PPU College Of Engineering and Technology
The Home of Competent Engineers and Researchers

Electrical and Computer Engineering Department
Industrial Automation Engineering Program

Design of Automated Filling Coffee Machine

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Design of Automated Filling Coffee Machine

By

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According to the direction of the project supervisor and by the agreement form the entire committee's members. This project was submitted to department of electrical engineering in College of Engineering and Technology to partially fulfill of the B.Sc requirements.

Project Supervisor Signature	Department Administrator Signature
Name: _________________	Name: _____________________

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Dedication

This project is dedicated to our parents, who taught us that the best kind of knowledge to have is that which is learned for its own sake.

In addition, it is dedicate to our family, who have always been there for us, and have never doubted our dreams, no matter how crazy they might be.

To our Friends

To our lecturers

To our project supervisor… Dr. Sameer Khader

Work Team

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We might not know where the life's road will take us, but walking with You, Allah, through this journey has given us strength.

No project of this size and duration can be completed without a great deal of help along the way. Therefore, we must sincerely thank the following people, all of whom have provided us with technical advice, critical feedback, and support:

- Dr. Sameer Khader has been the ideal thesis supervisor. His wise advice, insightful criticisms, and patient encouragement assisted the writing of this thesis in innumerable ways.
- A special thanks to our lecturers for their efforts, assistance, and support in this project that was greatly needed and deeply appreciated.

We wish to express our deep and sincere thank and gratitude to Palestine Polytechnic University, the Department of Electrical and Computer Engineering, College of Engineering and Technology.

Finally, we would like to express our sincere gratitude to Salisian Technical School for providing us excellent opportunity. We couldn't have finished the project without their approval to use the school as a place to assemble our project.

Work Team

Abstract

“Design of Automated Filling Coffee Machine”

Coffee is one of the most consumed beverages in Palestine, and is served several times throughout the day. This leads to the consumption of large amounts of coffee powder, the process of preparing coffee in stores needs time, first weighting the coffee beans, then grinding it and finally filling it in its’ bag.

However; there are several problems in this field. First, weight inaccuracy of the final product. Second, the problem of manual production process. Finally, time and effort inefficiency. Accordingly, we chose to exploit the developed industrial technology for designing an automated coffee filling machine; to overcome these problems.

We designed a coffee powder filling machine, that fills in plastic bags of different sizes compatible with the weight of the desired product by the customer (250 grams, 500 grams), and then close the bag tightly. In addition, we utilized the solar energy to provide electricity to the machine as an alternative source of electric power. Moreover, our design assists the operator who works on the machine to deal with it easily through automatic control system that depends on the data display screen.

الملخص

"تصميم آلي لماكينة تعبئة قهوة"

تُعد القهوة من أكثر المشروبات استهلاكا في فلسطين ، حيث يتم تقديمها عدة مرات طوال اليوم في البيوت والمقاهي وكثير من الأماكن، ذلك يؤدي إلى استهلاك كميات كبيره من مسحوق القهوة, التي يتم إنتاجها وتعبئتها في المحلات التجارية, حيث أن عملية إعداد مسحوق القهوة في المحلات التجارية تواجه بعض المشاكل.

في البداية، وزن حبوب القهوة، ثمّ طحنها، وأخيراً تعبئتها في أكياس, حيث تصاحب هذه السلسلة من العمليات عادة عدم دقة في تحديد الوزن المطلوب للعبوة النهائية للمستهلك، وهذا نابع بالطبع من التدخل البشري اليدوي في العملية, وما يلازمه من هامش خطأ اكبر من العملية الآلية .

إننا هنا نسعى ومن خلال مشروعنا هذا إلى التغلب على هذه المشكلات بمساعدة التطور التكنولوجي وأتمتة العملية بالكامل، من مرحلة ضبط الوزن إلى مرحلة التعبئة النهائية، مما سيسمح بتوفير وقت وجهد أكبر للمحلات التجارية، والحصول على دقة أكثر في الوزن.

و بناءً على ما سبق قمنا بتصميم ماكينة تعبئة للقهوة المطحونة في أكياس بلاستيكية مختلفة الحجم تتلاءم مع وزن المنتج المطلوب من قبل المستهلك (250 جرام، 500 جرام)، ثمّ لِحام تلك الأكياس بشكل محكم. بالإضافة إلى ذلك، استغلال الطاقة الشمسية في تزويد الماكينة بالكهرباء كمصدر بديل للطاقة الكهربائية. كما سيمكّن تصميمنا اليد العاملة على الماكينة من التّعامل معها بكل سهولة من خلال نظام تحكّم آلي يعتمد على شاشة عرض و إدخال البيانات سهلة الاستخدام.

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Chapter One

“ Introduction ”

1.1 Literature Review

1.2 Importance of The Project

1.3 Automated Filling Coffee Machine

1.4 Operation Flow Chart

1.5 Project Description

1.6 Time Table

1.7 Project Cost

1.1 Literature Review:

The background research for this project occurred in some stages. We studied previous designs to gain an understanding on how to fill the coffee in a special bag.

We found many ways to do this task, as the following:

- The first way depends on bringing a bag, and opening it by complex mechanically method.
- The second way depends on forming a bag of rolls of nylon, then filling the coffee powder.

All mechanism that we found and seen both on the ground or through the pages of websites use a fixed bag fill capacity that doesn't change automatically when we change the weight of the desired product. This leads to use the human factor in controlling the movements of the machine to fit the new capacity.

Most of these machines used the size to adjust the desired weight; however, this leads to have an error rate in the final product. Where other mechanism use weight sensor to adjust the required quantity; consequently, give the most accurate final weight at the lowest error rate.

1.2 Importance of The Project:

Based on our field survey over filing coffee machine "FCM" with respect to design, automation, and productivity; we found that there are huge variety of design, operation function and simplicity in determining the coffee filling weight, but with poor automating and interfacing capabilities. This drawback leads to inaccuracy in filling quantity "weight", with long time in filling process, and reduce productivity.

1.3 Automated Filling Coffee Machine:

Based on our field survey, we found that there is a possibility to do the same thing in order to improve this industrial sector; by designing automated FCM that should eliminate mentioned weakness.

The design idea has a smart control system that realizes high accuracy at any level of the components of final product. Moreover, to realize friendly used interface to facilitate dealing with the machine during the selection of the desired product according to customer request. Furthermore, implementation of photovoltaic "PV" supply is an alternative source that will be a great challenge for this sector, taking into account huge energy consumption of these machines.

1.4 Project Description:

The project is divided into three stages:

1. Providing the product data that is required by the control screen.
   This stage is divided into: electrical signal that offers information for weight, selection, and customer need.
2. Implementing the data and producing the required weight.
3. Packaging of the coffee powder in bags and complete the packaging process.

1.5 Time Table:

The proposed project is scheduled over 30 weeks, as shown in Table (1.1).

Table (1.1): Time Line 1 of the Project:

Tasks \ Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature Review and Problem Statement															
Proposing Methodology															
Component's Survey and Cost Estimation, Selection															
Reporting First Chapters															
Design of Electromechanical Parts															
Typing the Report "Draft Version"															
Report Submission															

Table (1.2) shows the time required for several project components, the overlapping during implementation over these weeks.

Table (1.2): Time Line 2 of the Project:

Task \ Weeks	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Starting Implementation of the Mechanical Design	■	■	■	■	■	■									
Purchasing the Components			■	■	■	■									
Assembly the Electrical and Mechanical Parts							■	■	■	■					
Testing and Calibration										■	■	■			
Typing the Final Report												■	■	■	
Report Submission and Preparing the Project Presentation															■

1.6 Project Cost:

The details of the project expenditures are showed in Table (1.3).

Table (1.3): Cost of the Project:

	The Content	Number of Quantities	The Price (NIS)
1	Stainless Steel		2,000
2	Iron		1000
3	Turning		2,000
4	PLC	1	4,100
5	Touch Screen	1	1,400
6	Relay	6	500
7	Piston	14	3500
8	Valves	14	1200
9	Weight Sensor	1	100
10	Vacuum System		1,300
11	Motor	3	900
12	Power Supply	2	500
13	Magnetic Limit Switch	11	1000
14	Circuit Breaker	13	130
15	Capacitive Proximity Switches	1	150
16	Air Pipelines		250
17	Wires		150
18	Conductor		150
19	Electric Board	1	350
20	Indictor Lamps		150
Total			**20,830 NIS**

Chapter Two

“ Theoretical Part ”

2.1 Pneumatic System

2.1.1 Service Unit

2.1.1.1 Air Filters

2.1.1.2 Air Pressure Regulator

2.1.1.3 Air Lubricator

2.1.2 Lines

2.1.3 Cylinders

2.1.3.1 The Single-Acting Cylinder

2.1.3.2 The Double-Acting Cylinders

2.1.3.3 Sizing a Cylinder

2.2 Capacitor Start/Induction Run Motor (CSIR Motor)

2.3 Shunt DC Motor

2.4 The Vibrator Motor

2.5 The Worm Gear

2.6 The Sensors

2.7 PLC

2.8 Touch Screen

2.9 Photovoltaic System

2.1 Pneumatic System:

Pneumatic system is a branch of technology, which deals with the study and application of use of pressurized gas to effect mechanical motion. [1]

2.1.1 Service Unit:

This unit has three main components: taking the air are filtration, regulation, and lubrication as shown in Figure (2.1) and Figure (2.2).

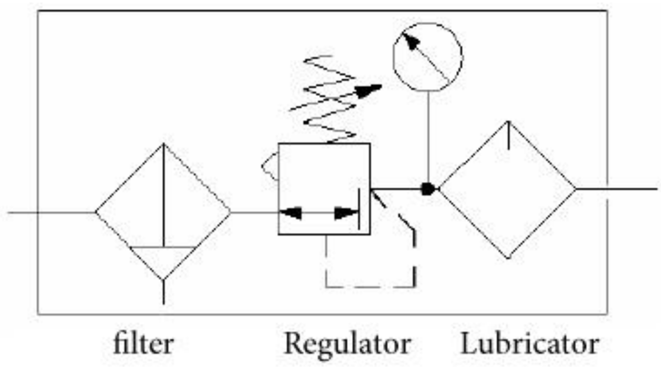


Figure (2.1): Symbol of the Service Unit

Figure (2.2): Practical Service Unit

2.1.1.1 Air Filters:

The air needs to be filtered to be free of moisture and contamination by the air filter. The filter elements remove the particles and moisture as small as 5 microns.

2.1.1.2 Air Pressure Regulator:

The pressure regulator is used to adjust the desired pressure for the pneumatic system. Here we use a piston to sense the downstream pressure fluctuations, where it works against a set of spring pressure. As the pressure downstream drops; it is sensed by the diaphragm that opens the poppet valve. This adjusts the position of the poppet valve, which limits the downstream pressure to the pre-set valve.

2.1.1.3 Air Lubricator:

A lubricator ensures proper lubrication of internal moving parts for pneumatics components. The proportional increase in oil mist by an increase of air flow is achieved by the spring loaded poppet assembly. As the flow increases and the valve opens, the area is increased and a pressure differential created.

2.1.2 Lines:

The components of a pneumatic circuit are connected through lines. Today they are typically made of plastic tubes from nylon or polyurethane. The material is chosen to meet the required permissible pressure, bending radius, temperature etc. For plastic tubes push-in fittings can be used which have a low resistance and the additional advantage that no tools are required to install or remove them.

2.1.3 Cylinders:

Cylinders convert pneumatic energy to mechanical work. They usually consist of a movable element such as a piston and piston rod, or plunger, operating within a cylindrical bore.

The cylinders divided into:

- Single-Acting Cylinders
- Double-Acting Cylinders

2.1.3.1 The Single-Acting Cylinder:

The single-acting cylinder as shown in Figure (2.3) works only in one direction, and consists of spring part where the cylinder can return back to initial position when we remove the input pressure air.

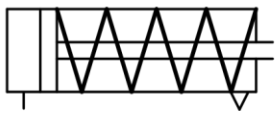


Figure (2.3): Single-Acting Cylinder

2.1.3.2 The Double-Acting Cylinders:

The double-acting cylinder as shown in Figure (2.4) works in the two directions, and there is no return spring. That means if we want to return the cylinder to the initial position we must active the part of the returning.

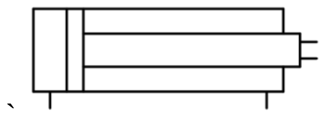


Figure (2.4): Double-Acting Cylinder

2.2 Capacitor Start/Induction Run Motor (CSIR Motor):

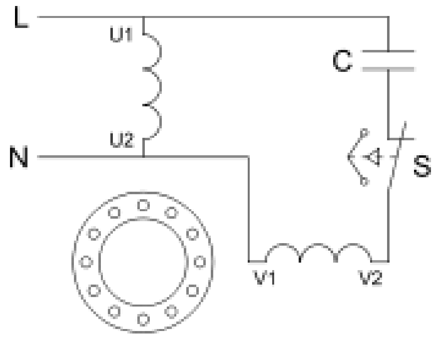


Figure (2.5): CSIR Motor

CSIR Motor shown in figure (2.5) consists of:

- Run Winding
- Start Winding
- Start Capacitor
- Centrifugal Switch

The resistance of the run winding is less than the resistance of the start winding. The cross section area of the run winding is higher than the cross section area of the start winding.

The run winding coil takes (2/3) of the field slot, and the start motor takes the result. These two windings have 90 electrical degrees in the motor [2].

The capacitor is connected in series with the start winding, aiming at reducing the total motor current, and realizing spinning flux which produces in turn self starting torque. The function of the centrifugal switch is that disconnect the starting winding at 75% of the synchronous speed [3].

2.3 Shunt DC motor:

The DC motor has two coils: armature and field coil. In shunt dc motor, the coils connect together by parallel connection as shown in Figure (2.6), and feed it by single power supply.

When voltage is applied to the motor, the high resistance of the shunt coil keeps the overall current flow low. The armature for the shunt motor is draw current to produce a magnetic field strong enough; so as to cause the armature shaft and load to start turning. When the armature begins to turn it will produce back EMF [4].

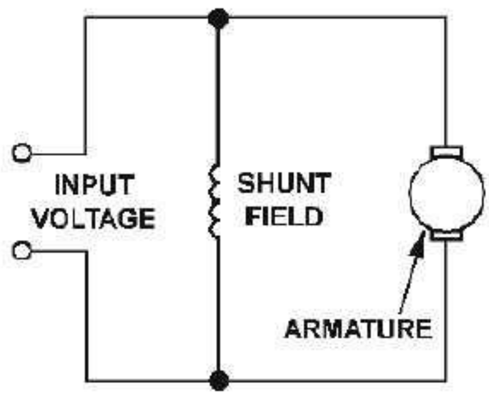


Figure (2.6): Shunt DC Motor

The back electromotive force (EMF) will cause the current in the armature to start diminishing to a very small level. The amount of current the armature will draw is directly related to the size of the load when the motor reaches full speed. Since the load is generally small, the armature current will be small. When the motor reaches full speed (rpm), its speed will remain fairly constant.

The armature's torque increases as the motor gains speed due to the fact that the shunt motor's torque is directly proportional to the armature current. When the motor is starting and speed is very low, the motor has very little torque. After the motor reaches full rpm, its torque is at its fullest potential.

The speed can be controlled by electrical or mechanical methods. We use mechanical method as a gear box so as to have a small speed with high torque. After running the motor, and performing its tasks, we will stop the motor in less time so as to have the correct weight of coffee in the weighting container [4].

We can stop the motor with electric braking of DC motor by three methods:

- Regenerative braking.
- Dynamic braking.
- Plugging or reverse current braking.

In our project we use dynamic braking method. Where the armature terminal disconnects from supply voltage, and connects to high value of resistance, as shown in Figure (2.7).

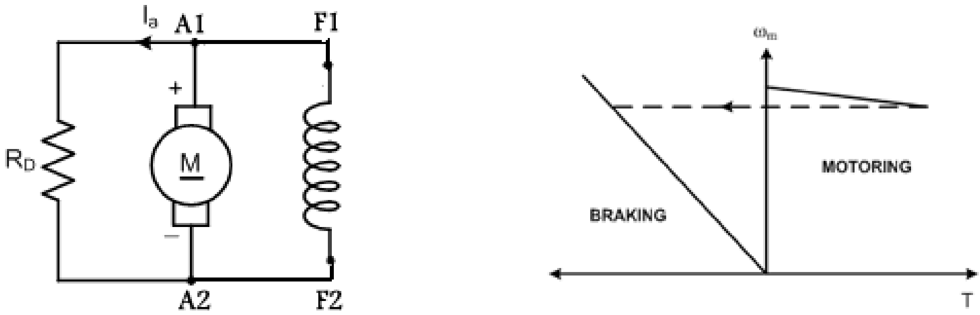


Figure (2.7): Dynamic Braking Method

When the DC motor is disconnected from the supply, the dc machine will acts as a generator and converts kinetic energy stored in its moving parts to electrical energy, which is dissipated as heat in the dynamic brake resistance (RD) and armature resistance (Ra). Finally, the motor stops[4].

2.4 The Vibrator Motor:

Coffee powder is characterized by a high degree of coherence. This coherence prevent the transfer of the coffee powder from one part to another in the machine, and suspension. Consequently, we need to find a mechanism to increase the flow of the coffee powder. So the vibrator motor as shown in figure (2.8) is the optimum mechanism to solve the problem.

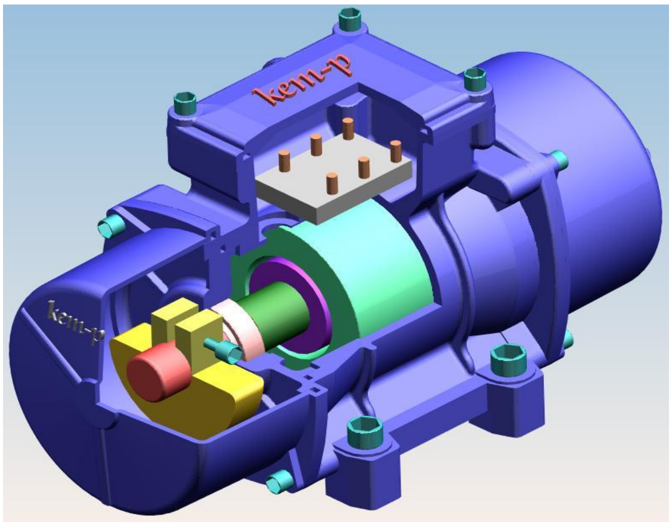


Figure (2.8): Vibrator Motor

The vibrator motor consists basically of an AC or DC electric motor. It is installed on the shaft in two sides a half a tablet, the rotation of motor leads to the formation of vibrate movement.

2.5 The Worm Gear:

Figure (2.9): Worm Gear

Worm gears are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater. In our design we want to use the reduction 10:1.

The worm gear has two basic components, and these components are:

- Worm.
- Worm-Wheel.

The worm connects with the motor, and the worm-wheel connects with the load. The worm is the one that leads the worm-wheel. The angle between the worm and the worm-wheel is 90°. [5]

The value of the reduction depends on the number of the worm-wheel teeth. The worm moves 360°, while the worm-wheel moves just one tooth. [5]

2.6 The Sensors:

The sensors that may be used in our project are:

- Magnetic field sensors.
- Weight sensor.
- Thermocouple sensor.
- Capacitive proximity switches

2.6.1 The Magnetic Field Sensors:

Magnetic field sensors are primarily used for monitoring the piston position on pneumatic cylinders, as shown in Figure (2.10). The magnetic field of a magnet embedded in the piston is detected by the sensor through the cylinder housing wall.

Figure (2.10): Magnetic Field Sensor

The magnet on the piston is inside the cylinder. When the magnet reaches the magnetic field sensor the sensor provides us with a signal. We benefit from this signal to control the operation of the cylinder. Moreover, this signal can be connected with the PLC as an input part.

2.6.2 The Weight Sensor:

In our project we will use weight sensor as shown in figure (2.11). We will use the Aluminum Single Point Load Cell sensor from VISHAY Company Tedea-Huntleigh model 1004.

Figure (2.11): Weight Sensor

Model 1004 is a very low capacity, very high precision single point load cell designed for direct mounting in low capacity scales and precision balances. (The data sheet of Model 1004 is in Appendix A).

The physical input is the weight of powder in the balance box. The output of this sensor is changing the value of the voltage; this value is sent to PLC, and is dealt by controlling the desired weight of the final product.

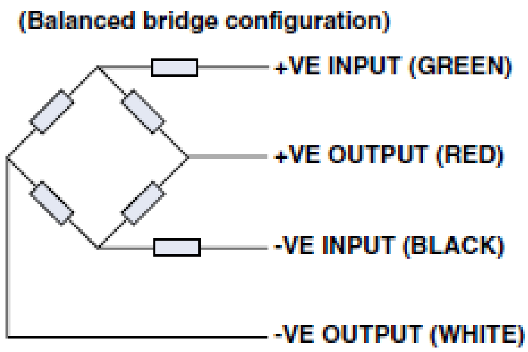


Figure (2.12): Wiring Schematic Diagram

The equivalent circuit for the load sensor (Weight Sensor) is shown in figure: (2.12).

2.6.3 The Thermocouple Sensor:

The Thermocouple sensor as shown in figure (2.13) consists of two electrical conductors made of different metals that are joined at one end. Changes in temperature at the measurement junction induce a change in voltage between the other ends.

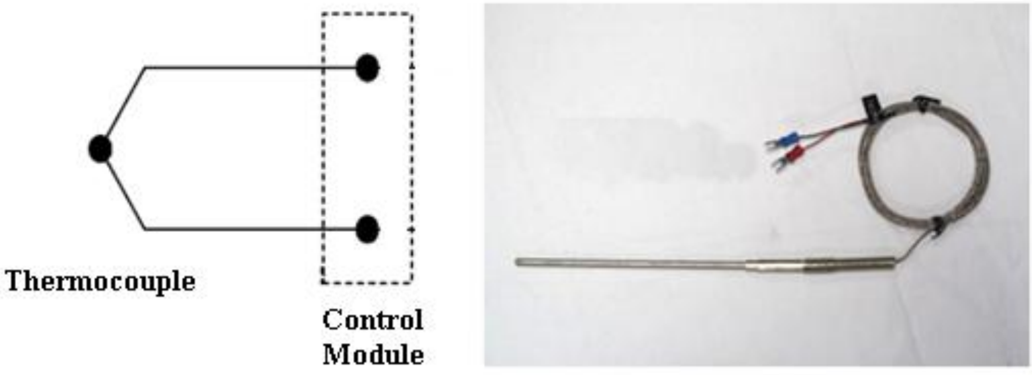


Figure (2.13): Thermocouple Sensor

Thermocouple are two groups, the base metal thermocouples J, K, T, E and N, and the precious metal thermocouples R, S and B[6].

In each type has a characteristic voltage against temperature curve and application range, as shown in Figure (2.14).

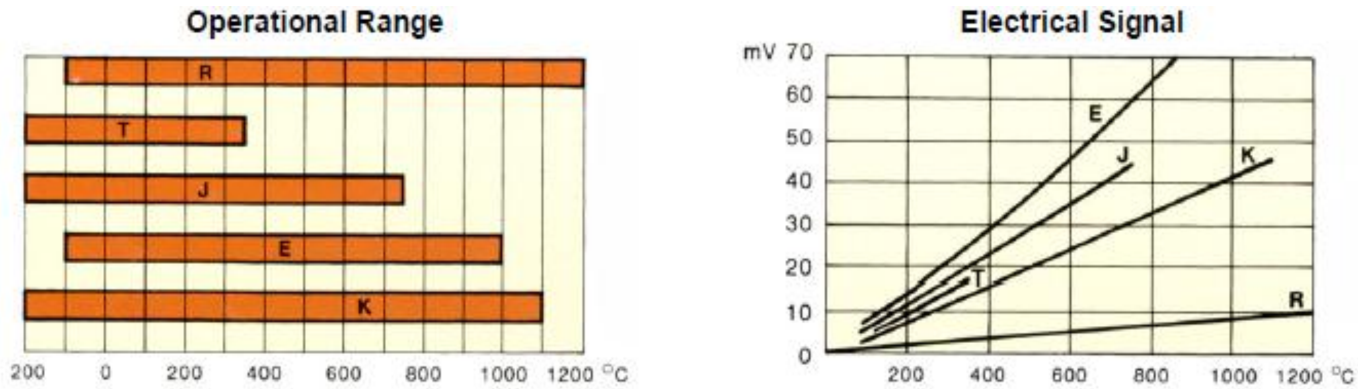


Figure (2.14): Thermocouple Characteristic Curve

The thermocouple sensor will be used in filling coffee machine to sense the temperature in welding heater. The value of voltage resulting from thermocouple feeds input port in PLC so as to close loop control of temperature.

2.6.4 Capacitive Proximity Switches:

Capacitive proximity sensors as shown in Figure (2.15) are capable of detecting both metallic and non-metallic targets such as powders, granulates, liquids and solids.

Capacitive proximity switches sense distance to objects by detecting changes in capacitance around it. A radio-frequency oscillator is connected to a metal plate[6].

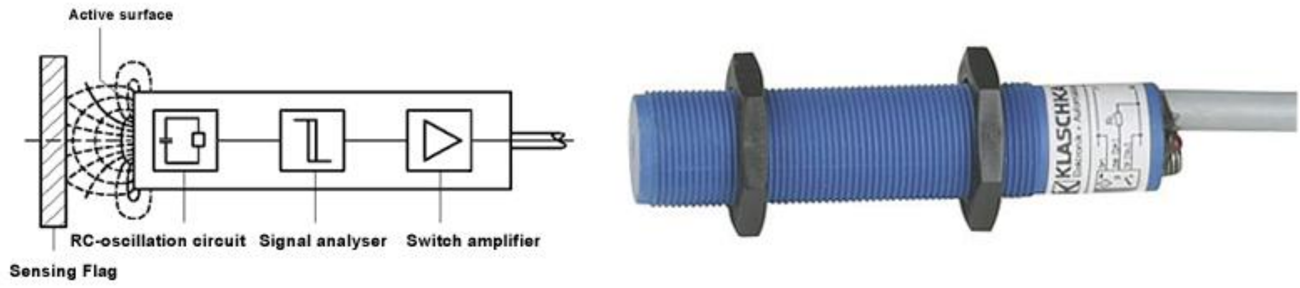


Figure (2.15): Capacitive Proximity Sensor

When the plate nears an object, the radio frequency changes; thus the frequency detector sends a signal telling the switch to open or close. Capacitive sensors employ a limited sensing range, in most cases 3 to 60 mm.

2.7 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 resistance to vibration and impact. [7]

PLC consists of:

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

These components are shown in Figure (2.16).

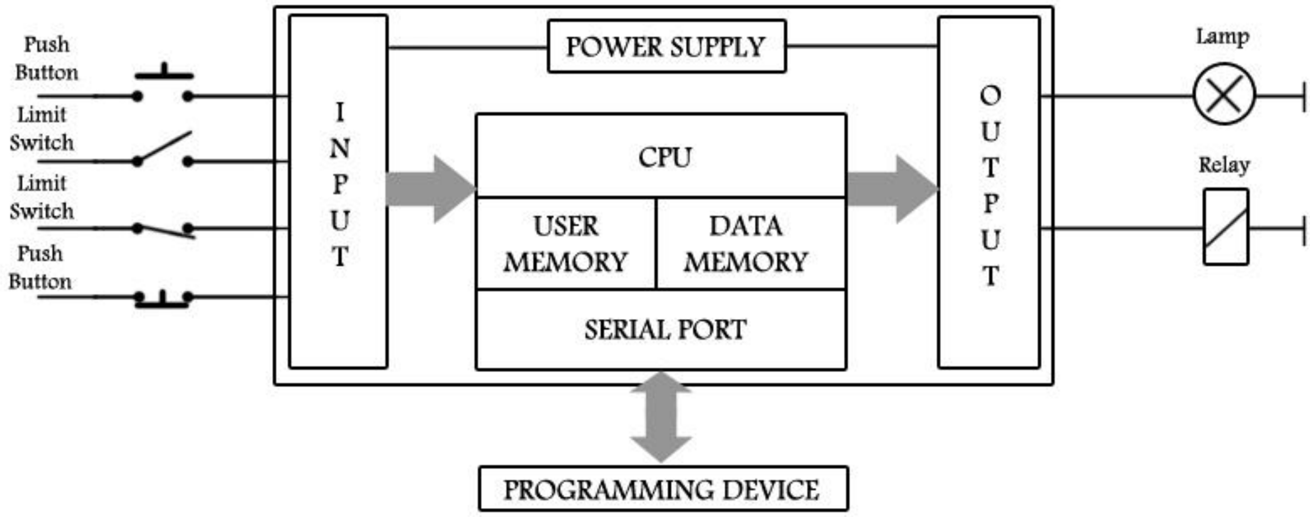


Figure (2.16): PLC Component

The PLC inputs are isolated from the output, as shown in Figure (2.17).

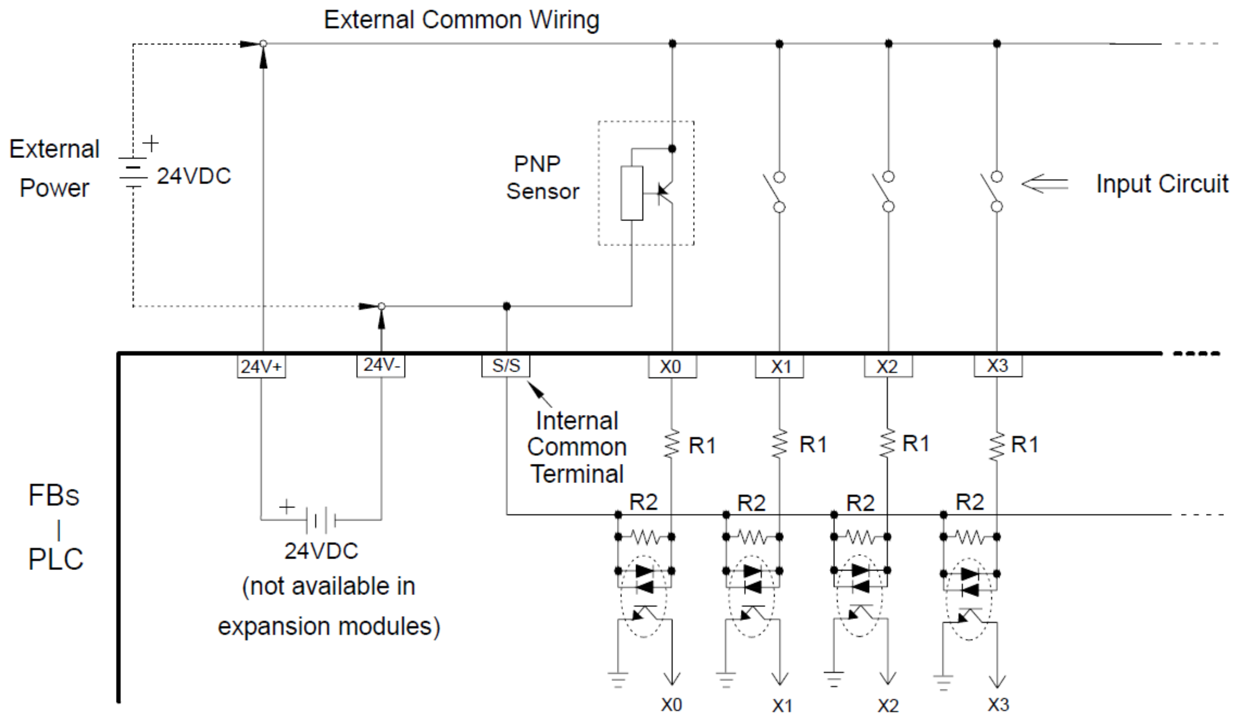


Figure (2.17): Input PLC Connections

The PLC outputs as shown in Figure (2.18) are the relay with no polarity. We can connect AC and DC load with this type of PLC.

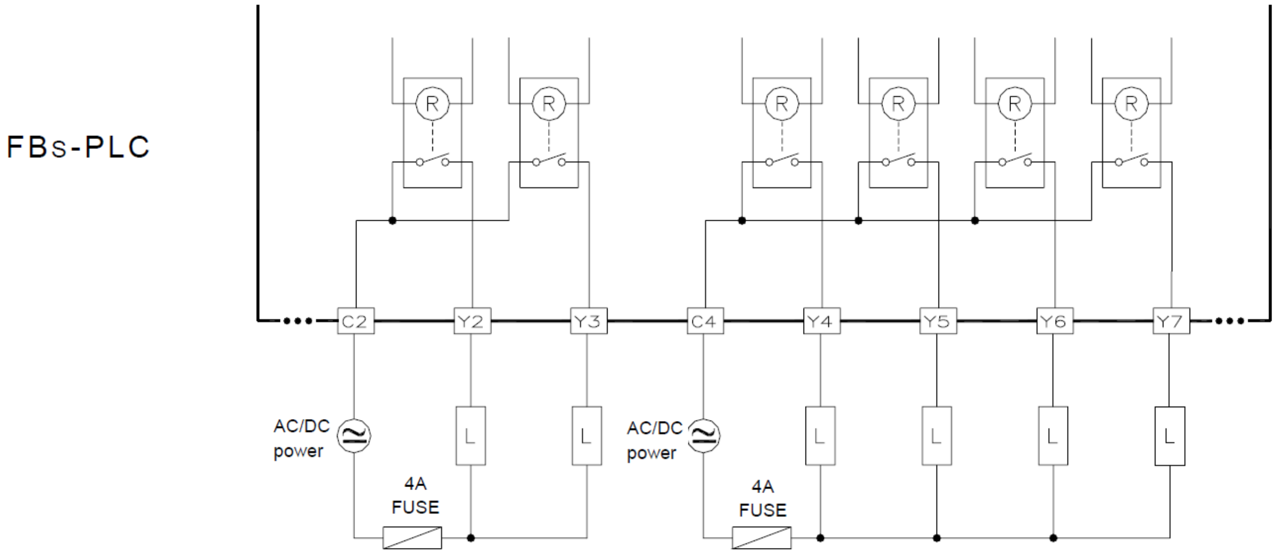


Figure (2.18): Output PLC Connections

To protect the PLC relay output contacts and lower noise interference, we must connect suppression devices in parallel with the inductive load. Where the suppression device looks like a diode, as shown in figure (2.19)

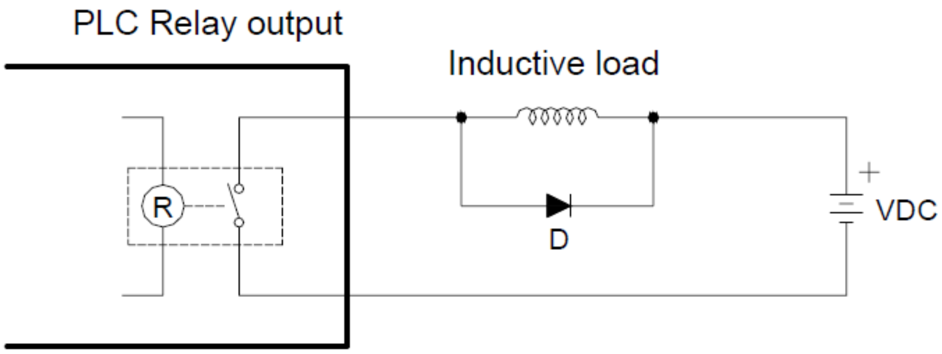


Figure (2.19): Suppression of Counter-Electromotive Force

The PLC can be programmed using different languages, such as:

- Ladder diagram
- Functional block diagram
- Instruction list

The advantages for using PLC in our design are:

- Low cost according for using the hardwired system control.
- Easy handling with it.
- To apply what we studied in our university.

2.8 Touch Screen:

Figure (2.20): PLC Touch Screen

The Touch screen as shown in Figure (2.20) is an electronic visual display that can detect the presence and location of a touch within the display area. The term generally refers to touching the display of the device with a finger or hand. [8]

Due to rapid growth of PLC technology nowadays PLC touch screen is found wide speed applications that give the user friendly and simply communication with the system. This visual display gives the consumer the possibility of dealing with the system easily.

The touch screen technology is called human-machine interaction (HMI). The main goal of this technology is to produce a user interface which makes it easy, efficient, and enjoyable to operate a machine in the way which produces the desired result.

This generally means that the operator needs to provide minimal input to achieve the desired output, and also that the machine minimizes undesired outputs to the human.

Some advantages of the touch screen:

- It is a mean to replace the operating signals.
- It is a mean to observe the operating process of the machine.
- It is a mean to dispense some external parts that is connected with the PLC, such as changing the time of the counter, and the time of the timer.
- It helps in detecting the error quickly.
- It detects the response time of fixing the error, whether it is slow or quick.

2.9 Photovoltaic System:

The solar energy conversion into electricity takes place in a semiconductor device that is called a solar cell. A solar cell is a unit that delivers only a certain amount of electrical power. In order to use solar electricity for practical devices, which require a particular voltage or current for their operation, a number of solar cells have to be connected together to form a solar panel, also called a PV module. For large-scale generation of solar electricity the solar panels are connected together into a solar array.

Solar Photovoltaic system is very reliable and clean source of electricity that can suit a wide range of applications such as residence, industry, etc.

❖ Major System Components:

Solar photovoltaic system is shown in figure (2.21), and includes different components that should be selected according to the system type, site location and applications. The major components for solar PV system are:

Figure (2.21): Photovoltaic System

- **Photovoltaic Module:**

The solar cell is the basic unit of a Photovoltaic system. An individual solar cell produces direct current and power typically between 1 and 2 W, hardly enough to power most applications. The solar cells are interconnected in series/parallel combinations to form a Photovoltaic module. Where, The PV module is shown in Figure (2.22).

The magnitude of the current output from a Photovoltaic module directly depends on the solar irradiance and can be increased by connecting solar cells in parallel. The voltage of a solar cell does not depend strongly on the solar irradiance but depends primarily on the cell temperature. It can be designed to operate at different voltages by connecting solar cells in series.

Figure (2.22): Photovoltaic Module

- **Charge Controller:**

Charge regulators are the link between the Photovoltaic modules, battery and load. They protect the battery from overcharge or excessive discharge. Photovoltaic modules that are used to charge batteries usually operate at an approximately constant voltage, which is selected to suit the local temperature.

- **Inverter:**

The main function of the inverter is the transformation of DC electricity into AC, wave shaping of the output AC electricity, and regulation of the effective value of the output voltage. The battery stores energy for supplying to electrical appliances when there is a demand. The load is an electrical appliance that connected to solar PV system.

- **Battery:**

The battery stores energy for supplying to electrical appliances when there is a demand.

- **Load:**

The load is an electrical appliance that connected to solar PV system.

Chapter Three

“ Machine Design ”

3.1 Block diagram

3.2 Mechanical Design

3.2.1 The Hopper

3.2.2 Balance Stage

3.2.3 Final Container

3.2.4 Storage Bags Container

3.2.5 Bag's Opening

3.2.6 Welding Stage

3.3 Electrical Design

3.3.1 The Motors Calculations

3.3.2 The Dynamic Braking Resistance Calculation

3.3.3 The Photovoltaic Calculation

3.3.4 The Control

3.1 Block Diagram:

The following figure (3.1) shows the block diagram of the proposed design for FCM:

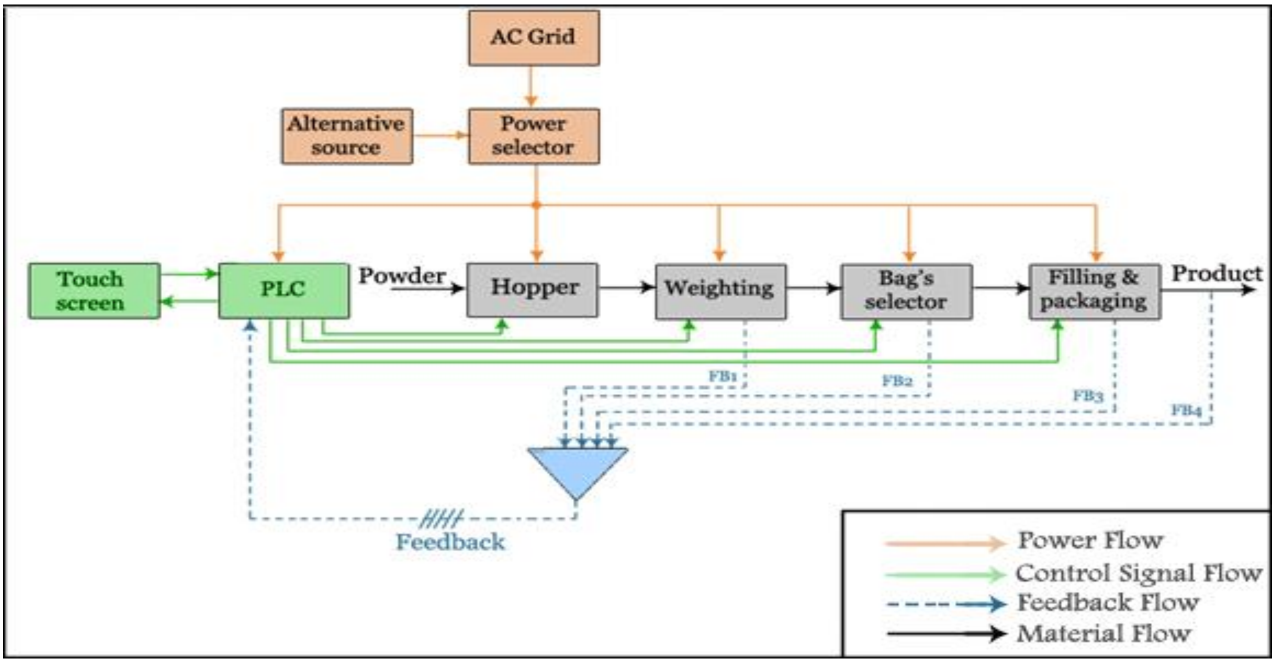


Figure (3.1): Block diagram

Where:

- FB1: the first feedback for taking a signal that if the weight reaches to the specific weight.
- FB2: the second feedback for taking a signal that if in the boxes bags or not.
- FB3: the third feedback for taking a signal when the machine finishes filling the bag.
- FB4: the fourth feedback for taking a signal when the machine finishes packaging the bag.

Moreover, there is another feedback in which to find the position of pistons, and the value of temperature of heater.

Table (3.1): Table of Equipments:

Equipment	Description
Hopper	Used for containing the coffee powder.
Mixer Motor	Used for moving the coffee powder in the hopper.
Vibrator Motor	Used for increasing flow coffee powder.
Screw Motor	Used for moving the coffee powder from the hopper to the balance container.
Balance Container	Used for weighting method, where it hold the weighted coffee powder.
Small Hopper	Used for helping moving the coffee powder from the balance container to the bag.
Bag Container	Used for holding the bags.
Vacuum Unit	Used for two things, first to hold the bag. Second, to opening the bag.
Welding unit	Used for welding the bag.
Touch Screen	Used for entering the data to calibrate, monitor, and starting the Filling Coffee Machine.

3.2 Mechanical Design:

In this section we 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 parts, 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 main hopper, passing through balance measurement and ending of packing in the bag and close tightly.

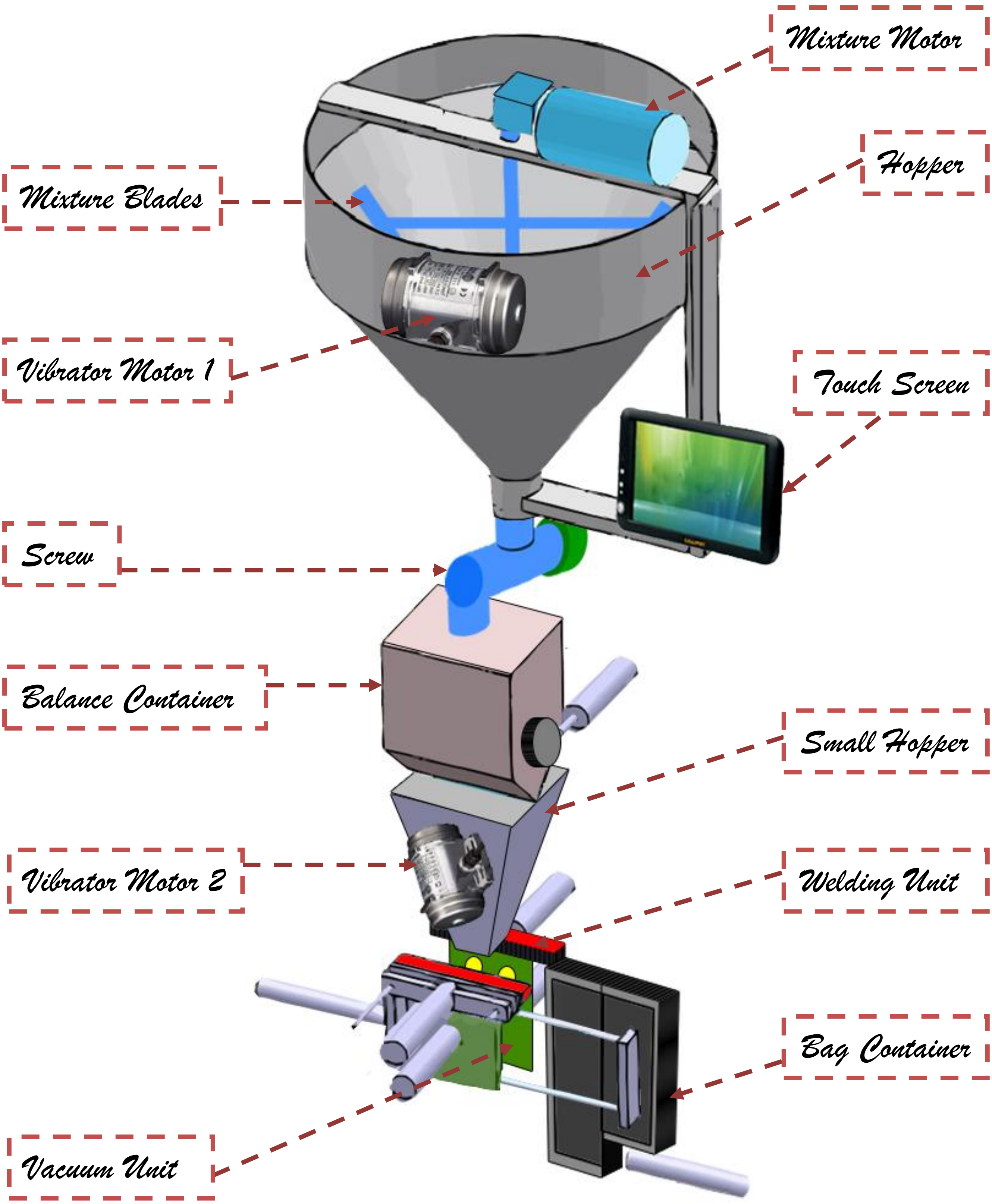


Figure (3.2): General Shape of the Machine.

3.2.1 The Hopper:

The main objective of the hopper as shown in Figure (3.3) is to contain coffee powder; that means the hopper must be formed from special metals suitable to save coffee without any changing in the taste. Therefore, we decided to use the stainless steel.

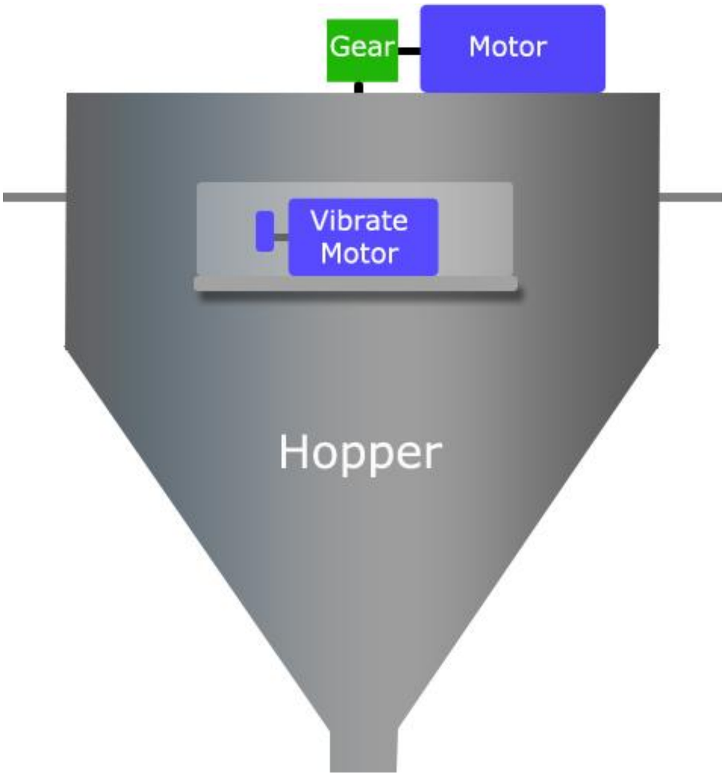


Figure (3.3): Hopper

The density of the coffee (roast beans) “d” is equal 432kg/m^3.

The powder density of the coffee “co” is equal 432 * 1.2 = 518.4 kg/m^3.

We can find the volume of hopper, if assume the desire weight in the hopper is 15kg.

The safety amount of coffee in the system is 15 * 1.3 = 19.5 kg.

The volume can be calculated by:

$$V = \frac{m}{co} \qquad \text{............... (1)}$$

Where:

- V: is the volume (m^3).
- m: is the mass (kg).
- co: is the density (kg/m^3).

V = 19.5 / 518.4 = 0.03476 m^3

❖ **The Hopper Calculation:**

If we have the shape of hopper as it is shown in figure (3.4):

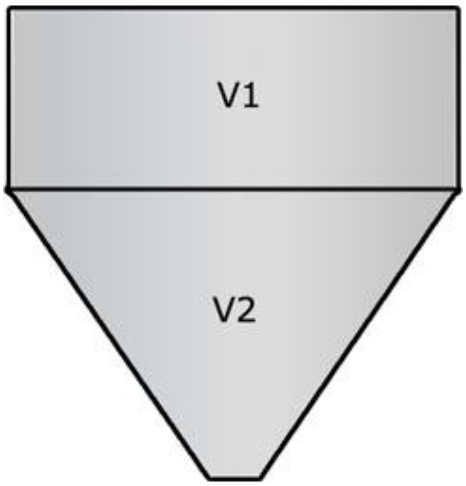


Figure (3.4): Hopper Parts

The sizes can found by calculate the volume of each part of hopper:

$$V_{Total} = V_2 + V_1 \qquad \text{............... (2)}$$

$$V_1 = \pi r^2 * h \qquad \text{............... (3)}$$

Where:

- V_1: is the volume of the cylinder (m^3)
- π : is equal 3.14
- r: is the radius of the cylinder (m)
- h: is the high of the cylinder (m)

$$V_2 = \frac{1}{3} * \pi * h * \left(r_1^2 + r_1 r_2 + r_2^2\right) \qquad \text{............... (4)}$$

Where:

- V_2: is the cone volume (m^3).
- π : is equal 3.14.
- r_1: is the radius of the top of the cone (m).
- r_1: is the radius of the bottom of the cone (m).
- h: is the high of the cone (m).

Through our search for used parts that contribute in reducing the cost of the project. We found a used hopper, in which dimensions as shown in figure (3.5). Based on that we complete our calculations as the following:

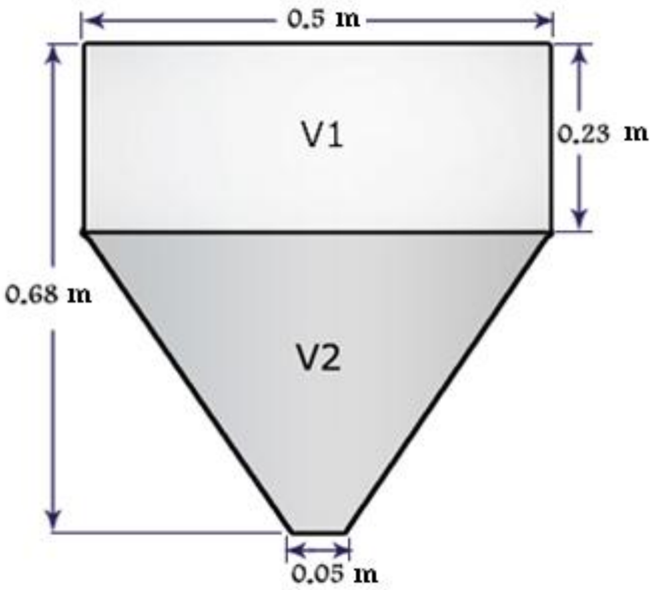


Figure (3.5): Used Hopper

Then:

$$V_{Total} = V_2 + V_1$$

$$V_{Total} = \left(\pi * r_1^2 * h\right) + \left(\frac{1}{3} * \pi * h * \left(r_1^2 + r_1 r_2 + r_2^2\right)\right) = 0.3111 m^3$$

❖ **The Mixture Weight's Calculation:**

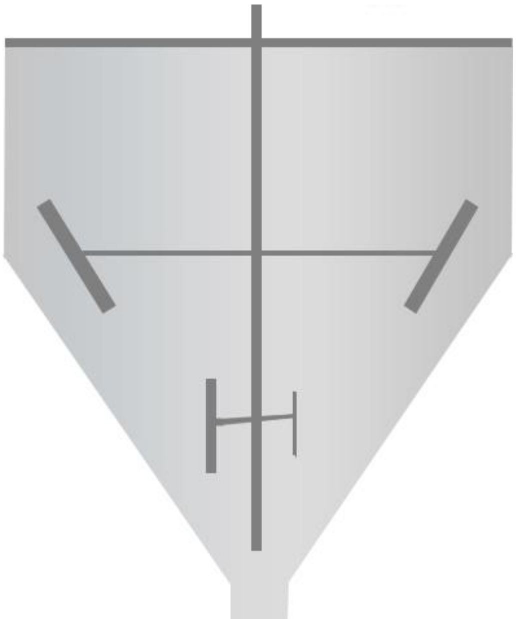


Figure (3.6): Mixture Blades

We have four areas in this mixture that affect on the coffee power.

The equations that we use to determine the volume of the mixture are:

<u>First</u>: we use equation (***number 3***) to determine the volume of the rod mixture, where the volume of the rod is equal $5.089 * (10^{-4})\ m^3$.

<u>Second:</u> we use equation (***number 5***) to determine the volume of the blades of the mixture.

$$V = a * b * c \qquad \text{............... (5)}$$

Where:

- V: is the volume of the rectangular (m^3)
- a: is the length of the rectangular (m)
- b: is the width of the rectangular (m)
- c: is the high of the rectangular (m)

The total volume of the blades of the mixture is equal: $4.96 * (10^{-5})\ m^3$

The total volume of the mixture is equal $5.089 * (10^{-4}) + 4.96 * (10^{-5})$
$= 5.585 * (10^{-4})\ m^3$

The stainless steel density is: 8000 kg/m^3

$$m = V * co \qquad \text{............... (6)}$$

Where:

- V: is the volume (m^3).
- m: is the mass(kg).
- co: is the density (kg/m^3).

V = 5.585 * (10^{-4}) m^3.

m = 5.85 * (10^{-4}) * 8000 = 4.468 kg.

The weight that will affect the selection of the motor is equal 4.468 kg.

The hopper from the top fully closed as shown in Figure (3.7). It is closed to prevent the coffee powder from the germs and dust, and to ensure the protection from external influences. However, there is a door for filling the coffee powder.

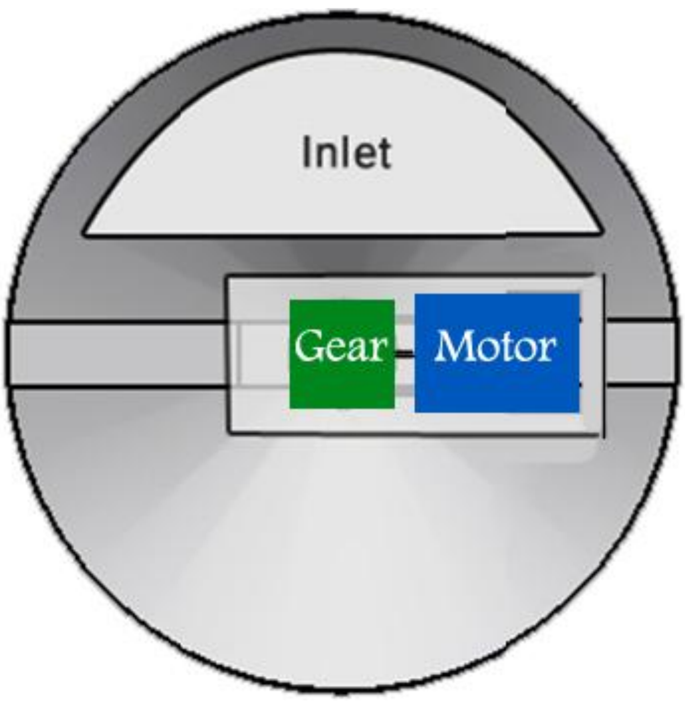


Figure (3.7): Hopper Wrap Up

The rotation of the mixture must be rotate at slow speed and in an appropriate torque. To provide this rotational motion we will use CSTR motor as a primary mover with 1500 rpm. This speed will be decrease by using the gear with conversion ratio equal 50:1; that means the output speed will be 30 rpm.

The coffee powder move from hopper to weighting container, by movable screw shown in figure (3.8), to get maximum accuracy, that mean when the weight of coffee powder in weight container reach the require weight, the powder will stop move to weight container by stop the screw.

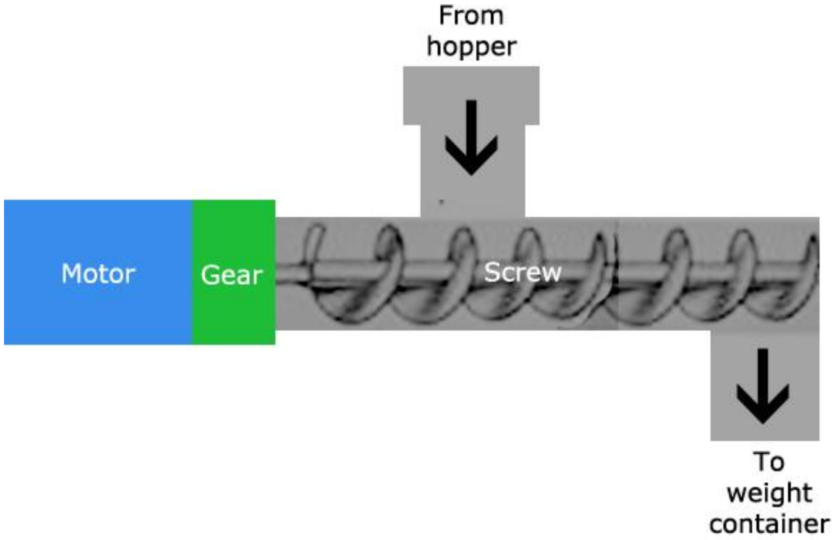


Figure (3.8): The Screw

3.2.2 Balance Stage:

From one of the most important characteristics of filling the coffee machine is the exact weight of the final product with the lowest error rate possible. Using the weight sensor is essential for measuring the powder in balance container as shown in Figure (3.9).

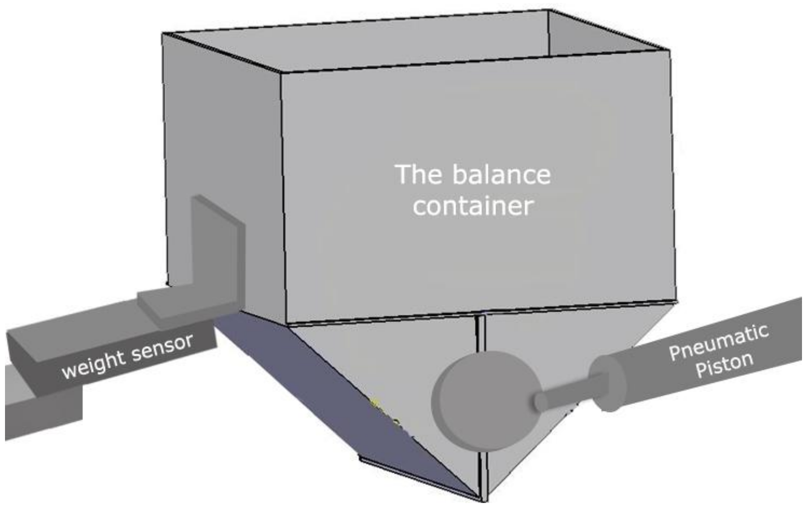


Figure (3.9): Balance Container

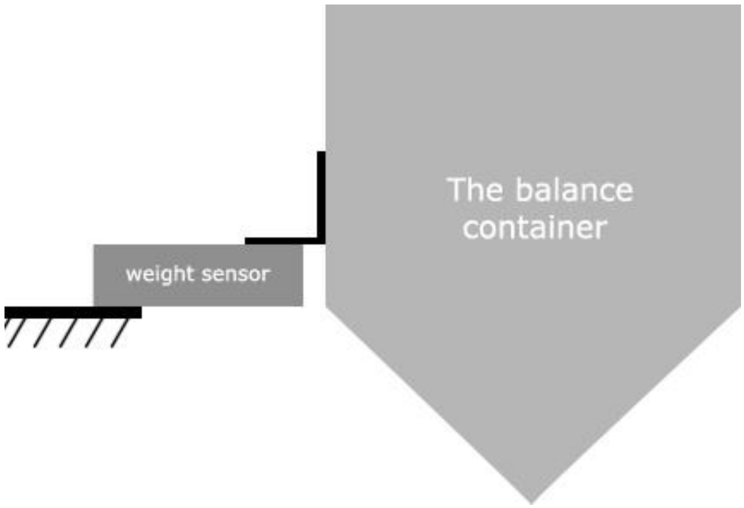


Figure (3.10): Balancer Entrance

The weight sensor finds the total weight, coffee powder and balance container itself.

❖ **The Balance Container's Calculation:**

Let the max weight in the balance include safety amount of coffee is 1kg, and then we can found the volume of container:

We use equation (***number 1***) to determine the volume of the balance container, where the volume of the balance container is equal 0.00193 m^3.

To calculate the size of container, we divide it by two parts as shown in figure (3.11). Where we assume all amount must exist in the top part (V1), and safety part (V2).

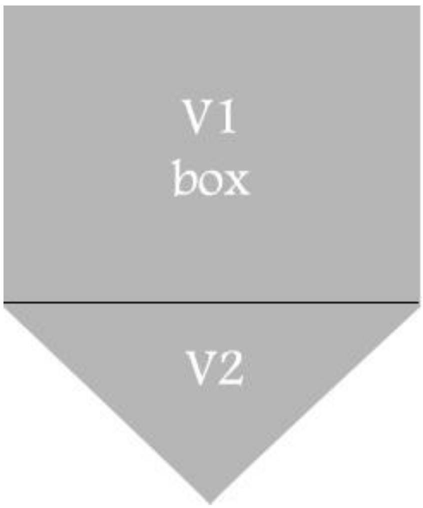


Figure (3.11): Balancer Container Parts

The volume of box can be calculated by:

$$V = a^3 \qquad \text{............... (6)}$$

Where:

- V: volume of the box (m^3).
- a: is the edge length of the cubic (m).

a = 0.124 m = 12.4 cm

3.2.3 Final Container:

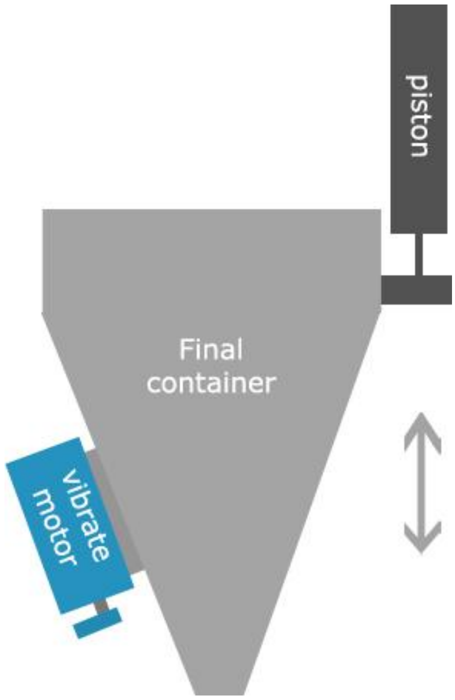


Figure (3.12): Packaging Container

After completion of the weighting stage, the coffee powder will be transmitted from the balance container to the final packaging container as shown in Figure (3.12). The main objective of this container is collecting all amount of coffee powder to fill it in the bag.

Upon completion of the processing bag packing in place under the container, the container will be down to enter little part of container in bag to move all the powder from the container to the bag. A pneumatic piston will be used to raises and lowers the container.

3.2.4 Storage Bags Containers:

The measures of the containers size depend on the size of the bags, and these sizes are shown in Figure (3.13). The containers move so as to take the suited bag by using the piston.

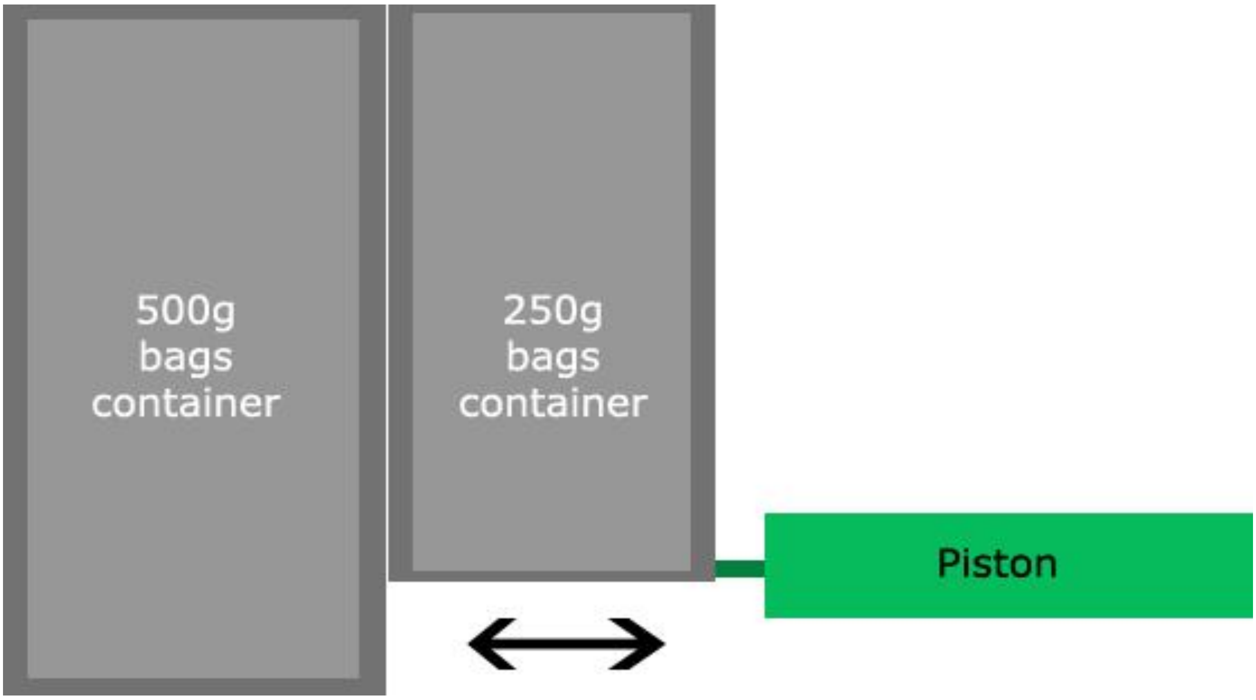


Figure (3.13): Storage Bags Containers

3.2.5 Bag's Opening:

In this stage, job of the moving part is to pull the bag by vacuum, open it, and fill it with powdered coffee.

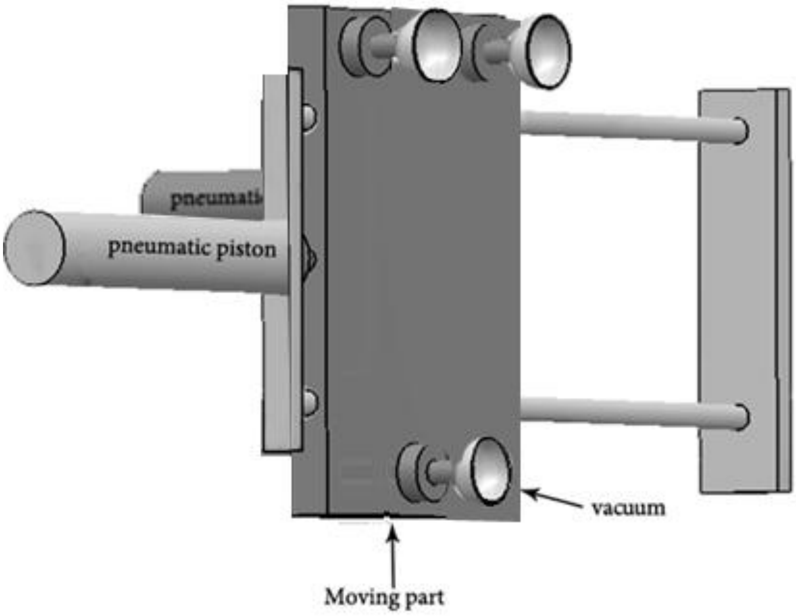


Figure (3.14): Back Interface of the Vacuum Cup

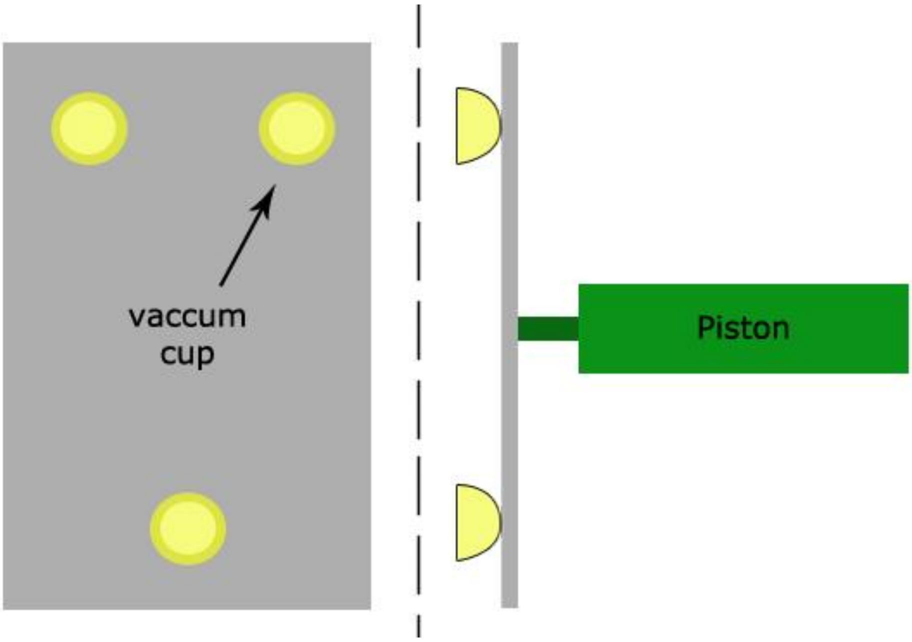


Figure (3.15): Front Interface of the Vacuum Cup

3.2.6 Welding Stage:

The welding stage represents the last step to the final product. It close the nylon bag tightly by heat, where the temperature of the heater is adjusted around 80-90 c^{o}.

The width of the heater as shows in the Figure (3.16) is 18cm. The goal for using this value is the width of the biggest bag, in addition, to be in the save side when welding the bag.

The space between the heater part and the rubber part as shown in figure (3.16) is 10cm. This value is enough to completely open the bag when filled by coffee powder.

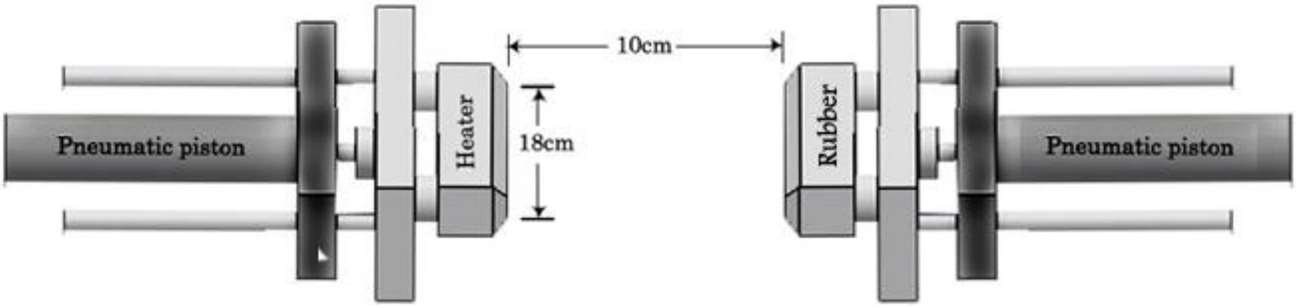


Figure (3.16): Welding Stage

Figure (3.17): shows the side view of the welding machine, and Figure (3.18): shows the top view of the welding machine.

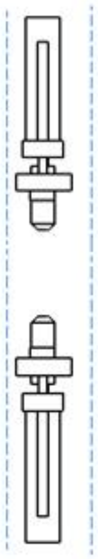


Figure (3.17):
Side of the Welding Method

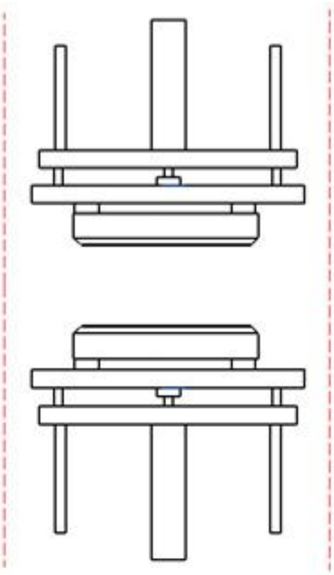


Figure (3.18):
Top Side of the Welding Method

❖ The Cylinder's Calculation:

To determine the size cylinder that is needed for a particular system, certain parameters must be known; so as to make a total evaluation of the load. This total load isn't only the basic load that must be moved, but also includes any friction and the force needed to accelerate the load. Also, the force must be included to exhaust the air from the other end of the cylinder through the attached lines, control valves, etc.

Any other force that must be overcome must also be considered as part of the total load. Once the load and required force characteristics are determined, a working pressure should be assumed. This working pressure that is selected must be the pressure seen at the cylinder's piston when motion is taking place.

It is obvious that cylinder's working pressure is less than the actual system pressure due to the flow losses in lines and valves. With the total load (including friction) and working pressure determined, the cylinder size may be calculated using Pascal's Law. Force is equal to pressure being applied to a particular area. The formula describing this action is: [9]

$$V = P * A \qquad \text{...............} \ \mathbf{(9)}$$

Force is proportional to pressure and area. When a cylinder is used to clamp or press, its output force can be computed as follows:

- P = pressure (pa).
- F = force (Newton's).
- A = area (m^2).

Piston-sectional area can be calculated using the following law:

$$A = \frac{D^2 * \pi}{4} \qquad \text{..............} \ \mathbf{(10)}$$

Where:

- A = area (m^2).
- D = Diameter (m).

Force required obtaining equal friction force, Can be calculated by the following relationship:

$$F_K = \mu_K * F_N \qquad \text{..............} \ \mathbf{(11)}$$

Where:

- F_k = Friction force (Newton's).
- μ_k = Coefficient of friction.
- F_N = Normal force.

The practical pneumatic circuit is shown in figure (3.19).

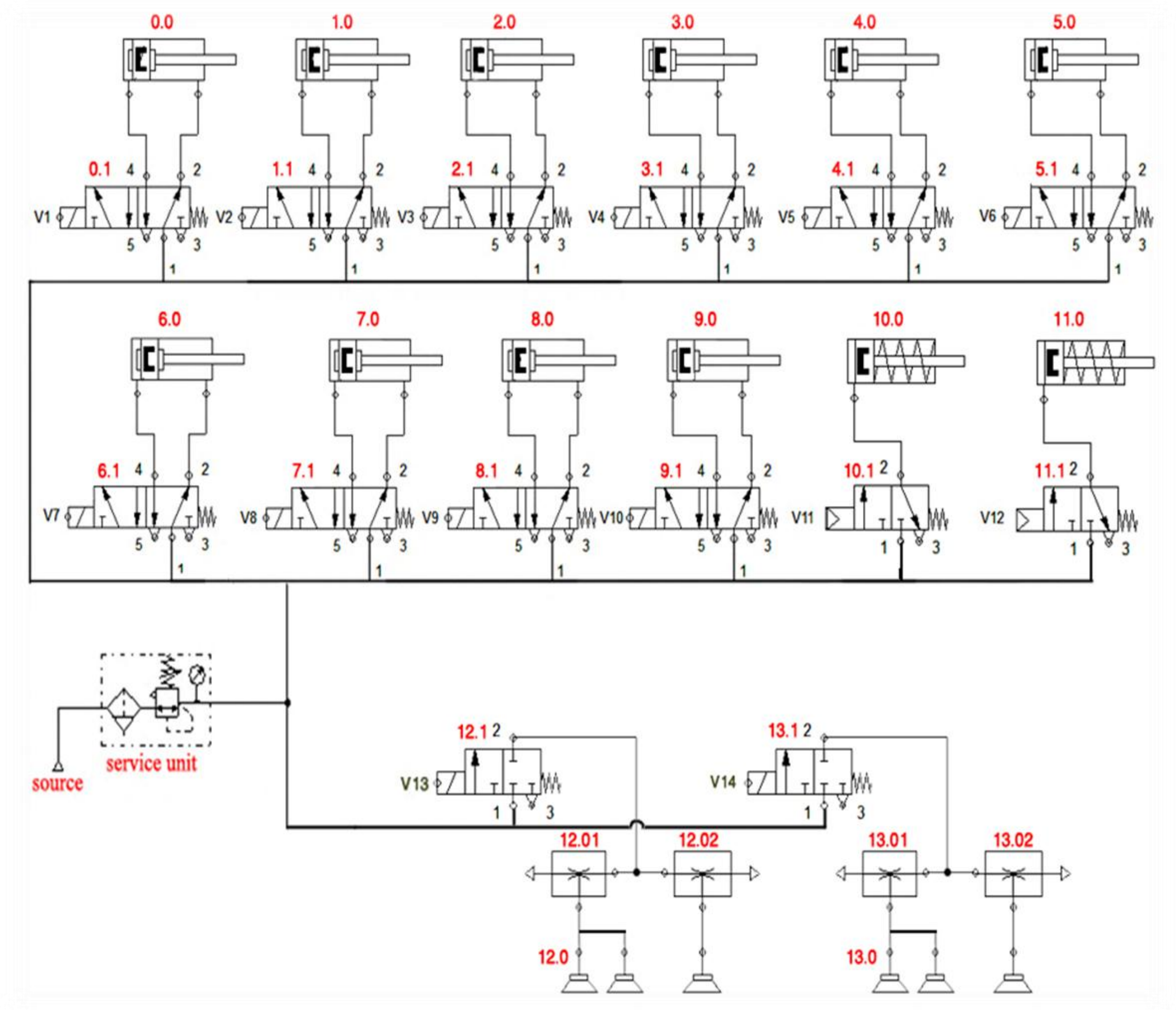


Figure (3.19): Pneumatic Circuit

Table (3.2): Table of Data Description in the Pneumatic Circuit:

Symbols	Description	Function
0.0	Double-acting cylinders.	For moving the small hopper down and up
1.0	Double -acting cylinders.	For pushing
2.0	Double -acting cylinders.	For welding (the cylinder that holds the heat)
3.0	Double -acting cylinders.	For welding (this cylinder that holds the rubber)
4.0	Double -acting cylinders.	For the bag container moving
5.0	Double -acting cylinders.	For holding the coup vacuum (the left hand)
6.0	Double -acting cylinders.	For holding the coup vacuum (the right hand)
7.0	Double -acting cylinders.	For moving the coup vacuum (the right hand)
8.0	Double -acting cylinders.	For eject the bag
9.0	Double -acting cylinders.	For holding the drum and eject bag cylinders
10.0	Single -acting cylinders.	For drumming the bag
11.0	Single -acting cylinders.	For opening the weight gate
12.0	Vacuum cup.	Vacuum coffee bag from the right.
13.0	Vacuum cup.	Vacuum coffee bag from the left.
0.1	5/2 way valve, electrical operation.	Control in piston 0.0, by electrical signal.
1.1	5/2 way valve, electrical operation.	Control in piston 1.0, by electrical signal.
2.1	5/2 way valve, electrical operation.	Control in piston 2.0, by electrical signal.
3.1	5/2 way valve, electrical operation.	Control in piston 3.0, by electrical signal.
4.1	5/2 way valve, electrical operation.	Control in piston 4.0, by electrical signal.
5.1	5/2 way valve, electrical operation.	Control in piston 5.0, by electrical signal.
6.1	5/2 way valve, electrical operation.	Control in piston 6.0, by electrical signal.
7.1	5/2 way valve, electrical operation.	Control in piston 7.0, by electrical signal.
8.1	5/2 way valve, electrical operation.	Control in piston 8.0, by electrical signal.
9.1	5/2 way valve, electrical operation.	Control in piston 9.0, by electrical signal.
10.1	5/2 way valve, electrical operation.	Control in piston 10.0, by electrical signal.
11.1	5/2 way valve, electrical operation.	Control in piston 11.0, by electrical signal.
12.1	3/2 way valve N.C, electrical operation.	Control in vacuum valve 12.01 and 12.02, by electrical signal.
13.1	3/2 way valve N.C, electrical operation.	Control in vacuum valve 13.01 and 12.03, by electrical signal.
12.01	Vacuum valve.	Control in vacuum cup 12.0
12.02	Vacuum valve.	Control in vacuum cup 12.0
13.01	Vacuum valve.	Control in vacuum cup 13.0
13.02	Vacuum valve.	Control in vacuum cup 13.0
Source	Air pressure source.	Air supply to the circuit.
Service unit	Service unit.	Adjust the air pressure, filtering, and lubricate it.

3.3 Electrical Design:

3.3.1 The Motors Calculations:

<u>First: Mixer Motor:-</u>

To determine or select the motor there are two things that will affect on the selection:

- The coffee friction with the mixture.
- The weight of the mixture.

The coffee friction with the mixture:

$$\boldsymbol{F = v * co * g} \qquad \text{.............. (12)}$$

Where:

- F: is the force (N)= kg.m/s^2.
- v: is the volume(m^3).
- g: is Gravity Acceleration = 9.807 m/s^2.
- co: is the Coffee Powder Density kg/m^3.

F = v * co * g

F = 5.585 * (10^{-4}) * 518.4 * 9.807 = 2.83N

$$\boldsymbol{T_l = F * r} \qquad \text{.............. (13)}$$

Where:

- T_l: is the torque load (N.m).
- F: is the force (N).
- r: is the radius of mixture rod (m).

r = 1.8 cm
= 0.018m

Tl = 2.83* 0.018
= 0.5094 N.m

$\boldsymbol{T_{Output\ of\ Gear} = TL}$

The gear ratio is: 10:1

$$\boldsymbol{a = Output\ Speed\ /\ Input\ Speed} \qquad \text{.............. (14)}$$

Where:

- a : is the gear ratio

a = Output / Input

a = 150/1500

= 0.1

$$\omega = (2 * \pi * n) / 60 \qquad \text{.............. (15)}$$

Where:

- ω: is the motor speed in the rad/s
- n : is the motor speed in rpm

$\omega = (2 * \pi * 1500) / 60$

$\omega = 157.08$ rad/s

The input gear part:

$$\boldsymbol{T_{Input} = (T_{Output} * a) / Efficiency} \qquad \text{.............. (16)}$$

Let the gear efficiency: 70%

$\mathbf{T_{Input}} = (0.5094 * 0.1) / 0.7$

$= 0.072$N.m

$$P_{Output} = T_{Input} * \omega \qquad \text{.............. (17)}$$

$P_{Output} = T_{Input} * \omega$

P_{Output} = 0.072 * 157.08
= 11.30w

The weight of the mixture that will affect on the selection the motor is 4.468 kg

$$F = m * g \qquad \text{.............. (18)}$$

Where**:**

- F: is the force (N).
- m: is the mass(kg).
- g: is Gravity Acceleration = 9.807 m/s^2

F = 4.468 * 9.807
= 43.81N

$T_l = f * r$
= 43.81 * 0.018
= 0.78858 N.m

$T_{Input} = (T_{Output} * a) / Efficiency$
= 0.78858 * 0.1/0.7
= 0.1126 N.m

$P_{Output} = T_{Input} * \omega$
= 0.1126 * 157.08
= 17.687w

The total power that affect on the motor selection = 11.30 + 17.687
= 28.98w.

From that calculation we need motor with 28.98 watt/24Vdc “shunt”.

Second: Screw Motor:-

To determine or select the motor we will use the following equations [14]:

$$V = \frac{Screw\ Diameter\ (m) * \pi * Rotations\ Per\ Minutr}{60} \quad \text{.............. (19)}$$

V: speed in m per sec

$$Q = \frac{\pi * D^2 * s * n * sg * i * 60}{4} \quad \text{.............. (20)}$$

Where**:**

- Q: is the capacity in kg per hour
- D: is the screw diameter in m
- s: is the pitch per minute
- n: is the rotations per minute
- sg: is the specific weight of the material
- i: is the degree of trough filling

$$P = \frac{Q * L * K}{407} \quad \text{.............. (21)}$$

Where**:**

- P: is the power (kw)
- Q: is the capacity in 1000 kg per hour
- L: is the conveyor screw length
- K: is the friction coefficient

3.3.2 The Dynamic Braking Resistance Calculation [10]:

To determine the value of the dynamic resistance we will use the equation (***number 19***).

$$R_D = \left(\frac{Va - (I_a * R_a)}{I_{max}}\right) - R_a \quad \text{.............. (22)}$$

Where:

- R_D: is the dynamic resistance (Ω).
- Va: is the armature voltage (V).
- Ia: is the armature current (A).
- Ra: is the resistance of the armature (Ω).
- Imax: is the maximum current (A).

The screw motor parameters as shown in table (3.2) are from the name of the motor plate.

Table (3.3): Table of Parameter of Screw Motor:

Parameter	Value
Va	24V
Ia	1.5A
Ra	2.1 Ω
Speed	180 rpm

$R_D = ((24 - (1.5*2.1)) /3) - 2.1$
$= 4.85\ \Omega$.

From that we want dynamic resentence with value 4.85 Ω to give us the perfect solution.

3.3.3 The Photovoltaic Calculation:

In Filling Coffee Machine have the following AC load:

Table (3.4): Table of Power Consumption of the Machine:

Element	DC Load (W)	AC Load (W)
Vibrate motor (1)		246
Vibrate motor (2)		20
Heater		800
Mixing motor	100	
Screw motor	30	
valves	42	
relays	18	
Total	**190**	**1066**

Assume the machine run (6) hours in every day, the total power consummation equal 7536 Wh/day. The losses during inverter equal 15%, then:

Total dc load (Wh/day) = dc load (Wh/day) + (ac load (Wh/day) / Inverter η) .... (23)

= 1140 + (6396 / 0.85)

= 8664.7 Wh/day

We have AC load equal 1066 W, then we must choose system voltage equal 24V. Now convert total DC load to load expressed as Ah@ the system voltage, by the following formula[13]:

Total load (Ah/day @ System voltage) = Total dc load (Wh/day) / System voltage (V) .. (24)

= 8664.7 / 24

= 361

The average peak sun hours of nearly location of Palestine (Cairo) equal 7h for December (the worst month of the year for illumination) [11], and estimated Coulomb efficiency (default 0.90), de-rating factor (default 0.90), I_r=7.72A[12], to determine design-month Ah/day delivered per string[13]:

Ah/day-string = Insolation (h/day @ 1-sun) × I_R (A) × Coulomb × De-rating .... (25)

= 7 × 7.72 × 0.90 × 0.90

= 43.7724

The number of parallel strings of modules based on:

Strings in parallel = Design-month load (Ah/day) / Ah/day per module .... (26)

= 361 / 43.7724

= 8.2

Then use 8 strings.

The nominal module voltage equals 21.2 V [12], then the number of modules in series:

Modules in series = System voltage (V) / Nominal module voltage (V) .... (27)

= 24/ 21.2

= 1.13

As a conclusion, we will use two modules in series.

To find battery size:

Peak sun hours are for the worst month of the year and availability is 7h, then from the figure (3.20).

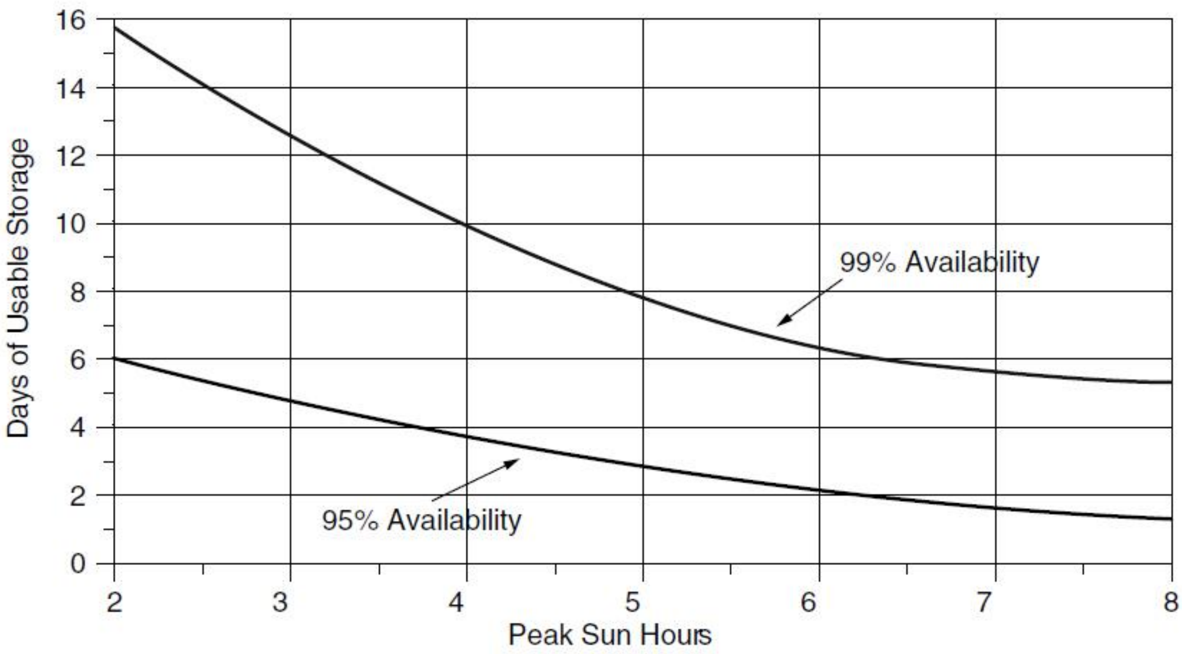


Figure (3.20): Days of Battery Storage Needed for a Stand-Alone System With 95% and 99% System Availability.

The days of usable storage equal 1.5 days, then the usable storage needed can be calculated by:

Usable storage (Ah) = Total load (Ah/day) × Days of storage (days) .... **(28)**

= 361 × 1.5

= 541.5 Ah.

If use the discharge rate is C/ 20, and the less temperature is -2^{o} then the (T,DR) = 0.85 as shown from figure (3.21).

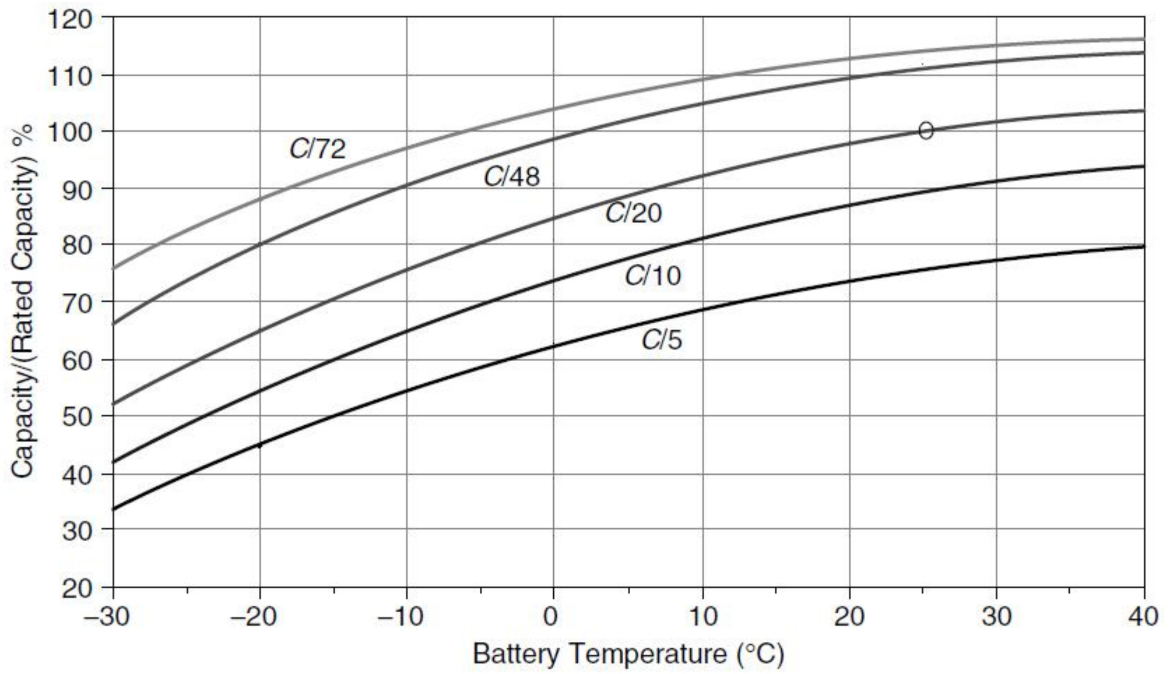


Figure (3.21): T,DR curve

We used a deep-cycle lead-acid battery, then the maximum depth of discharge (MDOD) = 0.8

Then the total storage capacity:

$$\textbf{Total Storage Capacity} = \frac{\text{Usable Storage (Ah)}}{(\text{MDOD}) \times (\text{T,DR})} \qquad \textbf{................. (29)}$$

= 541.5 / (0.8 × 0.85)
= 741.5Ah

Number of Batteries in Series = System Voltage / Nominal Battery Voltage .... (30)
= 24 / 12
= 2 battery.

$$\textbf{Number of Batteries in Parallel} = \frac{\text{Total Storage Capacity (Ah)}}{\text{Capacity of One Battery (Ah)}} \qquad \textbf{............... (31)}$$

= 741.5 / 240
= 3.098 battery

Then use 4 string.

Table (3.5): The PV Calculation Result:

Element	Type	
	String	Series
PV Modules	8	2
Battery	4	2

❖ **The Practical Photovoltaic Circuit**:

From our calculations we planned to do the photovoltaic circuit as shown in figure (3.22); so as to give us the perfect performance.

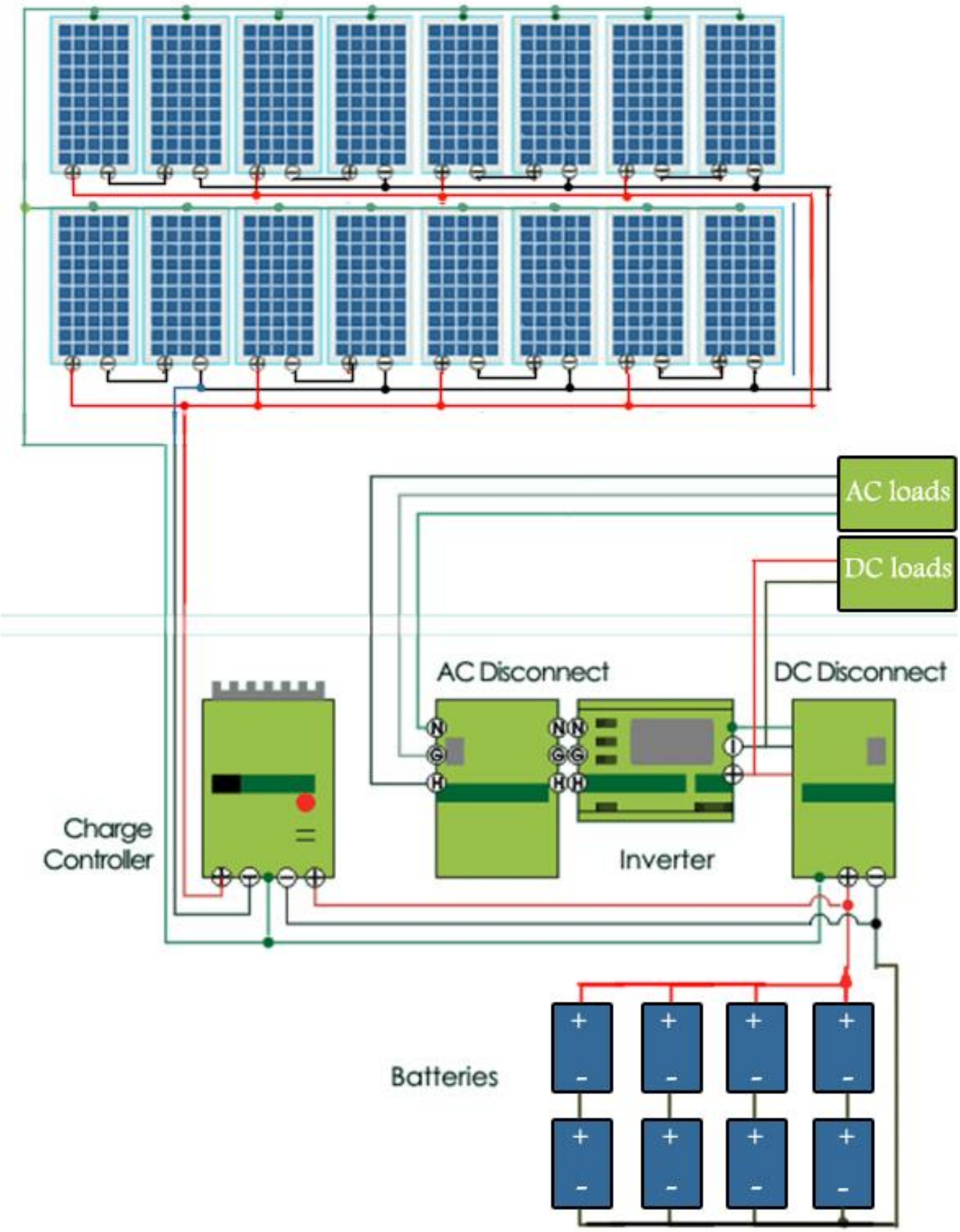


Figure (3.22): Practical Photovoltaic Circuit

3.3.4 The Control:

The electrical circuit has two main parts: power and control circuit.

The following table (3.6) has symbols of all elements connected with the PLC, such as: digital and analog inputs, digital outputs, and its description.

Table (3.6): Table of Data Description in the PLC Connection:

Symbols	Description
S1	Emergency switch used for stopping the machine.
S2	Pressure sensor used for indicating whether the air in the system or not.
S3	Magnetic limit switch gives indication that the holding vacuum (Front) cylinder is backward.
S4	Magnetic limit switch gives indication that the push eject cylinder is forward.
S5	Magnetic limit switch gives indication that the holding vacuum (Backward) cylinder is backward.
S6	Magnetic limit switch gives indication that the holding vacuum (Backward) cylinder is forward.
S7	Magnetic limit switch gives indication that the holding vacuum (Front) cylinder is forward.
S8	Magnetic limit switch gives indication that the pushing (R\L “30cm”) cylinder is forward.
S9	Magnetic limit switch gives indication that the small hopper cylinder is forward.
S10	Magnetic limit switch gives indication that the pushing (F\B “20cm”) cylinder is forward.
S11	Magnetic limit switch gives indication that the pushing (F\B “20cm”) cylinder is backward.
S12	Magnetic limit switch gives indication that the pushing (R\L “30cm”) cylinder is bacward.
S13	Magnetic limit switch gives indication that the welding cylinder is forward.
S14	Proximity sensor used for indicating whether there is a bag or no.
Weight Sensor	To indicate whether the weight reach the optimum value.
Thermocouple Sensor	To indicate whether the temperature reach the optimum value.
V1	To control the cylinder that moves the small hopper down and up.
V2	To control the pushing cylinder.
V3	To control the welding cylinder (this cylinder is holding the heat)
V4	To control the welding cylinder (this cylinder is holding the rubber)
V5	To control the bag container cylinder.
V6	To control the holding the coup vacuum cylinder (the left hand).
V7	To control the holding the coup vacuum cylinder (the right hand).
V8	To control the moving the coup vacuum cylinder (the right hand).
V9	To control the ejection of the bag cylinder.
V10	To control the holding cylinder that holds the drum and ejects bag cylinders.

V11	To control the drumming on the bag cylinder.
V12	To control the opening of the weight gate cylinder.
V13	To control the Vacuum cup unit from the right.
V14	To control the Vacuum cup unit from the left.
R1	To select the screw motor speeds (fast or slow).
R2	To connect the dynamic braking resistance with the screw motor.
R3	For switching the mixture motor ON/OFF.
R4	For switching the big vibrator motor.
R5	For switching the small vibrator motor.
R6	For switch the conductor.
K1	For switch the heater ON/OFF.
H1	Indicate lamp give us indication whether there is electricity or not.
H2	Indicate lamp give us indication whether the PLC work or not.
H3	Indicate lamp give us indication whether there is error or not.

Chapter Four

“ Implementation ”

4.1 Implementation Process

- **4.1.1 The Body**
- **4.1.2 The Hopper**
- **4.1.2 The Mixer**
- **4.1.3 The Screw**
- **4.1.4 The Weight Scale**
- **4.1.5 The Small Hopper**
- **4.1.6 The Vacuum Unit Device**
- **4.1.7 The Welding**
- **4.1.8 The Bag Container**
- **4.1.9 The Drum**
- **4.1.10 The Final Shape of the Machine**

4.2 Implementation of the Touch Screen

4.3 Obstacles and solutions

In chapter three we explained how to make the design and its' calculations for the project. From that result we started implementing the project practically not just theoretically. In this chapter we will explain the implementation process, providing photos of the project in different viewpoint, and the target from every part.

4.1 Implementation Process:-

4.1.1 The Body:

First part that we worked on is body of the machine as shown in figure (4.1), where this body will hold all parts of the machine. By using this body, we can easily assemble and disassemble the other parts of the machine. We gild the machine by using brown dotted black color, by paint oven.

Figure (4.1): Body of the Machine

4.1.2 The Hopper:

The first assemble part in the machine is the hopper as shown in figure (4.2), where this hopper will hold the quantity of the coffee powder that we previously calculated.

Figure (4.2): Hopper

4.1.2 The Mixer:

For increasing the coffee powder flow in the hopper we use mixer blades as shown in figure (4.3). This mixer moves by using an electrical motor. Figure (4.4) shows the mixr blades inside the hopper.

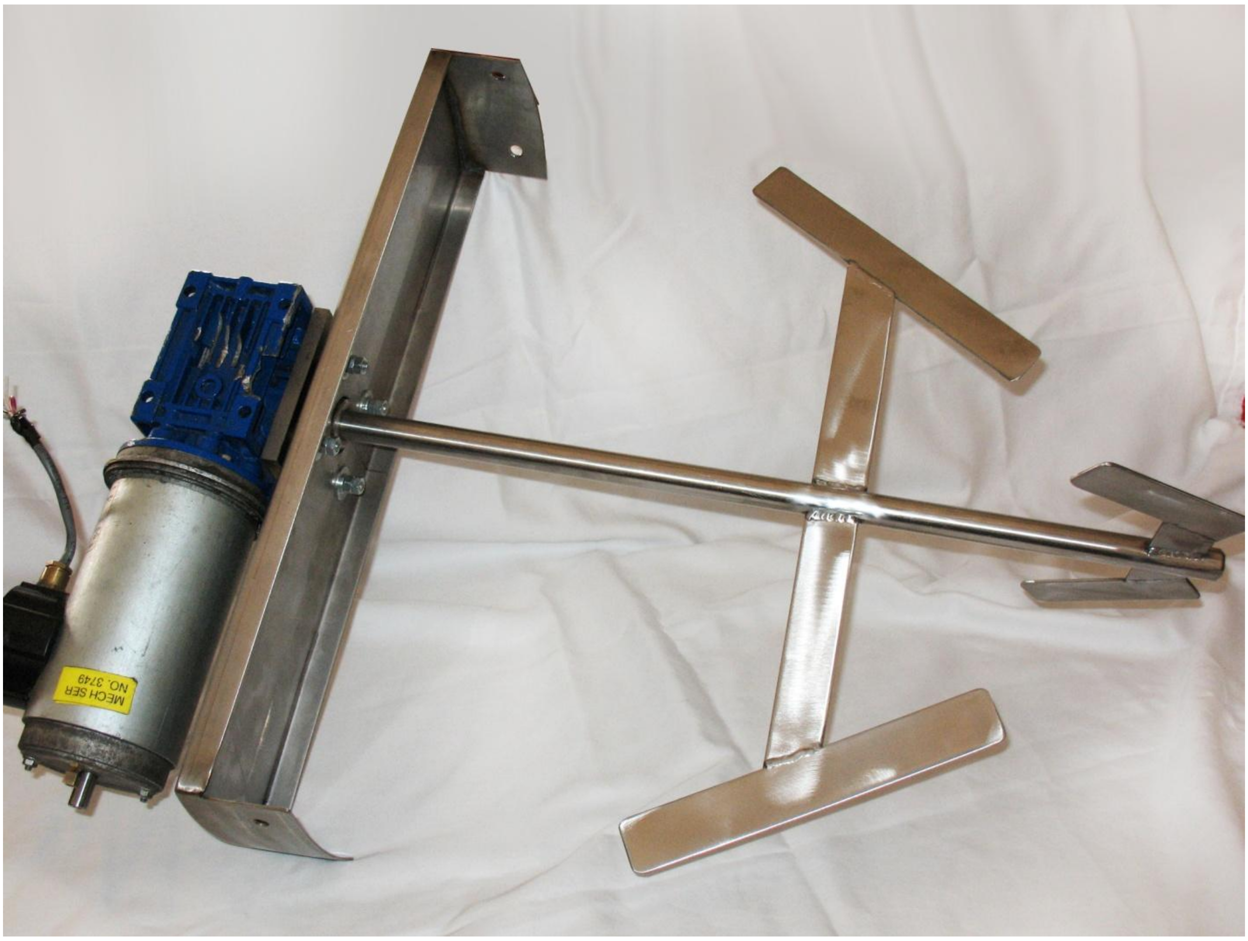


Figure (4.3): Mixer Blades

Figure (4.4): Mixer Blades inside the Hopper

4.1.3 The Screw:

To transfer the coffee powder from the hopper to the wegiht we use a screw as shown in figure(4.5). We control the motion speed to have a perfect result in the weighing method. Also the figure (4.6) shows how the srew is connected with the hopper.

Figure (4.5): Screw

Figure (4.6): Screw Connection with The Hopper

4.1.4 The Weight Scale:

After the transaction of the coffee powder from the screw to the weight scale as shown in figure (4.7), the powder gets weighted to reach the optimum weight scale.

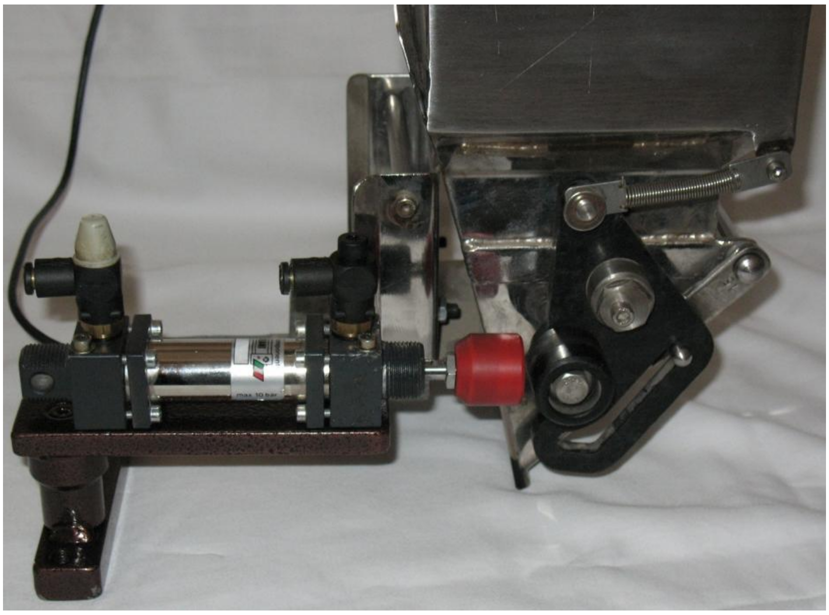


Figure (4.7): Weight Scale

To get the optimum weight we use the load cell sensor as shown in figure (4.8).

Figure (4.8): Weight Scale

Figure (4.9) shows how the weight scale is connected with the body of the machine.

Figure (4.9): Weight Scale Connection with the Body of the Machine

4.1.5 The Small Hopper:

We use the small hopper as shown in figure (4.10) as a device for transferring the coffee powder from the weight scale to the bag.

Moreover, we use a vibrator motor as shown in figure (4.10) for easy flow of the coffee powder.

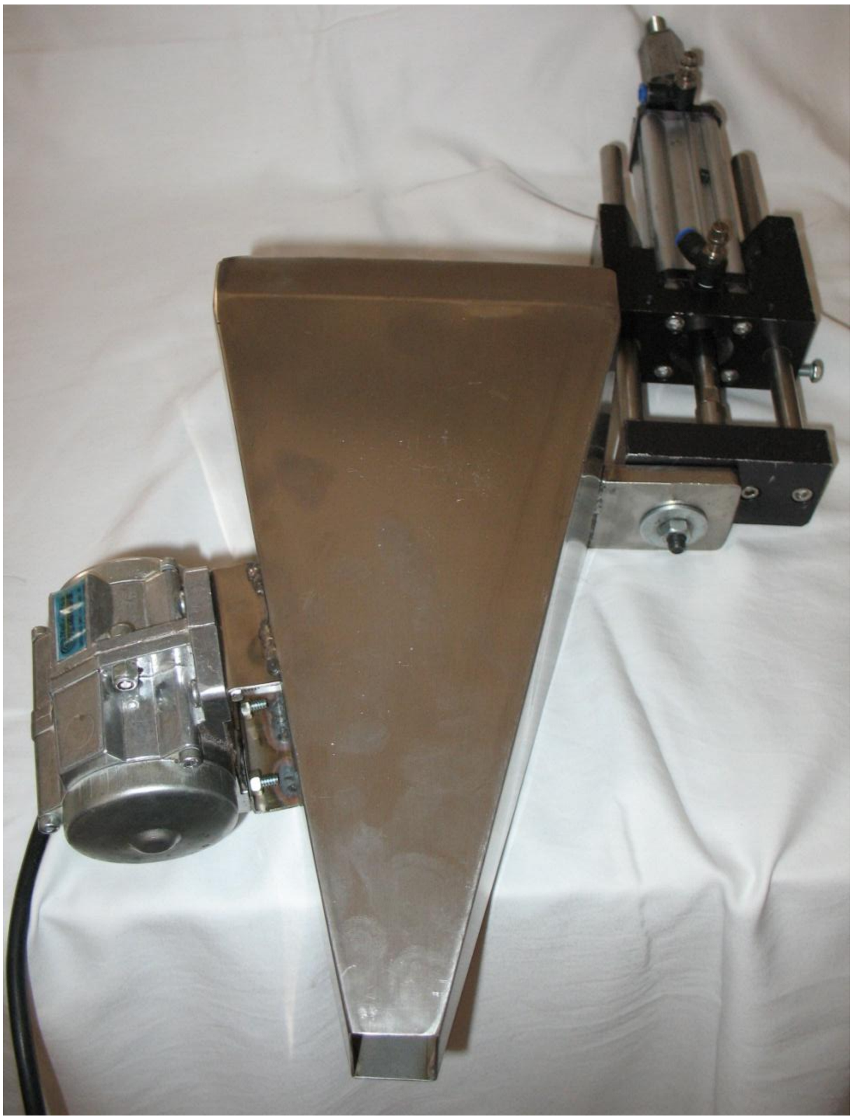


Figure (4.10): Small Hopper

Figure (4.11) shows how the small hopper is connected with the body of the machine.

Figure (4.11): Small Hopper Connection with the Body of the Machine

4.1.6 The Vacuum Unit Device:

Using the vacuum unit device as shown in figure (4.12) helps taking the bag from the bag container, in addition opening the bag for preparation of packaging it.

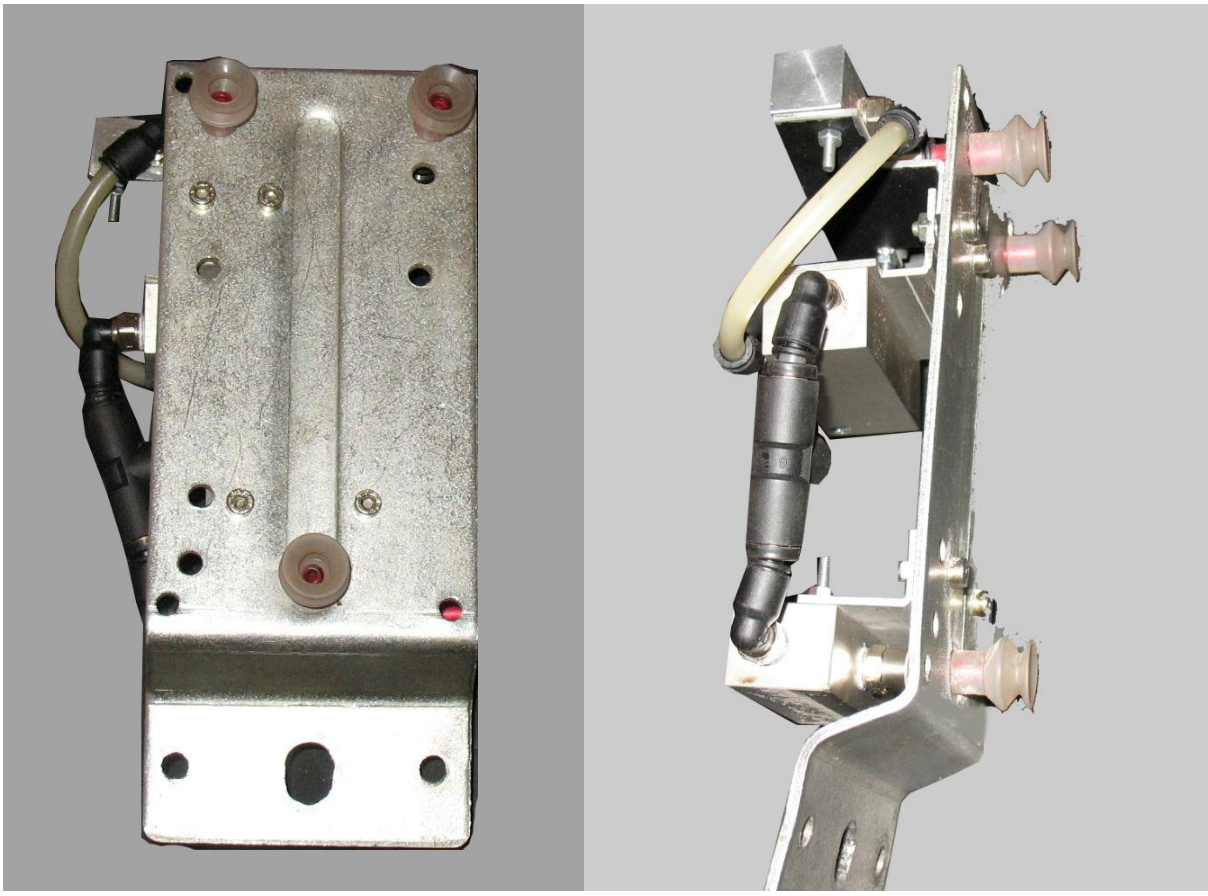


Figure (4.12): Vacuum Unit Device

Figure (4.13) shows how the small hopper is connected with the body of the machine.

Figure (4.13): Vacuum Unit Device Connection with the Body of the Machine (From the Right-Hand Side)

4.1.7 The Welding:

After opening and filling the bag with the coffee powder, the bag will be welded by the welding resistor as shown in figure (4.14) and thermo rubber as shown in figure (4.15).

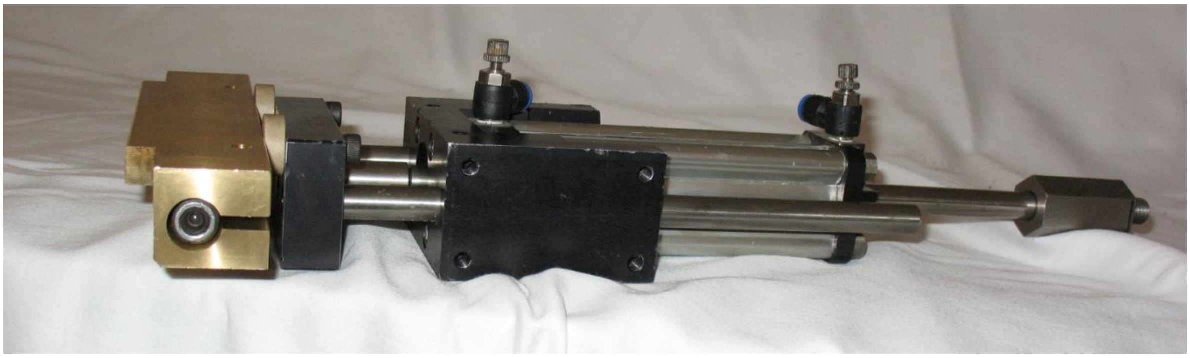


Figure (4.14): Welding Resistor

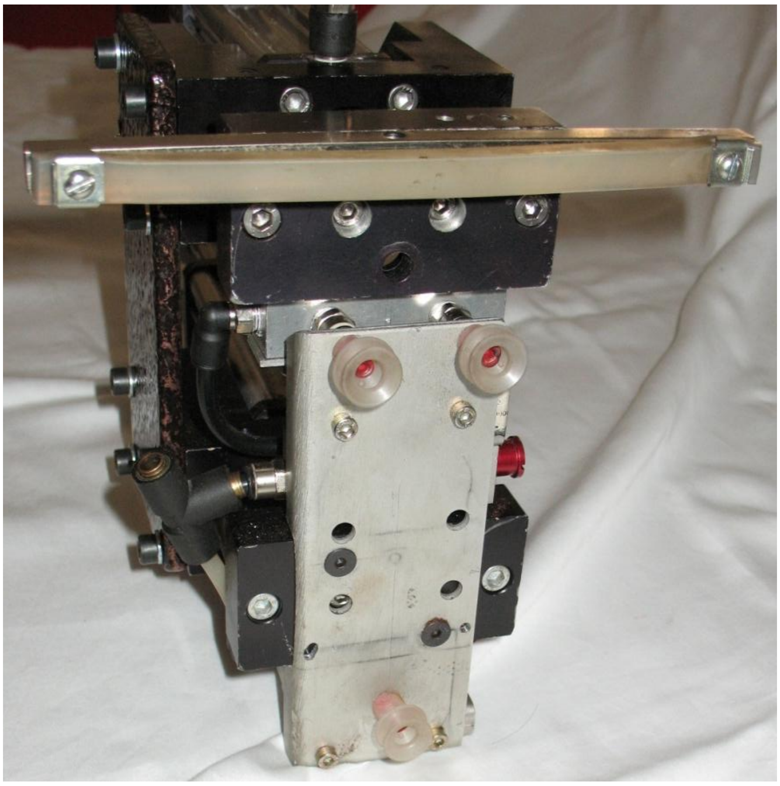


Figure (4.15): Thermo Rubber

Furthermore, figure (4.15) shows the thermo rubber and the vacuum unit from the left-hand side.

Figure (4.16) shows how the small hopper is connected with the body of the machine.

Figure (4.16): Vacuum Unit Device Connection with the Body of the Machine

4.1.8 The Bag Container:

The bag container as shown in figure (4.17) is used for storing the bags. In addition, it store two different sized of bags.

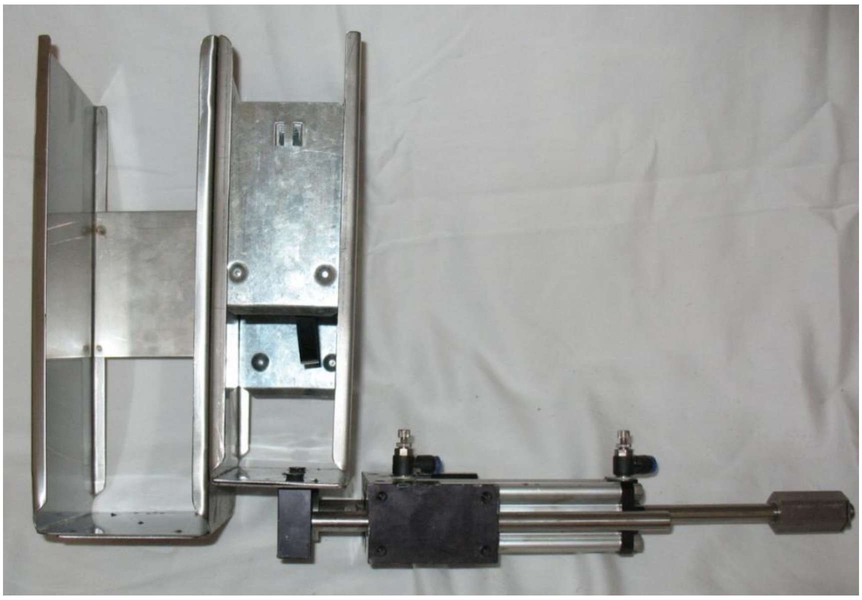


Figure (4.17): Bag Container

Figure (4.18) shows how the bag container is connected with the body of the machine.

Figure (4.18): Bag Container Connection with the Body of the Machine

4.1.9 The Drum:

Figure (4.19) shows how the drum cylinder is connected with the body of the machine. It is used for drumming the bag, because the weighted coffee powder takes a small place in the bag, for taking a good weld.

Figure (4.19): Drum Cylinder Connection with the Body of the Machine

Figure (4.20) shows how the drum and the eject cylinder are connected with the body of the machine.

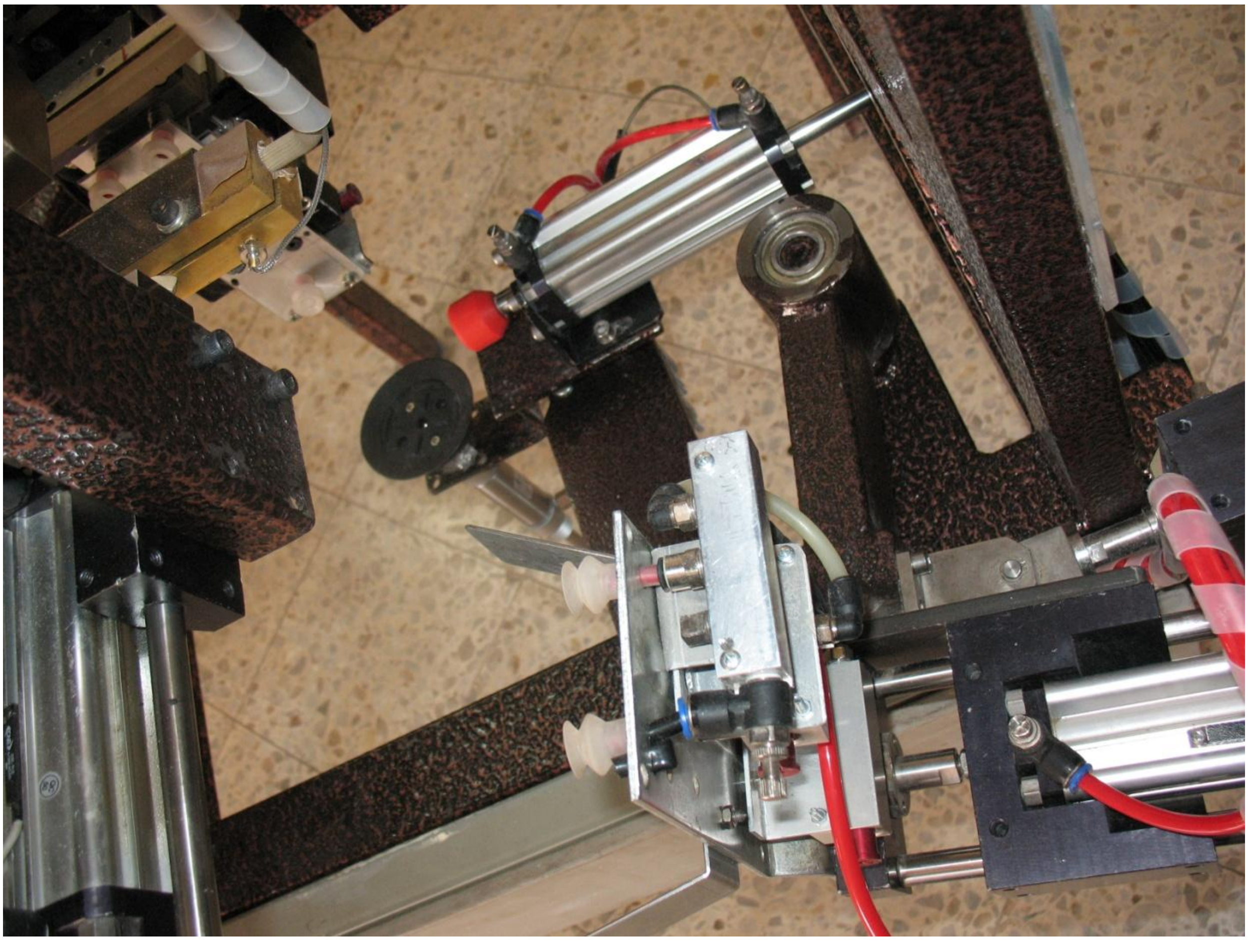


Figure (4.20): Drum and Eject Cylinders Connection with the Body of the Machine

Figure (4.21) shows the valves connection in the air board of the machine.

Figure (4.21): Valves Connection of the Machine

Figure (4.22) shows the indicator lamp and the pressure regulator of the machine.

Figure (4.22): Indicator Lamp and Pressure Regulator of the Machine

Figure (4.23) shows the electrical board of the machine, and the PLC connection.

Figure (4.23): Electrical Board of the Machine

4.1.10 The Final Shape of the Machine:

The final mechanical shape of the machine is shown in figure (4.24).

Figure (4.24): Final Mechanical Shape of Filling Coffee Machine

The final shape of the machine is shown in figure (4.25).

Figure (4.25): Filling Coffee Machine

4.2 Implementation of the Touch Screen:-

The figures below show the progamming that we made to program the touch screen.

Figure (4.26) shows the main page of programing the touch screen for the filling coffee machine (FCM). In this page we can choose calibration, operation, monitor, or error.

Figure (4.26): Main Page

Figure (4.27) shows the calibration page, where we can choose the heat, or weight.

Figure (4.27): Calibration Page

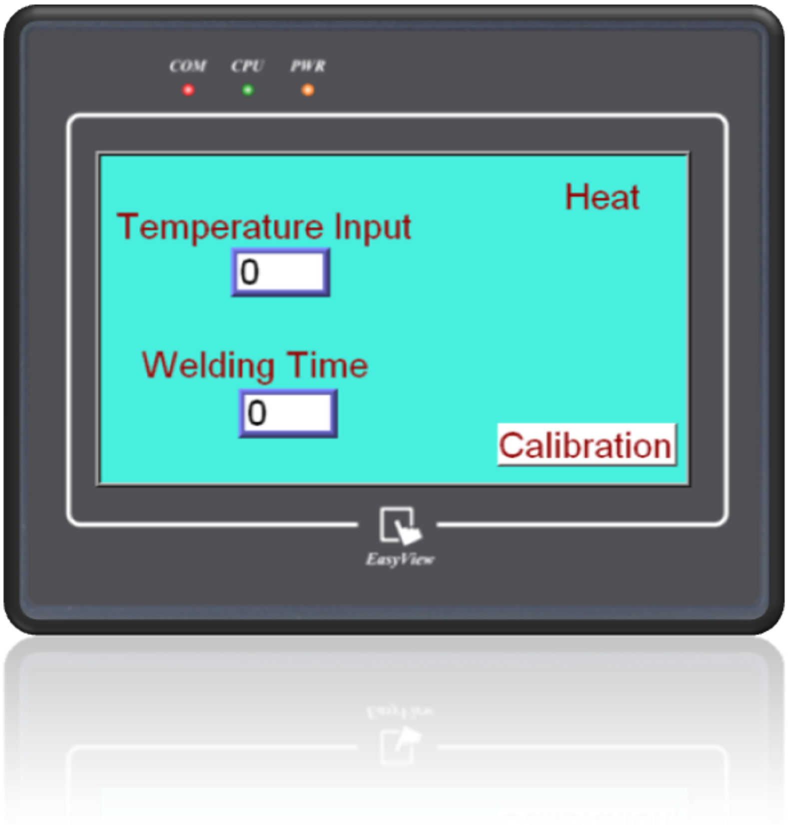


Figure (4.28): Heat Calibration Page

Figure (4.28) shows the heat calibration page, where we can enter the temprature value for the heater to reach the entered value and the time for welding the bag.

Figure (4.29) shows how we can enter the value from the touch screen.

Figure (4.29): Entering Value

Figure (4.30) shows the weight calibration page. Where we can select the type of the bag according to the weight value.

Figure (4.30): Weight Calibration Page

Figure (4.31) shows the 250g calibration page. Where we can enter the weight value and the bag quantities. The most important thing in this section is that the weight value is flexibel, not fixed.

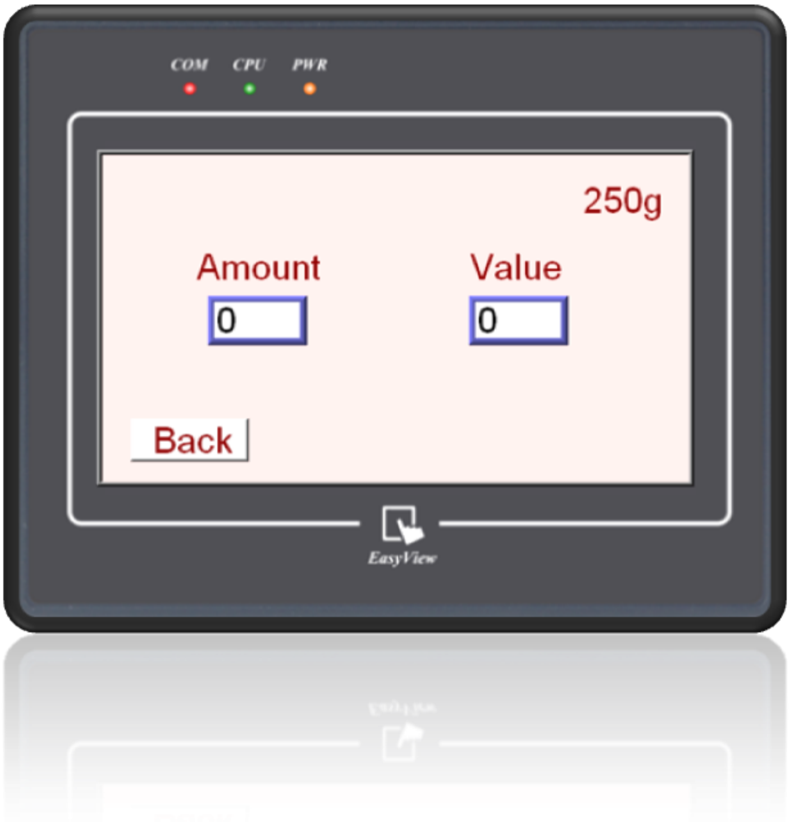


Figure (4.31): 250g Calibration Page

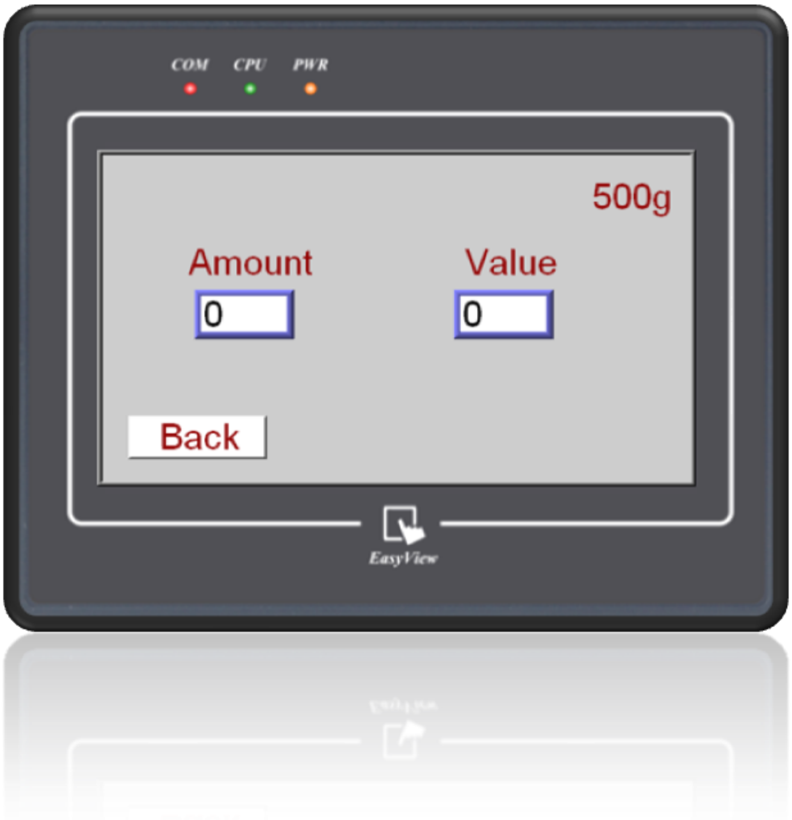


Figure (4.32): 500g Calibration Page

Figure (4.32) shows the 500g calibration page. Where we can enter the weight value and the bag quantities. The most important thing in this section is that the weight value is flexibel, not fixed.

Figure (4.33) shows the operation page. Where we can start, or stop the filling coffee machine (FCM) operation.

Figure (4.33): Operation Page

Figure (4.34): Monitor Page

Figure (4.34) shows the monitor page. Where we can observe the heat tempreture, and the weight value in the operation method.

Figure (4.35) shows the error page. Where we can observe the error when it happenns, whether it's in the pressure air, the coffee powder, and the bag.

F

Figure (4.35): Error Page.

4.3 Obstacles and solutions:

We faced several obstacles during the implementation phase; therfore we tried to overcome them. They are:

1. The vacuum:
   There are specific cups of vacuum that holds the bags. We used the wrong one, and it took us a period og time to figure the right vacuum cup and that made a delay with the implementation process.

2. The small hopper:
   We used a hopper with many edges. These edges made the flow of the coffee powder difficult from one part to another. Accordingly we designed a new hopper with less edges.

3. The big hopper:
   There was an edge between the screw and the hopper. This edge leds to rigid transission of the coffee powder between the parts. Thus we trimmed the edge so as not to let the coffee powder get stuck.

4. Opening the bag:
   We fixed the vacuum unit from the right-hand side, and that led to not openning the bag to the optimum space. Therefore we made the vacuum unit move forward and backward.

Chapter Five

“ Conclusions and Recommendations ”

5.1 Conclusions

5.2 Recommendations

5.1 Conclusions:

This section presents some conclusions that resulted from implementing and testing the project. Also it explains in details the goals that were achieved from the project. We can sum up the conclusions in the following points:

1. The team work of the project put the aims of the project and studied the theoretical part of the project (theories and laws). The team proved that the theoretical methods can be executed in real world and they can be applicable.

2. From using the temperature, and the load cell modules they increase the data accuracy. Also they help us in programming the control of the machine.

3. In the initial design of mechanical parts, we put vertical screw between the hopper and the balance container. But after testing it, we found that there is transmission of a small amount of coffee powder after stopping the hopper motor. This small amount of powder leads to increase the error rate in weight; thus failure to achieve the main goal of the project which is to get the highest accuracy in weight. Therefore, we made some amendments to the design to overcome the problem; by placing the screw in a horizontal position, and controlling it with an electrical motor.

4. Coffee powder is characterized by a high degree of cohesion, which means that the powder can't move easily from one part to another in machine. So we found it necessary to use vibrator that contribute to increase the degree of flow of coffee powder.

5. We used many of the vacuum cup, different shape and size. Finally we found that there is only one type capable of vacuuming the bag. However, other species don’t give the desired result with less suction power.

5.2 Recommendations

In the end, we have many recommendations that can contribute to the provision of improvements to the project, could have been done, but there was no plenty of time, and not have the financial support needed for them. These recommendations can be summarized in the following points:

1. Use a thermocouple sensor to measure the temperature, requires changing after period of time. Because of the increasing rate of error of using for extended periods of time, as well as the permanent need for calibration; accordingly we recommend using PTC sensors that are characterized by: a higher resolution, greater stability, and ability to work for longer periods without the need to calibrate or replaced it by another sensor.

2. Increase the weight selection level, where it becomes 250g, 500g, one kilogram or more.

3. This machine can be part of an integrated production line that contains: grinding coffee, the completion of mixtures, then use the machine in the packaging to have the final product.

4. To complete implementing the Photovoltaic System, that we calculated.

References

[1] P. Beater, *Pneumatic Drives*, Springer, Berlin Heidelberg, New York, 2007.

[2] *Transformers and Motors*, George Patrick Shults, 1996.

[3] http://www.newagepublishers.com/samplechapter/001136.pdf

[4] *Fundamentals of Electrical Drives*, Gopal K.Dubey, 1995.

[5] http://science.howstuffworks.com/transport/engines-equipment/gear5.htm

[6] *Sensor Technology, Handbook*, Jon S. Wilson, Elsevier, 2005.

[7] *Programmable Logic Controllers*, W. Bolton, Newnes, 2009

[8] http://en.wikipedia.org/wiki/Touchscreen

[9] *Fluid power, theory and applications*, James A. Sullivan, 2003.

[10] *Electric Motors and Drivers*, Austin Hughes, 2006.

[11] http://www.ncdc.noaa.gov/oa/climate/online/ccd/cldy.html

[12] http://www.solarcynergy.com/images/PV-SC120J12_PV-SC145J12_PV-SC167J12_PV-SC190J12.pdf

[13] *Renewable and Efficient Electric Power Systems*, Gilbert M. Masters, 2004.

[14] http://www.vavconveyors.com/_pdf/vav/en/screw-calculations.pdf

Appendix "A"

Appendix “B”

Appendix "C"

FBs-1LC

Load Cell Input Module

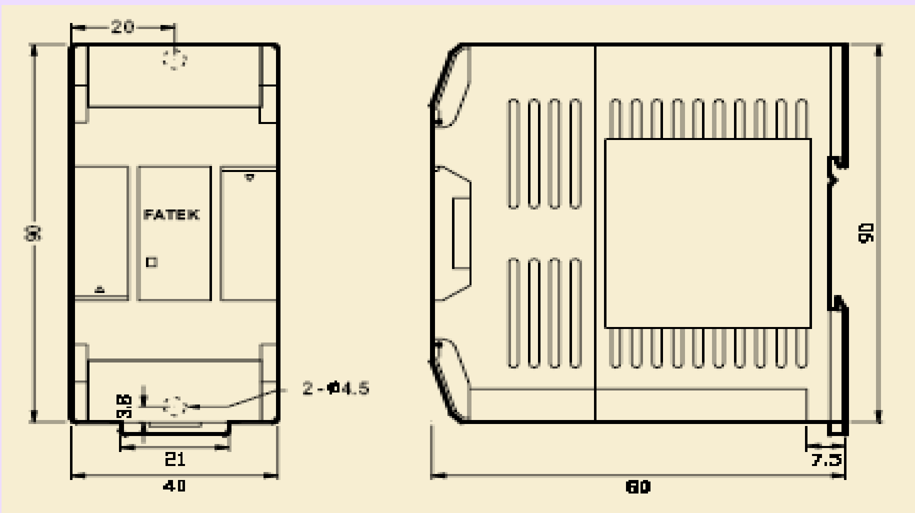
Introduction

FBs-1LC is one of the analog input modules of FATEK FBs series PLC. It can connect one load cell input for weight measurement. The conversion result is represented by a signed 16 bit integer value. In order to filter out the field noise imposed on the signal, it also provides the average of sample input function.

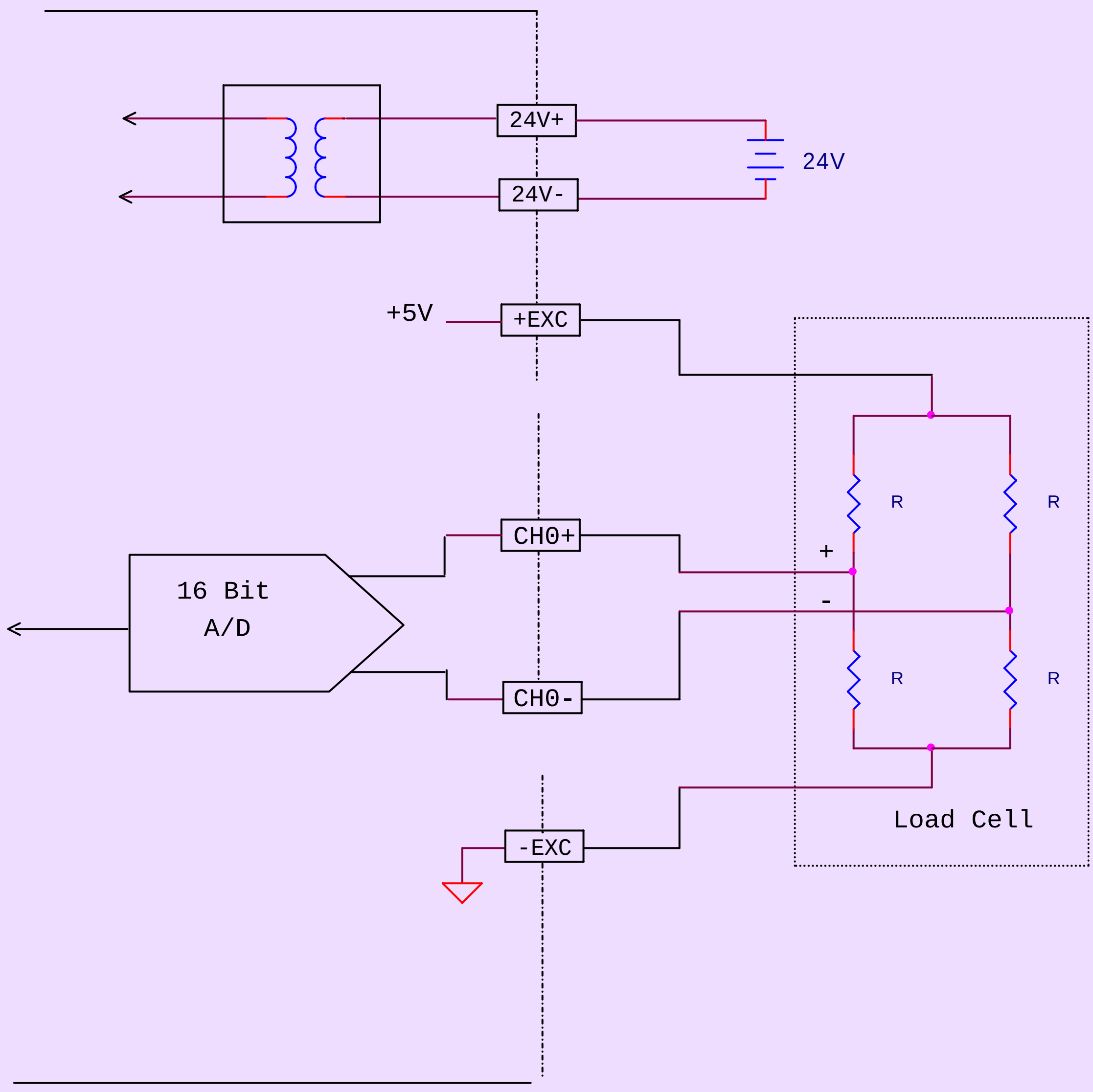
Specifications

Total Channels - One channel
Resolution- 16 bit (include signed bit)
I/O Points Occupied - 1 RI(Input Register) and 8 DO
Conversion Rate- 5/10/20/25/60/120/240/480 Hz
Non-Linearity- 0.01% F.S. (@25℃)
Zero Drift- 0.2 µV/℃
Gain Drift- 10 ppm/℃
Excitation Voltage – 5V with 250Ω load
Sensitivity - 2mV/V, 5mV/V, 10mV/V, 20mV/V
Software Filter- Moving average
Average Samples- 1~8 configurable
Isolation- Transformer(Power) and photo-coupler(Signal)
Indicator(s) - 5V PWR LED
Supply Power- 24V-15%/+20%, 2VA
Internal Power Consumption- 5V, 100mA
Operating Temperature- 0 ~ 60 ℃
Storage Temperature- -20 ~ 80 ℃
Dimensions- 40(W)x90(H)x80(D) mm

Dimensions



Wiring Diagram



The conversion result is represented by a 16 bit signed value, there should put an additional LCNV (FCN33)or MLC(FCN34)function instruction in the ladder diagram, which will convert the raw reading value into the desire weight value. Because the measurement signal is quite small, for common practice, manual zero adjustment is required in order to overcome the null drift.

PLC Control

The interface between PLC and 1LC module is thru 8 Pts. Of DO and one input register (RI). Thru the control of DO signal, the user can select the conversion rate, operating range and samples for average. Detail description of DO is listed at below. **Y_s** is the staring number of DO allocated for this module**.** The conversion result is carried in RI with 16 bit signed format.

Signal	Name	Function Description	
Y_{s+1},Y_{s+0}	**SPAN**	00	0~10mV(2mV/V)
		01	0~25mV(5mV/V)
		10	0~50mV(10mV/V)
		11	0~100mV(20mV/V)
Y_{s+2}	**Speed Range*1**	=0, Normal Speed =1, High Speed	
Y_{s+3}	**RESERVED**	Reserved	
Y_{s+5},Y_{s+4}	**CONVSERSION RATE Y_{s+2} = 0**	00	5Hz
		01	10Hz
		10	20Hz
		11	25Hz
	CONVSERSION RATE Y_{s+2} = 1	00	60 Hz
		01	120 Hz
		10	240 Hz
		11	480 Hz
Y_{s+7},Y_{s+6}	**AVERAGE COUNT**	00	No Average
		01	2 Samples
		10	4 Samples
		11	8 Samples

Note*1: This feature is supported after V1.2 (include) firmware

Clement Number	Cable Number	Description
1	2	PE
2	1	L “Main cable(220V/50Hz)”
3	3	N
4	59	Ph
5	3	N “Transformer”
6	2	PE
7	60	24Vac “Transformer”
8	61	24Vac
9	62	24Vdc (+ve) “Diode Bridge”
10	63	24Vdc (-ve)
11	76	Ph
12	3	N “Vibrator Motor 1”
13	2	PE
14	78	Ph
15	3	N “Vibrator Motor 1”
16	2	PE
17	80	Ph “Heater”
18	81	N
19	67	24Vdc (+ve) “Mixer Motor”
20	63	24Vdc (-ve)
21	71	Screw Motor
22	74	
23	12	V1 (+ve) “Eject Bag”
24	9	COM (-ve)
25	15	V2 (+ve) “Vacuum 1 Holder”
26	17	V3 “Vacuum2 Holder”
27	9	COM
28	18	V4 “Vacuum2”
29	21	V5 “Small Hopper”
30	9	COM
31	23	V6 “Bag container”
32	24	V7 “Vacuum1”
33	9	COM
34	25	V8 “Welding ”
35	26	V9 “Drum”
36	9	COM
37	27	V10 “Rubber”
38	28	V11 “Weight”
39	9	COM
40	29	V12 “Table”
41	30	V13 “R-L”
42	9	COM
43	31	V14 “20cm”
44	37	24Vdc (+ve) “From PLC”

45	38	24Vdc (-ve)
46	52	Capacitive Proximity Sensor
47	37	24Vdc (+ve) “From PLC”
48	37	24Vdc (+ve)
49	40	S2 “Vacuum1 Holder (0)”
50	41	S3 “Eject Bag Sensor (1)”
51	42	S4 “Vacuum2 Holder (0)”
52	43	S5 “Vacuum2 Holder (1)”
53	44	S6 “Vacuum1 Holder (1)”
54	45	S7 “[R-L]30cm (1)”
55	46	S8 “Small Hopper (1)”
56	47	S9 “Pressure Air Sensor”
57	48	S10 “20cm (1)”
58	49	S11 “20cm (0)”
59	50	S12 “[R-L]30cm (0)”
60	51	S13 “Welding (1)”
61	38	24Vdc (-ve) “From PLC”
62	38	24Vdc (-ve)
63	11	24Vdc (+ve) “Power Supply”
64	9	24Vdc (-ve)
65	32	“Green Lamp”
66	33	“Orange Lamp”
67	34	“Broun Cable”
68	35	“Red lamp”
69	36	“Buzzer”
70	53	(+ve) “Thermocouple”
71	54	(-ve)

FBs-TC2

2 Channel Thermo-Couple Temperature Input Module

Introduction

FBs-TC2 is one of the temperature input modules of FATEK FBs series PLC. It provides 2 channels of thermo-couple temperature measurement input with 0.1 ℃ or 1 ℃ resolution. The scan rate for 0.1 ℃ resolution is 2 seconds, while the scan rate for 1 ℃ resolution is 1 seconds. The cold junction compensation is carried out inside the module, also it provides wire broken detection feature. To give the user more choices for the selection of thermo-couple type and in order to enhance the noise immunity, the isolation scheme is per channel basis. All the optional features of this module are software configurable, there are no hardware jumpers or switches for user to setup.

Specifications

Total Channels - 2 CH

Resolution- 0.1 ℃ or 1 ℃

I/O Points Occupied –

1 RI(Input Register)

8 Discrete Output(DO)

Conversion Time- 1 or 2 Seconds

Accuracy- ±(1 %+1℃)

Sensor Type- J,K,R,S,E,T,B,N

Software Filter- Moving average

Average Samples- 1,2,4,8,16 configurable

Compensation- Built in cold junction compensation

Measurement Range-

J: -200~1200℃ K: -200~1200℃

R: 0~1800℃ S: 0~1700℃

E: -190~1000℃ T: -190~380℃

B: 350~1800℃ N: -200~1000℃

Isolation- Transformer(Power) and photo-coupler(Signal)

Indicator(s) – 5V PWR LED

Supply Power- 24V-15%/+20%, 2VA

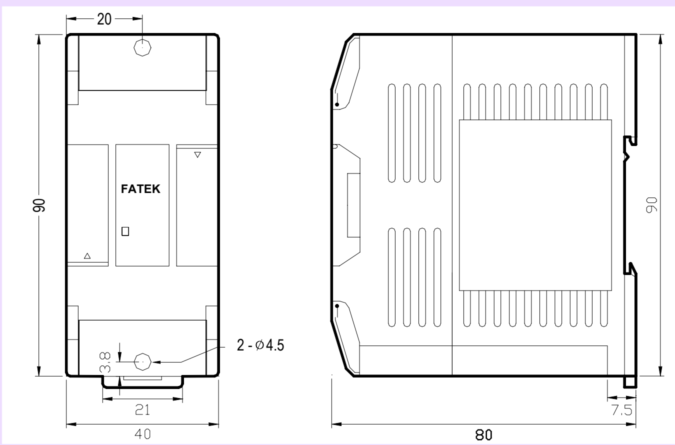
Internal Power Consumption- 5V, 35mA

Operating Temperature- 0 ~ 60 ℃

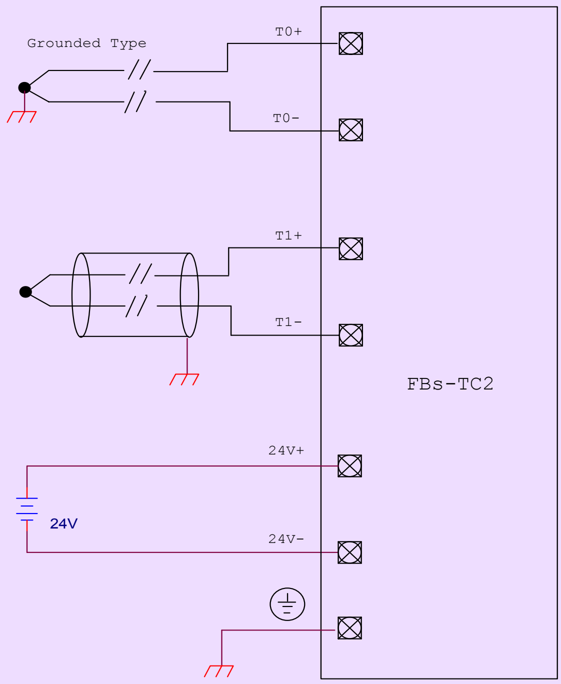
Storage Temperature- -20 ~ 80 ℃

Dimensions- 40(W)x90(H)x80(D) mm

Dimensions



Wiring Diagram

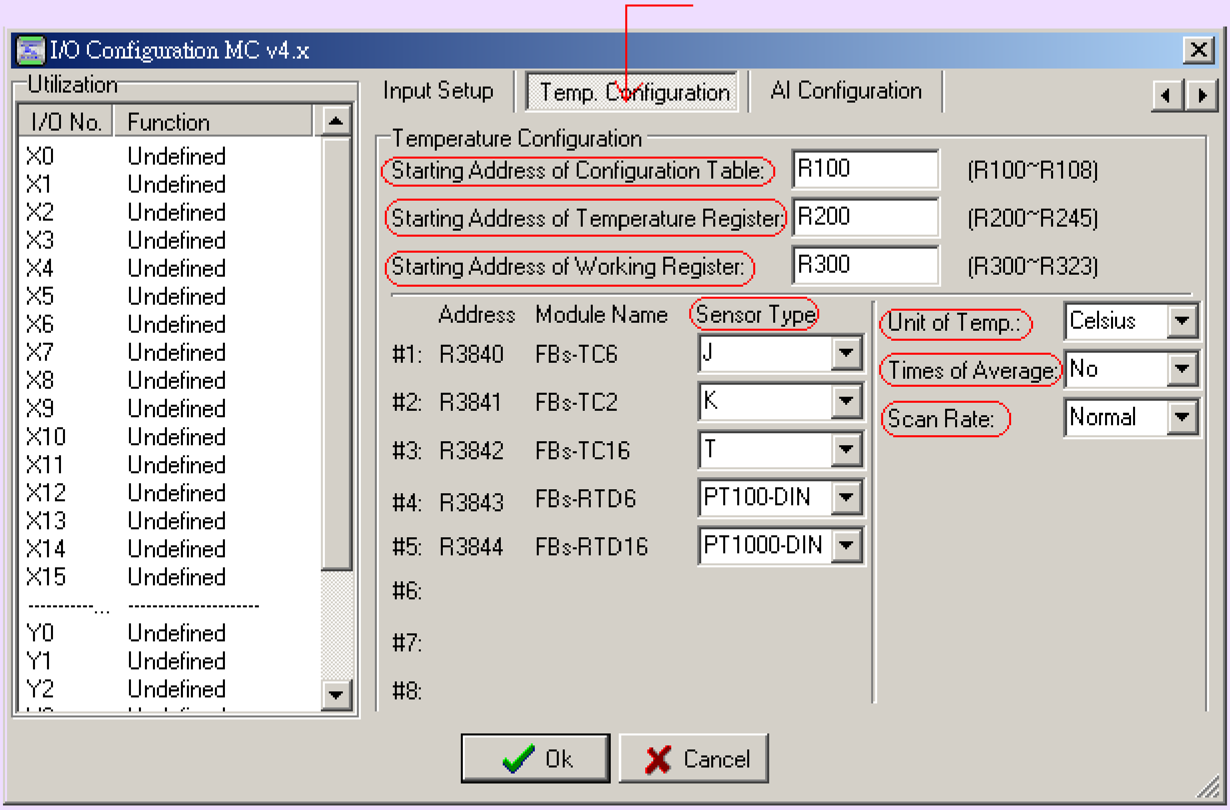


Note:

Because the thermo-couple signal is very small (in an order of uv), if possible please use the shielded twisted cable for signal wiring. Also if the length of thermo-couple wire is not long enough, please make sure to use the proper compensation wire otherwise will cause excessive error on cold junction compensation.

I/O Configuration

Before the temperature value can be retrieved, the user should perform the I/O configuration of temperature module with the help of Winproladder software. The following screen will be shown when perform the I/O configuration



The user need to assign a starting register of a contiguous register area for holding temperature reading value and areas for storing the configuration table and working scratchpad and define the sensor type, unit of temperature, scan speed and samples for average. Please refer the advanced manual II for detail explanation.

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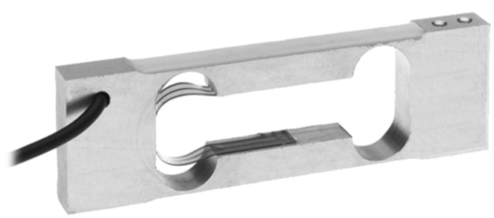
Aluminum Single Point Load Cell



FEATURES

- Capacities 0.3 - 3kg
- Aluminum construction
- Single point 200 x 200mm platform
- IP66 protection
- Total error better than 0.0067% of R.O.
- OIML approved

OPTIONAL FEATURE

- Capacity 200g at 0.8mV/V

DESCRIPTION

Model 1004 is a very low capacity, very high precision single point load cell designed for direct mounting in low capacity scales and precision balances.

This load cell is suitable for applications including jewellery scales, analytical balances, medical equipment, medical and pharmaceutical research and low level force measurement.

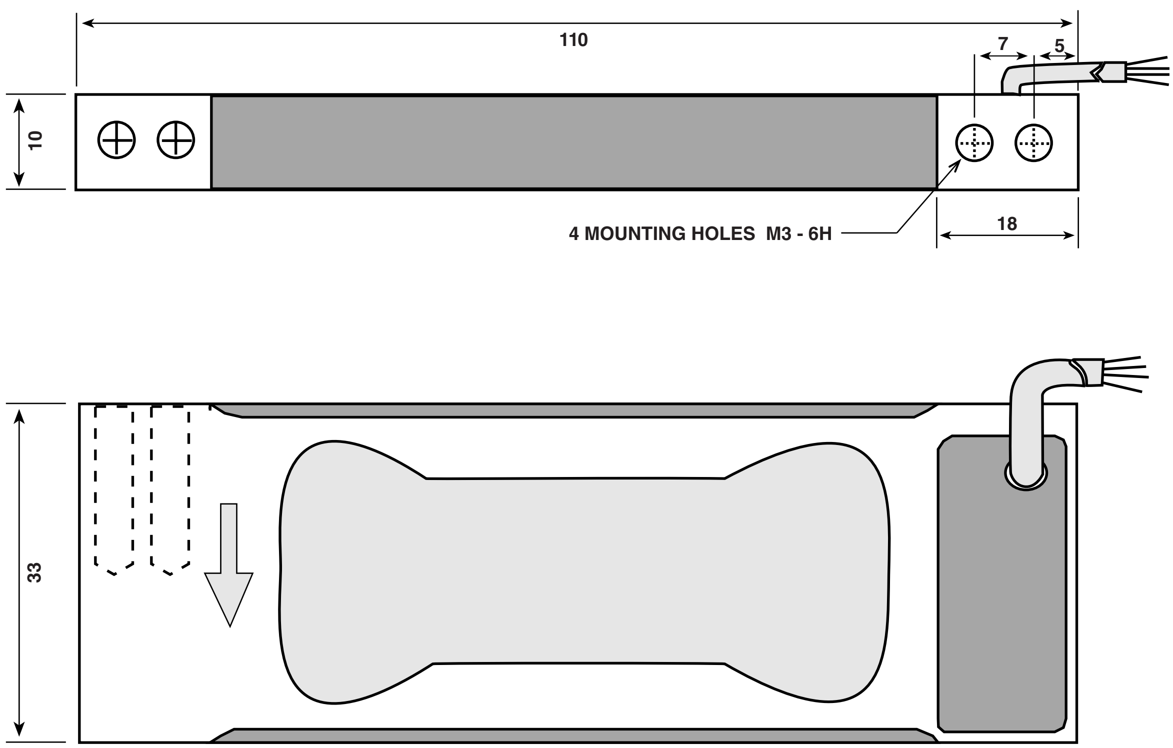
The model 1004 offers up to 30000 divisions short term precision at stable room temperature. A special two-stage humidity resistant protective coating assures long term reliability.

An overload protection device can be easily included in the application design. A threaded hole is provided in the loading end of the load cell for this purpose.

APPLICATIONS

- Low capacity scales
- Precision scales
- Jewelry scales
- Pharmaceutical scales

OUTLINE DIMENSIONS in mm



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Document Number: 12002
Revision: 16-Feb-10

VISHAY PRECISION GROUP

Model 1004

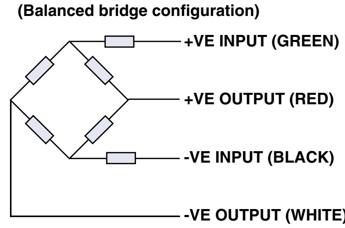
Aluminum Single Point Load Cell

Tedea-Huntleigh

SPECIFICATIONS

PARAMETER	VALUE			UNIT
Accuracy class	GW	JW	C3	
Rated capacity-R.C. (E_{max})	0.3, 0.6, 1.5, 3			kg
Rated output-R.O.	0.9			mV/V
Rated output tolerance	0.1			±mV/V
Zero balance	0.045			±mV/V
Zero Return, 2 minutes	0.0100	0.0033		±% of applied load
Zero Return, 30 minutes			0.017	±% of applied load
Total Error (per OIML R60)	0.0100	0.0067	0.02	±% of rated output
Temperature effect on zero	0.0040		0.004	±% of rated output/°C
Temperature effect on output	0.0020		0.001	±% of load/°C
Eccentric loading error	0.0033			±% of rated load/cm
Temp. range, compensated	+5 to +40			°C
Temp. range, safe	-3 to +70			°C
Maximum safe central overload	150			% of R.C.
Ultimate central overload	250			% of R.C.
Excitation, recommended	10			Vdc or Vac rms
Excitation, maximum	15			Vdc or Vac rms
Input impedance	415±20			Ohms
Output impedance	350±3			Ohms
Insulation resistance	>2000			Mega-Ohms
Cable length	0.4			m
Cable type	4 wire, PVC, spiral shield			
Construction	Aluminum			
Environmental protection	IP66			
Platform size (max)	200 x 200			mm
Recommended torque	2.0			N*m

WIRING SCHEMATIC DIAGRAM
(Balanced bridge configuration)



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