Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 6 Issue 12, December - 2019

Applications of Intellectual Systems to Packaging Systems in Industrial Environment

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***Abstract*—In the present thesis the applications of pneumatic systems in industrial environments and in particular the study of packaging systems have been studied. Additionally, a thorough definition of the pneumatic systems is being presented throughout the research. In addition to that, a meticulous study was made about the properties of the gases used in pneumatic systems, the benefits of air use, their usage & functionalities in the industrial units via air compressors (and their types), the process of preparation for compressed air, the types of filters available and used in each case,the pressure regulators, the operating positions and the direction control valves. Subsequently, we examined case studies of pneumatic systems in general, while also delved deeper into the study of the packaging process. Furthermore, fundamental values and units of measure will be defined, as well as the measurable quantities, such as work, energy, power, system performance and system acceleration (Newton's 2nd law), and last but not least we'll analyze the magnetic detection cylinders. In conclusion, this is about a very comprehensive examination/study with the sole purpose of understanding both theoretically & practically the subject of pneumatic systems.**

Keywords—component; formatting; style; styling; insert (key words)

I. INTRODUCTION

A. *Pneumatic Systems*

Pneumatic systems, are a collection of interconnected components using compressed air to do work for automated equipment. Pneumatic systems use gas or pressurized air to move cylinders, motors or other mechanical parts to perform a task that can be either repetitive or dangerous to an operator or may require precision and speed. This work is produced in the form of linear or rotary motion. The compressed air or pressurized gas is usually filtered and dried to protect the cylinders, actuators, tools and bladders performing the work. Pneumatic systems are easier to design and use than their electrical counterparts in many applications.

Pneumatics is an application of fluid power, which uses air pressure to generate, transmit and control power;(In contrast with Hydraulics, that make use of fluid power in liquid form, such as oil) typically using compressed gas at a pressure of 60 to 120 pounds per square inch (PSI). Compressed air needs to be processed before it can be used. While we only need the force itself, air can become contaminated with dust particles, water vapor or other risk elements. These can cause friction within the pneumatic parts.

Fig. 1. *Packaging equipment relies heavily on pneumatics for safe operating functionality*

In a variety of automated machines, pneumatic power transmission is often the best way to grip, lift, press, shift or stack products. Pneumatic applications are relevant to a wide variety of industries, including construction, healthcare, mining, the automotive industry and many others.

Examples of pneumatic applications:

Home Systems: Heating and air conditioning control

Healthcare: Dental drills, vacuum pumps and pressure regulators

Transportation: Air brakes for trains or buses, air engines and compressed air-powered vehicles.

B. *Advantages and Basic concepts of Pneumatic systems*

Storage: The compressor will start working only when there is a need. The compressed air that is stored, can be taken from a gas tank and transported in containers.

Temperature: Compressed air is not sensitive to temperature fluctuations. That is why we have reliable operation at extreme temperatures.

Explosive Property: Compressed air is safe, does not cause explosions, therefore expensive devices are not required for a hazardous environment.

Quantity: We have compressed air available in large quantities.

Transportation: Compressed air is easily transported through pipes over long distances.

Environment: Compressed air is clean. So any leakage does not cause contamination, so they are used in food industries etc.

Manufacturing: Functional components are simple to manufacture and inexpensive.

Speed: Compressed air is a fast working medium in order to achieve high speeds.

Overload Safety: Compressed air tools and components are charged up to a certain point so that they can be safe from overloads.

Compressibility: With compressed air we achieve constant piston speeds.

Air Purification: When released, air causes noise. This problem has been solved thanks to sound absorbing materials.

Cost: Compressed air is an expensive medium of power. Although, the high cost is reduced due to cheap production materials.

Preparation: Compressed air requires good preparation, so there does not exist any dirt or moisture.

II. METHODOLOGY- PROGRAMMABLE LOGIC CONTROLLERS (PLC)

Fig. 2. PLC representation

A. *What is a PLC?*

PLC is a digital electronic system, which is designed for use in an industrial environment. It uses a programmable memory to store commands and perform various functions, such as logical, time, metering and arithmetic functions. PLC continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices.

- PLC is a special device, which came to replace all auxiliary relays, timers and counters in the classical automation table

- PLCs belong to the broader category of digital computing systems

PLCs are used to control machines and processes that require automatic operations and motion accuracy: exclusively in industry but also, in buildings, shipping, large public or private projects, vehicle traffic control, airport lighting, elevator systems and dozens of other areas.

PLC controlled electro/pneumatic systems vary in complexity and applications. Components of a PLC that we need to know in order to implement various applications:

Hardware: by hardware we mean, all those electrical and electronic parts that will be used in the installation process or the application of the system, through which all functions will be implemented in a programmatic order.

CPU: the most important element for maintaining the sequence of automation movements is the programmable logic PLC controller which through its CPU, processes the input signals so it can give the appropriate output commands to trigger the electromagnetic outputs.

The data that are being processed by the CPU are in binary state.

Input and Output modules make it possible to connect PLC with actuators and sensors.

Also, an equally important part of the CPU, is the indicator memory. The indicators are single-bit memories through which the PLC can read the state of the binary signals.

B. *PLCs operating cycle*

PLCs operate in four steps phases; Input Scan, Program Scan, Output Scan and Housekeeping. These steps continually take place in a repeating loop.

Input Scan: CPU starts scanning input devices, tries to detect high voltage input (logical 1) or low voltage input (logical 0). Input values (0's or 1's) are being stored in a special are of memory, the input image area.

Program Scan: Microprocessor uses the input values to execute commands that it has been programmed to do. This operation actually contains a number of sequential steps. Then, the results are stored in a special area of memory, which is called an output image.

Like the input image, the output image contains the value 0 or 1 for each output.

Output Scan: Results from the logical actions that take place at CPU will be assigned to output devices. High voltage will be given at any output device and it will be represented by the value 1. Low voltage will be given at any output device and it will be represented by the value 0.

Housekeeping: Completing input, program and output scan will result in a 3 step cycle. On housekeeping, PLC communicates with programming terminals, internal diagnostics, etc. Then the 4 step process starts again.

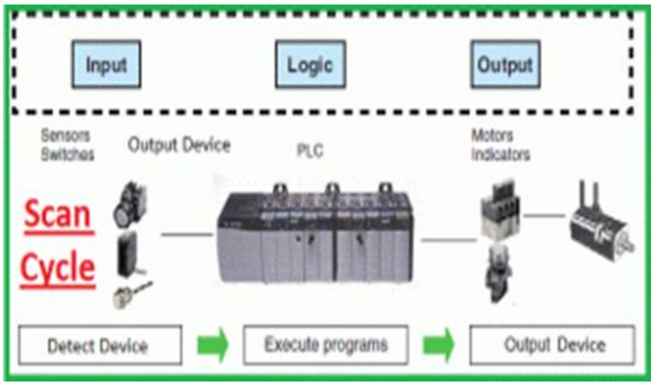

Fig. 3. PLC operation cycle

C. PLC Programming Language

Ladder Logic is the most commonly used PLC programming language, it is not the only one.

Ladder Diagram (LD) Traditional ladder logic is graphical programming language. Initially programmed with simple contacts that simulated the opening and closing of relays, Ladder Logic programming has been expanded to include such functions as counters, timers, shift registers, and math operations.

Function Block Diagram (FBD) - A graphical language for depicting signal and data flows through re-usable function blocks. FBD is very useful for expressing the interconnection of control system algorithms and logic.

Structured Text (ST) - A high level text language that encourages structured programming. It has a language structure (syntax) that strongly resembles PASCAL and supports a wide range of standard functions and operators.

Instruction List (IL) - A low level "assembler like" language that is based on similar instructions list languages found in a wide range of today's PLCs.

Sequential Function Chart (SFC) - A method of programming complex control systems at a more highly structured level. A SFC program is an overview of the control system, in which the basic building blocks are entire program files. Each program file is created using one of the other types of programming languages. The SFC approach coordinates large, complicated programming tasks into smaller, more manageable tasks.

D. Supervisory Control and data acquisition – SCADA

SCADA systems are used to monitor equipment in industries such as energy, oil and gas refining, transportation, waste control and telecommunications. A SCADA system gathers information, such as determining if a leak has occurred, if the leak is critical, carrying out necessary analysis and control. Then the information that are gathered, are displayed in a logical and organized fashion. SCADA systems can be found on small office buildings with a relatively simple setup, which will monitor environmental conditions etc. or can be found on large and complex setups, such as monitoring the activity of a municipal water system or in a nuclear power plant etc.

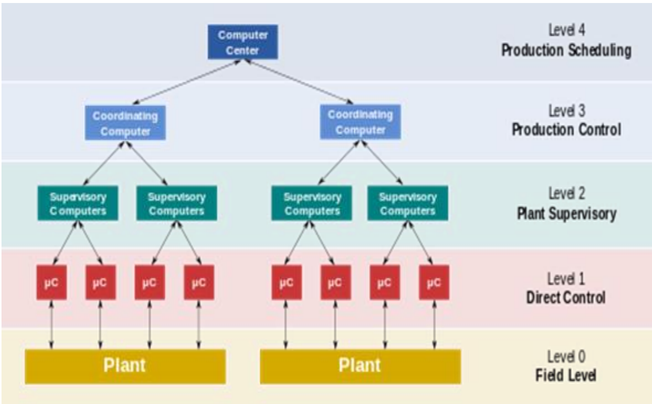

Fig. 4. Functional levels of a manufacturing control operation

A SCADA system usually consists of the following main elements:

*a) **Supervisory computers**, this is the core of the SCADA system, gathering data on the process and sending control commands to the field connected devices.*

*b) **Remote terminal units**, RTUs are connected 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.*

*c) **Programmable logic controllers**, PLCs are connected to sensors and actuators in the process, and are networked to the supervisory system in the same way as RTUs. PLCs have more sophisticated embedded control capabilities than RTUs, and are programmed in one or more programming languages.*

*d) **Communication infrastructure**, This connects the supervisory computer system to the RTUs and PLCs, and may use industry standard or manufacturer proprietary protocols. Both RTU's and*

PLC's operate autonomously on the near-real time control of the process, using the last command given from the supervisory system.

*e) **Human-machine interface**, HMI is the operator window of the supervisory system. It presents plant information to the operating personnel graphically in the form of mimic diagrams, which are a schematic representation of the plant being controlled, and alarm and event logging pages.*

E. Case studies of Pneumatic systems and PLC

One application used in some industry, is the automatic carton handling and palletising. The project that will be described, was carried by MEGA S.A., which is one of the largest producers of personal hygiene products in Europe.

In the factory of MEGA S.A., a wide variety of hygiene products are produced and packed. The need that arise after a large expansion in the manufacturing and warehousing sectors of the factory, was the arrival and safe transfer of carton packed products from twelve producing lines that are spread through different buildings, so they can finally be palletized and stored in an automatic way.

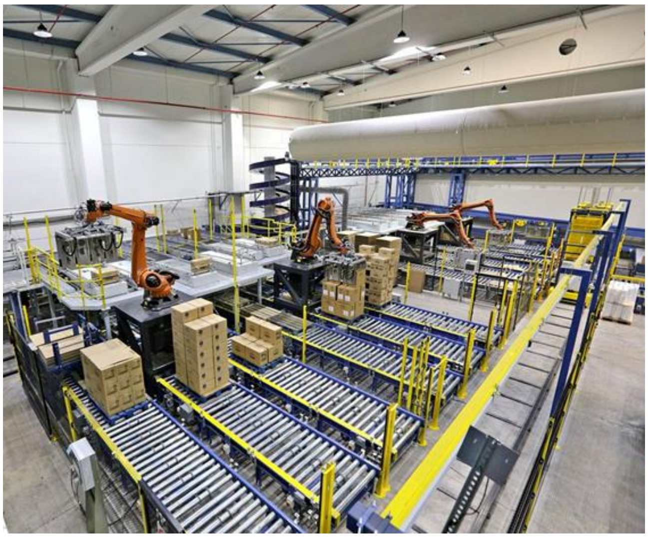

Fig. 5. KUKA robotic arms

There was implemented an air-borne system, with conveyor belts and rollers that are over 600 meters long, which are being fed by twelve producing lines. Cartons arrive at two palletizing stations at a speed of 40000 pieces per minute per station, the appropriate quality control is achieved through suitable 3D scanners, bar code readers and sorters separate products in an appropriate way.

The palletization process continues with the help from four robotic arms made by KUKA, which have special designed handle grips. After, a central wrap and corner system made by Robopac, wraps the pallets. Finally, the use of sensors and automatic recording cameras ensure the traceability of the products.

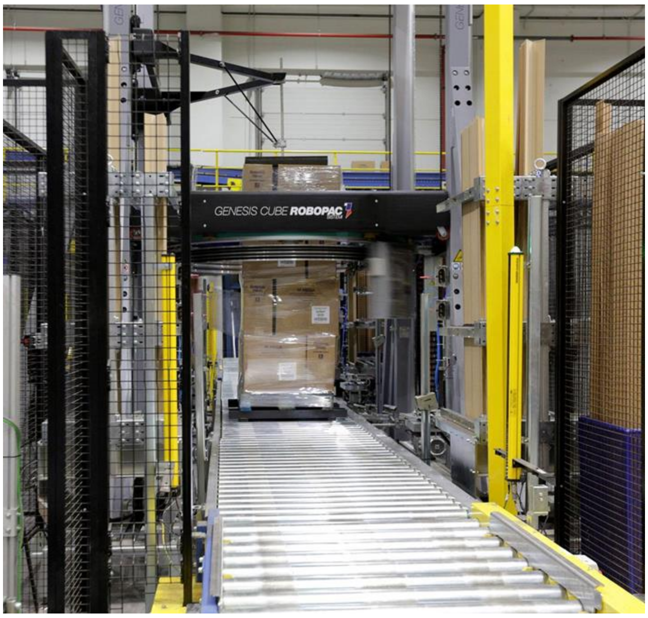

Fig. 6. Pallet wrapping process

III. Conclusion

Primary goal of this thesis was to understand and analyze the pneumatic systems in the industrial environment, study PLC systems and how to do monitoring with Supervisory Control and Data Acquisition (SCADA). We understood the life cycle of the pneumatic system, PLC and SCADA. That said, through case studies we have an insight how pneumatic systems are implemented in industrial environments. Automation in engineering industry brought a revolution, with the implementation of PLC systems we avoid human mistakes and increase production.

Acknowledgment

All authors would like to thank the University of West Attica and specifically the Post Graduate Program of Studies (MSc) "New Technologies in Shipping and Transportations", for the financial support provided to them to undertake this research project.

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