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Conceptual design of control system for component sorting

Oleksandr Postrygan
ATS Automation Tooling Systems Inc., 730 Fountain Street North, Building #2, Cambridge, Ontario, Canada,
oleksandr.postrygan@gmail.com

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Abstract: This article deals with the conceptual design of the control system for a line intended for sorting products. It is an automated workplace with sensor differentiation of products and subsequent separation. The preliminary arrangement of the workplace and the placement of sensors and actuators is proposed. Control networks for the control system in the form of block diagrams are also proposed.

1 Introduction

The article deals with a case study of an automated production line for sorting and transporting products in crates to their final destination. This is a model situation created for educational purposes. The creation of such models is a suitable tool for training technicians and operators of production lines [1-5].

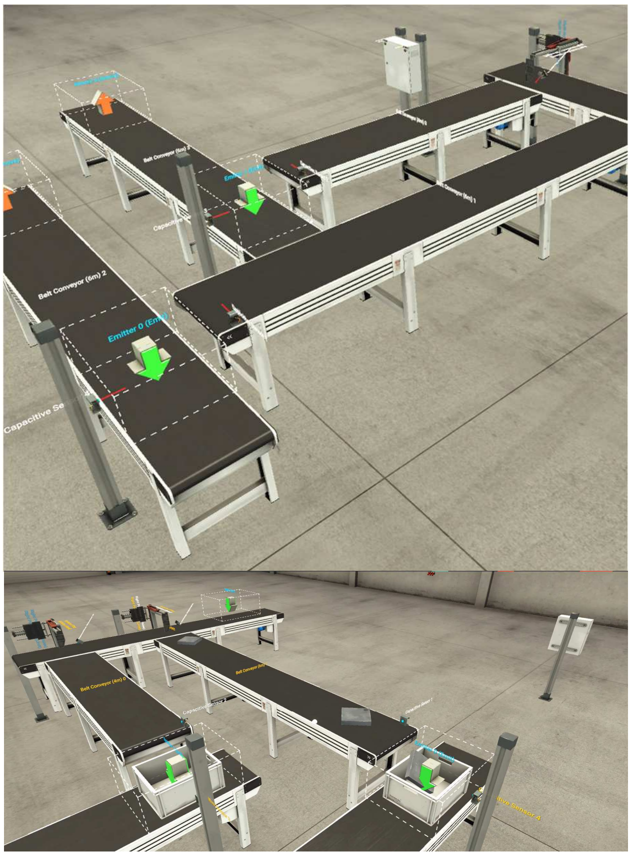

Figure 1 Sorting line concept with conveyors

The concept of this production line (Figure 1) consists of five connected conveyors. The first conveyor contains a sorting station with two linear actuators for moving the product to the next conveyor (Figure 2). The sorting and movement of the linear sorting linear actuators is automatically controlled according to the information from the sensors for detecting the material of the product, and accordingly the products are moved to the next appropriate conveyor (Figure 2).

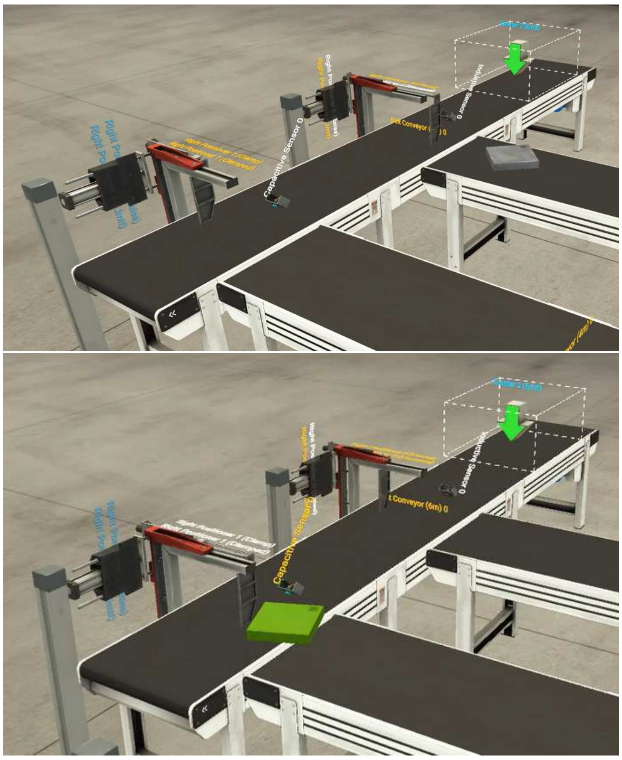

Figure 2 Sorting of products

The system includes, from the sorting conveyor, two paths of transport conveyors for the transport of sorted products. The products are then transported to the end of the conveyor where they are moved by gravity into the crate, which is placed on another conveyor located lower by the height of the crate (Figure 1). The sensor detects the gradual collection of products into the crate, and after counting the desired number of products, the crate with the products is set in motion by means of a conveyor and

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transported to the destination zone. From these conveyors, the parts crates are then taken to the next part of the production process.

For the purposes of the design of the control system and the program, a logistic scheme with the placement of sensors and actuators was designed (Figure 4).

The next part of the article describes the design of the control program for the PLC system, which will be the control system for this proposed sorting system (Figure 3).

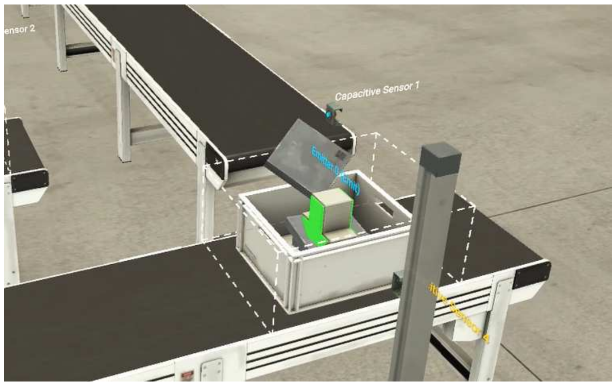

Figure 3 Storing products in a transport box

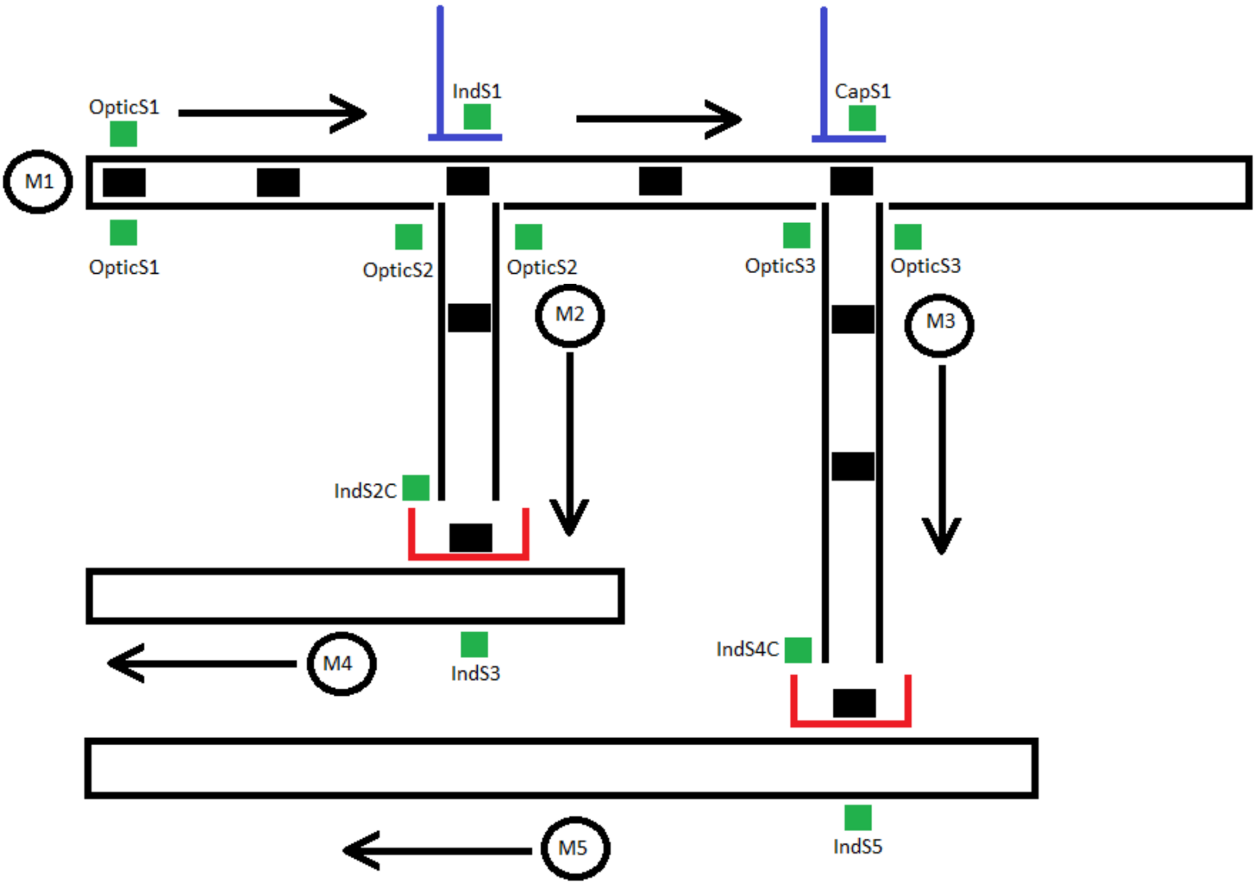

Figure 4 Schematic of the placement of sensors and actuators

2 Control program proposal

All programs for the PLC system are designed in FBD (Function Block Diagram) language. The control program for the motor M1 is designed in Figure 5 and is solved using a flip-flop SR block. The control program for the first sorting arm (Figure 6) is solved using the timer block and is connected to the corresponding sensor of the product IndS1. The control program for motor M2 (Figure 7) is compiled using a timer block and is started using information from the Optics2 sensor. The control program for the sorting arm (Figure 8) is similarly solved using a timer block triggered by information from the CapS1 sensor. The control program for the M3 motor (Figure 9) is started by the timer block connected to the OpticS3 sensor.

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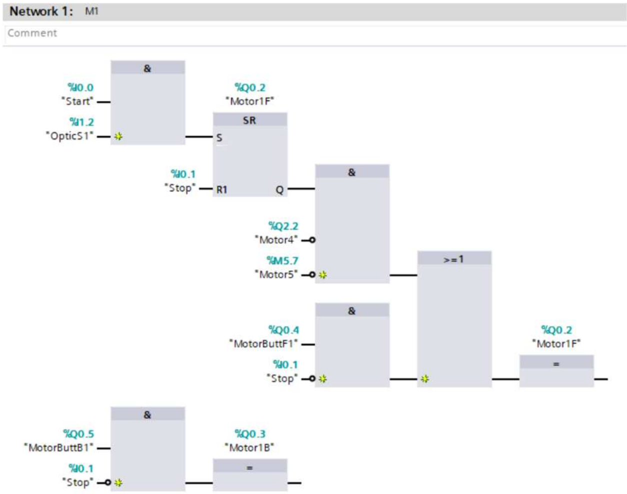

Figure 5 Control diagram for motor M1

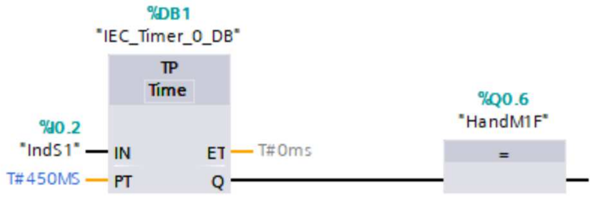

Figure 6 Control program for 1st sorting arm

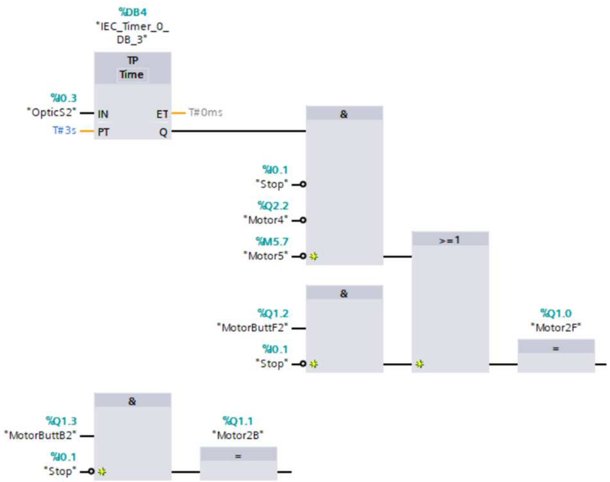

Figure 7 Control program for motor M2

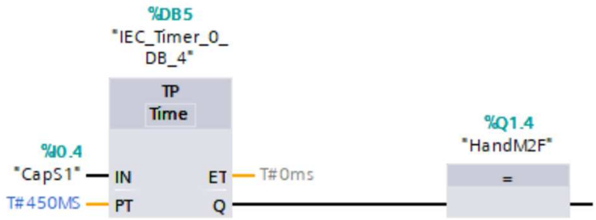

Figure 8 Control program for 2nd sorting arm

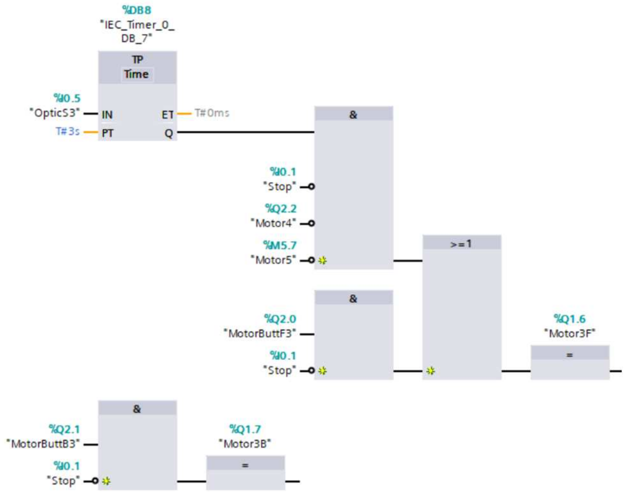

Figure 9 Control program for motor M3

The control program for motor M4 and motor M5 (Figure 10 and Figure 11) is solved using the counter block connected to sensors IndS3 and IndS5.

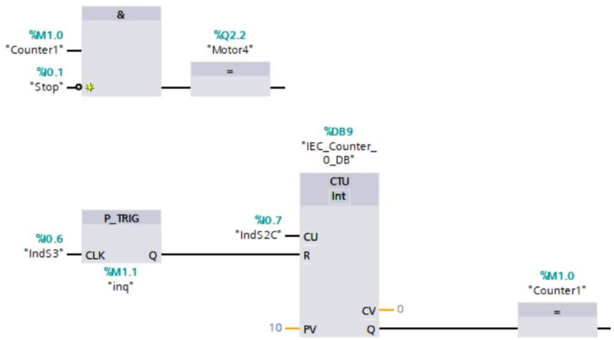

Figure 10 Control program for motor M4

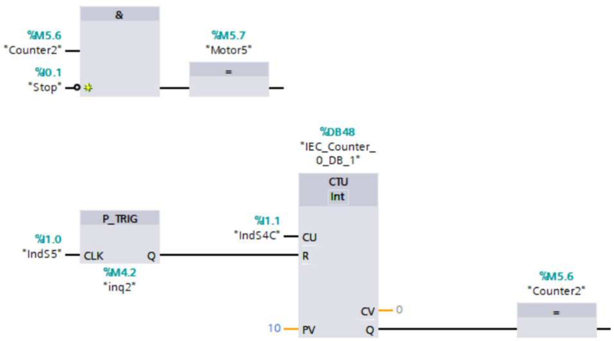

Figure 11 Control program for motor M5

The HMI (Human Machine Interface) interface (Figure 12) is designed for a 7" TFT color display. The movements of individual products are indicated using motion animation. The counting of individual products is displayed in a text window. The display also has buttons for starting and stopping the entire system, as well as buttons for manual control of the device. Product sensors are highlighted in color at the moment the product is detected on the conveyor.

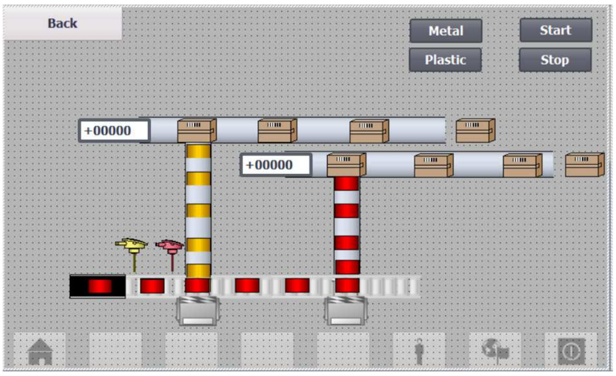

Figure 12 HMI design

3 Simulation

An essential part of the design of the control program and application for HMI is the simulation of the entire production process (Figure 13, Figure 14, Figure 15). This is a very important part because almost all the flaws and weaknesses of the design will be covered here. At the same time, the simulation will show the measures that need to be taken during the actual design of the mechanical and electrical parts.

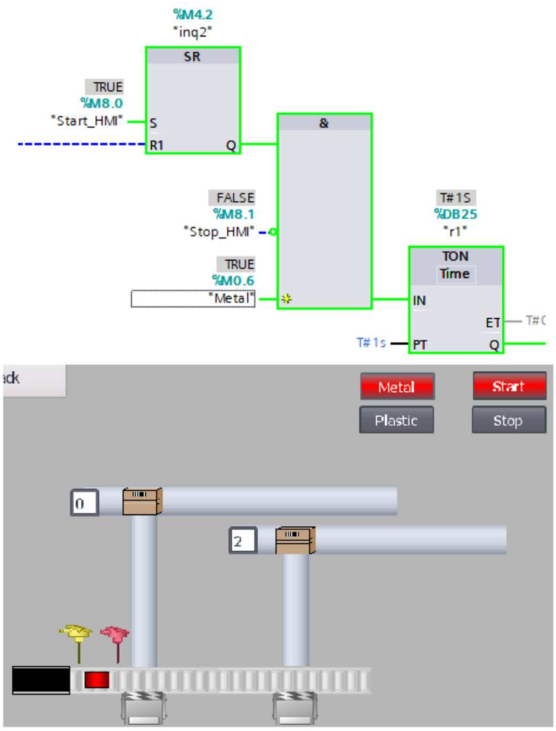

Figure 13 Simulation of metal part transport

In the simulation, it is indicated by color which parts are active with a logical value of 1 and which parts are with a logical value of 0. Along with the simulation of the block diagram, it is also possible to simulate an HMI application that is linked to the function of the FBD diagram.

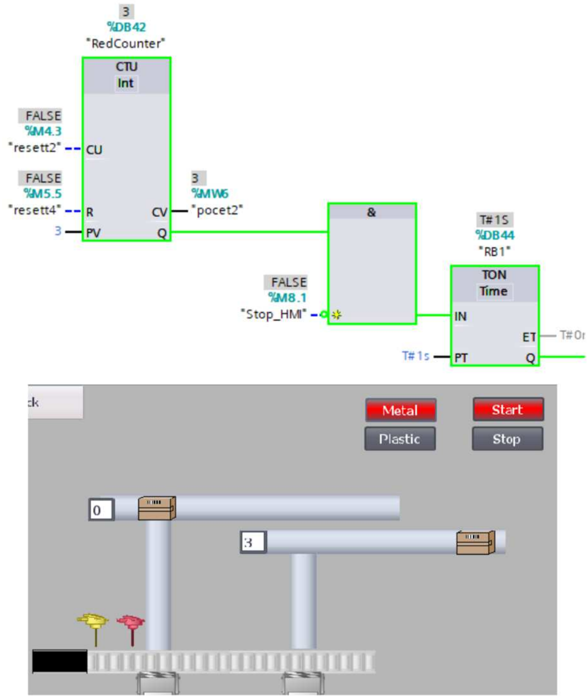

Figure 14 Simulation of box transport

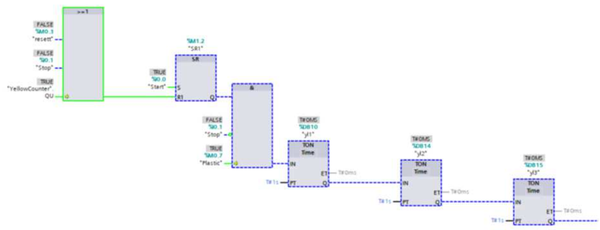

Figure 15 Simulation of transport abortion of part on conveyor

However, these simulation results are often incomprehensible to the customer, and it is more appropriate to add a visualization in a 3D environment to the simulations (Figure 16, Figure 17, Figure 18, Figure 19), where it is possible to see the movement of the products in real time and thus it is also possible to test the timing individual operations. In Figure 16 shows the arrangement of the sensors and in figure 17 the proposed arrangement of the sorting arms is shown. The collection of products into the box and the transport of the box with the product is shown in the simulations in Figure 18.

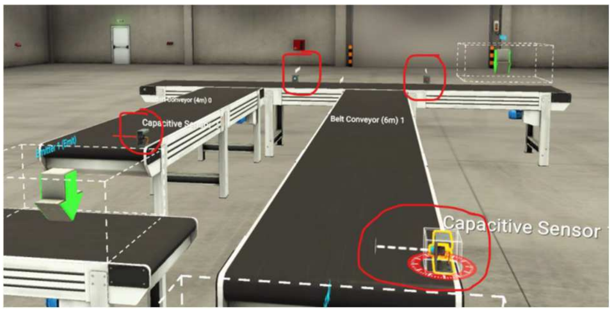

Figure 16 Placement of sensors in simulations

Figure 17 Creation of sorting arms

The overall view of the simulation is in Figure 19 and can be rotated and zoomed. The control panel of the device can also be part of the simulation model of the line.

The simulation confirmed the suitability of the chosen concept for an automated sorting line. The overall simulation provides a comprehensive idea of the spatial arrangement of the line and provides space for structural mechanical designs and electrical designs.

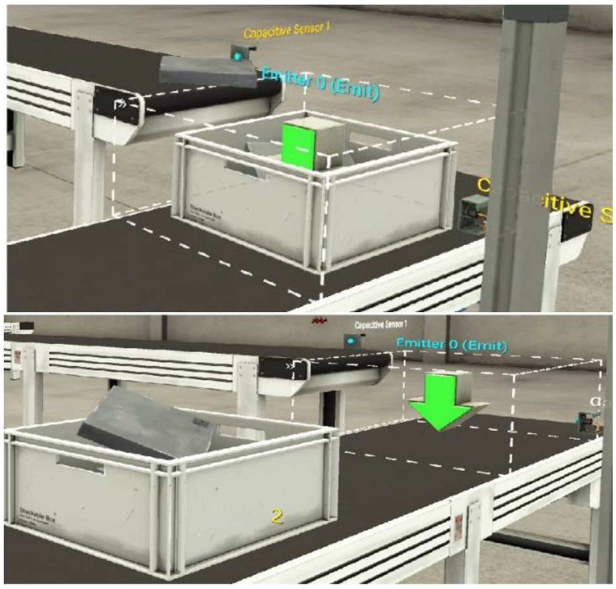

Figure 18 Box movement simulation

Figure 19 Simulation of the entire system

4 Conclusion

The article presents a methodology for designing a management concept for an automated sorting line. This concept was refined into a proposal for the arrangement of sensors and actuators, and control programs were created for individual actuators located in the device. An HMI panel with an application for process visualization and device control was also designed. Realized simulations showed the suitability of the designed concept and control programs.

Simulation proves to be a useful tool in the design of automated processes, where it offers the possibility of testing the device at an early stage of the design in order to complete the design of the device in detail and modify it from the point of view of safety and reliability, taking into account the energy point of view [6-14].

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