Design and Development of a Colour Sorting Machine using PLC and SCADA

K.Sasidhar[1], Shahwar Farooqi[2], Mohammed Abdul Moin[3], M Sachin[4]

[1]*Assistant Professor, Dept. of EED, Muffakham Jah College of Engineering &Technology, Hyderabad, India*

[2,3,4] *Student, EIE, Muffakham Jah College of Engineering &Technology, Hyderabad, India*

Abstract: **The purpose of this project is to present a Programmable Logic Control (PLC) and SCADA based control system that is applied to the Colour Sorting Machine. In many industrial applications, there is a need of sorting. Sorting can be done by using many ways according to the dimensions, colours, weight, using machine vision (image processing), material of an object etc. For example, in Thermal Power Station, electromagnetic sorting technique is used to sort ferromagnetic materials from coal. This project consists of components such as PLC, SCADA software, conveyors, colour sensors, electronic system and motors. The objects are being sorted according to their respective colour. The main conveyor is supported of two branches to load the distinguished object on to the respective one as separated by the electronic system and detected by the proximity sensors. In this project, SCADA provides a user-friendly environment to establish an easy communication between humans and process. SCADA shows the activation of various parts of the system, i.e. conveyors, motors, LDRs and electronic devices.**

Keywords: **Programmable Logic Controller (PLC), LCA (Low Cost Automation), SCADA Supervisory Control and Data Acquisition (SCADA), RGB.**

I. INTRODUCTION

Automation is the technology by which a process or procedure is performed without human assistance. Automation or automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduced human intervention. Some processes have been completely automated [7].

Sorting is a task carried out by a machine that sorts objects such as containers or heavy goods. Traditional methods of sorting involved placing objects onto a conveyor and sorts only one object at a time. This method is time-consuming and expensive. Our paper aims at sorting simultaneously [2]. The sorting operation takes place in a synchronized manner. It also includes a user-defined volume selection menu through which the user can input the desired object to be sorted. The entire system is more flexible and time-saving. The sorting operations are controlled using a Programmable Logic Controllers (PLC). This is because PLCs are very flexible, cost-effective, space efficient and reduces complexity. By programming the PLC, we control the entire system. SCADA (Supervisory Control and Data Acquisition) is used to monitor the process [4].

II. LITERATURE SURVEY

Industrial automation and robotics play important role in growth of industry. The main criteria in industry are quality and flexibility of the product. In 80's robot were used to perform tasks like machine tending, material transfer, painting, welding which does not require high accuracy. Considering greater role of robots it was predicted in 90's that industrial robots will become increasingly vital in applications which require high precision and accuracy. Autonomous robots with sensors are used for accuracy and precision in product which gradually improves the growth of industry. To achieve this precision, robots are programmed for a single task taking sensory information. Real time and highly accurate characteristics of small objects in a fast flowing stream would open new directions for industrial sorting processes. Recent advances in electronics and printed circuit board technology open new perspectives for industrial application in this field [1].

Existing System:

In currently existing systems, use of different technology is made according to budget and scope of industry. It includes robotics systems, microcontroller based system, sensor based system and pneumatic based system, etc.

Sensor Based System

The advance system of carton sorting is according to weight, old system was based on sensor. There were some systems which counts that how many objects are going from the conveyor belt. Such systems make use of sensor. When carton passes through conveyer, at the side of conveyer normally transmitter and receiver infrared sensor were used. When the carton cuts the infrared beam the electronic counter system in digital form gets '0' which was counted as count. Sensor based system sense coming object and count it. But the drawback of the system is that it can only senses the object it cannot calculate the weight of object. So it is not having the provision of sorting carton as per required weight Sensor-Based Sorting is addressing new developments and applications in the field of automatic sensor separation techniques for primary and secondary raw materials [5].

Robotics Systems

The robotic arm is controlled using servo motors whose degree of rotation is controlled by the on a timer of the pulse rail appearing at its control inputs. According to the structure of robotic arm, various degree of rotation for the servomotor are assigned to carry out the operations. The arm of the robot is realized using aluminium brackets. Four types of brackets are arranged for this purpose [3]. The robotic arms are too costly and complex due to the complexity and the fabrication process. Two types of the brackets are for holding the servo motors and two types for the extensions and interconnections of the robotic arm. The IR sensor identifies the box and it sends the data to a microcontroller which controls the arm motion according to the height of the box. The motion of the servo motor is controlled in a manner so that each box is dropped into a respective boxes place in a predetermined position. The time taken by the robotic arm for a single motion is set to approximately 0.5 seconds. Eight steps of motion of robotic arm are required for a box to be picked up and to be dropped in the correct basket. That includes motion of arm from the default position, picking a box, motion to the correct basket, dropping the box to the basket and return to the default position. The number of steps taken by the arm to pick the box and drop the box counts to seven steps and from there to back to default position needed one step.

Approximately time needed for the microcontroller to identify height of the box is around one second. Therefore, the total time needed for picking and dropping the box including identifying the height is around five seconds. Four motors are used in the robotic arm. One to control the rotational motion of the base, one to control the angle at the elbow, one to control the wrist movement and last one to control the gripper, that is to hold and drop the ball. The initial position of the robotic arm when power is applied and the robot is ready for operation. A lever mechanism is used for opening and closing the gripper. So a single motor is enough for the gripper control. Fingers come closer to pick and hold the box and move apart when it drops the box. Two positions are designed for the fingers by using a single servo motor. One in close position and other in open position. Two motions are permitted for the motor at wrist and elbow that is to move up and down [9].

Microcontroller Based System

The microcontroller-based systems are having kind of artificial efficiency as microcontroller can be programmed as per the system requirement. The microcontroller is programmed to count the carton passing from conveyer and also to measure the weight of carton box. As this system has its drawback on microcontroller measuring weight with advance measuring weight demands. There are many such systems are available which use online check-weightier to calculate the weight of object. If we use microcontroller then cost price of the system get increased. The major drawback of using microcontroller is that its hardware requirements will also go on increasing as it does not contain inbuilt timer, counter [4]. All this drawback of existing system is overcome in PLC based object sorting automation which sort object according to the height [1].

III. PROGRAMMABLE LOGIC CONTROLLER

A programmable logic controller (PLC) is an industrial computer used to control and automate complex systems. Programmable logic controllers are a relatively recent development in process control technology. It has designed for use in an industrial environment, which uses a programmable memory for the integral storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control through digital or analog inputs and outputs, various types of machines or processes. Programmable logic controllers are used throughout industry to control and monitor a wide range of machines and other movable components and systems. PLC is used to monitor input signals from a variety of input points (input sensors) which report events and conditions occurring in a controlled process. Programmable logic controllers are typically found in factory type settings. PLCs are used to control robots, assembly lines and various other applications that require a large amount of data monitoring and control [10].

Ladder Logic

The Ladder logic is widely used in programming PLC where sequential control of a process or manufacturing operation is required. It is a graphic Language and can be used to transcribe relay diagrams, and is suited to combinational processing. It provides basic graphic symbols, contacts, coils, and blocks. Specific calculations can be executed within the operation blocks. Any control task modifications are done by changing the program [11].

IV. SUPERVISORY CONTROL AND DATA ACQUISITION

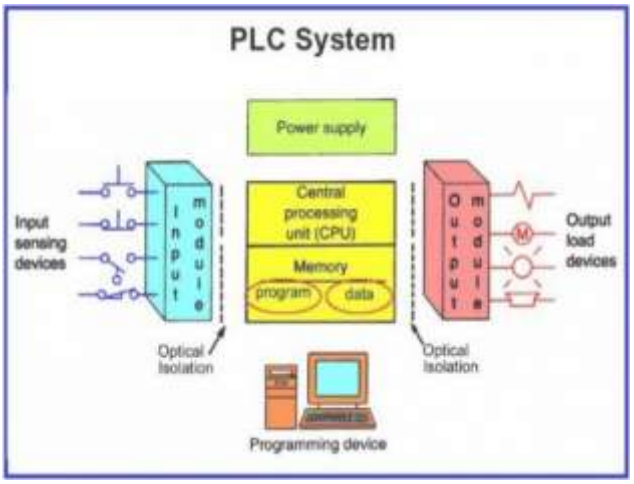
SCADA system, gathering data on the process and sending control commands to the field connected devices. It refers to the computer and software responsible for communicating with the field connection controllers, which are RTUs and PLCs, and includes the HMI software running on operator workstations. In smaller SCADA systems, the supervisory computer may be composed of a single PC, in which case the HMI is a part of this computer. In larger SCADA systems, the master station may include several HMIs hosted on client computers, multiple servers for data acquisition, distributed software applications, and disaster recovery sites. To increase the integrity of the system the multiple servers will often be configured in a dual-redundant or hot-standby formation providing continuous control and monitoring in the event of a server malfunction or breakdown [8].

Remote terminal units

Remote terminal units, also known as (RTUs), connect to sensors and actuators in the process, and are networked to the supervisory computer system. RTUs are "intelligent I/O" and often have embedded control capabilities such as ladder logic in order to accomplish boolean logic operations [6].

V. SYSTEM ARCHITECTURE

The system consists of many functional units such as photo sensor, Colour sensor, Conveyor belt, DC gear Motors as shown in figure 1. Here PLC plays vital role i.e. it is heart of this proposed system. The PLC is burnt with program that is necessary (shown in figure 2) to control the sensors and relays, and conveyors interfaced to it. The interfaced units are controlled by the PLC in an efficient and faster manner, thus providing the system to be reliable than the existing ones.



VI. DESCRIPTION OF PROPOSED SYSTEM

Our project is PLC and SCADA based automatic Colour sorting machine divided into four cycles namely: Object Detection, Conveyor starting, Sensory Detection and Sorting mechanism.

Our project involves reducing the industrial cost employed in installation and functioning of multiple conveyor belt systems in different industries like Food Processing Industry, Medicine Industry etc. for sorting of different colour objects. This is achieved by setting up a single conveyor belt which carries objects and then the PLC module along with the sensor module which detects the objects and then the objects are sorted accordingly. With this the operational costs, labour costs and installation costs are reduce in manifold by minimal increase of the inputs for the PLC. The ease of use is provided by SCADA.

We shall now discuss our project in detail by providing a descriptive analysis of various modules required in our project.

Overview of the Modules

- PLC Module
- Conveyor Belt Module
- Sensor module

PLC Module

Our PLC module consists of the following

- Allen Bradley MICROLOGIX 1200
- 24V DC power module
- 16 digital I/O Module

Understanding the basic features of MICROLOGIX 1200 in our facility would maximize our productivity by increasing the operation of our project. The MICROLOGIX 1200 includes fault detection with built–in diagnostics. Understanding these features is critical in running an efficient operation. Allen Bradley PLC is widely used in several industrial automation operations across Indian sub – continent.

Conveyor Belt Module

The next concept in our project is of the conveyor belt, on which the objects are kept. Here instead of using multiple conveyor belts for different operation we are using a single conveyor belt which takes the objects to the DC motor where the objects are separated and the sensing of the objects is done and then sorting operation is done simultaneously.

Sensor Module

In our project PLC based automatic object sorting machine. We are using an IR Sensor for detection of object presence and Colour sensor for detection of objects based on colour. The operation of IR sensor and Colour sensor (as shown in figure 3) here are programmed such that when the object comes and when it is detected the sensor senses it for some time delay and if the object is removed during that time delay and placed again then the sensor again starts the sensing time delay from the beginning and after that the instruction of object being sensed is send to the PLC.

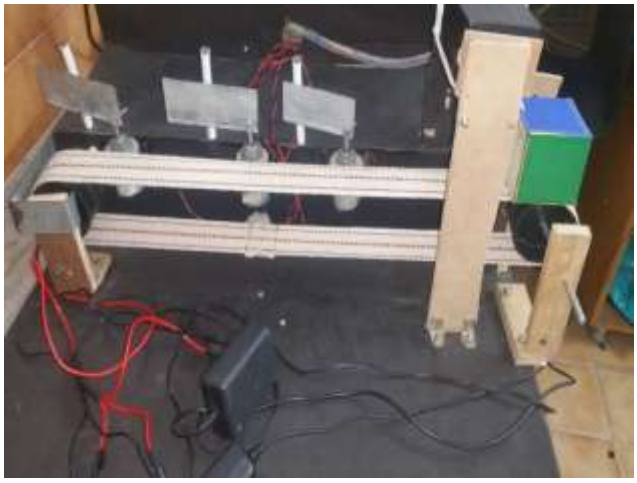


Figure 1: Colour Sorting Machine

Figure 2. PLC module

Figure 3. Sensor module

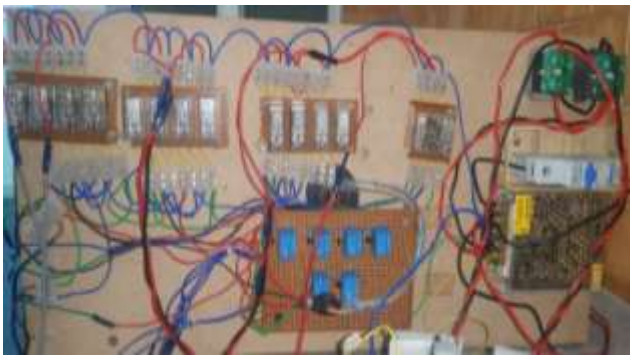


Figure 4: Connection panel

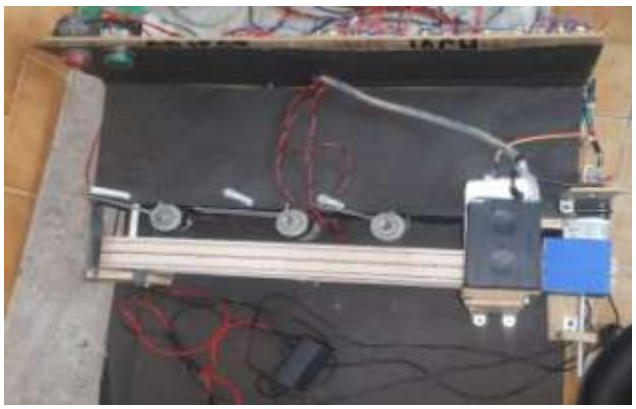


Figure 5: Prototype of Project

Figure 5: Front-end SCADA

VII. CONCLUSION

The main objective of this project was to develop an object sorting system based on certain specifications. This was successfully implemented. We consider this project as a journey where we acquired knowledge and also gained some insights into the subject which we have shared in this report.

PLC with front end SCADA was used to control the various operations. More features can be added to this system as follows: depending on the size, shape and weight of the objects, sorting operations can be implemented. Sorting operation can be improvised using a piston arrangement.

VIII. FUTURE SCOPE

It is very useful in wide varieties of industries along with the help of PLC and SCADA, especially in the packaging process. Automatic sorting machine enhances efficiency, practicality, and safety of operators. It ensures remarkable processing capacity as well as peerless performance including colour detection. Of course we need to add high speed DC Motors and sensors with appreciable response to speed up the system for industrial application.

The model can be improved by making some changes in the program and components. Some suggestions are given below.

- We can add a load cell for measurement and control of weight of the product
- We can also add a counter for counting the number of products
- Speed of the system can be increased accounting to the speed of production
- The system can be used as a quality controller by adding more sensors
- The sensor can be changed according to the type of product

REFERENCE

[1]. Bickman, Josh, “Automated Color-Sorting uses optical technology”, vol. 13, 1996.
[2]. C. Zhang and K. S. Suslick, “Colorimetric sensor array for soft drink analysis”, J. Agric Food Chem, vol 55, pp 237-242, 2007.

[3]. M. Frank, Nobert Kaiser, Wolfgang Buss, Ramona Eberhardt, "High-speed industrial color and position sensors", Electronic Imaging'99, pp 50-57, 1999.
[4]. YV Aruna, Beena S "Automatic convey or system within- process sorting mechanism using PLC and HMI System", Int. Journal of Engineering Research and Applications ISSN:2248-9622, Vol. 5, Issue 11, (part-3) November 2015,pp.37-42
[5]. D.J. Lee and R. S. Anbalagan, "High-speed automated color sorting vision system", in Optical Engineering Midwest'95, pp 573-579, 1995.
[6]. https://en.wikipedia.org/wiki/Remote_terminal_unit
[7]. https://en.wikipedia.org/wiki/Automation
[8]. https://www.elprocus.com/scada-systems-work/
[9]. http://vtc.internshala.com/course/content.php?topic_id=15&moduleid=2&course=robotics101&demo=true
[10]. https://en.wikipedia.org/wiki/Programmable_logic_controller
[11]. https://en.wikipedia.org/wiki/Ladder_logic

BIOGRAPHY

K.Sasidhar received B.Tech degree in Electronics and Instrumentation Engineering from JNTU in 2004 and M.Tech degree in Instrumentation and control sysems from JNTU,kakinada in 2007. He joined Muffakham Jah College of Engineering and Technology in 2007, where he is currently working as Assistant Professor of Electrical Engineering Department. His research interests include Automation, Embedded Systems and Digital Signal Processing.

Shahwar Farooqi pursuing B.E degree in Electronics and Instrumentation Engineering from Muffakham Jah College of Engineering and Technology in the year 2014-2018.

Mohd Abdul Moin pursuing B.E degree in Electronics and Instrumentation Engineering from Muffakham Jah College of Engineering and Technology in the year 2014-2018.

M Sachin pursuing B.E degree in Electronics and Instrumentation Engineering from Muffakham Jah College of Engineering and Technology in the year 2014-2018.