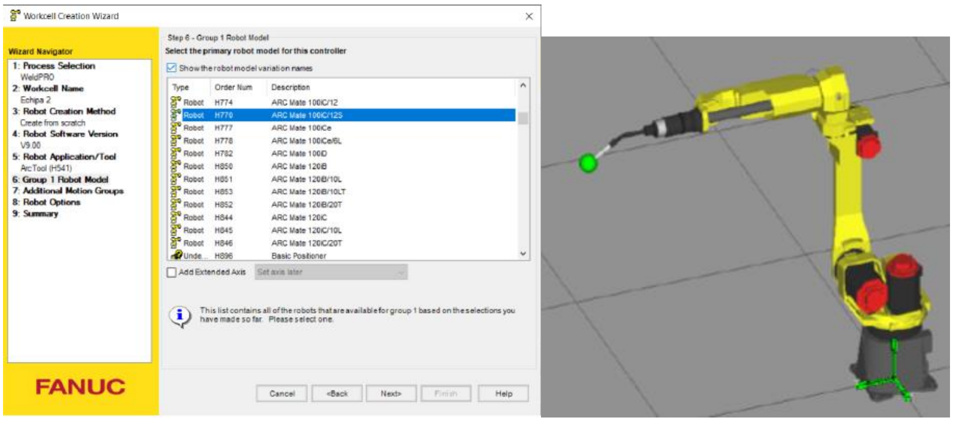

Fig. 4. Robot model selection (left) and 3D model of the ARC MATE 100iBE (right)

2.2.3. Welding torch

In the Arc Tool welding module the welding head was chosen from the software library.

Fig.5. Welding torch used in the "Roboguide" program

2.2.4. Positioning table

The positioning table is chosen by selecting Add Fixture-Single CAD File.

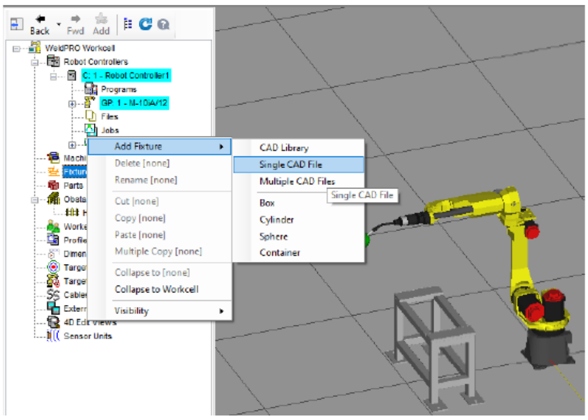

Fig. 6. Welding table in the „Roboguide” program

2.5. Choice of flange type

The "Roboguide" program allows us to choose between several models of flanges, we will choose the one corresponding to our model.

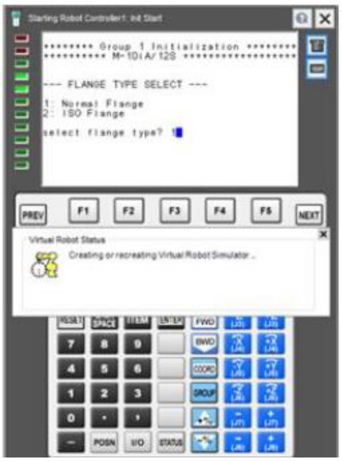

Fig. 7. Flange selection

2.6. Defining coordinate systems

UFRAME represents the coordinate system of the robot, while UTOOL represents the coordinate system of the robot relative to the tip of the welding torch (wire-electrode).

Fig. 8. UFRAME and UTOOL inseration

For the movement of the robot it is necessary to define the coordinate system relative to the welding robot and the work tool (welding head).

When positioned in the welding coordinates the arc start point is defined with the Weld Start command. Depending on the length and complexity of the weld bead new intermediate welding points can be defined by calling the Weld point command. The end of the weld bead is defined with the WeldEnd command. Moving the robot between intermediate points can be done with the remote control shown in the bottom right corner of fig 9.

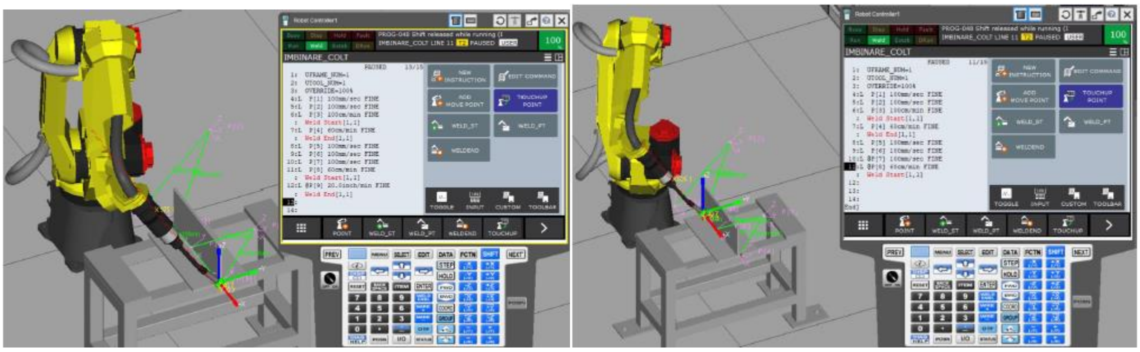

Fig. 9. Memorarea punctelor de început și finale de sudură

3. Conclusions

This paper presents the possibility of offline programming of welding robots. Offline programming offers a number of advantages such as:

-time savings through simulations in a virtual environment;
-economy of materials;
-reduced work cell load;
-in the context of recent restrictions, programming can be done from anywhere;
-without requiring direct interaction with the robot in the production hall;
-developing the new concept of Industry 4.0.

4. Bibliography

[1]. C. Rontescu, Gh, Mazareanu– *Mecanizarea si automatizarea proceselor de sudare*, Editura Printexh, 2011, București

[2] https://www.fanuc.eu/ro/ro/robo%C5%A3i/accesorii/roboguide

[3] https://new.abb.com/products/robotics/application-software/arc-welding

[4]https://www.kuka.com/en-de/products/robot-systems/software/planning-project-engineering-service-safety/kuka_sim