Robotized application of assembly and soldering – case study

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Abstract. Robotic assembly is increasingly encountered in various technological processes. This can also be followed by robotic operations such as soldering some components. This paper presents the robotics of two operations to which an electric contactor is subjected. The first operation is the robotic fitting of a rubber bandage. The second robotic operation is the soldering of two electrical contacts. For the transfer of the pieces, a poly-gripper is used and it consists of six grippers with jaws, each of which grasp an electric contactor. This solution was chosen due to the large number of contactors to increase the productivity of the process. The technical projects and 3D models of the gripper and the poly-gripper are shown. For each robotic operation, the structure of the robotic cell is presented and the simulation of the transfer operations of the electrical contactors from the initial positions to the workstations and then to the storage places points of view is shown too.

1. Introduction

Currently, industrial robotics is highly evolving. Robotic applications are multiplied at the level of different technological processes. These processes can be complex or simpler. There are situations when a unit of average complexity requires operations that cannot be achieved at the desired productivity and efficiency parameters otherwise than with robotic equipment. This paper presents the case of a part to which a rubber band has to be added and after completion with specific electrical components, two double-wired electric contacts have to be soldered.

Given a relatively large number of parts, a solution of simultaneous execution was chosen on six parts, with two robotized operations: adding the rubber band and then soldering the electrical contacts. Robotized soldering is widely applied to electronic circuits [1-4]. Other significant data on robotic soldering applications are given in the papers [5-10]. However, it can be specified that the papers dealing with the problem of robotic soldering are relatively few, and those that present concrete solutions are very rare, which significantly raises the importance of this paper, which is absolutely original, in addition to the literature on robotic soldering applications.

2. Description of the working assembly

The assembly envisaged is an electric contactor consisting of a base part on which several components are mounted. In a first phase, a rubber band 1 according to figure 1 a, b has to be added, after which two electrical components (2 and 3) are added and then two stitches are necessary (4 and 5, figure 1c) of the wire ends coming from these electrical components. Until the soldering of the electrical contacts, a plastic ring 6 was added to the central housing.
3. Designing the gripper and poly-gripper

In order to grip the basic part of the given assembly, a original gripper (figure 2) was proposed, whose jaws have stepped tips [11-16]. The step corresponding to the large diameter is required for gripping and displacement in order to add the rubber band when the central housing with a diameter of 20 mm is free, and the second step is required for gripping to ease handling for the soldering operation after adding a plastic ring in the central slot.

![Figure 2. Technical drawing (a) and 3D model of the gripper (b).](image)

Jaws 1 and 2 (figure 2b) are displaced by means of a part, 3 mounted on the axle of a Festo linear pneumatic motor. The horizontal positioning of the jaws is $\Delta S = \Delta d \cdot \tan \alpha$ (figure 2a). Since the number of assemblies is estimated to be large to very large (10,000 per month), for higher efficiency the solution of designing a poly-gripper (figure 3) was adopted, which contains 6 grippers arranged on a support plate, which can be attached to the final part of the robot arm. In more detail, if we used a
single gripper with jaws, the time of making a part (only applying the rubber band and then soldering
the electrical contacts) was estimated at 240 seconds, a relatively long time, which is why it was
proposed to use a poly-gripper consisting of 6 grippers, which can interact simultaneously with 6
contactors, so that the time for completing a single contactor part will be 40 seconds, which
significantly increases the efficiency of the solution used.

![Figure 3. Technical drawing (a) and 3D model of the poly-gripper (b).](image)

4. Structure and functional simulation of the robotic cell
The robotic cell was designed in two variants. A first CI variant is for the operation of adding the
rubber band, and the second CII variant is intended for the operation of soldering the electrical
contacts. The structure of the robotic cell is original and was finalized after a careful analysis of the
problem to be solved and of several known solutions [1, 4, 5]. To test the proposed solution, a
simulation of the stages of making an electrical contactor is performed, which is described below. The
simulation is useful for the validation of the proposed solution, but also for its optimization, being
possible the necessary modifications in the CAD design phase, after which the solution is put into
practice, thus the costs necessary for the modifications of the solution already made, generally
important costs being eliminated.

4.1. The robotic CI cell for adding the rubber band
4.1.1. Structure of the robotic CI cell. Figure 4 shows the structure of the robotic cell CI for adding the
rubber band. It consists of the robot 1 equipped with the poly-gripper 2, the table 3 on which the plate
3.1 is found with the parts before the rubber band is added. Then, there is table 4 on which the special
plate 4.1 is placed where the rubber band is inserted, then the gripped parts are transferred to the
second plate 3.2 on table 3. Command unit of the robot is noted with 5.

![Figure 4. Structure of the robotic CI cell.](image)
4.1.2. Functional simulation of the robotic CI cell. The robotized operation for adding the rubber band has the following main sequences (figure 5): moving the robot 1 from the initial position to table 3 (figure 5a); gripping the 6 parts on the support plate 3.1 (figure 5b); transferring the parts to the rubber banding table (figure 5c); placing the parts on the special worktop to add the rubber band (figure 5d); gripping the parts (figure 5e) and placing them on the support plate 3.2 on table 3 (figure 5f).

![Figure 5](image)

**Figure 5.** Functional simulation of the robotic CI cell.

Subsequently, the parts go into other operations to add electrical components.
4.2. CII robotic cell for soldering electrical contacts

4.2.1. Structure of the robotized cell CII. The robotized cell for soldering electrical contacts consists of (figure 6): the robot 1 equipped with the poly-gripper 2, the support table 3 on which there are the support plates for the assemblies prepared for the purpose of soldering the electrical contacts, the table 4 on which there is the soldering robot 5 of UNIX-DF404S type [17] and table 6 on which box 7 is located where the assemblies will be stored after soldering.

![Figure 6. Structure of the robotized cell CII.](image)

4.2.2. Functional simulation of robotic cell CII. The robotized operation for soldering electrical contacts has the following sequences (figure 6): moving robot 1 from the initial position to the support table 3, where the support plates containing the assemblies are located before soldering the electrical contacts; the six assemblies gripping on the first support plate 3.2; moving the robot to the soldering robot table; placing the 6 assemblies on the support plate on the soldering robot table; soldering the electrical contacts by the soldering robot using a special soldering unit; gripping the six units after soldering with the poly-gripper 2; displacement of the robot with the poly-gripper containing the six assemblies to the storage box (figure 7a) and release from the grippers of the 6 contactors with the electrical contacts soldered in the storage box 7 (figure 7b).

![Figure 7. Release from the grippers of the 6 contactors with the electrical contacts soldered in the storage box 7 (without the soldering robot 5-figure 6).](image)
Obviously, the functional simulation described can be diversified to simulate operation in different situations such as the use of a single gripper for a contactor to accurately estimate the required execution times.

5. Conclusions
On the basis of the information presented in this paper, the following conclusions can be drawn:

- In order to obtain an average complexity unit, some phases of the technological flow can be robotized;
- In order to increase efficiency when conditions allow it, poly-grippers can be used that can grip and ensure the transfer of a larger number of units simultaneously;
- Depending on the construction features, appropriate adaptations will be used to reduce the robotic components needed, such as: stepping jaws to allow the grippers to be used for different configurations of the assembly involved in the robotized operation;
- The robotic cell used can be reconfigurable so that it can perform several types of operations in that technological flow;
- In order to verify the correct operation of the robotic cell and to optimize the structure and operation by modifications without additional costs, it is useful to simulate the CAD operation of the proposed robotic solution.

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