SUDAN UNIVERSITY OF SCIENCE &TECHNOLOGY

COLLEGE OF GRADUATE STUDIES

AUTOMATION OF GRAIN DRYER SYSTEM BY USING PLC

أتمتة نظام تجفيف الحبوب بإستخدام متحكمة المنطق المبرمجة

A Thesis Submitted in Partial Fulfillment for the Requirements of the Degree of M.Sc in Mechatronics Engineering

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November 2019

الآية

بسم الله الرحمن الرحيم

قال تعالى :

(قُلْ لَوْ كَانَ الْبَحْرُ مِدَادًا لِكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْرُ قَبْلَ أَنْ تَنْفَدَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا)

صدق الله العظيم

سورة الكهف الآية (109)

Dedication

I dedicate this work to my family and my friends. Special feeling of gratitude to my loving parents, whose words of encouragement always help me a lot to complete this thesis.

Acknowledgements

Our first and greatest thanks to almighty Allah, for his mercy and help, without his supports none of this work would have been done.

I would like to express my sincere gratitude to my supervisor Dr. Awadalla Taifour Ali for his support of my research, for his patience motivation, his guidance which helped me.

I would like to acknowledge and extend my heartfelt gratitude to Mr.Mohammed Shams Elhuda Arafa Ahmed who help and teach me how to use Simatic step 7-200 Micro win in IO training center. I would like to express my thanks to Sudan University of Science and Technology members and staff.

Abstract

In this thesis, researcher highlighted the grain dryer control systems using Programmable Logic Controllers (PLCs), which increased their efficiency and easy of handling. It also raised safety and security standards. Which in recent decades has received great attention and interest. There is no doubt to turn a blind eye to the value of this research when it worked to solve one of the issues that concern the field of grain quality of production and reduce the cost, which may open the door for the future of many research in this area. The work of this system helps to eliminate human intervention and increase productivity in the system. Using limit switches, mixer, elevator, heat system and some sensors that were then connected with programmable logic controllers to enable the desired process according to the ladder program written to control the process of grain system. The system work depends on fill the grain in tank and heats it to expel moisture, then cool grain to be sure the temperature will not to reach the point roasting. Then place in the storage tank to use.

مستخلص

في هذا البحث تم تسليط الضوء على نظام التحكم في انظمة تجفيف الحبوب بإستخدام المتحكم المنطقي القابل للبرمجة. مما رفع من كفاءتها وسهولة التعامل معها ورفعت ايضا من معاير السلامة والامان الذي ظل في العقود الاخيرة يحظى باهتمام و حرص كبيرين. و مما لاشك فيه انه لايمكن غض الطرف او تغافل عن القيمة التي اكتسبها هذا البحث عندما عمل على حل احد القضايا التي تعنى بمجال تجفيف الحبوب من حيث جودة انتاجها وتقليل التكاليف الإنتاجية لها مما قد يفتح الباب مستقبلاً للعديد من البحوث في هذا المجال.مما قد يساعد عمل هذا النظام على تقليل التدخل البشري في عملية تجفيف الحبوب داخل الخزانات الضخمة.مما يعني تفادي الأخطاء البشريه وزيادة الإنتاجية. ويتم ذلك باستخدام مفاتيح المستوى و خلاط ومصاعد ونظام تسخين وبعض الحساسات التي بدورها تم توصيلها مع المتحكم المنطقي القابل للبرمجة لتنفيذ العملية المطلوبة وفق البرنامج السلمي الذي تمت كتابته بغرض التحكم في عملية تجفيف الحبوب . يعتمد عمل النظام على إضافة الحبوب للخزان وتعريضها للحرارة لطرد الرطوبة الداخلية من الحبوب وبعد التاكد من تمام جفافها تبرد الحبوب حتى لا تصل الى درجة التحميص وتجمع في خزان اخر الى وقت الإستخدام.

Table of Contents

List of Figure

List of Abbreviation

PLC	Programming Logic Control
RH	Relative Humidity
HDGMC	Hydromantic Division of the General Motors Corporation
CPU	Central Processing Unit
I/O	Input/Output (I/O) interface system
DC	Direct Current
ROM	Read Only Memory
RAM	Random Access Memory
PROM	Programmable Read Only Memory
EPROM	Erasable Programmable Read Only Memory
EAPROM	Electrically Alterable Read Only Memory
EEPROM	Electrically Erasable Programmable Read Only Memory
IL	Instruction List
ST	Structured Text
LD	Ladder Diagrams
FBD	Function Block Diagram
SFC	Sequential Function Chart
RTD	Resistance Temperature Detector
EMF	Electro Magnetic Field
SCADA	Supervisory Control and Data Acquisition
HMI	Human Machine Interface

Chapter One

Introduction

1.1 General Overview

Drying is an important operation that can preserve grain and lower losses during storage. The main objective of any drying process is to produce a dried product of desired quality at minimum cost and maximum throughput and to optimize these factors consistently [1, 2]. In the test results of [3] a tempering process can increase the drying rate, reduced the energy consumption and crack rate during paddy drying. The interaction between the critical moisture content of paddy, drying rate, drying time, and hot air temperature, in which the hot air temperature is the main parameter [4]. Grain moisture changes with air temperature and Relative Humidity (RH) during storage [5]. Many factories use programming logic control in automation processes to diminish production cost and to increase quality and reliability [6]. The automation of grain drying machine involves the use of PLC to control the sequencing of various motors. The two major requirements for automation are the sensing part and the control. The sensing involves the use of various sensors which act as the input to the PLC.

1.2 Problem Statement

In the grain season, the production is larger than the demand, it needs to store grain. Drying process must be used before store that can preserve grain and lower losses drying process have two methods: First method is natural drying which its efficiency depends of weather condition. The second method is industrial drying which its efficiency depends of control drying condition, this is achieved by tightly and high performance control system.

1.3 Objectives

The main aims of this study are to:

- Develop sequential control to increase efficiency.
- Minimize the requirement of manual expertise.
- Improve the drying rate.
- Lowest cost**.**

1.4 Methodology

- Study the system diagram and principle of operation to determine the control sequence
- List out the controller inputs and outputs variables
- Select a PLC controller that compatible with the inputs/outputs of the system which is Siemens step7-200 (CPU 224).
- Configure the PLC using ladder logic diagram language.

1.5 Layout

This study consists of five chapters. Chapter one is an introduction for research including the research problem identification. The problem proposed solutions besides the research objectives and goals are clarified and the method that been used so as to solve the problem and achieve the objectives. Chapter two deals with literature review basic information about methods of drying grain and control system overview. Chapter three describes the system hardware and software. Chapter four handles the control system design, implementation and testing. Chapter five gives the research conclusion and recommendations.

CHAPTER TW0

Theoretical Background and Literature Review

2.1 Grain Dryer System

When grain is harvested from the field, it contains dry matter and water while water is necessary for plant growth and grain production excess moisture after grain maturity can lead to storage related problems. Grain moisture content is expressed as a percent of the grain weight. As rule dryer grain and cooler temperatures increase safe storage durations. In contrast wetter grain and warmer temperature increase the potential for pests, insects, mold and fungi to reduce grain quality and market value. Therefore, the primary objective of grain drying and storage is to manage the temperature and moisture of the air around the grain to minimize grain quality and market value losses. While holding grain for better market opportunities. Maintaining grain quality requires drying the grain to safe moisture content levels after harvest followed by lowering and maintaining the grain temperature within a few degrees of ambient air temperature. Traditionally, on farm grain drying and storage has seen limited. However, recent changes in agricultural markets and technological advances have made grain production more attractive resulting in more producers and more production [7].

This increased supply is associated with a large grain price wing between harvest and non-harvest periods. There for in addition to more control of harvest timing there are potential economic advantages to on farm drying and storage. Accordingly, producers indicated their interest in exploring the possible techniques of on farm grain drying and storage. This fact sheet provides an overview of the basics of on farm grain drying and storage methods. This leads to increased dependence on the environment and loss of grain if improperly dried. The drying of grain by the conventional method cannot achieve the desired moisture level as per the user's requirement. The use of grain dryers will not only reduce the environmental dependence of the drying process but will also provide customizable moisture content in the grain according to user's demands. The storage of the grain requires is to be below at a particular moisture level else it would lead to the development of molds which will damage the grain. So to facilitate the storage requirement of the grain the dryers would dry the grain quickly and efficiently [7].

A methodology is developed for drying the grains through the use of humidity sensing techniques and the use of PLC to control the entire drying procedure. Drying is an important operation that can preserve grain and lower losses during storage. Dryers are used mainly in grain processing industries, 70% of the grain stored is sun dried. The reasons for nonuse of dryers at farmer level are: unawareness of the importance of grain drying; non-availability of dryers within their reach; high initial capital investment required; and lack of incentive for properly dried grain. The preservation of agricultural produce by drying is a long-established technique. The drying time required in the open sun for these crops ranges from 5 to 45 days depending upon the crop to be dried. It is well-known that deterioration inequality caused by improper drying cannot be eliminated until improved drying systems based on mechanical dryers have been adopted. However, for many reasons, these systems have not been adopted. The main reason that is encountered is a lack of adequate expertise about the drying technique. A second important reason for not using dryers is their high initial costs. Most of the commercially available dryers are designed to suit the needs of the processing industry and their output capacity is therefore far above the needs of individuals, or even of farmer groups [7].

2.2 Grain Drying Basics

The grain drying consists of many of stages:

2.2.1 Storage moisture content

The first step in drying grain is determine the desired, or target grain moisture content level. Under drying grain reduce safe storage time increases the potential for quality losses and increases the like lihood of high moisture price dockages upon sale. Over drying grain reduces in come due to increased drying costs. In addition, since grain is usually sold on a weight basis one of the expenses involved in drying grain is the "cost" of the weight loss that occurs during the drying process. This weight loss by drying is referred to as "shrink" and is expressed as a percentage of the original quantity before it is dried. Shrinkage should be considered to accurately determine the total cost of mechanical drying. When choosing the desired target moisture content, safe storage time grain shrinkage age and buyer's requirements should be considered. Grain conditioning by drying and cooling to target ranges should begin immediately after harvest. As indicated earlier, grain temperature and moisture content dictate how quickly grain quality and market value are reduced. Drying and cooling freshly harvested grain will delay spoilage and must begin within 24 hours and preferably within 12 hours after the harvest [8].

Grain drying season is a very short period of time, which takes only a few weeks per year, but it has a great impact on the whole farm’s profitability. Problems with the dryer are usually noticed at the beginning of the drying period, when the grain drying starts. Depending on the quality of the problem repairing may take a long time and drying is carried out with the dryers of other farms, which may be expensive. For this reason, the dryer’s functionality should be secured by using the latest technology [8].

2.2.2 Natural air and warm air dryers

Natural air and warm air dryers are based on externally heated warm air which is sucked or blown through the heat exchangers, whereby warm air binds the grain moisture. After that the cool, humid air is directed out of the dryer. In the warm air dryer, the air usually circulates in the dryer so that grain germination and characteristics as food will not suffer. If the grain doesn't circulate, hot air flow burns the grain and the grain cannot be used anymore as seeds or food. The most common fuel in these dryers is oil [8].

In the natural air dryer grain is dried with unheated air. This method is slower than the warm air drying and drying grain in Finland with this method in the usually humid autumn may take a long time, because cool air doesn't bind as much moisture from the grain as the warm air does. The natural air dryer's expenses are much smaller than in the warm air dryer because the grain doesn't have to move during the drying process and the fuel is not consumed for heating. Natural air dryers are often used during the warm days of late summer and also as pre-dryer before the warm air dryer. This way the warm air drying time is reduced and fuel saved. The benefit of natural air dryer is also that the threshed grain doesn't decay in this dryer as easily as in the cart when waiting for proper drying. [8].

2.2.3 Vacuum and over pressure dryers

In over pressure grain dryer heated air mass is blown through the grain. This method is the most common, but it has the disadvantage of dustiness. Over pressure drying technology is now increasing being replaced with vacuum drying because of better efficiency and profit ability. In a vacuum dryer heated air is drawn through heat exchangers by centrifugal fan. Because the air is drawn through the grain, drying is almost free of dust. Vacuuming the grain also removes mold spores from the grain. Warm under-pressured air absorbs more moisture than over-pressurized air. The manufacturers of vacuum dryers often allow to use a constantly higher drying temperature than with over pressured dryers because drying facilities are free of dust and vacuum reduces the risk of fire. Increasing the drying air temperature from 70 degrees to 100 degrees reduces fuel consumption by 10-15% and because of that the vacuum dryer is a better choice for new drying facilities [8].

2.3 The Meaning of Modern Grain Drying

Grain has to be dry to ensure long-term storage of grain and to maintain the characteristics of grain. The two main factors in the grain's preservation are the storage temperature and grain moisture percentage. Grain has to be dried to a moisture content of about 14 % to prevent mold spores to evolve and to prevent decay, while retaining the grain germination characteristics when it is used as a seed. 14 % moisture is also used as moisture limit in trade because wetter grain is a great risk of decaying in the long-term storages as shown in Figure 2.1. Drying under 14 % is unnecessary because the grain drying requires a lot of energy, the benefits achieved are very small and germination of seed grain gets worse [8].

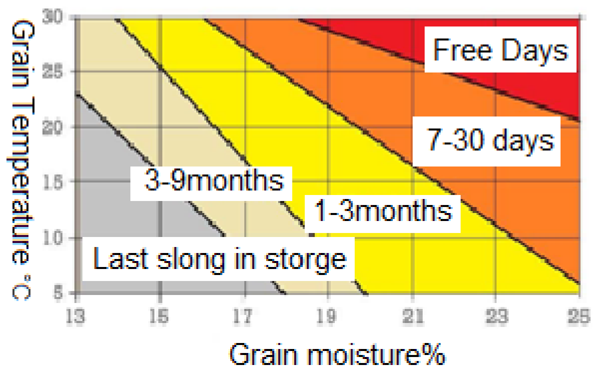


Figure2.1: Grain moisture and temperature effects when stored

2.4 Programmable Logic Controllers

PLCs also called programmable controllers, are solid-state members of the computer family, using integrated circuits instead of electromechanical devices to implement control functions. They are capable of storing instructions, such as sequencing timing counting, arithmetic, data manipulation, and communication, to control industrial machines and processes. As shown in Figure 2.2 shows a conceptual diagram of a PLC application. Programmable controllers have many definitions. However, PLCs can be thought of in simple terms as industrial computers with specially designed architecture in both their central units (the

PLC itself) and their interfacing circuitry to field devices (input/output connections to the real world) [9].

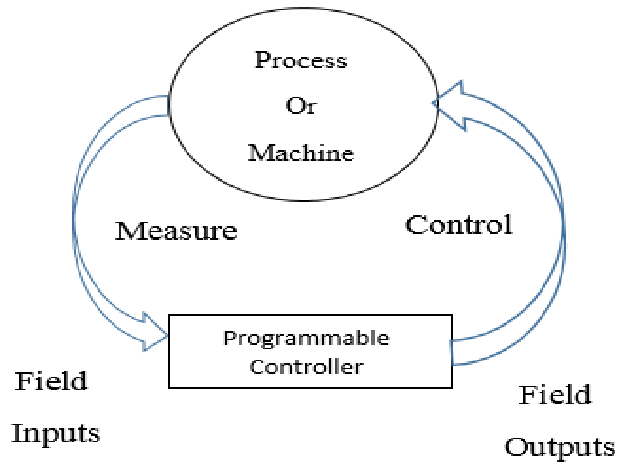


Figure 2.2 PLC conceptual application diagram

2.4.1 A historical background

The Hydromantic Division of the General Motors Corporation (HDGMC), specified the design criteria for the first programmable controller in 1968. Their primary goal was to eliminate the high costs associated with inflexible, relay controlled systems. The specifications required a solid-state system with computer flexibility able to:

- Survive in an industrial environment.
- Be easily programmed and maintained by plant engineers and technicians.
- Be reusable.

Such a control system would reduce machine downtime and provide expandability for the future. Some of the initial specifications included the following:

• The new control system had to be price competitive with the use of relay systems.

• The system had to be capable of sustaining an industrial environment.

• The input and output interfaces had to be easily replaceable.

• The controller had to be designed in modular form, so that subassemblies could be removed easily for replacement or repair.

• The control system needed the capability to pass data collection to a central system.

• The system had to be reusable.

• The method used to program the controller had to be simple, so that it could be easily understood by plant personnel [9].

Programmable logic controllers are mature industrial controllers with their design roots based on the principles of simplicity and practical application. The product implementation to satisfy hydramatic’s specifications was underway in 1968; and by 1969, the programmable controller had its first product off springs. These early controllers met the original specifications and opened the door to the development of a new control technology. The first PLCs offered relay functionality, thus replacing the original hardwired relay logic, which used electrically operated devices to mechanically switch electrical circuits. They met the requirements of modularity, expandability, programmability, and ease of use in an industrial environment. These controllers were easily installed, used less space, and were reusable. The controller programming, although a little tedious, had a recognizable plant standard: the ladder diagram format. In a short period, programmable controller use started to spread to other industries. By 1971, PLCs were being used to provide relay replacement as the first steps toward control automation in other industries, such as food and beverage, metals, manufacturing, and pulp and paper [9].

2.4.2 Principles of operation

A programmable controller, as illustrated in Figure 2.3 consists of two basic sections:

• The Central Processing Unit (CPU).

• The Input/Output (I/O) interface system

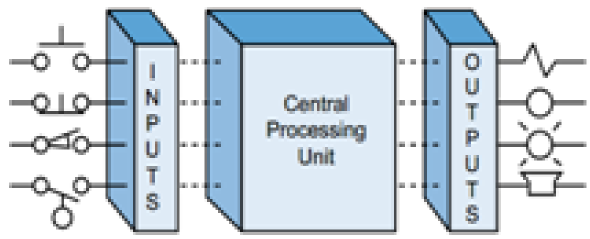


Figure 2.3 Programmable controller block diagram

The (CPU) governs all PLC activities. The following three components, shown in Figure (2.4), form the CPU

• The processor

• The memory system

• The system power supply

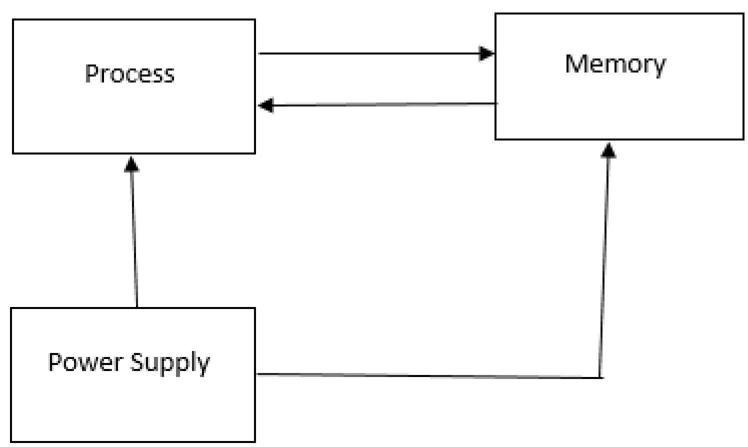


Figure 2.4 Block diagram of major CPU component

The operation of a programmable controller is relatively simple. The I/O system is physically connected to the field devices that are encountered in the machine or that are used in the control of a process. These field devices may be discrete or analog input/output devices, such as limit switches, pressure transducers, push buttons, motor starters, solenoids, etc. The I/O interfaces provide the connection between the CPU and the information providers (inputs) and controllable devices (outputs) [9]. During its operation, the CPU completes three processes:

(1) it reads, or accepts, the input data from the field devices via the input interfaces.

(2) it executes, or performs, the control program stored in the memory system.

(3) it writes, or updates, the output devices via the output interfaces.

This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as scanning. Figure (2.5) illustrates a graphic representation of a scan [9].

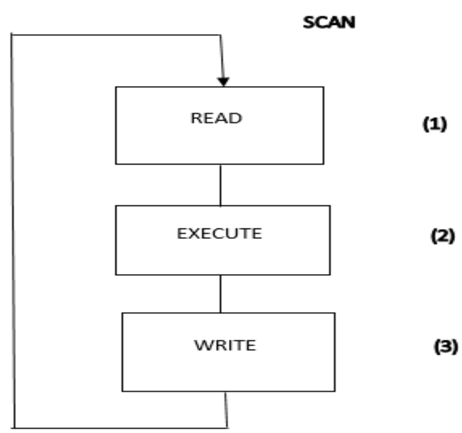


Figure 2.5 Scan graphic representation

The input/output system forms the interface by which field devices are connected to the controller as shown in Figure 2.6. The main purpose of the interface is to condition the various signals received from or sent to external field devices. Incoming signals from sensors (e.g., push buttons, limit switches, analog sensors, selector switches, and thumbwheel switches) are wired to terminals on the input interfaces. Devices that will be controlled, like motor starters, solenoid valves, pilot lights, and position valves, are connected to the terminals of the output interfaces. The system power supply provides all the voltages required for the proper operation of the various central processing unit sections.

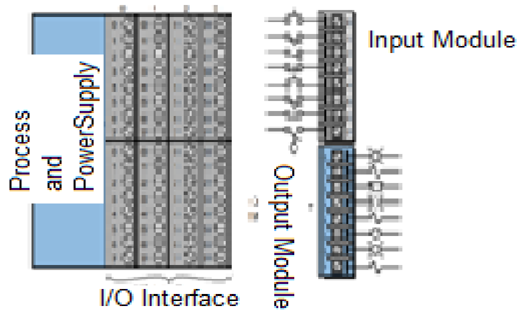


Figure 2.6 Input/output interface

Although not generally considered a part of the controller, the programming device, usually a personal computer or a manufacturer's mini programmer unit is required to enter the control program into memory as shown in Figure 2.7. The programming device must be connected to the controller when entering or monitoring the control program. Figure 2.8 shows the mini programmer unit

Figure 2.7 Personal computer

Figure 2.8 Mini-programmer unit

The CPU is the most important element of a PLC The CPU forms what can be considered to be the “brain” of the system. The three components of the CPU are:

• The processor.

• The memory system.

• The power supply.

Figure 2.9 illustrates a simplified block diagram of a CPU. CPU architecture may differ from one manufacturer to another, but in general, most CPUs follow this typical three-component organization. Although this diagram shows the power supply inside the CPU block enclosure, the power supply may be a separate unit that is mounted next to the block enclosure containing the processor and memory. Figure 2.10 shows a CPU with a built-in power supply. The programming device, not regarded as part of the CPU per se, completes the total central architecture as the medium of communication between the programmer and the CPU [9].

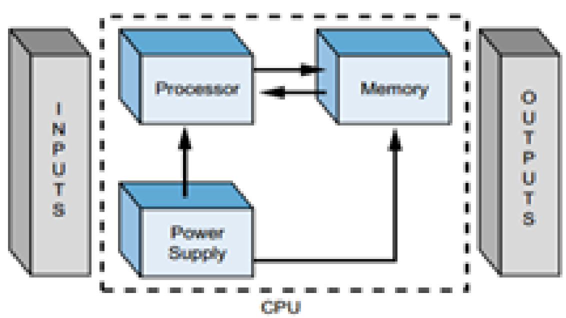


Figure 2.9 CPU block diagram

Figure 2.10 Two PLC CPUs with built in power supplies (left with fixed (I/O) blocks and right with configurable I/O)

In general, the processor executes the control program stored in the memory system in the form of ladder diagrams, while the system power supply provides all of the necessary voltage levels to ensure proper operation of the processor and memory components.

2.4.3 Power supply

The system power supply plays a major role in the total system operation. In fact, it can be considered the “first-line manager” of system reliability and integrity. Its responsibility is not only to provide internal Direct Current (DC) voltages to the system components but also to monitor and regulate the supplied voltages and warn the CPU if something is wrong. The power supply, then, has the function of supplying well-regulated power and protection for other system components [9].

2.4.4 Memory overview

The most important characteristic of a programmable controller is the user’s ability to change the control program quickly and easily. The PLC’s architecture makes this programmability feature possible. The memory system is the area in the PLC’s CPU where all of the sequences of instructions, or programs, are stored and executed by the processor to provide the desired control of field devices. The memory sections that contain the control programs can be changed, or reprogrammed, to adapt to manufacturing line procedure changes or new system start-up requirements.

i. Memory sections

The total memory system in a PLC shown in Figure 2.10 is actually composed of two different memories

• The executive memory.

• The application memory.

Figure 2.11 simplified block diagram of the total PLC memory system

The executive section is the part of the PLC's memory where the system's available instruction software is stored. This area of memory is not accessible to the user. The application memory provides a storage area for the user-programmed instructions that form the application program. The application memory area is composed of several areas, each having a specific function and usage.

ii. Memory types

Memory can be separated into two categories:

*** Volatile memory** loses its programmed contents if all operating power is lost or removed, whether it is normal power or some form of backup power. Volatile memory is easily altered and quite suitable for most applications when supported by battery backup and possibly a disk copy of the program for example:

- Random Access Memory (RAM)

*** Nonvolatile Memory** retains its programmed contents, even during a complete loss of operating power, without requiring a backup source. Nonvolatile memory generally is unalterable, yet there are special nonvolatile memory types that are alterable for examples:

1- Read Only Memory (ROM).

2- Programmable Read Only Memory (PROM).

3- Erasable Programmable Read Only Memory (EPROM).

4- Electrically Alterable Read Only Memory (EAROM).

5- Electrically Erasable Programmable Read Only Memory (EEPROM) [9].

2.4.5 PLC languages

The IEC standard 1131-3 [5] defines the software model of programmable controllers and the languages to program it. The many proposals and dialects from PLC vendors result in a suite of five programming languages:

• Instruction List (IL): A low-level textual language with a structure similar to assembler.IL is well suited for solving small straight forward problems and producing optimized code.

• Structured Text (ST): A high-level procedural programming language.ST enforces data typing and support structured programming. it provides useful means to handle the complexity and modularity of modern programmable controllers.

• Ladder Diagrams (LD): an evolution of electrical wiring diagrams. LDs supply a programming style borrowed from electronic and electrical circuits. The programmable controller was developed for ease of programming using existing relay ladder symbols and expressions to represent the program logic needed to control the machine or process. The resulting programming language, which used these original basic relay ladder symbols, was given the name ladder language. Figure 2.11 illustrates a relay ladder logic circuit and the PLC ladder language representation of the same circuit. Figure 2.11 hardwired logic circuit and its PLC ladder language implementation. The evolution of the original ladder language has turned ladder programming into a more powerful instruction set. New functions have been added to the basic relay, timing, and counting operations. The term function is used to describe instructions that, as the name implies, perform a function on data that is, handle and transfer data within the programmable controller. These instructions are still based on the simple principles of basic relay logic although they allow complex operations to be implemented and performed.

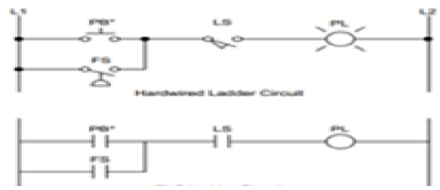


Figure 2.12 Hardwired logic circuit and its PLC ladder language implementation

• Function Block Diagram (FBD): A graphical language similar to structured analysis [7]. Controllers are modeled as signal and data flows through processing elements (functionblocks3). FBD transforms textual programming ST into connecting (already defined) building blocks, thus improving modularity and software reuse.

• Sequential Function Chart (SFC): SFC elements partition processing elements into sets of steps and transitions among them interconnected by directed links [14].

2.5 Sensors

Sensor is a devise that convert unknown input signal (not suitable for controller) to another one which control can dial with it. It is use transducer to convert physical or chemical phenomena to electrical quantity related with input by convert equation call transfer function (e.g. resistant, voltage, current, capacitive, inductive, and switching in electrical controller).

2.5.1 Humidity sensor

Instruments that determine the density or pressure of water in vapor form in the atmosphere, generally either measure relative humidity or they measure dew point temperature. The pressure of water vapor just above a liquid water surface when the vapor is in equilibrium with the liquid water is the saturated vapor pressure of the water. This saturated vapor pressure increases with the temperature and equals atmospheric pressure at the boiling temperature of water. Relative humidity is the ratio of the vapor pressure in air to the saturated vapor pressure at the temperature of the air.

i. **Capacitive humidity and moisture sensors**

The permittivities of atmospheric air, of some gases, and of many solid materials are functions of moisture content and temperature. Capacitive humidity devices are based on the changes in the permittivity of the dielectric material between plates of capacitors. The main disadvantage of this type sensor is that a relatively small change in humidity results in a capacitance large enough for a sensitive detection. Capacitive humidity sensors enjoy wide dynamic ranges, from 0.1ppm to saturation points. They can function in saturated environments for long periods of time, a characteristic that would adversely affect many other humidity sensors. Their ability to function accurately and reliably extends over a wide range of temperatures and pressures. Capacitive humidity sensors also exhibit low hysteresis and high stability with minimal maintenance requirements.

ii. **Aluminum type capacitive humidity sensors**

The majority of capacitive humidity sensors are aluminum oxide type sensors. In these types of sensors, high-purity aluminum is chemically oxidized to produce a prefilled insulating layer of partially hydrated aluminum oxide which acts as the dielectric. In another type, the aluminum-aluminum oxide sensor has a pore structure the oxide, with its pore structure, forms the active sensing material. Moisture in the air reaching the pores reduces the resistance and increases the capacitance. The decreased resistance can be thought of as being due to an increase in the conduction through the oxide. An increase in capacitance can be viewed as due to an increase in the dielectric constant. The quantity measured can be resistance, capacitance, or impedance. High humidifies are best measured by capacitance because resistance changes are vanishingly small in this region.

iii. **Tantalum type capacitive humidity sensors**

In some versions of capacitive humidity sensors, one of the capacitor plates consists of a layer of tantalum deposited on a glass substrate. A layer of polymer dielectric is then added, followed by a second plate made from a thin layer of chromium. The chromium layer is under high tensile stress such that it cracks into a fine mosaic structure that allows water molecules to pass into the dielectric. The stress in the chromium also causes the polymer to crack into a mosaic structure [10].

iv. **Silicon type capacitive humidity sensors**

In other capacitive humidity sensors, silicon is used as the dielectric. The structure and operation of silicon humidity sensors are very similar to the aluminum oxide types. Some silicon-type humidity sensors also use the aluminum base and a thin-film gold layer as the two electrodes. The silicon dielectric has a very large surface area, which means that the sensitivity is still relatively large even if the sensing area is very small. This is an important feature with the increasing trend of miniaturization. Both sensor types are now typically found as extremely small wafer-shaped elements, placed on a mechanical mount with connecting lead wires.

v. **Polymer Type Capacitive Humidity Sensors**.

In some sensors, the dielectric consists of a polymer material that has the ability to absorb water molecules. The absorption of water vapor of the material results in changes in the dielectric constant of the capacitor. By careful design, the capacitance can be made directly proportional to percentage relative humidity of the surrounding gas or atmosphere. In general, an important key feature of capacitive humidity sensors is the chemical stability. Often, humidity sensing is required in an air sample that contains vapor contaminants (e.g., carbon monoxide) or the measurements are performed on a gas sample other than air (e.g., vaporized benzene) [10].

2.5.2 Temperature sensor

The temperature at a given site and time is a superposition of the mean temperature and the fluctuations from this mean temperature caused by current cloud and wind conditions, the past history of the air mass passing over the site, and inter annual variations that are not yet well understood. The common methods of measuring atmospheric temperature include the following:

i. **Resistance Temperature Detector (RTD)**

The variation of the resistance of a metal with temperature is used to cause a variation in the current passing through the resistance or the voltage across it. The electric circuit used for the measurement of temperature can utilize a constant current source, and temperature is determined from the voltage across the resistance after the circuit is calibrated. Alternatively, a constant voltage source can be used with the current through the resistance determining the temperature [10].

ii. **Thermocouples**

A thermocouple shown in Figure 2.12 is a type of temperature sensor, which is made by joining two dissimilar metals at one end. The joined end is referred to as the junction. The other end of these dissimilar metals is referred to as the cold end or cold junction. The cold junction is actually formed at the last point of thermocouple.

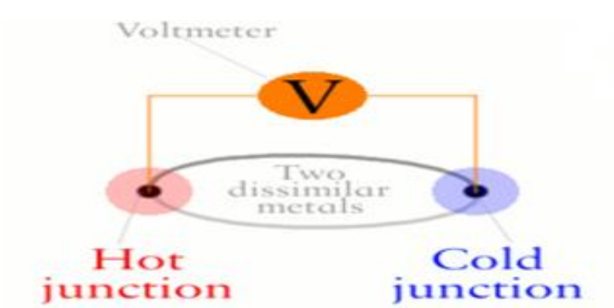


Figure 2.13 Thermocouple

If there is difference between the hot junction and cold junction. A small voltage is created. This voltage is referred to as an Electro Magnetic Field (EMF) and can be measured and in turn used to indicate temperature [10].

2.6 Elevator

A mechanical device, that use to transporting people or loads from one level to another. The term lift or elevator generally denotes a unit with automatic safety devices. Lifts consist of a platform (cabin) or car travelling in vertical guides in a shaft, with related hoisting and lowering mechanisms and a source of power.

2.6.1 Classification of the elevator

Basically they can be divided into two main groups: Personal lifts load (or service).

The major classification can be made according to the working mechanism as follows:

1. Transaction (mechanical rope): The transaction elevator system is the most popular grace to its flexibility. The machine is composed of two parts: the gear box and the electric motor.

2. Hydraulic: A hydraulic lift is driven by an oil pump and jacks. More expensive than transaction lifts but less noisy operation.

2.6.2 Components of a lift system

1- Guide rails.

2- Counter weight.

3- Buffer or bumper.

4- Speed regulator.

5-Parachute system.

6- Electricity arrangement.

7- Control system.

8- Ropes or cables.

9- Cabin doors: Cabin doors can be separated in three according to their operation as follows:

* Slam-doors: opened and closed by hand.

* Semi-automatic doors: closed with the help of shock absorbers.

* Full-automatic doors: operate by electric motors.

Chapter Three

System hardware and software

3.1 Introduction

The control system has two main parts: hardware which is the core of the system, and the software. The hardware consists of sensors, actuators, and PLC; the software is a control program design using ladder language to control the system. The researcher used simulation software to show a result and describe the system behavior.

3.2 System Description

The proposed system consists of two sensors for measured temperature and humidity in dryer chamber; the main idea is to measure the moisture expulsion from interior grain. The system block diagram is shown in the Figure 3.1.

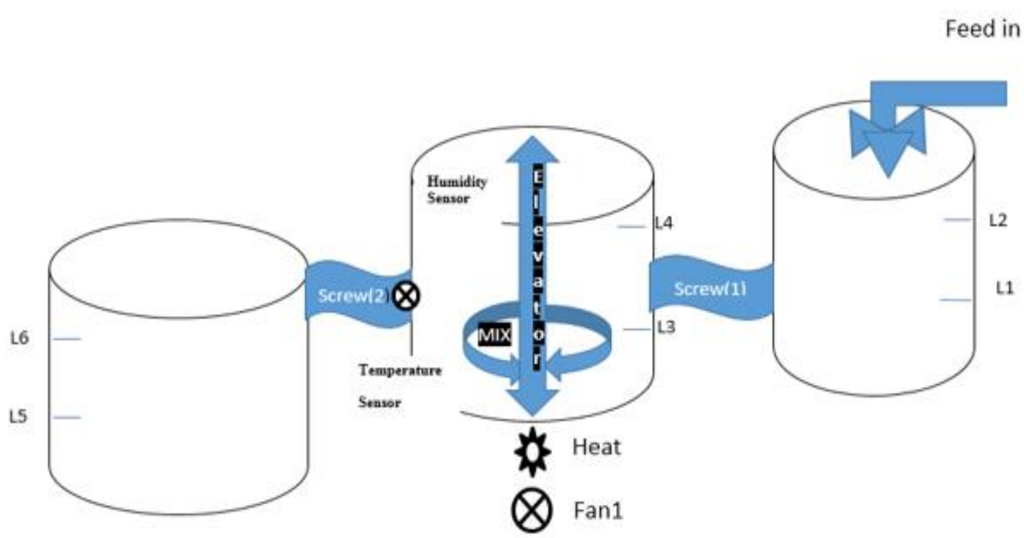


Figure 3.1: System block diagram

3.3 System hardware

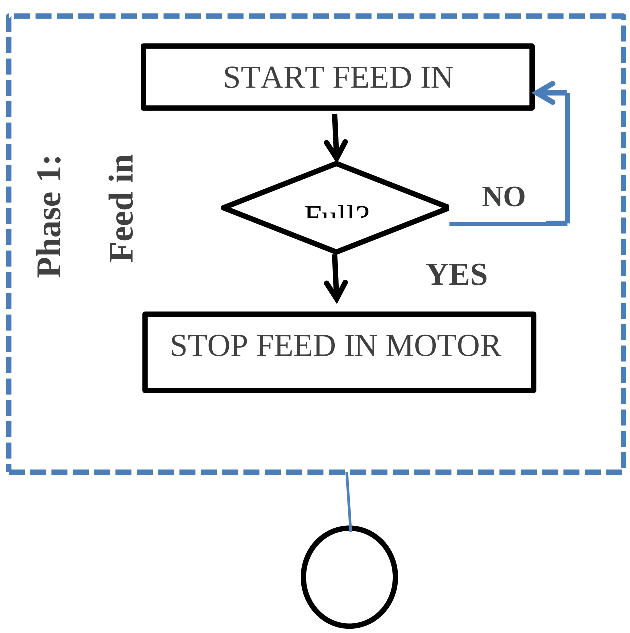
The hardware of system consists of major components: grain dryer hardware, and its control system components**.** The S7-200 series of Micro PLCs can control a wide variety of devices to support your automation needs. The S7-200 monitors inputs and changes outputs as controlled by the user program, which can include Boolean logic, counting, timing, complex math operations, and communications with other intelligent devices. The compact design, flexible. Configuration, and powerful instruction set combine to make the S7-200 a perfect solution for controlling a wide variety of applications

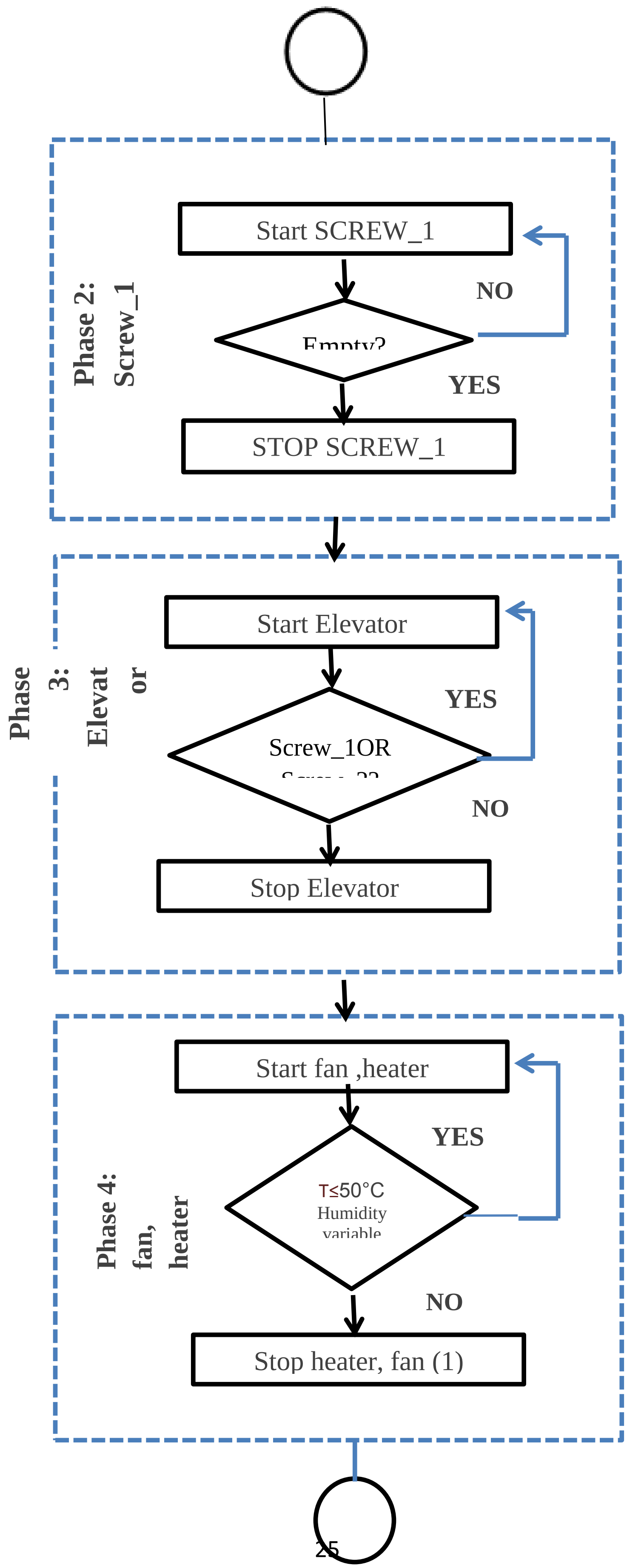
3.4 system software

The programming software package used in this system is Simatic step 7-200 Micro win. The Step 7-200 programming package provides a user-friendly environment to develop, edit, and monitor the logic needed to control your application. This program provides features as editors for convenience, and efficiency in developing the control program for your application. To help you find the information you need, Simatic STEP 7-200 provides an extensive online and offline help system and a documentation CD that contains an electronic version of this manual, application tips, and other useful information.

3.4.1 System flowchart

The system can be explained by the flow chart




Phase 2: Screw_1
Start SCREW_1
Empty?
NO
YES
STOP SCREW_1
Phase 3: Elevator
Start Elevator
Screw_1OR
YES
NO
Stop Elevator
Phase 4: fan, heater
Start fan ,heater
T≤50°C
Humidity
variable
YES
NO
Stop heater, fan (1)

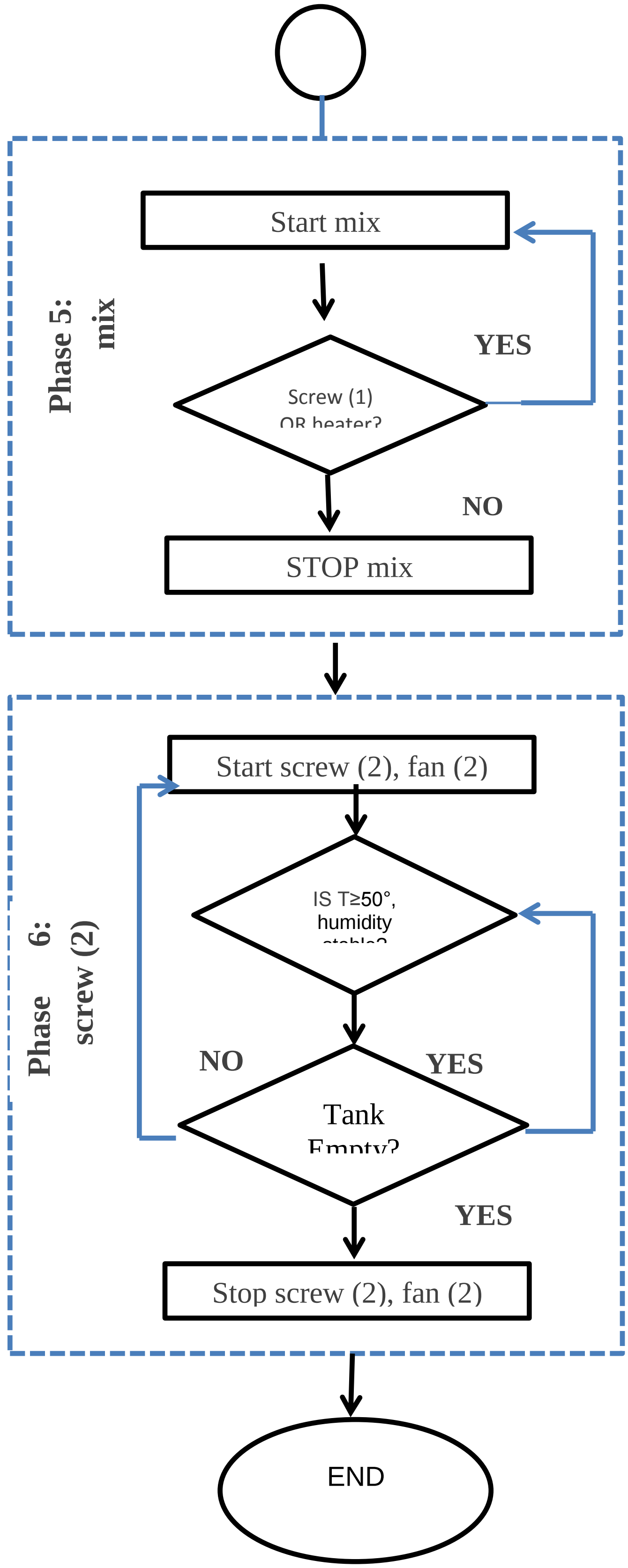


Figure 3.2: system flowchart

3.4.2 Control program

Simatic S7-200 simulator has been used as simulator software. In this simulator all control process is simulated, includes the opening process closing process, and other interlocking process .To start simulator researcher design a program control using Simatic s7-200 Microwin software to create a new project then exported the application to simulator software, using load program command, and then configuration hardware of plc and selecting the type of controller (S7-224) and analog extension module (EM-235) which has three analog inputs and one analog outputs,as shown in Figure3.3.

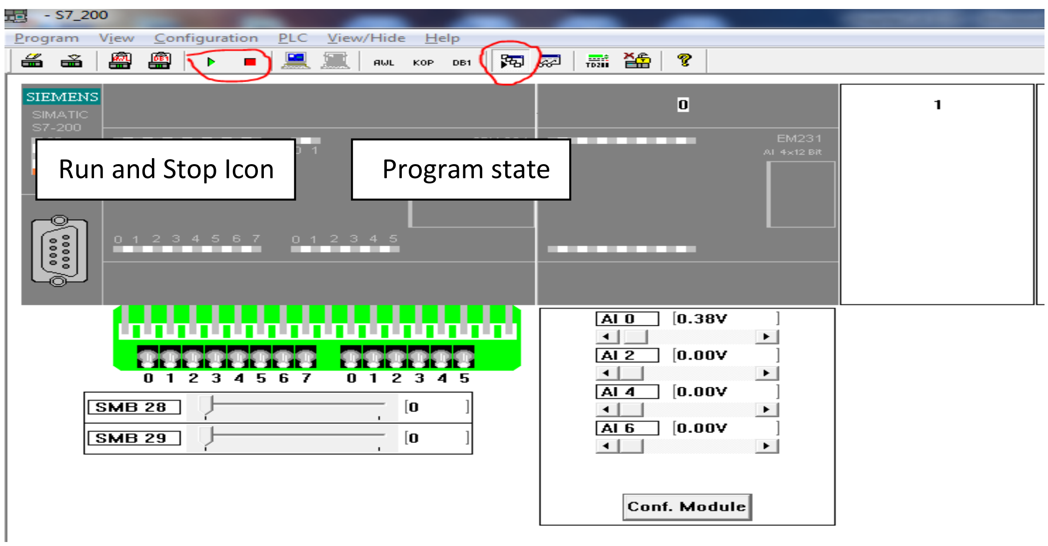


Figure 3.3 Simulator software view

After the new project has been loaded on the simulator run the simulation by click on run button in plc menu or located on the toolbar, all inputs signal can be simulated and to show the result in outputs, and it can be monitored by enable monitor mode (program state) in toolbar.

3.4.3 PLC programming

The PLC is controlling the whole system based on the installed program which act like a guideline to perform the needed process in a sequential method and to ensure high efficiency in implementation. The pictures below illustrate the system’s PLC program.

Step 1:

This step illustrates the over view page of the program, as shown in Figure 3.4.

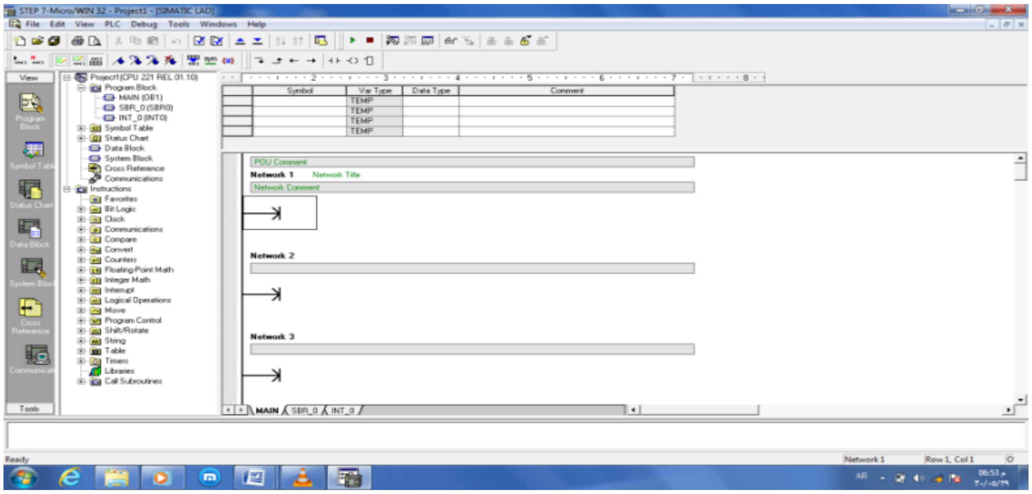


Figure 3.4: Main Screen of program

Step 2:

This step illustrates the input output data type & address number, as shown in Table 3.1.

Table 3.1: Inputs and outputs variables data type and address number

Input device		**Output device**	
Stop bottom	I0.0	Main relay	Q0.0
Start bottom	I0.1	Feed in	Q0.1
Over load (1)	I0.2	Screw(1)	Q0.2
Over load(2)	I0.3	Fan(1)	Q0.3
Limit (1) l1	I0.4	Heater	Q0.4
Limit (2) l2	I0.5	Mixer	Q0.5
Limit (3) l3	I0.6	Elevator	Q0.6
Over load(3)	I0.7	Fan (2)	Q0.7
Over load(4)	I1.0	Screw(2)	Q1.0
Over load(5)	I1.1	Store tank	Q1.1
Limit (4) l4	I1.5		
Limit (5) l5	I1.2		
Over load(6)	I1.3		
Limit (6) l6	I1.4		
Over load(7)	I1.6		
Temperature Sensor	AIW0		
Humidity Sensor	AIW2		

Step 3:

This step illustrates the ladder diagram in general, as shown in Figure 3.5.

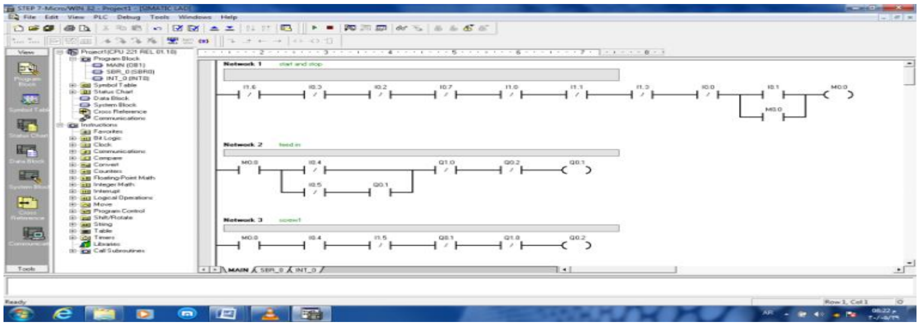


Figure 3.5: Ladder diagram of the system

Step 4:

The main screen in simulator as shown in Figure 3.6.

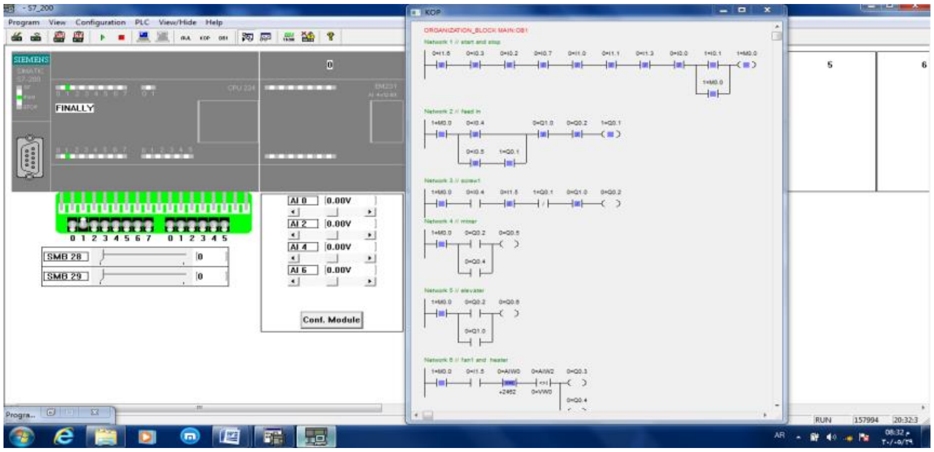


Figure 3.6: Main screen in simulator

Step 5:

The system at ideal position, as shown in Figure 3.7.

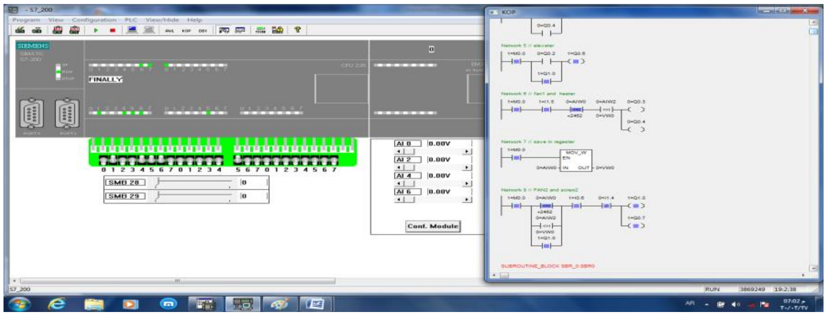


Figure 3.7: System at ideal position

Step 6:

This step illustrates the system when the operator pressed the start push button the system started and the feeder begins to work at the same time, as shown in Figure 3.8.

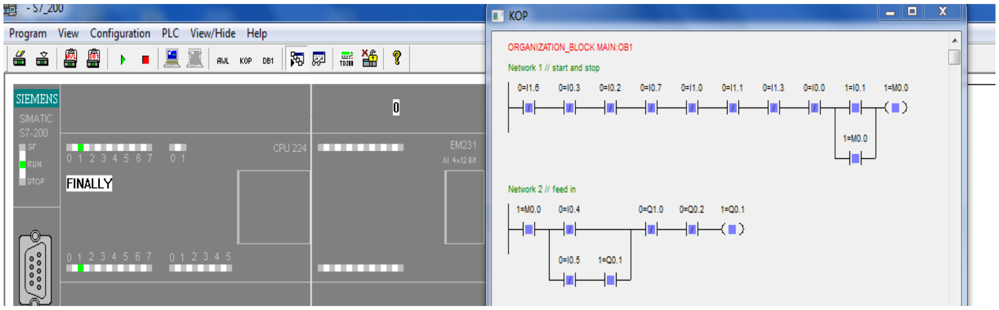


Figure 3.8: System when the operator pressed the start push button

Step 7:

This step illustrates the system when the screw (1) starts the mixer and elevator work at the same time, as shown in Figure 3.9.

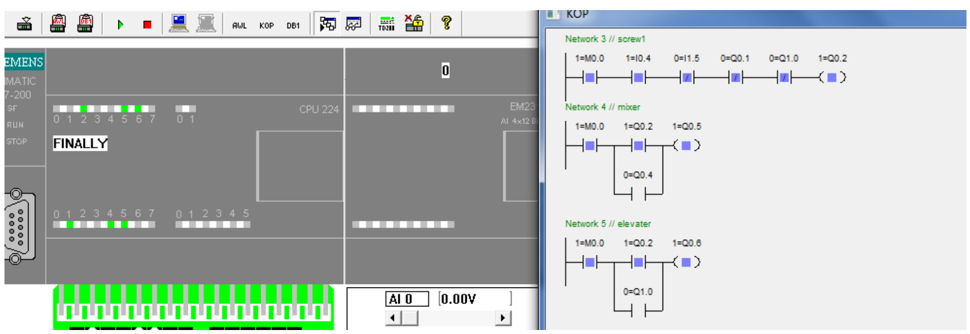


Figure 3.9: System when the screw (1) and mixer, elevator work

Step 8:

This step illustrates the system when the fan (1) starts the heater and mixer work at the same time and start save the humidity sensor reading in a plc memory register, as shown in Figure 3.10.

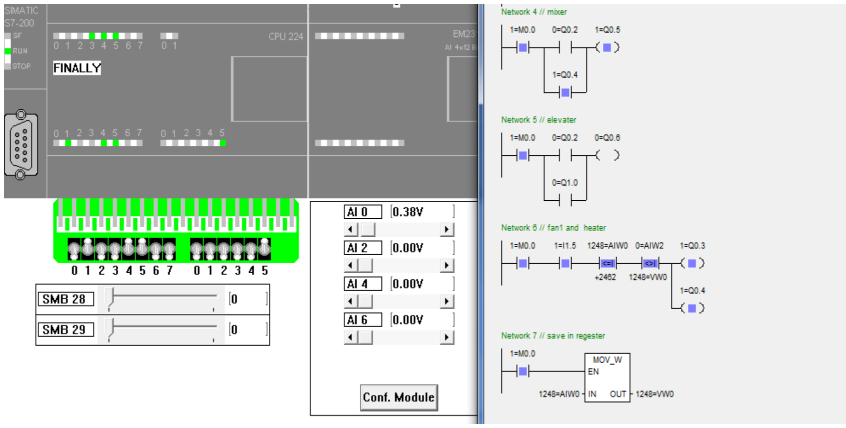


Figure 3.10: System when the fan (1) starts the heater and mixer

<u>Step 9:</u>

This step illustrates the system when the fan (2) started and the screw (2) worked at the same time, as shown in Figure 3.11.

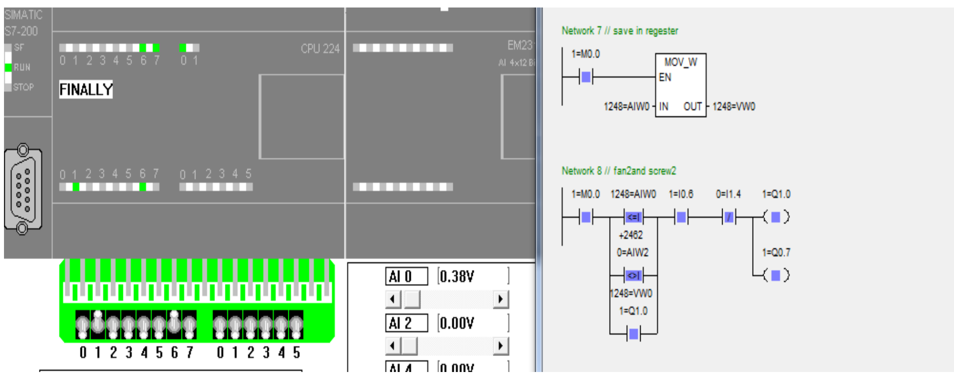


Figure 3.11: System when the fan (2) starts and screw (2) work at the same time

Chapter Four

System Implementation and Testing

4.1 Introduction

After studying the system in the previous chapters the system hardware components and the process variables of the system have been identified furthermore the control philosophy and the type of control and hence the controller has been defined.

4.2 Control Circuit Design

The control system type depends on system process variables types whether it is analog or digital and the total numbers of these variables. Therefore, the controller has been selected to satisfy these parameters specifications. Since the grain dryer system process variable are digital and analog as shown in Table 3.1 besides the total numbers of these parameters are almost are fourteen digital inputs and two analog input and ten digital outputs the controller that compatible with these design requirements is Siemens simatic CPU type 224 which has fourteen digital inputs and ten digital outputs with analog module EM-235 has three analog inputs and one analog output. Furthermore, the power supply type for process variables is very crucial for selecting controller type for instance; the power supply for inputs variables for the system is DC as selected by the system designer. Whereas the supply power output variable is Alternation Current (AC) so as to start the system equipment through relay outputs so the relay output is selected to be a PLC output. In addition, to this the AC power is selected to feed the PLC itself. Figure 4.1 shows the control circuit of the system including the programmable logic controller.

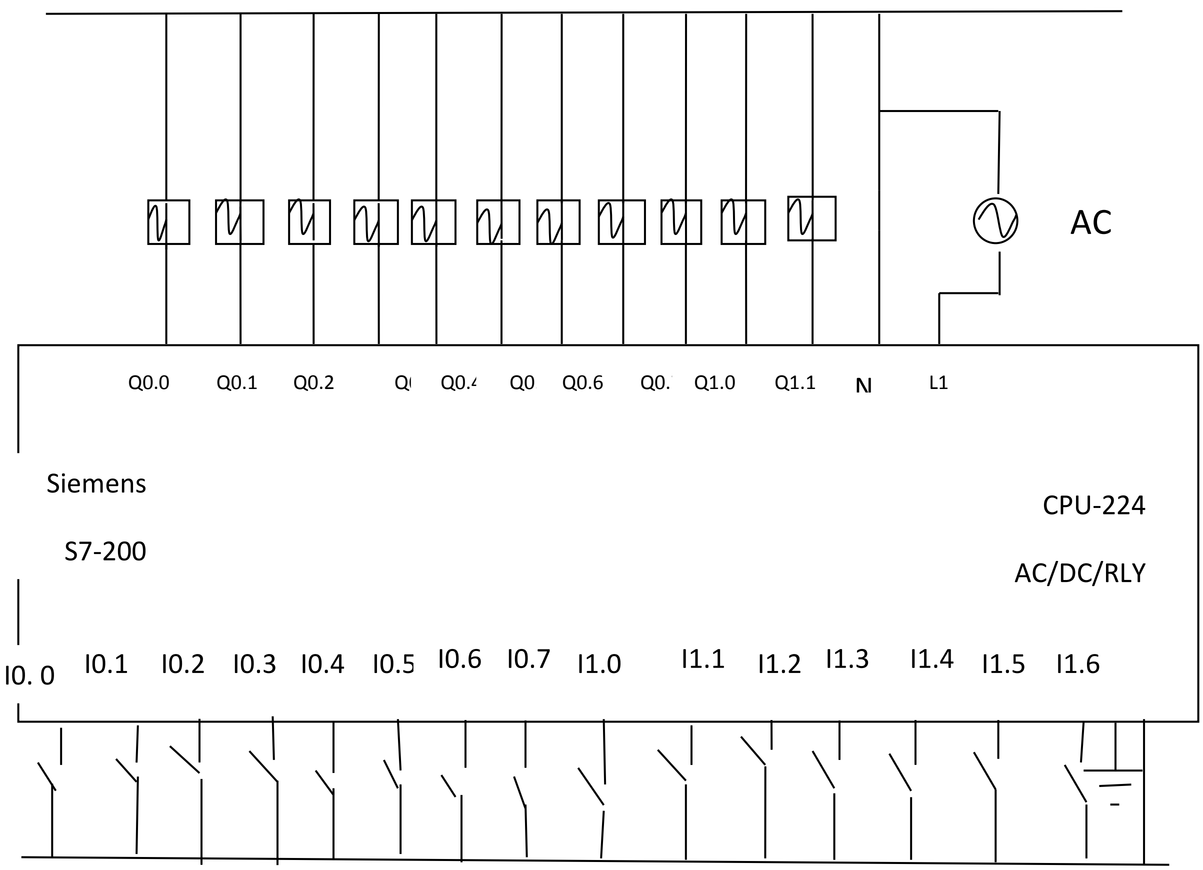


Figure 4.1: System control circuit

At the bottom of the figure there are inputs variables that include all inputs that mentioned in Table 3.1 and fed by 24 VDC. At the top the output relays are existed to work as interface between the controller and system components which needed power supply to activated actuator. A terminal used to connect power supply for programmable logic controller itself. To see the lighting (true or one logic) and darkness (false or zero logic) With the sequence of the system. In which the type of device to be used for the practical application and completion of the system is chosen to be closer to what will happen in fact and to ensure access to the results of satisfactory.

4.3 System Implementation and Discussion

In network 1 a marker relay used to start and stopping of system and must contain start and stop push button and all the elements of operation required to protect the system from abnormal operating condition (over loads to safe all the machine in the system). The first stage in the operation of the system is the feeding in, it operated while all other stage is stopped, this stage uses two limit switch: limit switch one (L1) which started stage. The feeding is work until the grain is full the tank detected by limit switch two (L2) used to stop stage as shown in Figure 4.2.

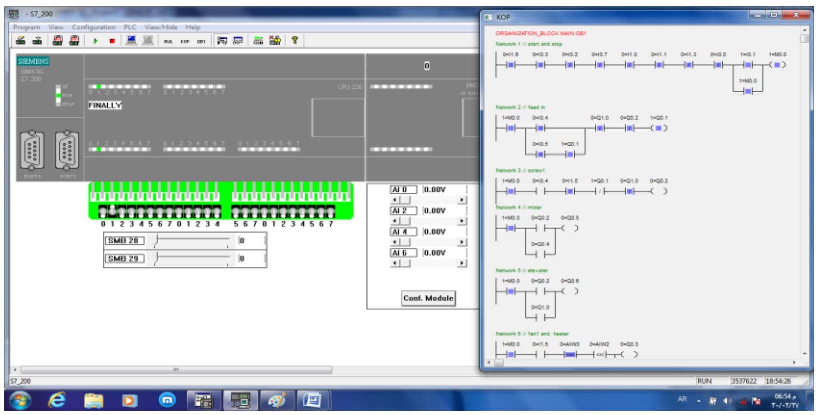


Figure 4.2 Stage (1) in the system work

The second stage in the work of the system is pull the grain from tank (1) to tank (2) by screw (1) until the grain is not less than limit 1, when screw1 is work the mixer and elevator work to distribution the grain in tank, as shown in Figure 4.3

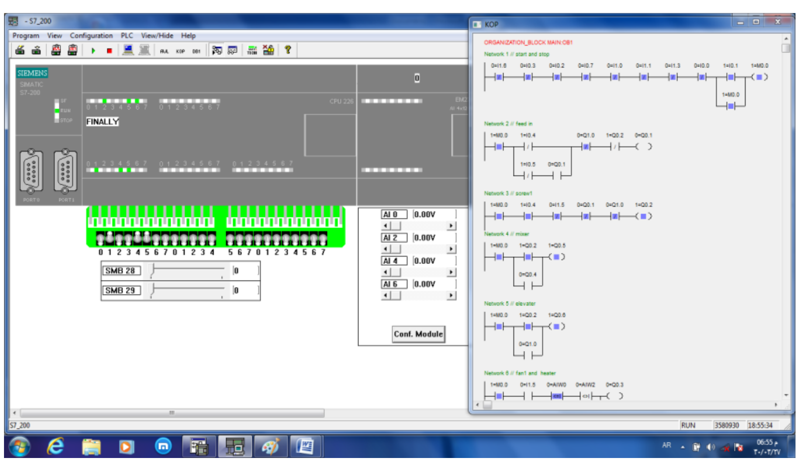


Figure 4.3 Stage (2) in the system

The third stage of the work of the system is running fan (1) and heater to reach temperature to 50^{O}C, to ensure the arrival of the temperature 50^{O}C and stability of humidity which achieve by moving reading of humidity sensor to registered and compare it with second reading of sensor. The temperature in the tank compare to 50^{O}C, as shown in Figure 4.4.

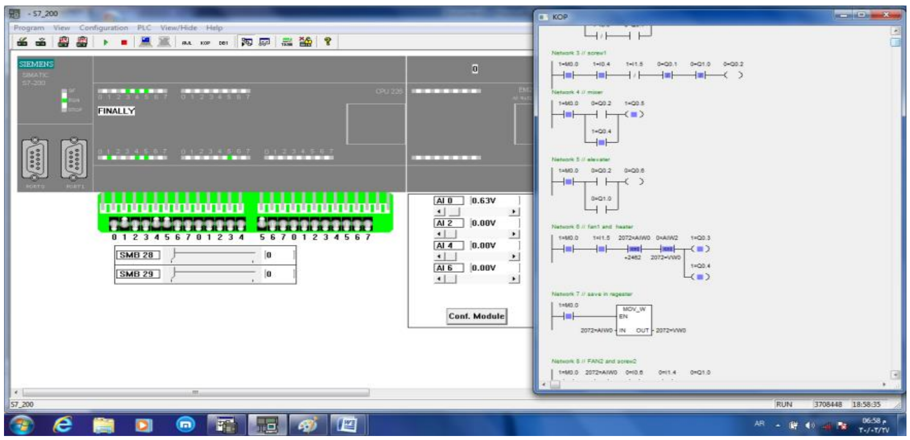


Figure 4.4 Stage (3) in the system

After the arrival of temperature 50^{O}C fan (1), and heater stopped, and start operation of the elevator to move grain to the tank (3) by screw (2) and running fan (2) to cool the grain before entering the tank (3), this is shown in Figure 4.5.

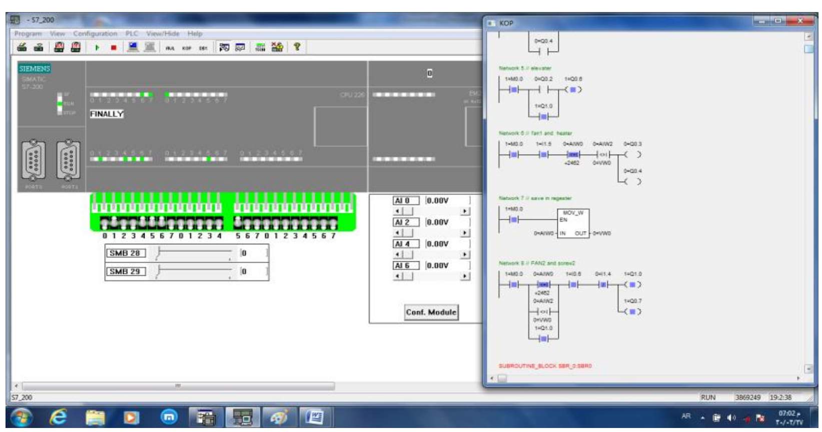


Figure 4.5 Shows Stage (4) in the system

Chapter Five

Conclusion and Recommndations

5.1 Conclusion

In end of this thesies it can conclusion that: used a tieted control to control the drain system benefit the maximum production of crops agricultural drained. Achieved less cost by developing the old ways (which was based on the operator) by used full automatic control system.Automatic conrol decreased the probability of faults and therefore influence on productivity and increasd quantity produced continuity process of drying throughout the year Therefore, reduce the corruption probably of the product.

5.2 Recommndaions

The process of grain drying is dependent on the temperature and moisture content of the grain. Different type of grain requires different temperatures and moisture contents handling for proper drying process. Increasing the temperature range in control system, benefit on increase the types of grain that can process in the drain system. Monitoring the operation of the system can be enhanced by using a supervisory control and data acquisition (SCADA) control system and use human machine interface (HMI) that allows the user to accurately monitor and control the process.

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