MREN 320 - Industrial Automation

Group #24

Laboratory #6 – Sorting Station

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Summary

This report documents the design and operation of the puck sorting station. The machine is shown in **Fig. 1** with main components labelled. The main purpose of this machine is to sort and organize pucks based on color. When the PLC is turned on, the conveyor gets activated which begins the process. Firstly, a puck is placed next to the color sensor, then the sensor sees the puck and asses it. If the puck passes through without activating the pneumatic stopper, it then gets sorted and placed into its respective chute via the attached paddles.

Machine Operation:

The operation of the machine is given in the following steps**:**

1) Puck is placed at the front of the assembly; the conveyor motor turns on moving it forward (**Fig.3**).
2) If the puck is red, silver, or black, the pneumatic stop retracts, if the puck is clear, it does not (**Fig.4**). This stops the clear puck until another non clear puck comes along. The clear puck will then be sorted along with that puck.
3) If the puck is red, the first paddle is extended, directing the puck into the first chute. If the puck is silver, the second paddle is extended, directing the puck into the second chute. If the puck is black, no paddles get triggered, directing the puck into the third chute. This can be seen in **Fig.5**.
4) If a paddle was extended, it now retracts; conveyor motor turns off and pneumatic stop extends.
5) Steps 1 through 4 keep on cycling until either one chute contains more than 4 pucks (**Fig.6**), or the system is manually turned off (**Fig.7**).

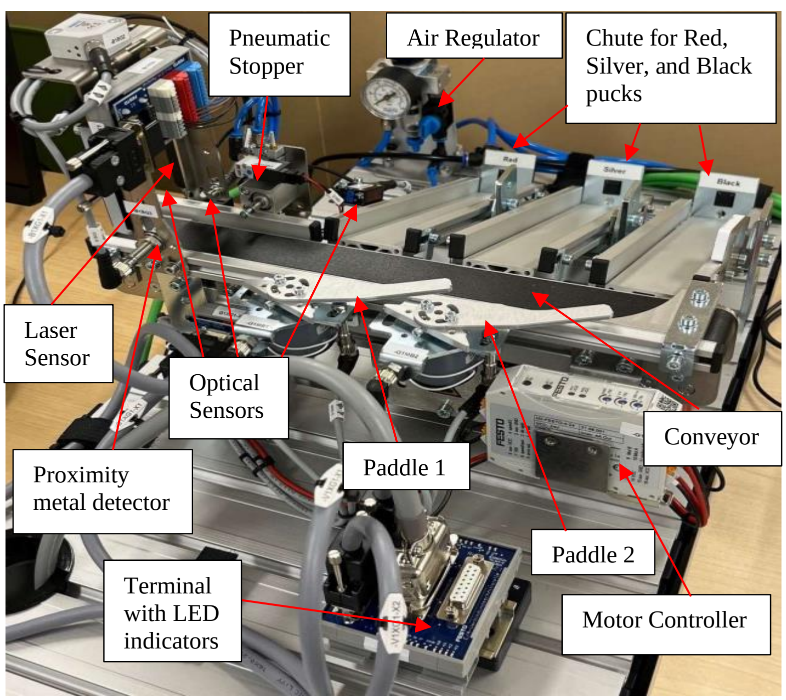

Fig. 1. Machine overview with main components labelled.

Fig 2: Three different colours of pucks. (With the exception of the clear puck.)

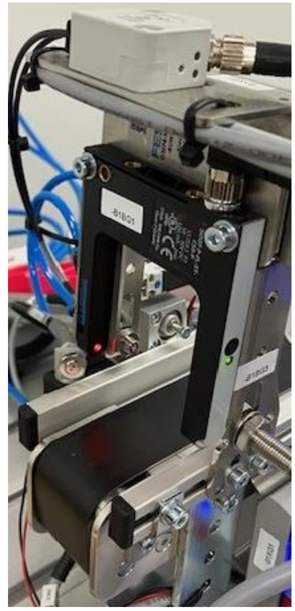

Fig 3: Pucks are placed at the front of the conveyor were the first optical sensor senses the presence of a puck and starts the conveyor forward.

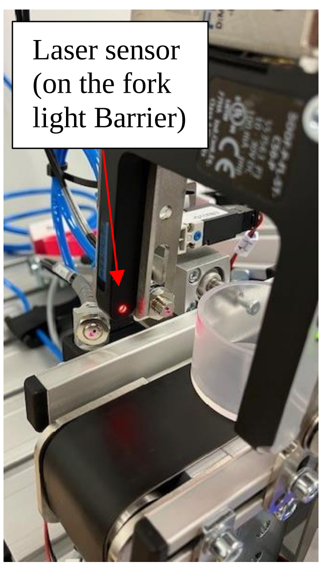

Fig 4: If the puck is clear, it does not trigger the laser sensor and the pneumatic piston stays extended, stropping it from going forward.

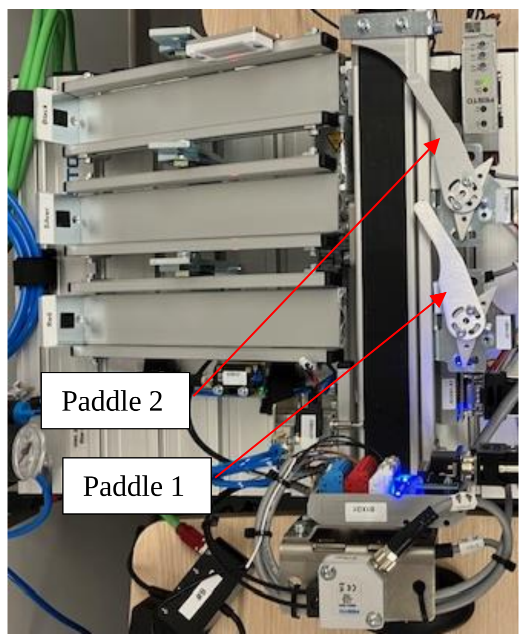

Fig 5: If the puck is not clear it triggers the laser sensor, and the pneumatic piston retracts. The puck then passes in front of the inductive sensor and the second optical sensor. The inductive sensor detects the silver pucks while the second optical sensor detects red and silver pucks. If the puck is red, the second optical sensor gets triggered, but the metal sensor does not get triggered, this causes the first paddle to rotate onto the conveyor, directing the puck into the first chute. If the puck is silver, both the second optical sensor and the metal sensor get triggered, causing the second paddle to rotate onto the conveyor, directing the puck into the second chute. If the puck is black, both the second optical sensor and the metal sensor don’t get triggered, causing no paddles to rotate onto the conveyor, directing the puck into the third chute.

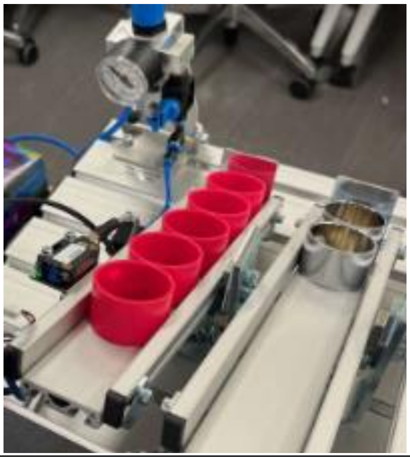

Fig 6: If more than four pucks accumulate in one chute the third optical sensor detects the fifth puck, stopping the sequence of operations.

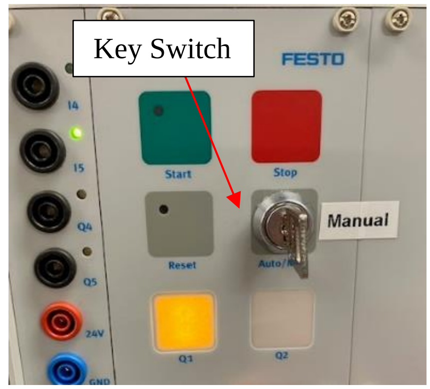

Fig 7: The conveyor can be stopped at any moment by turning the key switch to horizontal. To stop the sequence of operations the key switch is set to horizontal, and the Stop button is pressed.

Sensors:

The sensors used by the machine are illustrated in **Figs. 8** to **12**.

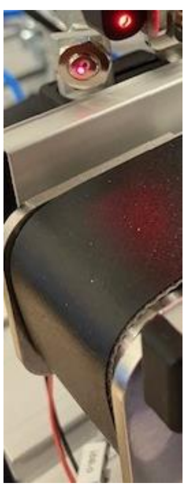

Fig 8: Check placed

Fig 9: Second optical sensor. Since black pucks absorb most of the light emitted from the optical sensor. Setting it at a low sensitivity enables it to only detect red and metallic pucks.

Fig 10: Laser Sensor on the fork light barrier. Detects red, silver, and black pucks.

Fig 11: Third optical sensor. Checks if there are more than four pucks in any of the three chutes. If this is the case, it stops the program.

Fig 12: The inductive proximity sensor. Detects metal and therefore the presence of the silver pucks.

Actuators:
The actuators used by the machine are illustrated in **Figs. 13** to **15**.

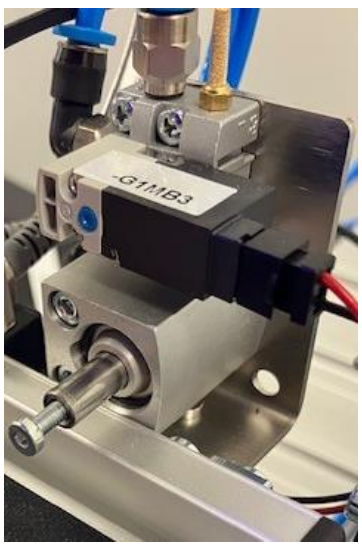

Fig 13: Pneumatic stopper with solenoid valve. Stops clear pucks.

Fig 14: DC motor. Drive the conveyor belt forwards (and backwards if necessary).

Fig 15: Paddle actuators. Extend and retract paddles directing pucks in their designated chutes.

Controllers:
The controllers used to control the machine and its components are illustrated in **Figs. 16** and **17**.

Fig. 16. PLC.

Fig. 17. Festo motor controller.

Figure 16 depicts the PLC unit that was used. This device serves as the central control unit for orchestrating the operation of the entire sorting assembly machine. PLCs are specialized industrial computers designed to automate processes by receiving input signals from sensors, processing them based on programmed logic, and then controlling output devices such as actuators, motors, and valves. The PLC acts as the brain of the system, executing programmed instructions to coordinate the movement of components, monitor sensor feedback, and ensure the seamless execution of the assembly process. Its nature lies in its programmability, robustness, and reliability, making it an ideal choice for industrial automation applications.

Figure 17 depicts the Festo motor controller. This device is responsible for regulating the operation of the motors in the assembly machine by managing the speed, direction, and torques of motors used in various components such as the conveyor belt and the stoppers. It interprets commands from the PLC and translates them into electrical signals that control the motor's behavior accordingly. The motor controller's nature is characterized by its ability to interface seamlessly with the PLC and provide precise control over motorized equipment. Its purpose in our project is to ensure smooth and efficient movement of components throughout the assembly process, contributing to the overall productivity and reliability of the machine.

Peripherals:
The peripherals used to support the operation of the machine are illustrated in **Figs. 18** to **20**.

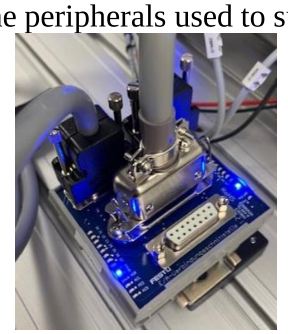

Fig. 18. Terminal with LED indicators. Indicates the states of the inputs (sensors) and connects PLC to computer.

Fig. 19. Emergency stop button. Stops the operation of the machine in case of emergencies.

Fig. 20. Air pressure gauge. Indicates the pressure of the air being fed into the pneumatic stopper.

Faults:

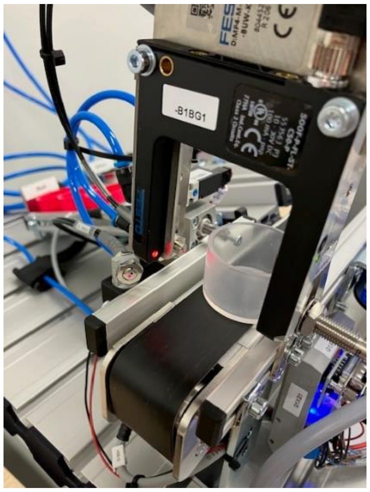

Fig. 21. Fault with clear puck.

As shown in **Figure 21**, when the clear puck gets detected and stopped by the pneumatic stopper, it stays in the middle of the track. Then, if a following non-clear puck comes along, the pneumatic stopper is retracted, and the pucks are directed towards the chute corresponding to the non-clear pucks colour. This then causes the clear puck to be put in a chute (which it is unwanted) and sometimes also causes the non-clear puck to stay on the track, creating a pile up on the track.

Fig. 22. Fault when no air.

As shown in **Figure 22**, the air supply to the pneumatic stopper is turned off. This causes the pneumatic stopper to always stay retracted and prevents the assembly from stopping the clear pucks.

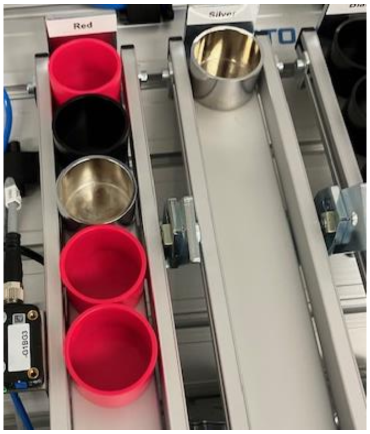

Fig. 23. Fault when puck starts on wrong side.

As shown in **Figure 23**, sometimes the assembly is not able to properly read the colour of the pucks. This happens when, either, the silver puck is too far away from the induction sensor, causing it to not detect the metal and mistake it for red, or when the black puck is too close to the second optical sensor, causing it to receive some reflected light back from the face of the puck and mistake it for red.

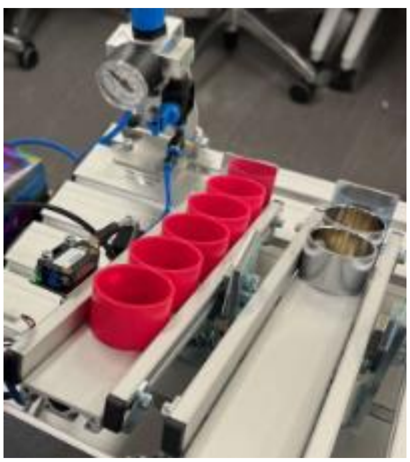

Fig. 24. Fault when there are more than 4 pucks in the chute.

As shown in **Figure 24**, when there a more than 4 pucks in a chute the third optical sensor is triggered. This then stops the rest of the station from running.

Suggested Design Changes:

To minimize the occurrence of the faults listed above, the first design change I would implement would be to add a pick and place mechanism. This will resolve the faults caused from both **Figure 21** and **24** since the mechanism would be able to take off the clear pucks from the track as well ass clear the chutes so that they never contain more than four pucks at a time. With this addition the station will be able to run continuously. The second design change I would incorporate would be to tape a border on the left and right sides of the track with the goal of guiding the pucks to its center. This will minimize the faults caused in **Figure 23** since the pucks will always be a good distance away from the sensors.

Appendix A: Problem of Synchronization

Answers to the questions in Lab #6A (page 5). Note that the answers are related.

Q1: What does synchronization mean for this step? (answer with URL)

Synchronization, in the context of programming and project management, refers to the process of ensuring that multiple copies or versions of a project or dataset are consistent and up to date with each other. It involves aligning the changes made by different users or systems to maintain coherence and avoid conflicts.

In essence, synchronization aims to achieve a unified and coherent state across all copies or versions of the project, allowing for efficient collaboration and minimizing discrepancies between different iterations.

https://support.industry.siemens.com/cs/document/82142829/how-do-you-synchronize-projects-for-the-s7-1500-in-step-7-(tia-portal)-when-multiple-users-are-working-on-a-task-at-the-same-time-?dti=0&lc=en-US

Q2: What does differences between modules mean for this step? (answer with URL)

A "difference between modules" refers to a situation where there is a discrepancy between the configured module in the project and the actual module present in the hardware setup.

https://support.industry.siemens.com/cs/document/109744163/how-do-you-load-the-project-data-if-the-version-of-the-firmware-installed-in-the-s7-1500-cpu-cannot-be-selected-in-the-hardware-catalog-of-your-version-of-step-7-(tia-portal)-?dti=0&lc=en-US