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Computation of Length and Chopping using PLC

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ABSTRACT
The computation of length and chopping are two of the most important processes in the manufacturing industries. In the traditional ways of production, the cutting process is done manually with the help of human labour and the material is measured manually with a ruler to a specified length. In fact, everything has its own set of advantages and disadvantages. The disadvantage here is that when the cutting is done manually, it may lead to improper cutting and improper measurement due to irregular cutting since both processes are dependent on each other. For example, in the process of extrusion, which is one stage in the tyre building process, improper cutting of the materials like thread and other components may lead to improper bonding of the material.

As technology advanced, many industrial processes advanced and underwent significant changes in the name of the industrial revolution. Nowadays, various tasks such as computing and material chopping have been automated using various methods.

While talking about the industrial revolution, PLCs play a vital role in the automation of various processes. So, in our project, we have discussed the automation of the computation of length and chopping in the extrusion process using a programmable logical controller (PLC).

Here in our project, the material is feed into the conveyor, which is controlled by a PLC. After the material of the specified length is detected, the chopping process is done. Here the length is computed with the help of two sensor inputs that are given to the PLC as input. The output of the PLC is given to the pneumatic circuit, which consists of a double-acting cylinder, a 5/2 DCV, some feedback sensors, and the blade that executes the process of chopping.

Keywords—Conveyor System, PLC, Pneumatic System, Cutting Mechanism

1. Introduction:

In many industrial processes, it is necessary to compute the length of material being produced and chop it into specific lengths. This is particularly important in extrusion processes, where a continuous stream of material is extruded and needs to be cut into pieces for further processing. A programmable logic controller (PLC) can be used to automate the computation of length and chopping of the extruded material. The PLC is a digital computer that can be programmed to control the process, improving efficiency and accuracy.

The Program S7-1200 PLC for executing automatic length cutting by measuring the length of the given material with help of sensor and pneumatic cylinder motion which reduces the time in manual cutting sequence. The programming of the PLC is done with help Siemens TIA portal software. Once the length is computed, the PLC can be used to control the cutting mechanism to chop the extruded material into specific lengths. The cutting mechanism can be a pneumatic cylinder, a cutting mechanism. The PLC can be programmed to control the cutting mechanism based on the computed length, ensuring precise and consistent cutting of the extruded material. Overall, the use of a PLC in the extrusion process can improve efficiency, accuracy, and consistency. It can also reduce waste and increase productivity, making it a valuable tool in many industrial applications.

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1.1 Programmable logical controller (PLC):

Programmable logic controller (PLC) is a specialized industrial computer used to control and automate manufacturing processes or other machinery in industries such as automotive, food processing, and packaging.

PLCs are designed to be easily programmable and reprogrammable, allowing engineers and technicians to customize them for specific tasks. They typically consist of a central processing unit (CPU), input/output (I/O) modules, and communication modules.

The CPU receives signals from sensors and other devices through the I/O modules and uses the programmed logic to make decisions about how to control machinery or other equipment. The communication modules allow the PLC to communicate with other devices and systems, such as human-machine interfaces (HMIs), supervisory control and data acquisition (SCADA) systems, and enterprise resource planning (ERP) software.

PLCs are commonly used to control processes such as assembly lines, packaging machines, and material handling equipment. They are also used in building automation systems to control heating, ventilation, and air conditioning (HVAC) systems, lighting, and security systems. Architecture of PLC is shown below.

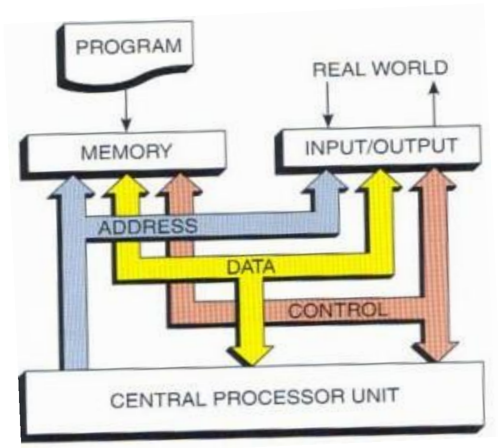

Figure 1

1.2 Total Integrated Automation (TIA):

The Totally Integrated Automation Portal (TIA Portal), provides an engineering framework for implementing automation solutions in all industries around the globe. From designing, commissioning, operating, and maintaining to upgrading automation systems, the TIA Portal saves engineers time, cost, and effort. SIMATIC STEP 7 in the TIA Portal is the software for the configuration, programming, testing, and diagnosis of all modular and PC-based SIMATIC controllers, and includes a variety of user-friendly functions.

2. Experimental Methods or Methodology:

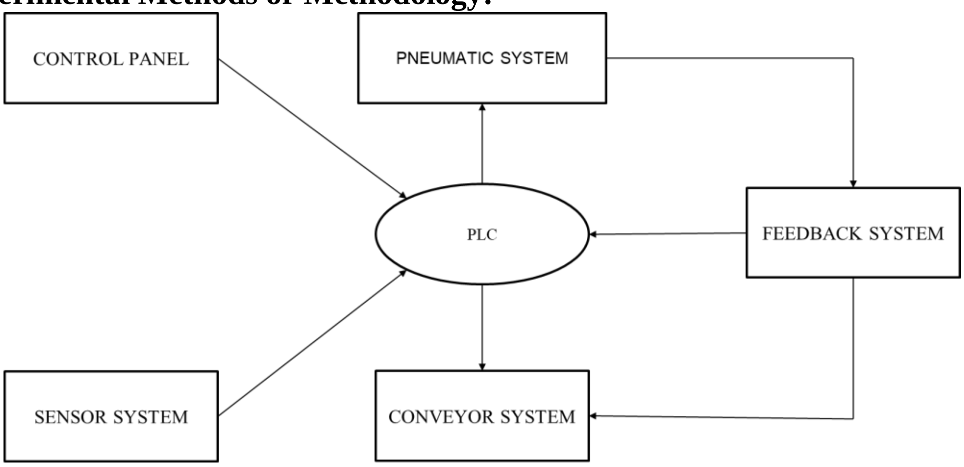

Figure 2

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Here the PLC is the centralized control unit the system consists of control panel, sensor system and feedback system as input systems and pneumatic system and conveyor system as output systems. While the sensor system consists of two IR or photoelectric sensor which acts as input for the detection of material and the computation of length of the material. And the pneumatic system performs the chopping process. Which consists of pneumatic source, 5/2 directional control valve, double acting electro pneumatic cylinder and FRL unit. And cutting blade which is attached to the cylinder. And the conveyor system consists of conveyor motor, roller and belt. Control panel acts input control.

2.1 Hardware components:

- Siemens S7-1200 Programmable logical controller
- Control panel designed specifically for requires operation
- Conveyor system and drives
- Double acting electro pneumatic cylinder
- 5/3 directional control valve
- Cutting blade
- Blade mounting
- Pneumatic source (compressor, FRL)
- Photo electric or IR sensor

2.2 Software used:

- Siemens TIA portal v15/17
- Siemens Simatic manager v5.6
- Siemens PLC-SIM v5.6 sp8

2.3 More about components:

2.3.1 S7-1200 (PLC):

SIMATIC S7-1200 Basic Controllers are the ideal choice when it comes to performing automation tasks in the low to mid-performance range with maximum flexibility and efficiency. They deliver convincing results thanks to their comprehensive range of technological functions and integrated I/O, as well as their compact, space-saving design. Thanks to standardized Remote control protocols, you can connect Simatic s7-1200 controllers directly to your control centre without any programming effort.

2.3.2 Conveyor system:

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transport of heavy or bulky materials. Conveyor systems allow quick and efficient transport for a wide variety of materials, which make them very popular in the material handling and packaging industries. They also have popular consumer applications, as they are often found in supermarkets and airports, constituting the final leg of item/ bag delivery to customers. Many kinds of conveying systems are available and are used according to the various needs of different industries.

2.3.3 5/2 directional control valve:

5/2 solenoid valves and 5/3 solenoid valves are most often used as directional control valves for double-acting pneumatic actuators. The single-coil type of 5/2 valve usually has a spring or pilot air return so that when de-energized, the valve returns to it's starting function. Dual coil valves do not have this return facility and require the second coil to be energized to return the valve to the start position. 5/3 valves have 2 coils and if neither is energized, the default state it returns to in the centre position can either be all ports blocked, all ports open or pressure applied in that the inlet pressure is connected to both outlet ports. Manual reset valves require operator intervention in order for the valve to maintain the energized position.

2.4 Programming PLC using LLD:

LLD has various set of instructions for various operation. The ladder logic diagram is based on operating logic of device and process to be done. LLD determines the operation of PLC – programmable logical controller. The logic of the program varies on the basics of programmer and

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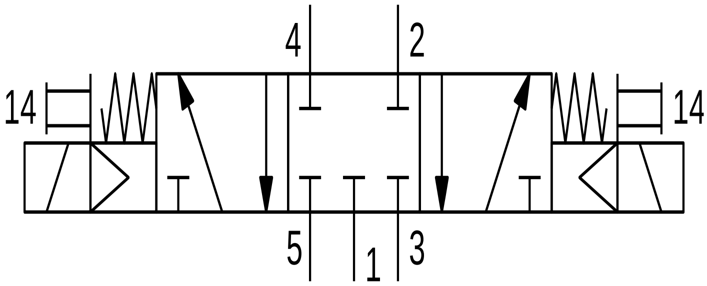
logic and steps of the operation. The basic the important step of ladder logic diagram is defining the input and output of the operation needed to be done.

The cutter has to cut the material after reaching the specified length by getting the input from two sensors. Where home sensor is fixed and end sensor is adjustable. The cutting is done by up and down movement of blade with the help of double acting cylinder which is controlled by 5/3 DCV and inputs of reed switches to the plc. Here the cylinder used is electro pneumatic. And the source of the cylinder is pneumatic (air) which is supplied by compressor through FRL unit. Here the sensor used is photo electric sensor. Here the controlling plc is s7-1200. And the control panel is designed as per the requirement.



2.4.1 Input and output definition:

As first step it is important to define input and output

Input (I):

- I0.0 - Start
- I0.1 - Stop
- I0.2 - Emergency stop
- I0.3 - Home sensor
- I0.4 - End sensor
- I0.5 - Cylinder up feedback
- I0.6 - Cylinder down feedback

Output (Q):

- Q0.0 - Process start light
- Q0.1 - Conveyor motor
- Q0.2 - Sensor on light
- Q0.3 - Cylinder down
- Q0.4 - Cylinder up

Memory (M):

- M0.0 - process start
- M0.1 - sensors on

2.5 Program Networks for computation of length and chopping:

Network 1: which controls the start and stop and emergency stop and it also contains the memory bit and light for process start indication.

Network 2: It controls the on and off of the conveyor motor by getting the input from process start memory bit, end sensor and cylinder up feedback. The main function of network 2 is to control the conveyor to avoid safety and defect issues.

Network 3: which consists of home sensor, end sensor, process start memory bit and sensors on light and sensors on memory bit. The inputs from End sensor is used in network2 when the end sensor detects the material. It turns into NC in network 3 and NO in network 2.

Network 4: Network 4 controls the cylinder down movement by getting the output from process start memory, sensors on memory bit which is fed into the timer which delays the input to the cylinder down movement. Here the delay is applied to maintain the safety conditions.

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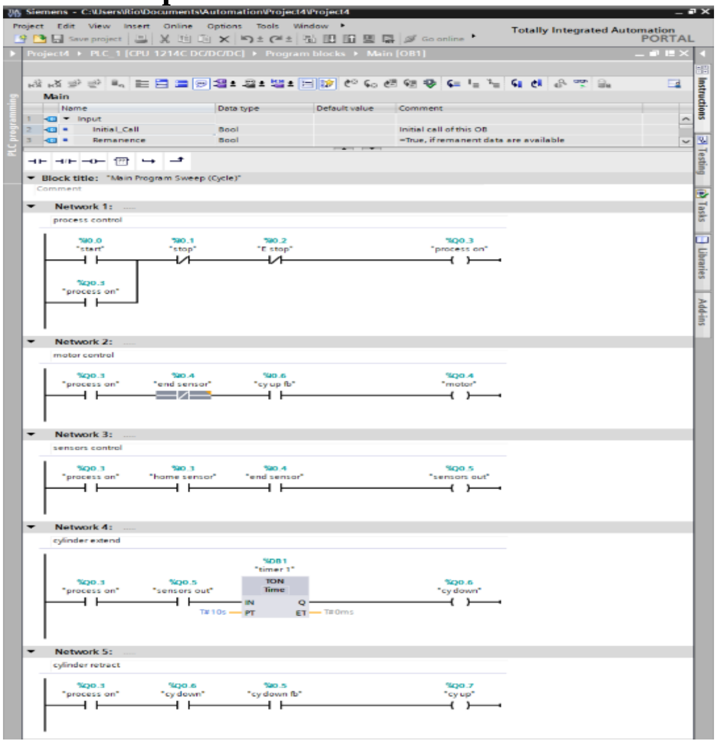
Network 5: Network 5 consists of process start memory cylinder down feedback and cylinder up output. The network 5 also controls the conveyor motor on and off as link to the network 2 which has cylinder up feedback which is used to ensure safety and to avoid material damage. Because the conveyor should not runs when the blade is down since it damages the material and the blade used.

2.5.1 Programming done in TIA portal:



3 Result and discussion:

3.1 Simulation in Solid works of designed model:

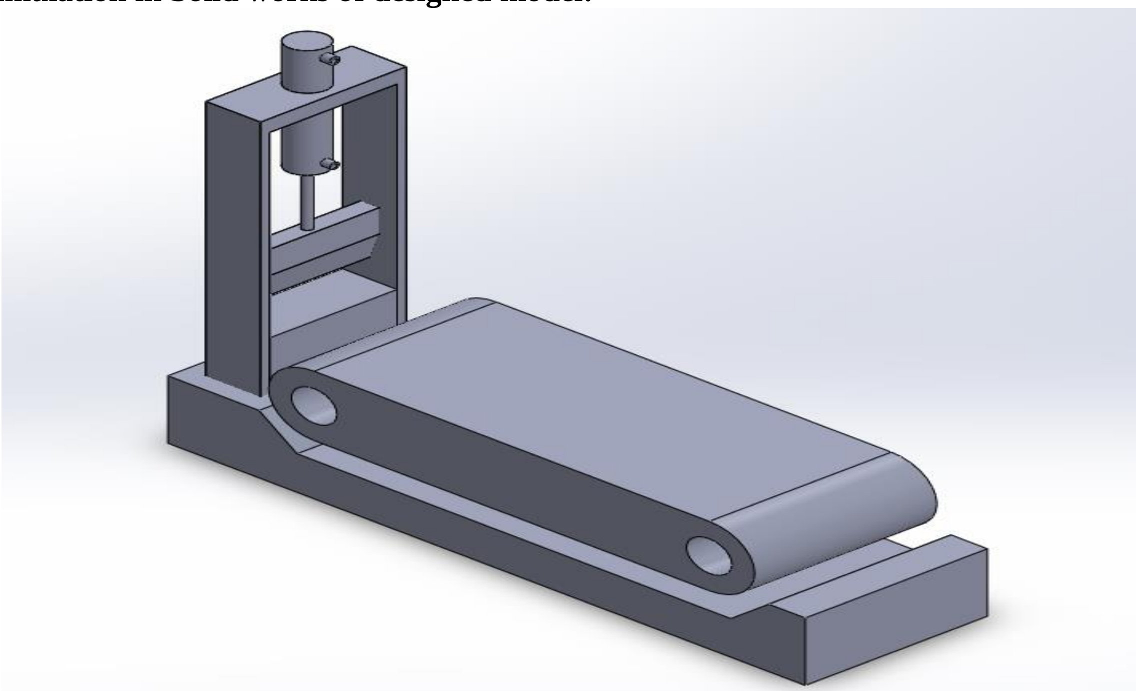


Figure 3

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3.2 Design calculation:

Pneumatic Cylinder:

Piston=50mm
Piston Rod Diameter=16mm
Forward Stroke =355mm
Return Stroke =280mm
Pressure=5 bar
Force = {P* π/4 *d^2 * 1/10}

Conveyor:

Length = 900mm
Width = 200mm

3.3 Result:

Our Project using PLC for Computation of length and chopping can be significant improvements in efficiency and accuracy of the industrial process.

This automated process reduces the risk of human error, resulting in more accurate and consistent cuts. It can also increase the speed of the process, resulting in greater productivity and cost savings.

3.5 Conclusion:

In conclusion, the market for PLC-based length computing and chopping systems is growing, driven by the increasing demand for automation, precision, and standardization in manufacturing. While the market is relatively fragmented, there are several key players competing for market share. As manufacturing industries continue to grow, the demand for these systems is expected to increase.

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