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Automation of Bottle Filling Plant with Industry 4.0

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ABSTRACT: This paper presents technical communication of automation industry which describes the technical issues of automation control system in operation development, improving management level and high efficiency process in bottle filling plant. In the bottle filling plant various processes need to be controlled and monitored regularly. Thus it becomes tedious job to handle the plant manually. PLC automates the sequence of operation to avoid human interference so accuracy is improved and speed of process has been increased. But still we require human effort. The aim of this paper describes implementation of industry 4.0 to existing real-time model of the water treatment plant using PLC. This paper is about how industry 4.0 concepts are useful in bottling industry. It's all about atomizing bottle filling industry to overcome the market demand in less time. The paper gives basic approach to move towards automation at higher level and totally digitize the industry so we can obtain efficient output in less time.

KEYWORDS: Automation, Industry 4.0, Bottle filling process, Implementation in plant;

I.INTRODUCTION

Over the years the demand for high quality, greater efficiency and automated machines has increased in the industrial sector. Industry 4.0 facilitates the vision and execution of a "Smart Factory". Within the modular structured Smart Factories of Industry 4.0, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services, both internal and cross-organizational services are offered and utilized by participants of the value chain. Normally our bottling industries are automated with the PLC. These bottling industries can be automated with this industry 4.0concepts. Automation is used for all control systems and the technologies in PLC is use to reduce the human work and helps in increasing the production. PLC plays an important role in the world of automation industry.

II. BACKGROUND

1. About Industry Automation

The term "Industry 4.0" is used for the next industrial revolution - which is about to take place right now. This industrial revolution has been preceded by three other industrial revolutions in the history of mankind. The first industrial revolution was the introduction of mechanical production facilities starting in the second half of the 18th century and being intensified throughout the entire 19th century. From the 1870s on, electrification and the division of labor (i.e. Taylorism) led to the second industrial revolution. The third industrial revolution, also called "the digital revolution", set in around the 1970s, when advanced electronics and information technology developed further the automation of production processes.

2. About Bottling Plant

All bottling plant in today automated using PLC (programmable logic controller). PLC atomizes the plant which not only monitor but controls operation on each stage. It controls conveyor, capping cylinder, flow of water from tank with help of hydraulic solenoid valve.

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III.DESIGN OF AUTOMATIC BOTTLE PACKAGING MACHINE IN PLANT

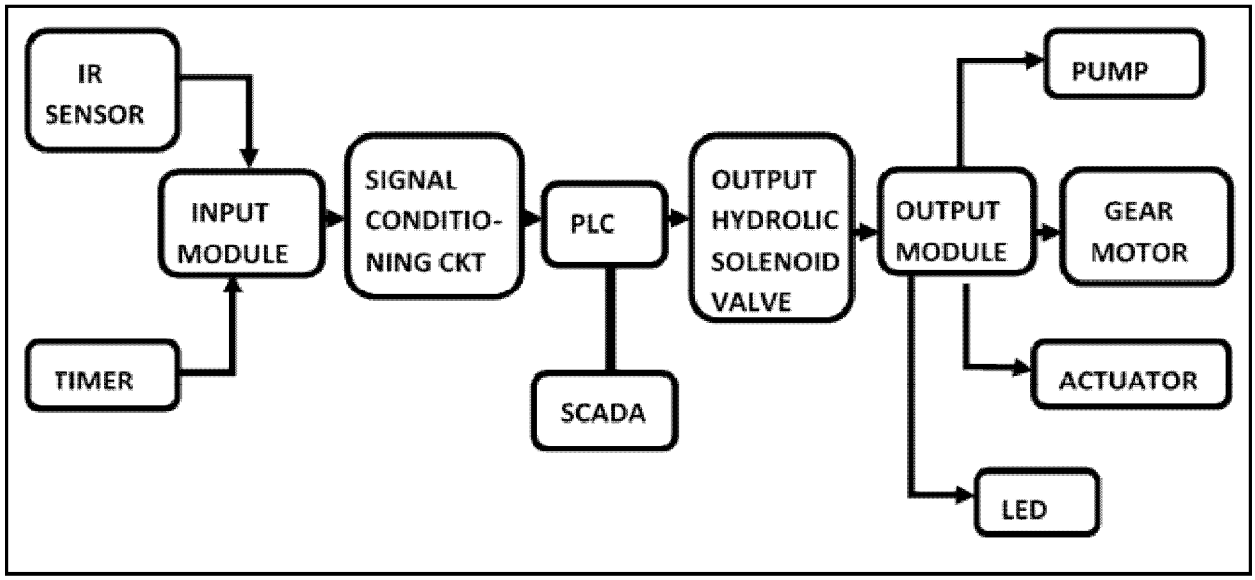

Fig 1.block diagram of bottle filling process

1. Input Module

The input module includes the IR sensors. There are two pairs of IR sensors whose output is given as an input to the PLC. The 1 IR pair sensors kept near the input side, where the bottles are fed into the conveyor, are called detection sensors and the one used for stopping the conveyor at the filling and capping operation side is called the stop sensor. Thus, these are the inputs given to the input module.

2. Signal Conditioning

The output of the sensors cannot be given directly to the PLC as the input voltage to the PLC should be 24V. Hence they are given through signal conditioning circuits which condition the input signals and in turn give it as an input to the PLC.

3. PLC

PLC's are well-adapted to a range of automation tasks .All control operations (filling and capping) are done using the PLC. The entire bottling process is automated by feeding the necessary conditions into the PLC using ladder logic. Ladder logic is one of the methods of programming a PLC. Thus, depending on the logic developed the various operations take place and the filling and capping of bottles are done. PLC consists of an I/O unit, central processing unit, and a memory unit. All logic and control operations, data transfer and data manipulation operations are done by the central processing unit. The results and statuses are stored in the memory of the PLC.

4. Hydraulic Solenoid Valve

The solenoid valve operated when it get signal from PLC to fill the bottle. It depends on detection sensors used at input side.

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5. Output Module

The various output devices used in the bottling process are gear motors, pumps, actuators and LED's. Depending on process flow each component work to make required output. This completes the filing process as we want.

IV. ACTUAL BOTTLE FILLING PROCESS

To go towards automation of bottling plant we must go through what happens in bottling plant. The process of bottle filing plant is given as follows:

1. Bottle Detection Using Sensors

Bottles are kept in position in their respective holders which are fixed to the conveyor at the input side. IR sensors are used to detect the presence of bottles in the holder. Depending on the output of the sensors the filling and capping operation takes place. A time delay is given in order to set the status of the bottles. If bottle 1 is present the corresponding status bit in PLC is set to 1 else it is set to 0. The outputs of these sensors are given to the PLC and depending on this output the filling and capping process for the bottles takes place. Thus if all the n bottles are present in the input side then the sensor gives the corresponding output to the PLC which in turn switches ON the corresponding pumps for filling operation to take place. If a particular bottle is not present the corresponding pumps remain OFF.

2. Filling Operation

Once the bottles are detected in the input side the conveyor motor switches ON and it starts moving in the forward direction. The bottles then reach the desired position for filling and the conveyor stops. The corresponding pumps in process tank switch ON and filling operation takes place. For e.g. if only bottle 1 is present then pump 1 switches ON and pump 2 and pump 3 remain switched OFF. There are three tanks present in the filling side namely: process tank, concentrate tank (tank 1) and tank to store water (tank 2).Tank 1 and tank 2 have low level and high level sensors (LLS and HLS) respectively. Process tank has three level sensors (LLS, HLS and MLS).MLS is used to denote the middle level of the tank. When the liquid in the process tank reaches below low level (LLS) pumps in tank 1 and tank 2 switches on and the process tanks get filled. When the level of liquid reaches high level (HLS) the pumps in tank 1 and 2 switch off

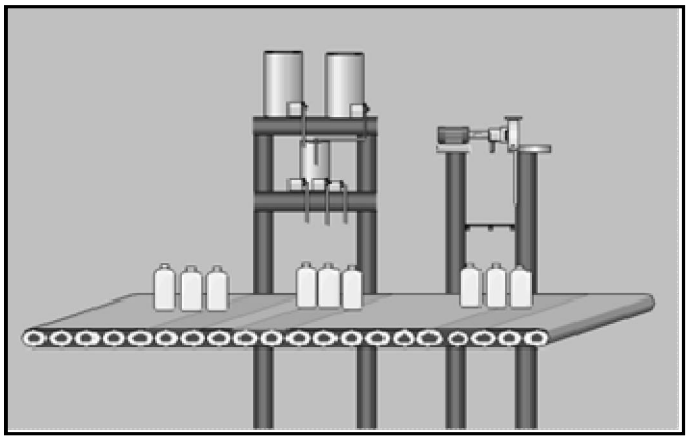

Fig 2. Process Description

3. User-Defined Volume

The filling operation is accompanied with a user defined volume selection menu. The desired volume is fed into the PLC and depending on the volume the filling of liquid takes place. The filling is done using timing operations. Thus the pump remains on for the preset value of the timer and switches off once time is out. Once the filling process is done the conveyor starts moving again.

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4. Capping Operation

The bottles are transported to the capping arrangement. IR sensors are kept to stop the bottles in the desired position for capping to take place. Once the bottles reach the position the conveyor motor switches OFF. The capping of bottles is done using actuator arrangement. Three actuators which move in forward and reverse directions are used to cap the bottles. The actuator applies a force on the caps which are placed in their respective holders. This force helps the caps to fit into the bottles at the required position. Similar to filling, if a particular bottle is not present it does not get capped. Thus the capping is done and the conveyor starts moving again. When the capping operation for one batch is done simultaneously the filling operation for another batch takes place. The entire sequence of operations continues until there are not bottles present in the input side. All these are automatically coordinated using the PLC. PLC gets the input from the input devices and sends the signals to the various output devices depending on the conditions that are fed into the PLC. Thus bottles get filled and capped.

IV. CONCEPT OF INDUSTRY 4.0

1. Design Principles:

There are six design principles in Industry 4.0. These principles support companies in identifying and implementing Industry 4.0 scenarios.

- Interoperability: the ability of cyber-physical systems (i.e. workpiece carriers, assembly stations and products), humans and Smart Factories to connect and communicate with each other via the Internet of Things and the Internet of Services
- Virtualization: a virtual copy of the Smart Factory which is created by linking sensor data (from monitoring physical processes) with virtual plant models and simulation models
- Decentralization: the ability of cyber-physical systems within Smart Factories to make decisions on their own
- Real-Time Capability: the capability to collect and analyse data and provide the derived insights immediately
- Service Orientation: offering of services (of cyber-physical systems, humans or Smart Factories) via the Internet of Services
- Modularity: flexible adaptation of Smart Factories to changing requirements by replacing or expanding individual modules

The basic principle of Industry 4.0 is that by connecting machines, work pieces and systems, businesses are creating intelligent networks along the entire value chain that can control each other autonomously.

2. Implementation in bottling plant

We can use these concepts to atomize whole plant, for that we follow the principles given above. We make our system cyber physical by connecting whole factory to internet. I know there is risk of security while connect whole system to internet but more secured algorithms in big data can be used. These system makes virtual copy of the system on cloud. In industry as whole system is connected we take market requirement and do the production. Likewise it also gives time to time report that how much time required for output filled bottles. The virtual copy of plant is given in fig 2.which shows all process from garbage plastic material to full lot of packaged bottles. The system is controlled through PLC and at each stage we have sensor which continuously monitor for its performance, maintenance and speed of operation. It measure at what rate bottles are filled and counts for quantity.

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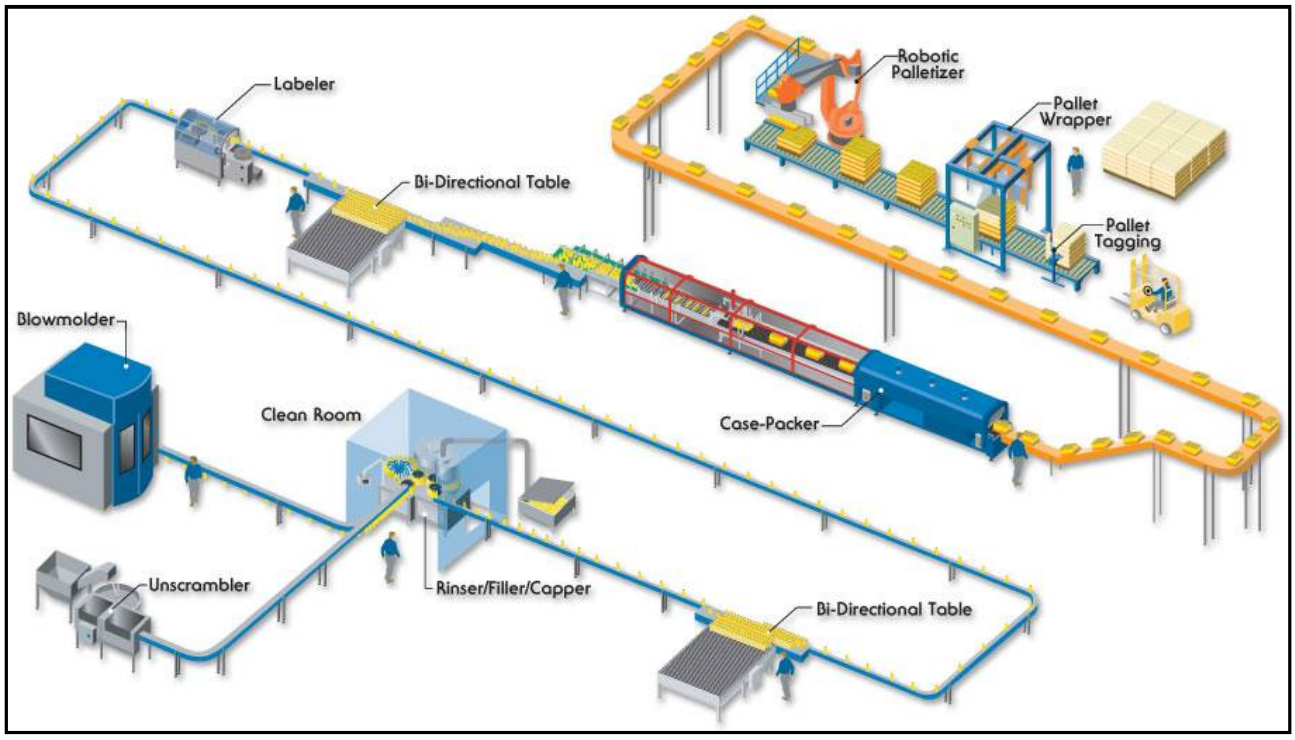

Fig 3. Virtual bottling plant

In this paper we implement many operations like Blow moulder, Unscrambler, Cleanroom, rinse/filler capper, Labeller, Case packer, Robotic palletiser, Pallet wrapper, Pallet Tagging etc. automatically using PLC and cyber physical System. Blow moulder is used to create hallow bottles from the plastic. This plant directly communicate with the vendor for requirements of the resources through cyber physical system. Clean room consist of cleaning the bottles to remove unwanted dirty particles. In the rinse/filler/capper section filling the bottles with user defined volume selection and capping is done automatically. Labeller is used to attach the label to the bottles sequentially. Case packer packs the bottles. Robotic palletiser arranges the packed bottles properly. Pallet wrapper wraps the arranged packets of bottles into the box. At the end through the pallet tagging the bottles are ready to provide to the end user. All the synchronization operation is controlled through industry 4.0 concept. If the plant is not able to fulfil requirement of market then it communicates with another plant through industry 4.0 concept. For example if it have an order of 1000 bottles in half hour and it isn't able to fulfil this order then it communicate with another plant for production it is possible only through the cyber physical system.

VI. CONCLUSION

This paper has proposed an application of automation illustrating a PLC based fully automatic untouched liquid filling system with industry 4.0 which operated totally through cyber physical system. The system meets the demand of high-speed production using the least mechanism requirements and human efforts. The system also provides high accuracy and precision.

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