INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN MULTIDISCIPLINARY EDUCATION
ISSN(print): 2833-4515, ISSN(online): 2833-453
Volume 03 Issue 05 May 2024
DOI: 10.58806/ijirme.2024.v3i5n12, Impact factor- 5.138
Page No. 779 - 786

Development And Utilization of An Innovative Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System: An Industrial Process Simulator for Teaching Electrical and Electronics Courses

Jomel R. Angangan[1], Allen A. Alejandro[2]
[1,2]College of Engineering Architecture and Technology, ISABELA STATE UNIVERSITY, CITY OF ILAGAN.

ABSTRACT: The main purpose of this study is to develop and evaluate an innovative industrial automated PLC electro-pneumatic feeder and pick-and-place system to improve technical instruction and address the inadequacy of electrical and electronics training equipment in the BS Industrial Technology program of Isabela State University, City of Ilagan Campus. Likewise, this study was conducted to evaluate the functionality, durability, safety, and instructional applicability of an innovative industrial automated PLC electropneumatic feeder and pick-and-place system. The descriptive method of research was used, with sets of questionnaire checklists supplemented by unstructured interviews and observations as the main gathering instruments. A five-point Likert rating scale was used to determine the descriptive meanings of the indicators of the variables used. The study respondents were third-year electronics and electrical students of the Industrial Technology program, electrical and electronics teachers, engineers, and industry experts. The statistical tools used in the study were percentage and weighted mean. The developed project mean was 4.82, which suggests that the project is "highly acceptable." This implies that the developed instructional equipment is highly suitable for instruction and simulation in industrial automation processes, and is highly preferred by evaluators. It can also be said that the constructed industrial automated PLC electro-pneumatic feeder and pick-and-place system is well designed, durable, functional, safe to use, and easy to maintain.

KEYWORDS: PLC, Automation, -Electro-Pneumatics, Trainer

1. INTRODUCTION.

Industrial automation has increased the efficiency, productivity, and quality of processes in the manufacturing industry. The integration of automation in processes and control has evolved to increase productivity in most industries. The use of electro-pneumatic systems for automation has increased production, efficiency, and quality control. Pneumatic linear actuators can be controlled throughout the operation to accommodate additional work and even operate outside business hours. With the introduction of electro-pneumatics, it has become easier for people to work in automated factories and industrial plants. Few workers are assigned to control these electro-pneumatic systems instead of requiring them to carry out the task by themselves. The Programmable Logic Controller (PLC) has made the control easy. To automatically control every aspect of the operation without human intervention, PLC is now used in every modern production process. It is an industrial digital computer that has been adapted for the control of manufacturing processes, such as assembly lines, conveyors, robotic devices, or any activity requiring high consistency, and replaces hard-wired electromechanical relays and timers.

As a result, the concept of this research project will be of great assistance in the advancement of learning of PLC electro-pneumatic system by developing an instructional equipment in an effort to improve the quality of learning outcomes for both electrical and electronics students and teachers of ISU Ilagan Campus. It also aims to meet the demand of trained students equipped with creativity, innovation, productivity and entrepreneurial skills and the development of new and appropriate technology in the field of electrical and electronics technology

The general objective of this study is to develop an innovative industrial automated PLC electropneumatic feeder and a pick-and-place system prototype. The specific objectives are as follows: to design an Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System; to develop and simulate a learning material for a PLC Electro-Pneumatic Feeder and Pick and Place System that imitates real industry applications; and to evaluate the PLC-based pick and place industrial pneumatic trainer based on its acceptability in terms of their design, functionality, safety, and instructional applicability.

Conceptual Framework

The Input-Thruput-Output of the developed Innovative Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place

System. The input box describes the knowledge required before the module development process. The thruput box gives the idea of the step to be undertaken in the process of module development, leading to the completion of the project showing the project output, as illustrated in the third box. After the module has been developed, an evaluation process by projected end users will follow for the acceptability of the developed project.
Thus, the process to wit:

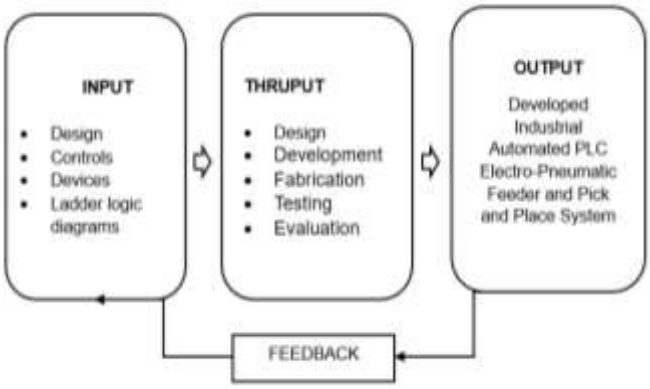

Figure 1. Development of Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System

2. METHOD/S

This research used a developmental method, wherein it involves systematically drawing on existing knowledge gained from practical experience that is directed toward producing new materials, products, and devices (Catane, 1998). In other words, this type of research is applied to the present study wherein the researchers conceptualized the design and specifications of the construction of the innovative industrial automated PLC electro-pneumatic feeder and pick-and-place system. In this study, the project was designed, constructed, and assembled in conformity with this design. Subsequently, revisions were followed for any defect and reassembled until it was found to be functional.

This type of research also refers to Research and Design programs that deal with developing instructional equipment for electrical and electronics technology that simulate real industrial applications utilizing PLC software as a simulation tool for conveying technical knowledge in PLC programming and control.

Furthermore, the study utilized descriptive-evaluative research. This type of research is most appropriate because it describes the process that is ongoing, conditions and relationships that exist, effects that are evident, trends that are developing, and even opinions that are held (Fraenkel and Wallen 2007). Since the study aims to describe the perceptions of the respondents' evaluation of the constructed project, the researcher believes that this type is the most appropriate.

The participants were 3rd-year students who took the degree of Bachelor of Science in Industrial Technology (BSINDT), majoring in Electronic and Electrical Technology, and faculty in the field. Likewise, the external recipient was an electrical technician within the locality.

Figure 2. Process Workflow

The phasing procedure shows how the study was conducted. Project design shows how the project was developed. A block diagram of the project is shown in Figure 2, which illustrates the classification of the raw materials and their specifications. The power supply 24VDC is the power source of the project, and the aluminum profile was used for the construction of the different electro-pneumatic modules. The PLC module is the center of the control. It saves and sends data to control the sensors and switches, and solid-state relays are a type of voltage controller used to energize the solenoids and the DC motor. The other purpose of solid-state relays in the project is to control the actuator and other load components, such as indicator lights, which shows whether the project is on operation by the command of the PLC.

The flow control 24VDC solenoid valves are the pneumatic controllers used to open and close pneumatic cylinder0s; the linear actuator is the main actuator in the project, which illustrates the movement of pick and place motion and other activities; and the sensors in the project are used as a detector component. These are the functions of the components in Figure 3 below. It illustrates an arrow to designate how the research study process works.

Project Development.

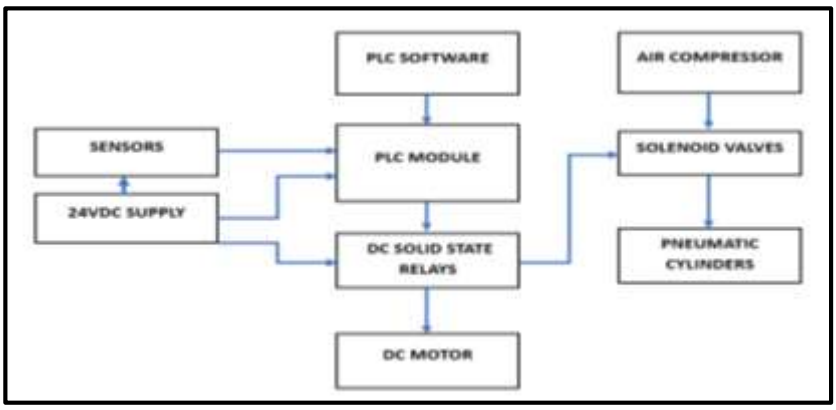

Figure 3. Block Diagram Showing the Interrelationship of the Parts of the Project

Operation and Testing of the Completed Project.

This stage involves testing and retesting. Problems were addressed, and adjustments were made until the project was performed. The following are the instructions for conducting laboratory activities in the project, concerning the electrical components. First and foremost, ensure that the source has been de-energized. Based on the diagram, ensure that the terminals of the various devices have the correct polarity. Second, using the multi-tester, verify the voltage sources of each terminal. Third, proceed with caution and safety.

On the pneumatic circuit. First, determine whether the amount of air pressure is within the operating pressure of your components. Check again if necessary. Second, inspect your pressure pipe to ensure that each hose's connection corresponds to the diagram. Third, do it with caution and safety.

Wear Personal Protective Equipment (PPE) during the test run for your own safety. Prepare and arrange all the materials required for the procedure. Connect the input terminals to the PLC's appropriate input and output signals. Create a ladder logic program on the computer for the design application and upload it to the PLC. Check all terminals and wire connectors to ensure there are no wire shorts before putting the PLC into run mode. Then, switch the PLC to run mode. Examine the trainer's performance to see if it adheres to the program.

Defects	Change made
1. Loose terminals	Apply exact heat in soldering wire in terminal connections.
2. Loose connectors	Use standard size of wire connectors.
3. Installation of PLC software installer to the laptop	Use the complete version of software
4. Communication cable	Make sure that the port is in good condition
5. Leakage on pneumatic fittings	Insert the hose properly

Table 1. Defects found and Revisions Made

Using a questionnaire checklist, respondents evaluated the constructed Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System based on the following criteria: design, functionality, safety and instructional applicability. The respondents of the study were selected Electrical and Electronics Technology students and Instructors from ISU Ilagan Campus. A number of Industry Experts from different electrical firms in the locality were also invited by the researchers to evaluate the project. These respondents were asked to accomplish an evaluation form that determines the acceptability and functionality of the project.

3. RESEARCH AND DISCUSSION.

A. Project Description.

The developed Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System can execute a variety of activities, including object transportation, pick and place simulation, metal and nonmetal separation, and other PLC exercises. It also represents a simulation of a manufacturing or power facility. It has two major functions: manually and automatically. It is operated manually using switches and relays. However, if it is automated, it solely depends on the input sensors and the PLC program or exercise that is about to be done.

The Panel Board is the main activity board, made of acrylic plastic and mounted on a tubular frame. All components and devices needed for performing various laboratory activities and interconnecting them are mounted in front. PLC modules and other devices are detachable to avoid moisture or dust. It is safer to use because it can only be powered by a low voltage (24 volts DC). The software utilized is user-friendly since it is compatible with various computer operating systems. The design is modular, so you can quickly detach the various parts for other laboratory tasks. Because it has ball casters, it can be simply transported to other areas. The project includes simple measuring equipment, testers, and banana jack connectors. Because of its standard fittings, it may simply be connected to another compressor. Because the different devices are exposed and easily removed, it is simple to troubleshoot and repair. It has a standby mode and secondary power switching.

Based on the gathered information and trainings attended, the researchers conceptualized the design and layout of the Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System.

B. Designing the Trainer.

This involves the drawing plans of the trainer to provide a useful concept and structure for the project.

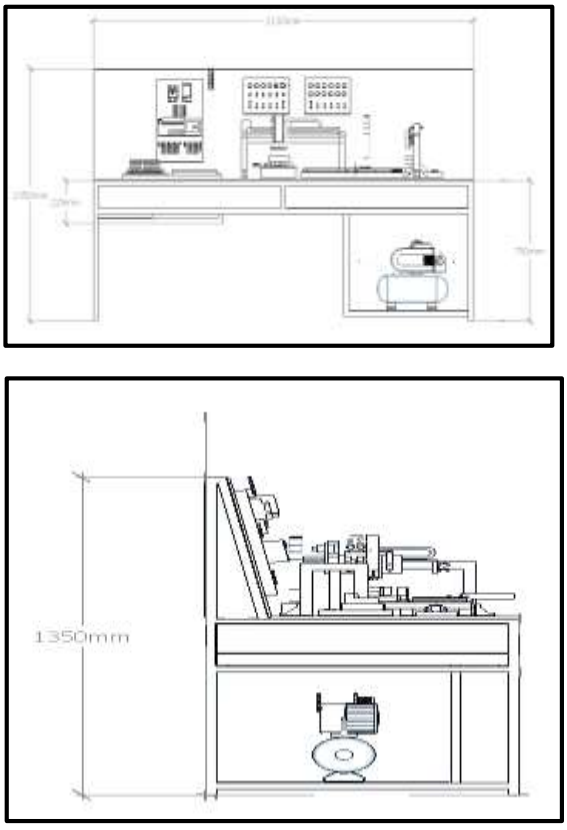

Figure 4. Front and Side View of Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System

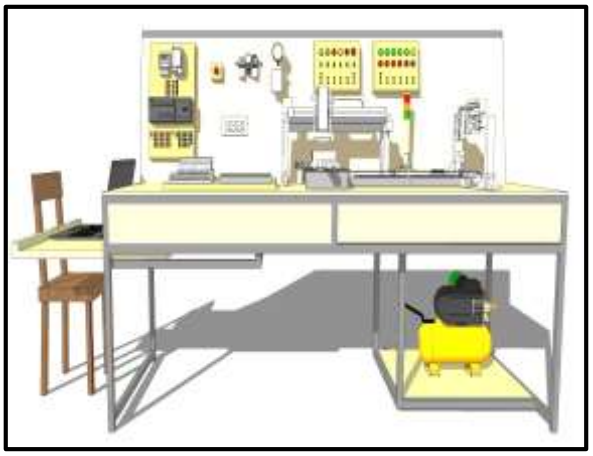

Figure 5. Perspective View of Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System.

Figure 6. Photos of the completed Project

Capabilities and Limitations of the Developed Project.

Capabilities.

The capabilities of the developed Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System are to demonstrate the pick and place motion by the sequential movement of the actuator. It is used as instructional equipment for installing the different components and to show the actual operation of what the PLC programmed. It is capable of demonstrating a simulation process in different processing plants where pneumatic cylinders and solenoid valves are used.

Components

- Linear Actuator simulates the movement of the pick and place.
- Flow control Solenoid valves is the pneumatic controller through electricity. It plays only in an open and close switch.
- Solid State Relay is a kind of voltage controller that also plays an open and close switch. The main purpose of relaying the project is to control the actuator and other load components by commanding the PLC.
- Filter, regulator, and lubricator (FRL), in compressed air systems deliver clean air at a fixed pressure in the pneumatic system. They are lubricated, if necessary, to ensure the safety of cylinders and solenoids in the project, which increases their operational lifetime.
- Proximity Sensor is used to determine if the solenoids are in an open or closed position.
- Programmable Logic Controller refers to the programmable controllers which have both hardware and software features that make attractive as in various electro-pneumatic operation in the trainer.
- Compressor is used under high pressure to energize the cylinders from the attacked position to retract in the project.

Limitations

- It was only designed for instructional purposes.
- Only to complete the task in the software that has been programmed.
- It is not used in the production system.
- It only demonstrates a linear pick-and-place motion and not a robotic pick-and-put motion.

PROJECT EVALUATION.

The researchers designed the Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System to have an instructional material on campus, specifically in the program of BS Industrial Technology at ISU Ilagan, that can be used by the instructor to gain more practical experience in the field of automation.

Evaluation Material

The instrument used by the researchers to evaluate the Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System is the Multi-Meter and pressure gauge. With the help of these instruments, the researchers found out that the project was functional.

Figure 6. Photo of Multi-Tester

A typical multimeter can measure voltage, current, and resistance. Analog multimeters use a micrometer with a moving pointer to display the readings.

Figure 7. Pressure Gauge

These instruments are used to measure and display pressure in an integral unit.

Results of using Multi Meter and Pressure Gauge Instrument

The researchers set the multimeter in the 50V DC range to measure the power supply output, solenoid valves, relays, and all sensors' power inputs. Table 2 shows the results of the operational testing and procedure of the hard wiring test.

Parts to be Assessed & Evaluated		Results
Power supply output		24V DC
Relays triggering voltage		24V DC
Solenoid Valves triggering voltage		24V DC
Proximity sensor	Output voltage	24V DC
	Triggering voltage	24V DC
Retro-reflective sensor	output voltage	24V DC
	triggering voltage	24V DC

Table 2. Results of Multi-Tester

The researcher uses the pressure gauge to set the pressure of the air so that it fits the working pressure of the pneumatic cylinder. Therefore, it is in acceptable working condition for the parts. Likewise, Table 2 shows the result of the operational testing and procedure of the pneumatic test in favorably likely operating working conditions.

Parts to be Assessed & Evaluated	Results
Working pressure of the pneumatic cylinder	145 to 145 psi
Operating pressure of FRL	145 psi (max)
Operating pressure of air regulator	145 psi (max)

Table 3. Results of Pressure Gauge

Summary of the Ratings Given by Respondents on the General Acceptability of the Completed Project

Table 4. The General Level of Acceptability of the Completed Project.

CRITERIA	RATING	
	Grand Mean	Remarks
Functionality	4.79	Highly Acceptable
Durability	4.77	Highly Acceptable
Safety	4.84	Highly Acceptable
Instructional Applicability	4.90	Highly Acceptable
Overall Mean	**4.82**	**Highly Acceptable**

As shown in Table 4, the completed Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System received mean ratings of 4.79, 4.77, 4.84, and 4.90 for their functionality, durability, safety, and instructional applicability, respectively. The developed project was perceived to be highly acceptable by the respondents in all criteria presented. The computed overall mean was 4.82, which suggests that the Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System is "highly acceptable" This implies that the developed project is highly suitable for instructions and simulators in industrial automation. This implies that the developed project is highly preferred by the evaluators. It can also be said that the constructed project is well-designed, durable, functional, safe to use, and easy to maintain.

4. CONCLUSION AND RECOMMENDATIONS

The Industrial Automated PLC Electro-Pneumatic Feeder and Pick and Place System is a teaching tool that simulates and prototypes actual industrial processes. It can be utilized to illustrate how an industrial feeder works, as well as pick-and-place activities using electro-pneumatics and Programmable Logic Controllers (PLC). The trainer's overall performance is highly acceptable. It is capable of executing a variety of tasks and is precise in its execution.

REFERENCES

1) **Herman S. L. (2016)** Electric Motor Control, 9 th Edition. Delmar, Cengage Learning. Herman S. L. (2014) Industrial Motor Control, 7th Edition. Delmar, Cengage Learning.
2) **Petruzella F. D (2010)** Electric Motors and Control System, 2nd Edition. New York Cencage Learning.
3) **Yaakub M. N et al. (2015)** Research in TVET Made Easy, Fourth Printing CPSC Manila, Philippines. (page19,22)
4) **Programmable Logic Controller Web** Article URL: https://en.wikipedia.org/wiki/Programmable_logic_controller
5) **Solenoid Valve and Cylinder** Online Store URL: https://www.festo.com/cat/en-ph_ph/products

6) **Proximity and Retro-Reflective Sensor** Online Store URL: http://www.sensopart.com/jdownloads/Systembeschreibungen/Photoelectric_sensors_proximity_sensors_ system_description.pdf(07/26/2021)
7) **Ryan M. Robinson et. al**, Control of a Heavy-Lift Robotic Manipulator with Pneumatic artificial Muscles (2013) Web Article URL:http://www.mdpi.com/2076-0825/3/2/41/htm
8) **Pimentel, et al. (2016).** Outcome-based Trainer for Table Top Industrial Motor Control Utilizing Variable Frequency Drive and Programmable Logic Controller. Volume, Issue 5, ISSN 2348- 4098, International Journal of Science, Engineering and Technology. Retrieved July 28, 2020. From http://www.ijset.in/wpcontent/uploads/20 16/11/10.2348.09160784.pdf
9) **Tejano, L.L (2018)** Programmable Industrial Motor Control Trainer, International Research Journal of Engineering and Technology (IRJET) Volume 5, Issue 7, ISSN: 2395-0056. Retrieved July 28, 2020. From https://www.irjet.net/archives/V5/i7/IRJE T-V5I7441.pdf