Palestine Polytechnic University
College of Engineering

Cardboard Baler with Suitable Capabilities

By

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Submitted to the College of Engineering
In partial fulfillment of the requirements for the
Bachelor's degree in Industrial Automation Engineering

2022

Dedication:

We dedicate this research to our beloved homeland Palestine

To those who lighted the way for us and gave us unlimited support

And to our families, and friends.

الاهداء

إلى معلمنا الاول ومعلم الناس الخير، نبينا محمد صل الله عليه و سلم

إلى من زرعوا فينا الطموح والمثابرة و الاجتهاد، آباؤنا الافاضل

إلى ينابيع المحبة و العطاء، أمهاتنا العزيزات

إلى إخوتنا وأخواتنا، إلى معلمينا و معلماتنا

إلى الاصدقاء و الزملاء

إلى من ناضلوا من أجلنا، شهدائنا وأسرانا وجرحانا

إلى هذه الارض التي نحب، فلسطين

Acknowledgments:

We thank our Polytechnic University in general for its support and for providing the appropriate environment for the educational environment, from teachers and students, particularly Prof. Dr. Abdel-Karim Daud who was with us and supported us in this research.

Abstract:

A cardboard baler is a machine that possesses many modern technologies based on the establishment of industrial automation engineering to achieve sustainable development and environmental protection. The suffering of factories and commercial establishments from the phenomenon of accumulation of waste of various kinds, such as cardboard and plastic, led to the manufacture of a machine that helps to organize waste in a more appropriate way to be recycled and benefited from.

The electrical components and mechanical components were selected and linked through study and analysis to employ these components in proportion to the goal for which the machine was made and its principle of operation. Where the machine built to produce from two to four bales per hour with 70*70*70 cm and 30 kg of compressed cardboard or other waste, through its consumption of electrical energy by half a dollar per hour with a single-phase feed source.

ملخص:

مكبس الكرتون عبارة عن آلة تمتلك العديد من التقنيات الحديثة القائمة على ترسيخ هندسة الأتمتة الصناعية لتحقيق التنمية المستدامة وحماية البيئة، حيث أدت معاناة المصانع والمنشآت التجارية من ظاهرة تراكم المخلفات بمختلف أنواعها كالكرتون والبلاستيك، إلى صنع آلة تساعد على تنظيم المخلفات بطريقة أنسب لإعادة تدويرها والاستفادة منها.

تم اختيار وربط المكونات الكهربائية والمكونات الميكانيكية من خلال الدراسة والتحليل لتوظيف هذه المكونات بما يتناسب مع الهدف التي صنعت له الآلة ومبدأ عملها، حيث تم بناء الالة لانتاج من اثنان الى اربعة بالات في الساعة بأبعاد 70*70*70 سم وبوزن 30 كغم من الكرتون المضغوط او المخلفات الاخرى وذلك من خلال استهلاكها للطاقة الكهربائية بمقدار نصف دولار في الساعة بمصدر تغذية احادي الطور.

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Chapter One
Introduction

1.1 Introduction

Carton baler is a widely used baler for recyclable hard materials such as cartons, plastic, car tires, clothes, and other waste.

The baler makes the waste block into bales with dimensions suitable for transportation needs.
Baler optimizers improve paperboard recycling and waste handling efficiency and are an important tool for businesses and organizations of all sizes.

1.2 Project Idea Description

The main objective of this project is to design a press machine for cardboard and plastic, choose its appropriate dimensions, and control its parts through a programmed logic controller (PLC).

1.3 Project Objectives

This project will achieve the following objectives:

1) Study the Product packaging.
2) Design the body of the machine.
3) Implement a Hydraulic piston and control it.
4) Implement a control system for the baler machine to control the motor pumps and cylinder.

Connecting parts and controlling them through a programmable logic controller (PLC).

1.4 Project Importance

The importance of the project is concentrated on the following points:

1. Provide an easy way to control the machine.
2. Save time and effort for factory workers and for the markets.
3. Provide a suitable machine and give us suitable output stuff.

4. The work of a control system in a way that provides safety for the worker and the machine.

This machine came to reduce the spread of waste, maintain a clean city, reduce the burden of violations on shop owners, and provide a source of raw materials by recycling the waste that was weighed inside the press.

In addition, the machine enjoys ease of transportation, its appropriate size, and the possibility of connecting it to the power source available in homes.

1.5 Project Motivation

Increasing the percentage of waste, prompting the municipality, which would monitor violations related to the environment, public health, and infringement on the general appearance of the city, to impose fines on shop owners to preserve the environmental situation and the aesthetic of the town and to show it in the best way. The idea of this machine came to reduce the accumulation of waste in front of the shops and the containers to preserve the city in its best form and benefit from the waste by recycling it and reduce the burden on the municipality in transporting the waste and avoid the shop owners from paying the fines resulting from these violations.

1.6 Block Diagram

The motor fed by a single-phase voltage source from a single-phase VFD Converter and the motor connected to the cylinder by a mechanical link. The status of the cylinder will be read through a sensor and sent to the PLC to work in a way that ensures high product quality and high efficiency as shown in Figure (1.1).

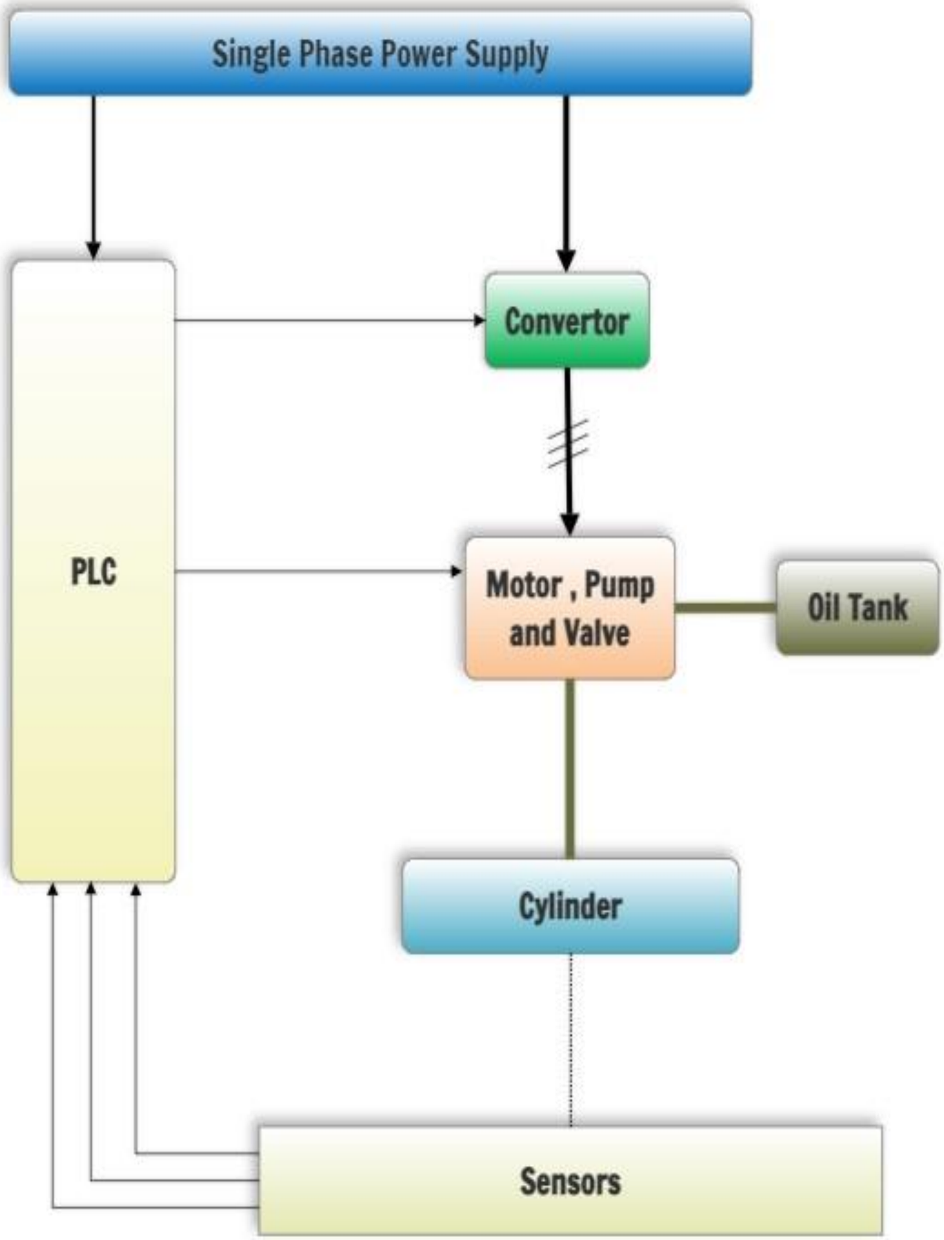

Figure (1.1) General Block Diagram

1.7 Time Schedule

Table (1.1) illustrates the tasks that were accomplished it takes weekly for each task:

Table (1.1) Time Schedule First Semester Introduction to Project

Week Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Finding Project Idea															
Proposal															
Search and Collect data															
Documentation															
Preparing for presentation															
Print documentation															

Table (1.2) illustrates the tasks that were accomplished it takes weekly for each task:

Table (1.2) Time Schedule Second Semester Graduation Project

Week Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Purchase of parts and equipment															
Implementation the project															
Documentation															
Preparing for presentation															
Print documentation															

1.8 Work Plan and Technology

- The appropriate structure of the machine built in proportion to the different components of the machine, such as the cylinder, to ensure the durability of the machine and increase its life span.
- The programmer logic controller programmed to suit the machine and facilitate the operation of the machine by the user in safe ways.
- Searching for the appropriate machine’s components to serve the machine’s work appropriately.
- Connect the control panel's electrical parts in inappropriate ways.
- Employing electrical and design programs in our studies, such as Sketch-up, AutoCAD, and Festo.

1.9 Budget

After studying and analyzing the components of the project, the prices as a total will cost 2000-3500 $ as shown in table (1.3).

Table (1.3): Price List.

#	Name of part	Quantity	Cost
1	Structure and implementation	1	1200$
2	Power switch and circuit breakers	8	80$
3	PLC	1	220$
4	VFD Converter	1	280$
5	Motor	1	170$
6	Pump	1	120$
7	Valve and coil	1	200$
8	Pressure Switch	1	210$
9	Cylinder	1	280$
10	Sensors	5	100$
11	Another electrical component	-----	150$
12	Engineering supervision and job	-----	300$
	Total		3310$

Chapter Two
System Components

2.1 Overview

In this chapter a brief review of all components that should be used in this project, concerning their principle of operation, production flow, and need for feedback signals

2.2 Block Diagram

Figure (2.1) appeasers a functional block diagram illustrating the machine's operation

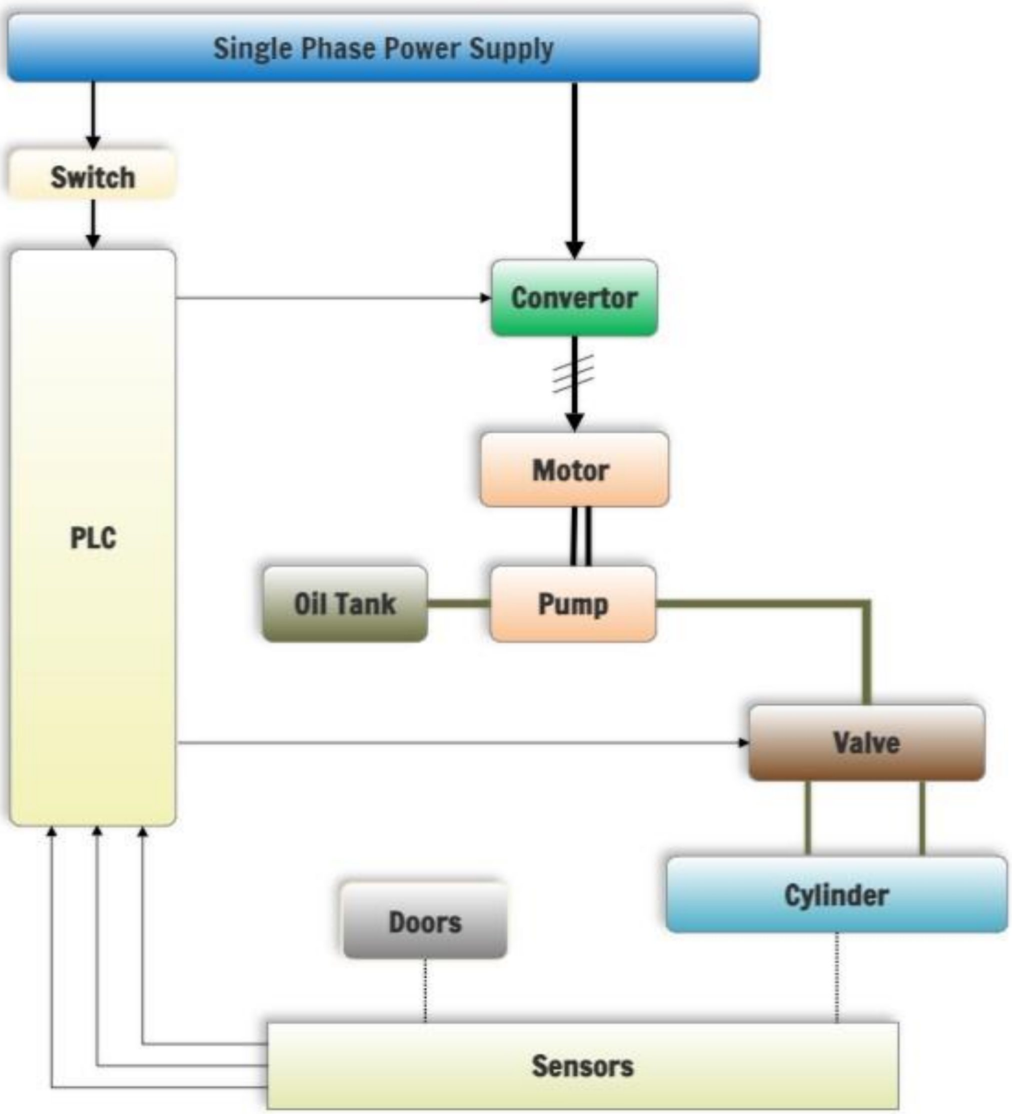

Figure (2.1) Block Diagram

The motor will be fed with a single-phase voltage source by PLC control.

The supply source will be transmitted to the motor through a transducer, the motor will be mechanically connected to the pump, and the cylinder will be controlled through the valves which will be controlled by PLC. The status of the cylinder will be read through a sensor and sent to the PLC.

Signals will be taken to study the condition of the cylinders and doors and returned to the PLC so that the machine can operate in a manner consistent with the protection systems.

By means of the power switch, the programmable logic controller will be fed with electricity, which in turn will completely control the operation of the machine.

2.3 Project Components

The main project components can be stated as follow:

1. 1- Phase Power supply.
2. Power switch and circuit breakers.
3. PLC.
4. VFD Converter.
5. Motor.
6. Pump.
7. Valve.
8. Cylinder.
9. Sensors.

2.4 Principle of the Work Components

All components of the system are selected and their working principle is known in order to the general shape of the machine and determines the sequence in which the energy will pass through the components to achieve the productivity of the machine.

2.4.1 Power Switch and circuit breakers

Figure (2.2) Switch and circuit breakers

The main switch, power switch, and on/off switch are the three main classifications of electrical switches that are used in electrical systems. Figure (2.2) shows some types of electrical switches.

Different types of switches are used in the electrical system of the project [1]:

1. Main switch.
2. Device switch.
3. Power switch.
4. Push-button switch.
5. Emergency switch.
6. Limit switch.
7. Approximate switch.

2.4.2 PLC

PLC stands for “Programmable Logic Controller”. A PLC is a computer specially designed to operate reliably under harsh industrial environments – such as extreme temperatures, wet, dry, and/or dusty conditions. PLCs are used to automate industrial processes such as a manufacturing plant’s assembly line, an ore processing plant, or a wastewater treatment plant as shown in Figure (2.3) [2].

Figure (2.3) Delta ES2/EX2 PLC Series.

Table (2.1): Comparison between several types of PLC:

PLC’s Brand and Developed Country	Software	Used in the industry	price and maintenance
Siemens PLC Germany	Step 7- Simatic Manager	Littlie use	Expensive and complicated to maintain
Schneider PLC Europe	Control Expert	Medium use	Acceptable price and high to maintain
Delta PLC Taiwan	WPL Soft ISP Soft	Frequently used	Low cost and easy to maintain

2.4.3 Converter

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 [3].

Figure (2.4) Converter (VFD)

A variable Frequency Drive (VFD) Converter is used to indirectly convert power from an alternating current supply directly into an alternating current load of the different voltage levels at a fixed frequency or variable frequency as shown in Figure (2.4).

How a Variable Frequency Drive Works:

VFDs give you control over system performance, monitoring the speed of motors or pumps and adjusting current on demand. The VFD accepts a 3-phase AC input and then outputs the desired AC or DC. This allows motors to operate efficiently under load variations.

How the VFD Benefits the System:

Controlling the motor speed offers many advantages. First, the VFD provides greater efficiency in both power use and transfer rate in a pump or motor. The VFD senses the load on the system and provides power to compensate. It also manages such problems as system malfunctions and overloads. This automatic, intelligent control can extend motor life, prevent system failure, and increase operational output [3].

2.4.4 Motor

Figure (2.5) 3-Phase induction motor.

Figure (2.5) show an induction motor is the most used electrical machine from the construction point of view, in the majority of the cases. Induction motors are by far the most common type of motor used in industrial, commercial, or residential settings [4].

Advantages:

I. Good Speed Regulation.
II. High P.F for high-speed setting.
III. High Efficiency at all speeds except synchronous speed (ns) [5].

Operating a single motor with a variable frequency drive is not advisable.
While it is technically possible, the disadvantages far outweigh any benefits that might expect.
In a majority of cases, it is less expensive to upgrade to a 3-phase motor for use with a VFD [3] [4].

Problems with Using a Single-Phase Motor:

Single-phase motors are wound differently than a 3-phase motors. To use a single-phase motor with a VFD, the motor must be inverter grade, which means paying to have the existing motor rewound, or purchasing a new motor. Even when the motor specifications have been met, you may experience single-phase motor operation problems. This is commonly noticed at low speeds where the motor is forced to operate at lower rpm [3] [4].

Advantages of Upgrading the Motor:

Modifying a single-phase motor to work with a VFD is not cost-efficient. Rather than expending resources to make the necessary changes, it is usually better to upgrade to a 3-phase motor. In addition to being less expensive, 3-phase motors are often smaller and lighter. Upgrading means a longer system life, and greater output control, and will provide additional benefits such as reducing operating temperatures [3] [4].

2.4.5 Pump

Figure (2.6) Pump

Each industry and each pumped fluid have special requirements and require a different approach.

Gear pumps are the most common type of positive displacement pumps, which are often used in pumping relatively highly viscous fluids such as hydrocarbons, motor oil, liquid fuels, and adhesives. For any rotodynamic pump, as viscosity goes up, pump performance diminishes due to increasing in friction. But in the case of gear pumps, the effect is the opposite. An increase in viscosity results in higher volumetric efficiency as viscous liquids fill the clearances of the pump.

There are two types of gear pumps which are internal and external pumps Internal gear pumps typically have better suction capabilities than external gear designs and are suitable for high-viscosity fluids as shown in Figure (2.6) [6].

2.4.6 Valve

An oil electro-control valve is used to pass the oil to the cylinder as shown in Figure (2.7).

Directional control valves are devices that influence the path taken by hydraulic fluid. The primary functions of a DCV are to stop, start, check, divert, shuttle, and divide proportionally the flow of hydraulic fluids in one or more ways [7].

Figure (2.7) Directional control valve (DCV)

2.4.7 Cylinder

Figure (2.8) Double acting cylinder

Pumping hydraulic fluid to the rod end will retract the piston rod and pumping fluid to the head end will extend the piston rod. Most of the raising and lowering devices are applications of this type as shown in Figure (2.8) [7].

2.4.8 Sensors

Sensors are used in this machine for the stuff in the machine if it's existed or not and for the doors open or close in addition to displacement for the cylinder.

Factors for choosing sensors: When challenging or buying a sensor, several things must be taken into account, including 1 Type of material used 2 Connection distance 3 Frequency of disconnection and connection 4 Working conditions such as temperature and pressure 5 Operating voltage and type 6 load current 7 Connector type and a number of terminals 8 PNP or NPN and this selection It is important to know how to connect especially with PLC Programmable Controllers. PNP means that the load is connected to the negative terminal of the source and the signal is negative. NPN means that the load is connected to the positive terminal of the source and the signal is positive. [1]

Optical sensor

It relies on the principle of a currency on a transmitter and receiver of the reflected rays that turn into an electrical signal that is used for connection or separation and is used to control relatively long distances compared to sensors of other types and is used to detect the presence or absence of materials Figure (2.9) [1].

Figure (2.9) Optical sensor

Mechanical sensor

Figure (2.10) Limit switch [1]

Limit switch: A switch that determines or terminates the state of a machine or motor and is connected to the control circuit, but depends on a movement in the machine through which an order is produced to start, stop, divert, monitor, or mutual protection Figure (2.10).

The switch usually contains one or more contacts, one of which is closed N.C and the other is open N.O when activated, the closed contacts are separated and then the open contacts are closed [1].

The limit switch is one of the switches that are used in control systems Automatic, as almost no mechanical machine is devoid of this, this switch consists of a mechanical actuator and connection points. The function of the actuator is to translate the mechanical force applied to it to close or open connection points as shown in Figure (2.10) [8].

There are several types of limit switches that differ from each other in how to activate only, and they do not often differ in the shape of the contacts inside, and the contactors often bear 10 amperes, and this is suitable for use in the control circuit, such as: "Ending and stopping the state of the machine" "Part of the process has started." "Preventing the operation" "Determining the location of the product" "The arrival of the vehicle" and "Determining the size and weights" [1].

Pressure Switch

The pressure switch shown in Figure (2.11) is an example of a single pole double throw (SPDT) switch, which has a mechanical operation principle.

All of the components are inside the switch case (F), and it has one inlet pressure port (H). In short, the inlet pressure pushes a piston (D) against a spring (C) that has a known resistant force.

Then, the piston triggers the micro-switch (A), moving it between normally closed (NC) and the normally open (NO) position through an operating pin (B) and an insulated trip button (E).

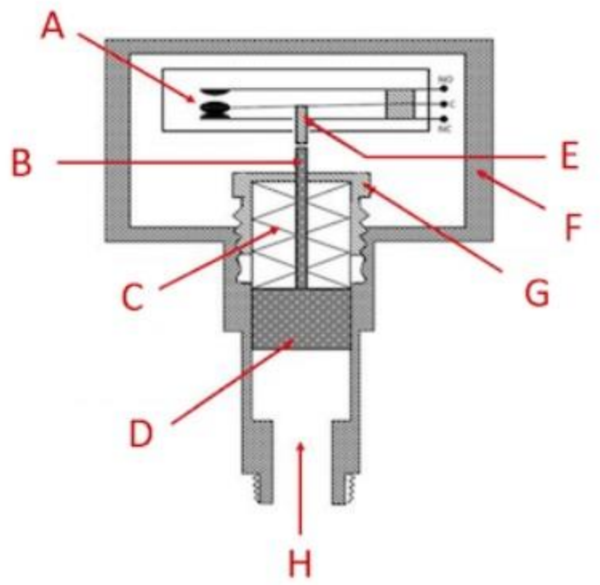

Figure (2.11) Sketch from Pressure switch

To set the pressure level at which the micro-switch switches between NC and NO, the trip-setting nut (G) changes the spring pocket depth.

This depth change allows the spring resistant force to increase or decrease, which correlates to a set pressure to trigger the micro-switch. The inlet pressure (H) exerts pressure upon the operating piston (D), generating a force opposing the range spring (C).

Once the inlet pistons force is higher than the opposing spring force, it pushes the operating pin (B) into the insulated trip button (E).

This button then moves the micro-switch from the NC position to the NO position. If the pressure decreases below the spring force, the button, pin, and piston move away from the micro-switch, breaking the connection. The connection then goes from the NO position to the NC position as shown in Figure (2.12).

Figure (2.12) Pressure switch

After knowing the required elements in the machine, these parts will be identified, selected, and studied in the fourth chapter.

Chapter Three

Mechanical Components Selection

3.1 Overview

The functional flowchart is illustrated. The mechanical design is going to be described throughout the proposed flowchart illustrated in Figure (3.1) The main function of this chart is how to control the machine in our system.

3.2 Functional description and Flowchart

Functional description: The following describes the operation sequence of the machine from placing the waste to removing the bale

1. The carton is packed manually by a worker through the feed opining, and the working mechanism of the machine is determined by two automatic and manual systems, one of which the worker chooses through the selector switch located on the control panel.
2. In manual operation, the worker can control the machine during the pressing process by controlling the cylinder through continuous pressure on the push button Down or the lifting push button UP located on the control panel. In the case of selecting manual operation, the Yellow lamp is ON with operation, the Green lamp is ON and the Yellow lamp is kept ON.
3. In auto operation the Yellow lamp is ON after the operating conditions are met door close, door out close, Limit switch retrace enable and optical sensor enables this is to indicate that the machine is ready to run.
4. The worker presses the operation button once to start the three-stage pressing process the first stage is either to reach the end of the cylinder limit switch extend enable or the second stage, getting a pressure of 70 bar on the carton through the pressure switch signal, or the third stage, which is the last and final stage or the product formation stage is called, where a pressure of 70 bar is reached through the pressure switch At the same moment that the limit switch level is enabled.

5. When the cylinder returns after the first or second stage, the carton is placed manually by the worker, and the process is repeated after fulfilling the operating conditions until the final stage is reached.

6. In the final stage, three lights are ON Green is ON, Yellow is ON, and Red is ON, to alert the worker that the product is ready to be removed from the machine. Before removing the product from the machine, the bale is tied manually by the worker and a signal is given to the machine to complete that process by pressing on the push button finish without the need to fulfill the operating conditions.

7. In the event of any Error in the operating conditions door close, door out close, Limit switch retrace enable and optical sensor enables, the Red light is ON.

8. The worker can switch from automatic to manual mode or vice versa at any stage of operation.

Flowchart for controlling the system parameters

Through the previous functional description, the work algorithm becomes clear to us, as shown in Figure (3.1).

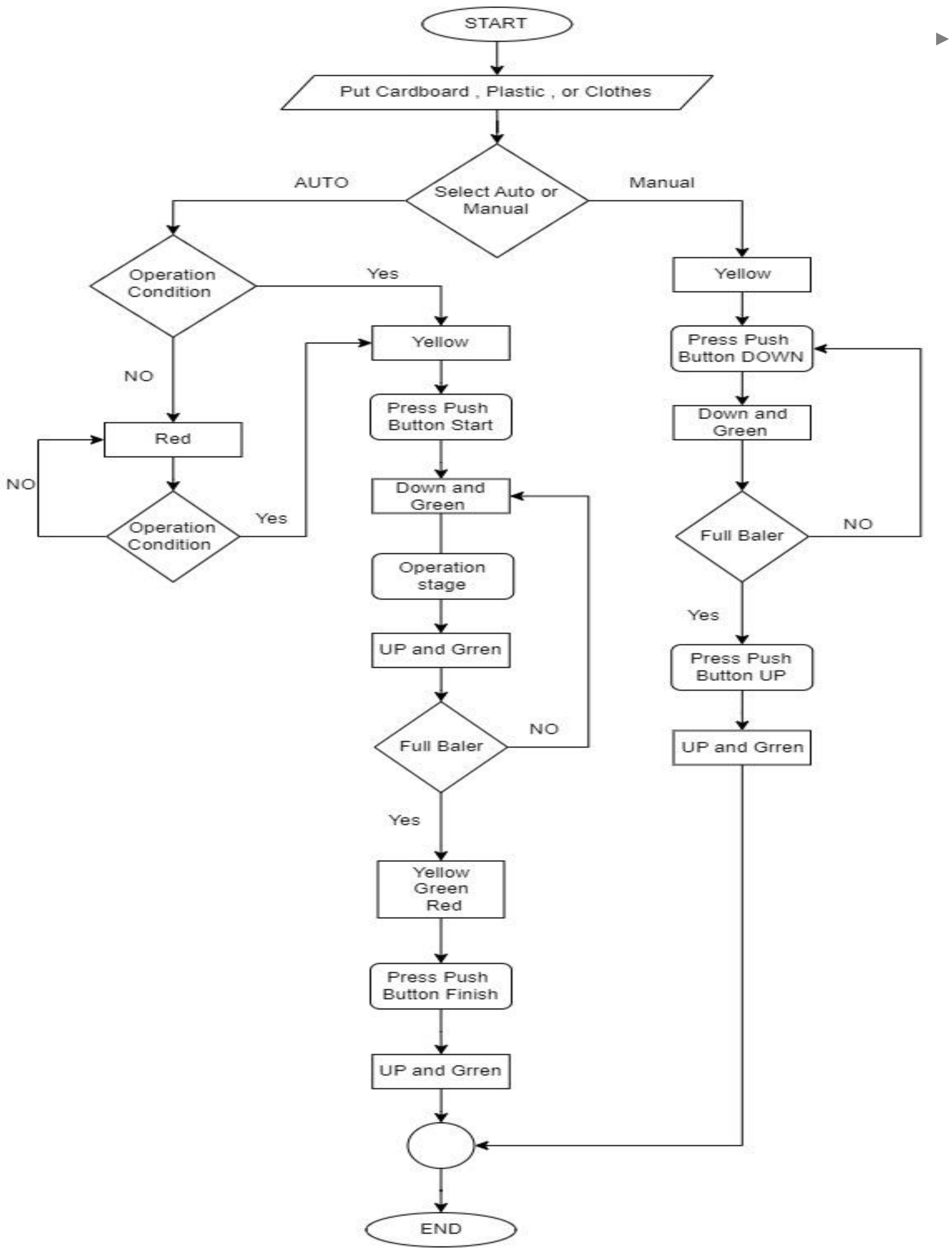

Figure (3.1) Flowchart for the machine

3.3 The machine Body design

The parts were placed on the machine and designed in accordance with the nature of the machine’s work and the nature of its use. Iron bars were chosen to protect the general structure of the machine during the pressing process. The base of the machine was made to facilitate its movement from one place to another through the traction cart. The piston and pump were placed at the top to reduce the space of the machine and where it fits with the work of the machine as a whole as will be explained in this part.

The final shape of the machine to be manufactured is illustrated which was drawn using Sketch-Up in Figure (3.2).

Figure (3.2) Overall view of the Machine

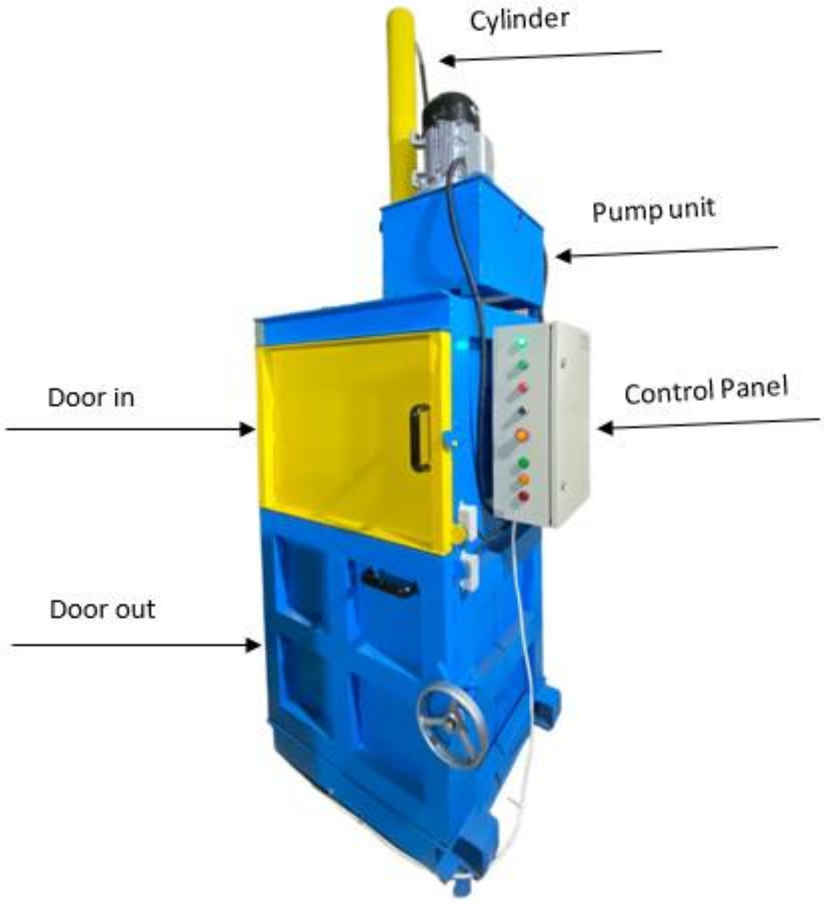

Figure (3.3) Overall view of the Machine

The final shape of the manufactured machine is shown in the Figure (3.3) with the parts that have been selected.

Figure (3.4) shows the external structure of the machine and the distribution of the parts of the drive system in the machine.

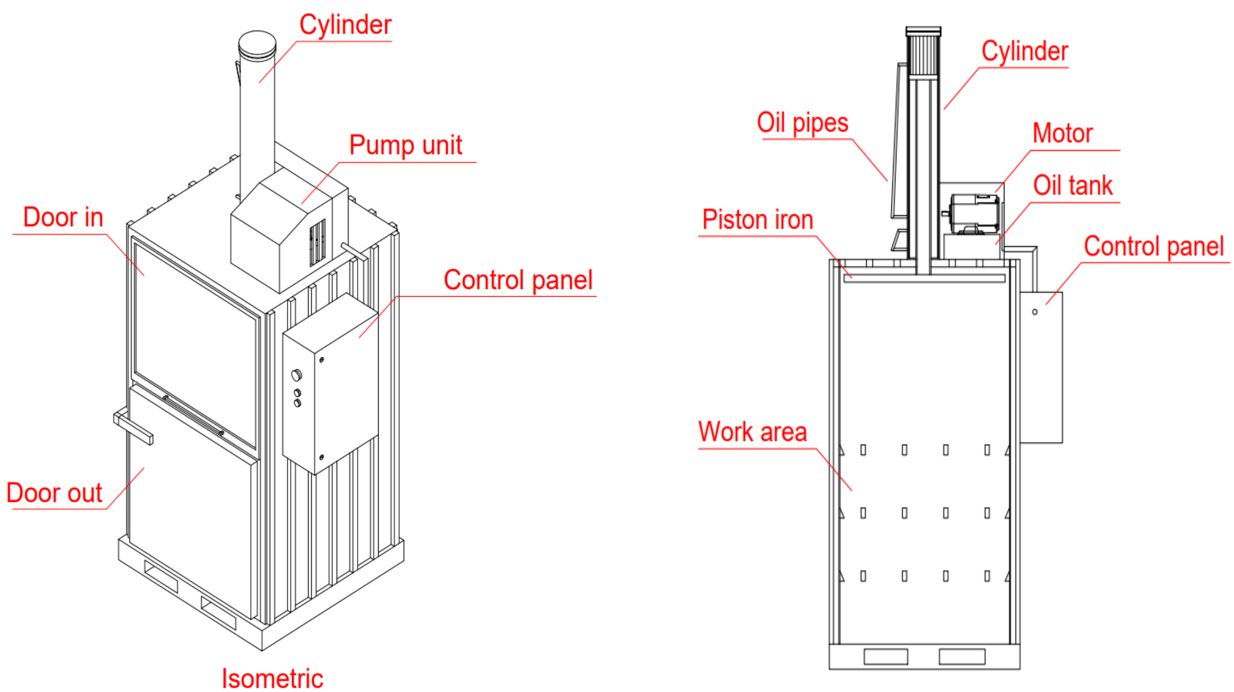

Figure (3.4) Place component of the drive system

Figure (3.5) shows the multiple interfaces of the machine so that its dimensions are determined in proportion to the machine's work and the nature of its use.

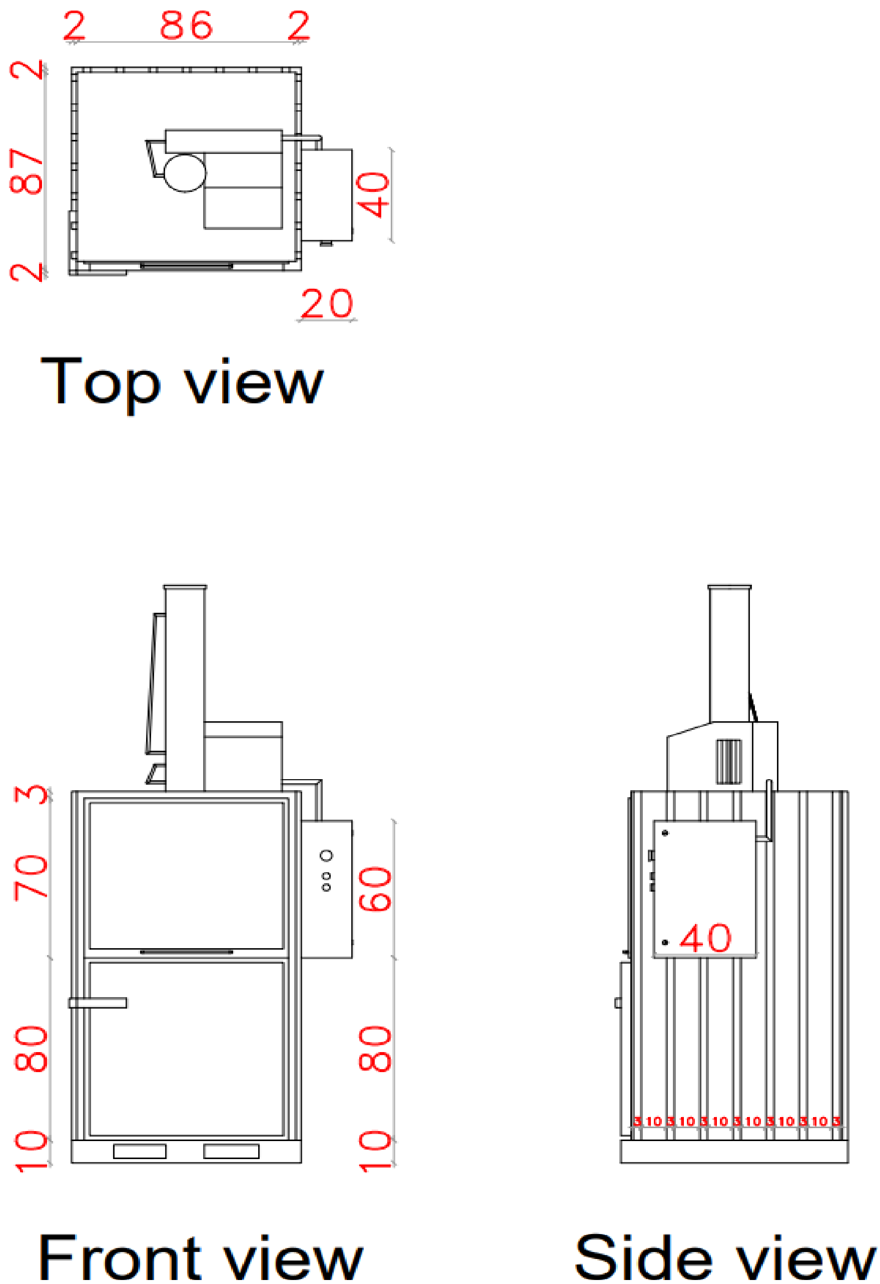

Figure (3.5) Dimension of the machine in cm.

3.4 Mechanical parameters Calculation and components selection

Analysis of piston-cylinder force and time to achieve desired pressure to Calculate pump flow rate and pressure power [7].

The Area occupied by the flow oil inside the cylinder is equal to area of Bore piston subtracted from its area Rod piston as follows:

$$A = A_B - A_R \tag{3.1}$$

Where:

- A_B: Area of Bore Piston, cm^2
- A_R: Area of Rod Piston, cm^2
- A: Area occupied by the flow oil inside the cylinder, cm^2

The Area of Bore piston as follows:

$$A_B = R^2\pi \tag{3.2}$$

Where:

- R: Radius of Bore Piston , cm

With the Bore piston radius = 5cm the area of the Bore piston A_B = 78.54 cm^2.

The Area of Rod piston as follows:

$$A_R = D^2 \frac{\pi}{4} \qquad (3.3)$$

Where:

- D: Diameter of Bore Piston , cm

With the Rod piston diameter = 5 cm the area of the Rod piston A_R = 19.64 cm^2.

With the area of Bore piston A_B = 78.54 cm^2 and the area of Rod piston A_R =19.64 cm^2 The Area occupied by the flow oil inside the cylinder A = 58.9 cm^2.

The compressive force is expressed through multiply the Area occupied by the flow oil inside the cylinder by operating pressure from pump as follows:

$$F = AP \qquad (3.4)$$

Where:

- F: is compressive force, N
- P: Operating Pressure, bar

With the Area occupied by the flow oil inside the cylinder A = 58.9 cm^2 and operating pressure of P = 70 bar, compressive force should be F = 4123 N.

The force of weights is expressed in newton by multiplying the mass by the gravitational factor as follows:

$$F_W = mg \tag{3.5}$$

Where:

- m: mass, Kg
- g: gravitational factor, 9.81

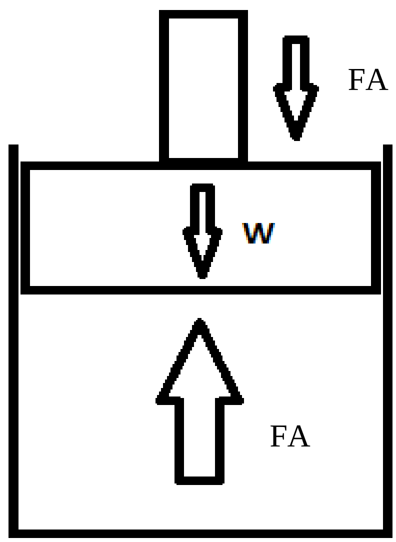

Figure (3.6) Sketch for the force.

With a mass of baler slab = 83 Kg, the Weight force = 814.23 N

The actual force pressure in extended cylinder is expressed through the compressive force subtracted from its Weight force as follows:

$$F_A = F\text{-}F_W \tag{3.6}$$

Where:

- F_A: is Actual Force, N
- F_W : Weight force, N

With Weight force = 814.23 N and compressive force should be F = 4123 N, Hence the actual force pressure in extrude cylinder F_A= 3308.77 N.

The actual force pressure in retracted cylinder equals the compressive force and Weight force as follows:

$$F_A = F + F_W \quad (3.7)$$

With the Weight force = 814.23 N and compressive force should be F = 4123 N, Hence the actual force pressure in retraced cylinder F_A=4937.23 N.

The pressing speed by:

1. Estimate the time required in our machine at 22 seconds
2. The pressing distance in the machine (Stroke length) is 84 cm

$$V = L/t \quad (3.8)$$

Where:

- V: velocity, cm/s
- L: Distance, Cm
- t: Time, Second

$$V = 3.82\ cm/s$$

The oil flow rate for the pump is expressed in newton by multiplying the velocity by the useful piston surface area [9] as follows:

$$Q = VA \qquad (3.9)$$

Where:

- Q: Oil flow, L/min
- V: velocity, cm/s
- A: useful piston surface area, cm^2

With an area of A = 58.9 cm^2 and velocity V = 3.82 cm/s, the oil flow rate for the pump should be Q=13.5 L/min.
The total pump efficiency (Volumetric efficiency and Mechanical efficiency) in the internal gear pump between the presser 50 to 150 bar getting between 85% to 90% [10].

The pump speed in rpm as flowing:

$$N = Q/V\eta_{tot} \qquad (3.10)$$

Where:

- N: pump speed, rpm
- Q: Oil flow, L/min
- V: Displacement the pump, cm^3/rev
- η_{tot}: The total efficiency in pump

With the oil flow Q = 13.5 L/min, the displacement V = 12 cm^3/rev and total efficiency is 85% the pump speed N = 1323.5 rpm.

The power of the pump:

$$P_{kW} = \mathrm{P}Q/600 \qquad (3.11)$$

Where:

- P_{kW}: electrical power, kW
- P: Operating Pressure, bar
- Q: Oil flow, L/min

$$P_{kW} = 1.6\ kW$$

The power in hp:

$$P_{hp} = P_{kW}/0.746 \quad (3.12)$$
$$P_{hp} = 2.11\ hp$$

The Cylinder Datasheet is attached In Appendix A
The Pump Datasheet is attached In Appendix B
The Valve Datasheet is attached In Appendix C

Table (3.1): Selected mechanical components ratings:

Mechanical Components and calculations	Value
The Bore piston radius in cm	5
The rod piston diameter in cm	5
The stroke length in cm	84
The pressing speed in cm/s	3.82
The oil flow in L/min	13.5
The speed of the pump in rpm	1323.5
The power of the pump in kW	1.6

Chapter Four

Electrical Components Selection

4.1 Overview

This chapter will talk about electrical circuits and control methods during this project, as talked in previous chapters about what parameters want to control and the main components in the system. Such as the follower.

4.2 Motor

Referring to the power needed to work the pump in chapter three, 1.6kW it is the mechanical power that the pump needs to pump 13.5 L/min with an operating pressure of 70 bar. And the speed 1323.5 rpm in order to rotate the pump at the appropriate speed for the requirements of the system and the line voltage from VFD is 220V.

MMSTD – SINGLE PHASE motors – 230V, 50Hz, 3hp, 4-pole, with a rated speed of 1350 rpm, and a power factor is 0.7 and the efficiency 0.85.

The electrical power of single phase $P_{in} = V\ I\ Cos\theta$

$$P_{in} = \frac{P_{out}}{\eta}$$

With the electrical power = 2200W and with efficiency η = 0.85 the output power of motor Pout = 1875.95W.

The current in single phase motor as follows:

$$I = \frac{P_{in}}{V\ cos\theta} \qquad (4.1)$$

Where:

- I: current, A
- P_{in}: input power, W
- V: voltage, V
- $cos\theta$: power factor

With power = 2200W, line voltage = 220V and power factor (PF = $cos\theta$) is 70% the motor current $I = 14.28\ A$

The speed of motor is [4]:

$$n_s = 120f/P \tag{4.2}$$

Where:
n_s: Synchronous speed, rpm.
F: Frequency, Hz.
P, Number of poles.

$$n_s = 1500rpm$$

The torque of the motor:

$$P = T\ \omega \tag{4.3}$$

$$T = 15.56\ N.m$$

The current of single phase motor:

$$I = \frac{P_{in}}{V\ cos\theta} \tag{4.4}$$

$$I = 14.28\ A$$

Fig (4.1): Nameplate of three phase induction motor

SIEMENS – THREE PHASE motor – Δ/Y 230/400V, 50Hz, 3hp, 4-pole, with a rated speed of 1420 rpm, and a power factor is 0.82 and the efficiency 0.81.

The electrical power of three phase $P_{in\ 3\emptyset} = 3\ V_L\ I_L\ Cos\theta$

$$P_{in} = \frac{P_{out}}{\eta}$$

With the electrical power = 2200W and with efficiency η = 0.81 the output power of motor Pout = 1787.67W.

The current in three phase motor as follows:

$$I = \frac{P_{in}}{\sqrt{3}\ VL\ cos\theta} \qquad (4.5)$$

Where:

- I: current, A
- P_{in}: input power, W
- V: line voltage, V
- $cos\theta$: power factor

Power factor varies considerably with the motor mechanical load. An unloaded motor is analogous to a transformer with no resistive load on the secondary. Little resistance is reflected from the secondary (rotor) to the primary (stator).

In three phase induction motor power factors getting between 80% to 90% [11].

With power = 2200W, line voltage = 230V and power factor (PF = $cos\theta$) is 82% the phase current $I = 3.88\ A$

The speed of motor is [4]:

$$n_s = 120f/P \qquad (4.6)$$

Where:
n_s: Synchronous speed, rpm.
F: Frequency, Hz.
P, Number of poles.

$$n_s = 1500rpm$$

The torque of the motor:

$$P = T\ \omega \qquad (4.7)$$

$$T = 14.8\ N.m$$

The current of three phase motor:

$$I = \frac{P}{3\ V\ PF} \qquad (4.8)$$

$$I = 3.88\ A$$

Table (4.1): Different between induction motor single and three phase.

Difference Elements	Induction Motor	
	Single phase Motor	Three phase Motor
Voltage Source	Through MCB circuit breaker	Through VFD
Connecting with VFD	Connection through electrical circuits	Direct Connection
Type connection		Delta
Voltage	230V	230V
Motor Current	14.28A	3.88A
Torque	15.56N.m	14.8N.m
Power	2200 W	2200 W
Speed	1350 rpm	1420 rpm
Cost	250$	200$
Availability in the local market	Less available	More available
Size of motor	Small	Medium

Through this data, a three-phase motor was chosen for the project due to its availability in the market, as it provides high productivity for the machine

4.2.1 Circuit Breaker

A circuit breaker is a switching device that interrupts the abnormal or faults current. It is a mechanical device that disturbs the flow of high magnitude (fault) current and in addition, performs the function of a switch. The circuit breaker is mainly designed for closing or opening an electrical circuit, thus protecting the electrical system from damage [12].

Circuit Breaker

$$CB = \text{Next Standard } (1.25 \times In) \quad (4.9)$$

CB=10A

4.2.2 Overload

To protect the motor we used overload switches and defined as overload relays are intended to protect motors against excessive heating due to long-time motor currents up to and including locked motor currents. Protection of the motor due to short circuits or grounds is a function of circuit breakers, or motor short-circuit protectors [12].

Overload

$$OL = In \times 1.05 \quad (4.10)$$

OL=10A

The Motor Datasheet is attached In Appendix D

Table (4.2): Selected protection components ratings:

Name	Current (A)	CB size(A)	Overload size(A)
Motor	3.88 A	10A	10A

4.3 Convertor

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. Circuit of VFD and how finally gets a variable voltage And variable frequency [3].

In Figure (4.4) the motor is connected to the VFD by connecting the poles of the motor to the output of the VFD and the VFD is connected to the single-phase voltage source by connecting the source wires to the input of the VFD.

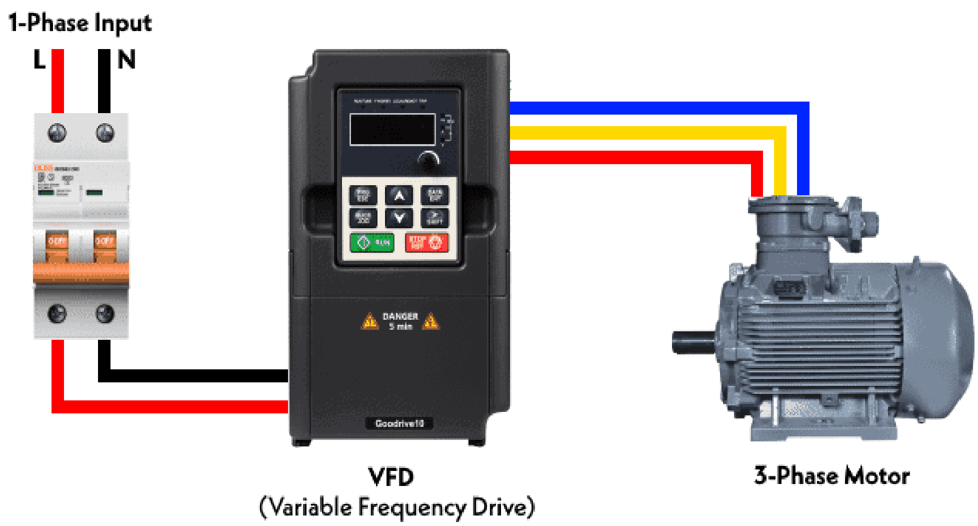

Figure (4.2): VFD connection with Motor.

After determining the power of the motor, a VFD was chosen with a capacity equal to the power of the motor, and the type of input voltage source (single phase or three phase) was determined.

Therefore, the machine needs a VFD with a 1hp, as is known in the markets, and a single-phase feed source to suit the work environment.

The VFD DELTA_022EL21W_1 Control Diagram is attached In Appendix E

4.4 Controller

Delta ES2/EX2 PLC Series. Compact with MPI should be used in this project [2]

The project contains a set of inputs and outputs that will be linked through the PLC. An appropriate and sufficient PLC must be selected for these inputs and outputs, which are as follows: The inputs are sensors and there are eleven sensors there are three switches, and six outputs.

The second determinant of choosing a PLC is the availability of this device in the local markets and the availability of its software program.

The PLC DELTA-DVP24ES2 Datasheet is attached In Appendix F

Table (4.3) PLC Compare devices

Device	Cost	Software
Schneider	High	difficult to handle with
Siemens	Mid	difficult to handle with
Delta	Low	Easy to handle with

4.5 Sensors

Sensors are used in this machine for the stuff in the machine if it's existed or not and for the doors open or close in addition to displacement for the cylinder.

Factors for choosing sensors: When challenging or buying a sensor, several things must be taken into account, including 1 Type of material used 2 Connection distance 3 Frequency of disconnection and connection 4 Working conditions such as temperature and pressure 5 Operating voltage and type 6 load current 7 Connector type and a number of terminals 8 PNP or NPN and this selection It is important to know how to connect especially with PLC Programmable Controllers. PNP means that the load is connected to the negative terminal of the source and the signal is negative. NPN means that the load is connected to the positive terminal of the source and the signal is positive. [1]

The programmed logic controller gives an electrical signal with a DC voltage of 24 volts, as it supplies the sensors with this voltage, so the machine needs sensors that operate with a voltage of 24 volts as shows in the Figure (4.3).

Figure (4.3): PLC Ports.

Table (4.4) Sensors Selection

Sensors	Name	Type	Voltage	Cause of chose	Place
Limit Switch	LS Door in	Mechanical	24V/DC	To match the inputs and voltages of the PLC	In the Feed opening
Limit Switch	LS Door out	Mechanical	24V/DC	To match the inputs and voltages of the PLC	In the outlet hole
Limit Switch	LS Retrace	Mechanical	24V/DC	To match the inputs and voltages of the PLC	At the top baler
Limit Switch	LS Level	Mechanical	24V/DC	To match the inputs and voltages of the PLC	At the middle baler
Limit Switch	LS Extend	Mechanical	24V/DC	To match the inputs and voltages of the PLC	At the lowest baler
Optical Sensors	S Optical	Electrical	24V/DC	To match the inputs and voltages of the PLC	Inside the baler opposite the feed opening
Pressure Switch	S Pressure	Mechanical	24V/DC	To match the inputs and voltages of the PLC	On the oil tank after DC Valve

Pressure Switch is attached In Appendix G

4.6 Design the Control Unit

Figure (4.5) show the connection between the system modules, PLC with sensors, and actuator.

Figure (4.4): PLC connection with sensors and actuator

After connecting the sensors through low-voltage control wires in the PLC and connecting them to the control circuit, the PLC performs the operation based on the conditions of the sensors used, where they are directed to the control circuit of the motor and pump and valve.

4.6.1 Hydraulic and Power Circuits

The following Figure (4.5) shows the hydraulic diagram of the system and how the hydraulic parts are connected to each other.

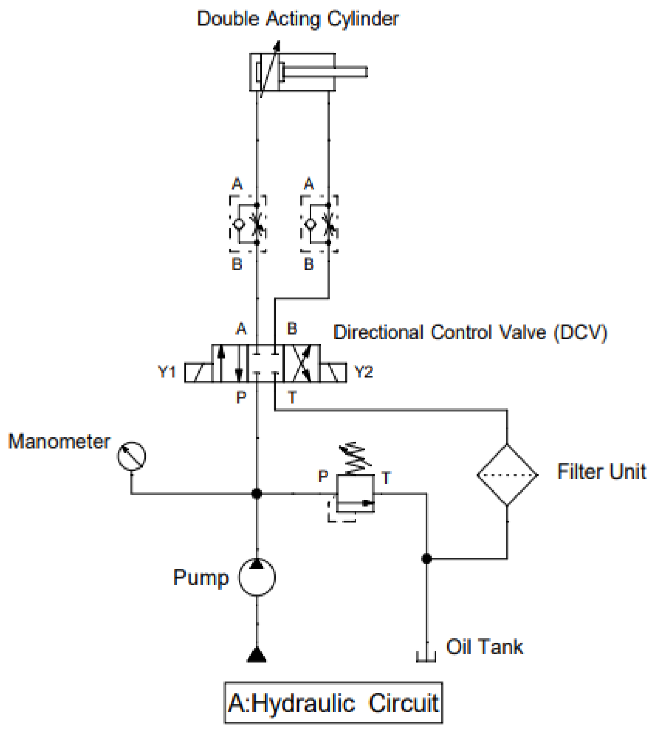

Figure (4.5): Hydraulic Circuit

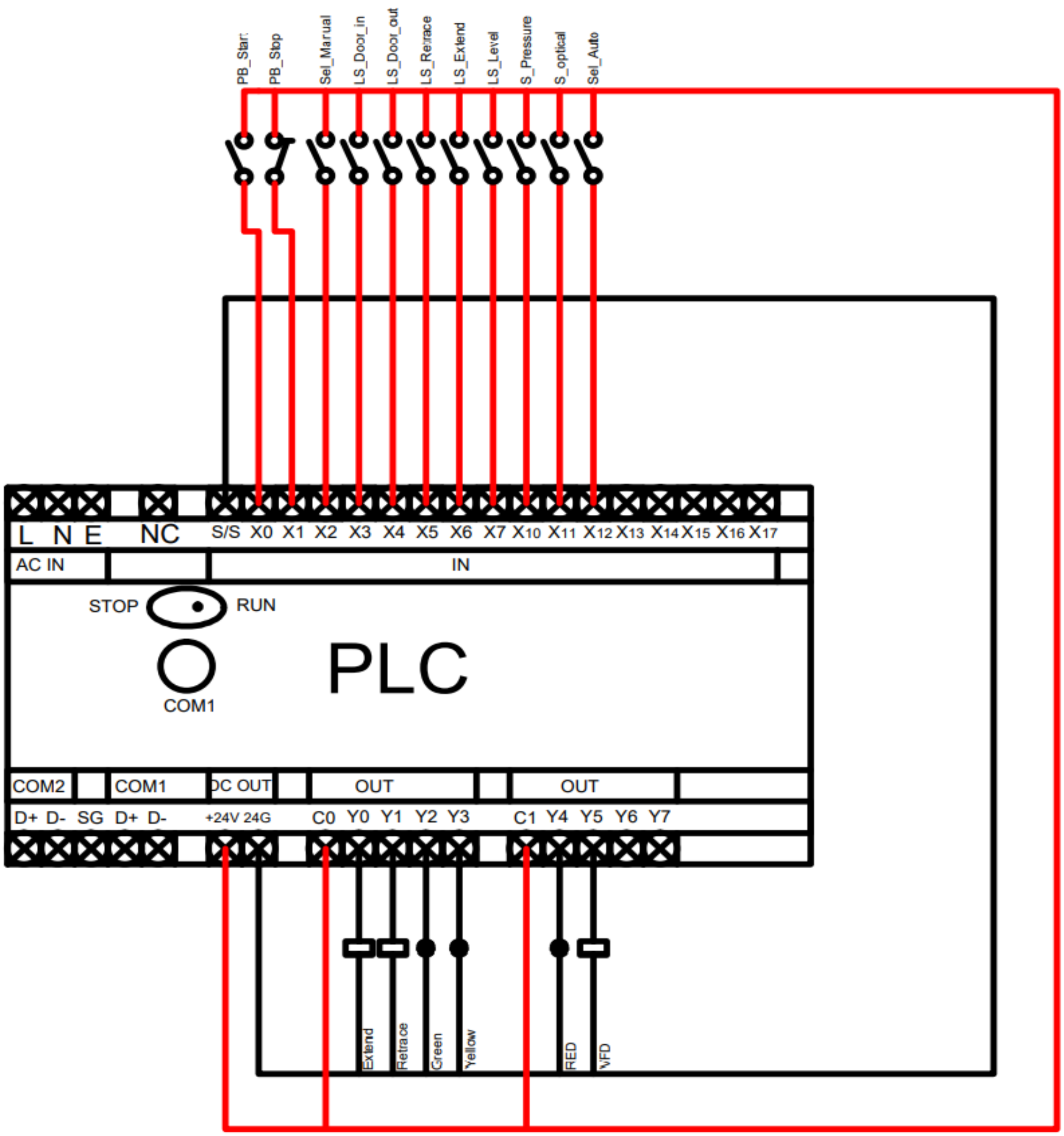

Figure (4.6): Control Circuit

Through the pump, the oil is pumped through the pipes of the cylinder by the valve A-P which is controlled by the PLC. The process of extruding the cylinder is started until it reaches the end switch of the first half, which in turn sends a signal to the PLC to activate the valve B-T to enable the cylinder to return to the normal position.

PLC Code is attached in appendix I

In a power circuit, an overload is used to protect the motor as the motor is connected with the VFD. The motor is grounded and connected to the grounding network for protection. The VFD is directly related to a voltage source through the Circuit Breaker for protection. Figure (4.7) VFD is controlled by PLC.

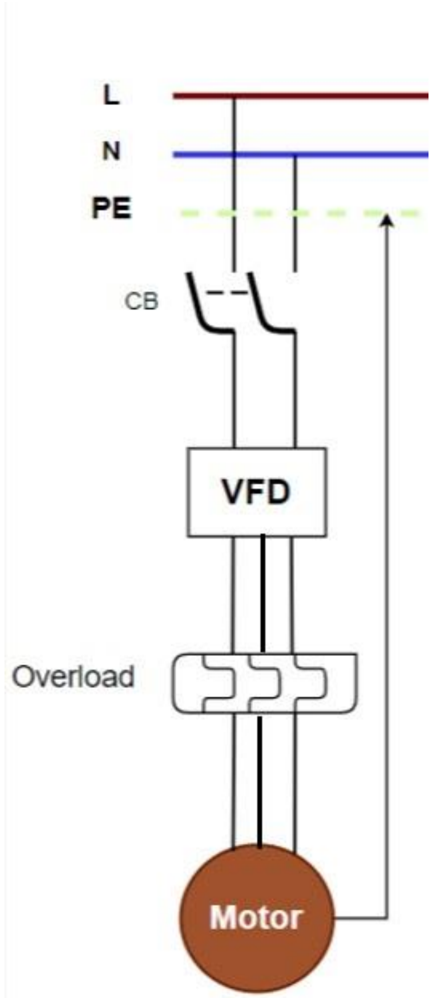

Figure (4.7): Power Circuit for motor

Chapter Five

Practical Result and Recommendation

5.1 Introduction

This chapter will talk about the practical implementation of the project and the result of the machine from the design of the machine to the final result for it.

In the Figure (5.1) the machine at the beginning of the design and before implementation.

Figure (5.1): Design and before implementation

In the Figure (5.2) the machine at the end of the implementation.

Figure (5.2): Machine after implementation

The machine after implementation and the different form the design the colors and the open of the doors in the design the door open to the right and in the implementation the doors open to the left.

5.2 Practical Result

Figure (5.3): Machine Control Panel From Inside

The control panel of the machine as illustrated in Figure (5.3) and it contain the devices and the connection of the power and control circuit.

Where the VFD was placed at the top of the Control panel according to the conditions of its installation Protection devices such as Circuit Breaker and Relay are placed on the OMGA Bridge beside the programmed logic controller.

Figure (5.4): Machine Control Panel From Outside

In the Figure (5.4) shows the control panel of the machine through which the worker can control the operation of the machine as shown on the identification labels for the function of each button.

Figure (5.5): Motor for pump unit

As shown in the Figure (5.4), the location of the Motor in the machine is above the oil tank and close to the cylinder, as it passes the oil from the tank to the cylinder, which is an important part of the hydraulic oil pump.

Figure (5.6): Cardboard Bale

In the adjacent Figure (5.6) the final product of the cardboard press is in the form of bales with dimensions of 70L* 70W * 70H cm and the Wight of the bale 25kg to be recycled.

Table (5.1): Project description

Project description	Model	CBHM5/70
	Voltage Source	1 Phase
	Feed Opening	(80*60) (L*H)cm
	APPROX. Bale Size	70*70*70 (L*W*H)cm
	Bale Weight	25-40kg
	Capacity	2-4 bales/h
	Total Force	5 ton
	Main Motor	2.2kW (3hp)
	Main Cylinder Bore Piston Rod Stroke	10cm 5cm 84cm
	Cycle time (no load)	40s
	APPROX. Machine Size	80*80*245 (L*W*H)cm
	Wight Machine	690kg

Extra Cardboard baler photo is attached in appendix H

5.3 Economic Feasibility

The economic feasibility study was conducted through three economic categories as follows:

First, the violations imposed on the owners of shops and commercial establishments the municipalities impose financial fines on the owners of shops and commercial establishments in the event that cardboard waste is found in front of those shops and establishments, amounting to 1500 dollars annually, in order to limit the spread of waste and preserve the environment and aesthetics of the city. This machine came to reduce these violations and this economic burden on the owners of these shops and establishments.

Secondly, the cost of energy consumption and labor the working hours of the Palestinian Labor Office depend on 8 hours per day and a minimum wage of $20 per day. This is for the labor force. As for the cost of energy consumption, the price of one kilo of electrical energy imposed by the Hebron Municipality on its customers is estimated at $0.20. Therefore, the energy consumed by the machine Electricity during business hours is $3.5.

Third, the cost of the product the price of one kilo of recycled cardboard is estimated at 0.09 dollars. Therefore, the price of one average bale weighing 32.5 kilograms equals 2.74 dollars, and by calculating the average daily production of the machine, which equals 24 bales per day, the daily yield of the machine is 65.8 dollars.

5.4 Recommendation

Finally, we have a number of recommendations that could add to the improvement of the project, however we did not have time to implement it and we did not have enough experience in mechanical matters.

First, adding an HMI Human machine interface screen to the machine to control the machine, monitor its work, and ease of operation and use.

Secondly, working on adding an additional processing stage for the product (the bale) by tying it automatically by placing plastic ties that work automatically to tie the bale and remove it in a final and appropriate manner.

Third, work to reduce the weight of the machine through the use of lighter iron in manufacturing in a way that guarantees a correct pressing process without affecting the structure and durability of the machine.

Conclusions

Achieving the foundations of sustainable development, which are environmental, economic, and social.

With the increase in the dimensions of the machine, the pressure required to form the bale increases, which leads to an increase in energy in operating the pump and an increase in its volume.

The use of customized dimensions in designing the machine structure to bear the pressure of the internal machine.

The final product will be a cube-shaped bale with a width of 70 cm, a length of 70 cm, and a height of 70 cm, so it will be easy to transport and make use of.

The addition of VFD to control the speed of the oil flowing into the piston leads to an increase in the productivity of the machine because the increase in pressure speed leads to an increase in the speed of forming the final product inside the machine.

The productivity of the machine is 4 bales per hour, depending on the speed of pressure, the amount of waste to be disposed of, and the need for operation.

The presence of optical sensors inside the machine increases its economy, as these sensors will give the machine the right to start work with the required need and the required time in a way that ensures saving working time, thus saving energy consumption.

The presence of limit switches in the machine increases its safety, as the limit switches will give the machine the right to start work after the safety conditions are met to ensure public safety and worker protection.

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APPENDIX

Appendix A

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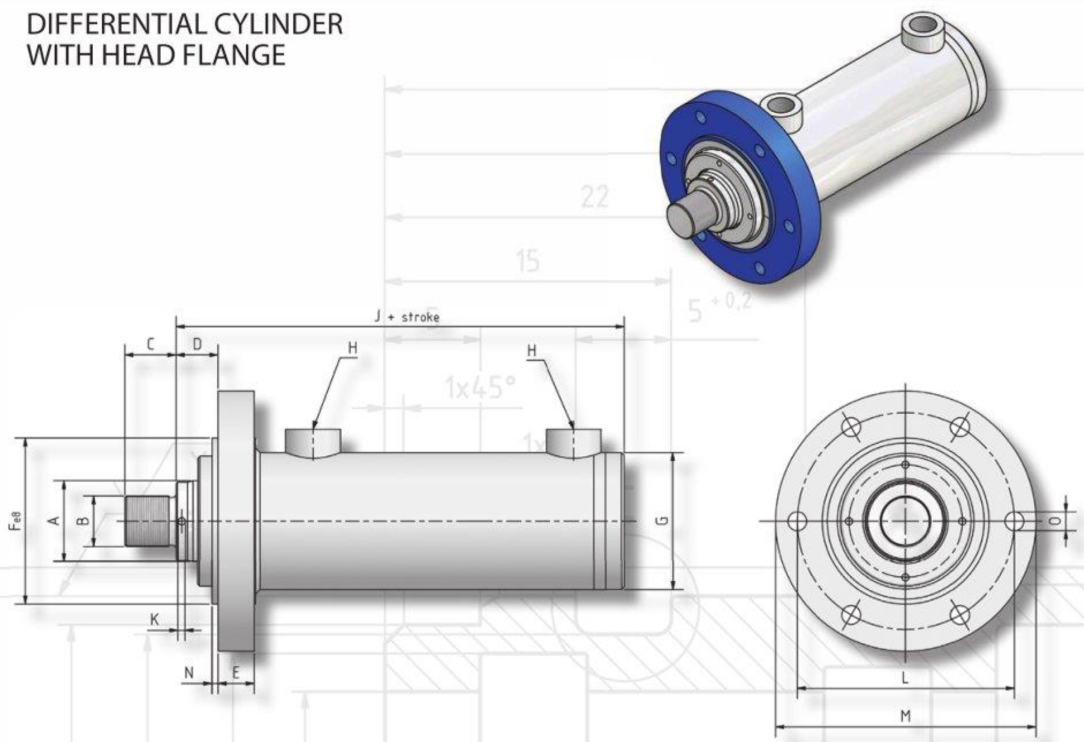
DIFFERENTIAL CYLINDER WITH HEAD FLANGE



Differential cylinder with head flange

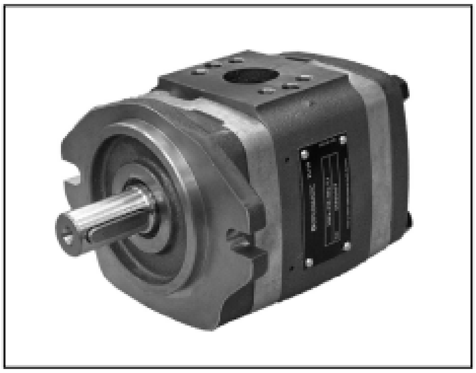
Type	Piston Ø (mm)	Piston rod Ø A (mm)	B	C	D	E	Fe8 Ø	G Ø	H W-Tube (Standard)	H Metr.	J	K Ø	L Ø	M Ø	N	O Ø	GIHR-K, SA-K, GK (equipm.)	Weight (kg) for stroke 0mm	Weight (kg) each 100mm of stroke
HYKS-...-K-32/18-...	32	18	M16 x 1,5	16	21	12	56	42	G 3/8	M18 x 1,5	130±2	3	78	98	3	9	20	2	0,7
HYKS-...-K-32/22-...		22																	0,8
HYKS-...-K-40/22-...	40	22	M16 x 1,5	16	26	15	65	50	G 3/8	M18 x 1,5	153±2	3	90	110	3	9	25	3	0,9
HYKS-...-K-40/28-...		28																	1
HYKS-...-K-50/28-...	50	28	M22 x 1,5	22	26,5	18	75	62	G 1/2	M22 x 1,5	165±2	4	100	125	3	11	30	5	1,3
HYKS-...-K-50/36-...		36																	1,6
HYKS-...-K-63/36-...	63	36	M28 x 1,5	28	28	22	90	75	G 1/2	M22 x 1,5	188±3	4	115	140	3	13	35	8	1,8
HYKS-...-K-63/45-...		45																	2,2
HYKS-...-K-80/45-...	80	45	M35 x 1,5	35	29	25	115	95	G 3/4	M27 x 2	210±3	5	150	180	4	13	40	14,5	2,9
HYKS-...-K-80/56-...		56																	3,5
HYKS-...-K-100/56-...	100	56	M45 x 1,5	45	34	35	140	120	G 3/4	M27 x 2	240±3	5	175	210	4	17	50	25,5	4,7
HYKS-...-K-100/70-...		70																	5,8
HYKS-...-K-125/70-...	125	70	M58 x 1,5	58	40	40	170	145	G 1	M33 x 2	270±3	6	210	250	5	22	60	41,5	6,4
HYKS-...-K-125/90-...		90																	7,7
HYKS-...-K-140/90-...	140	90	M65 x 1,5	65	45	45	190	165	G 1	M33 x 2	315±4	6	235	280	5	22	70	62	9,7
HYKS-...-K-140/100-...		100																	11
HYKS-...-K-160/100-...	160	100	M80 x 2	80	45	50	220	190	G 1 1/4	M42 x 2	350±4	8	270	320	5	30	80	91	12,6
HYKS-...-K-160/110-...		110																	14
HYKS-...-K-180/110-...	180	110	M100 x 2	100	50	60	250	220	G 1 1/4	M42 x 2	405±4	8	305	360	5	33	90	140	17,4
HYKS-...-K-180/125-...		125																141	19,5
HYKS-...-K-200/125-...	200	125	M110 x 2	110	55	65	280	245	G 1 1/4	M42 x 2	430±4	8	340	400	5	33	100	187	22
HYKS-...-K-200/140-...		140																188	24,4

14/20

Appendix B

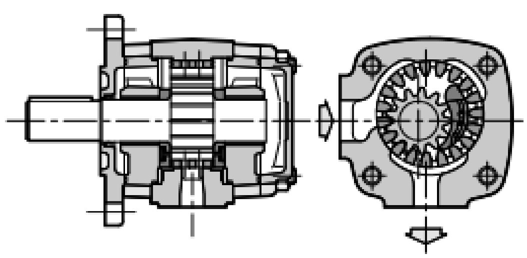
DUPLOMATIC MOTION SOLUTIONS

12 100/118 ED



IGP
INTERNAL GEAR PUMPS
SERIES 11

OPERATING PRINCIPLE



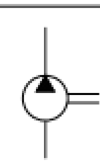
- IGP pumps are volumetric displacement pumps with internal gears, available in five sizes, each divided into a range of different displacement.
- The pumps feature high volumetric performance levels, thanks to both radial and axial compensation in proportion to operating pressure, in addition to low noise levels.
- Optimal load distribution and special friction bearings enable continuous duty at high pressures and ensure extended pump lifetime.
- IGP pumps are also available in multiple versions which can be combined to make multi-flow groups.

TECHNICAL SPECIFICATIONS

PUMP SIZE		3	4	5	6	7
Displacement range	cm^3/rev	3,6 ÷ 10,2	13,3 ÷ 32,6	33,1 ÷ 64,9	64,1 ÷ 126,2	125,8 ÷ 251,7
Flow rate range (at 1500 rpm)	l/min	5,4 ÷ 15,3	19,9 ÷ 48,9	49,6 ÷ 97,3	96,1 ÷ 189,3	188,7 ÷ 377,5
Operating pressures	bar	see table 2 - performances				
Rotation speed	rpm	see table 2 - performances				
Rotation direction		clockwise or counterclockwise				
Loads on the shaft		refer to our technical dept. for permitted axial and radial loads				
Hydraulic connections		SAE J518 c fittings, flanged (see par. 9)				
Mounting flange type		SAE J744 - ISO 3019-1				
Mass (single pump)	kg	4 ÷ 4,8	8,6 ÷ 11	15,5 ÷ 18,7	29,2 ÷ 35	46,5 ÷ 59

Ambient temperature range	°C	-20 / +60
Fluid temperature range	°C	-20 / +80
Degree of fluid contamination	see section 3.2	
Recommended viscosity	cSt	25 ÷ 100

HYDRAULIC SYMBOL



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2 - PERFORMANCES

(obtained with mineral oil with viscosity within 25 ÷ 100 cSt)

PUMP SIZE	NOMINAL DELIVERY	DISPLACEMENT [cm³/rev] NOTE 2	MAX. FLOW RATE. [l/min] (at 1500 rpm)	PRESSURE [bar] NOTE 3 steady	PRESSURE [bar] NOTE 3 peak	ROTATION SPEED [rpm] NOTE 4 max	ROTATION SPEED [rpm] NOTE 4 min
IGP3	003	3,6	5,4	330	345	3600	400
	005	5,2	7,8				
	006	6,4	9,6				
	008	8,2	12,3				
	010	10,2	15,3				
IGP4	013	13,3	19,9	330	345	3600	400
	016	15,8	23,7			3400	
	020	20,7	31,0			3200	
	025	25,4	38,1	300	330	3000	
	032	32,6	48,9	250	280	2800	
IGP5	032	33,1	49,6	315	345	3000	400
	040	41	61,5			2800	
	050	50,3	75,4	280	315	2500	
	064	64,9	97,3	230	250	2200	
IGP6	064	64,1	96,1	300	330	2600	400
	080	80,7	121,0	280	315	2400	
	100	101,3	151,9	250	300	2100	
	125	126,2	189,3	210	250	1800	
IGP7	125	125,8	188,7	300	330	2200	400
	160	160,8	241,2	280	315	2000	
	200	202,7	304,0	250	300	1800	
	250	251,7	377,5	210	250		

NOTE 1: Under continuous operating conditions, the allowed suction pressure range is 0.8 ÷ 3 bar abs. For shorter time, a minimum suction pressure of 0,6 bar abs is allowed.

NOTE 2: Production tolerances can reduce the displacement by 1,5% max. The flow rate at 1500 rpm shown in the table, considers operation with pressure of 10 bar.

NOTE 3: The continuous and peak pressures are valid for rotation speeds between 400 and 1500 rpm. For speeds of more than 1500 rpm the peak pressure must be reduced. The peak pressure is applicable for 15% of the operating time, with a maximum cycle time of 1 minute.

NOTE 4: Variable speeds require pressure limitations if they are out of 400 ÷ 1500 rpm range. Contact our technical department for applications of this kind.

Appendix C

6519
for extended
temperature range

bürkert

Type 6519 for extended standard temperature range

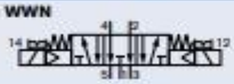
Technical data	Aluminium	Stainless steel
Orifice	9	9
Body material Pilot valve Main valve	 Stainless steel Aluminium ematal coated	 Stainless steel Stainless steel 1.4571
Threaded socket material	in aluminium	in stainless steel
Seal material	FPM, NBR	PU, NBR, FPM
Medium	Neutral medium, eg lubricated or non-lubricated compressed air	
Compressed air quality	ISO 8573-1:2010, Class 7.2.4*	
Medium temperature	-30 °C to +80 °C	-30 °C to +80 °C
Ambient temperature	-40 °C to +80 °C	-30 °C to +80 °C
Pneumatic connection Supply port connection 1, 3, 5 Service port 2, 4	 Thread G ¼, (on request NPT ¼) Thread G ¼ (on request NPT ¼)	
Operating voltages	24 V DC 24/ 110/ 230 V/ 50-60 Hz	
Voltage tolerance	+10%	
Electr. power consumption	2 W	
Duty cycle	100% continuous operation	
Electrical connection	Tag connector acc. to DIN EN 175301-803 (previously DIN 43650) Form A for cable plug Type 2508	
Type of protection	IP65 with cable plug	
Installation	As required, preferably with actuator upright	

Response times	5/2	5/2-bi	5/3	3/2	5/2	5/2-bi
Opening [ms]	16	18	16	13	12	14
Closing [ms]	27	18	22	47	74	14

* To prevent freezing of the expanded compressed air, the pressure dew point must be at least 10 K lower than the temperature of the medium.

Ordering chart for valves in aluminium with manual override (without manual override on request)

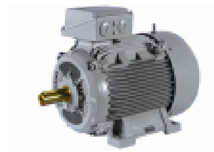
All products come with a standard stainless steel cap nut. This cap nut protects the exhaust channel from penetrating humidity.

Circuit function	Orifice [mm]	Seal material and body	Threaded port connection [inch]	Q_{Nn}-value air [l/min]	Pressure range [bar]	Weight [g]	Nominal power [W]	Voltage/ Frequency [V/Hz]	Article no.
5/2 WWH 	9.0	FPM, NBR	G ¼"	1800	2.5-10	680	2	024/DC	231386
								024/50-60	231387
								110/50-60	231388
								230/50-60	231389
5/2-bistable WWZ 	9.0	FPM, NBR	G ¼"	2100	2.5-10	990	2	024/DC	231390
								024/50-60	231391
								110/50-60	231392
								230/50-60	231393
5/3 WWL 	9.0	FPM, NBR	G ¼"	1500	2.5-10	1060	2	024/DC	231394
								024/50-60	231395
								110/50-60	231396
								230/50-60	231397
5/3 WWN 	9.0	FPM, NBR	G ¼"	1500	2.5-10	1060	2	024/DC	231399
								024/50-60	231400
								110/50-60	231401
								230/50-60	231402

Appendix D

SIEMENS

Data sheet for three-phase Squirrel-Cage-Motors



MLFB-Ordering data: **1LE7501-1AB43-5AA4**

Frame size: **100L**

Client order no.:	Item no.:
Order no.:	Consignment no.:
Offer no.:	Project:
Remarks:	

U	Δ / Y	f	P	I	n	M	M	NOM. EFF at ... load [%] *			Power factor at ... load *			I_A/I_N	M_A/M_N	M_K/M_N	IE-CL
[V]±10%		[Hz]±5%	[kW]	[A]	[1/min]	[kgf.m]	[Nm]	4/4	3/4	2/4	4/4	3/4	2/4	I_l/I_N	T_l/T_N	T_B/T_N	
415	Δ	50	2.20	4.80	1440	1.5	14.6	84.3	84.3	83.3	0.76	0.67	0.54	6.6	2.8	3.0	IE2
Data subject to tolerance as per IS 12615 / IEC 60034-1								SF: 1.00			*sinusoidal feed						
Environmental conditions : -20 °C to +50 °C / 1000.0 m								locked rotor withstand time (hot / cold) : 8.0 s / 10.0 s									

Mechanical data		
Sound pressure level 50Hz | 60Hz	62 dB(A)	65 dB(A)
Type of construction	IM B3 / IM 1001	
Bearing DE | NDE	6206 2ZC3	6206 2ZC3
Type of bearing	Locating (fixed) bearing, NDE	
Lubricants	Esso Unirex N3	
Regreasing device	- / -	
Grease nipple	- / -	
Bearing lifetime	50000 h	
Condensate drainage holes	Yes (standard)	
External earthing terminal	Yes (standard)	
Vibration severity grade	A (Standard)	
Insulation	F utilized to B	
Duty type	S1	
Direction of rotation	Bidirectional	
Frame material	Cast iron	
Data of anti condensation heating	-/-	
Coating (paint finish)	Standard paint finish	
Color, paint shade	RAL7030	
Motor protection	(A) without	
Method of cooling	IC411 - Self ventilated, surface cooled	
Degree of protection	IP55	
Weight in kg, without optional accessories	34 kg	
Rotor weight in kg	7 kg	
Moment of inertia | Rotor GD²	0.0086 kg m²	0.0344 kgf.m²

Terminal box	
Terminal box position	Top
Material of terminal box	Aluminium
Type of terminal box	TB1 F04
Contact screw thread	M5
Max. cross-sectional area	16.0 mm²
Cable diameter from ... to ...	11.0 mm - 21.0 mm
Cable entry	2xM32x1,5
Cable gland	2 Plugs

Notes

I_A/I_N = locked rotor current / nominal current M_K/M_N = break down torque / nominal torque

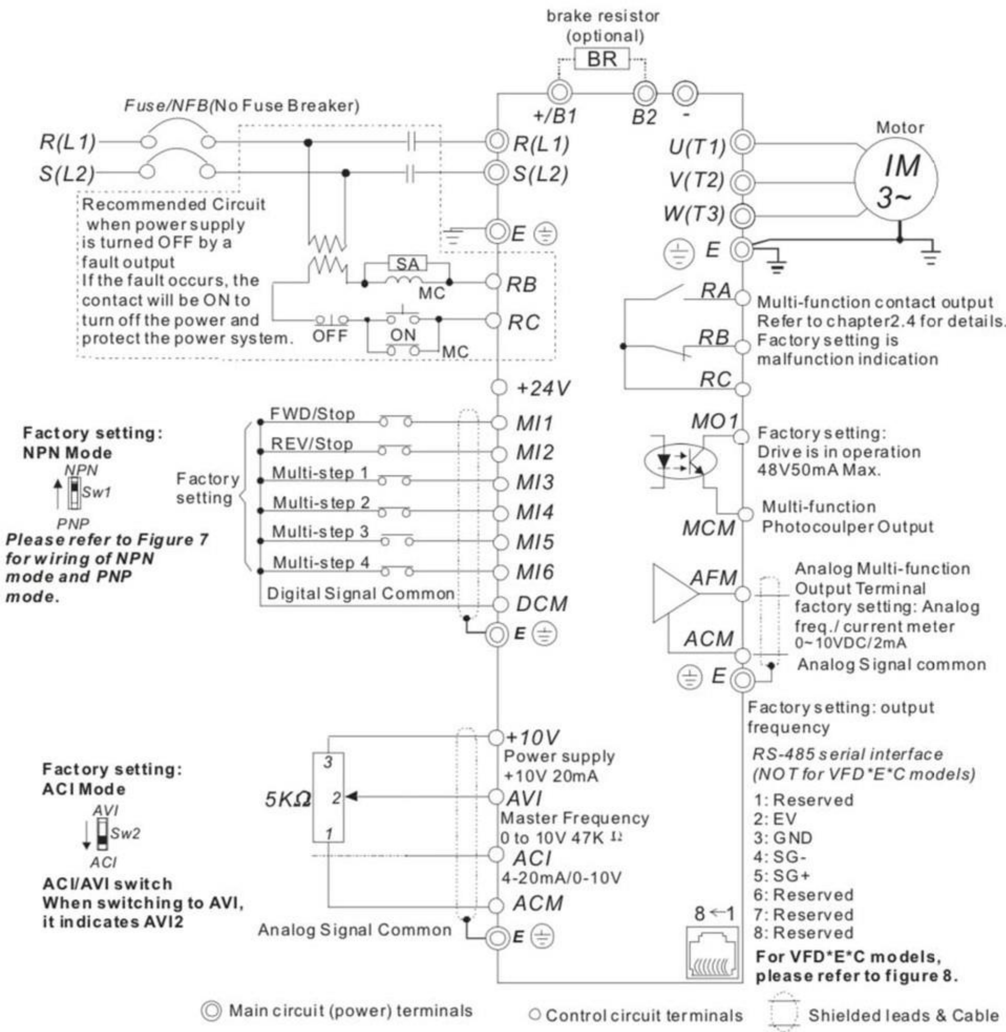
M_A/M_N = locked rotor torque / nominal torque

Technical data are subject to change! There may be discrepancies between calculated and rating plate values.

Version: 2019.03
Generated: 06.08.2019 11:35:57

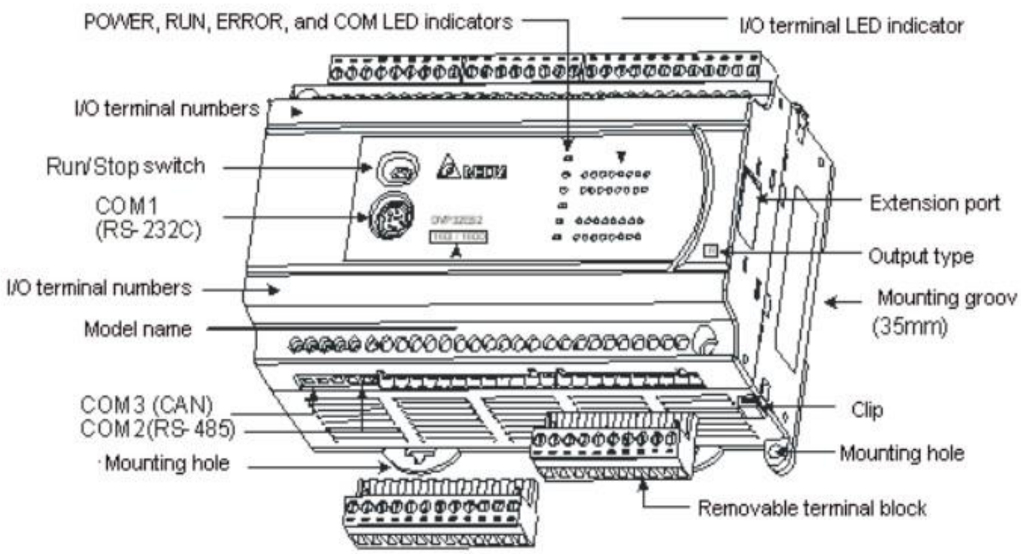
Appendix E

Figure 3 for models of VFD-E Series
VFD007E11A, VFD015E21A, VFD022E21A, VFD007E11C, VFD015E21C, VFD022E21C



Appendix F

Specifications						
Control Method					Stored program, cyclic scan system	
I/O Processing Method					Batch processing method (when END instruction is executed)	
Execution Speed					LD instructions – 0.54μs, MOV instructions – 3.4μs	
Program language					Instruction List + Ladder + SFC	
Program Capacity					15872 steps	
Bit Contacts	X	External inputs			X0~X377, octal number system, 256 points max, (*4)	Total 256+16 I/O
	Y	External outputs			Y0~Y377, octal number system, 256 points max, (*4)	
	M	Auxiliary relay	General		M0~M511, 512 points, (*1) M768~M999, 232 points, (*1) M2000~M2047, 48 points, (*1)	Total 4096 points
			Latched		M512~M767, 256 points, (*2) M2048~M4095, 2048 points, (*2)	
			Special		M1000~M1999, 1000 points, some are latched	
	T	Timer	100ms (M1028=ON, T64~T126: 10ms)		T0~T126, 127 points, (*1) T128~T183, 56 points, (*1)	Total 256 points
					T184~T199 for Subroutines, 16 points, (*1)	
					T250~T255(accumulative), 6 points (*1)	
			10ms (M1038=ON, T200~T245: 1ms)		T200~T239, 40 points, (*1)	
					T240~T245(accumulative), 6 points, (*1)	
			1ms		T127, 1 points, (*1) T246~T249(accumulative), 4 points, (*1)	
	C	Counter	16-bit count up		C0~C111, 112 points, (*1) C128~C199,72 points, (*1)	Total 232 points
					C112~C127,16 points, (*2)	
			32-bit count up/down		C200~C223, 24 points, (*1)	
					C224~C231, 8 points, (*2)	
			32bit high-speed count up/down	Soft-ware	C235~C242, 1 phase 1 input, 8 points, (*2)	Total 23 points
					C232~C234, 2 phase 2 input, 3 points, (*2)	
				Hard-ware	C243~C244, 1 phase 1 input, 2 points, (*2)	
					C245~C250, 1 phase 2 input, 6 points, (*2)	
					C251~C254 2 phase 2 input, 4 points, (*2)	
	S	Step point	Initial step point		S0~S9, 10 points, (*2)	Total 1024 points
			Zero point return		S10~S19, 10 points (use with IST instruction), (*2)	
			Latched		S20~S127, 108 points, (*2)	
			General		S128~S911, 784 points, (*1)	
			Alarm		S912~S1023, 112 points, (*2)	
Word Register	T	Current value			T0~T255, 256 words	
	C	Current value			C0~C199, 16-bit counter, 200 words	
					C200~C254, 32-bit counter, 55 words	

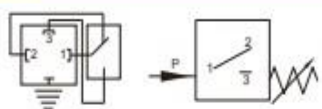

POWER, RUN, ERROR, and COM LED indicators
I/O terminal LED indicator
I/O terminal numbers
Run/Stop switch
COM1
(RS-232C)
Extension port
Output type
I/O terminal numbers
Mounting groov
(35mm)
Model name
COM3 (CAN)
COM2(RS-485)
Clip
Mounting hole
Mounting hole
Removable terminal block

Appendix G

Pressure Switch > Hydro-electric Type

JCD-02

SYMBOLS



ORDER CODES

JCD-02S - 1

❶ Model Name	JCD-02S, JCD-02H, JCD-02HH	
❷ Thread Connection	1	1/4" PT
	2	1/4" NPT
	3	1/4" BSPP

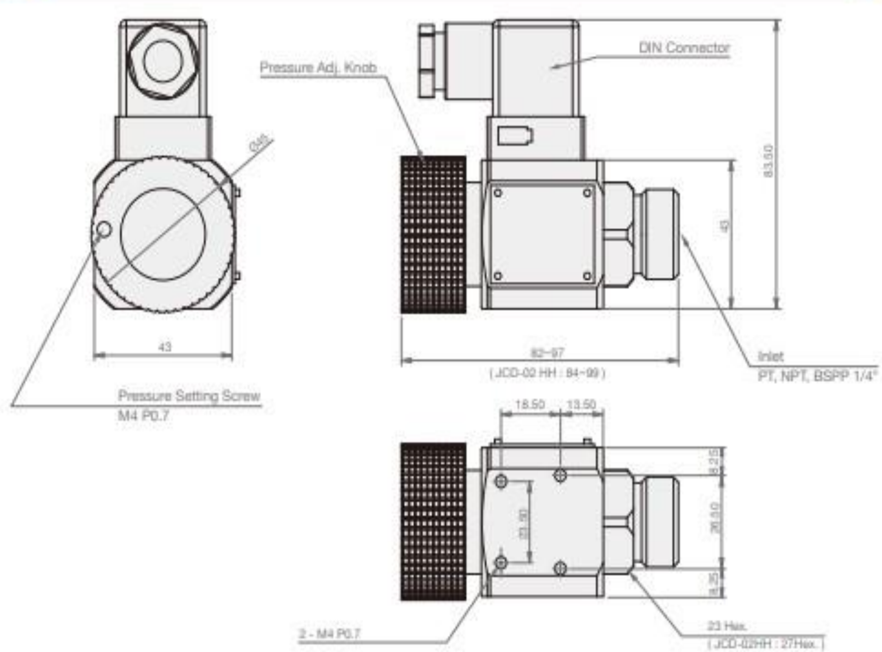
MODEL SPEC.

Model	Used Pressure (kgf/cm²)	Max. Pressure (kgf/cm²)	Weight (kg)
JCD-02S	4 - 26	50	0.8
JCD-02H	15 - 200	350	
JCD-02HH	20 - 360	600	

Operational Voltage / Current	
AC250V / 3A AC125V / 5A	DC24V / 20mA

DIMENSION

(UNIT : mm)

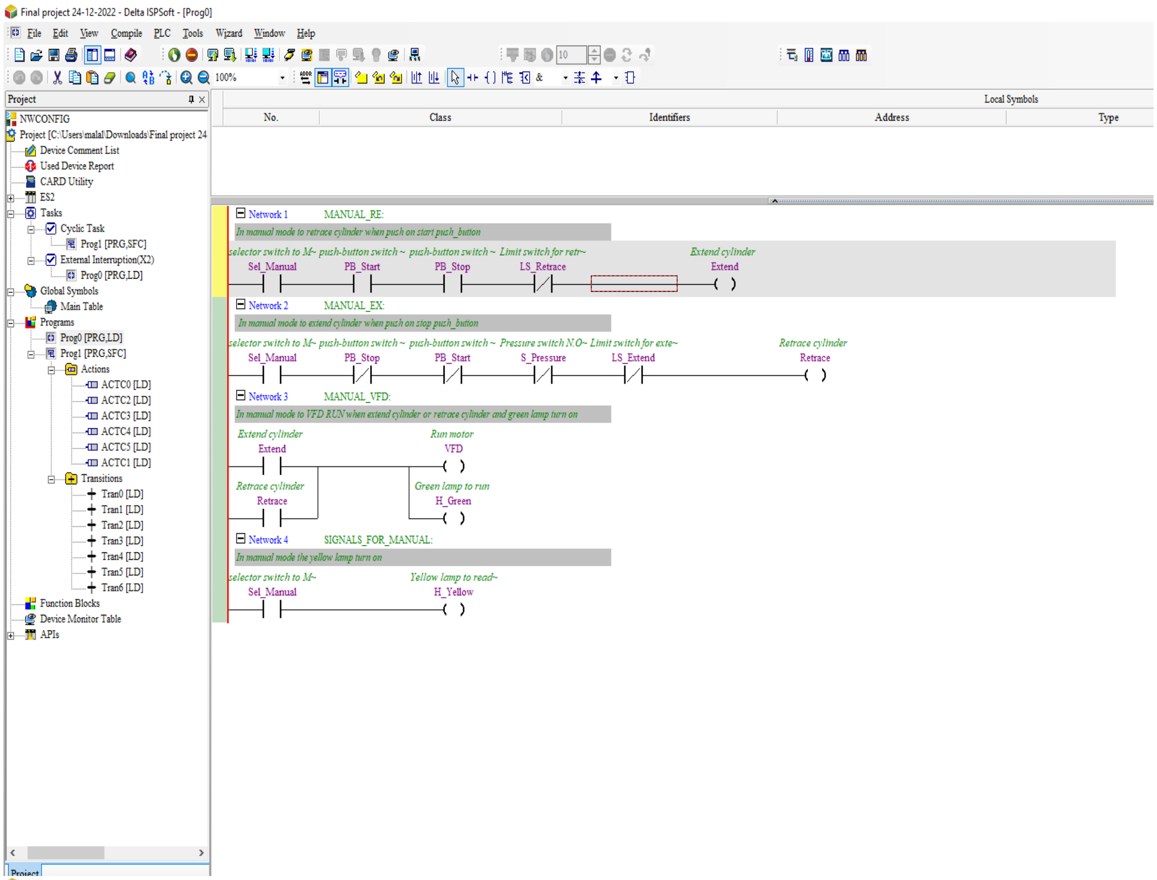


Appendix H

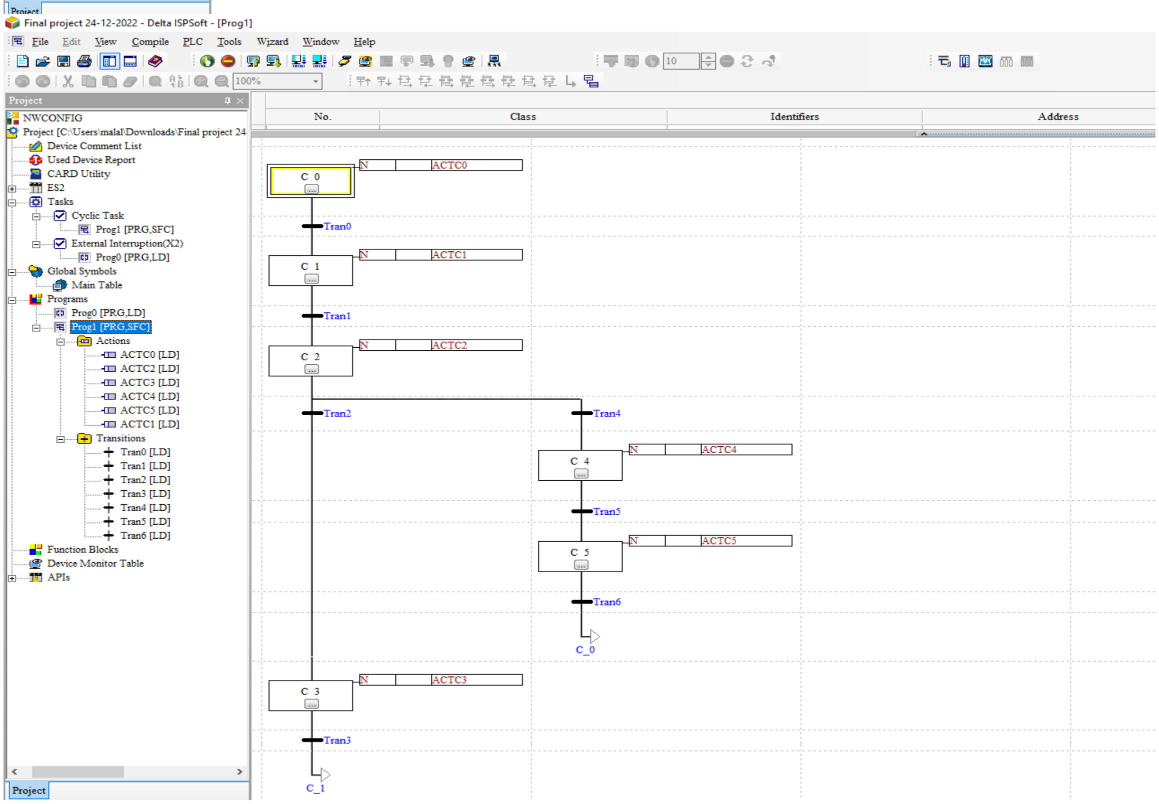

STAR gauge


NASA SAE 100 R2AT-DIN EN 853 2SN 3/8"
HOF

Appendix I



Final project 24-12-2022 - Delta ISPSoft - [Prog0]
Network 1 MANUAL_RE:
In manual mode to retrace cylinder when push on start push_button
Sel_Manual
PB_Start
PB_Stop
LS_Retrace
Extend
Network 2 MANUAL_EX:
In manual mode to extend cylinder when push on stop push_button
Sel_Manual
PB_Stop
PB_Start
S_Pressure
LS_Extend
Retrace
Network 3 MANUAL_VFD:
Extend
VFD
Retrace
H_Green
Network 4 SIGNALS_FOR_MANUAL:
In manual mode the yellow lamp turn on
Sel_Manual
H_Yellow



Final project 24-12-2022 - Delta ISPSoft - [Prog1]
ACTC0
Tran0
ACTC1
Tran1
ACTC2
Tran2
Tran4
ACTC4
Tran5
ACTC5
Tran6
C_0
ACTC3
Tran3
C_1