Palestine Polytechnic University

College of Engineering

Department of Electrical Engineering

Industrial automation Engineering

Project Name:

HerbsSeparate and SieveSystem

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Abstract

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الملخص

في الوقت الحاضر، نواجه العديد من المشاكل في عملية فصل الزعتر. تعمل هذه المشاكل في صعوبة انتاج كميات كبيرة من الزعتر في وقت قصير وعدم الوصول الى الكفاءة المطلوبة. وبسبب هذه المشاكل فكرتنا هي تصميم نظام اوتوماتيكي يعمل على فصل أوراق الزعتر عن ساقه من خلال استخدام التكنولوجيا والتقنيات الحديثة للحصول على كفاءة وسرعة في الإنتاج باقل تكلفة.

خلال خذا المشروع تم العمل على تشغيل اهم جزء في النظام وهو (Zig-Zag Channel)والتحكم به من خلال وحدات التحكم المنطقي المبرمج (PLC) بالإضافة الى بناء لوحة كهربائية تحتوي دوائر التحكم و دوائر القدرة التي ستزود الماكينة بالطاقة اللازمة لعملها.

تم عمل دورة هواء مغلقة داخل الماكينة عن طريق محركات الشفط وتم التحكم في سرعة الهواء الخارج من محركات الشفط عن طريق التحكم في سرعة محركات الشفط من خلال ال (Variable Frequency Inverters).

الاهداء

السلام عليكم ورحمه الله وبركاته

أيام مضت من عمرنا بدأناها بخطوة وها نحن

اليوم نقطف ثمار مسيرة أعوام كان هدفنا فيها واضحا وكنا نسعى في كل يوم لتحقيقه والوصول له مهما كان صعبا

وها نحن اليوم نقف أمامكم وها نحن وصلنا وبيدينا شعلة علم وسنحرص كل الحرص عليها حتى لا تنطفئ

ونشكر الله أولا وأخير على أن وفقنا وساعدنا على ذلك

ثم نتقدم بالشكر إلى القلب الحنون من كانت بجانبنا بكل المراحل التي مضت من تلذذت بالمعاناة وكانت شمعه تحترق لتنير دربنا

إلى أمهاتنا الحبيبات

وإلى من علمنا أن نقف وكيف نبدأ الألف ميل بخطوة إلى يدنا اليمنى إلى من علمنا الصعود وعيناه تراقبنا ....والدنا

لمن أمسك بيدينا وعلمنا حرفا ..حرفا ..سنهدي له نجاحنا اليوم إلى من كانوا سندا لنا

إلى من لهم الفضل بإرشادنا إلى طريق العلم والمعرفة إلى أساتذتنا الأفاضل كم نحن فخورون بكم

أصدقائنا وأحبتنا ومن سهروا معنا في مسيرتنا العلمية إلى من مدوا أياديهم البيضاء في ظلام الليل

وكانوا عونا لنا

أيام جميله قضيناها نعيشها الآن لحظة... بلحظة ونشعر وكأنها شريط يمر بمخيلتنا من جديد عام ..وعام يوما.... ويوم

لن ننساكم ما حيينا

... ولن ننسى هذا المكان الذي جمعنا بمقاعده وأبوابه حتى فنائه إلى كل جزء به

ولن ننسى وطننا المعبّق بأريج الحب لن ننساه وسنقدم كل ما بوسعنا له وسنجعل كل ركن به يشهد بما سنقدم

وسنكون كالمطر ولن نبخل بما تعلمنا

وسنكون كالماء أينما وقعنا نفعنا

نشكركم بكل ما تحمله كلمة شكر من معنى ونهدي لكم كل عمرنا يا أجمل مامضى به

نشكركم تنطقها قلوبنا على ألسنتنا نشكركم كلمة تعني لنا الكثير وتحمل من الشعور الكثير

.تخوننا كل عبارات الشكر في تقديم مايليق بكم لن ننسى الفضل ولن ننساكم أبدا

Abstract

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Chapter One

Introduction

1.1 Overview.

1.2 Introduction.

1.3 Project Idea and Quality.

1.4 Project Objectives.

1.5 Time schedule for the project.

1.6 Total cost for the project.

1.1 Overview

This chapter illustrates an introduction to the project, the objectives and motivation of the project.

This chapter also shows the methodology used to build and complete this system, the parts of the system is mentioned, some of risk management, results and problems are mentioned, the estimated cost is modified, after that, the control of the report is shown.

1.2 Introduction

Nowadays, industrial machine is very important in the daily life, get the task to be done very fast than before .thus; the production line for the product is given more and bigger. Now the intelligent computers and intelligent control system is introduced to a machine to increase its accuracy and safety when doing work, it is also important for the production process that is complicated to deal with.

Thyme machine, with its new design help the industrial companies to produce clean thyme with short time compared with a human work time. This new design decreases the number of workers to do the task.

1.3 Project Idea and Quality

The idea of the project is to design and implement a machine that produce a thyme by an automatic way and is controlled by a programming PLC.

In Palestine and other Arab world countries, there's need for machine that gives a high quality of thyme, our project will give higher quality than all current ways of traditional production methods, by using a modern method of production that will concerned cleanliness of the product and an elaborate form of the product.

According to the questionnaire, the machine must have the following features:

1. Low noise.
2. Ease for use.
3. High safety factor, safe for worker.
4. Keeps clean and healthy

1.4 Project Objectives

This project aims to achieve the following:

- Increase supplying thyme product to markets.
- To produce thyme leaves with high purity, with less impurities and crushed stems, by separating leaves out of stems using thyme Separation machine.
- Rid of traditional ways of thyme separation.
- Implement a new technology to the machine in order to increase its accuracy, safety, and reduce the losses.

1.5 Time schedule for the project

- Stage 1 : Select the Idea

Determine the idea of the project, the motivation and the main objectives that intend to be achieved.

- Stage 2 : preparing for the project and collecting data

In this stage, more and deeper determination of the tasks and steps are done, and more information about the project is prepared.

- Stage 3 :project Analysis

In this step, a study of all possible design option to determine the design process.

- Stage 4 : Determine the project requirement

After determine the project design scheme, the entire needed requirement detailed mathematical model for the system is specified, software and hardware and try to bring them to be ready for the implementation stage.

- Stage 5 : Documentation Writing

Documenting the project is beginning from the first stage to the last stage.

- Stage 6 : make the hardware available

In this stage, the needed hardware devices are brought for the next steps, motors, PLC, and gears.

- Stage 7 :build up the machine and finishing

  All the machine equipment and devices bought it there is an available source in the market or if not, going to the lath to introduce the mechanical parts.

- Stage 8: testing the machine

Detect if there is an error occurred and making a report about that.

- Stage 9 : finishing the graduation final report

All documentation has made is to be checked and done in this stage, every change in it is to be added and to be noticed that something is changed.

- Stage 10 : preparing for the final presentation

The presentation will prepare to show the project and its parts

Table (1.1): Timing plant of the first semester

Task	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14
Stage 1														
Stage 2														
Stage 3														
Stage 4														
Stage 5														

Table (1.2): Timing plant of the second semester

Task	W 16	W 17	W 18	W 19	W 20	W 21	W 22	W 23	W 24	W 25	W 26	W 27	W 28	W 29
Stage6														
Stage 7														
Stage 8														
Stage 9														
Stage 10														

1.6 Total cost for the project

Table (1.3): Total Cost

Components	Price(NIS)	Quantities	Total Cost(NIS)
Contactors	100	6	600
PLC(Fatek)	800	1	800
Overloads	150	5	750
Motors	300	5	1500
Suction Motors	600	2	1200
Inverter	600	2	1200
Gears	250	5	1250
switches	9	25	225
Cyclone	100	2	200
Pipe	150	5	150
Body	2000	-	2000
Other Components	800	-	800
		Total Cost=	10675 NIS

Chapter Two

Theory

2.1 Introduction

In this chapter we will show all of main techniques it will used in the desired design, and it will be discuss the traditional ways of separation and sieving thyme. After using this technologies and knowing how the traditional ways working on separate thyme we will finally design our machine according on it.

2.2 Zig-Zag Separator

Zigzag air classification is a separation process in which particles are classified mainly according to their falling behavior in airflow. Figure 2.1 shows a zigzag air classifier. The channel consists of rectangular sections joined together at an angle to create a zigzag shape. A dispersion of particles is fed to this channel. The aerodynamically "light" particles are carried to the top by the airflow that is led through the classifier. The "heavy" particles fall to the bottom. In principle, many channel configurations are possible. Some of these have been patented. Differences in configuration are for instance. [1]

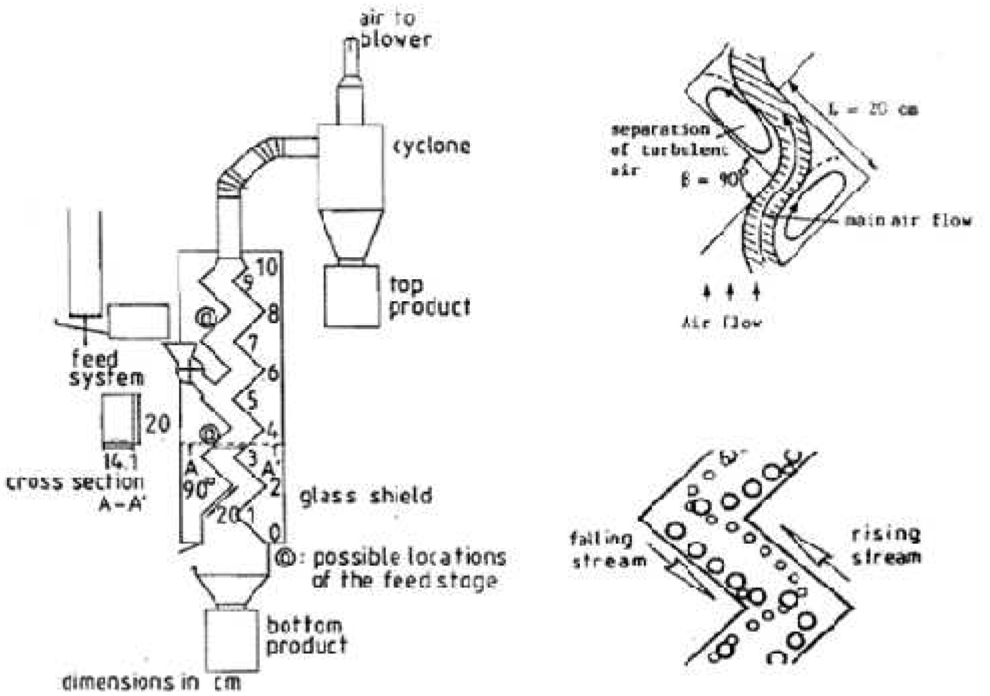

Figure (2.1): Geometry of 90 degree of zig-zag separator.

Zig-Zag air separator the feed material is conveyed onto an airproof item to the separator channel. According to the multiple-cross flow-separating process, light material is separated from heavy material. The airflow required for separation is blown through the separation channel from button to top. Light material is carried by the airflow. Heavy material is carried by the airflow. Heavy material falls through the airflow and is discharged through the separator base. The light material transported by the airflow to the cyclone is separated there and is discharged via rotary gate valve. Zig-Zag Air Separator Plants are usually operated in recirculation air mode, whereby the cleaned air is returned via blower to the separator base. In case of dusty or moist products the operation of the plant is also possible in partly air circulation or suction mode. A radial blower generates the required airflow and pressure.

Application of the Zig-Zag air separator:

- Very precise separation due to by multi-stage-cross-flow separation (8 to 15 separation stages).
- Based on arranged upon another separation steps and the consequential multiple impacts of the mass flow, the desagglomeration and release of product knots is ensured.
- To reach stable operating conditions, we use a special designed ventilator rotor disk. Constant product quality is provided via regulation of airflow and -control (option).
- Due to additional cleaning valves in the separator channel, the plant can be cleaned easily.
- In the air recirculation mode exists no emission source.
- High availability due to robust construction and no rotating parts in the separator.
- Sturdy design.

.2.3 Cyclone air separator

Cyclone separators or simply cyclones are separation devices that use the principle of inertia to remove particulate matter from flue gases. Cyclone separators are part of a group of air pollution control devices known as recliners as they are generally used to roughly remove larger pieces of particulate matter. This prevents finer filtration methods from having to deal with large, more abrasive particles later one. As well, several cyclone separators can operate in parallel, and when this is set up the system is known as a multi cyclone.

It is important to note that cyclones can vary drastically in their size. The size of the cyclone depends largely on how much flue gas must be filtered, and thus larger operations tend to need larger cyclones. For example, several different models of one cyclone type can exist, and the sizes can range from a relatively small 1.2-1.5 meters tall (about 4-5 feet) to around 9 meters or about 30 feet (which is about as tall as a three story building).

How it works: In a cyclone separator, dirty flue gas is fed into a chamber. Inside this chamber exists a spiral vortex, similar to a tornado. This spiral formation and the separation are shown in Figure (2.2). The lighter components of this gas have less inertia, so it is easier for them to be influenced by the vortex and travel up it. Unlike these particles, larger components of particulate matter have more inertia and are not as easily influenced by the vortex. [2]

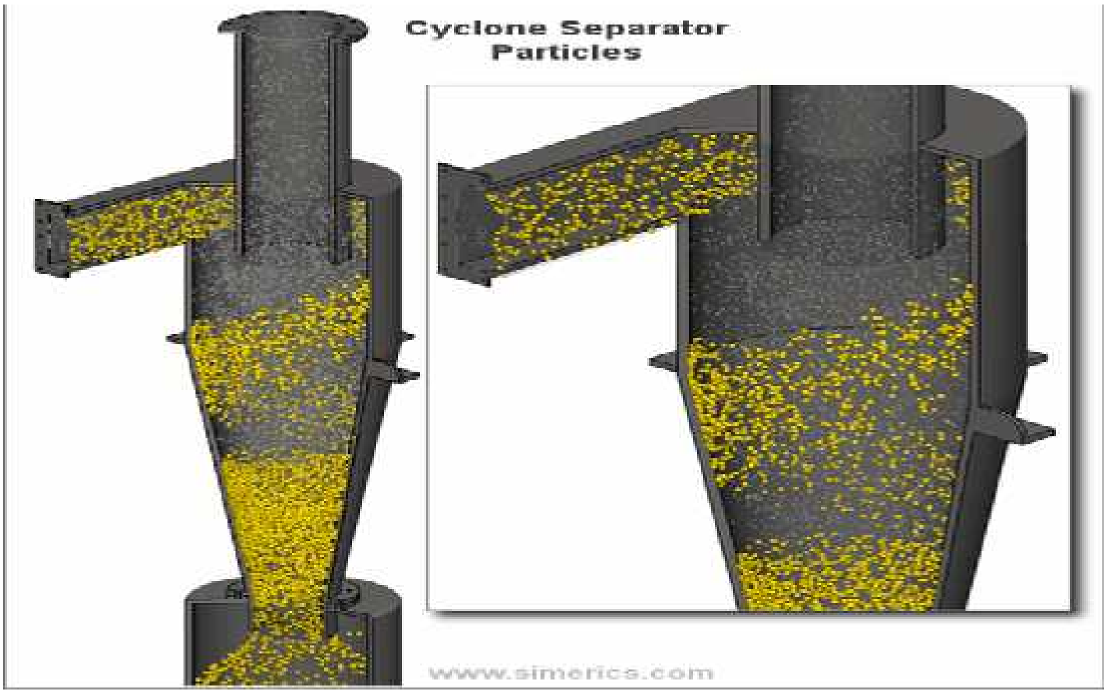

Figure (2.2): Cyclonic separator.

Because these larger particles have difficulty following the high-speed spiral motion of the gas and the vortex, the particles hit the inside walls of the container and drop down into a collection hopper. These chambers are shaped like an upside-down cone to promote the collection of these particles at the bottom of the container. The cleaned flue gas escapes out the top of the chamber.

Most cyclones are built to control and remove particulate matter than is larger than 10 micrometers in diameter. However, there do exist high efficiency cyclones that are designed to be effective on particles as small as 2.5 micrometers. As well, these separators are not effective on extremely large particulate matter. For particulates around 200 micrometers in size, gravity settling chambers or momentum separators are a better option.

Out of all of the particulate-control devices, cyclone separators are among the least expensive. They are often used as a pre-treatment before the flue gas enters more effective pollution control devices. So, cyclone separators can be seen as "rough separators" before they reach the fine filtration stages.

Cyclone separators are generally able to remove somewhere between 50-99% of all particulate matter in flue gas. How well the cyclone separators are actually able to remove this matter depends largely on particle size. If there is a large amount of lighter particulate matter, less of these particles can be separate out. Because of this, cyclone separators work best on flue gases that contain large amounts of big particulate matter.

There are several advantages and disadvantages in using cyclone separators. First, cyclone separators are beneficial because they are not expensive to install or maintain, and they have no moving parts. This keeps maintenance and operating costs low. As well, the removed particulate matter is collected when dry, which makes it easier to dispose of. Finally, these units take up very little space. Although effective, there are also disadvantages in using cyclone separators. Mainly, the standard models are not able to collect particulate matter that is smaller than 10 micrometers effectively and the machines are unable to handle sticky or tacky material well.

2.4 Electrical Components

This section contains the electrical component specifications (contactors, and frequency inverter) and electrical protection from failures.

2.4.1 Programmable Logic Controller (PLC):

A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes. PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise and to vibration and impact.

PLC consists of:

- Central processing Unit (CPU).
- Power Supply Unit.
- Memory Unit.
- Input/output Interface
- Programming Device.

These components are shown in figure (2.3).

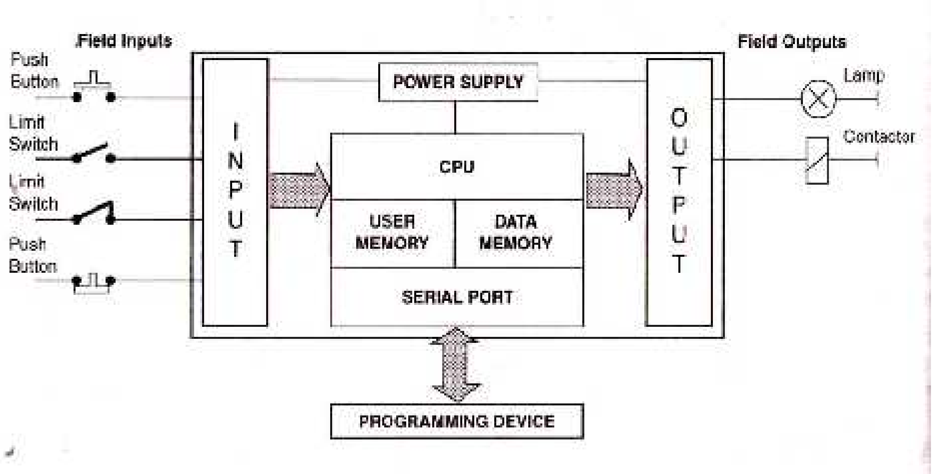

Figure (2.3): PLC Components.

2.4.2 Variable Frequency Drive (VFD).

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor. Other names for a VFD are variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, micro-drive, and inverter.

Frequency (or hertz) is directly related to the motor's speed (RPMs). In other words, the faster the frequency, the faster the RPMs go. If an application does not require an electric motor to run at full speed, the VFD can be used to ramp down the frequency and voltage to meet the requirements of the electric motor's load. As the application's motor speed requirements change, the VFD can simply turn up or down the motor speed to meet the speed requirement.

By adjusting the frequency and voltage of the power entering the motor, the speed and the torque may be controlled. The actual speed of the motor, as previously indicated, is determined as Ns = ((120 x f) / P) x (1 - S) where: N = Motor speed; f = Frequency (Hz); P = Number of Poles; and S = Slip. Figure (5.2) shows the circuit of VFD and how finally gets a variable voltage and variable frequency. [3]

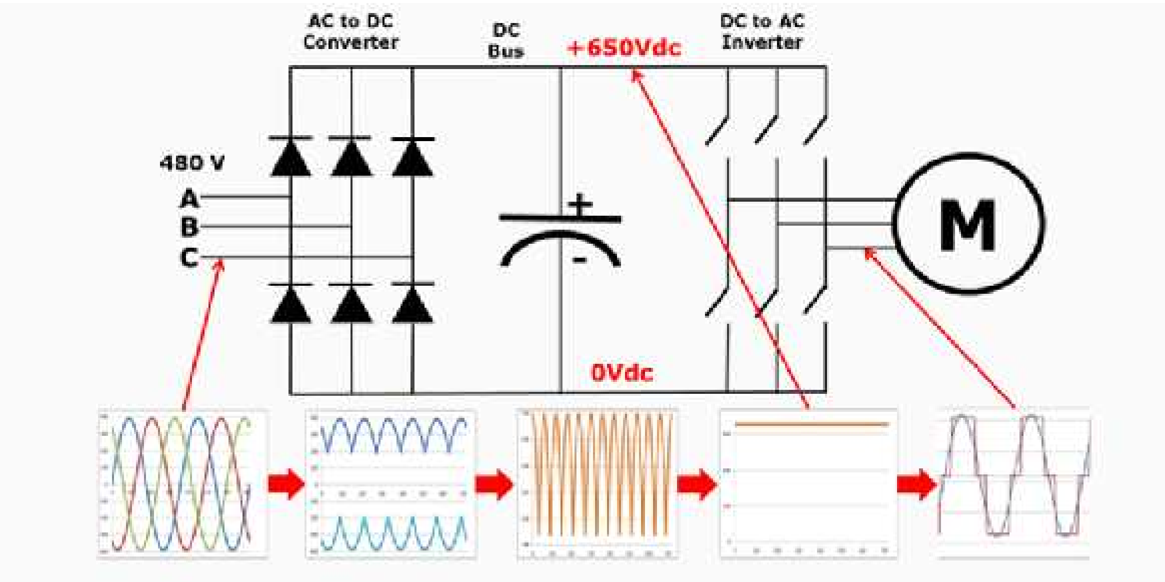

Figure (2.4): Convert from constant AC to variable AC.

2.4.3 Protection

Circuit Breaker (CB):

If a power surge occurs in the electrical wiring, the breaker will trip this means that a breaker that was in the on position will flip to the off position and shut down the electrical power leading from the breaker. Essentially, a circuit breaker is a safety device. When a circuit breaker is tripped it may prevent a fire to start in overloaded circuit, it can also prevent the destruction of the device that is drawing the electricity. As shown in figure (2.5).

Figure (2.5): Circuit breaker

Overload relay:

Overload relays shown in figure (2.6) are intended to protect motors, controllers and branch-circuit conductors against excessive heating due to prolonged motor over currents up to and including locked rotor currents. Protection of the motor and other branch-circuit components from higher currents, due to short circuits or grounds, is a function of branch-circuit fuses, circuit breakers or motor short-circuits protectors. The system needs two overloads to protect the vibrations motors.

Figure (2.6): Overload relay.

Emergency-Stop Button:

Emergency-Stop Button is shown in figure (2.7) provides safety for humans and the machine; it offers a wide range of safety components for the protection of humans, machine and production goods in emergency situations.

It is the purpose of emergency-stop device to deflect or minimize the risk as quickly as possible and optimally in the event of an emergency arising.

Figure (2.7): Emergency-Stop Button

Earth leakage:

An Earth-leakage shown in figure (2.8) is a safety device used in electrical installations with high earth impedance to prevent shock. It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected. Once widely used, installations that are more recent instead use residual current circuit breakers that instead detect leakage current directly.

Figure (2.8): Earth leakage.

2.4.4 Contactors

Contactors are an electrically controlled switch used for switching a power circuit similar to a relay except with higher current ratings.

A contactor is controlled by a circuit that has a much lower power level than the switched circuit.

Contactors come in many forms with varying capacities and features. Unlike a circuit breaker, a contractor is not intended to interrupt a short circuit current, contactors range from several amperes to thousands of amperes. The physical size of contactors ranges from a device small enough to pick up with on hand to large device as shown in figure (2.9). In this project, we used two contactors for two vibrating motors.

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Figure (2.9): Contactor.

2.5 Gears

A gear motor is a specific type of electrical motor that is designed to produce high torque while maintaining a low horsepower, or low speed, motor output. Gear motors can be found in many different applications, and are probably used in many devices in your home.

Gear motors are commonly used in devices such as can openers, garage door openers, washing machine time control knobs and even electric alarm clocks. Common commercial applications of a gear motor include hospital beds, commercial jacks, cranes and many other applications that are too many to list.

A gear motor shown in figure (2.10) can be either an AC (alternating current) or a DC (direct current) electric motor. Most gear motors have an output of between about 1,200 to 3,600 revolutions per minute (RPMs). These types of motors also have two different speed specifications: normal speed and the stall-speed torque specifications.

Gear motors are primarily used to reduce speed in a series of gears, which in turn creates more torque. This is accomplished by an integrated series of gears or a gearbox being attached to the main motor rotor and shaft via a second reduction shaft. The second shaft is then connected to the series of gears or gearbox to create what is known as a series of reduction gears. Generally speaking, the longer the train of reduction gears, the lower the output of the end, or final, gear will be.[4]

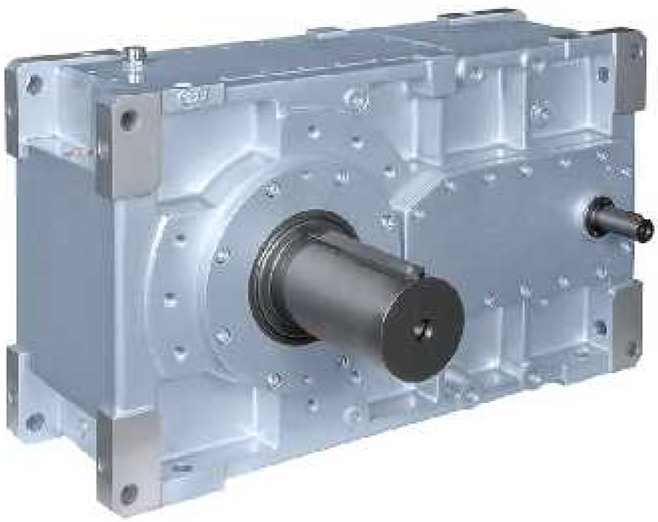

Figure (2.10): The Gear

2.6 Traditional method of sieving thyme.

The only way of sieving thyme is the traditional way, it's just a sieve as shown in figure (2.11) the thyme is put on it after that the sieving be shaken to get pure thyme (without stalk).

Figure (2.11): Traditional sieve.

This traditional way for sieving thyme has many drawbacks the most important is:

1. When it is required to produce a large amount of pure thyme the traditional way will fail, because the process will take long time to end the task.
2. Human drudgery: the thyme is sieve by a traditional sieve so its need many of workers. Therefore, this way increases human drudgery.
3. Low productivity: nowadays the population is increasing that is meaning the demand is rising. Therefore, this does not work in this case.

- ✓ Traditional method process:

They get thyme from farmers as shown in this figure (2.12):

Figure (2.12): Thyme from farmers.

After that, they use big holes sieve to red of the large size of stalks as shown in figure (2.13)

Figure (2.13): Removing large stalks.

And then they use thyme that get out from the first sieve process and put it inside the grinding machine to make the leaf softer sieve it by smaller holes sieve as shown

In figure (2.14) and figure (2.15), we can see the grinding machine and smaller sieve:

Figure (2.14): Grinding machine.

Figure (2.15): Smaller holes sieve.

As we describe before, they use the smaller holes sieve and repeat sieving thyme many times to get the pure thyme without any small stalks as shown in figure (2.16).

Figure (2.16): Pure thyme.

2.7 Automated Method of Production.

The airflow required for separation is blown through the separation channel from button to top. Light material is carried by the airflow up stream in to cyclone and through rotary sack in to sack on to the next conveyor. Heavy material cannot be carried by the airflow, falls through the airflow, and is discharged through the separator base.

The light material transported by the airflow to the cyclone is separated there and is discharged via rotary gate valve.

Zig-Zag Air Separator Plants are usually operated in recirculation air mode, whereby the cleaned air is returned via blower to the separator base. In case of dusty or moist products, the operation of the plant is also possible in partly air circulation or suction mode. A radial blower generates the required airflow and pressure. Shown in figure (2.17).

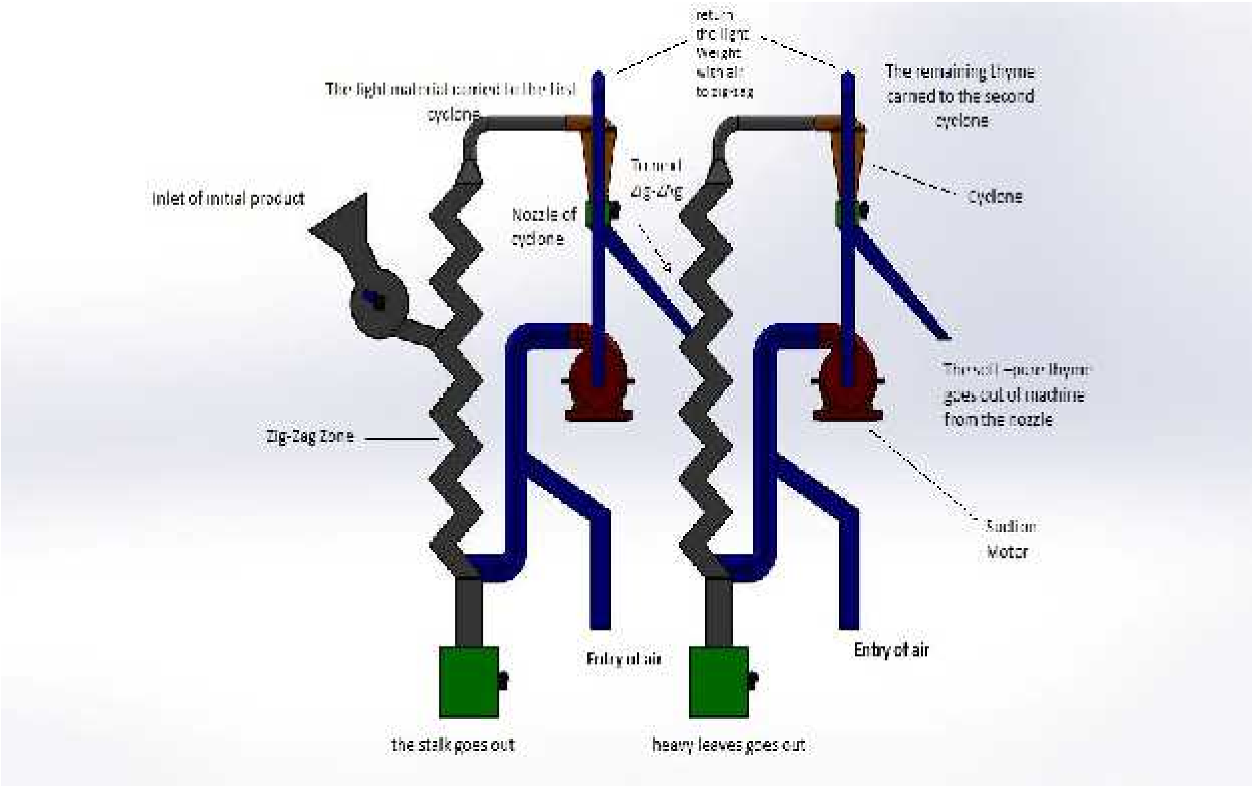

Figure (2.17): Principle of operation in our machine.

2.8 Block diagram

The block diagram as shown below explains how the thyme move inside the machine step by step into stages to reach the final destination. As shown in figure (2.18).

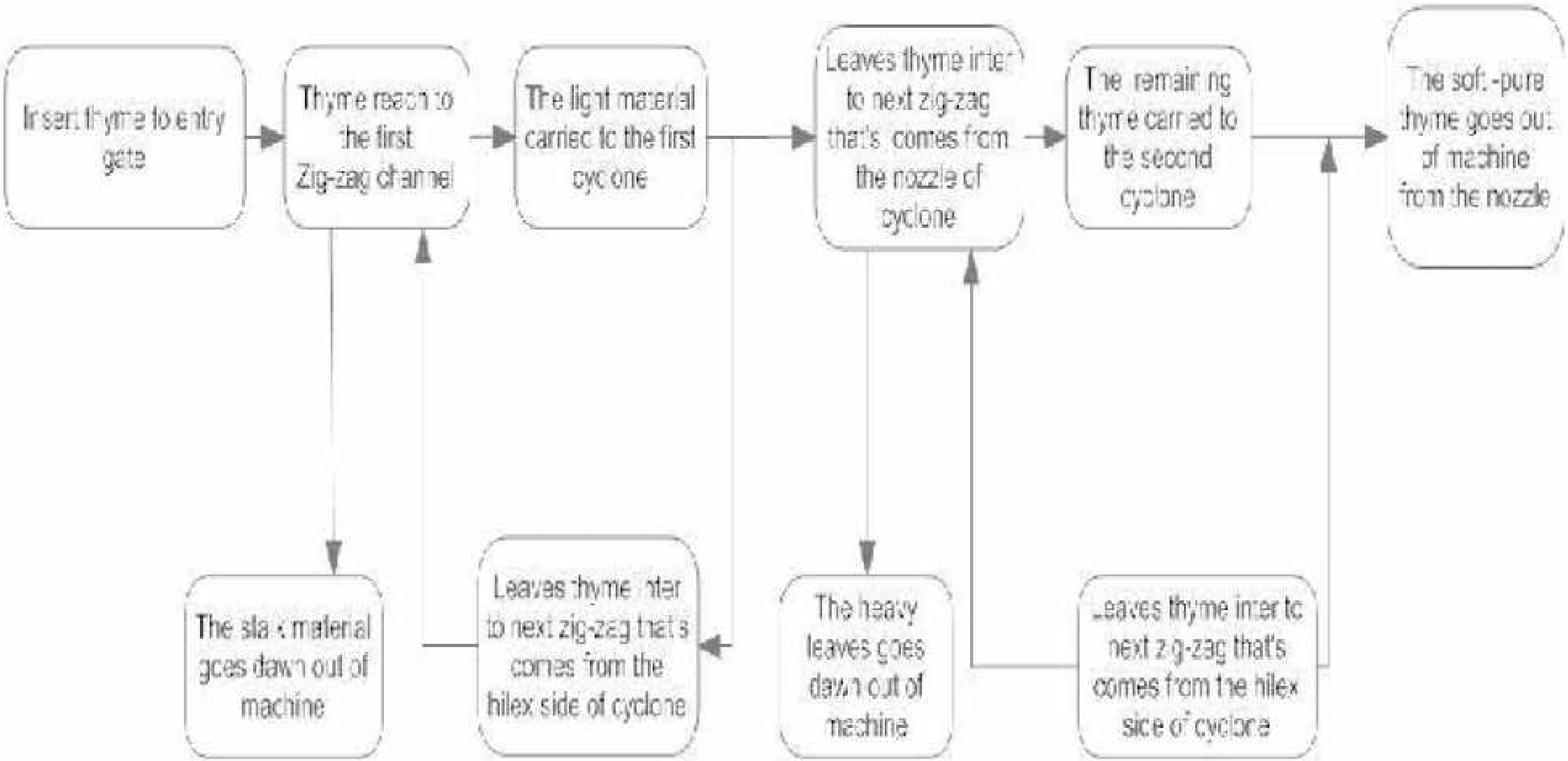

Figure (2.18) Block diagram

Chapter Three

Mechanical Design

3.1 Introduction

In this chapter, we will talk about the mechanical parts, the elements used and the construction of the implementation method. Moreover, there are detailed dimensions of the whole elements used with directed positions.

The mechanical system in the project has major part, these parts are combined together to form mechanical units, in addition these units are combined together for forming the machine.

The proposed design depends on the sequence of mechanical movement in the machine, starting from entry gate passing through Zig-Zag channel and cyclone separator.

3.2 Proposed System Description and Specifications

This chapter demonstrate how to design the machine, and how to make a solution for current problem, in our project we will show the new technology in separating thyme using air cleaner and using a full automated machine programmed with a PLC, to ensure that the product will be pure (without stalk) as possible.

Machine is bind as shown in figure (3.1).

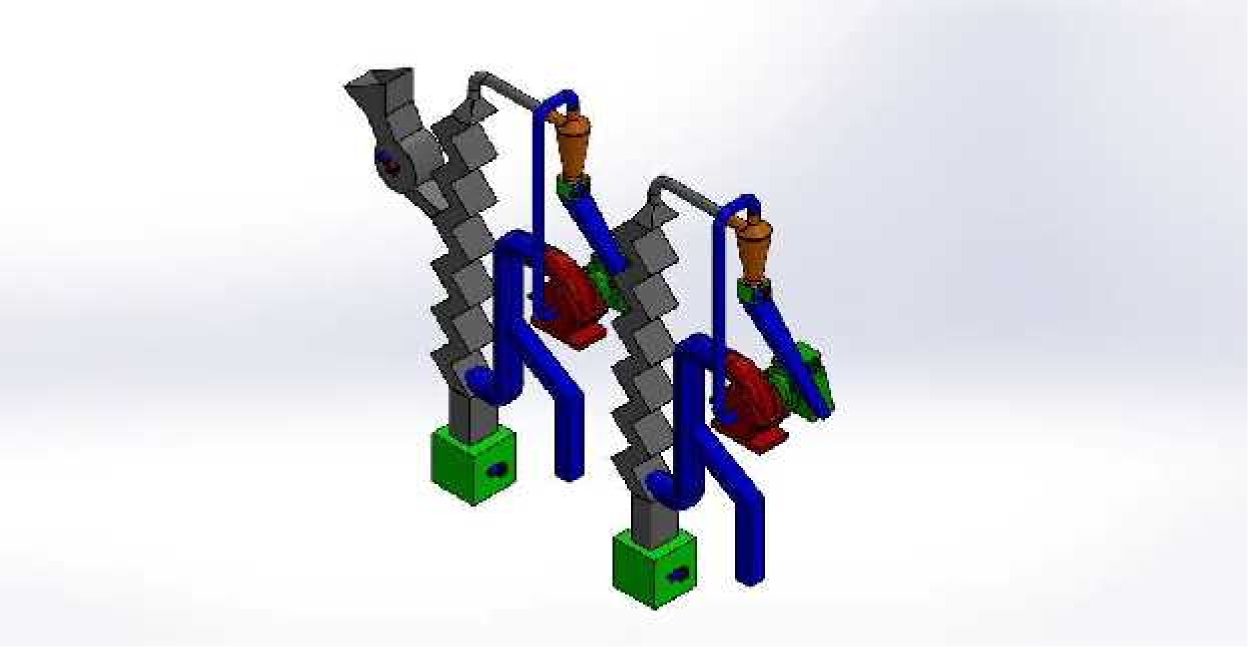

Figure (3.1): The machine in 3D.

The dimensions of whole machine are 2.45m height and 3.44m width as shown in figure (3.2).

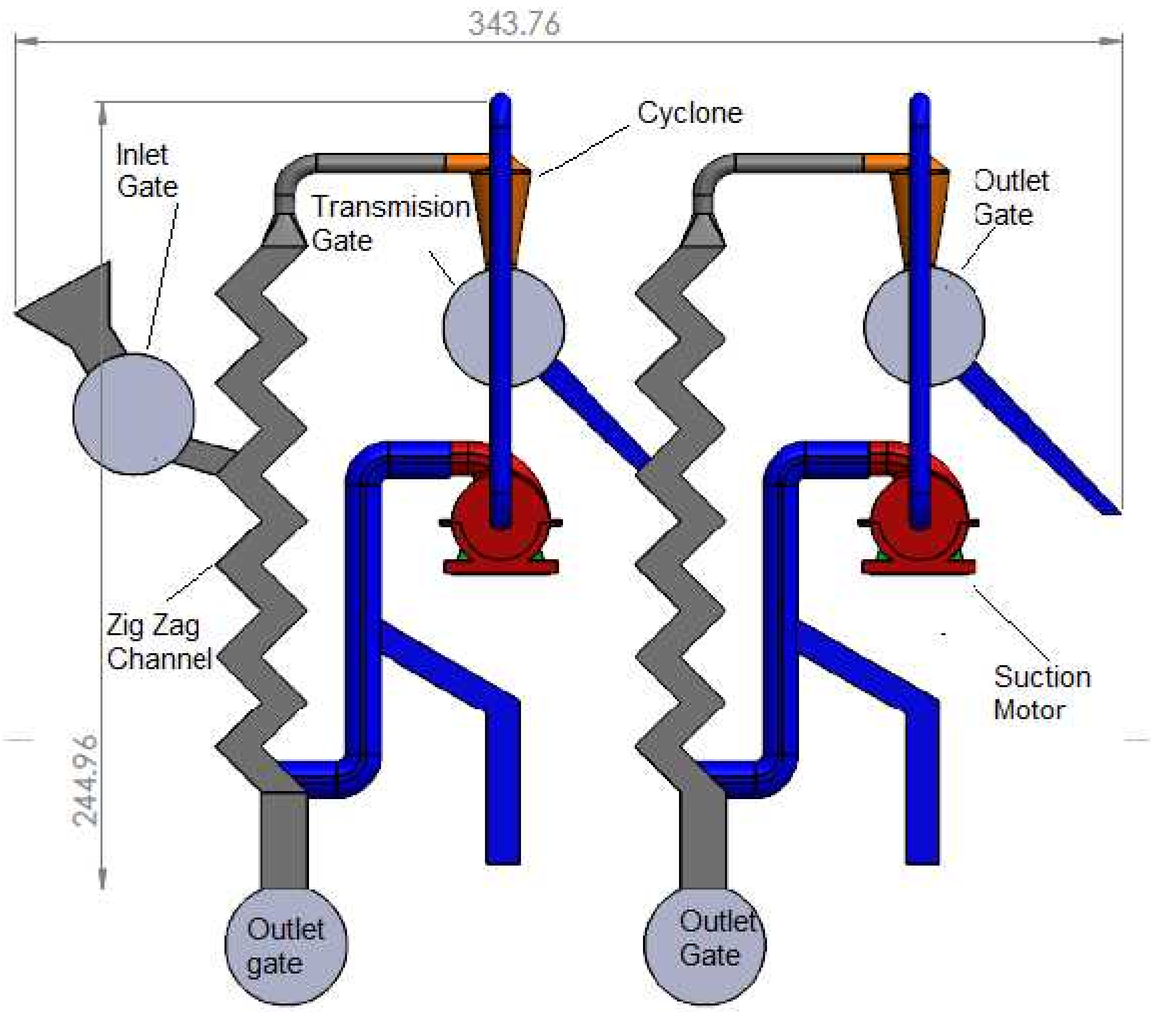

Figure (3.2): The machine in 2D.

3.3 Conceptual Design

It’s desired to design and produce a thyme separator machine fully automated and controlled, the process starts when the user, After study many design and strategies of different machines and visited companies that’s work in herbs and oregano production, so we reach to design that contains many strategies of sieving thyme to meet requirement of market.

In our design the machine is divided into two stages, every stage consist of two parts:

1. Thyme feed system.
2. Zig-Zag air separator.
3. Cyclone air separator.

Since the machine is used for production of thyme and in order to get the product clean and pure from stalks.

3.4 Mechanical Design

In this section, each block will be explained in details:

3.4.1 The gates.

We have one inlet gate for thyme, three outlet gate for deference output of thyme in machine, and one transmission gate that transmit the material between the two stages.

1. Inlet gate

The first step in the whole operation starts in the inlet gate as shown in figure (3.3), the main task of gate move thyme into zig-zag without any infiltration of air cycle in system.

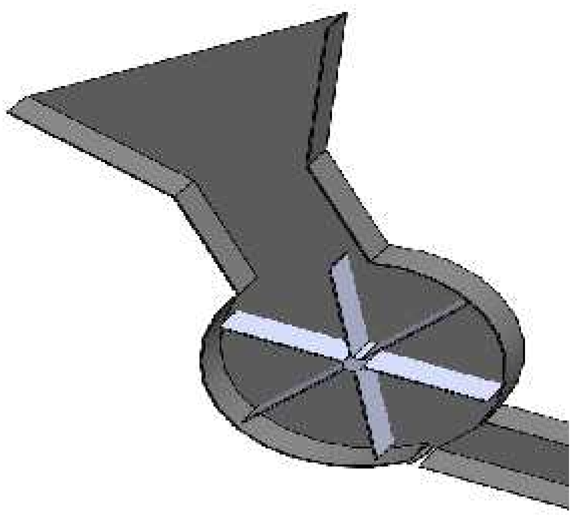

Figure (3.3): The inlet gate.

The demotions of the inlet gate are shown in figure (3.4).

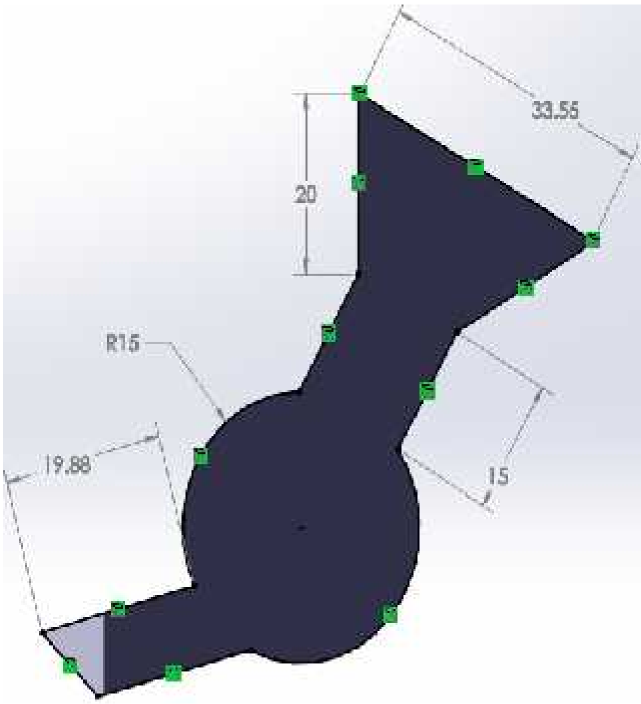

Figure (3.4): The dimensions of inlet gate.

2. Outlet gates:

In the machine there is three outlet gates, the main function to get the material out of machine without any infiltration of air cycle in system, each one have deferent output, the first one in the first stage it is get the stalk out, the second one in second stage at the bottom of second zig-zag to get the heavy leaves out of machine, the third one its position after the cyclone in the second stage to get the very-soft thyme out of machine. The shape of outlet gates is shown in figure (3.5).

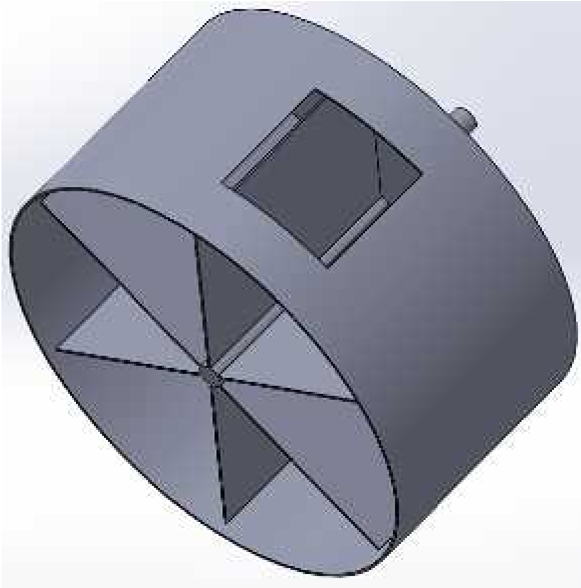

Figure (3.5): Outlet gates.

The outlet gates dimensions are shown in figure (3.6).

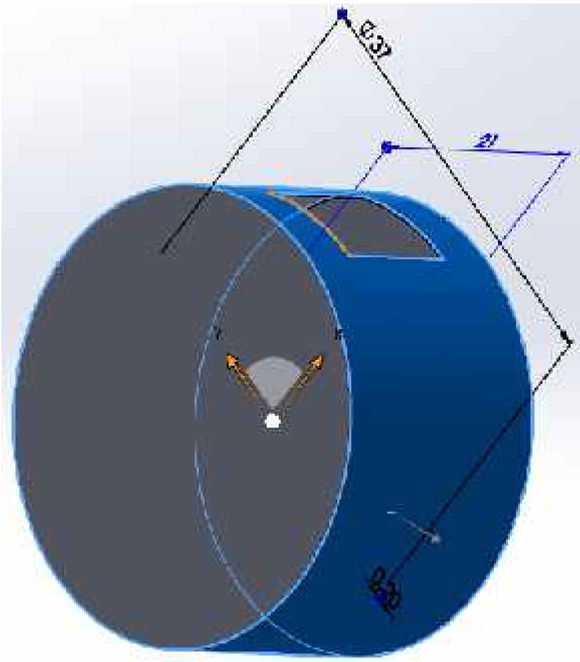

Figure (3.6): Outlet gates dimensions.

3. Transmission gate:

There is a gate between the two stages of zig-zag, its deliver the thyme comes from firs stage to the second stage without any infiltration of air in each cyclone. Shown in figure (3.7).

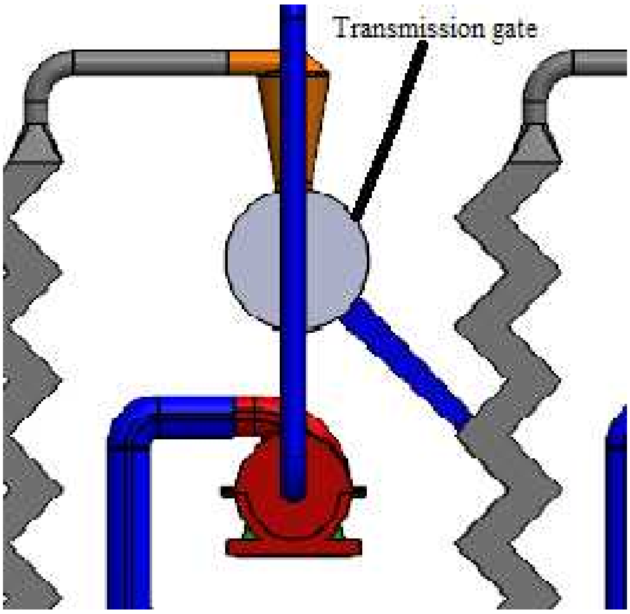

Figure (3.7): Transmission gate.

3.4.2 The Zig-Zag air separator.

In our project we have two symmetrical Zig-Zag channel each one consists of rectangular sections joined together at an angle is equal 90 degree to create a zigzag shapes shown in figure (3.8). A dispersion of particles is fed to this channel. The aerodynamically “light" particles are carried to the top by the air flow that is led through the classifier. The "heavy" particles fall to the bottom.

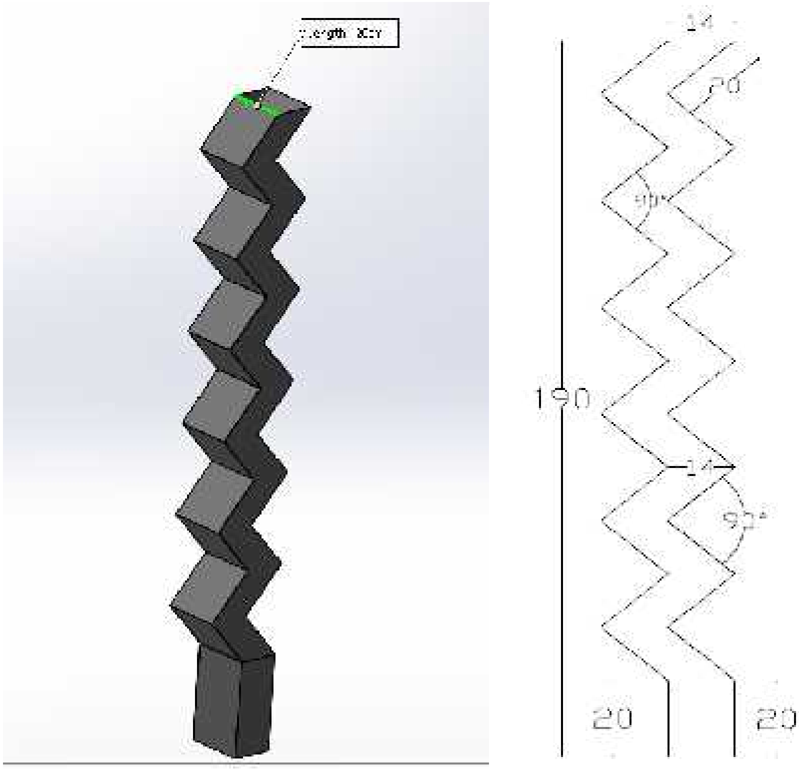

Figure (3.8): Zig-Zag Shape.

3.4.3 Cyclone air separator.

We have two corresponding cyclones in each stage, the Inside of cyclone make a spiral vortex similar to a tornado the function of cyclone is separate the particles without using any filters. The cyclone is shown in figure (3.9) with its dimensions, since the cyclone sustains until 1.5hp.

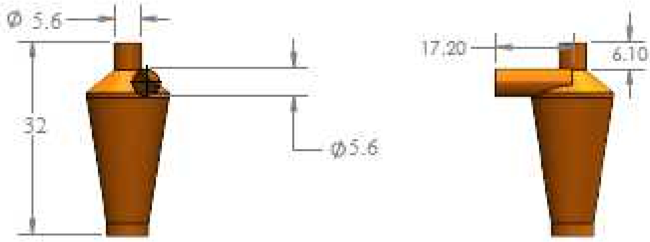

Figure (3.9): The Cyclone.

The technical parameters of cyclone are:

1. The air volume is 174-280 m^3 /m.
2. Wind pressure is 2.5-22 kpa.
3. Wind speed is 18-28 m/s.
4. The dust particle is 0.3µm-40mm.

Chapter Four

PLC Programming

4.1 Introduction

The separating thyme System is controlled system and the process is performed sequentially, this can be achieved by using PLC (Programmable Logic Controller). This made adding automation capability and safety precautions possible.

The PLC is chosen to be used on the system rather than the Microcontroller because the first one has an operating system and user program you can change its program easily, in PLC the inputs and outputs are scanned in each cycles each part of program is executed separately, but in Microcontroller run from first line to the end. Table (3.1) is showing a comparison between PLC and Microcontroller.

And this chapter contains the electrical component specification (motors, sensors, and transformer), control and power circuit, and protection.

Table (4.1): PLC VS Microcontroller.

	PLC	**Microcontroller**
Less initial cost	**NO**	**YES**
Less total cost	**YES**	**NO**
Build in modules	**YES**	**NO**
Faster response	**NO**	**YES**
Ease in programming	**YES**	**NO**
Work at 220 V	**YES**	**NO**

4.2 PLC Programming

In this section, we will show the PLC program in manual operation and automatic, in ladder and state graph programming and connection, we will explain each symbol in program, and the PLC Characteristic.

4.2.1 PLC Characteristic

Programmable Logic Controller (PLC) is a digital computer used for automation of electromechanical process, such as control of machinery on factory assembly lines, PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangement, extended temperature range, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up non-volatile memory. A PLC is an example of a hard real time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

In our controlling design it is desirable to use a PLC with 8 input and 9 outputs mention in the table (4.2) below, it must be compatible to use with220 volt.

Table (4.2): Logic Allocation.

input	Symbol	Address	Logic allocation
Pb(start)	**start**	**X0**	**Start the operation**
Pb(stop)	**Stop**	**X1**	**Stop all operation**
Select switch	**AUTOMATIC**	**X2**	**If the select switch in the right position the operation mode is Automatic.**
Select switch	**Manual**	**X3**	**If the select switch in the left position the operation mode is manual**

Emergency switch(NC)	**EMG**	**X4**	**Turn off all process.**
Switch1	**Motor_1** **Motor_2**	**X5**	**Turn on motor_1=1and motor_2=1.** **Turn on motor 1 and motor2**
Switch 2	**Motor_3** **Motor_4**	**X6**	**Turn on motor_3=1 and motor_4=1.** **Turn on motor 3 and motor4**
Switch3	**Motor_5**	**X7**	**Turn on motor_5=1** **Turn on motor 5**

output	**Symbol**	**Address**	**Logic allocation**
Motor 1	**Motor_1**	**Y0**	**Motor1 run**
Motor2	**Motor_2**	**Y1**	**Motor2 run**
Motor3	**Motor_3**	**Y2**	**Motor3 run**
Motor4	**Motor_4**	**Y3**	**Motor 4 run**
Motor5	**Motor_5**	**Y4**	**Motor 5 run**
Lamp 1	**H1**	**Y5**	**H1 on when start operation**
Lamp 2	**H2**	**Y6**	**H2 on when select Automatic**
Lamp3	**H3**	**Y7**	**H3 on when select Manual**
Lamp4	**H4**	**Y8**	**H4 on when stop operation**

The “Fatek FBs-24MCR2” PLC has 14 digital inputs, with 10 digital outputs. This device is good for our application because we don’t need more inputs or outputs. We used five inputs to control the operation with eight outputs to turn on the contactors & to turn on the lamps in front of the electrical board [6] .Shown in figure (4.1).

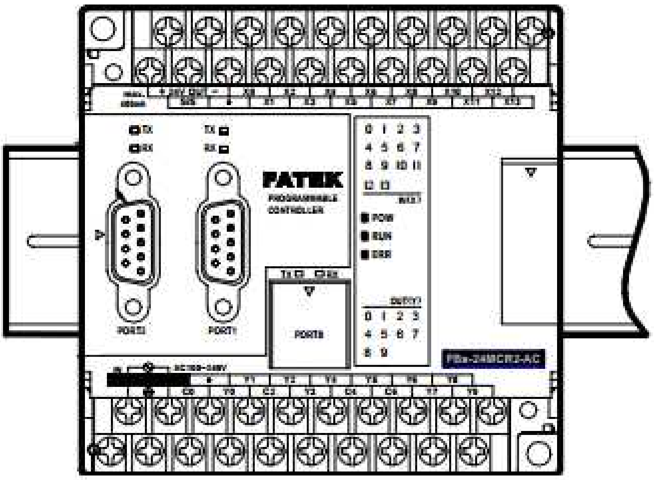

Figure (4.1): PLC Hardware.

Power Supply has an input of 220V AC and an output of 24V DC. We will use this power supply to protect the PLC & to provide enough power for the coils of the contactors.shown figure(4.2).

Figure(4.2): Power supply.

The software for “Fatek FBs-24MCR2” Winproladder Programming software as Shown in the figure (4.3).

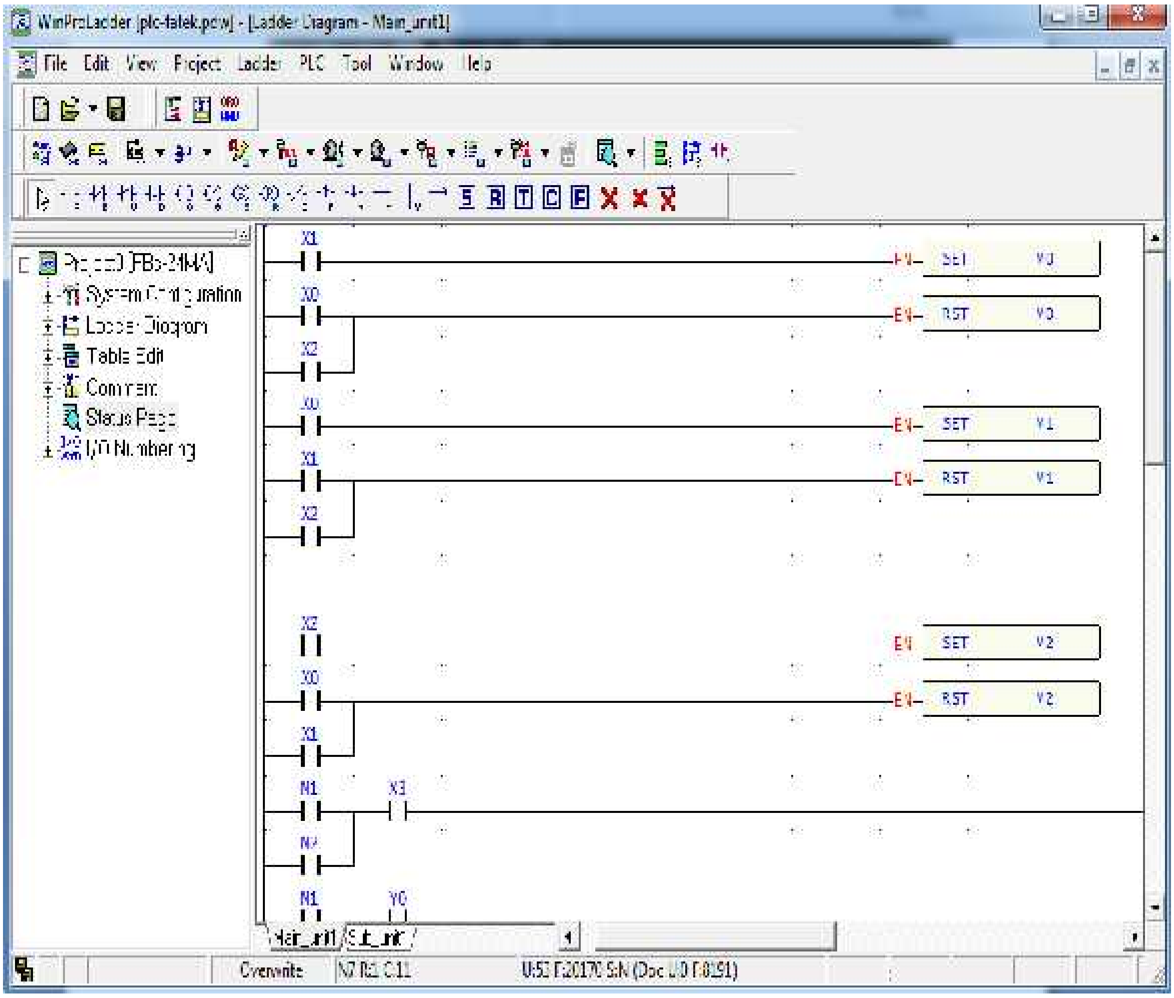

Figure (4.3): Winproladder Programming software.

The PLC connections inputs and outputs are shown in the figure (4.4).

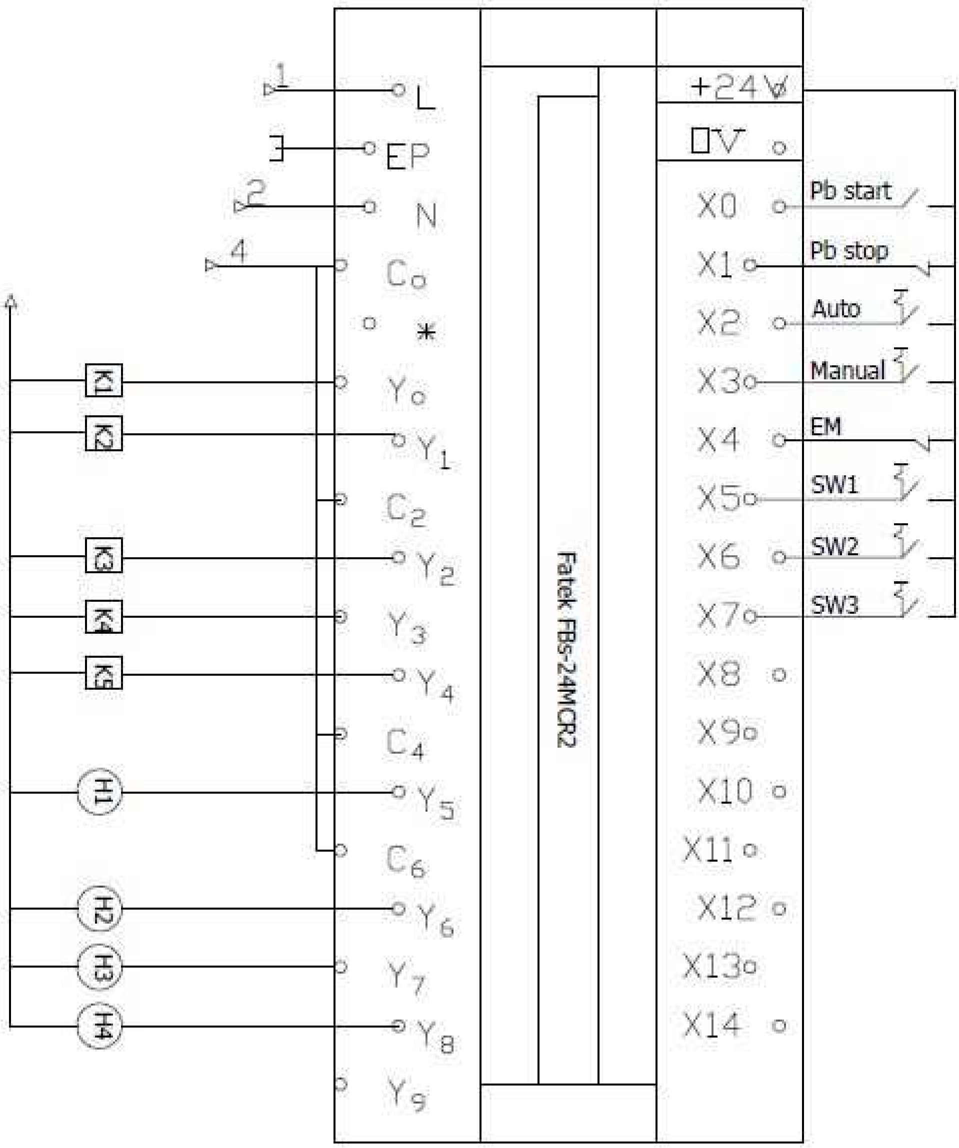

Figure (4.4): PLC connections.

4.2.2 PLC in state Graph

The machine will has two operation mode manual mode and automatic mode. The Manual mode is added for increasing the safety of the machine with the addition of the emergency switch and to allow the user to clean the machine. The selection between two modes can be made by using the switch; the transformation between the two modes can be implemented at any stage if an error is happened. The state graph Shown in figure (4.5), “Automatic mode “and Manual Mode“.

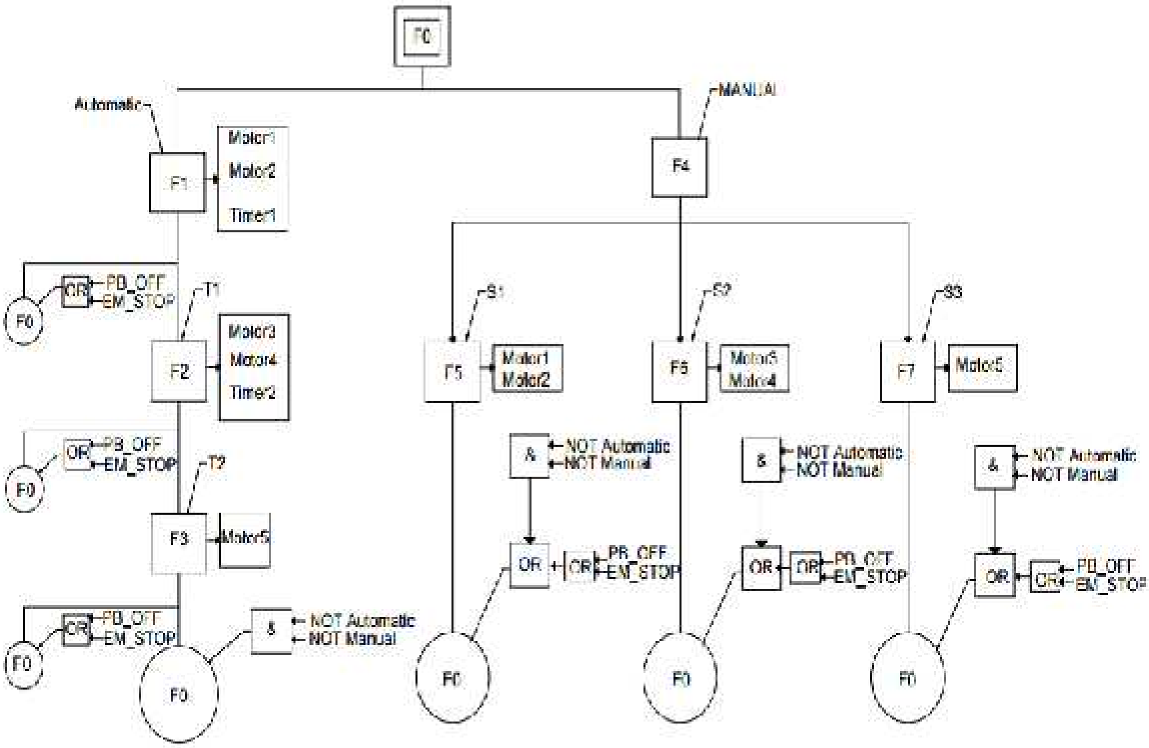

Figure (4.5): The state graph.

The initial step (F0) comes after pressing the (Start) push button Depends on the user of choosing between two kinds of operating, automatic operating or manual operating. If the user choose automatic operating the system will activate first step (F1) to turn on first contactor, second contactors & first timer. The system will continue and after the delay from timer 1 (T1), it will activate second step (F2) to turn on third and fourth contactor beside first two contactors with a second timer. After the delay from timer 2 (T2), it will activate third step (F3) to turn on five contactor beside first two contactors & the third contactor. There is a possibility to stop any action by pressing the (Stop) push button or the emergency switch, if pressed one of this two switches, the system will return to initial step (F0).

If the user select the Manual operating, the system will set the forth step (F4). At this step, the user will select one of three switches to start any system. If the user selects Switch 1, the system will set up fifth step (F5) to turn on first and second contactor for the first system. When selecting the second switch, the system will set up step 6 (F6) to turn on another two contactors alone for the second system. But when selecting the third switch, the system will set up step 7 (F7) to turn the fourth and fifth contactors. If the user want to turn off the system wherever it is, it can be done by pressing the (Stop) push button, active the emergency stop switch or to switch the selector to Zero, then the whole system will stop and go back to the initial step (F0).

4.3 Ladder Code

To build program for this system we used LDR language or ladder logic is widely used to program PLCs, where sequential control of process or manufacturing operation is required. Ladder logic is useful for simple but critical control systems or for reworking old hard-wired relay circuits. The ladder code is shown in figure (4.6).

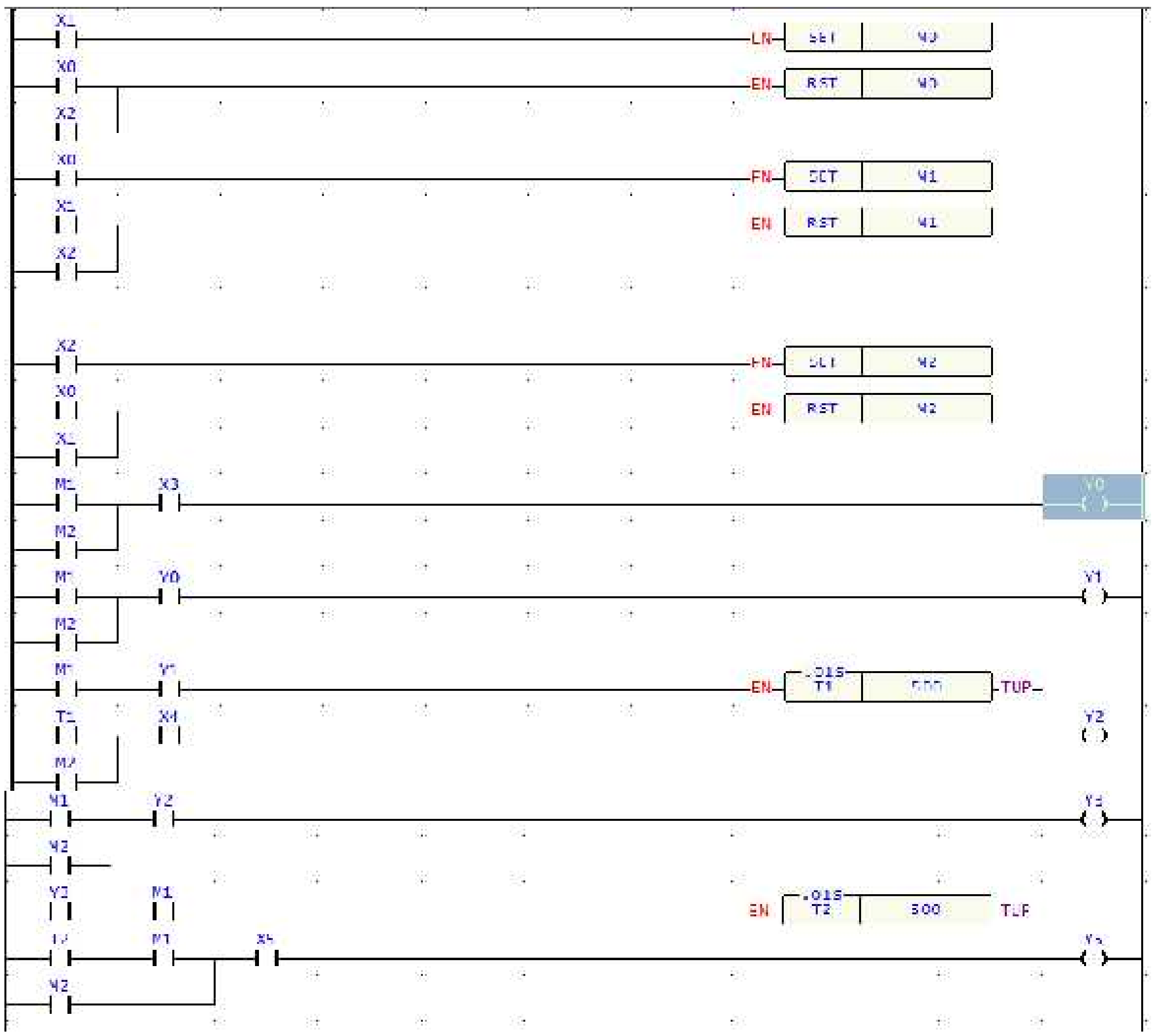

Figure (4.6): Ladder code.

Chapter Five

Electrical design and Protection.

5.1 Introduction.

This chapter electrical component specifications (overload, earth leakage, circuit breaker, etc.), contain motor and its calculation power and control circuit, and protection.

5.2 Motors and its calculations.

5.2.1 Gates motors.

We have five motors for the gates, the motors are similar so we will calculate for one motors.

We need the speed of gates is 50 rpm therefore the calculations as follow:

a= Output speed/ Input speed……………………………………………..………………... (1)

Where:

a: is the gear ratio.

a= 50/ 1500

a= 0.033.

$w = \frac{2\pi N}{60}$………………………………………………………………… …………………… (2)

Where:

w: is the motor speed in rad/s.

N: is the motor speed in rpm.

w = (2*π*1500)/60

w = 157.08 rad/s.

F = m*g.. … (3)

Where:

m: the mass (k.g).

g: Gravity acceleration (9.807m/s^2).

$m = m_{slides}+m_{rod}$.

m= 1.8+1.57

m = 3.37k.g

F = 3.37*9.807

F = 33.04 N

T_L = F*r……………………………………………………………………………. … (4)

Where:

T_L: the torque load (N.m)

F: is the force (N)

r: is the radius of rod

T_L = 33.04*0.018

T_L = 0.59 N.m

T_{IN} = (T_L*a)/efficiency……………………………………………………………..… (5)

Where the efficiency of the gear is 0.7

So,

T_{IN} = (0.59*0.33)/0.7

T_{IN} = 0.278 N.m

P_{out} = T_{IN}* w …... (6)

P_{out} = 0.278*157.08

P_{out} = 43.66 watt

The safety factor is 1.13. So, the P_{out} equal:

$P_{out} = P_{out}*SF$... (7)

$P_{out} = 43.66*1.13$

$P_{out} = 49.4$ watt

$P_{out} = 0.067$ hp.

So the power of the motor must be at least 0.067 hp. So we select the motors single phase 1500 rpm and 0.25 hp for the gates motors.

5.2.2 Suctions Motors

The machine has two suction motors; one motor for each stage the suction motor gives a suitable air flow in the channel of zig-zag and in the cyclone to make the separation process, the motor is 2800 rpm and 1hp. As shown in figure (5.1).

:

Figure (5.1): Suction Motor.

5.3 The Variable Frequency Inverters (VFDs)

Frequency converters are used to change the frequency and magnitude of the constant grid voltage to a variable load voltage. Frequency converters are especially used in variable frequency AC motor drives.

VFD007E21T Delta VFD-E input 1 phase 220 V output 3phase 0-380V 4.2A 0.1-600HZ

0.75KW 1hp inverter VFD AC motor drive with keypad .The VFD is shown in figure (5.2).

Figure (5.2): Variable Frequency Drive.

5.4 power circuit and control circuit

In this section we will take about the power and control circuit designed for our machine.

5.4.1 Power circuit

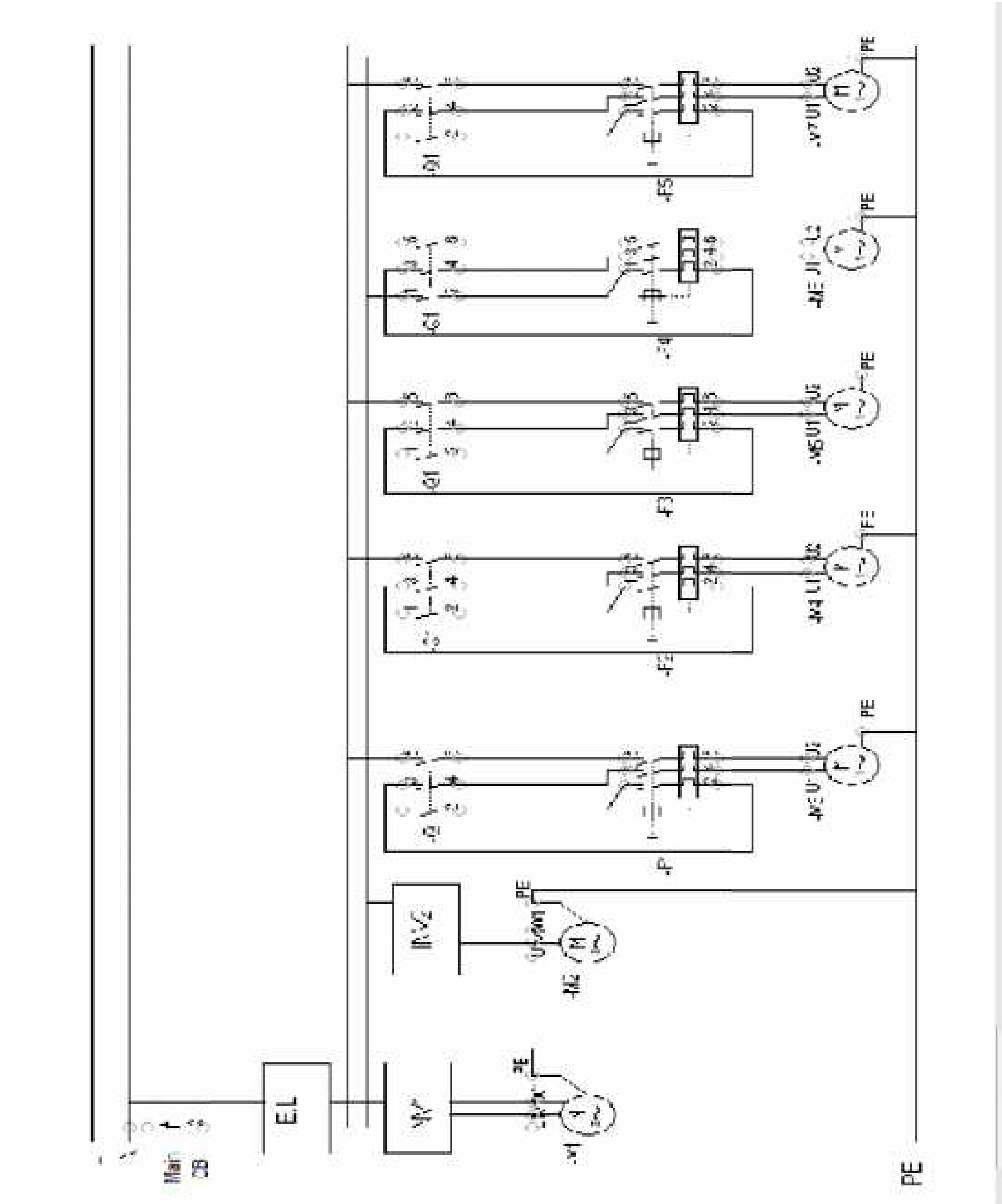

Figure (5.3): Power Circuit.

Since there is two suction motors are three phase, we will use frequency converters to control the speed of airflow of motors. Depending on the full load rated currents of all the motors we will use a 16A circuit breaker as a main circuit breaker. Then there comes the residual current device, which is a two pole breaker, it is important to protect the user if there is any leakage in the circuit or in the motor's coils. If the leakage is more than 30mA it will switch off & the whole circuit will stop working.

In our panel, since we have a power circuit with a control circuit, we used five colors of cables with a thickness of 1.5mm. The main cable for the whole machine will have a thickness of 2.5mm, because this cable can carry as maximum 16A and with all motors are turned on with the maximum rated current. The colors will be brown for Line, blue for Neutral & yellow and green for the earth system. For the control circuit, we used two colors only. Red for the +24VDC & black for the Zero DC. These two cables will deliver the DC voltage to the coils of the contactors and to the dedication lamps.

Contactors in our circuit will have a coil of 20-60 VDC, because the output voltage from the PLC is 24VDC, so we can deal with contactors without using any external device like a relay with a coil of 24VDC.

Overload, it has a thermal overload & current overload. We choose the suitable overload depending on the rated full current for every motor. The connection of the contactor with an overload will be like figure (5.4).

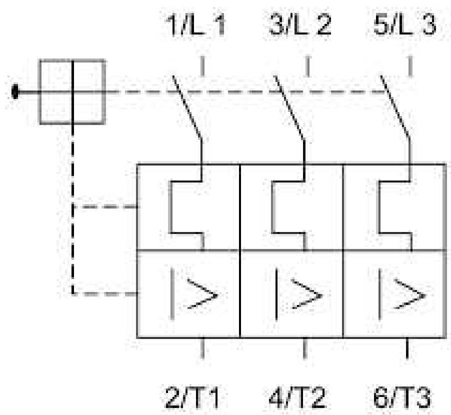

Figure (5.4): Three phase overload.

5.4.2 Control circuit design

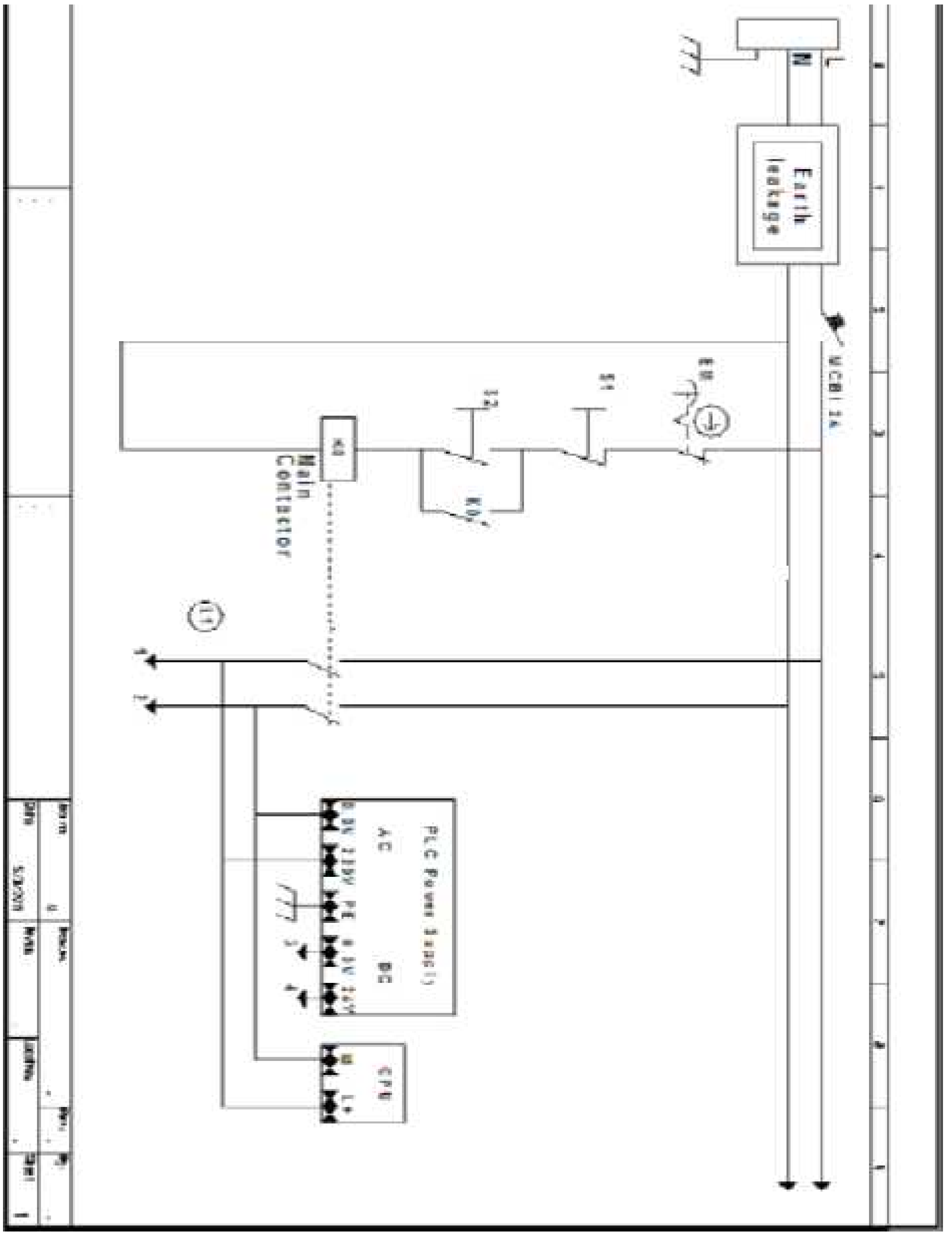

Figure (5.5): Control Circuit

5.5 Electrical panel

Inside the electrical board there are 5 rows, in order to arrange similar devices in a single row.

First row has a Bus bar, Circuit breakers & the PLC.

- Busbar: It's a distribution line, we used it to distribute the line cable and the neutral cable to the devices that needs AC power.
- Main Circuit Breaker: A protectrion device with a rated current of 16A.
- Residual Current Device: Protection device with a sensitivity of 30mA.
- Circuit Breaker: A protection device for the PLC and the Power Supply with a rated current of 6A.
- PLC "Fatek (FBs-24MAR2)": A Control device that has a 14 inputs & 10 outputs.

Second row has the main mini-contactor, two power contactors & a power supply.

- Main mini-contactor: We will use this device to activate the PLC & the external power supply. It has a coil of 220V AC. It's called the main because if it's not activated the whole machine will stay off.
- Power Contactors: Each one of this contactors will be activated by a signal from the PLC, it has a coils that can work with a range from (20 to 60) VDC.
- Power Supply has an input of 220V AC and an output of 24V DC. We will use this power supply to protect the PLC & to provide enough power for the coils of the contactors.

Third row has the Frequency converters.

- Frequency converters will be used to control the speed of the motors. The frequency converters will have a rated power of 2 horse power for the for the two suction motors.

Fourth row has theoverloads for the motors

- Overloads: We will use the GV2 overloads, because it has a Thermal Overload and a Current overload in the same device. This kind of overloads has a wide range and we can choose the overload depending on the rated current of each motor. Its much better than putting a thermal overload alone because it can be evaluated at the rated current of the motor, so we don’t need to put a another circuit breaker for each motor.

Fifth row has a Terminal Connectors.

- This connectors will be used to connect the main cable & the motor’s cables.

Outside the electrical board there are another 4 rows.

First row has a four detection lamps.

- First lamp will turn on when the PLC is active.
- Second lamp will turn on when motor1 and motor2 on.
- Third lamp will turn on when motor 3 and motor 4 on.
- Fourth lam will turn on when motor 5 on.

Second row has a selection switches.

- First Selector is a three position selection switch, it can let the user select the type of operating, Manual operation, Automatic operation or stays at Zero.
- Second selector is a two position selection switch, it will be used in the manual operation to activate motor 1 and motor 2.
- Third selector is a two position selection switch, it will be used in the manual operation to active motor 3 and motor 4
- Foutth selector is a two position selection switch, it will be used in the manual operation to active motor 5.

Third row has 2 push buttons.

- First push button (Green) is a normally open button, when the user push this button the PLC will turn on.
- Second push button (Red) is a normally closed button, it will turn off the machine if the user pushs it.

Fourth row has the emergency button only. When this button is pressed, it will turn off the PLC and the power supply.

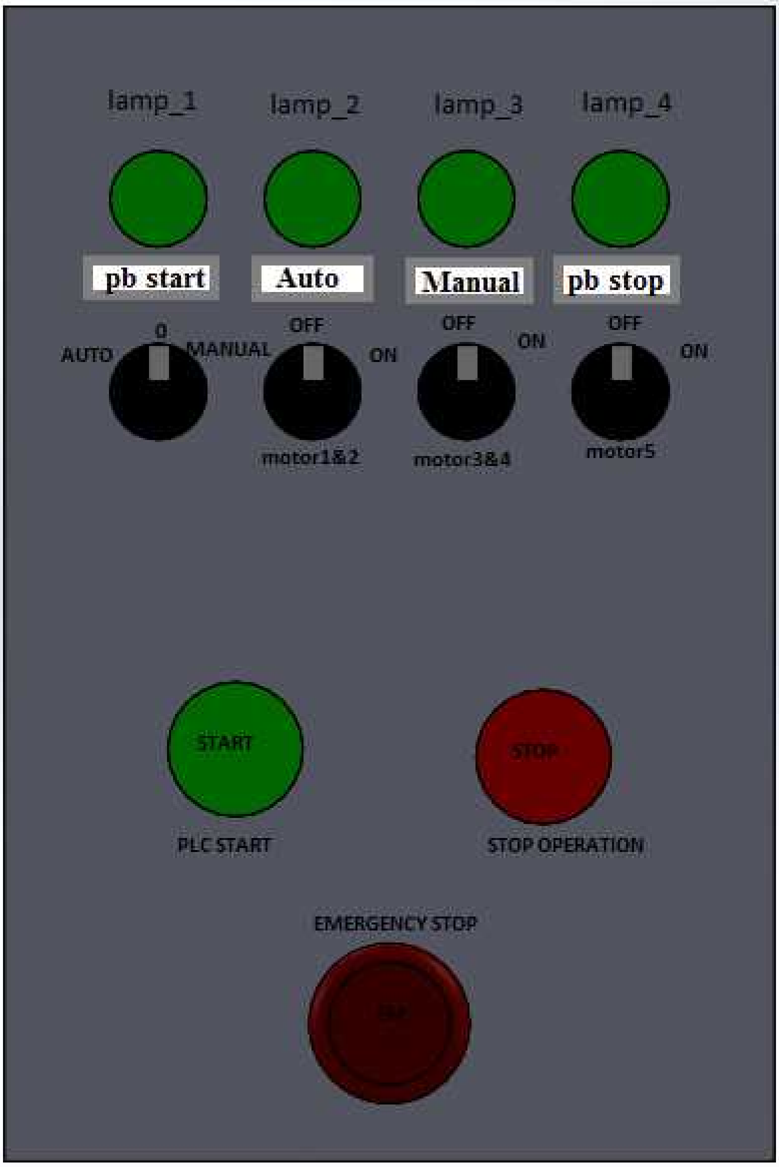

Figure (5.6): Exterior design of the panel electric.

Chapter Six

Experimental Result & Recommendations

6.1 Introduction

This chapter provides experimental result and some recommendations from the work learn for this project. In this chapter we are listing some goals hope to be accomplished or _at least_ under attention**.**

Figure (6.1): The final machine.

6.2 Experimental Result

We made some experiments on parts of our project and these are some of results:

1. We tried to check the first stage and see how the air flow into machine with small amount of thyme, the air cycle move correctly.
2. The air flow is not enough to move the thyme into cyclone in the first stage because the Zig-Zag channel is tall due to suction motors that used.
3. There is some losses of air flow that lost in pipes and cyclones. So we couldn’t reach the desired results.

6.3 Recommendations

These recommendations are recorded to people who can create opportunities for student to make something new and useful, in order to make difference in our country Palestine:

1. Such projects should be handled among different departments according to the project nature (we had lots of mechanical problems that might solve without having enough previous knowledge).
2. The Zig-Zag must be suitable with cyclone and the air flow.
3. The machine must not infiltrate any amount of air to ensure getting the required flow.

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References

[1] A.H.Stebbins, USA Patent 1,650,727, 28-9-1926.

[2] https://en.wikipedia.org/wiki/Cyclonic_separation

[3] http://www.vfds.com/blog/what-is-a-vfd

[4] http://www.doityourself.com/stry/how-a-gear-motor-works

[5] https://ar.aliexpress.com/item/free-shipping-High-quality-cyclone-dust-collector-1pc/32244091377.html?spm=2114.010208.3.20.re25Aq&ws_ab_test=searchweb0_0,searchweb201602_1_116_10065_117_10068_114_115_113_10084_10083_10080_10082_10081_10060_10061_10062_10056_10055_10054_10059_10099_10078_10079_427_10103_10073_10102_10096_10052_10050_10051,searchweb201603_4&btsid=aa3b7868-9659-4e45-8589-be7f90d28095

[6] http://www.fatek.com/en/technical.php?act=manual&catId=11

APPENDIX A

Ladder Language

Ladder logic was originally a written method to document the design and construction of relay racks as used in manufacturing and process control. Each device in the relay rack would be represented by a symbol on the ladder diagram with connections between those devices shown. In addition, other items external to the relay rack such as pumps, heaters, and so forth would also be shown on the ladder diagram. See relay logic.

Ladder logic has evolved into a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware. Ladder logic is used to develop software for programmable logic controllers (PLCs) used in industrial control applications. The name is based on the observation that programs in this language resemble ladders, with two vertical rails and a series of horizontal rungs between them. While ladder diagrams were once the only available notation for recording programmable controller programs, today other forms are standardized in IEC 61131-3 (For example, as an alternative to the graphical ladder logic form, there is also a more assembly language like format called Instruction list within the IEC 61131-3 standard.).

Overview

Part of a ladder diagram, including contacts and coils, compares, timers and constable multivibrators

Ladder logic is widely used to program PLCs, where sequential control of a process or manufacturing operation is required. Ladder logic is useful for simple but critical control systems or for reworking old hardwired relay circuits. As programmable logic, controllers became more sophisticated it has also been used in very complex automation systems. Often the ladder logic program is used in conjunction with an HMI program operating on a computer workstation.

The motivation for representing sequential control logic in a ladder diagram was to allow factory engineers and technicians to develop software without additional training to learn a language such as FORTRAN or other general-purpose computer language. Development, and maintenance, was simplified because of the resemblance to familiar relay hardware systems.[2] Implementations of ladder logic have characteristics, such as sequential execution and support for control flow features, that make the analogy to hardware somewhat inaccurate. This argument has become less relevant given that most ladder logic programmers have a software background in more conventional programming languages.

Ladder logic can be thought of as a rule-based language rather than a procedural language. A "rung" in the ladder represents a rule. When implemented with relays and other electromechanical devices, the various rules "execute" simultaneously and immediately. When implemented in a programmable logic controller, the rules are typically executed sequentially by software, in a continuous loop (scan). By executing the loop fast enough, typically many times per second, the effect of simultaneous and immediate execution is achieved, if considering intervals greater than the "scan time" required executing all the rungs of the program. Proper use of programmable controllers requires understanding the limitations of the execution order of rungs.

Example of a simple ladder logic program

The language itself can be seen as a set of connections between logical checkers (contacts) and actuators (coils). If a path can be traced between the left side of the rung and the output, through asserted (true or "closed") contacts, the rung is true and the output coil storage bit is asserted (1) or true. If no path can be traced, then the output is false (0) and the "coil" by analogy to electromechanical relays is considered "de-energized". The analogy between logical propositions and relay contact status is due to Claude Shannon.

Ladder logic has contacts that make or break circuits to control coils. Each coil or contact corresponds to the status of a single bit in the programmable controller's memory. Unlike electromechanical relays, a ladder program can refer any number of times to the status of a single bit, equivalent to a relay with an indefinitely large number of contacts.

So-called "contacts" may refer to physical ("hard") inputs to the programmable controller from physical devices such as pushbuttons and limit switches via an integrated or external input module, or may represent the status of internal storage bits, which may be generated elsewhere in the program.

Each rung of ladder language typically has one coil at the far right. Some manufacturers may allow more than one output coil on a rung.

Rung Input: Checkers (contacts)

— [ ] — normally open contact, closed whenever its corresponding coil or an input which controls it is energized. (Open contact at rest)

— [\] — normally closed ("not") contact, closed whenever its corresponding coil or an input, which controls it, is not energized. (Closed contact at rest)

Rung Output: Actuators (coils)

— ( ) — normally inactive coil, energized whenever its rung is closed. (Inactive at rest)

— (\) — normally active ("not") coil, energized whenever its rung is open. (Active at rest)

The "coil" (output of a rung) may represent a physical output which operates some device connected to the programmable controller, or may represent an internal storage bit for use elsewhere in the program.

A way to recall these is to imagine the checkers (contacts) as a push button input, and the actuators (coils) as a light bulb output. The presence of a slash within the checkers or actuators would indicate the default state of the device at rest.

Logical AND

```
------[ ]--------------[ ]----------------( )
   Key Switch 1      Key Switch 2       Door Motor
```

The above realizes the function: Door Motor = Key Switch 1 AND Key Switch 2

This circuit shows two key switches that security guards might use to activate an electric motor on a bank vault door. When the normally open contacts of both switches close, electricity is able to flow to the motor, which opens the door.

Logical AND with NOT

```
------[ ]--------------[\]----------------( )
   Close Door      Obstruction         Door Motor
```

The above realizes the function: Door Motor = Close door AND NOT (Obstruction).

This circuit shows a push button that closes a door, and an obstruction detector that senses if something is in the way of the closing door. When the normally open push button contact closes and the normally closed obstruction detector is closed (no obstruction detected), electricity is able to flow to the motor, which closes the door.

Logical OR

```
--+-------[ ]-------+-----------------( )
  | Exterior Unlock |                Unlock
  |                 |
  +-------[ ]-------+
    Interior Unlock
```

The above realizes the function: Unlock = Interior Unlock OR Exterior Unlock

This circuit shows the two things that can trigger a car's power door locks. The remote receiver is always powered. The unlock solenoid gets power when either set of contacts is closed.

Industrial STOP/START

In common industrial latching start/stop logic we have a "start" button to turn on a motor contactor, and a "stop" button to turn off the contactor.

When the "start" button is pushed the input goes true, via the "stop" button NC contact. When the "run" input becomes true the seal-in "run" NO contact in parallel with the "start" NO contact will close maintaining the input logic true (latched or sealed-in). After the circuit is latched, the "stop" button may be pushed causing its NC contact to open and consequently the input to go false. The "run" NO contact then opens and the circuit logic returns to its inactive state.

```
--+----[ ]--+----[\]----( )
  |  start |   stop    run
  |        |
  +----[ ]--+
      Run
-------[ ]--------------( )
      Run            motor
```

The above realizes the function: run = (start OR run) AND (NOT stop)

Note the use of parenthesis to group the logical OR function before evaluating the logical AND function (which has a higher order of operation priority). Also, note the use of NOT to represent the "stop" NC contact logic.

This latch configuration is a common idiom in ladder logic. In ladder logic, it is referred to as seal-in logic. The key to understanding the latch is in recognizing that "start" switch is a momentary switch (once the user releases the button, the switch is open again). As soon as the "run" solenoid engages, it closes the "run" NO contact, which latches the solenoid on. The "start" switch opening up then has no effect.

For safety reasons, an Emergency-Stop and/or Stop should be hardwired in series with the Start switch, and the relay logic should reflect this.

```
--[\]----[\]----+--[ ]--+---------( )
  ES    Stop    | Start |        Motor
                |       |
                +--[ ]--+
                   Run
```

Complex logic

Here is an example of what two rungs in a ladder logic program might look like. In real world applications, there may be hundreds or thousands of rungs.

Typically, complex ladder logic is 'read' left to right and top to bottom. As each of the lines (or rungs) are evaluated, the output coil of a rung may feed into the next stage of the ladder as an input. In a complex system, there will be many "rungs" on a ladder, which are numbered in order of evaluation.

```
1. ----[ ]---------+----[ ]-----+----( )
     Switch        |   HiTemp   |    A/C
                   |            |
                   +----[ ]-----+
                       Humid
2. ---- [ ] ---- [\] -------------------- ( )
       A/C    Heat                  Cooling
```

Line 1 realizes the function: A/C = Switch AND (HiTemp OR Humid)

Line 2 realizes the function: Cooling = A/C AND (NOT Heat)

This represents a slightly more complex system for rung 2. After the first line has been evaluated, the output coil "A/C" is fed into rung 2, which is then evaluated and the output coil "Cooling" could be fed into an output device "Compressor" or into rung 3 on the ladder. This system allows very complex logic designs to be broken down and evaluated.

Additional functionality

The PLC manufacturer as a special block can add additional functionality to a ladder logic implementation. When the special block is powered, it executes code on predetermined arguments. These arguments may be displayed within the special block.

```
                        +-------+
 ----- [ ] --------------------+ A    +----
  Remote Unlock            +-------+
                       Remote Counter
                        +-------+
----- [ ] --------------------+ B    +----
 Interior unlock          +-------+
                     Interior counter
                   +--------+
 --------------------+ A + B +-----------
                   | Into C |
                   +--------+
                     Adder
```

In this example, the system will count the number of times that the interior and remote unlock buttons are pressed. This information will be stored in memory locations A and B. Memory location C will hold the total number of times that the door has been unlocked electronically.

PLCs have many types of special blocks. They include timers, arithmetic operators and comparisons, table lookups, text processing, PID control, and filtering functions. PLCs that are more powerful can operate on a group of internal memory locations and execute an operation on a range of addresses, for example, to simulate a physical sequential drum controller or a finite state machine. In some cases, users can define their own special blocks, which effectively are subroutines or macros. The large library of special blocks along with high-speed execution has allowed use of PLCs to implement very complex automation systems.