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Implementation of PLC Based Automated CNG Tank for Chuter Assembly Line

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Abstract: ***The purpose of this study is to discuss Programmable Logic Controller (PLC). PLC is a type of digital computer that automates electromechanical activities like controlling machinery or manufacturing lines, among others. PLC's are employed in numerous equipment and industries. The primary purpose of implementing a PLC is to eliminate concerns with relay irregularity and logic control. HMI (Human Machine Interface) is used in conjunction with a PLC to control and monitor the performance of industrial devices***
The aim of this project is to illustrate the usage of PLC in automated CNG tank for chuter assembly line and the utilization of its high capabilities and efficiency to process input and output signals from several sensors.
With the help of software validation and hardware implementation used for demonstrating the ease of operation with the control system.
Keywords: PLC, HMI, Ladder logic diagram, Simulation, Automation

I. INTRODUCTION

The technology that enables a process or procedure to be carried out without human help is referred to as automation. It is carried out utilising a control system that combines a set of instructions into a programme to carry out the procedure. The terms mechanisation and automation are frequently compared and occasionally misunderstood. Mechanization is the use of machinery to supplement or take the place of human labourers in carrying out activities.
Automation is the use of automated equipment to carry out physical activities without a human worker's supervision.

II. PROGRAMMABLE LOGIC CONTROLLER

A programmable logic controller, often known as a PLC, is a microcomputer-based controller that employs pre-stored instructions in programmable memory to implement logic, timing, counting, and other operations using digital or analogue input/output signals to control devices and procedures.
Both process industries and discrete manufacturing use PLC applications. PLCs are typically used to control individual machines, machine cells, transfer lines, etc. in discrete manufacturing businesses.
Richard Morley was a partner at Bedford Associates, a New England consulting company that specialised in control systems for machine tool firms, in the middle of the 1960s.
Relays were mostly replaced by minicomputers in machine tool controls at the company.
The first programmable controller's specifications were written by Morley in January 1968.
He then named it as Modicon model084. In the same year that Morley invented the PLC, the Hydramatic Division of general motors corporation developed a set of specifications for a PLC.
In manufacturing industries it attempts to integrate or implement the new technologies in the current approaches.
Several industries utilize the industrial process which is respective in nature.
In the past, automation was done through the hardwired controllers composed of relays, logic controls, timers, counters.
There were difficulties occurred while reprogramming.
Since the human involvement was more the errors occurred were also more. But with the development of new technologies such as microprocessors or microcontrollers and new specific tool such as PLC, SCADA(Supervisory Control and Data Acquisition) & DCS(Distributed Control System) have increased the production rate its efficiency, precision and accuracy.
These system or process reduce the human interference and increase its flexibility in the process.

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III. ARCHITECTURE OF PLC

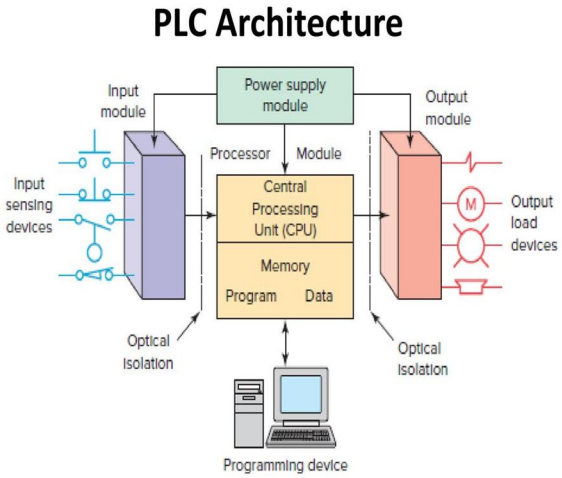


Fig 1: PLC architecture[11]

The following are the fundamental parts: the CPU, the memory unit, the power supply, and the I/O module. These parts are kept in a cabinet that is appropriate for an industrial setting. Furthermore, there is a programming device (e) that can be unplugged from the PLC when not in use. The processor serves as the PLC's central processing unit (CPU). CPU is connected to memory unit, which contains the program of logic sequencing and I/O operations. The connection to the industrial machinery or process that has to be regulated is made possible by the I/O module. Signals from limit switches, push buttons, sensors, and other on/off devices are inputs to the controller. [1]. The controller outputs signals to turn on and off valves, motors, and other devices.

IV. WORKING PRINCIPAL OF PLC

The working of PLC is different from other control system. The input modules input comes from sensors that physically translate the signals. Digital inputs are used. Smaller PLCs typically have built-in inputs that are set when purchasing the PLC's specifications. Inputs are acquired as modules or cards for bigger PLCs, with 8, 16, 32, and 64 of the same type of input on each card. [3]

Output modules: Output modules primarily serve as switches rather than power sources. The output card is attached to the modules, and the card controls whether each output is powered on or off. The most adaptable output devices are relays. Both AC and DC output can be switched by them. However, they are less effective, more expensive, and slower.

Principle of PLC scanning: A PLC programme is typically run as part of a repetitive procedure known as a scan. The CPU can access a memory location known as the "I/O image table," where the status of input signals is copied. [5] A PLC scan starts with CPU reading the status of inputs. The scan cycle concludes with an update of the outputs before restarting. The amount of communication needed, the size of the software, and the quantity of input and output all affect cycle time.

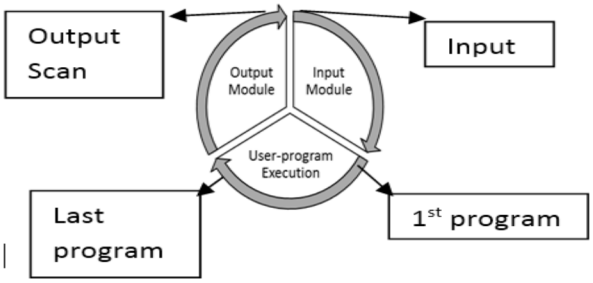


Fig 2: PLC scan cycle[5]

The ladder logic diagram is resolved by a PLC from top to bottom, rung by rung. Normally, the status of the internal register is used to update all of the outputs. The cycle's completion time is referred to as the scan time.

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1) Input scan: During the input scan, the most recent status of each signal from the input is saved in the memory, keeping it current. As a result, the PLC's memory is updated.
2) Program scan: The CPU launches its user programme by going through the input scan. The process of running a programme is initiating the instructions, moving on to the next instruction, and carrying out that instruction's execution steps. The CPU continuously updates its output image during the user programme.
3) Output scan: During programme scan, the output modules are transferred rather than continuously updated. As a result, the output devices are turned on appropriately. [5]

V. PROGRAMMING THE PLC

The process of programming is how a user enters control instructions into a PLC using a programming device. Switching, logic, sequencing, counting, and timing are among the most fundamental control instructions. The International Electrotechnical Commission released a standard for PLC programming in 1992. [4] This standard covers five different types of programming languages for PLCs: ladder logic diagrams, function block diagrams, sequential function charts, instructions lists, and structured text. There are three graphical languages and two text-based languages for PLC programming. [4]

In the project we are using ladder logic diagram (LDs) programming language. It is most widely used PLC programming language. This graphical approach has the essential advantage of being an electrical analogue of the logic and sequence control electrical circuits. The different components are shown along horizontal lines or rungs connected on either side of rails in a ladder logic diagram. The diagram is labelled as a ladder since that is how it is illustrated. The parts are contacts, which stand in for inputs, and loads, which stand in for output. Switches, relays, on/off sensors, timers, and other contact devices are examples of inputs. Loads include things like motors, solenoids, and alarms. In this case, the left side of the rung houses the inputs, and the right side houses the outputs.

Below fig shows a basic example of ladder logic used in programmable logic control program.

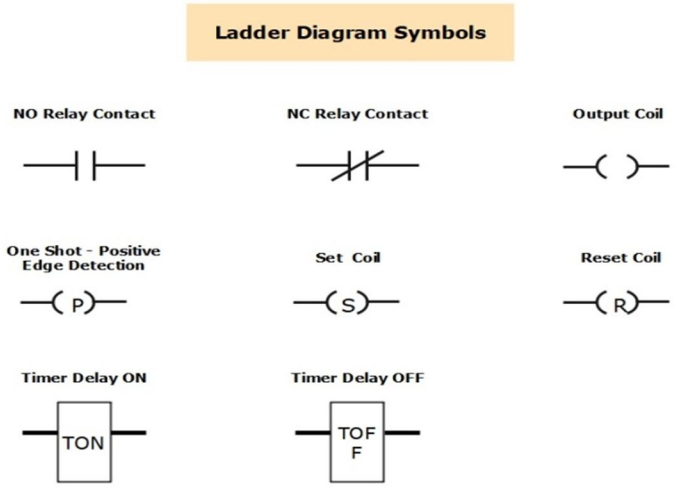


Fig 3: Ladder logic symbols[2]

Ladder logic components: The contact and coils are the two fundamental parts of ladder logic. The term "contact" refers to input devices that are controlled by an external switch. The output components are known as coils. Figure displays a few of these contacts, including output coils, set coils, reset coils, timer delay on (TON), and timer delay off, which are utilised in ladder programming (TOF). [6]

Normally open contact: This type of contact can be used to represent any type of input to the logic control, including switches, sensors, and contacts from outputs. As part of the solution, the input is checked for a true condition. The contact will break off if it's true, allowing reasoning to proceed from left to right. Logic will not follow if the status is false because it indicates that the contact is open.

Normally closed contact: When the problem is resolved, the input is checked to see if the power is off, in which case it will flow from left to right. There will be no power flow if the status is ON.

Normally open coil: To represent any discrete output from the control logic, use a normally open coil. A real output follows from a truthful input.
Timer delay on (TON): A timer's output will change state after a specific amount of time has passed after it has received a signal to turn on.
Timer delay off (TOF): It is to delaying he turning off of any output. It has an instruction used to keep track of time of occurrence of certain events.[6]

VI. SOFTWARE FOR PLC

The software which has been used in the project is CodeSys V3.5. It stands for Controller Development System. It is used in industrial applications for power generation and distribution. It serves as a development environment for controller application programming in accordance with IEC 61131-3, a global industrial standard. [9] The German software business is the one that trademarks and creates CodeSys. The software package provides a surface for a number of industrial automation technology facets. The tool is independent of the device manufacturer and is used for a wide variety of controllers, including PLCs, PACs, ECUs, and controllers for building automation, mostly for industrial applications. CodeSys easily adapts to vary system requirement and environment. PLC manufacturer use a toolkit to port the CodeSys runtime system on their device and turn it into compatible. The software is free and its features include PLC programming, simulation and HMI (Human Machine Interface) design. [9]



What is HMI?
While the phrase can technically be applied to any screen that enables a user to interact with a device, it is the user interface or dashboard that connects a human to a machine system or object. To get and present data for user viewing, HMI communicates with PLC and input/output sensors. PLC is used in HMI as a way to control outputs like control motors, valves, and other machinery utilised in a process.
HMI helps user to interact what operations is going on, what is the progress, how efficient the machine is running, and is there any alarms needed to be address. The PLC is also controlling the operations so through the HMI the operator can control the PLC this means they can perform actions starting and stopping of machine. [10]

VII. DESIGN AND IMPLEMENTATION

This section gives the design and implementation of PLC on chuter assembly line. I will start by showing the steps and methods used during the process of project.

A. PLC And Chuter Assembly Line

For the PLC itself, in this project the chuter assembly line is controlled by PLC programming. The chuter assembly line is of roller conveyor. It is also called as gravity type roller conveyor. The actual weight of CNG tank is 40-70kg. As per the design consideration which has been done in the software. The roller conveyor is of 4800mm long and 402mm wide. Roller diameter is 60mm and width is 400mm the inclination angle is 5^{o} degree.
In the first task we need to check the assembly line position and with the position it was only designed for CNG tank transfer line. There were others items which were not seen by the other user. So, in order to address this problem, my suggestion was to create an assembly line with an attached HMI display. Realizing the CNG tank's sensing was the first task. In order to do this, proximity sensors have been utilised, and they only detect metal objects that pass through them.

These sensors appeared to be the most suitable choice and are utilised on one side of the holder. Optical cable was used to generate these sensing sites. An Arduino mini has been utilised as a controller to process the sensors' digital signals. With this option, it was possible to manage the display in addition to processing the signals. This device was not included to the system with pre-testing in mind, but rather as a gadget. While starting the program in CodeSys software some address has given for input / output modules.

In this there are some physical input address has been given to the input modules such as air on, master on, loading station pusher, lifter 1 and 2 which has been used etc. They are addressed in the form of "%IX0.1" and there are also output modules address given, such as tower lamps, loading station lamp, unloading station lamp. These are addressed as "MX202.4". Timer has been used in this process so that when master is ON the machine should take a delay in the start for about 5 seconds which is set.

The output modules are connected to the indications, such as tower lamps, while the input modules are connected to the sensors, stopper, and used pushbutton. Since they serve as feedback devices in this application, the tower lamps have been programmed to operate as conventional coils or output. Every time the programme is run, a loop section runs continuously from start to finish. The lifter, which uses pneumatic air pressure, and the sensors are actuated here.

In the next task, placing of the CNG tank at the loading station in a systematic manner. Following with that the sensor senses the CNG tank placed on the roller conveyor and with that the pusher which is used to slide the CNG tank to next station, the pusher pushes the CNG tank to move forward to station and with that there is other drive which has been used called as stopper. At each stations there is a stopper provided. If there is other component in the next station the stopper stops the CNG tank to slide to next station.

In order to complete the work, I constructed the unit model in CodeSys and then used it to simulate the entire process. First, both a manual and automatic alternative was developed. In addition to that TOF timer, a TON timer was also utilised. This operates so that pressing the button rings the bell, which must be held ringing for five seconds before the programme can begin. And the process begins when the button is released.

B. Code Sys Simulation And Hmi

The final phase was creating the ladder logic diagram in accordance with the specifications and, concurrently, finding three-dimensional models of the drive that were coloured to be visible and afterwards loaded into CodeSys and given an ID. Rebuilding the drives with push buttons and LEDs was required to achieve the visual movements on the HMI. A test panel is built in the software itself for testing purposes so that we can see how it works visually. With the PLC ladder logic diagram the test is completed successful.

If we wish to use the final, industrial hardware with the previously created and tested programme. The controller performs a check on our written programme, but we could not see problems if we transfer the same programme to a PLC. To tackle this, "CodeSys," a free tool with features including PLC programming, simulation, visualisations, and HMI design, was employed.

The previously described buttons were initially built as a part of the HMI during the programme transition from controller to PLC. The buttons on the HMI were assigned after the HMI was designed and the Ardunio software was built in PLC ladder logic. [9]

Later the program written in CodeSys was ran, to ensure its error free functions. PLC based automated CNG tank for chuter assembly line was gained. In future the PLC controller with the help of HMI design projects can be implemented in industry, as it is freely editable.

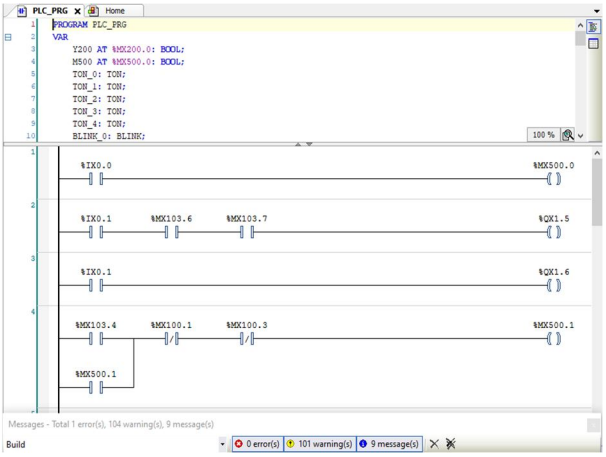


Fig 4 CodeSys – PLC program

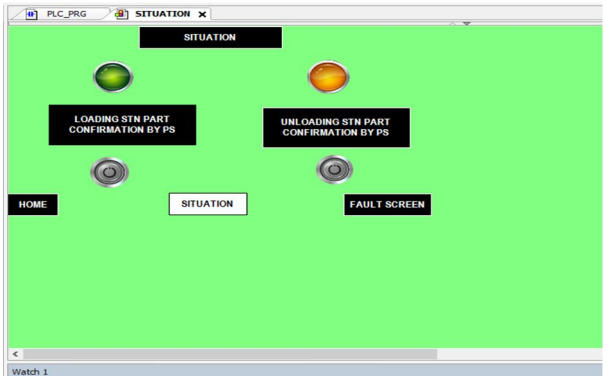


Fig 5 Visualization of simulation

C. Present Theories And Practices

In the present days everywhere the PLC has been implemented. With the implementation of PLC the automation has gone to whole new level. There are other control system present such as relay logic, digital / analog logic, and SCADA logic.[4] To overcome the issue occurred in the other logic control system. The PLC was created to take the role of a relay and timer logic control system that was hard wired. With PLC, it is possible to change a control system without having to rebuild the connections to the input and output modules, which is a greater advantage.

PLCs are very similar to computer but have certain features which are specific to their use as follows:

1) The main difference from other computer is that PLCs are armored for several condition such dust, moisture, heat and cold.
2) They are easily programmed with the personal computer and easily understood the programming language.
3) They are resilient and vibration-resistant.
4) They have the ability to create complex input/output configurations. These link sensors and actuators to the PLC.
5) It performs a certain type of memory input and output scan.
6) It offers diagnostics for error checking.
7) A PLC uses an HMI to provide monitoring functions.
8) A PLC can be created to do a wide range of tasks.
9) PLC offers excellent flexibility, high dependability, and robust, simple operation.
10) Overall PLC provides a better control system compared to others.[4]

D. Industrial PLC Finalizing

After writing the PLC program in the CodeSys software it was checked and got simulated and there were no errors. The same program was copied to the industrial trial. The input and output modules' address. The purpose of the timer TON in this situation is to start the machine with a 5-second delay. The input and output of the pushbuttons and sensors were connected to the corresponding modules. The PLC's IP address must be specified in order to enable stable communications with the PLC model that has been utilised in the project. The connections between the computer and the PLC are established via the cable and the router inside.

After completing the transfer of program to PLC it has been run and the errors were not found. The complete process has no other errors finding. The PLC program written was correct as per the requirement. A PLC-based automated CNG tank for the chuter assembly line was acquired as a result, and as it is freely customizable, it may be used in future controller or HMI applications. [10]

VIII. CONCLUSIONS

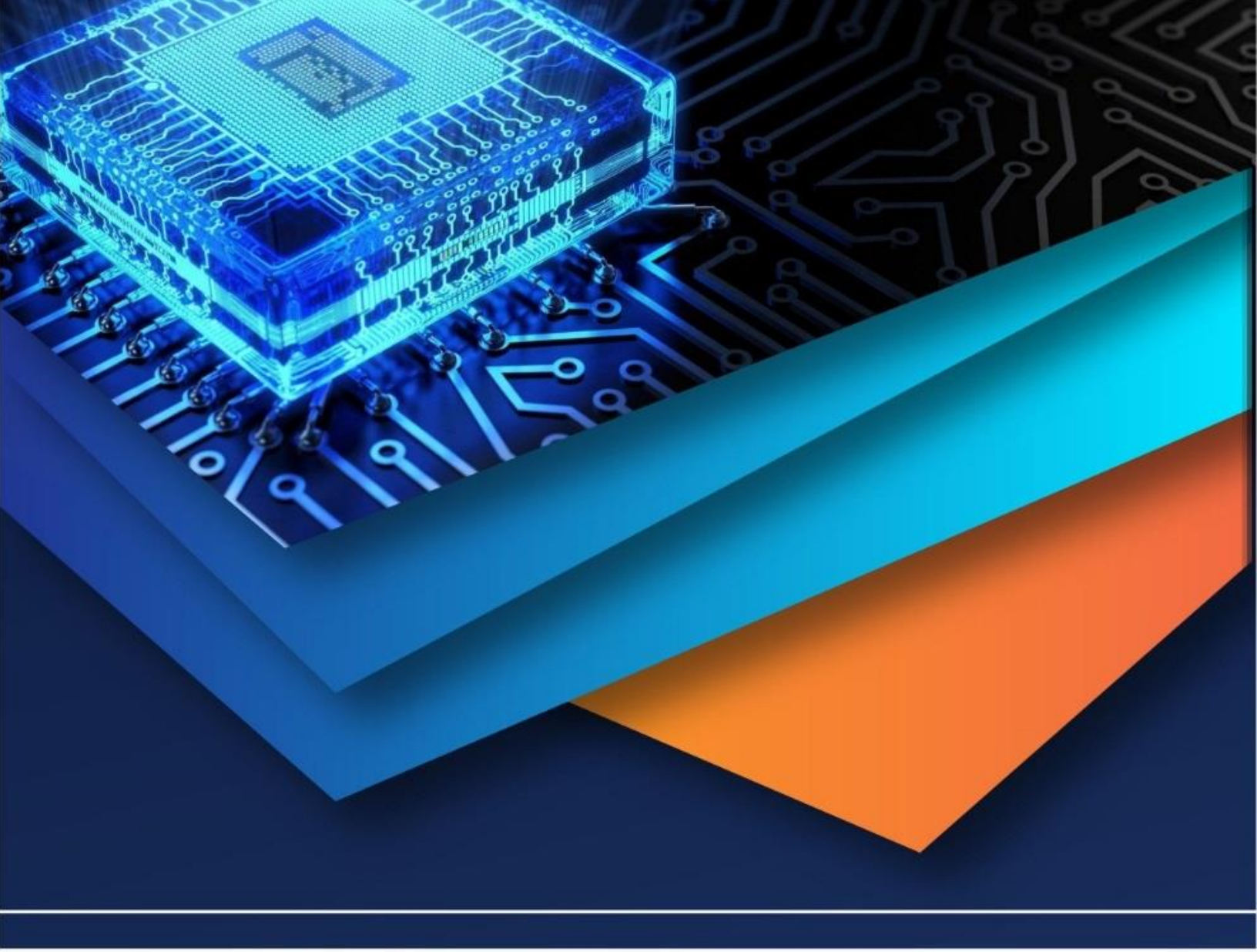
In this paper, the best of my knowledge on PLC data on assembly line with simulation control system. The automation have gone to vast competitive in world, so with that the PLC implemented has made it much more easier. The roller conveyor which has been used here has made it even more easy of transfer of CNG tank on chuter assembly line, with the help of proximity sensors and controller shields such as stopper at each stations made it a complete system. Simulation has been carried out in the CodeSys software itself with the visualizations effect.

It can be argued that a flexible, cost-effective system was developed with simple component replacement. Additionally, a piece of an inactive assembly line equipment that now functions dependably was brought back up and running.

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