AUTOMATED PRODUCT QUALITY TESTING USING IOT

Mithil Dharmadhikari[1], Yatish S.H[2], Nidhi P Closepet[3], Sukanya Deka[4], Silpa Ajith Kumar[5]

[1,2,3,4]*Students, Dept. of Electronics & Instrumentation Engineering, Dayananda Sagar College of Engineering, Bangalore, Karnataka, India*

[5]*Silpa Ajith Kumar, Assistant Professor, Dept. of Electronics & Instrumentation Engineering, Dayananda Sagar College of Engineering, Bangalore, Karnataka, India*

ABSTRACT*:—A manufacturing industry consists of various segments included in the process. Amongst these, the last and the final step before packaging a product is the Quality Control Management. Product quality testing is a vital process in any industry before it reaches the customer.*

With the advent of the Industrial internet of things(IIOT) and Industry 4.0, automated manufacturing and testing has become even more efficient. The project includes IIOT to allow the user to choose between the products that are to be tested remotely. Thereby reducing the on-site involvement of a human being. The aim of the project is to create an automated quality control line which is controlled over voice and checks the quantity and the wrapper of the product. We have used a Bosch Rexroth L20DP Programmable Logic Controller for quality testing. Load cell and proximity sensors are used to measure the parameter. These parameters are compared to set standards to perform quality testing. Pneumatic actuators are used for the pick & place and gate control action. The addition of voice command and IIOT allow for reduced human interaction in the overall quality control process

Keywords***: Automation; Quality testing; Programmable Logic Controller; IIOT; Cloud; Artificial Intelligence; Neural Network.***

1. INTRODUCTION

A programmable logic controller (PLC) or programmable controller (Refer fig.1.1) is an industrial digital computer that has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, robotic devices, or any activity that requires high reliability, ease of programming, and process fault diagnosis. They can be designed for many arrangements of digital and analog I/O, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. PLCs were first developed in the automobile manufacturing industry to provide flexible, rugged and easily programmable controllers to replace hard-wired relay logic systems. Since then, they have been widely adopted as high-reliability automation controllers suitable for harsh environments. In the recent world of vastly growing technology, the Programmable Logic Controllers have been made efficient in many ways. Initially, in order to integrate IoT based applications, the users had to use receivers and transmitters at every node or junction. In the current technologically driven world, the Programmable Logic Controllers have in-built modems or routers to perform the necessary task of wireless communication. Therefore, such Programmable Logic Controllers in the industries are called the Industry 4.0 PLCs.

The **Fourth Industrial Revolution** (or **Industry 4.0**) is the ongoing automation of traditional manufacturing and industrial practices, using modern smart technology. Large-scale machine-to-machine communication (M2M) and the internet of things (IoT) are integrated for increased automation, improved communication and self-monitoring, and production of smart machines that can analyze and diagnose issues without the need for human intervention. The fourth industrial revolution has integrated "smart" working in the daily industrial operations. The direct involvement of humans in the production operation has widely reduced. This has led to many advantages over a rather traditional operation.

The **Industrial Internet of Things** (**IIoT**) refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management. This connectivity allows for data collection, exchange, and analysis, potentially facilitating improvements in productivity and efficiency as well as other economic benefits. The IIoT is an evolution of a distributed control system (DCS) that allows for a higher degree of automation by using cloud computing to refine and optimize the process controls.

2. EASE OF USE

2.1 PROGRAMMABLE LOGIC CONTROLLER

There are various ways to program a PLC, like- the ladder logic, function block diagram, sequential flow chart, structured text and instruction list. All the mentioned programming languages are easy and user friendly which makes it easy for any person to set it up and debug an issue reducing the time spent. The PLC itself is a replacement for the relay logic, which helped in the simplification. Sensors of various kinds can be calibrated easily as per the industrial needs.

2.2 INDUSTRIAL INTERNET OF THINGS

With the vastly growing industries around us, time is an essential aspect to consider. Automation over the internet is a time reducing approach to our delegated task. Digitization has significantly increased the accuracy over the years making us bent towards the reduction of human interface in the production and assembly line. The usage of cloud to get the inputs from the sensors instead of the traditional data transfer cables is a reduction to the clutter around the workspace. With the increase in the number of machines used at the industries, it is risky for the engineers to go all the way to the machines in order to give a desired command every time. A voice command over the IIOT, from an isolated command room will significantly reduce the risk, increase the ease of operation and also eliminates the time wasted in order to get to the machine

3. COMPONENTS

3.1 BOSCH PLC:

This project has been implemented using the **BOSCH REXROTH L20DP PLC. The IndraControl L20 is a modular and scalable control.** It combines the benefits of a compact small control with a standardized I/O system on the basis of terminal technology. It is a hardware platform that can be used for PLC applications. It provides onboard interfaces, e. g. high-speed inputs and outputs (8 each) and communication interfaces, such as Ethernet, **PROFIBUS and RS232**. The locally available I/O units can be extended by the Rexroth Inline I/O system, just by simply mounting the components side by side. Application programs, incl. runtime, are completely stored to an easily accessible standardized Compact Flash medium.

3.2 LOAD CELL:

A load cell is a device that measures the weight of a product. The basic principle of a load cell is it converts physical quantities such as compression, pressure, force into electrical signals, hence measuring the weight of the object. The particular load cell used is a **strain gauge load cell**. This load cell is the most commonly used load cell because of its profound accuracy, versatility and cost-efficiency.

3.3 IR PROXIMITY SENSOR:

The IR proximity sensor is a simple fool proof sensor that works on a basic transmission and reception principle of infrared light. The sensor consists of an electromagnetic transmitter and a receiver which measures the distance of the object from the source based on the distance travelled by the ray.

3.4 ALEXA:

The IoT section of the project is led with the inclusion of Alexa. Alexa is an Artificial Intelligence voice assistant which can enlighten us with a lot of information about the questions we ask and it also can actuate appliances which are connected over the internet. Similarly, in our project, we use Alexa to control the product selection, hands-free, over the internet.

3.5 NODE MCU:

NodeMCU is a low-cost open source IoT platform. It is an easy-to-use computer with an esp-12 Wi-Fi module. It has an esp8266 CPU with a memory of 128kB and storage space of 4MB. Due to its on board Wi-Fi module, it is a very flexible open source IoT platform. This board can be easily programmed on the Arduino Integrated development environment. The board has 12 input output ports and can be configured according to our needs. In our project, it acts as the bridge between the PLC and alexa, it establishes connection with alexa over the internet.

3.6 PNEUMATIC ACTUATORS:

The motion of the pick and place robot entirely takes place with the actuators. These actuators convert the electrical signals from the PLC into mechanical action with the use of pneumatics. This pneumatic pressure exerted moves the robot up, down, back and forth. This operation uses a double acting cylinder which can be bi-directionally controlled by the pressurized air flowing in opposite directions. The individual action of the air flowing pushes the piston accordingly.

For the Gripping action, a pneumatic gripper is used. This gripper creates a vacuum between the surface of the object in contact and the surface of the gripper when the pressurized air is made to flow.

3.7 INDRAWORKS SOFTWARE:

Indraworks is a tool offered by **REXROTH BOSCH** in which we can create our desired PLC logic to dump. We benefit from quick and transparent access to all the functions and system data of the automation components. Indraworks offers continuous operation based on current Windows technologies and extensive wizards for the project planning of controls, drives, and peripherals.

4. WORKING PRINCIPLE

The process can perform several functions such as identification and selection of a product. It can then display data related to the product and take the parametric values for testing as an input.

Furthermore, it forms an IOT gateway between the field and control room. The overall objective of the process is to test selected products according to the set industry standards and to enable remote monitoring and controlling actions.

Quality testing is an integral part of any industrial manufacturing process. The testing process is a rigorous task, where the products are tested for hundred percent quality, post production. In our project, we intend to test the quality (weight/level and brand wrapping) of a product containing liquid quantity. With the inclusion of IIOT, we can regulate the initial product selection over the internet with a unique voice command. The following (fig 1) is the basic block diagram of the automated quality testing process.

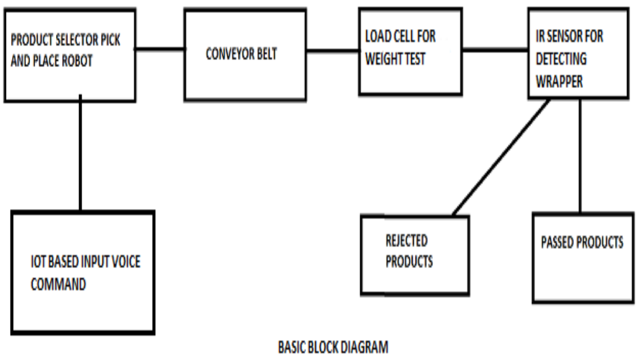

Fig. 1: BASIC BLOCK DIAGRAM

The second part of the process contains the mechanical parts such as the pick and place robot and conveyor belt. The pick and place robot receives the coordinates to pick the product from the plc. The place action places the specified product onto the conveyor belt which acts as a transfer line which takes the product towards the quality control section where the sensors check for quality according to predetermined set points.

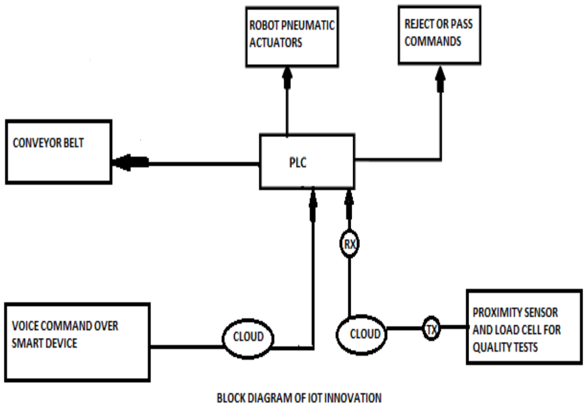

Fig. 2: IIOT INNOVATION

In the block diagram mentioned above (fig 2), the IIOT inclusion in the process is briefly specified. The Programmable Logic Circuit is fed with data from the sensors over the internet with the help of cloud data transfer. The IIOT inclusion starts from the control room where the voice command is initiated for the product selection. Based on the selection, the product scanner will send the information of the particular selected product to the PLC, which will in turn actuate the process with the help of a pick and place robot and transfer the product from the crate, on to the conveyor belt for further testing. At the testing section, first, the load cell will weigh the product making sure the liquid inside is at the desired level. Up next, the IR sensor will check if the brand wrapper is present on the bottle. Both this information (weight and wrapper check) is sent to the Programmable Logic Circuit over the internet with the help of cloud data transmission. Based on these inputs, the Programmable Logic Circuit will actuate a gate action which will either reject or pass a product completing the quality testing process of a production line. These passed products are further secured and ready to dispatch.

A **database** containing the obtained data regarding the input and output parameters for testing is created. This is then stored in a **cloud** accessible on a server. Therefore, the data can be monitored and controlled from a control room away from the testing site as well. The cloud used in our project is service based cloud from azure or waste database can be manipulated by using dams or query languages as well. Hence the overall inclusion of cloud allows us to not only safeguard our information but also efficiently manipulate it.

The final block diagram (fig 3) shows us the mechanical setup of the project. Which includes the pick and place robot and the conveyor belt. The choice of the robot and belt is decided depending upon the types of products that are to be handled. The passed products can either move to further testing or be packed for shipping. The conveyor belt action and speed are controlled by the inputs from the PLC. Timers and counters are used to decide the delay and runtime of the belt depending upon the type of product to be tested. The pick and place robot needs accurate input of the coordinates to work efficiently. This can be done only if we know the location of the product precisely. Although we are moving toward a more electronics era, electro-mechanical systems still play a major part in the

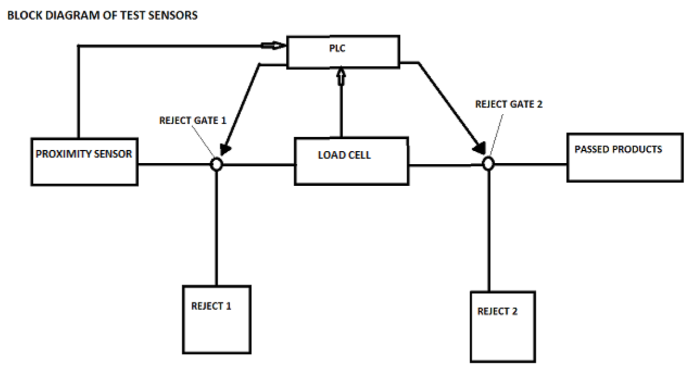

Fig.3:MECHANICAL SETUP

5. RESULTS

The results for the project can be divided into 3 parts.

1. NodeMcu and Alexa
2. Pick and Place logic
3. Conveyor Belt logic

1. NODE MCU AND ALEXA

We have to interface alexa and nodemcu to enable voice command ability of the project. For this we used the alexa app for interfacing (fig 5).

Fig.4:Alexa app interface

To program the nodemcu, it is plugged in with a micro-USB to the computer. The libraries required to program the nodemcu can be downloaded using the links as shown above.

In the program, the WIFI name and password is entered. To get the api key, Sinric.com is the website used. The api key is obtained and is copied into the program.

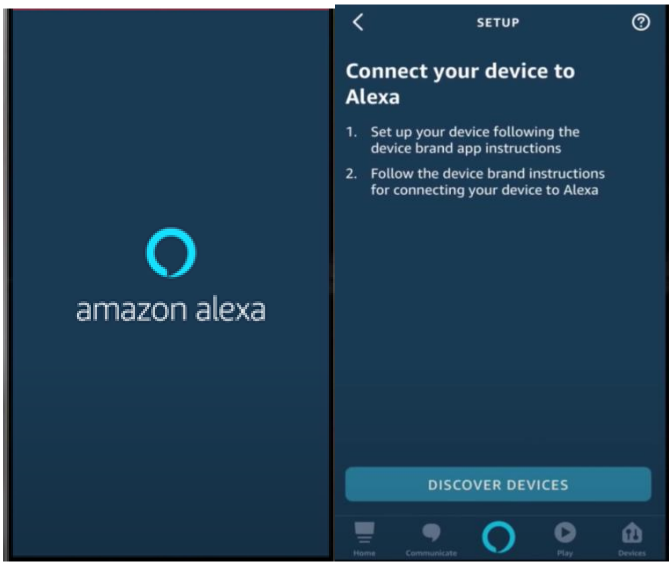

Fig.5:Alexa app interface

2. PICK AND PLACE LADDER LOGIC :

The pick and place operation is the second segment of our project . Refer fig 6 for the ladder logic of the operation. Once the command is received from the Control room via Alexa and Node MCU over the internet, the PLC receives its signal from the Node MCU. This signal decides whether product A or product has to be picked and placed on the conveyor belt.

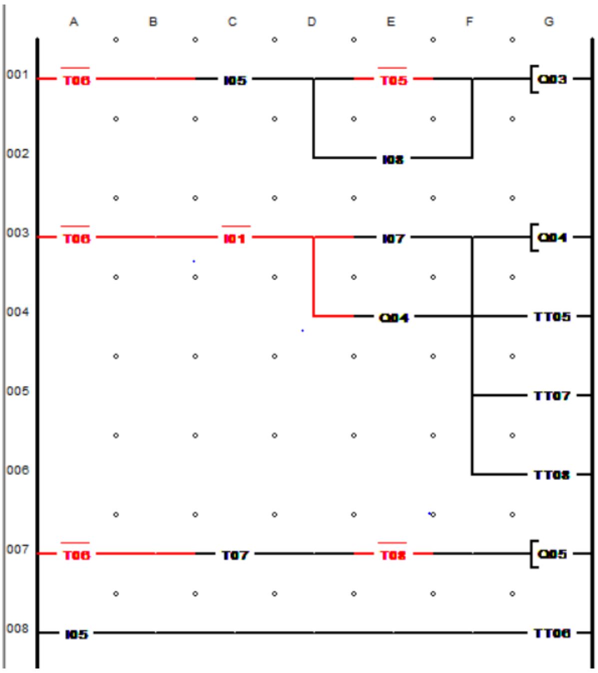

Fig.6:Pick and place ladder

Table1: Description of Inputs and Outputs for pick & place

INPUTS	OUTPUTS	TIMERS
I5- Product 1 signal I6- Product 2 signal I7- Gripper Close horizontal action begins I8- Horizontal extension sensor	Q3- Vertical Cylinder Q4- Gripper Action Q5- Horizontal Action	T5- Vertical Cylinder cut-off T6- Master process cut-off T7 Extension of horizontal Cylinder T8- Horizontal Cylinder cut-off

Ladder logic description -

- This is the initial state of the operation, i.e, before the PLC received the product selection signal.

- Once it receives the product selection signal, I5 (product A) the whole process immediately starts.

- Here product A is selected and the actuation for the gripping of product A is initiated. Once the vertical cylinder goes down, the I7 sensor detects the extension and starts the timer T5, T7 and T8. This sensor also initiates the vacuum gripper which picks the product.

- Once the timer is done, the vertical gripper goes back up. After the timer T7 is completed, the horizontal action is done.

3. CONVEYOR BELT LADDER LOGIC:

The following ladder logic (shown in fig 7) is developed to perform automated operation of the conveyor section of the process. The logic controls all actions of the section from detection of the bottle on the conveyor to controlling the rejection gate at the end of the conveyor.

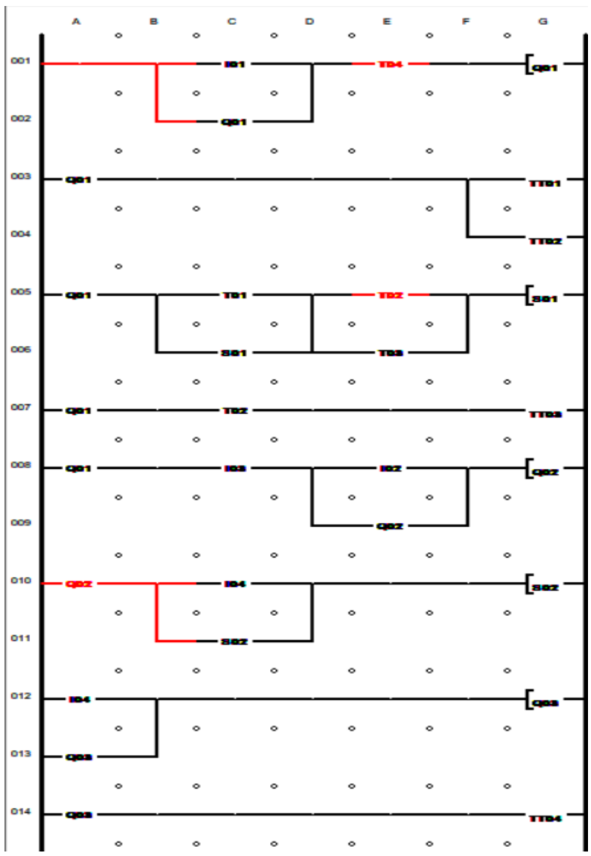

Fig.7:Conveyor belt ladder

Table2: Description of inputs and outputs for conveyor belt

INPUTS	OUTPUTS	TIMERS
I1- Bottle detection IR sensor I2- Wrapper detection proximity sensor I3- Load Cell I4- IR sensor for gate position.	Q1- Pilot light Q2- Virtual coil Q3- Virtual coil S1- Conveyor motor S2- Gate control	T1- Safety wait timer T2- Timer to run motor until quality control sensor T3- Safety timer T4- Restart quality testing cycle

Ladder logic description -

 Rung 1 and 2 control the detection of the test product through the IR sensor I1. It begi the process by switching on pilot light Q1. I1 triggers once it detects a product, and energizes the timers T1 and T2. It initiates the entire process after Pilot light Q1 is switched on.

● Rungs 3 to 7 control the driving action of the conveyor motor. Timers control the safety wait time and the time for which the conveyor motor runs in the first phase. Timer T1 is a safety timer to hold the product in place until the conveyor motor can start. Timer T2 is calibrated with the amount of time it takes for a product to reach the quality testing section of the conveyor.

● Rungs 9 to 14 define the logic for controlling the conveyor action and the gate action after the quality testing has been done. The gate is controlled once the product is detected by the I4 IR sensor. If the product quality is per standards, the gate will remain open; Q3 will remain off and I4 will trigger the gate to close and reject the object.

6. ADVANTAGES AND LIMITATION

ADVANTAGES:

- Completely automated (safety). Increased automation leads to reduced labour recruitment on site. This reduces the probability of accidents as the entire process is remotely operated.

- Inclusion of IOT for efficient data transfer and process control. IOT enables us to handle and monitor data transfer on a real time basis. Real time monitoring increases efficiency and allows for flexibility in setting the parameters.

- Efficient means of quality testing using several sensors. Use of several sensors increases the stability of the automated system.

Limitations:

- High initial cost. The inclusion of parts like PLC and IOT gateway make the initial setup relatively expensive.

- Maintenance of conveyor belt and pick and place robot required. The automated system contains mechanical parts such as the belt and the robot which require regular oiling and maintenance for efficient functioning.

- Multiple setups required for testing multiple products simultaneously. To test two are more different products at a time, we require as many setups of the conveyor belts and sensors.

7. APPLICATIONS

As the title suggests the project finds its applications in product testing. The setup is such that it allows us to select among several different products and test them for quality. The primary application is in testing of fluid-based products in bottles of different sizes for level and wrapper. But the application can be extended to packed carton box products and any other solid packing products. They can be tested for physical parameters such as level/weight, wrapper, standard size of packing etc.

The project can be implemented without the IOT applications too in small scale industries where cost is a factor. Therefore, the application of the projects is highly broad and can be applied to various industries from mineral water bottle manufacturing to car manufacturing assembly lines.

8. CONCLUSION AND FUTURE SCOPE

The quality testing process is a very efficient system for testing the post manufactured packaging quality of products such as bottles and boxes. It finds many applications in multi domain industries. As the process is based on capabilities of the PLC and sensors, it has a huge scope in the future with the advancement in range and capabilities of sensors and IOT.

The inclusion of **Artificial Intelligence and neural networking** in the scanning process will be a boon for this prototype. The image recognition can take place in two places- **the pick and place robot** and **brand wrapper test**.

The pick and place robot can use image recognition in order to segregate the product by itself, replacing the additional scanners placed in the products' crate.

The IR sensor can be replaced with image recognition, allowing it to recognize other details on the wrapper, like the bar code, size of sticker, expiry date, printing quality, etc.

Increasing the number of parameters for testing such as product standard size and other physical and chemical parameters will enable us to expand the scope.

The same idea can be applied to a manufacturing process such as an automated IOT based bottle filling machine to fill the bottle with different liquids which can be selected using IOT command.

With such advanced technology, we can further improve the efficiency and the scope of the project

8. REFERENCES

[1] Shahid Mumtaz; Ahmed Alsohaily; Zhibo Pang; Ammar Rayes; Kim Fung Tsang; Jonathan Rodriguez, "Massive Internet of Things for Industrial Applications: Addressing Wireless IIoT Connectivity Challenges and Ecosystem Fragmentation", IEEE Industrial Electronics Magazine (Volume: 11, Issue: 1, March 2017).

[2] Hugh Boyes, Bil Hallaq, Joe Cunningham, Tim Watson, "The industrial internet of things (IIoT): An analysis framework", Cyber Security Centre, WMG, University of Warwick, Coventry, CV4 7AL, UK, April 2018.

[3] Reinhard Langmann, "The PLC as a Smart Service in Industry 4.0 Production Systems", Hochschule Düsseldorf, Department of Electrical Engineering, September 2019.

[4] Mallikarjun G. Hudedmani, Umayal R M, Shiva Kumar Kabberalli, Raghavendra Hittalamani, "Programmable Logic Controller (PLC) in Automation", Department of Electrical and Electronics Engineering, KLE Institute of Technology, Hubballi , Karnataka, India . Advanced Journal of Graduate Research, Volume 2, Issue 1, pp. 37-45, July 2017.

[5] Somesh Bakshi, Gaurav Khairmode, Nilesh Varkhede, Swapnil Ayane, "Monitoring and Control of PLC Based Automation System Parameters Using IoT". International Research Journal of Engineering and Technology (IRJET), Volume: 06 Issue: 03 | Mar 2019.S

[6] Joji Parambath, "Troubleshooting Programmable Logic Controllers". Academia.edu, Apr 2016

[7] Joji Parambath, "Programmable Logic Controller Communication services", Academia.edu, Apr 2017