Acta Mechanica Slovaca **26 (2): 24 - 29,** June **2022**
https://doi.org/10.21496/ams.2022.023

Acta Mechanica Slovaca
ISSN 1335-2393
www.actamechanica.sk

Control Design for Sorting Conveyor System

Oleksandr Postrygan[1*]

[1] ATS Automation Tooling Systems Inc., 730 Fountain Street North, Building #2, Cambridge, Ontario, Canada

Abstract: The article deals with the design of the control concept of the sorting conveyor device, which is controlled using a programmable logic automaton. Sensors for detecting objects are designed, and manipulation mechanisms for sorting products according to the detected properties of objects are also designed. It is possible to sort according to the material or according to the dimensions of the objects. The simulation confirms the correctness of the designed control concept. In the next part, a visualization of the simulation of the designed control concept is shown.

Keywords: Control, sensor, conveyor, actuator, human machine interface

1. Introduction

In production processes, it is often necessary to solve the automated sorting of parts with their simultaneous sorting for the purpose of their further use in the production process. These are, for example, assembly applications, defect identification, product packaging and palletizing. There are many technical processes and devices, the designs of which require a detailed analysis and simulation of operating conditions already at the conception stage. These simulation experiments will demonstrate the correctness of the concept design. Any failure of the simulation will point out errors already in the initial concept design process [1-14].

In the device, the total switching on of the machine and the total switching off of the machine are solved. However, the emergency shutdown, which will bring the machine to a safe state, is not addressed. This will be addressed in further future research.

2. Production process

In the first step, the concept of the future sorting conveyor system was created (fig. 1). It contains conveyor segments that are driven by five motors. Three inductive sensors, one capacitive sensor and one optical sensor will be used to control the conveyor. This conveyor will be controlled by Start, Stop buttons and buttons that can be used to control individual belts. There are also two mechanized arms on the conveyor that will carry items from one conveyor segment to another.

The goal of this work is the design of a sorting conveyor device, which will be able to sort products according to material design and then pack them according to defined production batches.

The task of the conveyor is to sort 2 types of blanks, plastic and iron. When the start button is pressed, the controller, using an optical sensor, checks whether the workpiece has entered the conveyor. If the workpiece has arrived, the M1 motor is turned on and the workpiece begins to move along the conveyor. Then it passes an inductive sensor, which checks what the workpiece consists of. If it is plastic, then

*** Corresponding author:** Oleksandr Postrygan, ***E-mail address:*** *oleksandr.postrygan@gmail.com*

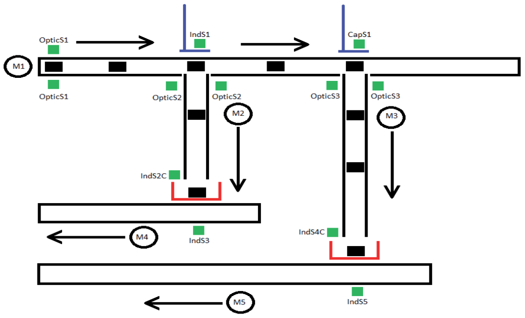

Figure 1: Concept of sorting conveyor system.

a mechanical arm is activated that moves the workpiece to the making conveyor for plastic parts. If the inductive sensor missed the part, then it is checked by the capacitive sensor for the presence of metal, after which the second mechanical arm is turned on, which transfers the part to the conveyor for metal parts.

Hitting the next conveyor is fixed by optical sensors OpticS2 or OpticS3, after which, depending on the part, the controller starts the motors M2 or M3. After the motor is triggered, the conveyor directs the part to the box, the number of parts that fall into the box is recorded by the IndS2C or IndS4C sensor. After hitting 10 parts, the conveyor stops and sends the box further with the help of M4 and M5 motors (depending on which conveyor the box was on). The arrival of a new box fixes the sensors u3 or u5 and until the new box appears, the conveyor will not start its work.

3. Design of control system – function block diagram

To create a control system, a PLC controller was chosen, and for the chosen logic, it is necessary to create a program executable in this platform.

In network1 (fig. 2), we implement the work of the first motor M1. It will turn on in two ways.

The first, if the start button is pressed and a signal comes from the optical sensor OpticS1. The M1 motor will not work if the Stop button is pressed or the M4 or M5 motors are running.

The second way to control the M1 motor is to press the MotorButtF1 button if we want the motor to work in the forward direction or MotorButtB1 button if we want the reverse to turn on.

The second network (fig. 3) includes operation implementation of the M2 engine and a mechanical arm.

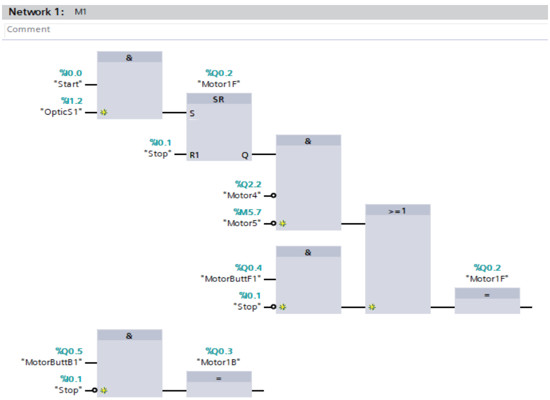

Figure 2: Network1 - work of the first motor M1

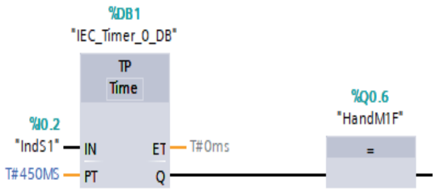

Figure 3: Network 2 - First mechanical arm working.

Here I used a timer, with the help of which, after receiving the indS1 signal, I pushed my hand forward for 450 ms and immediately pushed it back.

After the mechanical hand moves the workpiece to another line, a signal should appear on the TP timer from the optical sensor OpticS2. The timer will start the line for 3 seconds, which is enough for the workpiece to pass to the end and fall into the box. The process can be stopped by the stop button or the switched on motors M4 or M5. Also this motor can be controlled using the MotorButtF2 and MotorButtB2 keys (fig. 4).

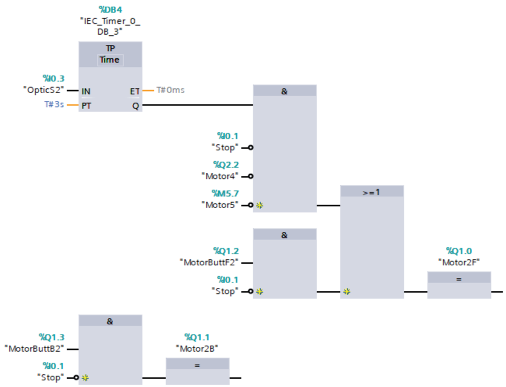

Figure 4: Network 2 - Motor M2 control.

Just like in network 2, there is a implementation of the work of the second mechanical arm, only now the capacitive sensor CapS1 and the optical sensor OpticS3 are used (fig. 5 and fig. 6).

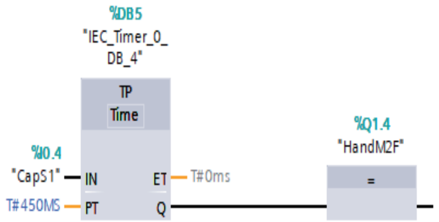

Figure 5: Network 3: Second mechanical arm working.

After draining the liquid from the master cylinder, the process of pumping the liquid back into cylinders A, B, C will begin so that these cylinders are filled up to the level of the sensors detecting the full state of cylinders A, B, C (fig. 6).

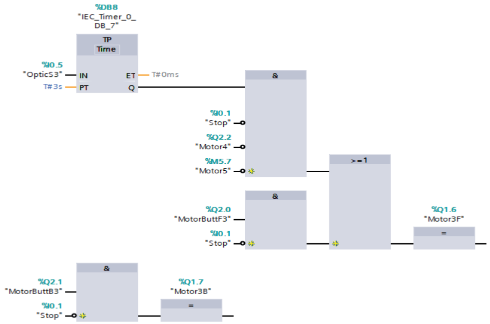

Figure 6: Network 3 - Motor M3 control.

In network 4, I use a counter to count 10 parts and sensors IndS2C and IndS3 (fig. 7).

Sensor IndS2C registers the entry of blanks into the box, and with the help of sensor IndS3 we know whether there is a box or in place. The M4 motor will work until a new box arrives and the IndS3 sensor works. At this point, all other motors do not work, and new blanks do not arrive.

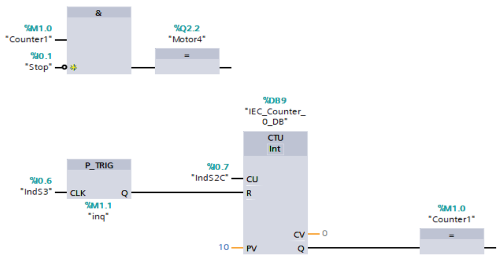

Figure 7: Network 4 - Motor M4 control.

The counter will reset after 10 parts after a new box hits the sensor IndS3. There is a need of P_TRIG so that the M4 does not turn off after the filling box passes the sensor IndS3 (fig. 7).

In the 5th network, there is a implementation of the work of the M5 motor according to the same logic as the M4 motor (fig. 8).

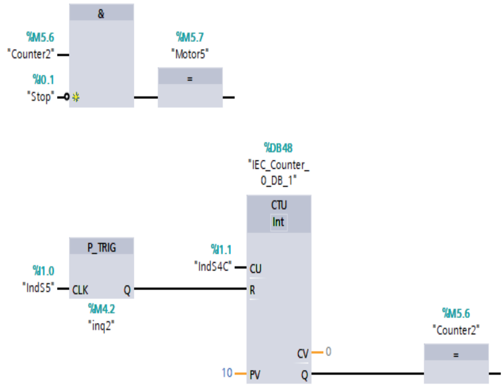

Figure 8: Network 5 - Motor M5 control.

4. Design of human machine interface

Human machine interface (HMI) is intended for service and technical personnel, who will use this device to switch the device on and off, set process parameters and monitor the current state of the device. To create this HMI panel, it is necessary to design a graphic interface and create functions that will be connected to individual graphic objects (fig. 9).Simulation of movement of metal part on conveyor is shown on figure 10. The movement of the boxes for packing will begin after counting of three metal parts (fig. 10).

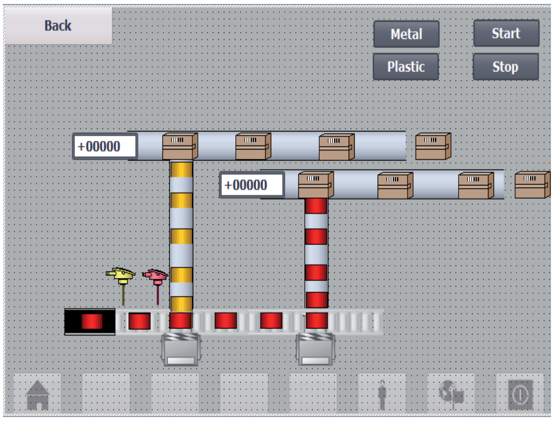

Figure 9: Graphical design of human machine interface panel.

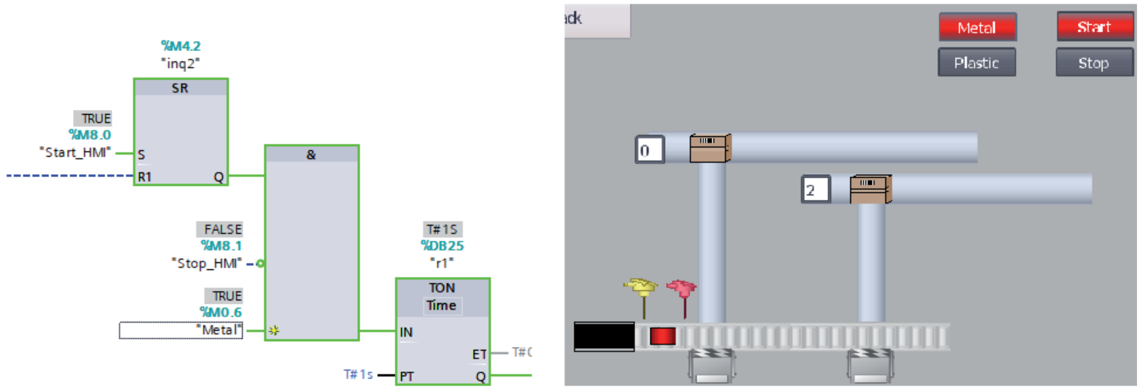

Figure 10: Movement of a metal part.

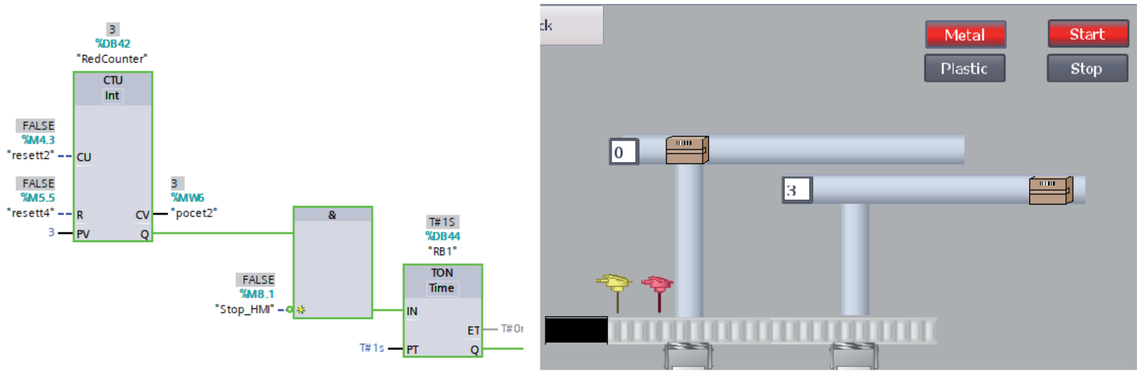

Figure 11: Box movement.

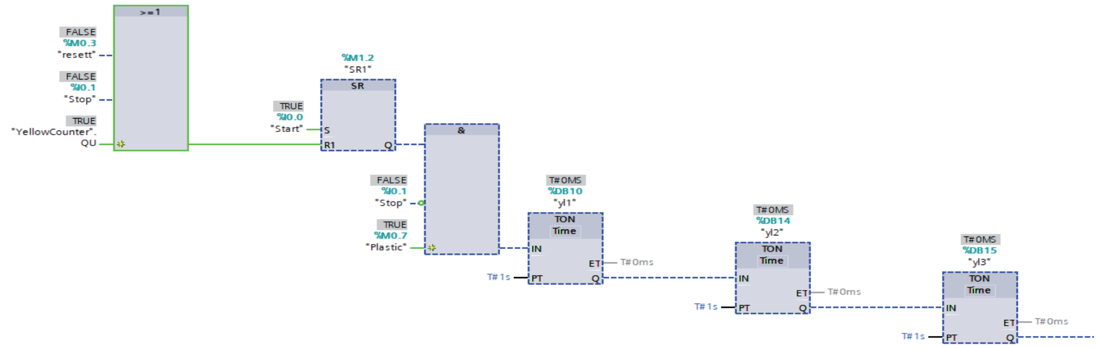

Figure 12: Stopping the movement of workpieces and the conveyor.

As it is visible (fig. 11), after the start button is pressed and a blank from metal is selected for example, a red square appears on the display. Now the animation will go forward until the counter gives the command to move the box. During the movement of the boxes, the program condition does not allow the timer cycle to start (fig. 12)

5. Visualization of process

Factory I/O 3D PLC Simulator is an impressive app that comes with over 20 scenes inspired by common industrial applications to practice real control tasks. Factory I/O 3D PLC Simulator allows you to create a virtual factory using many different industrial parts such as sensors, elevators, stations, conveyors and more. It has several intelligent editing tools that will make creating a 3D scene very convenient. You can use the Industrial Parts Library and customize Factory I/O by creating your own tutorial scripts. It uses drivers to interact with the PLC., PLC Simulators, SoftPLC and various other technologies.

Creating of scene and adding of sensor on conveyors is shown on figure 13. Two mechanical hands that will sort the parts is placed near the sensors (fig. 14).

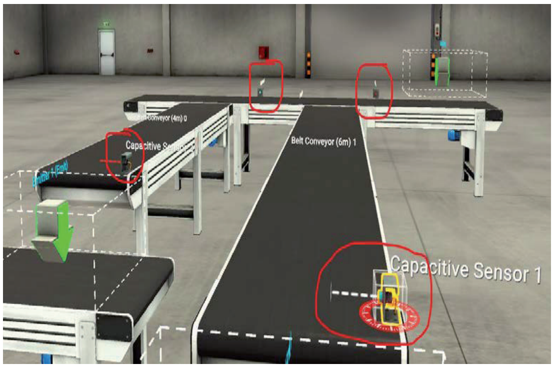

Figure 13: Creation of sensors on conveyors.

Having completed the creation of the conveyor line and editing the program, it is possible to start the simulation of the conveyor (fig. 15). As it is visible, as soon as the inductive sensor detects the part, it immediately sends a signal to the mechanical arm that pushes the workpiece onto another conveyor (fig. 16).

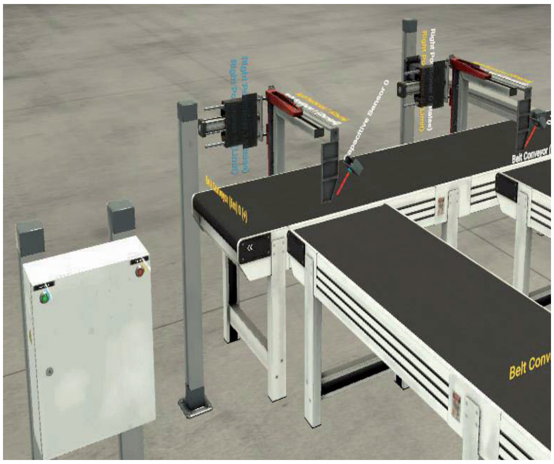

Figure 14: Creation of mechanical arms and control panel

Figure 15: Factory I/O simulation work.

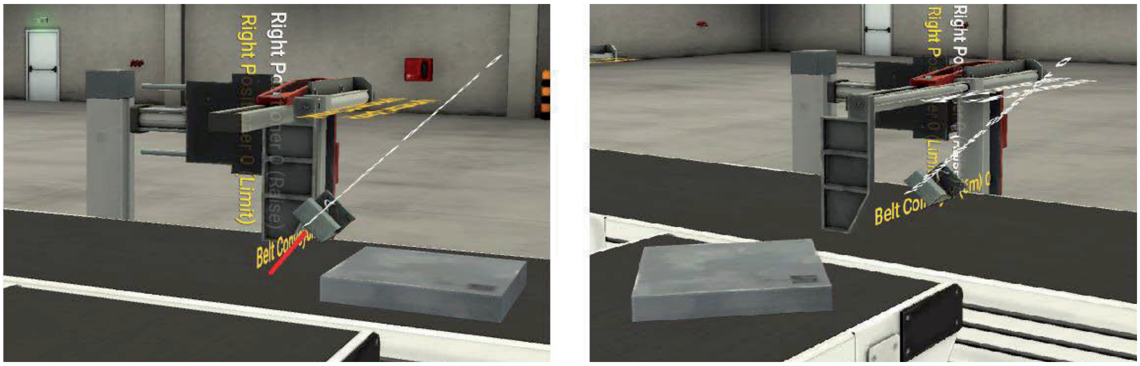

Figure 16: The work of the mechanical arm.

Figure 17: Box movement.

As soon as the 3 blank falls into the box, the movement of the blanks stops and the box starts moving forward (fig. 17). Next, the conveyor waits for the sensors near the boxes to be triggered, which will mean the start of the conveyor line. The work itself is also carried out on the 2nd line on which the plastic parts are loaded into the box.

6. Conclusions

The designed concept of the sorting system with the conveyor system is controlled using the PLC controller program. The simulation showed the functionality of the designed system and at the same time a human machine interface HMI was designed for operating the designed device. Visualization of the proposed concept and its simulation testing are also important in the conceptualization stage. The visualized system can also serve as a presentation tool for a customer demonstration. The used system can also be used as a visualization tool in the operation of the equipment for the customer.

References

[1] Ioannides, M.G (2004). Design and implementation of PLC-based monitoring control system for induction motor. IEEE Transactions on Energy Conversion, Volume: 19, Issue: 3, September 2004. Pp. 469 – 476. doi: 10.1109/TEC.2003.822303.

[2] Yilmaz, E., Katrancioglu, S. (2011). Designing Programmable Logic Controller (PLC) Experiment Set with Internal Experiment Blocks. Procedia - Social and Behavioral Sciences. Volume 28, 2011, Pages 494-498. https://doi.org/10.1016/j.sbspro.2011.11.095.

[3] Jakubkovič, E., Kelemenová, T., and Koláriková, I. (2021). Displacement Measurement in the Vertical Axis of the Measuring Microscope using Laser Triangulation Sensor. Acta Mechanica Slov, 25(2), 14-18. doi: 10.21496/ams.2021.019.

[4] Basl, J., & Edl, M. (2020). Industry 4.0 and Modification of Study Programs at the Faculty of Mechanical Engineering, UWB Pilsen. Acta Mechanica Slov, 24(4), 60-64. doi: 10.21496/ams.2021.004

[5] Palanisamy, A. (2020). Home Automation Using PLC and Arduino. Acta Mechanica Slov, 24(1), 56-68. doi: 10.21496/ams.2020.021.

[6] Siyal, A. (2021). Optical Distance Sensors. Acta Mechanica Slov, 25(3), 28-32. doi: 10.21496/ams.2021.034

[7] Juruš, O., & Ferenčík, P. (2021). Ultrasonic Sensors used to Detect the Position of the Mobile Service Robot. Acta Mechanica Slov, 25(1), 28-32. doi: 10.21496/ams.2021.010.

[8] Dubey, R., Agarwal, P. and Vasantha, M. K.. (2007). Programmable Logic Devices for Motion Control—A Review. In IEEE Transactions on Industrial Electronics, vol. 54, no. 1, pp. 559-566, Feb. 2007, doi: 10.1109/TIE.2006.885452.

[9] Bezák, M., Hajduk, M., Jánoš, R., Sukop, M., Semjon, J., Varga, J., Duchovič, P., & Zajačko, I. (2021). Contactless Measuring Device for Checking the Qualitative Parameters of Bead. Acta Mechanica Slov, 25(3), 40-45. doi: 10.21496/ams.2021.026

[10] Gmiterko, A., Kelemen, M., Virgala, I., & Miková, Ľ. (2014). Educational Model of Four Legged Robot. Acta Mechanica Slov, 18(3-4), 68-73. doi: 10.21496/ams.2014.032.

[11] Lachova, K. (2021). Digital Transformation as a Strategy of Value Creation in Industry. Acta Mechanica Slov, 25(3), 52-56. doi: 10.21496/ams.2021.027.

[12] Jeong, H. S., Ji, S. H., Jung, H. S. and Koo, J. C. (2017). Design of SW architecture for PLC integrated robot. 2017 14th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), 2017, pp. 874-876, doi: 10.1109/URAI.2017.7992851.

[13] Virgala, I., Miková, Ľ., & Kelemen, M. (2018). Robotic snakes. Acta Mechanica Slov, 22(3), 38-43. doi: 10.21496/ams.2018.025.

[14] Kelemenová, T., Kelemen, M., Benedik, O., Koláriková, I., Svrčina, M., Filakovský, F., and Leštach, L. (2021). Human Vital Signs Monitor. Acta Mechanica Slov, 25(4), 16-22. doi: 10.21496/ams.2021.033