SMART MOVING STORAGE CONVEYOR

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Abstract: This article deals with the problem of conveyor, which at the same time serves as a temporary storage of finished products. The construction of storage is given by closed circuit conveyor. Information about the final product is known for compliance with Industry 4.0 standards and is important for the future operation of storage. Conveyor must also be synchronized with the robotic SCARA manipulator, because the conveyor must be constantly moving due to distribution. The SCARA manipulator fills the conveyor with finished products, which are distributed to customers using this conveyor. The whole work is realized with an emphasis on the principles of Industry 4.0, because it is one part of a larger production unit.

Keywords: conveyor, storage, PLC, Industry 4.0, SCARA

1 INTRODUCTION

In today's accelerated times, great emphasis is placed on shortening the time of production and distribution of final products. This is leads to a major boom in the Industry 4.0 concept, which introduces new technologies and insights into the industry. This concept tries to bring more modifications of the product according to the customer's wishes, while maintaining production costs. The concept comes from the initiative of German industry, which wants to make progress in production.

In connection with this standard, the idea of merging conveyor and storage functionality arose. This would result in significant savings in warehouse space. At the same time, greater utilization of conveyor belts is achieved. This connection creates a movable storage.

2 INDUSTRY 4.0

The first industrial revolution broke out at the end of the 18th century and took place under the sign of the manufactories thatuse the energy of watercourses and steam.

The second took place at the beginning of the 20th century. They characterized hertrack production, use of electricity and internal combustion engines.

The third revolution started in the 1970s century with the advent of microprocessor, the use of computers and automation of individual productionlines.

The fourth industrial revolution is represented by cyber-physical systems that will create "smart factories". Intelligent devices will take over some of the activities that people have done. Methods of machine perception, autoconfiguration and diagnostics and computer connection of machines and parts are envisaged. [1]

3 TESTBED

The component created and described in this article is part of a larger unit called Testbed Industry 4.0. This device is being developed at the Department of Control and Instrumentation, Faculty of Electrical Engineering and Communication, Brno University of Technology. The total working area of the tesbed id 2000 x 1000 mm. On this area are located production cells and other equipment. The whole facility consists of two floors. The upper work area can hold up to 6 production cells and also features a SCARA robotic manipulator and a wheelchair conveyor. The lower floor is used for supporting technologies so that the whole can form a complete factory. It is the control unit of the manipulator, IT technology and cooling for individual production cells. [2]

All autonomous cells placed on the desktop are made of an aluminum frame with a ground plan of 330 x 330 mm and a height of 500 mm. A specific trajectory is defined for each cell that the manipulator follows when inserting or removing a glass into the cell. There is an effort to unify these trajectories as much as possible so that the individual cells are as interchangeable as possible. [3]

4 CONVEYOR

The conveyor consists of a closed oval with ten trolleys. These carts are used to distribute ready-to-drink beverages to customers and to collect empty glasses. The movement of the conveyor is provided by a stepper motor, which uses parts printed on the 3D printer to transmit the rotary movement of the shaft to a 1500 mm long toothed belt. The individual carriages are carried by means of pins that are attached to the belt. The track of these carts is given by a rail consisting of straight sections of aluminum profiles and curves printed on a 3D printer. Figure 1 shows the final form of the conveyor along with a description of the components used.

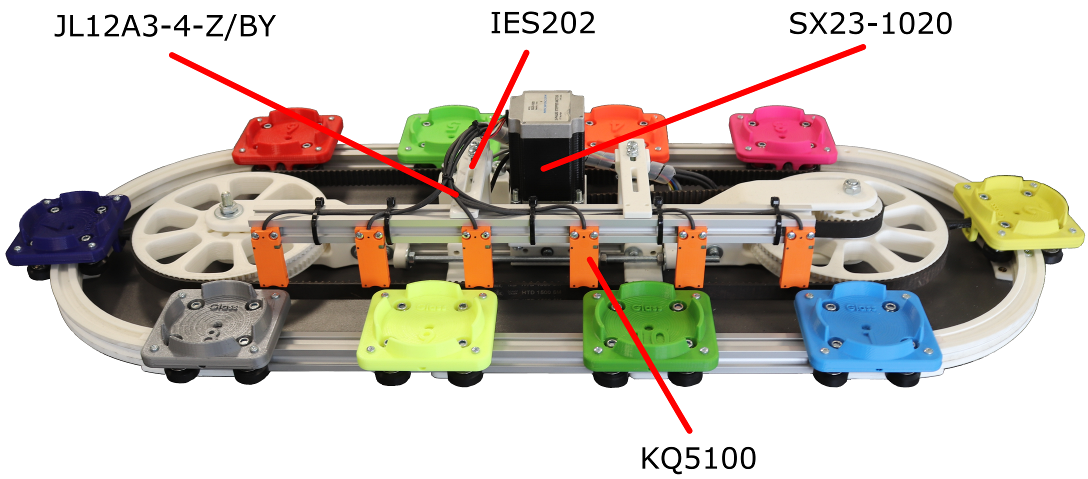

Figure 1: Implementation of the conveyor

4.1 USED COMPONENTS

All used components were selected with an emphasis on low cost and simple application. At the same time, it is a demonstration of a project that is functional and of good quality even at low cost. Lower component valency can be improved with good software implementation. Many machine parts are created using 3D printing. For example, there are ten carts that are specially shaped for glasses and color-coded for better recognition. Below is a brief description of all components used on the conveyor.

Now to the individual parts of the conveyor. The most important part is the control unit, which is a programmable logic controller (PLC) from Siemens S7-1200 series. Specifically, the 1214C DC/DC/DC. This PLC handles all conveyor peripherals. At the same time it is also extended with CM 1241 card for serial communication RS232. This card is added for communication with the robotic SCARA manipulator, which unfortunately does not have other peripherals.

The movement of the conveyor is ensured by a stepper motor, which creates sufficient torque combined with high precision. This accuracy is important with a view to achieving synchronization of the conveyor with the robotic manipulator. It is a stepper motor from the Microcon SX series, which is designed primarily for industrial use. The chinese stepper driver TB6600, which supports speed and direction control, was used to control the stepper motor. The micro-step and output current can be set using six DIP switches located on the top of the exciter. All signal terminals in the driver are designed for function with 5V logic. It was therefore necessary to adapt all high-speed optical separation so that it could be used on 24V PLC logic.

Sensors are also an important part of the conveyor, which are used to detect the cart and the contents of the glasses placed on them. Inductive sensors were used to detect the carts and capacitive sensors were used to detect glasses and their contents. Ifm sensors were used that can be connected to the AL1900 IO-link master. This has greatly reduced PLC inputs. This IO-link master serves as a communication gateway between intelligent sensors and the communication bus. [4]

A total of six capacitive sensors are used in the conveyor construction. They are used to detect the presence of glasses on individual carts and are also capable of detecting liquid inside the glass. With this functionality you can distinguish empty and full glasses or empty cart. This number of sensors has been chosen to provide sufficient coverage of the conveyor dispensing portion, which is necessary when the glass is removed from the conveyor belt and the glass is returned to the trolley. This is mainly to reduce the time when the PLC has no information about the glass. The sensor parameters are set via the IO-Link interface. High-quality inductive sensor IES202 is used for detecting the beginning of the conveyor belt. For this purpose, a small magnet is placed on the number one carriage, which is the only switching element of this sensor. As the carriage passes, an impulse is detected by which the conveyor is initialized. A second inductive sensor is used to detect the passage of each carriage. By nature of the sensor function, metal parts are detected, in which case the metal part is the screw head. This screw is used to connect the thorns and the 1500 mm long belt that moves the carriages. The sensor also serves for the aforementioned synchronization with the robotic manipulator.

The most important element of the whole production unit is the glass into which the drinks are prepared. It is a simple glass purchased from IKEA. The glass is 10 cm high and has a volume of 23 cl. An important element of the glass is the NFC chip glued to the underside of the glass. Used to identify a glass when placed on a rack in the cell. At the same time, all the information about the recipe and the actual contents of the glass is stored on this chip.

5 GLASS DETECTION

Verifying the presence of a glass or inserting a user glass is detected by a series of six capacitive sensors. The data obtained from the sensors is processed in the PLC. At the same time, data is processed from the three sensors in front of which the carriages are located. The Figure 2 shows the data flow of one of the six sensors. It shows the detection of the empty carriage, the empty glass carriage and the full glass carriage. The processing is carried out in such a way that when the carriage passes in front of the carriage sensor, the function for searching the maximum of the received data is started. The maximum search sections are highlighted in orange in the illustration. For clarity, the figure also shows the limit value for the empty trolley (purple line) and the limit value for the empty glass (red line). Values above the red line line correspond to a glass with a liquid content of 20 ml or more. This value corresponds to the dispenser volume in the alcoholic beverage store.

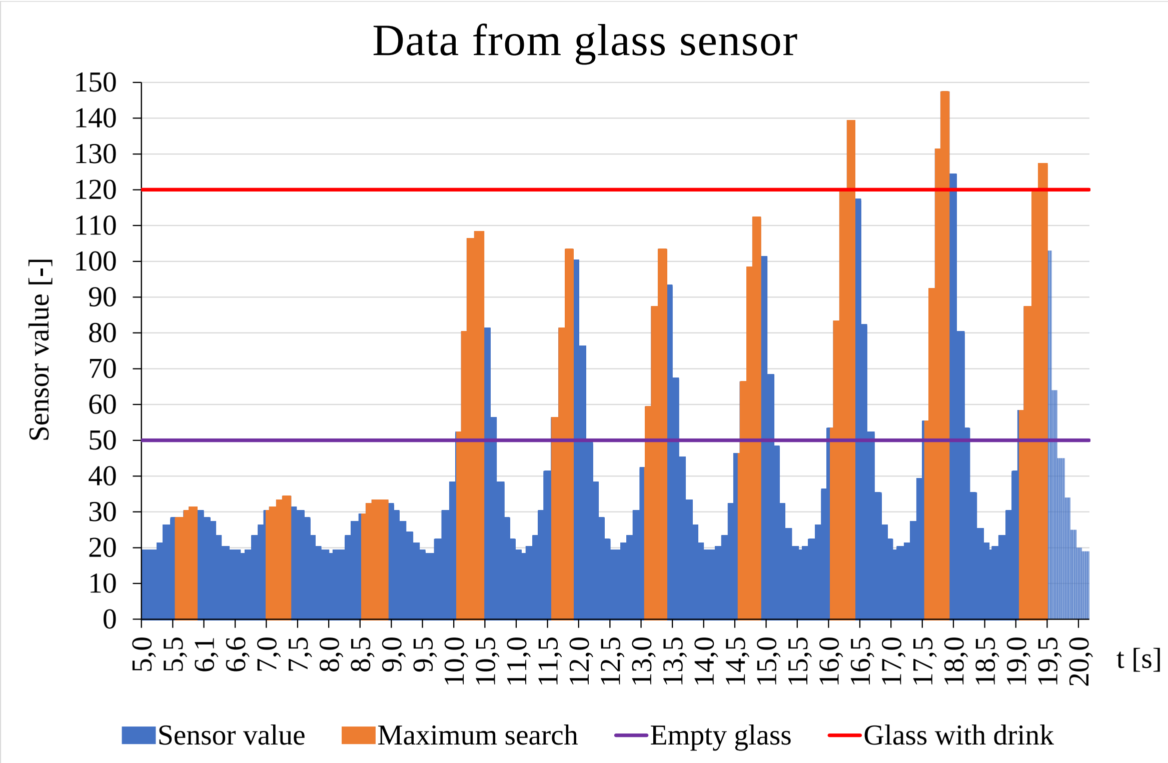

Figure 2: Graph of data from glass sensor

If the user puts the glass back on the conveyor, this is determined by the difference from the previous sensor. If this glass is returned with more than 20 ml of liquid, there is an immediate need for operator intervention. The operator must check the glass through the control panel (the glass is red on the control panel) and pour the contents of the glass. This is necessary to put the jars back into the jug cell, where liquid could spill unintentionally.

6 CONVEYOR SYNCHRONIZATION WITH MANIPULATOR

One of the main challenges of this work was the idea of placing the glass on the belt synchronously and removing the glass from the belt. The main reason for this solution was the elimination of the conveyor stop, which would frighten the user when taking ready drinks.

The manipulator movement permission is provided by the PLC functions. This function finds the first empty position on the conveyor when the glass is placed. When removing used glasses, this function searches for glasses that match their empty and used glasses. The shape of the curve for synchronous placing of the glass on the conveyor was chosen so that the manipulator speed could be easily recalculated according to the conveyor speed. The curve therefore consists of a section where the manipulator descends exactly to the position of the trolley. This is followed by a straight section that creates sufficient time to open or close the effector. Finally, the lift section of the manipulator above the conveyor so as not to collide with the other glasses. The shape of the curve is shown in the Figure 3.

To set the required manipulator speed in the slope and stroke sections, it was necessary to calculate the length of the trajectory that the manipulator was moving. Preferably select the length so that the manipulator speed is easily calculated according to the conveyor speed. The length was thus calculated using the Pythagorean theorem from the knowledge of the length of the sides of the triangle, which are formed by the starting and ending points of the aforementioned trajectory. Subsequently, it was possible to calculate the manipulator speed from the known conveyor speed from the trajectory length ratio.

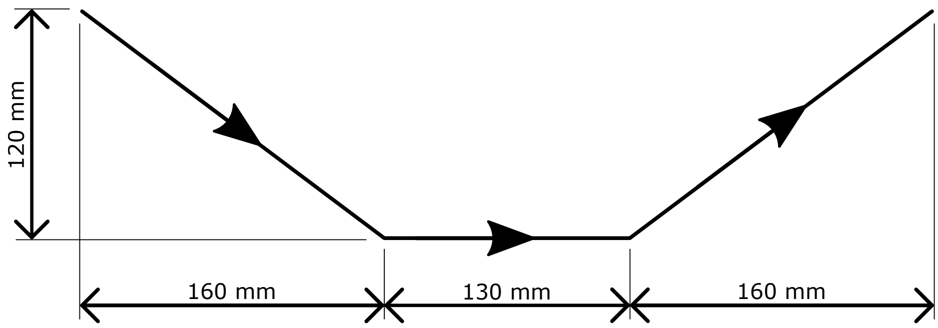

Figure 3: Trajectory of laying glass on conveyor

7 CONCLUSION

The result of this work is a new approach to understanding the use of Industry 4.0 in practice. Combining seemingly incompatible components of a production unit has created a new component whose use can have a major effect on the speed of production.

In the future it is expected to expand and improve this conveyor. An important element for safety is the optical gate, without which the device must not be used. Further, an extension of the conveyor by one NFC input reader or more readers placed directly on the wheelchairs is considered. A complete overhaul of the conveyor using magnetic rails, which would increase the accuracy by many times, would also be welcome.

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