ENGRAVING WITH LASER ON AN ARTICULATED SIX-AXIS KUKA ROBOT

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This paper has the objective to present the integration of a laser in an engraving operation on an articulated six axis robot KUKA KR 6 R 700-2. For this process we used this educational robot to improve from the cartesian structure which prove to be inaccurate. The laser that is used for this operation is a FB03, 4th class. It can engrave on different wooden materials by etching permanent, deep marks. Up to this point we were able to engrave the outline of some letters and geometrical shapes. After optimizing the current applications, we will move on to engraving on different planes other than XOY, XOZ, YOZ, also spherical and cylindrical surfaces.

Keywords: laser engraving, articulated robot, cartesian structure, 3D engraving

1. Introduction

The engraving with laser is used usually on a cartesian structure. We saw an opportunity, improving the application by moving the laser from the last structure to the six-axis robot. The laser used for this operation is FB03, 4th class, with 10 mm minimum focal distance. We've found out that the laser we use work on poplar wood without any unexpected difficulties.

Our six-axis robot used for this application is a KUKA KR 6 R 700-2. The improvement from the first structure reached an accuracy of a high precision, about ±0.02mm, and the facility to use 726 mm of workspace.

2. Overview

The image (fig. 1) contains the view of the first structure, where the laser was mounted on, however this structure proved to not be the best option for engraving, so the availability of a six-axis robot from KUKA was the best option to optimize the engraving process itself. The vibrations were significantly reduced. The interface of the robot, it's easier to understand and use, for us as students of Industrial Engineering and Robotics.

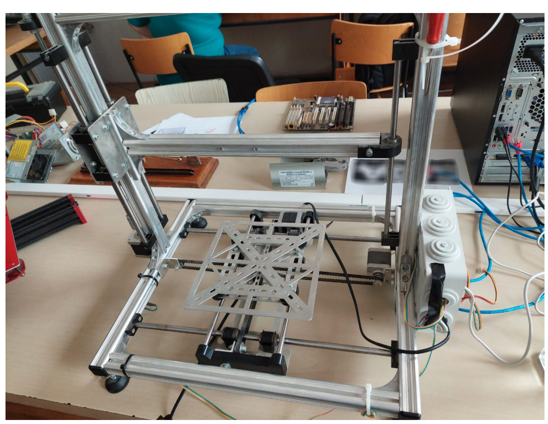

Fig. 1 The first structure

When we are talking about interface, we talk about the teach pendant, and the KUKA sim 4.0 software. The teach pendant interface looks like the Windows's interface, as a lot of us are used to it, it's simple to understand, to manipulate the robot and its workspace (fig. 2).

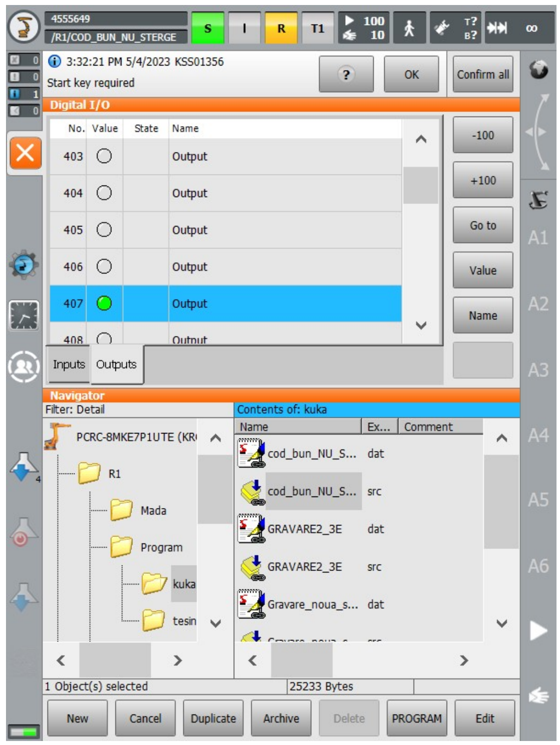

Fig. 2 Teach pendant interface.

KUKA Sim 4.0 was used to declare the points and the trajectory of the tool (laser), to realize the contour of the letters, or the geometrical shapes. In this software we created the codes, and applications of engraving process, by putting the right coordinates of the TCP, where we used a 3D CAD of the laser model with the focal distance. In the next image (fig. 3) we can see the KUKA Sim 4.0 interface, and the letter K. We have the tool path option on to preview the whole process. At that time, we didn't have a CAD added to the robot flange. However, in this image we can see the tool path from the home point to P1, and back.

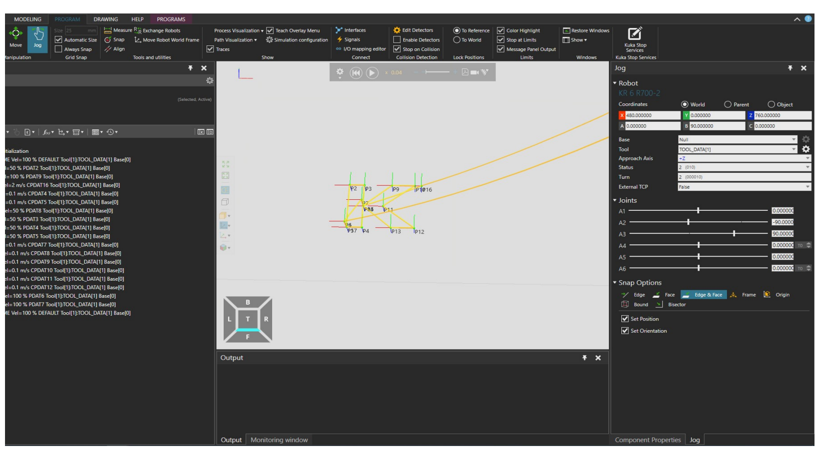

Fig. 3 Simulation on KUKA Sim 4.0

3. Rear electronics and laser connection

In the next image (fig. 4) we can see the laser we used for this application, a FB03, 4th class laser, as we mentioned earlier. To fix it to the robot flange, we made an adaptor using the 3D printing technology. The orange adaptor is used to expand the possibility of mounting different types of tools. The white adaptor is made to connect the laser to the robot. We chose this orientation in order to minimize the length of the end-effector. To further protect the connections between electrical components, a dressing was used (fig.6). Thus, we also tidied the cables and fixed them to some points on the robot so the accidental disconnection will not occur.

Fig. 4 FB03

A Zener diode (fig. 5) is a special type of diode that is designed to operate in the reverse breakdown region of its voltage-current characteristics. Zener diodes are commonly used in electronic circuits for various purposes, including voltage regulation, voltage clamping, surge protection, and voltage reference generation. They are often used in power supplies, voltage regulators, and in circuits that require stable and precise voltage levels. When a Zener diode is reverse biased and the applied voltage reaches its specified breakdown voltage (known as the Zener voltage or Zener knee voltage), it starts conducting current in the reverse direction. The Zener diode's breakdown region is highly stable, meaning that a small change in the reverse voltage does not cause a significant change in the current flowing through it. For our purpose, the diode was used to prevent a power surge in the laser. By regulating the voltage, we get a constant flow of light and the mark left on the plaque is consistent. The laser input is 5V and output from the robot is 27V, so the best option was to integrate the diode. In the (fig. 5) we can also see the electrical scheme of I/O signals with Zener diode.

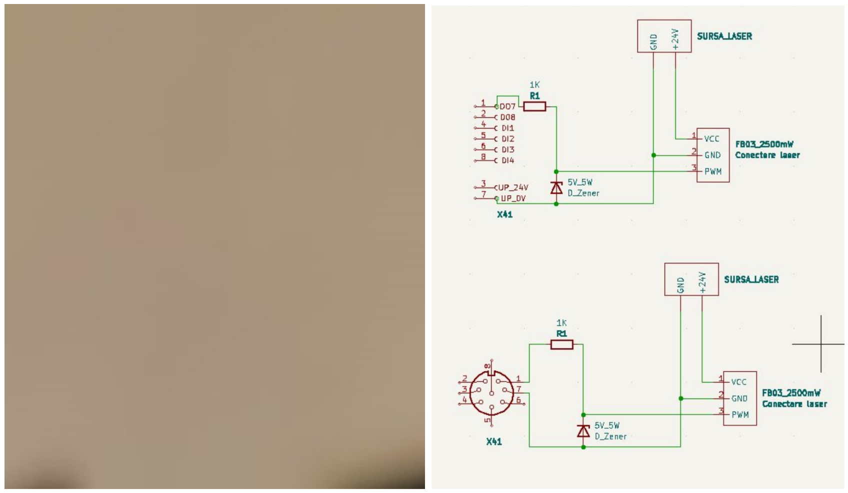

Fig. 5 Zener Diode and electronic scheme

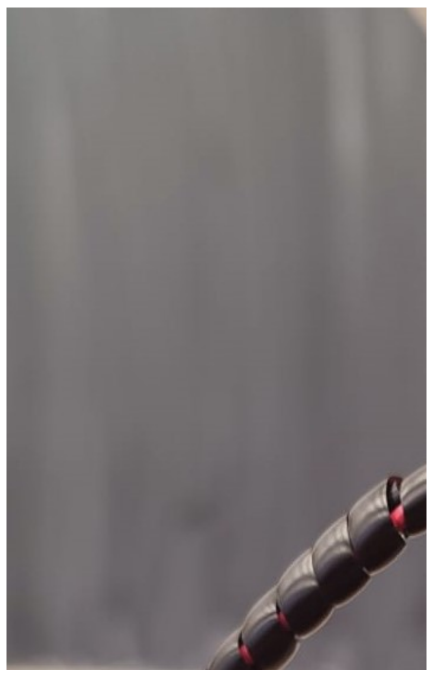

Fig. 6 The dressing

4. Engraving application

About the application, the laser must be first focused on the object that is engraved. Next, we select the program with the desired shape and the process can begin. The light emitted heats up on the focus point and leaves behind a deep mark on the object. The faster the laser is moving the shallower the mark is. For a good result, we must find the correct constant speed. What problem we encountered were any sharp angles. In that point, the laser stops briefly but long enough to leave a noticeable dot. The solution was creating a block spline, which realizes the optimal path between points declared in application. We also changed the time while the robot stays in a point from the block spline, engraving the shapes without additional dots. In the next image (fig. 7) we have the robot in the middle of execution of the new code, assisted by a human operator. This was also a test, the human operator, looking at the software, observing if the robot respects the code, or there are abnormalities.

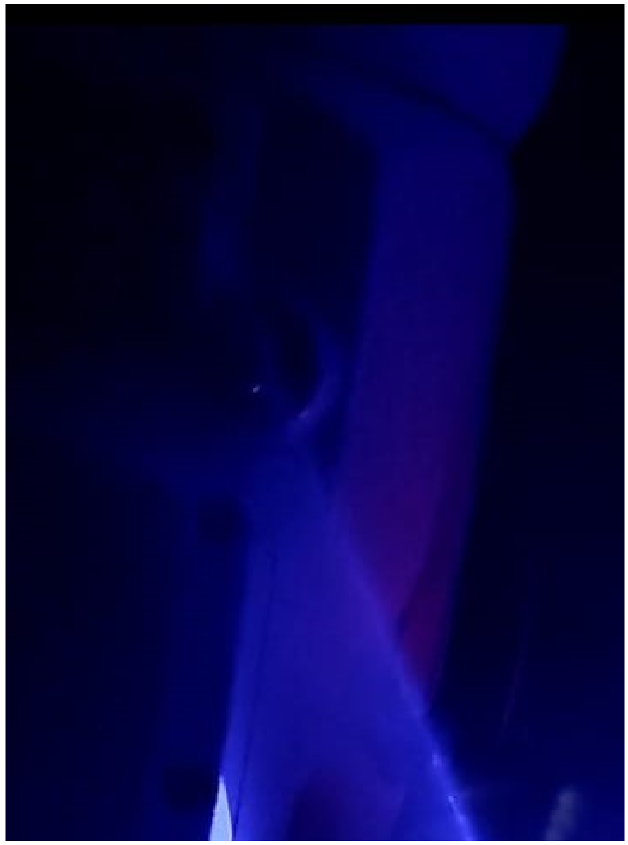

Fig. 7 The laser beam

To eliminate the need of human interaction, the port X41 from the A4 interface (fig. 8) was put in use. Because we did not need all the pins, a custom port was made just to command the laser through the teach pendant. Now the application does not require the human operator to get close to the workspace.

We can also see the signals in (fig. 2). There are implemented in the using code, before and after the block spline.

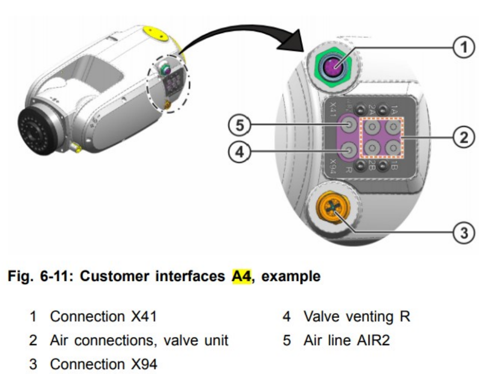

Fig. 8 I/O control

5. Conclusions and future work

In conclusion, integrating a laser into a wooden engraving application on a six-axis robot offers advantages such as precision, speed, versatility, customization, consistency, and automation. However, it is essential to consider safety measures and ensure compliance with regulations to maintain a safe working environment. For this reason, we would like to make use of a dedicated cell with blue light filter panels instead of safety goggles. In this way, we can make the process safe for everyone around it. After this cell, we can automate the process by adding a system for loading the next poplar plaque and a system to eject the final product. The next step for us is to research and develop a solution for 3D engraving. This technology fits perfectly with our articulated robot arm.

6. Bibliography

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